An Emergency Message Dissemination Protocol Using Greedy Forwarding Technique and Clustering for VANETS

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Candidate Declaration

I hereby certify that the work, which is being presented in the thesis, titled **An Emergency Message Dissemination Protocol Using Greedy Forwarding Technique and Clustering For VANETS**, in partial fulfillment of the requirements for the award of the degree of **Masters of Technology in Computer Science and Application** and submitted to the institution is an authentic record of my own work carried out during the period **July 2015** to **July 2017** under the supervision of **Dr.Prashant Singh Rana and Dr.Anju Sharma**. I have also cited the reference about the text(s)/figure(s)/table(s) from where they have been taken.

The matter presented in this thesis has not been submitted elsewhere for the award of any other degree or diploma from any institution.

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Abstract

Vehicular Ad hoc Networks (VANET) is oriented to vehicular communication also regarded as one specific application of Mobile Ad hoc Networks. The prospect of its applications in intelligent transportation and entertainment services is optimistic. While the mature routing protocols of MANET is not suitable for VANET because of its different features. Therefore, its significant to develop special routing protocols for VANET according to its features. In this thesis research is carried out on GPSR (Greedy Perimeter Stateless Routing for Wireless Networks) protocol. Analyze its functionality and point out its defects in different environments. Then put forward an improved GPSR protocol based on position vector aiming at some defects . Based on the comprehensive understanding of the routing mechanism, study the suggested solution for each of its defects. Based on the position vector calculation and simple redundancy elimination, GPSR protocol is modified. A preliminary assumption is taken into consideration for retrograde motion. NS2 (Network Simulator version2) has been used for simulation purpose. Comparative analysis of proposed work has been done with the original protocol and its performance is quite better. We want to carried out simulation for VANET in the computerised world i.e. we should do a computerized simulations. However, they may cause risk and sometimes may be danger free, we can provide or can generate the different scenario (rural, urban, collision of vehicles) of the VANET using this technique. So computerized simulation is also very important in VANET research. Simulation of VANET is broken into two part first is-Traffic simulation: Generates traffic movement. It define the mobility model for vehicles and also creating traffic movements. Secound is: Network simulation. It generates Inter communicating vehicle, Defining communication protocols. Both the simulation are connected in bi-directional coupling.

Keywords: VANET, NS-2, Network simulation, Traffic simulation, GPVR.

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Harpreet Singh

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List of Abbreviations

CCH	Control Channel
DoS	Denial-of-Service
DSRC	Dedicated Short Range Communication
ECDSA	Elliptic Curve Digital Signature Algorithm
ERD	Event Recording Device
FCC	Federal Communication Commission
GPS	Global Positioning System
OBU	On Board Unit
OSI	Open System Interconnection
RSU	Road Side Unit
SCH	Service Channel
TPM	Trusted Platform Module
TTP	Trusted Third Party
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VANET	Vehicular Ad-hoc Network
WAVE	Wireless Access in Vehicular Environment
GPSR	Greedy Protocol Stateless Routing
GPVR	Greedy Protocol Vector Routing
TCL	Tool Command Language
NS	Network Stimulator
WMN	Wireless Mesh Network
PN	Perhasive Network
VC	Vehicular Correspondence
AODV	Ad Hoc On Demand Distance Vector
DSR	Dynamic Source Routing
SP	Service Provider
DVB	Digital Video Broadcasting
LBS	Location Base Service
RSU	Road Side Unit
TPM	Trusted Platform Module
TPD	Tempered Proof Device
ET	Electronic Tag
CA	Certificate Authority

ITS	Intelligent Transportation System
CH	Cluster Head
CM	Cluster Member
GN	Gateway Node
NAM	Network Animator
DSDV	Destination-Sequenced Distance Vector
DSR	Dynamic Source Routing
GCC	Government Correspondence Commission
AP	Access Point
PDR	Packet Delivery Ratio

Chapter 1

Introduction

1.1 Perhasive Network

Perhasive Networking is seen as the capacity to communicate and get to similar sorts of service at any time and place. This is paying little attention to the area, kind of system or sort of gadget used to get system. There is a union of innovation , Technologies, business needs and end-client intrigue that is driving improvement of systems to bolster unavoidable changes, regardless of whether remote or wire line, whether it is for home, business, and coffeehouse or moving. Electrical workers are doubtlessly profiting by the way that Pervasive Networking happens over a LAN [1].

The Pervasive Network comprises of mobile nodes which are masterminded autonomously in the environment and In further they change their position dynamically. The best cases of Pervasive Network are MANET, WMN and VANET. A MANET comprises of portable nodes that are orchestrated self-governingly in the system condition. The nodes in MANET progressively change its position in light of the fact that the topology of the system changes as often as possible. It is extremely hard to give the dependable directing in MANET. The uses of Pervasive Network incorporate Military Applications, Road Safety Systems and furthermore for some basic applications.

Perhasive Network is a system which can give diverse administrations from a Single Access point. One of the utilizations of these systems is showed up as VANET. VANET is a system which contains vehicles as their members. The V To V Communication and the vehicle to street side base station can be conceivable in VANET.

1.1.1 Challenges and Issues

Optimization is the process to search the best alternative(s) from permissible available options which a given function can attain in its domain of definition, to produce satisfy result. For example, in mechanical stream, one is interested to get best possible design of a car to make a safe and economic structure. These type of problems are aiming to

get desirable response can be resolved scientifically through modeling and optimization. Modeling refers to convert the original problem into mathematical structure and to do the model must be designed in such a way that it includes all key characteristics of the original system. The created models are generally formulated as functions, are known as objective functions, in single or more variables that correspond to adoptable parameters of the system. Complex systems are modeled with complicated multi-dimensional functions in most of the optimization problems and therefore, they cannot be easily communicated. To solve such optimization problems numerically, algorithmic procedures which take full advantage of modern computer systems can be implemented. Thus, time constraint, computation accuracy and implementation efforts become important points of the numerical optimization procedure. In a large portion of such issues, the target work is uproarious, intermittent and with absence of analytical representation. Under these limitations, the pertinence also, effectiveness of traditional and deterministic streamlining calculations are questionable. The fundamental downsides with deterministic calculations are that they are not strong i.e. must be connected to confined class of issues and as well tedious or sometimes unfit to take care of certifiable issues. To maintain a strategic distance from these disadvantages, there is an incredible need to grow quick, precise and proficient calculation that can tackle true enhancements issues.

1.2 VANET

VANETs The systems that interconnect vehicles on street are called VANETs. "MANET comprises of portable nodes that associate themselves in as decentralized, self-sorting out way and may likewise set up multi-hop routes. If the nodes are car, then this is called Vehicular Ad Hoc Network ". "The fundamental focus of research in VANETs is the enhancements of vehicle wellbeing by methods for vehicular correspondence ". A few distinct applications are rising in VANETs. These applications incorporate security applications to make driving considerably more secure, portable trade and other data benefits that will educate drivers about a blockage, driving perils, mishaps, roads turned parking lots. VANETs have a few unique angles contrasted with MANETs, in that the nodes move with high speed in light of which the topology changes quickly. VANETs are likewise inclined to a few distinct assaults. Consequently, the security of VANETs is key. VANETs posture many difficulties on innovation, conventions, and security, which increment the requirement for research in this field.

VANET is a technology that utilize moving car as nodes in a system to make a portable system. VANETs transforms each car into a remote switch or node, permitting cars

roughly l00 -300m(meter) from one other to associate and, thus, make a system with a huge range. As car drop of the flag range and drops completely away from the system, different car may participate, associating vehicle to one other because of that a versatile system is made. That is assessed primary frameworks which will incorporate a innovation with cops as well as fire vehicle or some public emergency transport to speak with one other for securities reason or for emergency [28]. VANETs gone under the classification of remote ad hoc arrange. In vehicular specially appointed system or VANET, the hub might be a vehicle or the road side units.

They can speak with each other by permitting the remote association up to a specific range. Inter Vehicular Communications sometimes called VANETs have turned out to be exceptionally well. A VANET is a unique sort of MANETs is a sort of remote systems and is self-arranging system of versatile switches associated by remote connections) which utilize vehicles as nodes. The primary distinction is that versatile switches which manufacture the network are vehicles like cars or trucks. A few unique applications are developing as to vehicular interchanges. For instance, security applications for more secure driving, data administrations to educate drivers about the driving dangers and different business benefits in the region of the vehicle. Government, partnerships, and the scholastic groups are taking a shot at empowering new applications for VANETs. A primary objective of VANETs is to expand street wellbeing by the utilization of wireless communication.

To accomplish these objectives, vehicles go about as sensors and educate each other about anomalous and possibly perilous conditions like glazes, roads turned parking lots and coatings. Vehicular systems nearly look like specially appointed systems on account of their quickly evolving topology. Hence; VANETs require secure directing conventions. Various Applications are one of a kind to the vehicular setting. These applications incorporate well being applications that will make driver sheltered, versatile trade, roadside benefits that can insightfully advise drivers about clog, organizations, and administrations in the region of the Vehicle. VANETs, particularly contrasted with MANETs are described by a few remarkable perspectives. Nodes move with high speed, bringing about high rates of topology changes. As a result of quickly changing topology because of vehicle movement, the vehicular system nearly takes after an ad hoc system. The requirements and enhancements are astoundingly distinctive. From the system viewpoint, security and adaptability are two huge difficulties. A considerable arrangement of misuse and assaults end up plainly conceivable.

Subsequently, the security of vehicular systems is imperative. The developing significance of inter vehicular communication has been perceived by the administration, organizations,

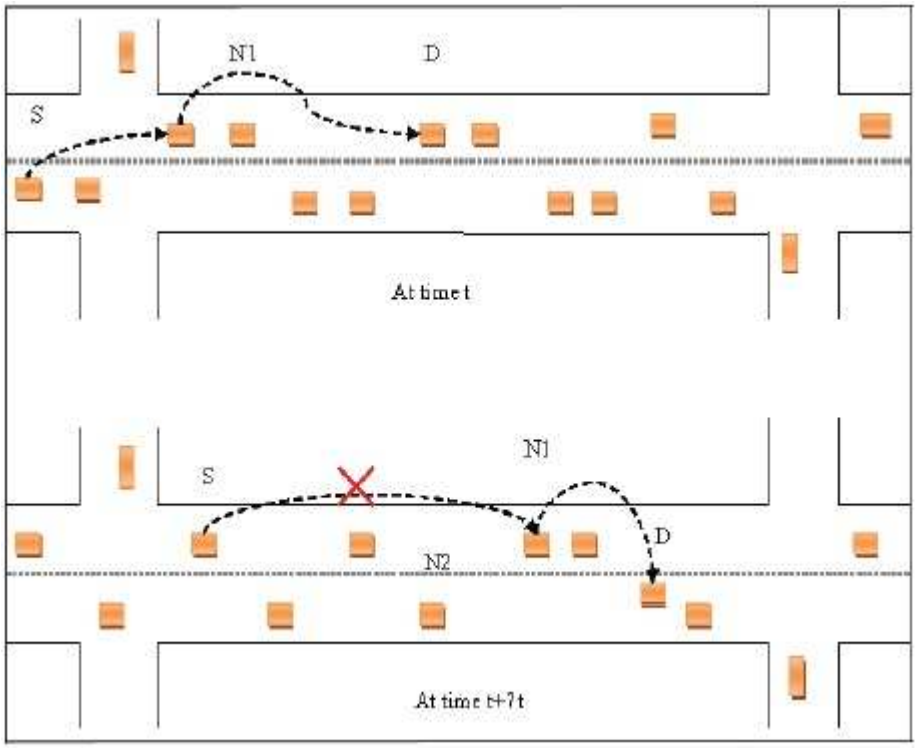
and the scholastic group. Government and industry collaboration has subsidized expansive IVC organizations or undertakings, for example, Advanced Driver Assistance Systems and CarTAlK 2000 in Europe, and FleetNet in Germany. VANETs posture many difficulties on innovation, conventions, and security which increment the requirement for research in this field

VANETs are relied to bolster a vast range of mobile dispersed applications that range from movement alert and dynamic route planning wanting to setting mindful promotion and document sharing. Looking at the vast number of nodes that take part in these systems and their very high adaptability, discussion still there about the practicality of use that utilization end to end multi hop correspondence. The fundamental concern is the execution of VANET routing protocol can fulfill the throughput and postpone prerequisites of such applications. Investigations of conventional steering protocol for MANETs exhibited that their execution is poor in VANETs. The principle issue with these conventions, e.g. AODV and DSR, in VANET conditions is their course flimsiness. The customary node driven perspective of the courses (i.e., a built up course is a settled progression of nodes between the destination and the goal) leads to ad hoc routes in presence of VANETs' high adaptability, as represented in Fig. l.l.

Subsequently, numerous packets are lost, and the overheaded because of route repairs or failure notices fundamentally builds, prompting low deleivery ratio and high transmission delays. One option approach is offered by topographical directing conventions, e.g., greedyfacegreedy , voracious other versatile face routing ,GOAFR, GPSR, which decouple sending from the hubs character. These conventions don't build up courses yet utilize the position of the goal and the location of the neighbor node to forward information. Not at all like nodes driven directing, land steering has the favorable position that any nodes that guarantees advance toward the goal can be utilized for sending. For example, in Figure 1.1, topographical sending could utilize node N2 rather than Nl to forward information to D. Regardless of better way steadiness, land sending does not likewise do well in structure of VANETs [28].

Its issue is that, customarily, it can't locate a next jump (i.e. a node is nearer to the goal than the present node). The recuperation procedures in the writing are regularly in view of planar diagram traversals, which were appeared to be ineffectual in VANETs because of radio hindrances, high node versatility, and the way that vehicle locates themselves on streets.

Vehicular Ad Hoc Network can offer different services and advantages to VANET clients and in this way merits arrangement exert. VANETs with interconnected vehicles and various administrations guarantee integration of computerized framework into numerous



(a) Pre-established routes frequently break in highly mobile VANETS

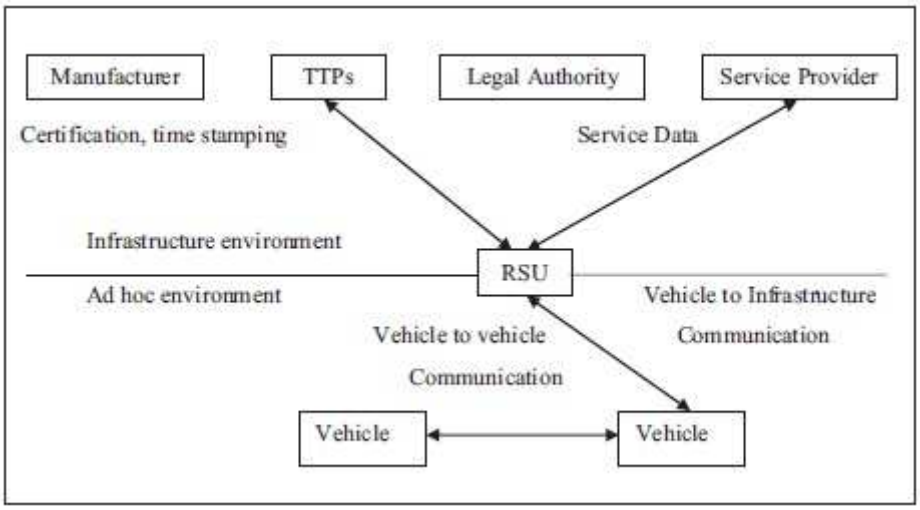
Figure 1.1: Pre-established routes frequently break in highly mobile VANETS .

parts of our lives, from vehicle to-vehicle, roadside gadgets, base stations, activity lights etc. A system of an enormous number of versatile and rapid vehicles through remote correspondence associations has moved toward becoming electronically and technically feasible and been produced for stretching out customary activity controls to brand new activity benefits that offer substantial movement related applications. Wellbeing of data trade empowers life-basic applications, for example, the cautioning usefulness amid crossing point navigating and path combining, and in this way assumes a key part in VANET applications. The appealing elements of VANETs definitely bring about higher danger if such systems don't consider before sending.

For example, if the wellbeing messages are altered, disposed of, or deferred either purposefully or because of equipment breaking down, genuine results, for example, wounds and even passings may happen.

1.2.1 VANET Model Overview

There are numerous substances required in a VANET settlement and arrangement. In spite of the fact that by far most of VANET nodes are vehicles, there are different elements



(a) VANET Model

Figure 1.2: VANET Model .

that perform essential operations in these systems. In addition, they can speak with each other in a wide range of ways. In this Section, right off the bat a depiction about the most well-known substances those show up in VANET, is given. In the second section, an investigation of the distinctive VANET settings that can be found among vehicles and the rest of the elements, is made.

Most Common VANET substances: Several distinct elements are generally accepted to exist in VANETs. To comprehend the internals and related security issues of these systems, it is important to dissect such substances and their connections. Figure l.2 demonstrates the run of the mill VANET plot.

As shown in Fig 1.2, two unique situations for the most part considered in VANETs:

Foundation condition in which, substances can be for all time interconnected. It is for the most part created by those substances that deal with the activity or offer an outer administration. On one hand, makers are once in a while considered inside the VANET demonstrate. As a component of the assembling procedure, they recognize interestingly every vehicle. Then again, the legitimate authority is generally present in VANET models. Despite of different rule and regulation on every nation, it is constantly identified with two primary assignments - vehicle enrollment and offense revealing. Each vehicle in a regulatory area ought to get enlisted once fabricated or manufactured. Thus of process, the authority issues a license plate. Then again, it likewise forms movement report and fines. Trusted Third Parties are additionally present in this condition. For that he also offer distinctive administrations like qualification administration or time span. Producers and the expert are identified with TTPs in light of the fact that they in the

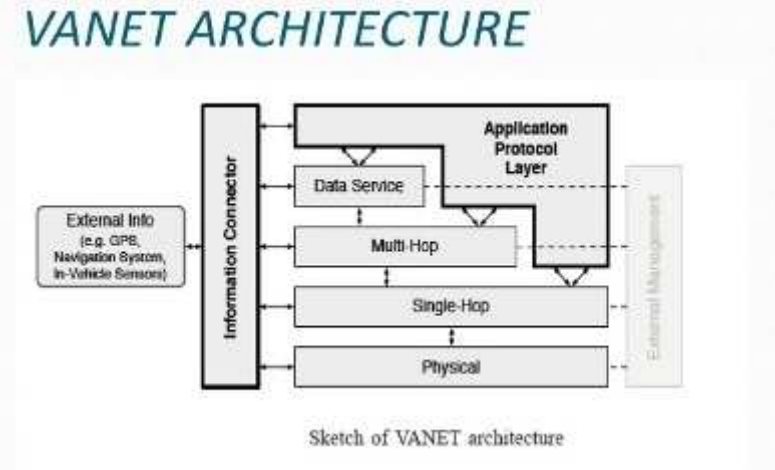
long run require their administrations (for instance, for issuing electronic accreditations like passwords). Service Providers are additionally considered in VANETs. They offer administrations that can be gotten to through the VANET. Location Based Services and Digital Video Broadcasting are two cases of such services.

Ad Hoc environment condition in which, sporadic communication are set up from vehicles. From the VANET perspective, they are outfitted with three distinct gadgets. Right off the bat, they are furnished with a correspondence unit OBU that empowers Vehicle-to-Vehicle and Vehicle-to-Infrastructure V2I, I2V interchanges. Then again, they have an arrangement of sensors to quantify their own status (e.g. fuel utilization) and its condition (e.g. dangerous street, security separate). These sensorial information can be imparted to different vehicles to expand their mindfulness and enhance street wellbeing. At last, a Trusted Platform Module is frequently mounted on vehicles. These gadgets are particularly intriguing for security purposes, as they offer dependable stockpiling and calculation. They as a rule have a dependable inside clock and should be alter safe or possibly alter clear. Along these lines, delicate data (e.g. client qualifications or pre-crash data) can be dependably put away.

1.2.2 System Architecture and Working of VANETs

Vehicular Networks System incorporates enormous number of center point, for the most part number of vehicles outflanking 750 million on the planet today, these vehicles will require an expert to speak to it, every vehicle can talk with different vehicles utilizing dedicated short radio signals (5.9 GHz), for range can fulfill upto l KM, this correspondence is an Ad hoc correspondence that induces each related center point can move clearly, no wires required, the switches used called Road Side Unit , the RSU fills in as a switch between the vehicles on the town and related with other structure gadgets. Every vehicle has OBU , this unit interfaces the vehicle with RSU by strategies for DSRC radios, and another gadget is TPD , this contraption holding the vehicle favored encounters, each one of the data about the vehicle like keys, driver's character, trip unnoticeable segments, speed, course and so on

The design of VANET proposes that the bestowing nodes in a VANET are either vehicles or base stations. Vehicles can be private (having a place with people or privately owned businesses) or open (i.e., open transportation implies, e.g.transports, and open administrations, squad cars). Base stations can have a place with the administration or to private service providers. As appeared in figure 1.7 the vehicles can speak with each other and speak with RSU.



(a) Architecture of VANET

Figure 1.3: Architecture of VANET.

1.3 Probability of Attacks in VANET

Other than having purposes of enthusiasm of the go-between re-encryption method for approval, there are still some attacks that can be possible that are cleared up as follow:

Denial of Service attack: Assailants(Attackers) may attempt to begin extraordinary authentication requests with a particular ultimate objective to cripple the benefits of the Access Point . A general game plan is purpose of repression the amount of affirmation request which can be set up in a unit of time period. This technique can ensure that the server is not overpowered by DoS. Regardless, this could in like way yield a demand. The use of the game plans must consider such tradeoffs.

Spying: Since the session key is figured in light of the nonce's contributed by the node and the AP autonomously. Both of the car's node nonce and the AP's nonce are blended by the comprehensive group key of the SP amidst transmission. The aggressor can uncover the session key, on the off chance that he/she got the SP's private key, or a proper re-encryption key/private key match.

Cover Attack: An unapproved car which did not subscribe advantage from the SP may get the endorsement messages reporting dynamically and attempt to have it avowed to the AP by replaying them. The aggressor(Attacker) can get the car's open key and introduction and replay the car's endorsement request. In the event that the nonce n1 (discretionarily picked) by the AP, matches with the one picked earlier, then the attacker can unravel the reaction message from the AP which is blended by the car's open key

[7].

Key Bootstrapping and Rekeying: Anonymous keys are preloaded by the transportation ace or the maker, however with various results. Besides, while Electronic tag are settled and ought to keep running with the vehicle for a long length (potentially its life cycle), undercover key sets must be sporadically restored after all the keys have been utilized or their lifetimes have snuck past. This empowering should be possible amidst the sporadic vehicle checkup (reliably yearly) or by proportionate theory. In spite of the ELP and Anonymous keys, every vehicle ought to be preloaded with the Certificate Authority open key.

1.4 Vehicular Network Challenges

Transportability: The basic thought from Specially appointed Systems is that each center in a MANET is flexible, and can move beginning with one place then onto the following inside the extension district, yet the compactness speed is limited. However, in VANET center points moving with quick, vehicles make relationship with various vehicles [8] which are open inside its correspondence range, and this affiliation exists for only a couple of minutes as vehicle move toward its, and both these vehicles never meet one another. So to secure flexibility test is a troublesome issue.

Volatility: The system among center points can be exceedingly momentary, and maybe won't happen yet again, vehicles experiencing extension district and makes relationship with various vehicles, these affiliations will be lost as each node has a high compactness, and may go in opposite bearing. Vehicular frameworks does not have the for the most part long life setting, so singular contact of customer's contraption to an issue region will require long life context and this will be outlandish for securing Vehicular Correspondence .

Privacy versus Verification: The importance of approval in Vehicular Specially appointed Systems is to neutralize attack. To keep up a vital separation from this issue, they can give a specific character for every vehicle, yet this game plan won't fit for many of the drivers who wants to keep their information guaranteed and private.

Assurance Versus Liablility: Liablility will give a fair open entryway for legitimate examination and this data can't be neglect (if there ought to be an event of setbacks), on the other hand the security must not be dismissed and driver have the capacity to keep his own information from others (Character, Driving Way, and Record Number for toll Authority).

Network Adaptability: The extent of framework on planet around outperforming the 750 million center points, and this number is building up, another issue rises when there is no overall master to speak to the measures of this framework, for instance: Gages for DSRC in America is different as compare to DSRC rules in Europe, the models for the GM Vehicles are different from as compared to BMW .

Bootstrap: Right now number of automobiles have the gear required for the DSRC radios, if they make a correspondence they have to expect that there is a foreordained number of cars that will get the correspondence, later on they ought to concentrate on getting the number higher, to get a budgetary favorable position that will encourage the business to place assets into the development.

1.4.1 Vehicular Communication

Rapid advances in wireless technologies offer chances to use these technologies in support of front line vehicle thriving applications. Specifically, the new Dedicated Short Range Correspondence offers the probability to sensibly bolster vehicle-to vehicle and vehicle-to-roadside flourishing exchanges, which has wound up being known as Vehicle Correspondence types of progress. DSRC empowers another class of correspondence applications that will develop the general success [24] and benefit of the transportation structure.

Intelligent Transportation System are the conceivable predetermination,future of transportation. Thusly of making norms, for example, 5.9 GHz submitted short-run correspondence, vehicles will soon be able to talk with each other and their condition. Distinctive applications will be made open for vehicular systems that update the general success of the transportation foundation. For example, the structure will be able to screen activity to empower advancement lights with the target that activity streams easily. Sensors will utilize incorporate from vehicles to perceive roads turned stopping ranges. Open flourishing vehicles will pass on, through the remote channel, to change advancement developments recalling the genuine target to react rapidly to a crisis. Cars will chat with each other to drive charmingly, thusly maintaining a strategic distance from accidents and enhancing capacity. These are a fragment of the conceivable applications, later on, that will be conceivable with the occurrence to the DSRC standard. Considering the epic great conditions predicted from vehicular correspondences and the immense number of vehicles, obviously vehicular spontaneous structures VANET are apparently going to twist up perceivably the most fundamental attestation of advantageous exceptionally assigned systems [24].

The fitting breaker of on-board PCs, helpers, and GPS orchestrating gadgets near to correspondence limits, opens massive open portals, moreover raises vital research challenges. DSRC is a credibility for use in a VANET, is a short to medium range correspondence advantage that bolster both open flourishing and private correspondence. The correspondence condition of DSRC is both vehicle-to-vehicle and vehicle-to/from-roadside.

The VANET plans to give a high information rate and in the interim limit in action inside a generally little correspondence zone. Diverse novel problems are associated with a VANET by ethicalness of the surprising characteristics of the structure. To start, the basic contrasts between a VANET and a MANET are a MANET generally has no framework open. By uprightness of a VANET, it is conceivable to intentionally get to focuses at the edge of the street, and thusly enable vehicles' path to the associations open from the framework. Also, one of the best inconveniences is the vehicles in the system move at more basic paces than most one of a kind MANETs, inciting a structure that can a critical piece of the time twist up clearly apportioned. Adaptability is one test to which there are two or three courses of action open in the structure [10]. Moreover, security and protection are a fundamental worry for a VANET.

Dedicated Short Range Correspondence is a standard that game plans to pass on vehicular structures to North America. Development fatalities have been a long standing issue in the Assembled States, as in whatever is left of the world. As a sign of the sincerity of the issue, in 1999 there were 6,279,000 engine vehicle occurrences that addressed 41,611 deaths in the Unified States. In 1991, the US Congress passed the Multi-purpose Surface Transportation Productivity Demonstration of 1991 that accomplished the improvement of the first of Wise Intelligent Transportation System . The objective of the ITS program is to breaker advancement into the transportation foundation to update flourishing. The first of the Dedicated Short-Run Correspondence structure works at 915 MHz and has a transmission rate of 0.5 Mbps. This meander had obliged achievement and was utilized basically by business vehicles and for toll gathering. One occasion of a novel DSRC application is uncovered that is utilized for electronic toll gathering. The second time of DSRC begun in 1997 when ITS America asked for that the Government Correspondence Commission apportion an extra 75 MHz of trade speed. In October 1999, the GCC alloted the 75 MHz of transmission point of confinement in the 5.9 GHz band for the second time of DSRC .

Since the task of the data transmission, institutionalization bodies have been handling the usage reasons for excitement of 5.9 GHz DSRC. The North American DSRC guidelines program goes for making an inter operatable standard for use in the Unitied States, Canada, and Mexico. The fundamental focus of the meander is to connect with drivers

to get jump forward data as to their wrapping condition, thusly reducing auto crashes [1].

Chapter 2

Background and literature Survey

An overview of Wireless Networks security, assumptions made when designing protocols, The Overview of Wireless Network security, when we outline the conventions there is an issue of the security in remote framework and remote innovation and we will talk about in this section why security is required , what is part of the security , what is security and why it is so important for us.

Zhang *et al.* [31]: In their research, Intrusion recognition in Wireless specially appointed Networks (Ad Hoc), the creators talk about a factual inconsistency identification approach for versatile mobile systems. Up until this point, the creators focus on reenactments at the directing convention level, yet they have not specified about multi-layer coordinated interruption detection that would be useful to expand identification rate. On the application layer, they propose to utilize measurable investigation of administration parameters, for example, benefit time or request rate. In any case, because of the constantly changing topology inside VANETs, a measurable abnormality identification approach (particularly on the directing level) appears not to be pertinent, since it is extremely hard to study typical conduct in preparing stages which will later vary from an assault(attack).

Lunt *et al.* [16]: In their research, Detecting and rectifying malevolent information in VANETs the creators expressed that - to meet execution objectives, it is generally concurred that vehicular specially appointed systems (VANETs) must depend intensely on node to node correspondence, therefore taking into account noxious information activity. In the meantime, the simple access to data managed by VANETs conceivably empowers the troublesome security objective of information approval. Also, they proposed a general way to deal with assessing the legitimacy of VANET information. In their approach a node looks for conceivable clarifications for the information it has gathered in light of the way that vindictive nodes might be available. Clarifications that are reliable with the node's model of the VANET are scored and the node acknowledges the information as managed by the most noteworthy scoring clarifications. Our strategies for producing and scoring clarifications depend on two suppositions: first; nodes can tell at slightest some different nodes separated from each other and second; a niggardliness contention

precisely reflect behavoir conduct in a VANET, they justify both presumptions and show our approach on particular VANETs.

Rawat *et al.* [22]: The VANET security has turned into a vital and dynamic region inside the research group. In spite of the different assaults gone for specific nodes in VANET that have been uncovered, many assaults including various nodes still accomplish little care. Besides, it may likewise need to do with the origination in which no scientific classification or overview has been performed to clear up the elements of a few different node assaults. This shows the aforementioned hole by offering a reasonable definition and arrangement of Sybil assaults in VANET. In the recommended work GA has been utilized with wellness work optimization. Hereditary Algorithm can be used to concoct rudimentary standards for systems movement. At in the first place, we build up a system as indicated by our necessity, then show Sybil assault on the system and look at some specific parameters esteem on these assaults on the system which are given as throughput, network load, end postponement and pdr. At that point, we exhibit hereditary calculation for advancement of extortion nodes on the other hand analyze the esteem contingent upon some specific parameters.

Kushwah *et al.* [15]: The vehicular specially appointed system now a day's developing field of research, due its framework or quickly change topology. VANET is sub some portion of MANET and blend of nodes and roadside units. VANET utilizes high versatile nodes when contrasted with MANET. VANET give remote correspondence among vehicles and vehicle to roadside unit for sharing data and wellbeing motivation behind drivers and travelers. There are different vindictive exercises performed in system like fake data assault, ID discloser, sybil assault and so on. Every one of these assaults attempt to divert drivers. In this we chip away at Dos assault in AODV directing convention. At the point when noxious node sends fake demands every now and again to different nodes it makes a blockage in system then hub is not ready to react to different nodes. In this Artificial Neural Network VANET is utilized; so neural system prepares the nodes and utilizations the back engendering and alter the weights. For the distinguishing proof of vindictive hub SOM classifier is utilized. SOM watch the conduct of nodes and groups as the typical node and malevolent node in the system.

Poonia *et al.* [19]: As of late,continous progress in remote network has opened another exploration field in PC systems. In present days remote ad hoc systems administration is a developing examination innovation that needs consideration.

A vehicular specially appointed system utilizes vehicles as versatile nodes to make portability in a system. Recreation is the generation of the technique for certifiable practices. The PC recreation keeps running on a solitary or a system of PCs to display and repli-

cate the conduct of a framework. This depends on the reasonable model to recreate the framework. In this exploration research, we will talk about the coupling test system Vanet MobiSim and NS2 for vehicular specially appointed systems. This yield will be helpful in executing effective devices on the reasonable parkway situation.

Kaur *et al.* [12] :A novel kind of ad hoc system is overcoming the streets: Vehicular Ad Hoc Networks. In these systems, vehicles speak with each other and maybe with a roadside foundation to give a not insignificant rundown of solicitations shifting from travel wellbeing to driver support and Internet access. Security is an indispensable worry for some Vehicular Ad-hoc Network applications. One particular genuine assault, known as Sybil assault, against specially appointed systems includes an aggressor illicitly guaranteeing various characters. In these systems, data of the ongoing position of nodes is a assumption made by most conventions, calculations, and solicitations. This is an exceptionally sensible suspicion, since GPS beneficiaries can be fitted effortlessly in vehicles, various which as of now accompanies this innovation. In this [3] strategy, every Road Side Unit figures and stores diverse parameter values (Signal Strength, separate) in the wake of accepting the inspirational packets from close-by vehicles.

Fathian *et al.* [9] :VANET is a system in which vehicles acting as unique node speak with each other. A VANET is a reasonable bit of framework for creating insightful transportation frameworks. Stable correspondence inside a VANET leads to upgraded driver wellbeing and better movement administration. The bunching system, which sorts out comparable vehicles into comparative gatherings, is a conceivable technique for enhancing the steadiness of availability inside a VANET. In this research, two new bunching calculations suited to the dynamic condition of a VANET are proposed. The multi-target information development analysis clustering techniques as a scientific grouping model and ant system based technique.

This is most usually utilized VANET grouping calculations. The outcomes demonstrate that the proposed calculations offer enhanced security and runtime alongside moderately preferable execution over existing calculations. Moreover, the outcomes demonstrate that in the VANET condition, the numerical bunching model proposed in this yields preferable outcomes over the meta-heuristic calculation.

Darwish *et al.* [5]: VANETs are increasing gigantic enthusiasm among scientists and ventures. In spite of the fact that the principle purpose behind creating VANETs is activity wellbeing, numerous applications, for example, movement status observing, street activity administration, directing and conveyance of information, have risen. VANETs abuse multi-hop correspondences among vehicles to convey information packets. However as it may, with quick versatility and link connection network between vehicles, productive

and solid steering in VANETs is turning into a difficult challenge. We must focus on the end goal to make routing protocol fast to successive correspondence disturbances and mindful of temperamental traffic and system conditions, a few new steering measurements have been coordinated with steering(routing) conventions. Such conventions are called traffic aware routing conventions as their directing choices are affected by movement and system status. The objective of this paper is to audit the latest movement aware directing conventions while underscoring on activity and system conditions awareness issues. Likewise, this audit examined TAR conventions capacities and impediments so far as steering procedure, directing measurements estimation, sending instruments and recuperation methods. In addition, challenges, basic issues and open research issues were talked about in the "Difficulties and issues to consider" segments.

Zeadally *et al.* [29]: VANETs have turned out to be essential parts of metropolitan range systems, and grouping for VANETS gives many focal points. In any case, the stability of current grouping calculations shows poor robustness on the grounds that is a VANET is exceeding in some unique situation. In this review, a novel multi-hop grouping plan for VANETs, which produces Cluster Heads by means of neighborhood take after connection between vehicles, is proposed. The plan depends on a sensible presumption that a vehicle can't positively recognize which vehicle its multi-hop neighbors is the most appropriate to be its CH, yet it can undoubtedly get a handle on which vehicle in one-hop separation is the most steady and comparative with it.Thus they belong to same cluster.

Tseng *et al.* [28]: Broadcasting is a typical operation in a system to determine numerous issues. In a MANET specifically, because of host mobility, such operations are required to be executed more frequently, (for example, finding a route to a specific host, paging a specific host, and sending an alert flag). Since radio signals are probably going to cover with others in a geological zone, a direct communicating by flooding is generally expensive and will cause serious redundancy, conflict, and crash, to which we call the broadcast storm issue. In this research, we distinguish this issue by demonstrating how genuine it is through analyses and recreations. We propose a few plans to decrease excess rebroadcasts and separate planning of rebroadcasts to ease this issue. Reenactment result are exhibited, which indicate distinctive levels of change over the essential flooding approach.

Chapter 3

Problem Statement and Objective

3.1 Motivation

After l980s and has now been a dynamic field of innovative work. Different sorts of difficulties in vehicular correspondences have been distinguished and tended to. A substantial number of routing protocol have been proposed for VANET. A directing convention administers the way that two correspondence substances trade data; it incorporates the method in building up a course, choice in sending, and activity in keeping up the course or recouping from steering disappointment. VANET directing conventions can be named based on topologies and geographic (position based). Topology based directing conventions can further be isolated into proactive (table-driven) and receptive (on-request) steering. Enough research has as of now been done which incorporates the correlation of different steering conventions and their execution assessment in view of various versatility models. It will enthusiasm to assess the execution of one of the directing convention by shifting the quantity of portable nodes. For this reason Ad Hoc On Demand Distance Vector steering convention is recreated on the grounds that it has been watched that AODV is a superior approach when contrasted with both Destination-Sequenced Distance Vector and Dynamic Source Routing [11].

Ad Hoc On Demand Distance Vector is a topology-based responsive steering convention, which works on jump by-bounce design. AODV keeps up the built up steering way in the given time frame and adapts well to quick changing system topologies and high relative vehicle speeds. The execution of the proposed convention can be assessed utilizing reproduction devices, fundamentally Network Simulator (NS-2)[13] and MOVE (Mobility show generator for Vehicular systems) [29] over SUMO (Simulation of Urban Mobility) [17].

3.2 Research Objective

The primary objective of this thesis is the simulation and analysis of GPSR and GPVR [20] routing protocol with mobility model for VANET [14].

To achieve this aim we have set the following objectives:

- Firstly, simulation environment is to be setup NS-2.35 where all the result will be perform ie.Throughput,PDR,Energy,Average Delay.
- The performance comparison is made with different number of nodes 10 to 50. Three different sets of node density will be used to comparing the performance of the GPVR protocol. Trace file used to generate graphs for evaluation.
- To develop an enhancement of a routing protocol that reduces average delay.
- Results are compared under these parameters like throughput, packet size, End to-End delay, overhead, energy etc.
- To evaluate the performance of the proposed routing protocol GPVR as compared to GPSR routing protocol regarding average delivery ratios ,end-to-end delay,PDR and Throughput.

3.3 Research Gaps

The researcher used many algorithms in VANET to monitoring the network performance. The entire researcher had shown some improvement with gaps in their work. They are:

- Most of the solution approaches in the literature review is based on VANET node and density Architecture.
- Most of the solution approaches based on Vehicle to Vehicle Communication, load-balancing, RSU and inter Vehicle architecture topology.
- In term of attack of a network researcher does not provide for prevention techniques.
- In Previous search author works only Mobility; Load balancing, Traffic generation, SUMO, MOVE etc.
- Author does not related the mobility to a different approach.

3.4 Clustering technique in VANET

A beneficial technique to organize Ad Hoc networks and group the nodes in to smaller segments is called clustering. Clustering is helpful in large scale distributed networks for simple management and information aggregation of each network segment [3].Classification of the nodes into clusters is performed according to special application requirements in order to provide a conveniently manageable network.

In cluster-based routing protocols, nodes are compared to each other and the most similar nodes based on their movement patterns are selected to join the same cluster. The comparison criteria between nodes are defined based on protocols application requirements. Applying clustering techniques to VANET applications is beneficial and is being used. Clustering has been mostly used for data dissemination and routing in VANET [18]. Employing cluster- based techniques for target tracking in VANET is still a challenge and has not been used frequently.

The main entities of a cluster are: Cluster Members , Cluster Head , and Gateway Nodes . CH is the leader node responsible for cluster management and communication with other clusters or infrastructures in the network. CH is also responsible for relaying information between nodes in the cluster or from cluster nodes to other clusters. CMs are the nodes which join a cluster based on their features and similarities. These nodes are responsible to [4] send their information and application- based data to CH in specific time intervals. CMs of one cluster are not supposed to communicate with CMs or CHs of other clusters. GW nodes are the shared nodes between two clusters [8]. These nodes can contribute to the communication between two clusters.

Clustering Advantages for VANETs In complex distributed and large scale networks, clustering is helpful for network management and data aggregation [21]. Due to VANET's special characteristics it would be effective to introduce an aggregator node responsible for data aggregation in a specific part of the network. The aggregator node may be referred to as the leader node or CH. CHs role is to build and maintain the cluster structure for communication of application- specific data. The CH receives messages from member nodes in its area and aggregates these messages [14].

The other nodes out of cluster area will only receive the aggregated message instead of receiving all of the messages from every node separately. This method is helpful in sending safety or hazard messages in VANETs [3]. The vehicles around the hazard area will send messages to a leader member instead of broadcasting their messages in the entire network. The leader gathers and processes the information and communicates

with other parts of the network. Clustering method helps in dividing the network into smaller segments which are easier to manage. Much research has been done on clustering techniques for VANET [23]. The major reasons to use clustering are: Increasing network scalability by creating network segments

Cluster Stability and Efficiency Features

Cluster steadiness is measured by different execution measurements that will be clarified in this segment . The greater part of the grouping calculations(cluster algorithm) are endeavoring to enhance these elements with a specific end goal to make more steady and strong bunching conventions that can work appropriately in VANET's profoundly in unique condition and can adjust to successive topology and thickness changes. The following are the stability and productivity feature considered in most bunching calculations(clustering algorithm). Change of these stability components would help to the plan and execution of a productive and stable grouping calculation [1].

Target Tracking in VANETs Since vehicles are accessible all over the place, and given the quick progression of present day strategies for vehicles, VANETs are viewed as the privilege and legitimate framework for different applications, for example, following [4] and observing. VANETs can be utilized when a police organization is searching for a particular vehicle with particular visual components, for example, tag, shading, model and so on. On the off chance that the police office depends exclusively on settled and already installed surveillance camera foundation over the city, there is a high likelihood that it would not discover the objective promplty, or it may even forget about the objective vehicle out and out in non-checked territories [1]. In this way, camera-equipped vehicles are a future reality, and the utilization of correspondence abilities on future vehicles would constitute the most proficient following framework [23].

Chapter 4

Installation, Simulation And Design

Creating VANETs in the handy application is too expensive, so recreation of VANETs assume significance in all the exploration exercises [1] . It is essential to assess convention executions in a genuine domain, reproductions are usually utilized as an initial phases in the convention improvement for VANET research. A few communication network is exist to give a stage to testing and assessing network protocol, for example, NS-2.35, OPNET . These apparatuses(tools) are not only customized for particular applications in the transportation condition rather these are essentially intended to give non specific reenactment situations. Stimulation assume a critical part in the zone of transportation. There are number of recreation instruments accessible, for example, PARAMICS , CORSIM and VISIM [27], MOVE,SUMO, NS-2, Vanet MobiSim and so on which have been produced to break down transportation situations at the small scale and full scale levels [24].

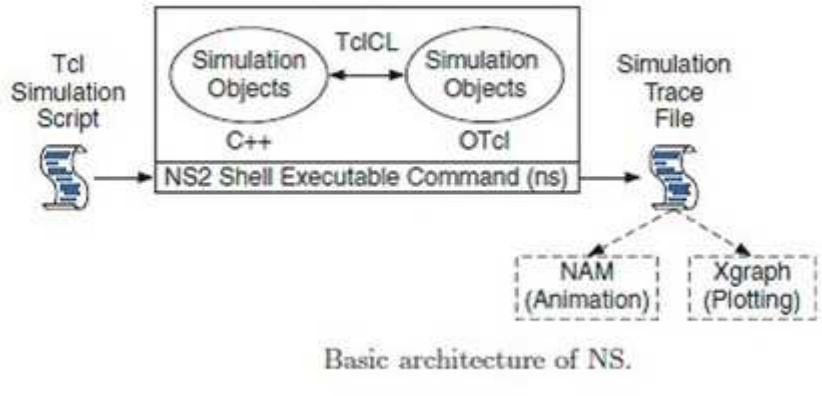
4.1 NS-2

A PC system is a mind boggling framework that requires a watchful treatment in plan and Implementation. Reenactment, viewed as a standout amongst the most capable execution analyse tool, is typically use in completing such a treatment to supplement the logical devices.

In this thesis the focus is mainly on time - Stimulation, which progresses in a period area. The time-subordinate reenactment can be isolated into two classes. Time-driven recreation propels the stimulation by settled time interims, while occasion - driven reenactment continues starting with one occasion then onto the next. NS2 is an occasion driven reenactment instruments.

4.1.1 Simulation Model

NS-2.35 is an open-source stimulation device running on Unix-like working frameworks [26]. It is a circumspect occasion test system focused at systems administration look and



(a) NS-2 Simulation Model

Figure 4.1: Architecture of NS-2 Simulation Model.

gives considerable support to reproduction(stimulation) of directing, multi-cast conventions and IP conventions, for example, UDP, TCP, RTP and SRM over wired, remote and satellite systems. It has many points of interest that make it a helpful device, for example, bolster for numerous conventions and the capacity of graphically specifying system movement. Moreover, NS-2 underpins a few calculations in steering and lining[11]. LAN steering and broadcast are a piece of directing calculations(routing algorithms). Lining calculation incorporates reasonable lining, shortfall round robin and FIFO. It is bundled with a heap of rich libraries for reenacting remote systems. All the portable nodes in NS-2 rapidly accept that they are the piece of Ad-Hoc network and the stimulation of versatile nodes associated with infrastructure network are not conceivable. For stimulation a remote node the physical layer, the link layer and MAC[1] (media get to control) convention are altogether included in the meantime.

4.1.2 Design and Tool

Essential Architecture Fig. 4.1 demonstrates the fundamental design of NS2. NS2 gives clients executable summon ns which go up against info contention, the name of a TCL stimulates scripting document. Clients are sustaining the name of a TCL recreation script (which sets up a reproduction(stimulation)) as an information contention of a NS2 executable summon ns. By and large, a reenactment follow record is made, and is utilized [1] to plot diagram or potentially to make movement [6].

4.1.3 Component of NS-2

Actualizing dialects(language) NS2 comprises of two key dialects: C++ and Object-arranged Tool Command language. While the C++ characterizes the inside component (i.e., a backend) of the reenactment questions, the OTCL sets up recreation by gathering and designing the items and in addition booking discrete occasions (i.e., a frontend). The C++ and the OTCL are connected together utilizing TCL.

4.1.4 Tool Command Language

Tool Command language [23] Short for Tool Command dialect, TCL is an intense deciphered programming dialect created by John Ousterhout at the University of California, Berkeley [2]. TCL is a capable and dynamic programming dialect. It has an extensive variety of utilization, including web and desktop applications, organizing, organization, testing and so forth. Tcl is a really cross stage, effectively conveyed and profoundly extensible [30].

The most noteworthy preferred standpoint of TCL dialect is that it is completely good with the C programming dialect and TCL libraries can be interoperated [25] straightforwardly into C programs

4.1.5 The Network Animator (NAM)

NAM [27] gives a visual understanding of the system topology made. The application was created as a feature of the Vanet extend. The NAM perception when .nam record has been stacked. This depiction is taken for system of l0 to 50 nodes at an occasion [13]time l00 sec.

Table 4.1: System Configuration OS.

Ubuntu	12.04(lts).
CPU	Intel(R) Core 2 Duo 1.80 GHz
RAM	3GB

Table 4.2: Configuration Parameters in NS-2 Simulator.

PARAMETERS	VALUES
Operating System	Linux (Ubuntu l2.04).
NS-2 version	NS-2.35 for IEEE 802.llExt.
No. of vehicles	l0, 20, 30, 40,50.
Number of road segments	4.
Speed of vehicles	20 m/s
Network interface type	Phy/WirelessPhyExts
Radio propagation model	Propagation/TwoRayGround

Table 4.3: Configuration Parameters of in NS-2 Simulator.

PARAMETERS	VALUES
Packet Size	15.
Traffic Type	UDP/CBR.
Simulation Time	100s.
Antenna Type	Omni-Antenna.
Transmission Range	l000*l000 m
Routing Protocol (Proposed)	GPVR (Greedy Perimeter Vector Routing)

Chapter 5

Results

5.1 Assumptions Algorithm

1. Here create a road topology with the help of node in ns2.35.

2. Each node contain a neighboring list based on the latest information that is received after certain time. Information messages sent to each and every one-hop neighbour. If a node does not receive messages from each neighbour during a certain time period, then the link assume to be down [28].

3. For route estimation a graph G(V, E) theory is used to consisting of a road intersections or junctions v V and road segments e E here every segments are connected with the intersections [18].

5.1.1 Optimal Route Selection

Algorithm l: route discovery

Input: ID of source node S and Destination node D Outputs: optimal route from source to destination Begin if (ID D = ID N) Forward packet to D; Else Determine the rectangle restricted searching area;

searching area = Xmin , Xmax , Xmin, Xmax;

broadcast REQ to D in the searching area;

Activate (BROADCAST TIMER); Calculate route probability of connectivity and packet delay;

if (p max p other Greater than E)

return route with the probability of connectivity pmax;

else

delete routes with the probability of connectivity p other ¡ p max p threshold;

return route with packet delay d min; end if

End of Route Discovery

Next-Hop selection

Algorithm 2: Next-Hop selection

Inputs: positions and speed of the neighbours

Outputs: The optimal next-hop forwarding node

begin

do

if (D forwarding-road-segment = D current-road-segment)

else forward to the N intersection-node;

else forward the packet directly to its farthest N neighboring-node;

while (forwarding node is not destination node);

forward packet to destination node;

end if

end while

End of Next-hop Selection

Evaluation Metrics

The execution of directing conventions is measured through execution measurements including the throughput, end-to-end defer and the parcel conveyance proportion. When all is said in done, as the movement stack builds, the directing convention needs to transport more information over the system, which causes more transmissions on the remote medium, bringing about more crashes and bundle misfortunes [23]. So also, high versatility additionally strains the execution of the steering convention by including always showing signs of change courses.

The end-to-end defer is additionally higher for high activity, portable topologies since there are an extensive number of impacts, which requires more regular retransmissions at the connection layer, bringing about long postponements. Specifically, the end-to-end postpone is likewise firmly combined with the system estimate since an expansive system has longer courses by and large, requiring more bounces and thus, more deferral [23].

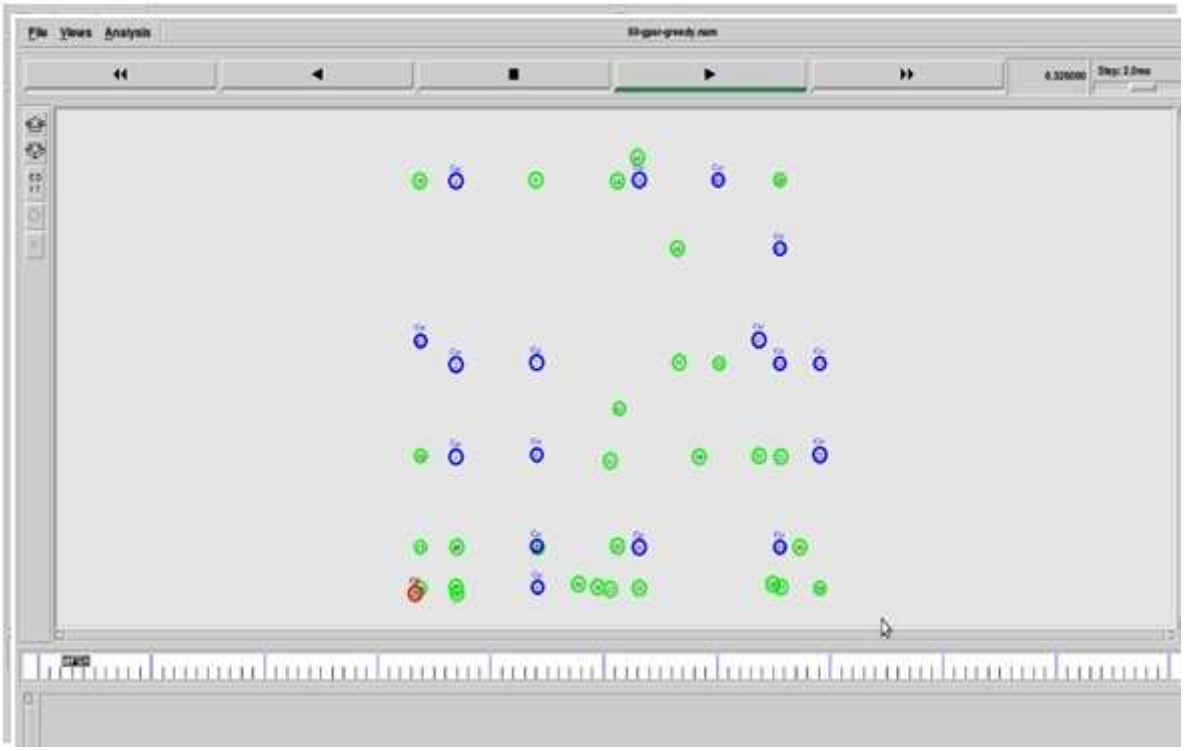


Figure 5.1: Communication of Nodes During Generating Cluster Head.

Table 5.1: Comparison between GPSR And GPVR protocol for all parameters

Greedy Protocol Stateless Routing(GPSR)-Existing					Greedy Protocol Vector Routing(GPVR)-Purposed				
Nodes	Throughput	Energy	Average Delay	Packet Deleivery Ratio(PDR)	Nodes	Throughput	Energy	Average Delay	Packet Deleivery Ratio(PDR)
10	14.02	80.70	7.04	50.00	10	39.83	41.74	12.70	100.00
20	6.98	80.60	6.77	75.00	20	28.05	21.30	53.57	100.00
30	79.06	79.70	380.50	65.20	30	40.03	5.97	112.77	99.75
40	79.32	79.77	433.69	65.7277	40	40.15	36.45	107.81	88.500
50	80.94	79.60	430.98	66.45	50	40.13	86.26	308.27	100.00

- **Packet Delivery Ratio:** The packet delivery percentage represents the percentage of total sent packets from source nodes, which are successfully received at the destination nodes.
- **Packet loss Ratio:** The Packet loss Percentage (or Ratio) represents the total number of packets lost in the network between source and destination nodes.
- **Aggregate Throughput:** The aggregate throughput is the total number of bytes received at the destination divided by the total time duration. This aggregates all the flows in the network.
- **End-to-End Delay:** The end-to-end delay is the averaged results of how long it takes a packet to go from the source to the destination.

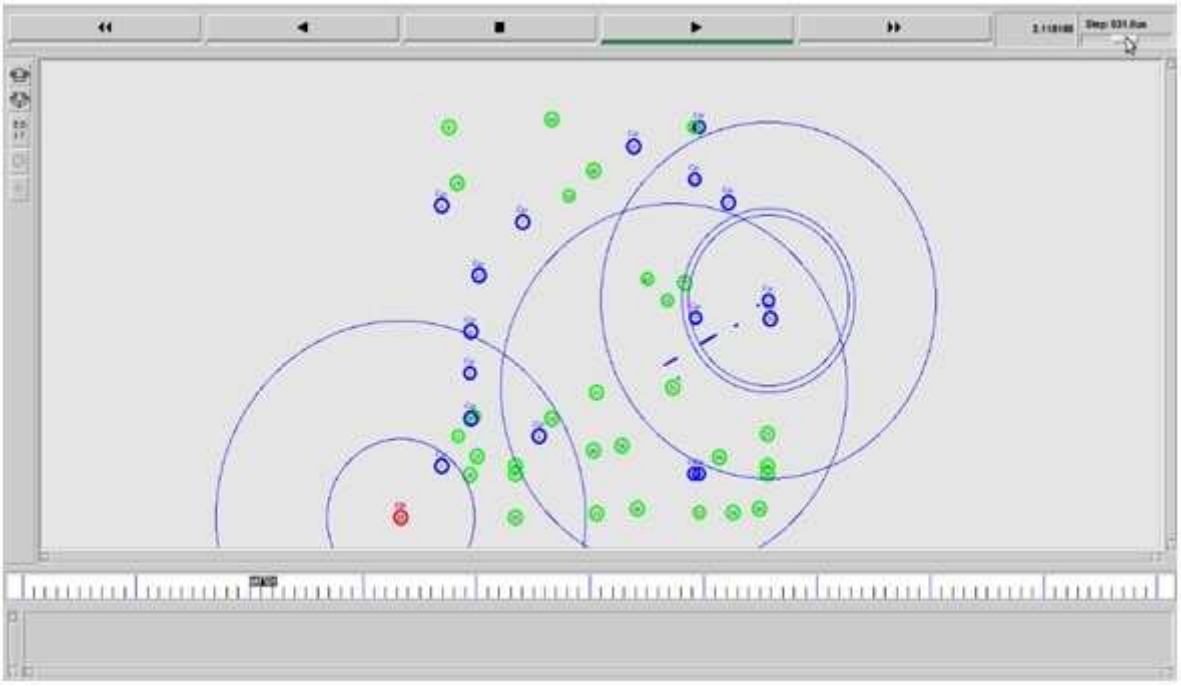


Figure 5.2: Communication of Nodes using Cluster Head And Start Communication .

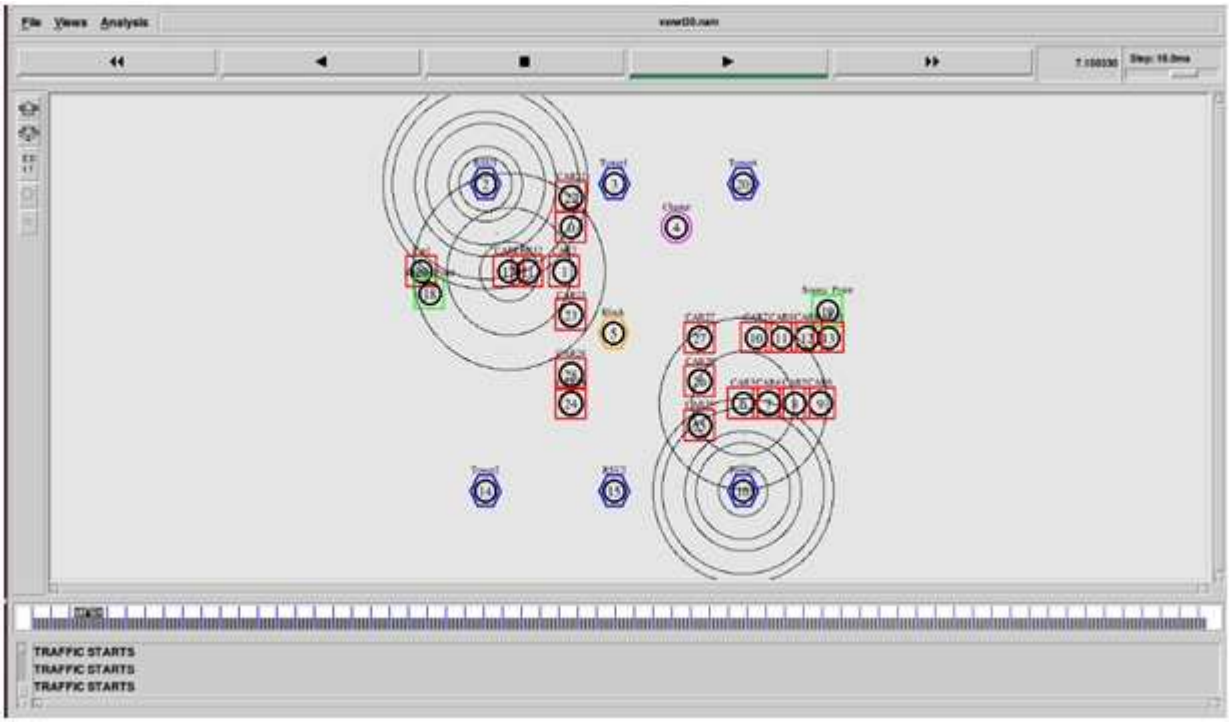


Figure 5.3: Generating RSU, TOWER, SOURCE AND DESTINATION point .

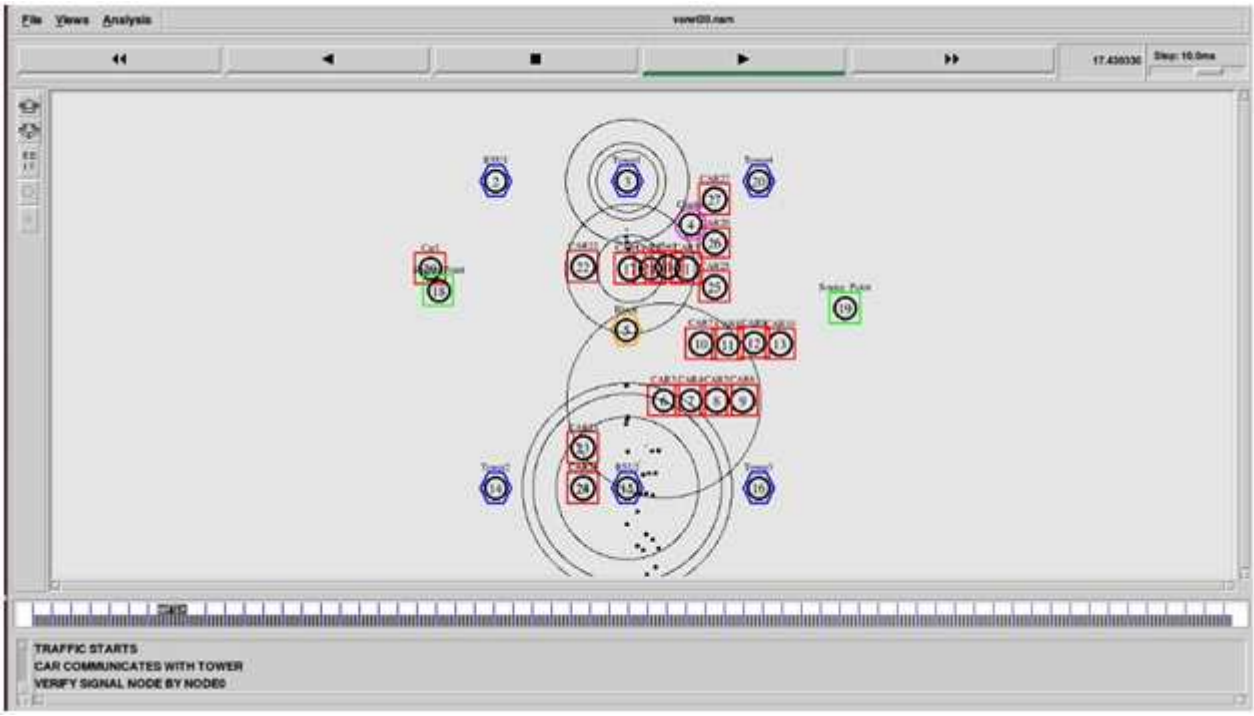


Figure 5.4: Move the Traffic using RSU .

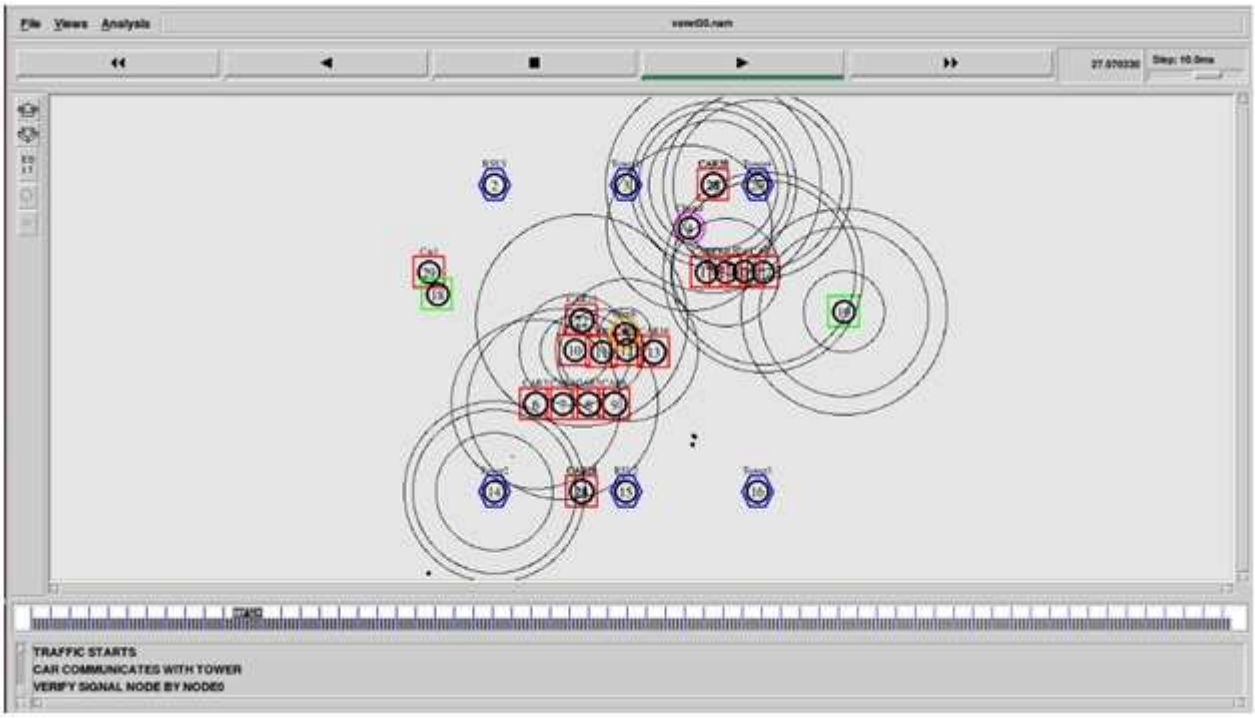


Figure 5.5: Communication Start using Cluster head in VANET .

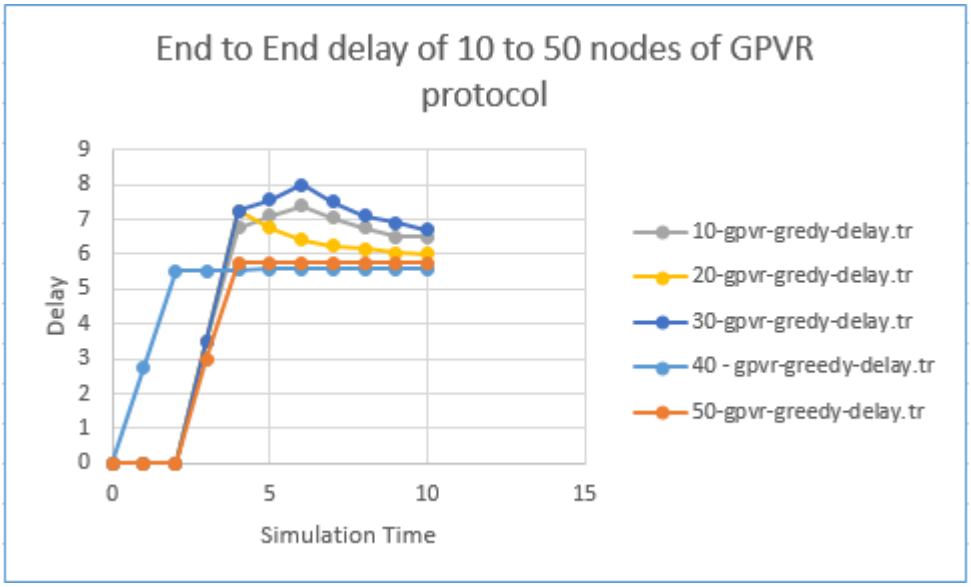


Figure 5.6: End-to-End Delay and Simulation Time of GPVR protocol .

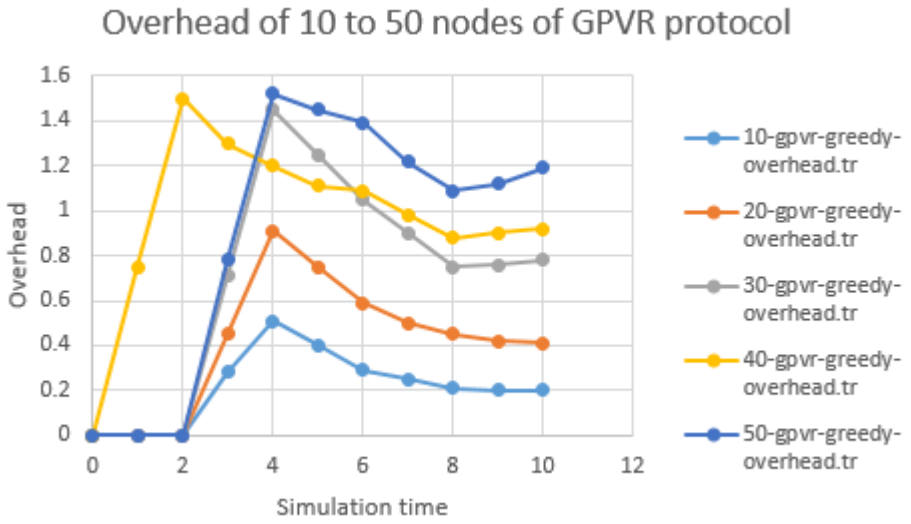


Figure 5.7: Overhead and Simulation Time of GPVR protocol .

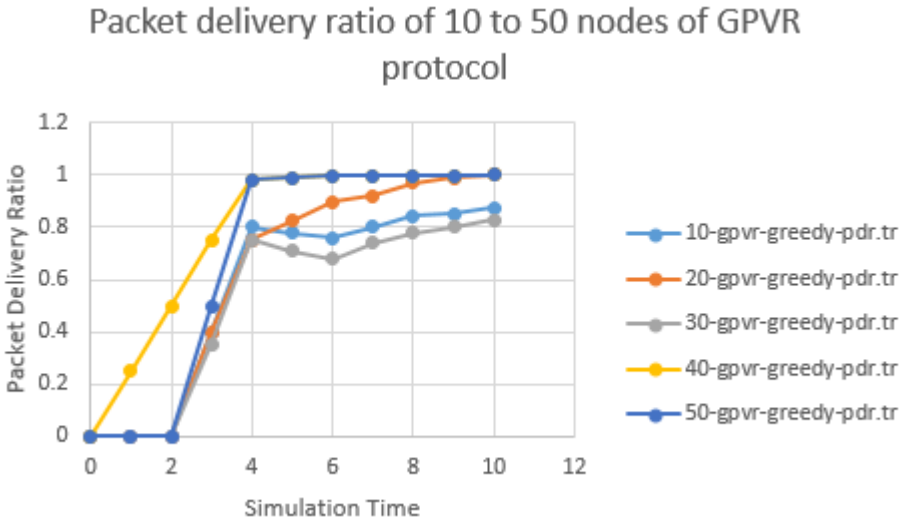


Figure 5.8: Packet Delivery Ratio and Simulation Time of GPVR protocol.

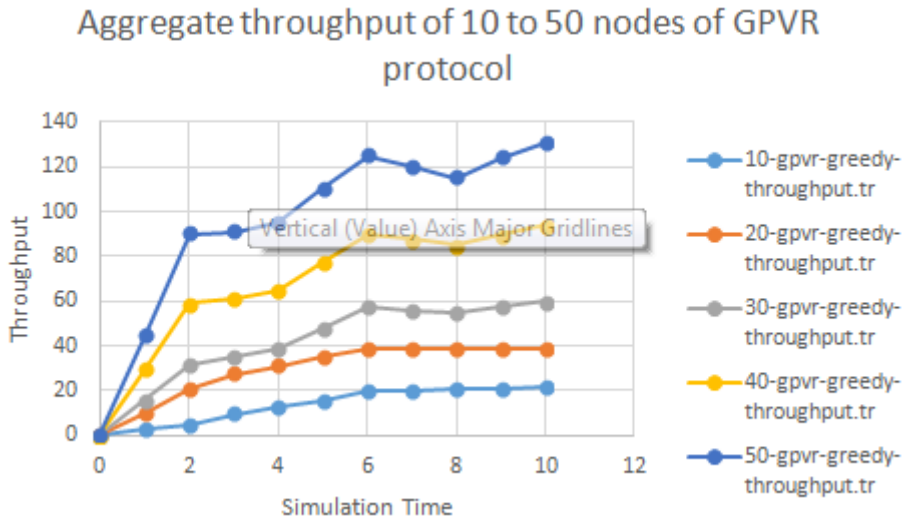


Figure 5.9: Aggregate Throughputs and Simulation Time of GPVR protocol .

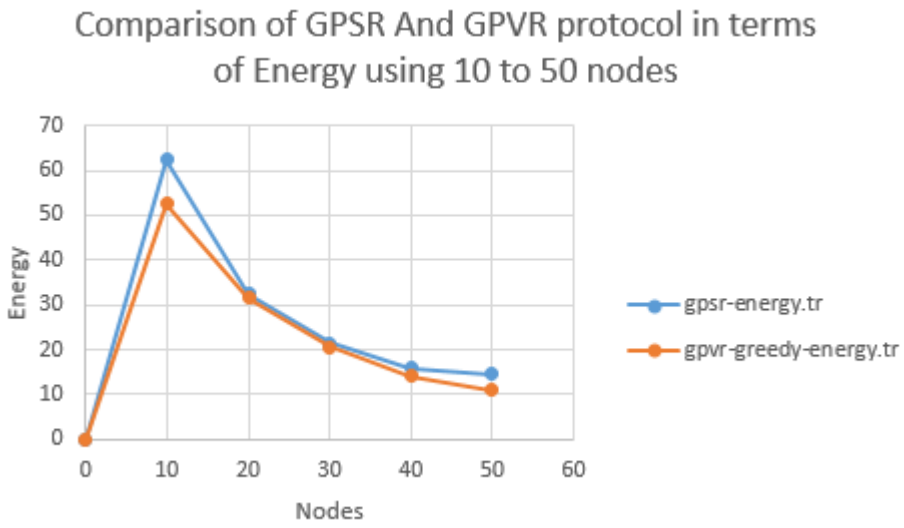


Figure 5.10: Comparison of GPSR And GPVR protocol in terms of Energy using l0 to 50 Nodes .

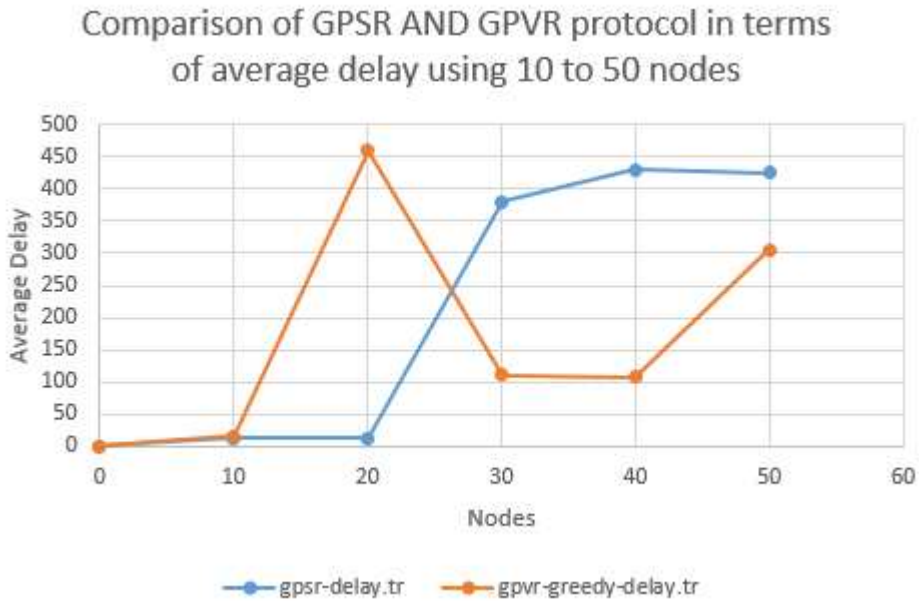


Figure 5.11: Comparison of GPSR And GPVR protocol in terms of Average Delay using l0 to 50 Nodes.

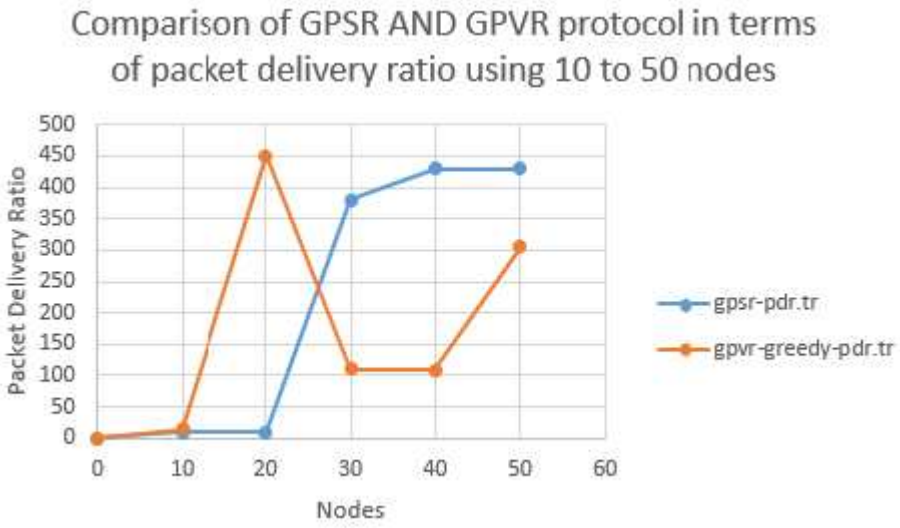


Figure 5.12: Comparison of GPSR And GPVR protocol in terms of Packet Delivery Ratio using l0 to 50 Nodes .

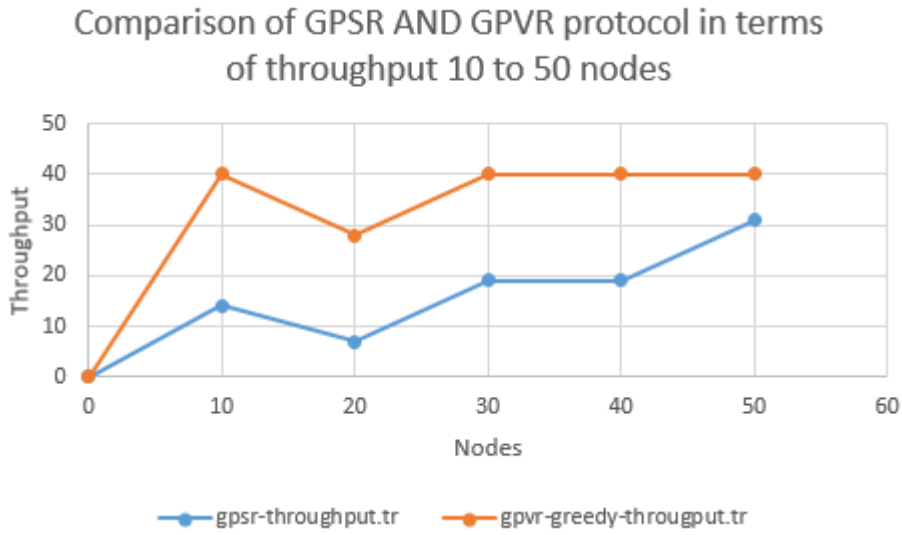


Figure 5.13: Comparison of GPSR And GPVR protocol in terms of Throughput l0 to 50 Nodes .

Chapter 6

Conclusion

6.1 Conclusion

This Disserttion work was to evaluated performance of routing protocols GPSR and GPVR. In this thesis, based on the results of simulation a comparative analysis was done between selected routing protocols GPSR and GPVR and the results were documented. The performance has been evaluated based on parameters that aim to figure out the effects of routing protocols. By comparing these protocol performances, this work justifies that the GPVR routing protocol performs better compared to GPSR in terms of: 1) End-to-end delay 2) Throughput 3) Packet loss 4) Packet delivery ratio 5) Routing overhead GPVR is a reactive protocol and creates a very low routing overhead due to discovering routes. From the comparative analysis of routing protocols, the GPVR performs better than the GPSR. The GPVR has low load than GPSR respectively. From the above results 5.6, 5.7, 5.8, 5.9,5.10,5.11,5.12 and 5.13 the behavior of all the routing protocols in different number of mobile nodes, it can be seen that which routing protocol perform well. In terms of network size, mobility and traffic load GPVR shows better results than GPSR.

From the simulated results the act for every routing protocols for various numbers of mobile nodes was observed and we came to the conclusion that GPVR routing protocol performs well. The study of these routing protocols show that the GPVR is better in Vehicle ad-hoc network according to the simulation results ,GPVR perform always better in all the networks. Its performance may vary by varying the network. At the end we came to the point that the performance of routing protocols vary with network size and selection of accurate routing protocols according to the network that ultimately influence the efficiency of that network in efficient way.

6.2 Future Scope

- Complex traffic modeling and driving behaviors (mobility models) that incorporate lane changing and multiple entry and exit points can be integrated to our simulation framework to validate and evaluate our algorithm in more complex scenarios, taking them closer to real world applications.
- Inner city traffic increasing more complex topologies exist and external events such as traffic lights need to be considered using sensor devices.
- Efficient broadcasting protocols for VANETs including hybrid protocols that use V2V and V2I communications.
- To study the effect of message losses, vehicle participation, transmit power and other physical variants of the underlying network may have in the effectiveness of congestion detection, load balancing.

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List of Publications

International Journal

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