Inter Vehicular Communication(IVC) for Next Generation Intelligent Transport System(ITS)

A Project Report submitted in fulfilment of the requirement for the award of the degree of

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Certificate

This is to certify that synopsis report entitled “Inter Vehicular Communication(IVC) for Next Generation Intelligent Transport System(ITS)”, submitted by “Ishani Sharma” in partial fulfillment for the award of degree of Master of Technology in Computer Science & Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been made under my supervision.

This report has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date: **Supervisor's Name & Signature**

Designation

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Abstract

VANET is a highly dynamic environment. Traditional routing protocols results in degraded performance. We proposed algorithm which are based on two topologies that are urban topology and highway topology in which carry forwarding mechanism for vehicular networks are used to send the packets from source to destination. In the algorithm, a message sender can select the best node among its neighbours with the help of on board vehicle algorithm so that it can send the message fastest to the destination nodes. Each node keeps on updating its position and velocity at each instance of time. Together with the current velocity and location we compute the predicted velocity by using two prediction techniques that are simple exponential smoothing and other technique is simple n average. Than the score of each node is computed which comes within the transmission range. Than the node with maximum score is selected to forward the packet. The score computation method is also been compared with the greedy method and the random approach. The packets are forwarded from source to destination as fast as possible by using the hops.

CHAPTER 1. INTRODUCTION

Now a day, wireless networks have been developed into a very important medium in the field of data communication. For the period of the last two decades an incredible improvement has been occurred in the area due to the technological advancement in Vehicular computers and wireless data communication devices. Therefore, wireless communication has become very popular for accessing information and various services in Vehicular environment where the users are not restricted to a particular location.

With the expected growth in mobile devices and mobile traffic, Vehicle-to-vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications are expected to become more in demand and will continue to grow. VANETs can be used to provide a wide range of services, including both safety and non-safety related applications. Examples include vehicular safety traffic management services, surveillance services, and mobile vehicular cloud services.

1.1 WHAT IS VANET

A Vehicular Ad-Hoc Network or VANET is a technology which is basically created by applying the principle of Mobile Ad-Hoc network. The moving vehicles are denoted as nodes which are creating a mobile network. Thus VANET are basically provided for communication between vehicles and fixed equipments. We can say that VANET turns vehicle into a wireless node, allowing them to connect to each other which are close to each other so as to create a wide range of network. If any car fall out of the range of the signal than it will be drop out from the present network, and other cars can join so that mobile Internet can be created. Direct wireless communication from vehicle to vehicle make it possible to exchange data even where there is no communication infrastructure such as base stations of cellular phones or access points of wireless networks [1].

Vehicular networks are very fast emerging application for deploying and developing new and traditional applications. It is characterized on the basis of change in the topology, increase in traffic and communication between vehicles. The movement and position of the vehicles are basically used to characterize VANETs.

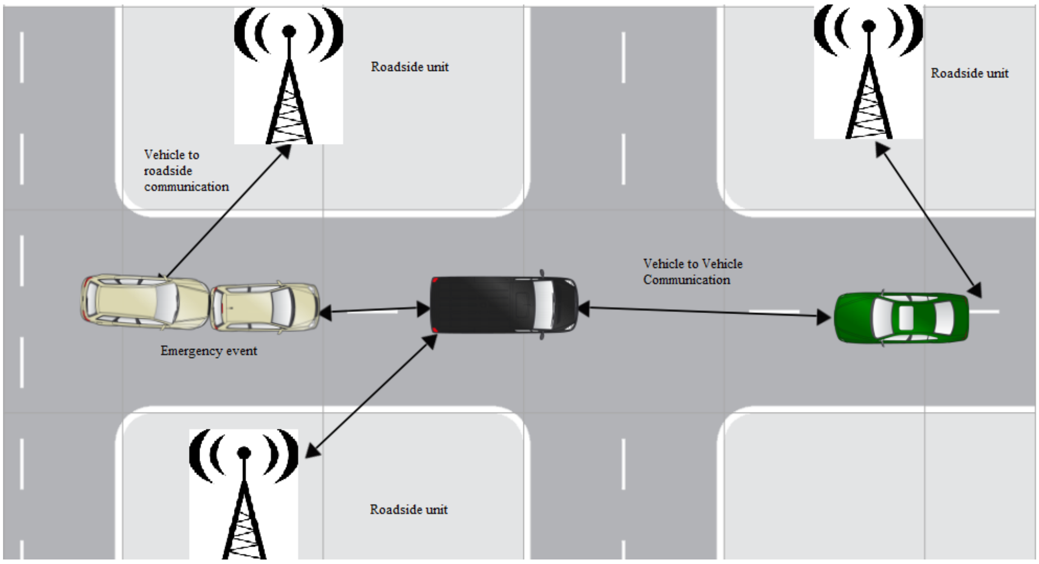

Fig 1.1 Vehicular Ad-hoc Network Architecture

VANET architecture is basically used to allow the communication between the vehicles and between vehicles and roadside infrastructural units which leads to the following possibilities as shown in Figure 1:

- **Vehicle-to-Vehicle (V2V) communication**: It allows the direct communication between the nearby vehicles without depending on the infrastructures which are fixed on the roadside and it can be mainly used for safety purposes and providing security.
- **Vehicle-to-Infrastructure (V2I) communication**: It allows a vehicle to communicate with the roadside infrastructural unit due to which vehicle can gather the information regarding other vehicles from data storage application of infrastructural unit.
- **Hybrid architecture**: It is basically a combination of Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I). In this environment, a vehicle can

communicate with the roadside unit which are fixed through single or multi hops, it can also communicate with infrastructure unit directly. The wireless connections are established so that they can communicate with the vehicles that are far away.

1.2 Properties of Vehicle for VANET

The moving vehicles are the main component in VANET. These vehicles are known as nodes in VANET. The following properties of vehicles are used for better operation in VANET. They are following.

a) **Sensing:** The different types of sensor are used for sense the Different vehicular and environmental conditions (state of the vehicle, state of road, weather condition, pollution and others).

b) **Processing:** the data or information coming from the different sensors are processed by the vehicles.

c) **Storage:** to store the different type of data and processing results for future uses require a large storage space.

d) **Routing:** The vehicles (nodes) should have the potential to communicate with each other in the VANET (IP or Cellular for example).

1.3 What is Smart Vehicle

Smart Vehicles are implemented with network interface cards, sensors which include radar and on-board wireless devices which include Bluetooth, UMTS which is basically used to increase the efficiency of transportation and applications are basically manage by concentrating on the optimized traffic flow of the vehicles by reducing the time to reach to the destination by taking the congestion free path. At a particular instance the sensor is implemented on infrastructural unit so that traffic congestion path and accidental area can be sensed and forward this information to vehicles so that it can automatically slow down the speed of the vehicles or change the route in which accident occurred so as to avoid the crash and traffic; this type of information is then broadcast through V2I or V2V within the vehicular network.

The different levels of functions are provided by the smart vehicle by using advanced applications in number of systems and sensors which are basically attained for intra vehicular communication which indicates crash on road, data is also recorded for further information, the brake system of the vehicle, control in the electronic stability, electronic steering of the vehicle, monitoring the pressure of the tyres of the vehicle, seat belt warning, power distribution and establishing the connectivity, cameras are also provided so as to see the rear images, emergency brakes system used during the parking or emergency areas.

Commonly, a smart vehicle is equipped with the following technologies and devices:

(i) A wireless receiver is implemented in vehicles for transmission of data among vehicles and from vehicles to RSUs;

(ii) A Central Processing Unit (CPU) which are basically used to equipped the system with the various applications and communication protocols;

(iii) A Global Positioning Service (GPS) is used for the navigational purpose in the vehicle so as to know about the path to reach towards the destination;

(iv)An input/output interface for the live communication between the human and system;

(v) Different sensors implemented in the vehicle or on the infrastructure unit are used to measure various types of parameters that can be acceleration, velocity, and distance between the vehicles.

Fig 1.2 Components of a Smart Vehicle and their location inside the vehicle

Smart Vehicles are basically used to for the purpose of issues related to the safety of vehicles by providing the communication among vehicles or between vehicles and roadside unit, proper assistance will be provided to the driver so that more efficient decision can be taken by the driver for the safety purpose. Various functionalities are also implemented for connection purposes.

Fig 1.3 Safety Application with the use of visible lighting

1.4 VANET APPLICATIONS

Vehicular applications are classified in the following categories:-

1) Safety oriented,
2) Commercial oriented
3) Convenience oriented and
4) Productive Applications

- **Safety Applications**

  Safety applications are basically used to observe the roads in a vehicular environment which will check the movement of the vehicles, environment of the road side area, curves on the road, surface area of the road etc. The Road safety applications can be classified as:

  1) Real-time traffic: The RSU is basically used to store the data regarding the traffic based on real time and the availability of this data is provided only on the basis of on demand request. Due to this it will be able to solve the issues regarding the congestion due to traffic jams, information regarding the crash on the road side area which will help to broadcast the emergency alert to all the vehicles.

  2) Co-operative Message Transfer: The communication among the vehicles via co-operative message transfer will help in maintaining the safety of other vehicles. The efficiency and delay in the message transfer is the major concern in the message transfer. The automated things are implemented in the vehicles which include emergency braking system used in emergency to avoid the accidents.

  3) Post Crash Notification: The post crash notification includes the broadcasting of message regarding the accident already occurred in an area which will be broadcast by the vehicles involved in that accident which will not only avoid the congestion on the road but the help will also be provided to them as soon as possible and car can be towed as early as possible to control the traffic jams.

  4) Road Hazard Control Notification: The vehicles will send a notification message to all the trailing vehicles in that area about the hazardous condition of the road which includes the landslides or information regarding the curve on the road.

5) Cooperative Collision Warning: The warning message is send to the vehicles which are having the potential to crash each other so they need to change their path to avoid the collision.

6) Traffic Vigilance: The cameras are installed on RSU so that they can observe the traffic in a continuous way which will help the traffic police to keep a check on the driving offences, or not following the traffic rules.

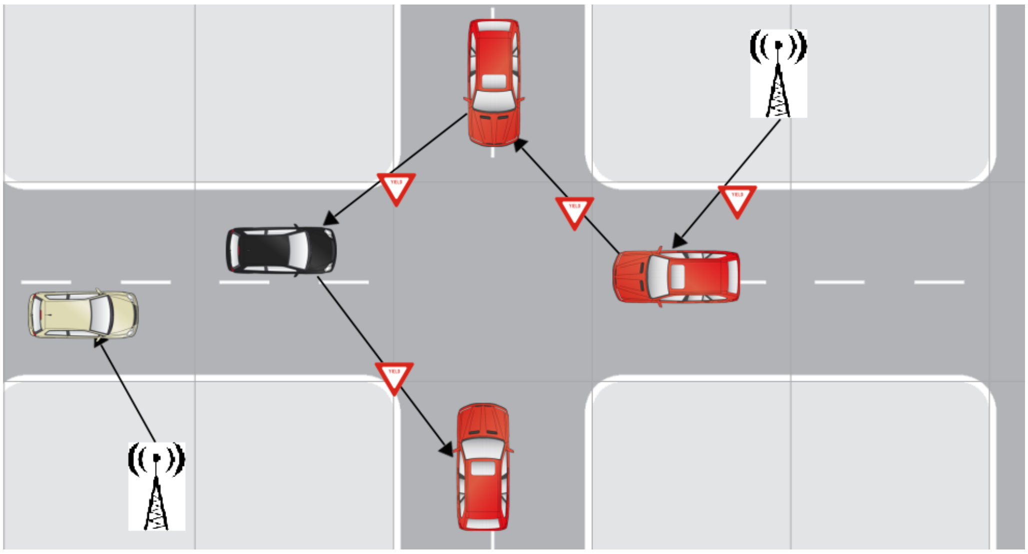

Fig 1.4 Emergency Situation Notifications

- **Commercial Applications**

  Commercial applications are used to provide media files which are related to entertainment and services which include audio and video. The Commercial applications can be classified as:

  1) Remote Vehicle Personalization/ Diagnostics: Remote vehicle personalization will help the driver download and upload vehicle settings and their diagnosis by using the information provided by the roadside infrastructural unit.

  2) Internet Access: RSU act as a router to provide the internet access to the vehicles.

  3) Digital map downloading: Digital maps are downloaded by the driver in their personalized vehicles so that it can provide continuous guidance while travelling on the road which is not known to the driver. It can also provide other valuable information regarding the food stations, petrol pumps etc

4) Real Time Video Relay: Relay time video relay is a live videos which act as a source of entertainment to the driver. Therefore on demand movies according to the choice of the driver is provided.

5) Value-added advertisement: Value added advertisements are provided within their communication range without using any internet. These services provided the information regarding the restaurants, stores; petrol pumps so that they can attract the customers.

- **Convenience Applications**

  These applications are related to the management of traffic so as to control the traffic leading to the congestion so as to efficiently providing the drivers the congestion free path to their destination. The Convenience applications can be classified as:

  1) Route Diversions: Diverting the route according to the information provided related to the congestion and accidents so that congestion free path will be taken.

  2) Electronic Toll Collection: The electronic toll collection is basically used to collect the toll electronically through the vehicles travelling on that path. These electronically tolls work through GPS so as to generate the receipt of the toll rate through wireless links to the vehicles. This application not only save the time of the customer but also be easier for the toll operators

  3) Parking Availability: The notification message is send to vehicles regarding the information about the availability of space of vehicles in the parking which will help in finding the parking way easier and will also take less time.

  4) Active Prediction: The active predictions are basically used to provide pre information regarding the topology of the road which will tell how the fuel usage can be done optimally by adjusting the speed of the vehicles and the assistance is also provided to the vehicles in controlling the vehicle and help in decision process.

- **Productive Applications**

  Productive application is basically an additional application according to the other application but it also has its own important features.

The Productive applications can be classified as:

1) Environmental Benefits: According to the research program AERIS [2] is generating the real time information which is relevant according to the environmental condition and these data will be used to create green transportation which should be accepted by the users and the operators provided by the transportation system. The AERIS research program is working with the V2V communication by implementing a multi model approach so as to check the connections between the vehicles so that they can provide the information related to the negative impact on road surface due to transportation services.

2) Time Utilization: Utilizing the time become very difficult if we are travelling and we got stuck in traffic jams so basic requirement is the internet which will help the driver utilize the time while waiting for the traffic to get clear.

3) Fuel Saving: Fuel saving can be done by not stopping at the toll for the payment and vehicles need to wait for 5-10 minutes. Therefore without stopping on the toll for the payment leads to save certain percentage of the fuel. [3]

1.5 ARCHITECHTURE OF VANETS

In this section we are describing the detailed architecture of Vehicular Ad-Hoc Network. Firstly we will describe the domain view of the main components of VANETs. Than secondly it will describe the communication part in which the interaction architecture is being explained [4].

1.5.1 Main Components

VANET architecture is divided into three domains in the main components that are: the mobile domain, the infrastructure domain, and the generic domain [5].

As is shown in Figure 5, the mobile domain are divided into two parts in which the vehicle domain are the domain which contains all types of vehicles which includes cars, buses, truck etc and the mobile device domain are the domain which contains all types of portable devices which includes smart phones, navigational devices and particularly provided with GPS services.

The infrastructure domain comprises of two parts that are roadside infrastructural domain which basically includes roadside infrastructural unit and the roadside entities that are traffic lights and second is central infrastructural unit which includes the main centres of traffic management and vehicular management which is having a full control on the vehicles and traffic [5].

The generic domain basically includes the interaction within the node and the server via internet.

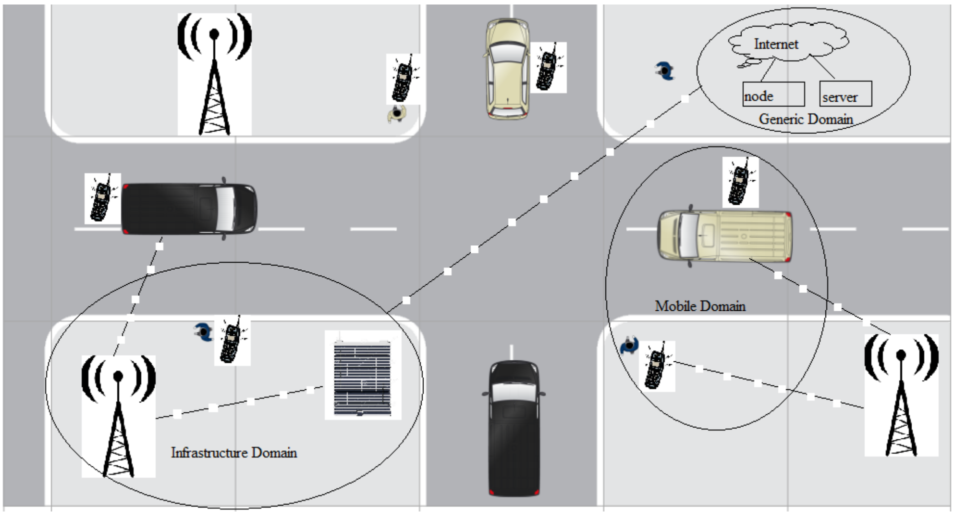

Fig 1.5 VANET system domain

1.5.2 Communication Architecture

Communication in VANETs can be divided into three types.

Figure 6 describes the types of communications. Communication within the vehicles is the most important part which basically refers to the vehicular domain which is included in the mobile domain. Due to this it can analyze the performance of the vehicles and will also check the driver's condition during driving which will affect the safety of its own and others.

The different types of communication in VANETs are as follows:

o **Vehicle-to-Vehicle (V2V) communication**: It allows the direct communication between the nearby vehicles without depending on the infrastructures which are fixed on the roadside and it can be mainly used for safety purposes and providing security.

o **Vehicle-to-Infrastructure (V2I) communication**: It allows a vehicle to communicate with the roadside infrastructural unit due to which vehicle can gather the information regarding other vehicles from data storage application of infrastructural unit.

o **Hybrid architecture**: It is basically a combination of Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I). In this environment, a vehicle can communicate with the roadside unit which are fixed through single or multi hops, it can also communicate with infrastructure unit directly. The wireless connections are established so that they can communicate with the vehicles that are far away.

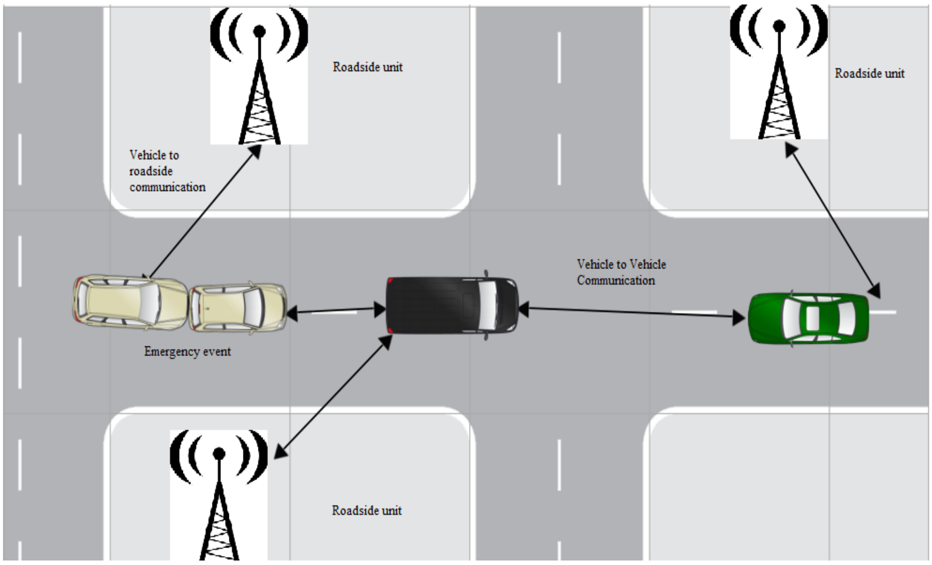

Fig 1.6 Communication types of VANETs

1.6. Challenging Issues in VANET

There are different challenging issues in VANET which are explained as below:

o Routing protocols: Routing plays an important role in VANET applications. Since there is a continuous change in the speed of the vehicles and change in topology due to the mobility of vehicle leads to the reduce the efficiency of the routing protocol in handling vehicular environment as vehicles which comes between the source and destination may change as it cannot be found as the same intermediate and connections between the end to end nodes may not be established always. Therefore research is established to find the scalable routing so that distributions in path due to the mobility of the vehicles.

o **Network Management:** Since the mobility of the vehicles is increasing, the topologies in the vehicular environment and condition of channel is changing continuously. Due to this a particular structure such as tree structure cannot be implemented due to the change in conditions of vehicular environment.

o **Congestion and collision Control:** Since the size of the network do not have any limits which becomes a challenge for the VANET. Since the load of traffic is different in urban and rural area. In rural areas load of traffic is different during the day and night which leads to change in network partitioning frequently during the day hours when there is more rush as compared to other time which increases the load of traffic due to which congestion and collision occur in a vehicular environment.

o **Environmental Impact:** The electromagnetic waves are basically used for the interaction purpose in the VANET due to which impact of the environment in the vehicular network must be considered.

o **MAC Design:** The source of medium which is basically used for communication purpose by the VANET generated a key issue in a MAC design. There are many approaches which are used by VANETs to overcome this issue. The most efficient approach to overcome this issue is IEEE 802.11 adopted the CSMA based Mac for VANET.

o **Security:** The security of the message is an important issue in the VANET. Since VANET is basically used for the purpose of road safety which are life critical. Therefore security should always be maintained.

Fig 1.7 Challenging Issues in VANET

1.7 What is Intelligent Transportation System (ITS)?

A system where without actually using intelligence, we can aim to provide innovative services relating to different modes of transport and traffic management. It therefore enables various users to be better informed and make safer and smarter use of the transportation networks. Fig. 8 represents an ITS developed by Google to detect traffic and show it with different colours on the map so as to obtain paths with the least traffic.

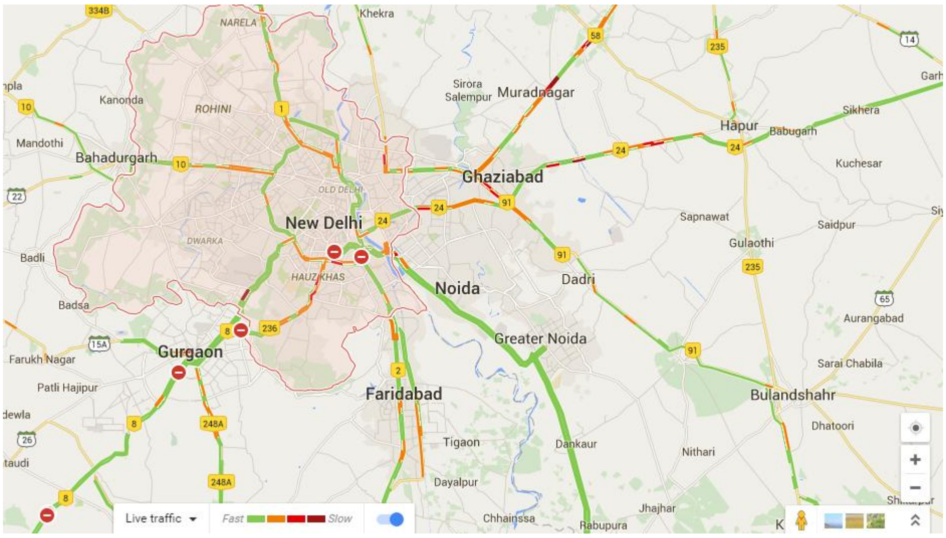

Fig 1.8 ITS developed by Google Traffic

A traffic congestion map is a graphical, real-time or near real-time representation of flow in the traffic in a particular vehicular environment. Since GPS and sensors are implemented on roadside areas which are being used by the traffic management centers to collect the information about the traffic and then it is broadcasted as a map to the users which demands for it.

There are many applications in the mobile, news channels, radio stations are used to show the condition of the traffic on the road to avoid the congestion. Sometimes they are displayed directly to motorists using electronic signs. Frequently these show conditions on highways, but local streets can also be shown.

Similarly, the project Traffic Congestion Mapping involves the use of graph based techniques to represent road maps in the form of graphs and represent actual traffic on its edges or use synthetic traffic generating algorithms to map that traffic. The nodes can be used to represent places on the graph while the edges can be used to represent the connecting routes to each node.

The weight associated with each edge would represent the corresponding distance on the roads or the graph. Traffic would be generated individually on each edge. Thereafter, we can use shortest-path calculating algorithms to obtain the short route from source to the destination nodes.

The path can therefore be highlighted to show the actual shortest path on the graph.

1.8 Problems/Challenges in ITS

- **ITS Design Requirements: Rugged, Small and Certified:** Transportation solutions are mostly available in the mobile vehicles, which is actually affected by the environmental conditions which includes the change in temperature, humidity which provide the support to work on these conditions also. Restriction in the space requires scaling function on small board form factors.
- **Locomotive Data Video Recording (DVR) and Data Gateway:** Locomotive data video recording is a technology which is provided as a solution for vehicular environment so that it become easier to analyse or investigate the accident more closely.

  The video can be stored on hard disk drives (HDD) and can be accessed for any further use. The whole setup was too costly and complex which would not have been implemented effectively.
- In order to be acceptable to public and private interests ITS applications must be cost-effective, reliable, and easy to use and maintain. For public authorities, these systems must be able to show increases in efficiency, reductions in environmental pollution, and most importantly reductions in the number of accidents involving injury and fatality.
- ITS applications that are perceived by the public to be hard to use or unsafe will not be acceptable. Ensuring adequate consumer information and, if necessary, training is also important although this must not exempt manufacturers from accepting responsibility for their products.

1.9 Applications of ITS

- **Emergency Vehicle Notification Systems**

  The emergency vehicle notification system is a system in which notification is generated in the form of eCall which can be done either by manually or automatically by sensors implemented in the vehicles after the accident occurred. Whenever an emergency occur, due to the sensors in vehicle it will automatically establish an emergency call carrying the data and voice to the nearest emergency point. At that point the eCall operator will communicate with the vehicle occupant and automatically data will be sending to the operator.

- **Automatic Road Enforcement**

  Automatic road enforcement is basically a traffic enforcement cameras implemented on the roadside area to analyze the movement of the vehicles which includes speeding by the vehicles, breaking the traffic rules etc. these data will be send to the controller which will generate the traffic tickets which will be send to the owner of the car via email. Various applications that are included in automatic road enforcement are as follows:

1. Speeding Cameras will be used to analyse the speeding of the vehicle which is not legal. To analyse these scenarios radars and electromagnetic waves are used in each road.
2. Red light cameras will be used to check the vehicles which will disobey the rules of traffic by crossing the lane during the red light.
3. Bus lane cameras are used to check the vehicles that are moving on the reserved lanes. In some areas reserved lanes can be used by other vehicles also.

- **Variable Speed Limits**:

  In certain areas they are experimenting on the speed of the vehicles which can change according to the road condition and congestion in the path. Speed limits are reduced during the poor conditions but not increased during the better conditions.

- **Collision Avoidance Systems:**

  Collision avoidance system is implemented on the road so that vehicle can know the vehicles that are ahead of them and can crash each other.

1.10 Motivation

- The original impetus for the interest in ITS was provided by the need to inform fellow drivers of actual condition of the road, delays due to congestion in vehicular environment, driving conditions of the driver and other similar concerns.
- There should be an application which is capable of assisting the driver about the road conditions and finding the best possible path.

- The transmission of packets which includes the updated value of speed of the vehicle, distance between the vehicles and predicted speed of vehicles should be delivered to the vehicles without any delay.

1.11 Objectives

- The main focus will be given on packet forwarding from source to destination in which optimal node which act as a medium between the source and destination is selected for the forwarding purpose.
- The speed of the vehicles is predicted by using different approaches so that optimal node can be selected.
- The transmission range of the vehicle is considered so that vehicle within its range is selected for transmitting the packet to the destination by considering the actual speed, predicted speed and distance between the vehicles.

1.12 Organization

This report is organized as follows. Chapter 2 describes the related work based on VANET. Chapter 3 represent the proposed model of carry and forwarding scheme in VANET is discussed in detail while, Chapter 4 present an analysis of the results of the result obtained. Finally Chapter 5 concludes the report with future directions.

Chapter 2 – Literature Review

Vehicular Ad hoc Network (VANET) is a promising Intelligent Transportation System (ITS) technology [6]. The authors of [6] assert that in many traffic information systems estimation of traffic density is one of the important metric. Many researchers studied infrastructure and infrastructure-free cooperative information systems for VANET. Density of traffic is an important metric and several routing protocols such as vehicle density based VANET routing, density-aware routing using road hierarchy depends upon road density in a real time environment. Moreover, many broadcasting schemes depend upon traffic density estimation techniques.

In ITS most of the schemes are infrastructure-based traffic information systems, which require deployment of vehicle detection devices, traffic surveillance cameras etc. The authors in [6] review the current techniques used to measure and estimate on road vehicle density [6]. Currently, infrastructure-based and infrastructure-free are two divergent techniques for estimation of traffic density. Moreover, the authors discuss the various techniques to classify the various available density estimation techniques.

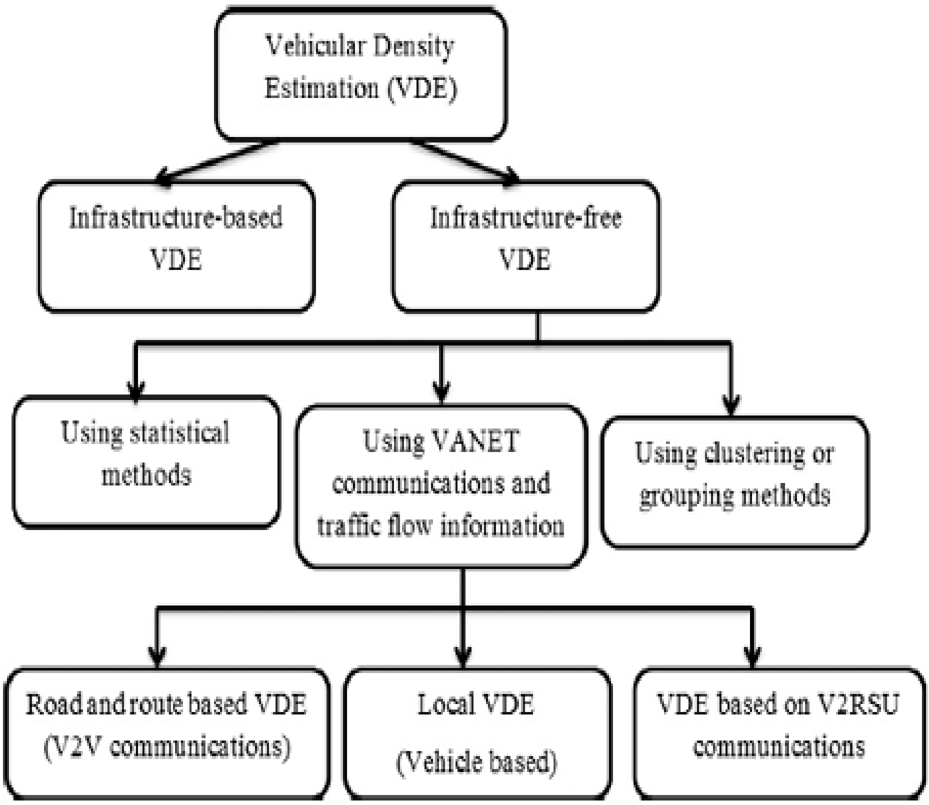

Fig 2.1 Vehicular Densities

In this work, density estimation is done using table which summarizes the aforementioned density estimation algorithms which depend on vehicle to RSU communications.

Vehicle density estimation based on vehicles to Road Side Units (RSUs) communications.

Algorithm	Evaluation scenario	Used data	Calculation method	Performance
[4] (App. 1)	Urban area	Speed, position and direction	By using vehicle location update information stored in location servers	In high density situation location server load increase and will consume longer time for data aggregation, processing and dissemination
[53] (App. 1)	Highway	Speed and lane change	By using vehicular infrastructure framework based on artificial intelligent	Data collection is limited to RSU coverage area and the proposed framework has to be installed in the RSUs
[5,54] (App. 1)	Urban area	Number of beacons received by RSU and the street to junction ratio for selected area	By Evaluating the obtained polynomial equation which was based on the relationship between maps topology, number of beacons received at RSU, and vehicles density	Depends on the availability and reliability of communication with RSUs and on the analysis of road maps

Table 2.1 Vehicle density estimation [6]

A frequent change in network topology is caused due to high speed of vehicles. In order to transfer of packet from node to node the most commonly forwarding technique used is nearest neighbour technique. However, due to heterogeneous vehicles and therefore their heterogeneous transmission range the forwarding policy may not yield the optimal results [6] and is an important design issue.

The authors of [7] investigate a method of next hop transmission method for VANET in heterogeneous environment. The algorithm takes into account these two parameter at each stage: (a) current packet-carrying node and (b) minimum hop count required from each neighbour to the destination of the packet. Further, routing is made based upon these two parameters. The proposed method improves the performance of the network in terms of delay and delivery of the packets. The author in [8] present the routing protocols which work on the basis of vehicle density by using messages and road information table to provide reliable and efficient path for the packet delivery which will be adapted in dynamic city vehicular environment.

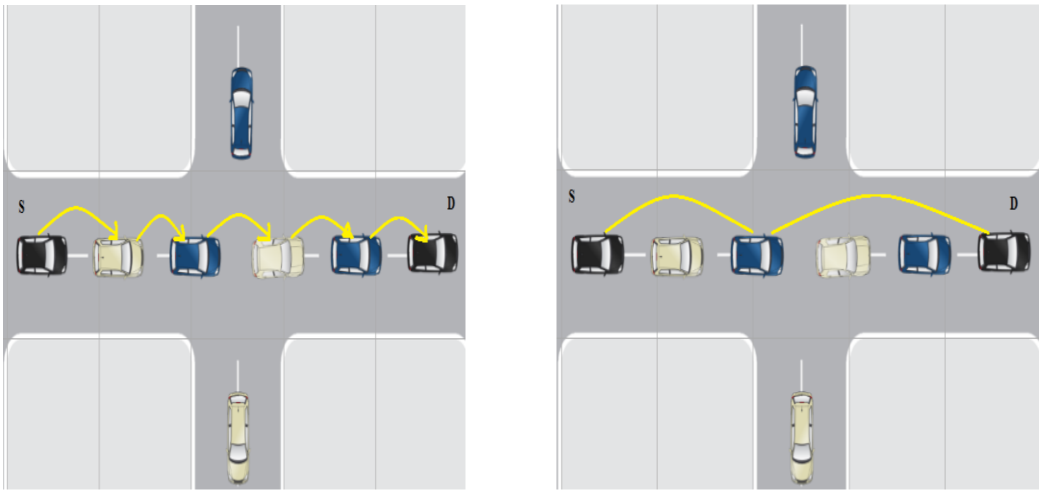

Fig 2.2 A counter example to illustrate traditional greedy routing approach in a heterogeneous case will not always gain minimum hop routing. [8]

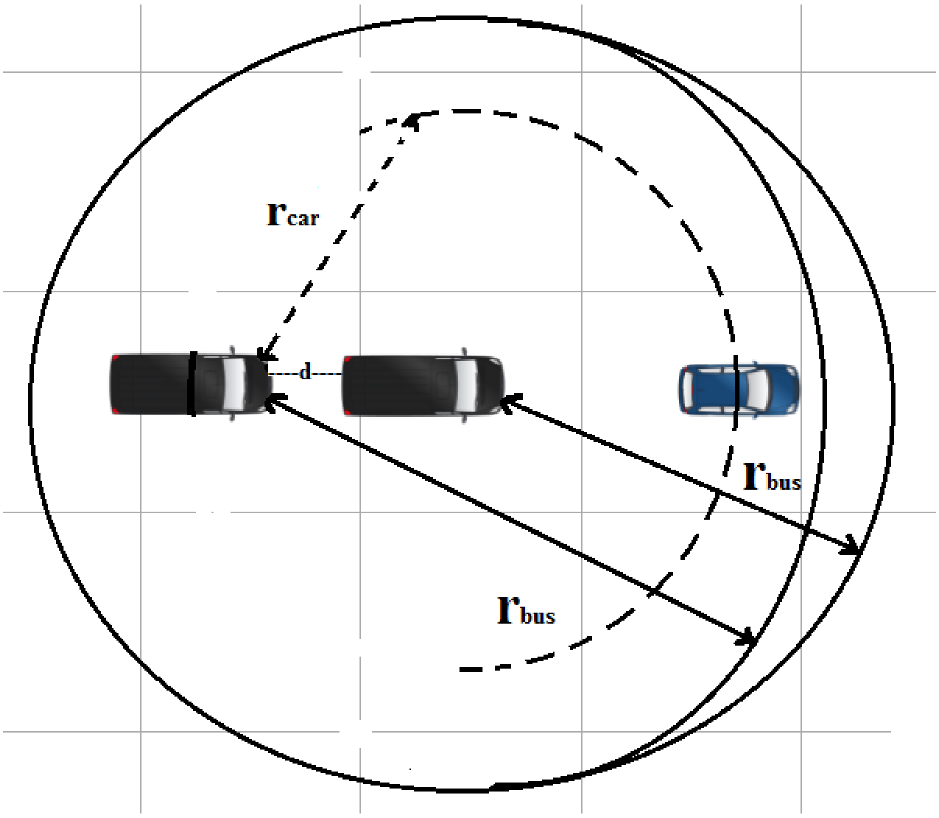

Fig 2.3 An illustration to demonstrate the forward decision making of the MIBR [8]

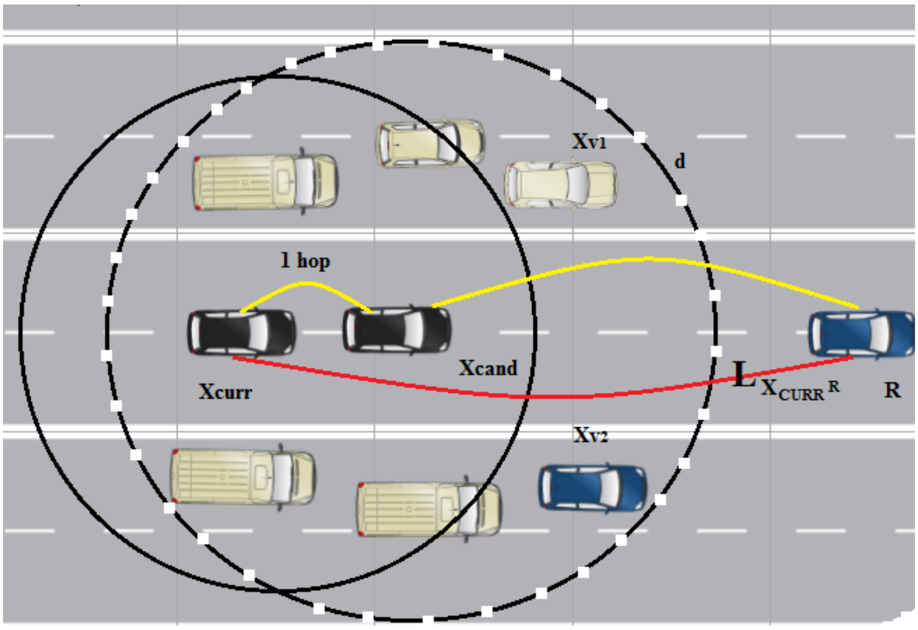

Fig 2.4 An illustration of considered environment [8]

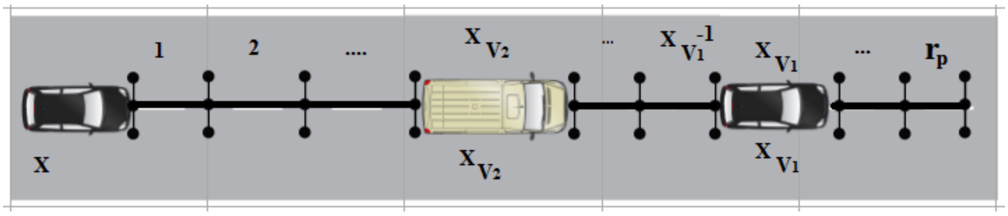

Fig 2.5 The illustrations for the location of nearest vehicles of X_{v1} and X_{v2} of type 1 and 2 respectively to the next junction point R [8]

The authors of [9] present an Efficient Detection Congestion (ECODE) protocol evaluated the characteristics of road segments in real time traffic and detected the congestion in that scenario. Various characteristics of traffic are evaluated on the basis of speed, density and travelling time of road segments. Due to these characteristics it is actually increasing the accuracy of traffic evaluation. In this protocol the direction of the traffic is also considered due to which path recommendation become more accurate.

The hybrid scheme in this protocol is providing the best results as compared to the previous schemes such as proactive and reactive. The bandwidth consumption and end to end delay is also enhanced more accurately as compared to the previous schemes.

Vehicular Ad hoc network (VANET) was introduced in the early 2000s which included vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications based on WLAN [10]. The author of [10] asserts the revolution that is taking place in vehicular networking. The progression taking place in VANET networking includes three main stages which includes past, present and future scenarios that are taking place in the evolution of VANET. According to the author Cooperative Intelligent Transport Systems are deployed so as to provide safety, comfort, efficiency in traffic etc. In present scenario, new applications are deployed with the support of electro mobility, cruise control, platooning, and protection from vulnerable road users. In future scenario it includes the improvement to baseline 802.11 so as to reduce the issues generated due to the services under the conditions through decentralized congestion control, geo-networking mechanisms, and multi-channel operations.

Clustering scheme in VANET helps in grouping all the vehicles based on their similar characteristics which includes the location of the vehicle, speed of the vehicle and direction in which vehicle is moving [11]. The author of [12] proposed fuzzy logic-based cluster head selection algorithm in which the vehicles are group together on the basis of the speed of the vehicles and distance travelled by the vehicles. The prediction schemes are also used to predict the mobility of the vehicles which will provide the more accurate performance of an algorithm in a vehicular environment. The author of [13] proposed a cluster algorithm for maintaining the connection of the nodes in a vehicular environment which will help to maintain the connection for longer time period. Vehicles are sending messages to other neighbouring vehicles to know the speed of those vehicles. The authors of [14] present a Hybrid Backbone Based Clustering algorithm in which the number of links and vehicular mobility is used for the formation of cluster and selection of the cluster head. The algorithm also incorporate contention based scheme in order to prevent frequent cluster re-organization when two CHs come in each other's range. The proposed algorithm reduces the overhead of CH election and re-election, leads to fewer status changes by a node within the cluster. The results show that the proposed technique reduces the overall communication cost due to involvement of less number of nodes in the CH election and re-election process and also increases the overall stability of the network.

The author [15] presents the carpooling schemes which are based on network which is basically generated to overcome the issues of traffic in metropolitan cities. Firstly the prediction algorithm is used to compare the predicted and original benefits due to carpooling scheme so as to get the feasibility. Than the hybrid carpooling scheme is designed by using the assistance of traditional methods which is related with interaction process and packet structuring.

The main goal of VANET is to allow the communication which includes vehicle to vehicle and vehicle to infrastructure. The author of [16] investigates the issues related to vehicle to infrastructure service. The new RSU selection algorithm is introduced to provide feasible access to V2I communication. In this it is basically removing the RSU which has been of no use. By utilizing the algorithm it is increasing the packet delivery ratio.

The author of [17] investigates the MOPR (Movement Prediction based Routing) which will be applied on the routing based on the position to select the next hop to generate the Greedy Perimeter Stateless Routing (GPSR) protocol. After comparing this new protocol with the previous protocol they conclude that it is actually improving the performance.

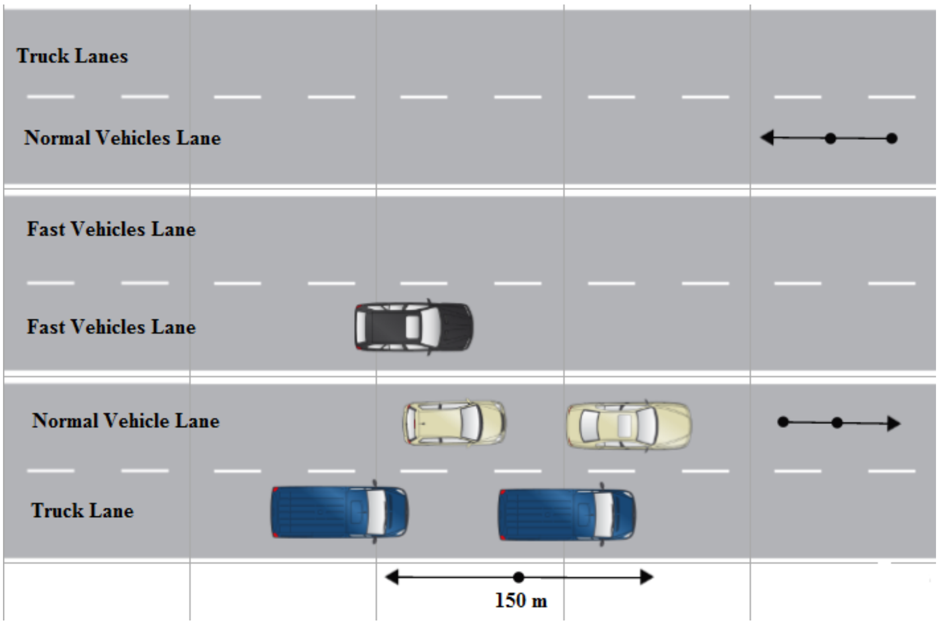

Fig 2.6 Different Lanes according to the type of vehicles [17]

VANET is used to help in reducing traffic and providing congestion free path to the vehicles by using Roadside Units [18]. The author of [18] investigates the cost issues due to the implementation of the RSUs on the two-lane road. The problem in the deployment of RSUs is taken as an integer linear program which is solved by using centre particle swarm optimization approach. This approach will not only increase the convergence speed but also perform better for moderate sized problems.

VSNs (Virtual Sensor Network) are used for road event detection so as to achieve efficient collaboration with the topologies in the network to improve the performance

[19]. The author of [19] present the behaviour-aware fleet construction schemes which includes fleet formation which is used to form the group of similar behaviour and stability vehicles, maintenance is used to update and manage the topology by exchanging the messages and providing the self-recovery process and data collaboration is used to sense the data in a “follower-to-leader” way with the fleet. This scheme is providing the better accuracy as compared to the previous work.

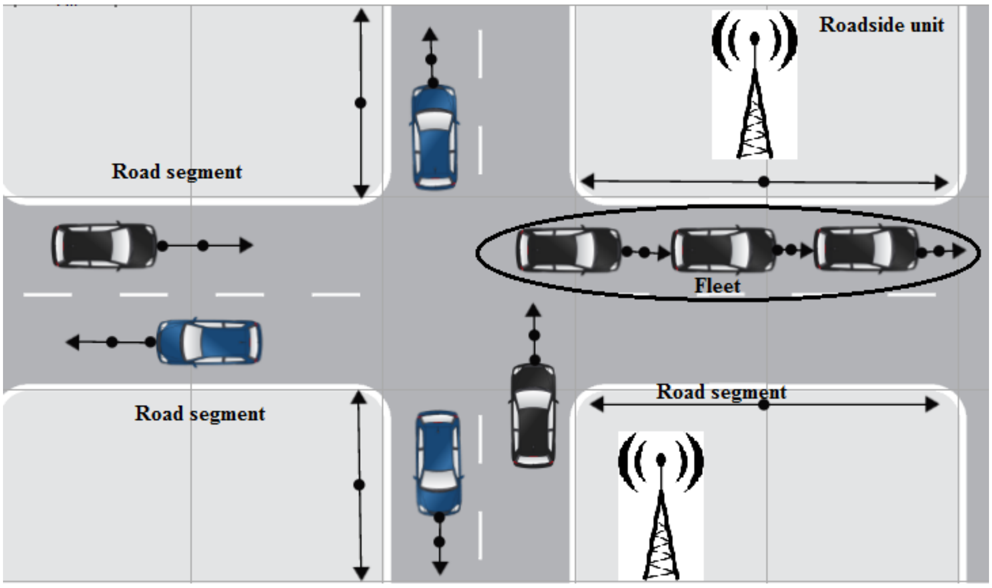

Fig 2.7 An illustration of road event detection by using VSNs [19]

The author of [20] is presenting an optimum problem known On-road Video Delivery (OVD) with integrated heterogeneous networks which is basically used to maximize the User Experience Index (UEI), which is basically used for measure the performance of user experience on-road video services. To solve the issue two solutions are provided which includes Divide-and-Conquer Strategy (DCS) which is used to solve the Wi-Fi bandwidth allocation and limit the usage of cellular budget and Integrate-and-Cooperate Strategy (ICS) also solve the same issues but jointly which is affecting the user experience.

VANET basically uses the routing protocols for establishing end to end connection among the nodes within the network [21]. The author of [21] is investigating the routing protocols which will be used in Vehicular Delay Tolerant Network in which the connection may not be able to exist which will affect communication between the vehicles and RSUs. Therefore for end to end communication various forwarding techniques are considered by using intermediate vehicles which within the path of source to destination. The routing protocols in Delay Tolerant Network are used to provide the maximum and efficient delivery from source to destination which will increase the packet delivery ratio and minimize the end to end delay and also reduce the congestion. The author of [22] proposed the graph based reliable routing scheme for VANET so as to provide the communication on highway to get the most efficient and reliable route from source to destination. The distribution of the moving directions of the vehicles and speed based model is proposed in which routing is used to select the best route without the request broadcasting. The author of [23] proposed a location routing algorithm by using directional clustering based flooding for creating a mechanism based on clustering in which more than one cluster head is present in an area. Routing the packets in a vehicular environment among the neighbours based on the location and direction of the source and the destination and neighbours which comes within the path of the route.

Nowadays in the metropolitan cities vehicles are increasing day by day which not only leads to the traffic congestion but also polluting the city by greater extent [24]. To overcome these problems new Vehicle Traffic Routing System (VTRS) was introduced by the author of [24] known as green VTRS which is basically used to reduce the rate of pollution by reducing the emission of CO_2 and traffic rate is reduced by providing the congestion free path. The author of [24] proposed an algorithm Ant-based Vehicle Congestion Avoidance System (AVCAS) that uses Signalized Intersection Design and Research Aid (SIDRA) for reducing the intake of fuel by the vehicle in its routing model and selecting a path or route which is congestion free or less congested.

Vehicle to Vehicle communication is the one of the important goal in VANET in which the routing is also required [25]. The author of [25] proposed the GeoRouting algorithms that provide the optimal path for transferring the packages between the source and destination which will generate the GeoNetworking in vehicular communication. This algorithm is implemented and tested on real time scenarios by using it in real vehicles and roads to evaluate the performance which will show that the reliable route is selected, packet delivery is more due to which it can be successfully used in real time world.

The author of [26] asserts the multi-hop connectivity of vehicles in a Vehicular Ad-Hoc Network (VANET) which is implemented on two parallel roads with large separation distance between the roads. All the models which were developed in this process are assuming Poisson vehicle process which will consider the vehicle densities, propagation distance, variance etc. The results are correct or not are verified by comparing it with other models.

Connected vehicles are nowadays used to reduce the problem of congestion that is faced in urban areas [27]. The author of [27] is evaluating the connected vehicles based on the choice of mode which includes the cycle, auto mode, walk mode etc in which the travelling time is different in each mode and then is the mobility in the transportation network which is pointing towards the traffic in the vehicular network environment. The result shows that with the increase from connected vehicles is increasing the average travelling time of auto mode which is moving automatically.

The author of [28] investigates the unicast communication in VANET which will be based on the connections established between the nodes and its duration of connection, increasing the packet delivery ratio and reducing the end to end delay which will be implemented in two different scenarios which includes urban area and highway environment which is overall analysing the QoS performances which will help to fulfil their requirements to increase the efficiency and feasibility of the communication in a vehicular environment.

The author of [29] asserts the path duration and probability density function (PDF) is measured in Vehicular Ad-Hoc Network which will be implemented on the single lane highway. To find the probability density function it will consider the speed of the vehicle distributed in a uniform manner and logarithmic sample values of the distances. Than the experiment is perform to find out the most efficient PDF which will be used for the duration of the link. These evaluation results can be further used for creating the most feasible and efficient routing protocol.

The author of [30] investigating the architecture for the media content delivery in urban transportation systems. The author first propose the new disconnection-tolerant network infrastructure which strengthen the connectivity between the connected commuters which are mobile in nature and it also uses the store and forward techniques to attain the efficient delivery between the media content. Secondly it proposed the router-centric prediction method which will collect the past data of the passengers so as to get the perfect scheme for delivery of packages. These proposed algorithms are evaluated on the urban scenario and helps in achieving the best delivery scheme.

The author of [31] investigating on distance based mechanisms by using broadcasting and selective forwarding. The author proposed the prediction and selective forwarding based broadcasting algorithm in which it need to predict the future velocity of the vehicle by considering the current velocity than the broadcasting process is perform in which the sender broadcast the message to all the nearest neighbours which will help to select the node which comes within the predicted mobility than that selected node will again broadcast the message the same way the previous node did. This will simulate that it will have maximum packet delivery ratio and minimum end to end delay.

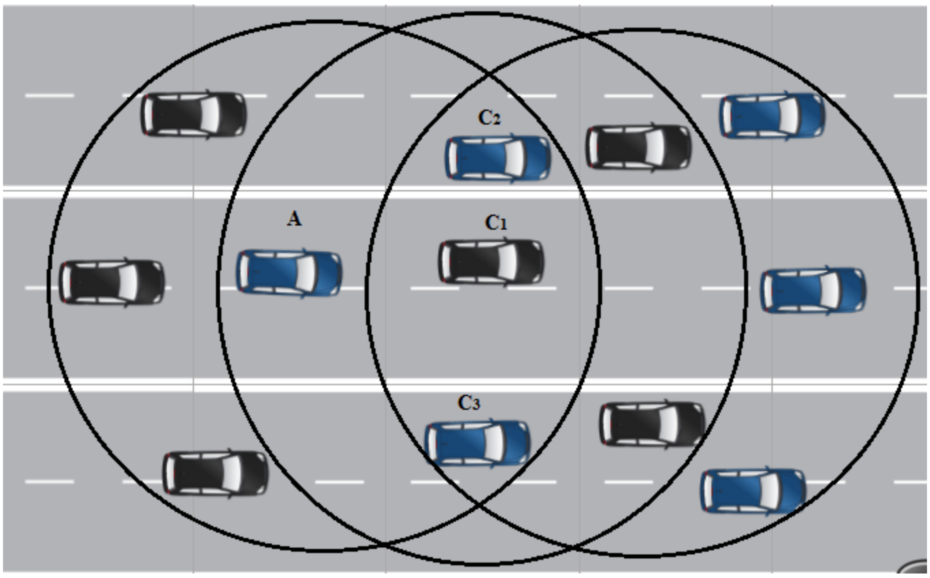

Fig 2.8 Basic Broadcasting Scenario [31]

Collision in a vehicular environment is an important issue which needs to be avoided for the safety purposes. Therefore optical and cooperative vehicular collision avoidance system needs to be proposed. Optical collision avoidance system uses the image processing to identify the nodes which are coming in their vehicular network area. The author of [32] is using a stereo infrared vehicular mounted camera which is basically used to track the walker moving at night. Since most of the accidents occur at night with the walker so they are using the vocal warnings and displaying their infrared image on the windshield for the safety purpose of the walker. The author of [33] are using the video cameras which will be set up at roads intersection point so as to predict the collision which is about to happen in that area by using general purpose computing hardware which is implemented in real time scenarios and also performing better. The author of [34] proposes the robust EKF for identifying the nodes with the help of camera which is overcoming the issues of noise and uncertainties generating on a vehicular environment and also providing more accurate results.

Chapter 3: Proposed Work

In this chapter, we discuss our proposed approach for next hop forwarding in Vehicular Ad Hoc Networks (VANETs). The scheme is based on predication approach for next hop forwarding in VANET. In the following subsection, we provide the problem description of the proposed scheme.

3.1 Problem Description

Our work aims to solve the issue of inter vehicle communication based routing in VANET. Similar to the work of previous researchers [31] and [35], our work predicts the speed and position of the neighbouring vehicles in advance. Some of the most challenging issues in VANET are mobility of the vehicles, dynamic topology, and density of the vehicles in urban, rural, and highway scenarios. One of the simplest approaches to forward the message from source vehicle to destination vehicle is to select one of the neighbouring vehicles. Then the forwarding vehicle selects the next neighbouring vehicle on random basis. The process continues till the message is delivered to the destination vehicle. However, this approach does not consider the location, speed, and distance between the vehicles. This has prompted us to find an algorithm in which selection of next hop neighbour for carry and forwarding the packet need to predict the future position and the velocity of the vehicle based on the past position and velocity values.

We assume that in a highly dynamic city or highway environment the driver is aware of the city conditions like, traffic, obstacles, accidents etc. These conditions are major concerns in the field of Intelligent Transport System. Thus there should be an application which is capable of assisting the driver about the road conditions and finding the best possible path under constraints. Further, these message needs to be transferred to the vehicles as fast as possible in the form of packets which are light weight and contains sufficient information. Based on our approach the vehicles can select the best possible path under given constraints so as to reach the destination in a reduced amount of time. Our next subsection presents the assumptions used in our work.

3.2 Assumptions

- Density of traffic is sufficient enough in order for the protocol to work. This is especially valid for urban, semi-urban, and highway scenario.
- Vehicles can have homogeneous or heterogeneous transmission range. This assumption represents real life situation as there can be several types of vehicles running on the road. For example, there can be vehicles of type A (ordinary cars), type B (high-speed cars), type C (buses), type D (trucks), type E (emergency vehicles or ambulances) etc.
- We further assume that type E emergency vehicles do not participate in the carry and forward scheme. These vehicles only can serve as source vehicles only. This is due to the nature of the job responsibility carried out by the emergency vehicles.
- We also assume that each vehicle is equipped with some sort of GPS facility for enabling the vehicle node to be aware of its location. Based upon the types of the vehicles, each of these vehicles can have a variable transmission range. For example an ordinary car can have a transmission range of 150 meters to 250 meters. Similarly, high end buses can have a transmission range of 250 meters to 400 meters.
- Each vehicle is aware of its one hop neighbour through message (MSG) exchange between the neighbouring vehicles. Two types of messages are considered in our work: REQUEST_MSG and REPLY_MSG. In addition, there are periodical HELLO_MSG to obtain the information of one hop neighbours.
- The road segments are considered to be straight or with intersections at right angles to one another. We ignore the curved roads in our work.

- There is Road Side Infrastructure (RSI) available at predetermined locations to assist the vehicles with preliminary information such as road conditions, forward traffic density, obstacles etc.
- Our approach works for the vehicles moving in the same direction or advance direction only. In order for our approach to work in backward directions, the messages to be forwarded through vehicles moving in the adjacent lanes in reverse direction.

3.3 Preliminaries

Table 3.1: Notations used in our work

Notation	Description
Tr	Transmission radius of vehicle
$V^i(t, p_i)$	Vehicle identification(time, location)
REQUEST_MSG	Request message consist vehicle id, location, predicted and actual velocity
REPLY_MSG	Reply message received with NGH((V^j)
NGH(V^i)	Neighbour table for the ith vehicle at time t
Ft(V^j)	Predicted Velocity of the jth vehicle at time t
SCORE (V^j)	Score of the of the jth vehicle at time t

Table 3.1 illustrates the notations used in our work. We now present the algorithm along with the state transition diagram, and flow chart of our proposed algorithm.

3.4 Our Approach

3.4.1 Algorithm 3.1 (OBV)

We propose an approach that can be used to handle inter vehicle communication for Intelligent Transportation System. Our algorithm On Board Vehicle (ORB) requires vehicles id, vehicle speed, and position of vehicle as input parameters. The output of our algorithm is the selection of next hop neighbour for carry and forwarding of the packet scheme.

$Input : V = (V^1(t, v_1, p_1), V^2(t, v_2, p_2), ..., V^k(t, v_k, p_k))$

$Output$: Selection of next hop neighbor at time t+1 $(V^{nhn}(t+1, v_{nhn}, p_{nhn}))$

Algorithm 3.1 (OBV)

Algorithm OBV is executed by the source vehicle. In this algorithm, initial vehicle will enter into a network coverage area. The vehicle sends its information to all the one hop neighbours and Road Segment. Further, the request message (REQUEST_MSG) is received by one hop neighbours of vehicle (V_i) or NGH (V_i) including the Road Segments in transmission range of vehicle (V_i). The message consists of unique id, time and location of the vehicle. The entire neighbour nodes send REPLY_MSG to vehicle (V_i). Now vehicle computes the predicated speed of all vehicles for the next iteration with the help of predication scheme. Further, the initiator vehicle selects the vehicle within its transmission range and assigns a score based on the Transmission range of the selected vehicle. Then, the vehicle with maximum score is selected as next hop forwarder for the message.

Algorithm 3.1: OBV_1

$V^i(t, v_i, p_i)$ send REQUEST_MSG to one hop neighbors at time t
▷ REQUEST_MSG consists of vehicle ID, vehicle location, and time of request
wait ();
REPLY_MSG received with NGH(V^i)
▷ REPLY_MSG consists of vehicle ID, vehicle location, vehicle predicted and actual velocity at time t-1
for $(V^j \in NGH[V^i])$ **do**
    ▷ Compute predicted velocity F_t
    $F_t(V^j) = \alpha \times Y_{t-1}(V^j) + \beta \times F_{t-1}(V^j)$
    ▷ $\alpha + \beta = 1$
    ▷ Compute predicted position P_t
    $SCORE_t(V^j) = p_{t-1}(V^i) - p_{t-1}(V^j) + P_t(V^j) \times \Delta t$
end
for $(V^j \in NGH[V^i])$ **do**
    if $SCORE_t(V^j) > MAX$ **then**
        $MAX = SCORE_t(V^j)$
        $index = j;$
    end
end
Forward the packet to (V^{index}) at time t

Algorithm complexity: the running time of the algorithm OBV1 is O (n).

According to the algorithm OBV_1, the vehicle V^i is initialized with the position of the vehicle (p_i), speed of the vehicle (v_i) at that particular instance of time (t). Than the vehicle V^i will send a Request_Msg which consist of vehicle id, location and time of request to the one hop neighbours at time t. Than vehicle needs to wait until it receives the Reply_Msg. The Reply_Msg consist of vehicle id, location, predicted velocity and actual velocity at t-1 with the Neighbouring vehicle (NGH [V ^{i}]. To find the predicted velocity it will use the simple exponential smoothing in weight is computed as w1=0.1, w2=0.5, w3=0.9. After computing the predicted velocity score is computed for the vehicles which are within the transmission range than the distance between the vehicles and predicted velocity with time is used to compute the score of the vehicle. The vehicle which is having the maximum score is selected for forwarding the packet.

State Diagram

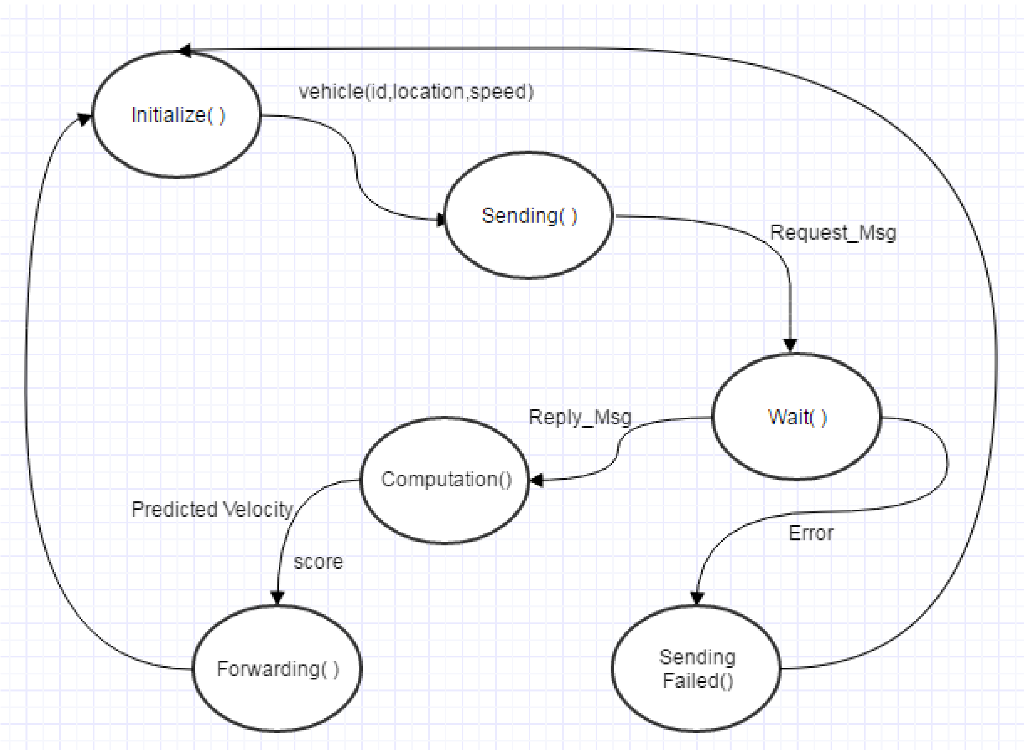

Fig 3.1 State Diagram

According to the state diagram, first initialized the vehicle with vehicle id, location and speed. Then send a request message to the next hop neighbour with vehicle id, position and time of request. After the wait reply message is received with the detail of the neighbouring vehicle if error does not occur. But if there is an error during the sending than sending will be failed. The computation is done in the form of scores using velocity. If the value of score is maximum for the vehicle than the packed is forward to that vehicle so that packet will be able to carry forward to the destination.

3.4.2 Algorithm 3.2(OBV2)

Algorithm 3.2: OBV_2

{
$V^i(t, v_i, p_i)$ send REQUEST_MSG to one hop neighbors at time t
▷ REQUEST_MSG consists of vehicle ID, vehicle location, and time of request
wait ();
REPLY_MSG received with NGH(V^i)
▷ REPLY_MSG consists of vehicle ID, vehicle location, average velocity $AVG(V^j)$ upto time t-1
for $(V^j \in NGH[V^i])$ **do**
    ▷ Compute predicted position P_t
    $SCORE_t(V^j) = p_{t-1}(V^i) - p_{t-1}(V^j) + AVG(F_t(V^j)) \times \Delta t$
end
for $(V^j \in NGH[V^i])$ **do**
    if $SCORE_t(V^j) > MAX$ **then**
        $MAX = SCORE_t(V^j)$
        $index = j;$
    end
end
Forward the packet to (V^{index}) at time t
}

Algorithm complexity: The running time of the algorithm OBV2 is O (n).

According to the algorithm OBV_2, the vehicle V^i is initialized with the position of the vehicle (p_i), speed of the vehicle (v_i) at that particular instance of time (t). Than the vehicle V^i will send a Request_Msg which consist of vehicle id, location and time of request to the one hop neighbours at time t. Than vehicle needs to wait until it receives the Reply_Msg. The Reply_Msg consist of vehicle id, location, predicted velocity and actual velocity at t-1 with the Neighbouring vehicle (NGH [V^i]. To find the predicted velocity it will use the simple n period moving average in which prediction at time t is computed by calculating the average of all the previous actual velocities at time t-1. After computing the predicted velocity score is computed for the vehicles which are within the transmission range than the distance between the vehicles and predicted velocity with time is used to compute the score of the vehicle. The vehicle which is having the maximum score is selected for forwarding the packet.

Chapter 4: Simulation and Results

We conduct simulations using ns2 simulator in order to simulate VANET environment for urban and semi-urban scenarios. Further, we performed simulation for highway scenario on our custom build simulator in C over Linux platform. Simulation environment for urban scenario is created using a 1250 meters *1250 meters grid and 152 points are placed in the network grid in which 20 nodes are considered as the vehicles. Wireless parameters like antenna type, channel type and propagation model are defined for each node. MAC layer is used in the simulation with standard following IEEE 802.11 and the radio model has been used.

Table 4.1: Simulation Parameters

Number of vehicles	20

Grid Area	1250*1250 m^2
Mac Protocol	IEEE 802.11
Propagation Model	Two-way Ground Model
Transmission Range	300m
Antenna Type	Omni-Antenna
Channel Type	Wireless Channel
Simulation Time	60sec

4.1 Description of the tools used in environment

NS is a separate affair simulator under the attack at networking research. It provides strength for simulation of TCP, routing, and multicast protocols over wired and wireless networks. Ns-2 is a standard experiment environment. The ns-2 wireless simulation model energizing nodes in motion an unobstructed plane. Motion follows the random waypoint model, a node pick a destination uniformly at random in the simulated region, pick a velocity uniformly at random from a configurable range, and then goes to that destination at the chosen velocity.

4.2 Simulation and results for Urban and semi urban environment settings

Case 1: Urban Topology

Simulation Parameters:

Number of Iterations: 10

Number of Vehicles: 20

Length of the Highway: 1250 * 1250 m^2

Lowest vehicle speed (LSPEED) 5m/s

Highest vehicle speed (HSPEED) 20m/s

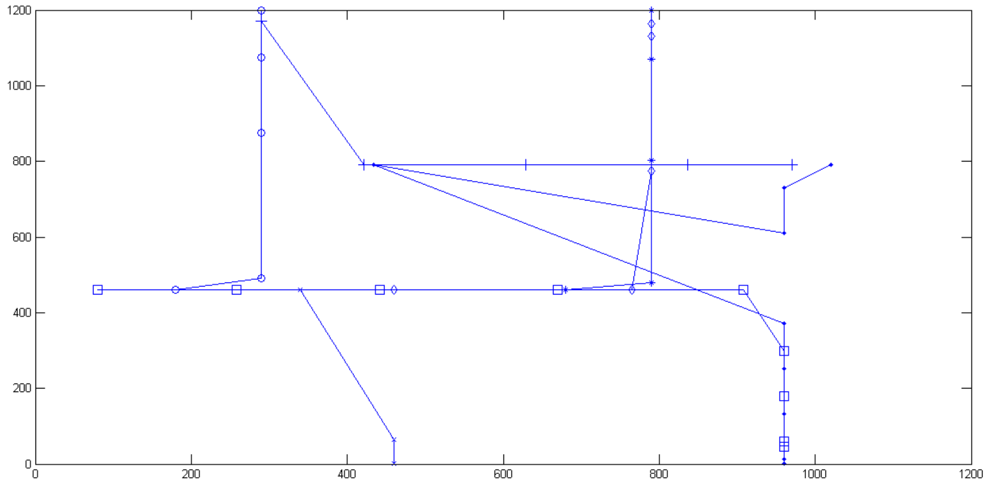

Fig 4.1 Position of the vehicles at each iteration

Effect of weights on deterministic distribution and moving speed of the vehicles

Initial distribution of nodes deterministic distribution of nodes vehicles moving with constant speed of 5 to 20 m/s. We studied the effect of initial node distribution on the score based carry and forwarding scheme. The transmission range is fixed at 300 meters. Further, the vehicle density is kept at a fixed numbers of 20 vehicles. The initial distribution of 20 vehicles over an urban topology of 1250*1250 meters^2 is taken as grid distribution of vehicles. We kept speed for each iteration within 5 to 20 meters per seconds. Moreover the weights for the exponential factor are kept at 0.1, 0.5 and 0.9 for w1, w2 and w3 respectively.

Effect of smoothing weight on speed of vehicles

The actual velocities of the vehicles are taken within the range of 5 to 20 metres per second. The predicted velocity is calculated by taking the smoothing constant which includes the weights that are w1=0.1, w2=0.5 and w3=0.9. The graph given below will show that predicted velocity is showing with weight w3=0.9 is showing very small error as compared to the actual velocity of the vehicles.

Fig 4.2 Speed of a Vehicle over the urban topology (m/s) Measured versus predicated with smoothing ((0.1, 0.9), (0.5, 0.5), (0.9, 0.1)) for three settings of (w1, w2) parameters.

Effect of transmission range

We studied the effect of transmission range on the carry and forwarding scheme. The transmission range is fixed at 300 meters. Further, the vehicle density is kept at a fixed numbers of 20 vehicles. The initial distribution of vehicles over an urban topology is of 1250*1250 meters² is taken as distribution of vehicles. We kept minimum and maximum speed for each iteration in the range of [5, 20] meters per seconds. Moreover the weights for the exponential factor are kept at 0.1, 0.5 and 0.9 for w1, w2 and w3 respectively.

Transmission range 200 m number of hops from source to destination: 5
Transmission range 250 m number of hops from source to destination: 4
Transmission range 300 m number of hops from source to destination: 3
Transmission range 350m number of hops from source to destination: 3
Transmission range 400m number of hops from source to destination: 2

According to this data the transmission range is inversely proportional to the number of hops. Due to which if the transmission range increases, the number of will start decreasing.

Fig 4.3 Effect of transmission range on number of hops

Effect of Data forwarding scheme

We studied the score based carry forwarding scheme. The transmission range is fixed at 300 meters. Further, the vehicle density is kept at a fixed numbers of 20 vehicles. The initial distribution of vehicles over an urban topology is of 1250*1250 meters² is taken as distribution of vehicles. We kept minimum and maximum speed for each iteration in the range of [5, 20] meters per seconds. Moreover the weights for the exponential factor are kept at 0.1, 0.5 and 0.9 for w1, w2 and w3 respectively which are basically used to predict the velocity. Than the score can be computed by using the predicted velocity of the neighboring node which comes within the range of 300 meters and distance between the initial vehicle and the selected neighboring vehicle with time. Score based carry forwarding is also compared with the greedy approach and the random approach.

Candidate vehicle lies in the transmission range(300m) of the vehicle at time (t) for packet forwarding.

Fig 4.4 Neighbouring vehicles at iteration 1

Comparison between the score based forwarding, greedy approach and random approach is shown in the graph. According to graph the performance of the score based forwarding is better than the greedy approach and the random approach. The scores of all the neighbouring vehicles for the initial vehicle is computed in the form of S1, S2, S3, S4. The neighbouring vehicle with maximum score is selected to forward the packets. The score based forwarding is better than the random approach.

Fig 4.5 Comparison between the carry forwarding approaches

Effect of density of vehicles on the number of hops

We studied the effect of vehicle density or number of vehicles on the carry and forwarding scheme. The transmission range is fixed at 300 meters. Further, the vehicle density is variable from 10, 20, 30, 40 and 50 vehicles. The initial distribution of vehicles over an urban segment of 1250*1250 meters^2 is taken as distribution of vehicles. We kept minimum and maximum speed for each iteration in the range of [5 , 20] meters per seconds. Moreover the weights for the exponential factor are kept at 0.5 and 0.5 for w1 and w2 respectively.

The densities of the vehicles are inversely proportional to the number of hops. If the density of the vehicle is increasing than the number of hops will decrease.

Fig 4.6 Effect of density of vehicles on number of hops.

4.3 Simulation and results for Highway environment settings

Simulation Parameters
Number of Iterations: 10
Number of Vehicles: 25
Length of the Highway: 1000 m

Lowest vehicle speed (LSPEED) 15 //30 m in 2 second or 30 m in 1 iteration or 54 Km/hr or 15m/sec
Highest vehicle speed (HSPEED) 25 //50 m in 2 second or 25 m in 1 iteration or 90 Km/hr or 25m/sec
Minimum displacement (MINDISPLACEMENT) 30 m in one iteration or 2 seconds
Maximum displacement (MAXDISPLACEMENT) 50 m in one iteration or 2 seconds

Weights for smoothing factor associated with Measured speed w1 0.5
Weights for smoothing factor associated with Predicated speed w2 0.5

Transmission range of the vehicle (TXRANGE) 150 m

Effect of weights on deterministic distribution and constant moving speed of the vehicles

Initial distribution of nodes deterministic distribution of nodes vehicles moving with constant speed of 20 m/s. We studied the effect of initial node distribution on the score based carry and forwarding scheme. The transmission range is fixed at 100 meters.

Further, the vehicle density is kept at a fixed numbers of 100 vehicles. The initial distribution of 100 vehicles over a highway segment of 1000 meters is taken as deterministic or grid distribution of vehicles. The initial vehicles for source and destination are taken as smallest and largest position vehicle in the highway segment of 1000 meters. We kept CONSTANT speed for each iteration as 20 meters per seconds. All vehicles are moving from left to right directions only. Each iteration is of the duration of 2 seconds in our simulation settings. Therefore the range of minimum and maximum displacement is fixed as 20 meters in our simulation settings. Moreover the weights for the exponential factor are kept at 0.5 and 0.5 for w1 and w2 respectively.

Initial Distribution of 25 nodes over the highway of 1000 m:

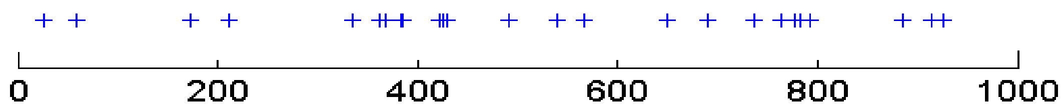

Fig 4.7 Initially Random distribution of 24 vehicles over highway segment of 1000 m.

MAXROUND 100

MAXVEH 100

MAXLENGTH 1000

CONSTANT SPEED 20 //40 m in 2 second or 40 m in 1 iteration

CONSTANTDISPLACEMENT 40

w1 0.5

w2 0.5

Initial distribution of nodes deterministic distribution of nodes

vehicles moving with constant speed of 20 m/s

weights 0.1, 0.9 number of hops : 9

weights 0.5, 0.5 number of hops : 9

weights 0.9, 0.1 number of hops : 9

Initial distribution of nodes deterministic distribution of nodes

vehicles moving with constant speed of 25 m/s

weights 0.1, 0.9 number of hops : 9

weights 0.5, 0.5 number of hops : 9

weights 0.9, 0.1 number of hops : 9

Initial distribution of nodes random distribution of nodes

vehicles moving with variable speed of [15m/s, 25m/s]

weights 0.1, 0.9 number of hops : 10

weights 0.5, 0.5 number of hops : 10

weights 0.9, 0.1 number of hops : 10

Initial distribution of nodes random distribution of nodes

vehicles moving with variable speed of [30m/s, 50 m/s]

weights 0.1, 0.9 number of hops : 10

weights 0.5, 0.5 number of hops : 10

weights 0.9, 0.1 number of hops : 10

Fig 4.8 Effect of weights on the moving speed

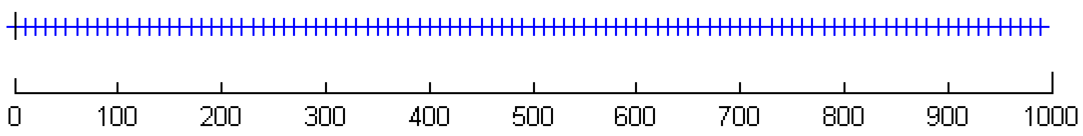

Fig 4.9 Deterministic position of vehicles as initial distribution and moving with constant speed

Predicated versus actual velocity

Measured value of speed in m/s of vehicle 0

Vs0 = [20.000000 ;15.000000 ;18.000000 ;19.000000 ;20.000000 ;24.500000 ;17.500000 ;20.000000 ;19.500000 ;18.000000]

Predicated value of speed in m/s of vehicle 0

VPv0 = [20.000000 ;20.000000 ;17.500000 ;17.750000 ;18.375000 ;19.187500 ;21.843750 ;19.671875 ;19.835938 ;19.667969]

Error or difference in measured – predicated (m/s)

Ev0 = [0.000000 ;-5.000000 ;0.500000 ;1.250000 ;1.625000 ;5.312500 ;-4.343750 ;0.328125 ;-0.335938 ;-1.667969]

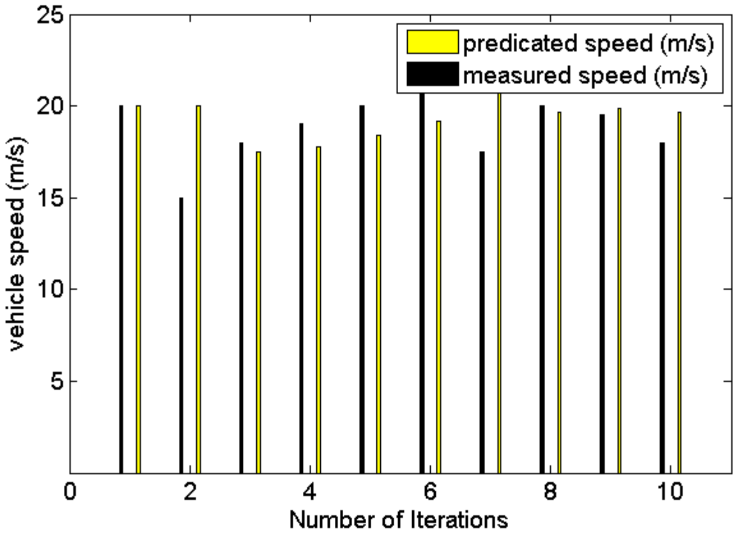

Fig 4.10 Speed of a Vehicle over the highway segment (m/s) Measured versus predicated with smoothing (w1 = 0.5, w2 = 0.5

Effect of transmission range on carry forwarding scheme

We studied the effect of transmission range on the carry and forwarding scheme. The transmission range is varied from 100 meters to 300 meters in step size of 50 meters. Further, the vehicle density is kept at a fixed numbers of 100 vehicles. The initial distribution of vehicles over a highway segment of 1000 meters is taken as random uniform distribution of vehicles. The initial vehicles for source and destination are taken as smallest and largest position vehicle in the highway segment of 1000 meters. We kept minimum and maximum speed for each iteration in the range of [15, 25] meters per seconds. Each iteration is of the duration of 2 seconds in our simulation settings. Therefore the range of minimum and maximum displacement varies in the range of [30, 50] meters in our simulation settings. Moreover the weights for the exponential factor are kept at 0.5 and 0.5 for w1 and w2 respectively.

Effect of Transmission range

1a) Score based carry and forwarding scheme

Transmission range 100 m number of hops from source to destination: 10

Transmission range 200 m number of hops from source to destination: 5

Transmission range 300 m number of hops from source to destination: 3

2a) minimum distance of destination from a neighbor node forwarding node scheme

Transmission range 100 m number of hops from source to destination: 10

Transmission range 200 m number of hops from source to destination: 5

Transmission range 300 m number of hops from source to destination: 3

3a) random selection of neighbor scheme forwarding scheme

Transmission range 100 m number of hops from source to destination: 19

Transmission range 200 m number of hops from source to destination: 10

Transmission range 300 m number of hops from source to destination: 6

4a) maximum distance of destination from a neighbor node forwarding node scheme

Transmission range 100 m number of hops from source to destination: 90

Transmission range 200 m number of hops from source to destination: 81

Transmission range 300 m number of hops from source to destination: 73

Fig 4.11 Effect of Transmission Range on number of hops.

Effect of vehicle density or number of vehicles

We studied the effect of vehicle density or number of vehicles on the carry and forwarding scheme. The transmission range is fixed at 100 meters. Further, the vehicle density is variable from 25, 50, 75, and 100 vehicles. The initial distribution of vehicles over a highway segment of 1000 meters is taken as random uniform distribution of vehicles. The initial vehicles for source and destination are taken as smallest and largest position vehicle in the highway segment of 1000 meters. We kept minimum and maximum speed for each iteration in the range of [15, 25] meters per seconds. Each iteration is of the duration of 2 seconds in our simulation settings. Therefore the range of minimum and maximum displacement varies in the range of [30, 50] meters in our simulation settings. Moreover the weights for the exponential factor are kept at 0.5 and 0.5 for w1 and w2 respectively.

Transmission range is fixed at 100

Vehicle density or number of vehicles: 25	No forwarding vehicle available from 1 Hop
Vehicle density or number of vehicles: 50	Number of Hops from src to dest: 11
Vehicle density or number of vehicles: 75	Number of Hops from src to dest: 11
Vehicle density or number of vehicles: 100	Number of Hops from src to dest: 10
Vehicle density or number of vehicles: 125	Number of Hops from src to dest: 10

Fig 4.12 Effect of vehicle density on the number of hops which are within the 100m range

Transmission range is fixed at 50

Vehicle density or number of vehicles: 25 No forwarding vehicle available from 1 Hop

Vehicle density or number of vehicles: 50 No forwarding vehicle available from 2 Hop

Vehicle density or number of vehicles: 75 No forwarding vehicle available from 5 Hop

Vehicle density or number of vehicles: 100 No forwarding vehicle available from 17 Hop

Vehicle density or number of vehicles: 125 Number of Hops from src to dest: 23

Vehicle density or number of vehicles: 150 Number of Hops from src to dest: 22

Vehicle density or number of vehicles: 175 Number of Hops from src to dest: 21

Vehicle density or number of vehicles: 200 Number of Hops from src to dest: 21

Vehicle density or number of vehicles: 225 Number of Hops from src to dest: 22

Vehicle density or number of vehicles: 250 Number of Hops from src to dest: 20

Fig 4.13 Effect of vehicle on number of hops which comes within the range of 50m

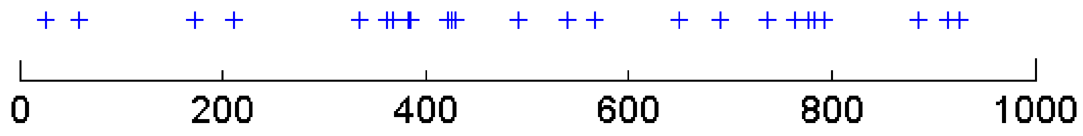

Fig 4.14 Selection of source and destination from 24 vehicles over highway segment of 1000 m. Source is selected from left side while destination is selected from right side

Source Position at Iteration 0: 27 m

Destination Position at Iteration 0: 926 m

Measured vehicles position

Vehmp[10][24]

383 886 777 915 793 335 386 492 649 421 362 27 690 59 763 926 540 426 172 736 211 368 567 429 782

413 921 820 957 827 372 434 533 679 467 393 61 726 105 808 958 585 460 215 773 249 402 616 461 821

449 965 859 1002 861 419 476 563 715 508 432 105 766 136 855 989 632 496 248 805 289 451 662 506 867

487 1006 902 1036 898 462 517 599 747 545 477 142 801 179 898 1032 670 536 286 851 332 484 702 555 911

527 1045 938 1068 940 509 565 648 790 591 517 172 837 223 930 1069 706 585 317 882 362 517 746 604 942

576 1091 978 1113 974 549 605 682 832 627 562 209 885 259 972 1106 755 624 357 916 408 548 776 638 984

611 1140 1018 1155 1022 597 645 722 863 663 594 253 927 293 1015 1150 789 666 396 964 444 596 809 671 1032

651 1186 1064 1193 1069 646 685 755 910 705 630 299 965 329 1063 1194 836 715 439 1003 475 643 847 706 1066

690 1228 1113 1228 1112 681 723 804 949 743 672 344 1008 373 1103 1226 876 756 471 1045 506 683 893 740 1106

726 1274 1157 1274 1152 728 753 835 992 779 712 383 1049 406 1140 1264 914 790 520 1082 551 716 930 779 1139

Forwarding = [27, 215, 289, 477, 648, 832, 1018 , 1150];

fory = [10, 10, 10, 10, 10, 10, 10, 10];

Scatter (forwarding, fory);

Number of hops: 6

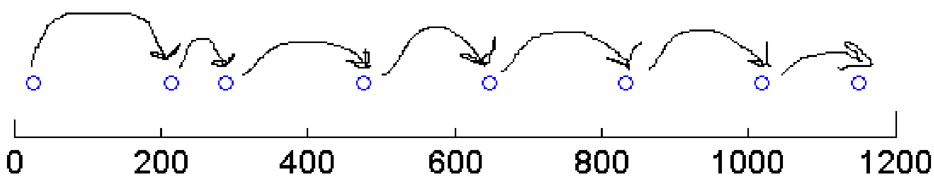

Fig 4.15 Number of hops from source and destination from 24 vehicles over highway segment of 1000 m. Source is selected from left side while destination is selected from right side based on smoothing factor (w1 = w2 = 0.5)

Chapter 5: Summary

5.1 Conclusion

VANET is a highly dynamic environment. Traditional routing protocols results in degraded performance. We proposed algorithm which are based on two topologies that are urban topology and highway topology in which carry forwarding mechanism for vehicular networks are used to send the packets from source to destination. In the algorithm, a message sender can select the best node among its neighbours with the help of on board vehicle algorithm so that it can send the message fastest to the destination nodes. Each node keeps on updating its position and velocity at each instance of time. Together with the current velocity and location we compute the predicted velocity by using two prediction techniques that are simple exponential smoothing and other technique is simple n average. Than the score of each node is computed which comes within the transmission range. Than the node with maximum score is selected to forward the packet. The score computation method is also been compared with the greedy method and the random approach. The packets are forwarded from source to destination as fast as possible by using the hops. The effect of increase in the nodes, transmission range, weights are shown in the form of graphs.

5.2 Future Work

In this work, we focused on the algorithm and feature that can be used to carry forward the packets from source to destination by using the additional feature of predicted velocity with high packet delivery ratio and less delay time.

However, the results show that there is further scope for performance improvement of this approach with additional features and practical knowledge which we aim to explore in future.

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