NODE DENSITY AWARE ROUTING PROTOCOL (NDARP) IN VANETs

Thesis

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Pantnagar ***(Priyankza Agrawal)***
August 2015 *Authoress*

CERTIFICATE - I

This is to certify that the thesis entitled **NODE DENSITY AWARE ROUTING PROTOCOL IN VANETs** submitted in partial fulfillment of the requirements for the degree of **MASTER OF TECHNOLOGY** with major in **COMPUTER ENGINEERING** of the College of Post Graduate Studies, G. B. Pant University of Agriculture & Technology, Pantnagar, is a record of *bona fide* research carried out by **Ms PRIYANKA AGRAWAL Id No. 45553** under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been acknowledged.

Pantnagar
August, 2015

(P.K. Mishra)
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CERTIFICATE - II

We, the undersigned, members of the Advisory Committee of **Ms. PRIYANKA AGRAWAL, Id. No. 45553** a candidate for the degree of **MASTER OF TECHNOLOGY** with major in **COMPUTER ENGINEERING** agrees that the thesis entitled **Node Density Aware Routing Protocol in VANETs** be submitted in the partial fulfillment of the requirement for the degree.

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ABBREVIATIONS

AODV	Ad-hoc On Demand Distance Vector Protocol
AOMDV	Ad-hoc On Demand Multipath Distance Vector Routing protocol
CBR	Constant Bit Rate
CBF	Contention-Based Forwarding
CTS	Clear To Send
CTODD	Centralized ver. of Traffic Oriented Data Dissemination Protocol
DSR	Dynamic Source Routing
DSRC	Dedicated Short Range Communication
DSDV	Destination-Sequenced Distance-Vector Routing
DYMO	Dynamic MANET On Demand Routing
FSR	Fisheye State Routing Protocol
GPS	Global Positioning System
GSR	Geographic Source Routing
GyTAR	Greedy Traffic Aware Routing
ITS	Intelligent Transportation System
IVE	In-Vehicle Equipments
LDU	Link Delay Update
LLC	Logical link control
MANET	Mobile Ad-hoc Network
MAC	Medium Access Control
MIVC	Multi hop IVC
MRP	Multi Point Relay
NDARP	Node Density Aware Routing Protocol
OBU	On Board Units
OLSR	Optimized Link State Routing Protocol
OSI	Open System Interaction
PDA	Personal Digital Assistance
PDR	Packet Delivery Ratio
PL	Packet Loss
RBVT	Road Based using Vehicular Traffic
RREQ	Route Request

RREP	Route Reply
RSU	Road Side Unit
RTS	Request To Send
RVC	Road Side Vehicle Communication
SADV	Static-Node assisted Adaptive Data Dissemination
SVAP	Simple Velocity Aware Probabilistic Route discovery
SIVC	Single hop IVC
SRVC	Sparse RVC
TCP	Transmission Control Protocol
TORA	Temporally-Ordered Routing Algorithm
TODD	Traffic oriented Data Dissemination
TWR	Total Weight of the Route
UDP	User Datagram Protocol
URVC	Ubiquitous RVC
VANET	Vehicle Ad-hoc Network
VADD	Vehicle Assisted Data delivery
V2I	Vehicle to Infrastructure
V2R	Vehicle to Road side
V2V	Vehicle to Vehicle
WAVE	Wireless Access in Vehicular Environments
WLAN	Wireless Local Area Network
ZRP	Zone Routing Protocol

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1.1 Introduction to Wireless Ad Hoc Networks

A wireless network is a kind of computer network that uses wireless data connection for connecting network nodes. Since its emergence in 1970 s, wireless network has become more and more prominent among computing industries. In the past, few considered that wired networks were safer than wireless networks. But frequent improvements in wireless networking standards and technologies have gnarled those differences.

There are two major types of mobile wireless networks. Figure 1.1 describes the taxonomy of mobile wireless networks. The first is infrastructure networks, these are the networks which have fixed gateways. The bridges for these networks are calledas base station. Fixed and mobile access networks are categorized as infrastructure wireless networks. Fixed wireless networks refer to the operation of wireless devices or system in fixed location such as homes and offices e.g. WLAN. Similarly a mobile access network is part of telecommunication network which connect its subscribers to their immediate service providers.

The second is infrastructure-less network or mostly known as Ad Hoc network. Ad hoc network does not rely on any infrastructure such as access points in infrastructure wireless network orrouters in wired networks. The nodes are free to move randomly and organize themselves arbitrarily. All the devices in the ad hoc network have the equal status and are free to connect with any other ad hoc device within the range. The decentralized nature of wireless ad hoc network makes it suitable for various types of theoretical and practical information such as medical emergencies, emergency search and rescue operation, national security etc. Ad Hoc networks consist of constantlyvaryingnumber of nodes, thus the topology of the ad hoc network is more vibrant than that of fixed networks.

The wireless Ad Hoc networks are further classified into two types. The first is the Static Ad Hoc networks and second one is the mobile ad hoc networks (MANET). Static Ad hoc networks may be defined as the networks in which the nodes are free to enter the network but once entered the geographical position is fixed. The most common example of static ad hoc networks is a network which connects the subnetworks of different buildings. On the other hand in mobile ad hoc network, nodes have the nature to move around. The topology in MANET is defined as the physical closeness between the nodes. As vehicles have the tendency to move around in vehicular network, therefore VANET belongs to the subclass of MANET.

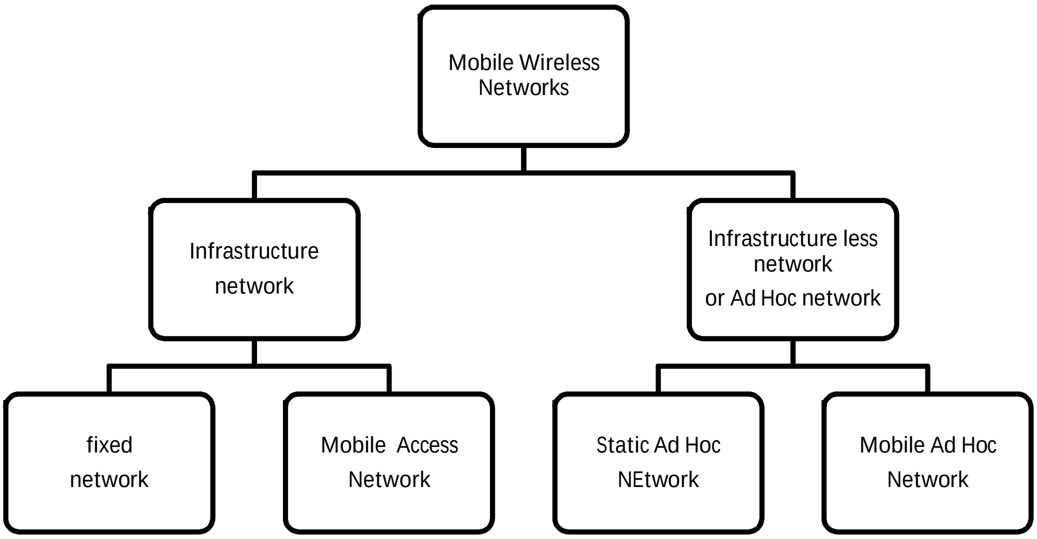

Figure 1.1: Taxonomy of Mobile Wireless Networks.

1.2 Mobile Ad Hoc Networks (MANET)

In the Mobile Ad-hoc Networks (MANETs), communication between nodes is established via other intermediate or forwarding nodes. The nodes in ad-hoc networks are dynamically formed with no need for an existing infrastructure or pre-configuration. MANETs can be deployed and operated without the need to rely on an infrastructure, which make them useful for various applications that run temporarily. Figure 1.2 shows the communication between nodes in MANETs.

MANET s technology has been a major avenue for many wireless and mobile network based applications in different fields including, but not limited to, industry, military, and public services as well as the emerging ones such as the intelligent transport systems (ITS) to enhance road safety, passenger comfort and logistics. Vehicle Ad-hoc Networks (VANETs) are one of the most common practical examples of MANETs, and they are the basic component of the ITS architecture.

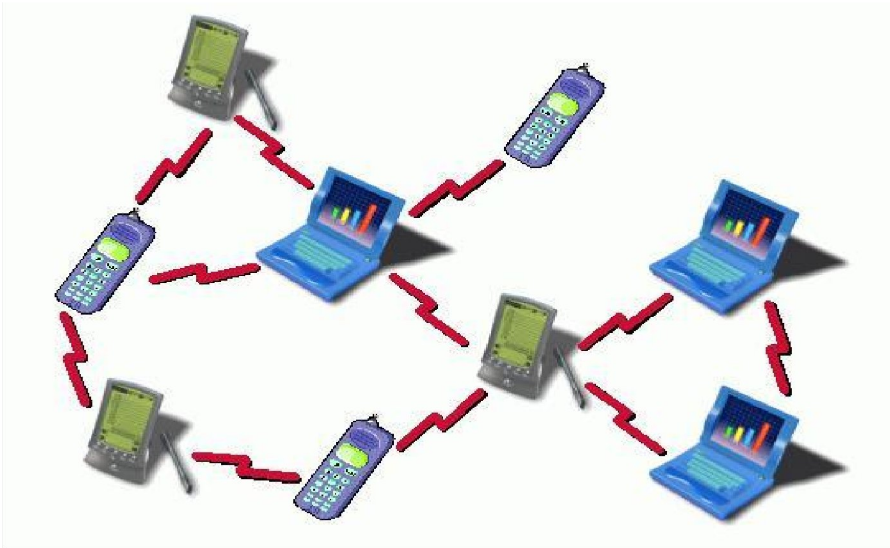

Figure 1.2: Communication between nodes in MANET

Nodes in MANETs move randomly and also they can arbitrarily connect and disconnect from the network. Vehicles in VANETs also connect arbitrarily, but vehicle movement and speed are very different, and are usually restricted by road constraints. Vehicles travelling in the same or opposite directions follow each other and move from one side to another according to road signs.

Broadcast communication has been the cornerstone of many VANETs and MANETs applications. It can be used to send information messages from either Road Side Unit (RSU) stations to vehicles, from a vehicle to other vehicles on the road, or to discover routes between vehicles. As example, when a source node needs to route data to a particular destination node, it broadcasts a Route REQust (RREQ) to all nodes in order to find the required destination.

1.2.1 Characteristics of MANETs

MANET has several exclusive characteristics, which distinguishes it from other types of wireless network. These characteristics affect most network operations such as routing and broadcasting.

1. Multi-hop communication:

In MANETs, nodes that are in the transmission range boundary of the source node are able to communicate with one hop transmission range. Nodes that are located away from source node s transmission range set up communication channels with the help of the intermediate nodes. This type of communication is named Multi-hop, and related only to MANETs.

2. Infrastructure-less network

Nodes in MANETs are directly connected together without an access point or base station assistance. Each node operates as a server or as a router which depends on the request that it has recently received. This characteristic makes MANETs very useful to applications such as disaster relief, search and rescue, and tactical operations where it is impossible to install a fixed infrastructure, or where the network is temporary or unavailable.

3. Resource-constrained and limited:

Devices equipped with nodes in MANETs have limited resources and operate with limited capacity, in terms of energy, computational power and memory.

For instance, nodes use batteries as a source of power to perform their tasks such as sending or receiving messages. However, batteries sometimes run out of power as they have a finite lifetime.

1.2.2 Applications of MANETs

Due to its high flexibility, easy installation and quick configuration, MANETs has a largeseries of applications which can be directly useful to a lot offactual scenarios (**Krishnamurthy*et al.*,2005)** (**Wong *et al.*, 2004)**. Below is a description of most common applications of MANETs.

1. General purpose applications

MANETs is useful in some military operations such as battlefields to exchange information between soldiers. MANETs is also useful in some serious applications, such as in rescue operations or disaster recovery where the communication link is frequently lost amongthe nodes, and quick restoration is of great importance. Sharing files, sending documents and showing videos in meeting rooms, class rooms and conference avenues need a temporary network such as MANETs to set up a communication between mobile devices such as Personal Digital Assistants (PDAs) or laptops.

2. Vehicular ad-hoc networks

Itis the largest commercial application which has emerged from MANETs. VANETs is the main component of the ITS and provides a communication infrastructure for all its applications.

1.3 Vehicular Ad Hoc Networks (VANETS)

Vehicles equipped with the microelectronics and wireless communication technologies they are becoming intellectual electronics equipments, and are known as wireless On Board Units (OBUs), often called as computers on wheels **(Imrich*et al.*, 2003)**. Along with the addition of advanced processers, GPS,storage space,and sensors, OBUs provide ad hoc network connectivity. Vehiclescan be in touch with each other and with fixed roadside units whiletravelling on roads. These fixed roadside infrastructures, described as roadside units (RSUs).

1.3.1 Vehicular communication in VANET

Figure 1.3 shows the taxonomy of vehicular communication in VANETs.

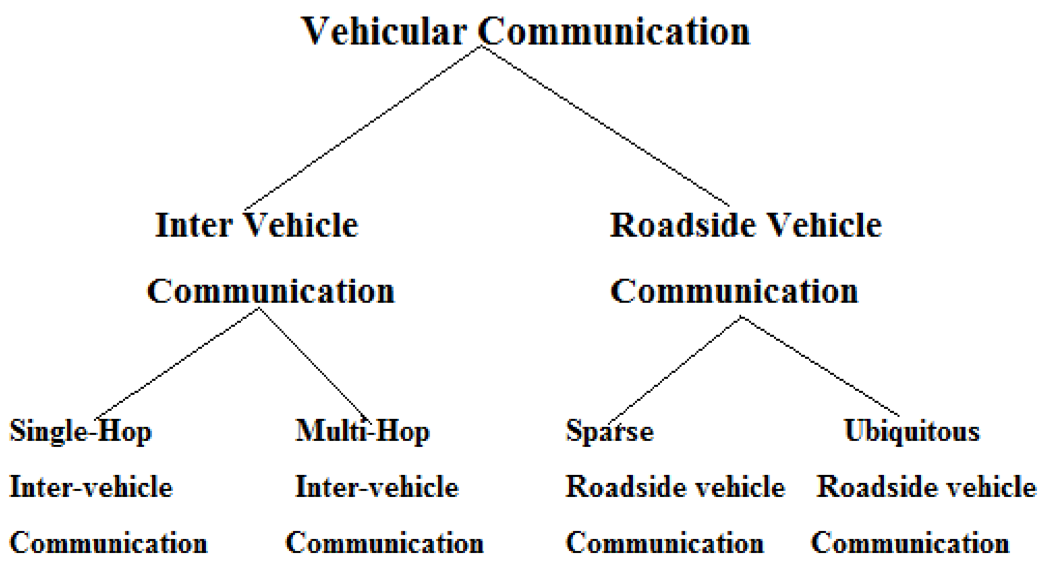

Figure 1.3: Taxonomy of Vehicular communication in VANETs

a) Inter-vehicle communication (IVC)

IVCs are totally infrastructure less and needs only OBUs, to communicate. IVCs are further divided into two categories, singe hop and multi hop. Single Hop IVCs or SIVCs are useful for application that require short range communication e.g. lane merging whereas Multi hop IVCs, MIVCs, are more difficult than SIVCs but can also sustain application that needextendedrange of communication for example, monitoring the traffic on the road.

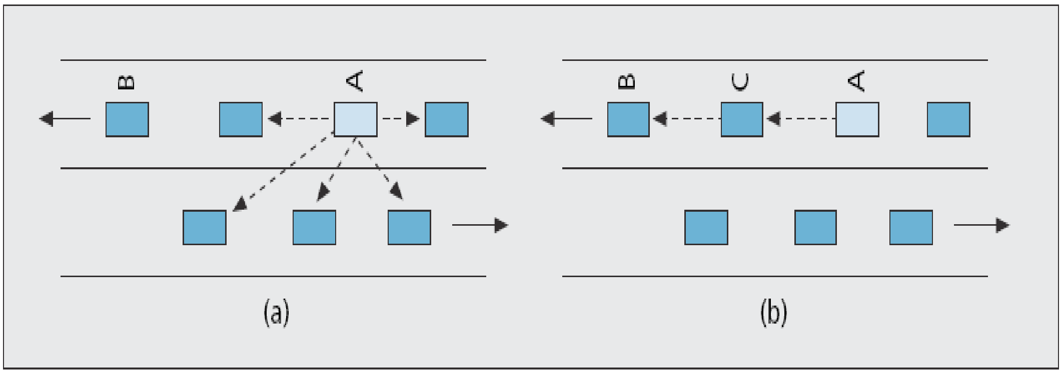

Figure 1.4(a): Single Hop IVC **Figure 1.4(b): Multi Hop IVC**

b) Roadside vehicle communication system (RVC):

In RVC Systems all communication takes place between roadside infrastructure (including RSUs), and OBUs. RVCs can be distinguished into two types, depending upon the types of infrastructure, one is Sparse RVC (SRVC) systems and the other is Ubiquitous RVC (URVC) system. SRVC systems are capable of providing communication services at hot spot e.g., parking availability at the airport. SRVC systems can be deployed gradually, thus not requiring substantial investments before any available benefits. On the other hand URVC systems are able toprovidethe roads with high speed communication link which allow applications that are engaged with any other system.

The wireless ad hoc networks are totallydisseminated and does not rely on any infrastructure. Oppositeto mobile cellular networks, they are prearrangedwith no access points that avert networks from blocking and unavailability. Therefore, the nonexistence of access pointsoffersquicker and less costly deployment. However the applications of VANET make it attractive. A VANET uses vehicles as mobile nodes in a MANET to build a network. Vehicles acting as nodes in VANET are capable to initiate queries and reply to queries from other participating node in the ad hoc network. The mobility of vehicles may cause topology change. Figure 1.5 shows how the communication takes place in between vehicles and between vehicles and roadside equipments. And figure 6 describes the network architecture of VANETs.

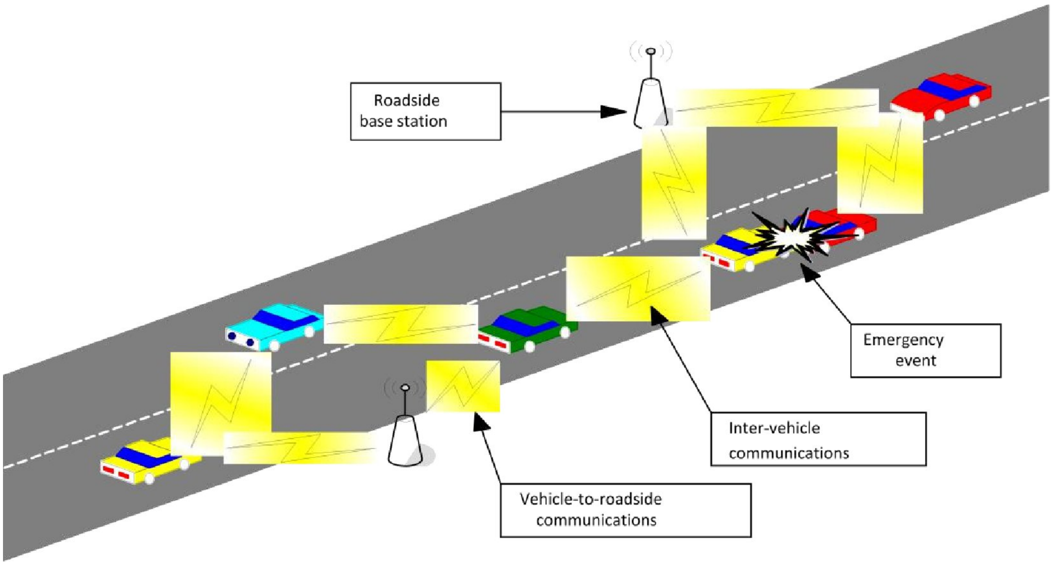

Figure 1.5: Example of IVC and RVC in VANETs (J. Rao *et al.*, 2008)

1.3.2   Characteristics of VANETs

MANETs and VANETs share a few features. Still, VANETs has distinct characteristics which makes it very different from MANETs. Figure 6 shows the architecture of vehicular ad hoc network. Some features of VANETs are listed in this section as follows.

1.   Mobility

Vehicles usually have an extremely high speed than mobile devices that depend on the movement of the human being. For this reason, the lifespan of connections between vehicles expires quickly. Hence, rebuilding a new one consumes recourses of the network. The final part of this thesis is dedicated to designing a routing scheme able of considering vehicles mobility conditions.

2.   Density

The topology of VANETs can be classified into three types, i.e., regular network,densenetwork, and sparsenetwork based on density inference. Density is usually calculated by an anticipated number of vehicles on the roads. In dense types, a message can reach out to other vehicles with lessnumeral of hops. Although, surplustransmissions and disputation between neighbor vehicles would cause messages bumpinto each other. On the other hand, disconnection problems can appear in sparse types, due to the greater spacein between the vehicles. Data packetsoften could not arrive atthe vehicles that are situatedouter to the transmission range.

3. Movement patterns

Vehicle movement is always restricted by road directions and boundaries. In other words, vehicles canmove in reverse directions, move left or rightand follow each otheras per thesigns on the road. The constancy of communication link between vehicles relies on the direction of movement of the vehicle. Vehicles moving together are able to be linked for a long period of time, whereas the connection between vehicles that are moving in different direction is brief.

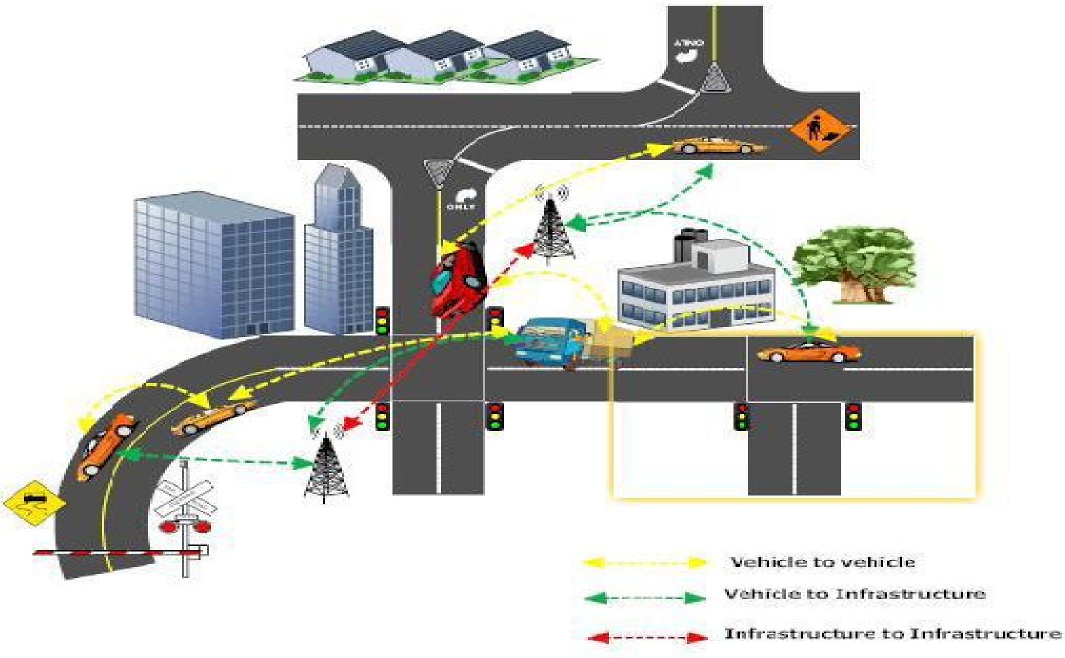

Figure 1.6: Architecture of Vehicular Ad Hoc Network (Jaiswal *et al.*,2014)

1.4 Motivation

VANET is a sub-class of mobile ad-hoc network (MANET) that allows vehicles to communicate with other vehicles and roadside infrastructure (**Saha*et al.*,2004) (Yousefi*et al.*,2006) (Jaap*et al.*,2005)**. Projects, such as Fleetnet**(Hartenstein *et al.*,2001)** or Networks on Wheels **(NOW)**, have already covered some of the aspects of vehicle to vehicle communication, however, many aspects still remain uncovered. They include efficient data dissemination protocols, routing protocols, and security to name some of the most significant ones. The research that is proposed in this document is focused on evaluating the routing protocols that can be used in a vehicular ad-hoc network in order to provide more reliable communication and lower latencies.

In recent times, emerging inter vehicular communication based on mobile networks have gainedhugeinterestfor the intelligent transportation systems (ITSs). VANETs conquer the restrictions of usual systems, like video cameras and radars, and allow more sophisticated services in ITS, by using a global positioning system (GPS). The most recent developments in communication technology have provided the facility for vehicles to exchange information with oneanother without any fixed infrastructure so that the motorists can be equipped with the useful information in a timely fashion. The ever-increasing availability and truthfulness of communication systems has reinforced the need for a competent protocol capable of managing vehicular communication. Another important advancement over the last few years is that the Global Positioning System (GPS) technology has inexpensively become available and the use of GPS tool is suitable for vehicular applications as the availability of power is not a subject of matter.

Protocols developed for MANETs have proven unsatisfactory for VANETs in a number of ways. However these protocols have been enhanced in order to make suitable for VANETs. Still their performance decreases rapidly as far as mobility of nodes is concerned. Although there are many routing protocols that have been developed for VANETs in the recent years in order to remove the inefficiency of MANET routing protocols but due to the highly dynamic nature of the network the need of a flawless protocol is still not fulfilled. Every routing protocol developed for VANETs can be enhanced for its betterment. This motivates me to work in this field. In this thesis we are interested in enhancing the communication among the vehicle by ensuring the link breakage problem in the existing AODV routing protocol. The efficient data dissemination from source to the destination is being proposed, by using the real-time traffic information of vehicles to find the next hop with low overhead and end to end delay and high packet delivery rate.

A need for a smart protocol is hence raised that can have the merits or both reactive and proactive routing protocol and that removes the disadvantages of both with the following advantages:

1. Minimize network traffic overhead by using efficient routing strategies that reduces blind flooding.
2. Locate destination nodes without relying on fixed infrastructure or the use of a location service.
3. Provide a mechanism to minimize the link breakage problem in the network to a maximum.
4. Provide the ability for the vehicles to communicate. The gathering/ sharing of information will permit the expansion of useful tools that can be used locally by the vehicles in order to help drivers take better decisions regarding driving conditions on their current travelling road. They may, for example, gather information from other vehicles down the road in order to forecast traffic environment in their way.

1.5 Objective

This research has developed a new protocol for use in Intelligent Transportation Systems based on Ad Hoc Network of Vehicles. This protocol is based on a generalized structure of communication for vehicular traffic application. The basic functionality of finding the neighbouring node has been taken from the existing AODV routing protocol. The protocol makes the useof the real time traffic information in order to dynamically select the best relay vehicles. The main objectives of this work includes

1. To determine the best relay vehicles to forwarding the packets using vehicle density factor.
2. To determine the density value for each vehicle using real-time traffic information such as vehicle speed, distance to the destination, direction, and transmission range.

3. Using this density factor, to find the best route from to destination so as to improve the Packet delivery ratio, end to end delay, and throughput.
4. And to avoid the link breakage problem.

1.6 Problem Statement

The work that is being proposed in this thesis is to determine the efficient path from the source to the destination by using the existing on demand routing protocol with the enhancement of calculating the weight of each node (which is termed as density of a node in this work) in the network. The density of each node can be calculated by using some real time vehicular information like position (x,y), speed, distance, energy, direction and transmission range. The purpose of this protocol is to avoid the link breakage problem of AODV using real time traffic information to find the best relay node to which the packet is transmitted. The main aim of the proposed protocol is to reduce the overhead and transmission delay by eliminating the link breakage problem in vehicular ad hoc network. The name given to the proposed protocol is the Node Density Aware Routing Protocol (NDARP) in VANETs.

1.7 Thesis Outline

The rest of the thesis is organized as follows:

Chapter 1: This chapter discusses about the introduction to wireless networks, MANETs and VANETs, Motivation, Problem Statement and objective of this research.

Chapter 2: This chapter presents the review of literature that proved to be really helpful in the research process.Here some of the existing protocol has been described.

Chapter 3: This chapter describes the tool and the methodology used in the research work in details.

Chapter 4: This chapter evaluatesthe proposed protocol with two existing ones and the simulation results are provided that has been compared and discussed with graphs and tables.

Chapter 5: At last the conclusion and the summary of the work have been provided with the possible future work.

This Chapter gives a review of the various researches done in the field of vehicular ad hoc network has been presented that proved extremely useful in the progress of the projected work.

2.1 Classification of Routing Protocols

An ad hoc network desires a routing protocol thatpermitsdata packets to be circulated from one vehicle to other vehicle. Usually, the routing protocol in ad hoc network is divided into three major classes: first is proactive, second one is reactive (on-demand) and hybrid protocols. Figure 2.1 depicts the taxonomy of routing protocols in VANET.

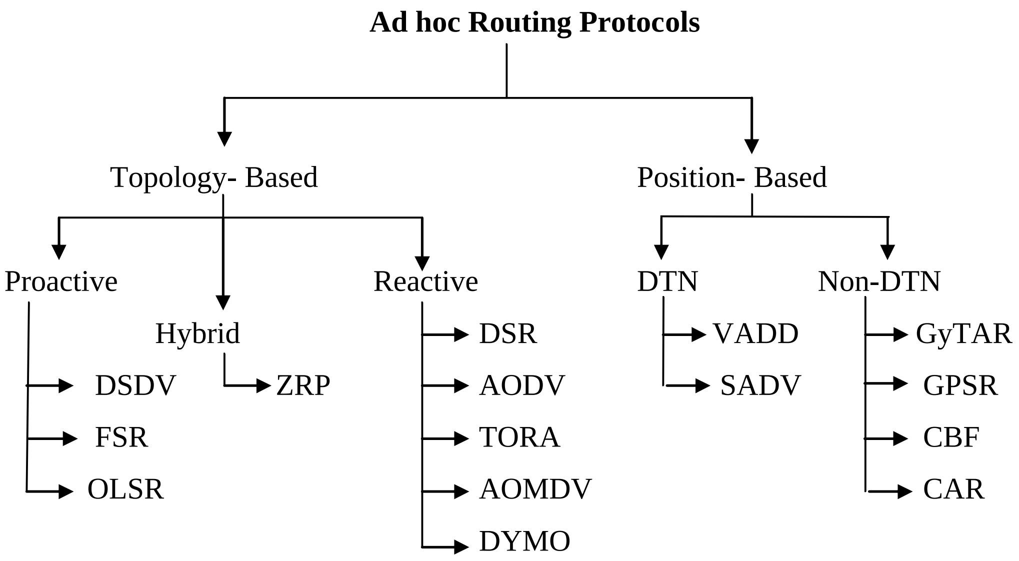

Figure 2.1: Taxonomy of routing protocols in VANETs

2.2.1 Proactive routing protocols

Proactive routing protocols are commonlytermed as table driven routing protocol. In this each node containsa routing table that consists of information to all other node in the network. Because of the mobility of the nodes, they keep on changing their location, the routing tables maintained by unlike nodes are periodic or whenever a change happens they are restructured. The proactive routing protocols differ in various areas like how the changes are propagated in the network. The examples of proactive routing protocols are discussed in details in the following paragraphs.

Perkins *et al*. (1994) proposed Destination Sequenced Distance vector routing protocol.. In DSDV, nodes transmit updates at regular intervals to its neighbour nodes with the data of its own routing table. This protocol makes the use of tables for ad hoc mobile network andrelated to Bellmen Ford algorithm.It maintains a routing table that store cost metric for routing path, the destination sequence number assigned by the destination node and tackle of the next node selectiontill the destination. In DSDV, a new sequence number is essential when the topology of the network changes before the node altered theinformation in the routing table and send updates to its neighbour.

Gerla*et al*. (2000), proposed a Fisheye State Routing Protocol, a routing scenario for Ad Hoc networks. FSR is a table driven routing protocol where the information of each vehicle is collected from the neighbouringvehicle. This protocol isbasically improvement to the Link State Routing and Global State Routing. It works as an proficient link State routing that upholds a topology map at every node and propagate the state of links update with immediate neighbor only and not on the overall network. Theinformation of the link state is broadcasted in diverse frequencies for dissimilar entries depending on their hop distance from the recent node.

Jacque *et al*. (2003) proposed Optimized Link State Routing (OLSR) proactive routing protocol for wireless ad hoc network. It is an optimization of a pure link state protocol for mobile ad hoc networks. In OLSR, three levels of optimization are achieved. First, few nodes are selected as Multipoint Relays (MPRs) to broadcast the messages during the flooding process. This is in contrast to what is done in classical flooding mechanism, where every node broadcasts the messages and generates too much overhead traffic. A set of neighbour nodes are selectedby each node in the network, known as multipoint relays (MPR) that further transmits the packets. The packets are only read and process bythe neighbour nodes that are not available in its MPR set. This methodin turn lowers the number of transmissions in a broadcast procedure.

2.2.3 Reactive routing protocol

Reactive routing protocols are also called as the on-demand routing protocols. In reactive protocols route framingoccurs only when thecommunication is required from the source node tothe destination node and no set of previously determined routes exist in the network. The source node will begin a route findingprocedurewhenthere is no route from the source to the destination but a source node desires to send a packet to a destination node, to construct a communication route. Later when the route is settled, a preservationprocess will take place for route maintenance until the link breaks. This in turn diminishes the traffic in the network and saves bandwidth. On demand routing protocols are appropriate for huge ad-hoc networks which are extremelyportable, movable and havedynamic topology.

The following paragraphs demonstratesome of the reactive routing protocols.

Johnson *et al*. (1996) proposed a Dynamic Source Routing protocol for ad hoc networks. This protocol is based on the source routing, i.e. when any noderequires a route to other node, it vigorouslyfind one based on cashed information and on the result of route discovery protocol. The two phases of this protocol is Route discovery and maintenance. Whenever the node needs to send a message it verify its route cache for an unexpired route to the destination, if it found one it starts transmission of packet else starts searching for a new route in between source to destination. Each route request packet have a source node address, a new sequence number and the destination node s ID. The DSR protocol was able to quickly adapt the changes such as host movement in wireless ad hoc networks, and requires no routing overheads over the periods when such changes do not occur.

Perkins *et al*. (1999) proposed Ad hoc On Demand Distance vector routing (AODV), for the operation of ad hoc networks. AODV is quite suitable for a dynamic self starting network as it provides loop free routes even while repairing broken links. AODV combines the destination sequence number in DSDV with on demand route discovery technique in DSR. AODV is based on hop by hop routing approach. The source node initiates a route request packet to its neighbors for searchingroute from source node to destination node and theprocedure it repeated until the path to the destination node isobtained. This process also checks the sequence number at eachin-between node to create a loop free path. If a node gets the sequence number in its routing table then the node reject the route request packet or else stores the number in its routing table. The reverse path of the route request packet is followed by the route reply packettherefore the AODV protocol makes the use of only symmetric links between neighbouring nodes.

Marina *et al*. (2001) proposed On Demand Multipath Distance Vector Routing for mobile Ad Hoc Networks. It is an extension to AODV, and the resulting protocol is referred to as AOMDV. The protocol computes multiple loop free ad link disjoint paths. Link-disjointness of multiple paths is achieved by using a particular property of flooding. It was designed for highly dynamic ad hoc networks where link failure occurs frequently. The key concept in AOMDV is computing multiple loop free paths per route discovery. Due to the availability of multiple redundant paths, the protocol switches to a different path when an earlier path fails. In AOMDV only link disjoint paths are computed so that the path fails independently of each other.

2.2.3 Hybrid routing protocols

The benefits of the proactive routing and the reactive routing are combined in hybrid routing protocol. Hybrid routing is also known as balanced-hybrid routing, incorporates link-state routinganddistance-vector routing. Distance-vectors are being used in these protocols to find best paths to destination nodes, and retransmit routing data only when the network topology varies. To lower the control overhead of proactive routing protocols and lessens the initial route discovery delay in reactive routing protocols, hybrid protocols are being used. Thus it works better in highly dynamic topology such as VANET. A Hybrid routing protocol for Ad hoc networks, ZRP, is described below.

Haas *et al*. (2002) proposed a hybrid routing protocol named, the Zone Routing Protocol (ZRP), which is designed by combining the best properties of both proactive routing protocol as well as reactive routing protocol. This protocol divides the whole network into zones. In a network, zone is a group of nodes which are in a radius. Zone radius size depend on its length α where α is the number of hops to the perimeter of the zone. In ZRP, for intra-zone communication,an IARP, stands for inner-zone reactive routing protocol and Intra-Zone routing protocol (IARP) is used. The main purpose of ZRP is to find loop free routes to the destination.

2.3 Routing Protocols based on Metric evaluation

Füßler*et al.* (2004) proposed a Contention Based Forwarding (CBF) for street scenarios in VANETs. The contention-based forwarding (CBF) algorithm is a greedy position-based forwarding algorithm that does not require the proactive transmission of beacon messages. Instead, data packets are broadcast to all direct neighbours and the neighbours themselves decide if they should forward the packet. When the neighbor receives the data packet,it determines a timeout based on the progressthat the packet will make in relation to its destination if the neighbour retransmits it. In CBF, the next hop is selected through a distributed contention process based on the actual positions of all of the current neighbours. In this contention process, CBF makes use of biased timers. The actual forwarder is selected by a distributed timer-based contention process which allows the optimal node to forward the packet and to suppress other potential forwarder.

Nzouonta, *et al.* (2009) proposed a Road Based using Vehicular Traffic (RBVT) routing for vehicular ad hoc networks.RBVT protocol makes the use of the real-time traffic information of vehicles to generate road-based paths contained of intersection at roads that have relativelylarge network connectivity among all. Geographical forwarding is used to transfer packets between intersections on the path, reducing the path s sensitivity to individual node movements. Thevehicles are required to transmit several control packets to all the other vehicles in order to determine routing paths that are connected to each other, create routes and keep route information up to date. Fordense networks, it advanced the forwarding using a distributed receiver-based election of next hops based on a multi criterion prioritization function that takes non uniform radio propagation into account. Here two protocols are designed by the author one is reactive routing protocol, RBVT-R, and the other one is proactive routing protocol, RBVT-P.

Jerbi, *et al*. (2009) proposed an Improved Greedy Traffic aware Routing (GyTAR) protocol for vehicular scenarios. In this the road segments are divided into different cells and a leader vehicle. It consists of two modules first one is the selection of junction and second one is the data transmission between two junctions. Everydata packet needs to bypass the junction in order to reach its destination node. At every junction selection method is applied and at each junction a valueis assigned by analyzing the traffic density between the current junction and the next candidate junction and the curve metric distance to the destination and finally thejunction with maximum value will be selected for data packet transmission. In other module a table is maintained in every vehicle which comprises of velocity, position and direction of everyneighbour vehicle and periodical updating of table is needed. Thus, upon receiving the data packet, the transmittingnode evaluates the new forecasted position of each neighbour through the table and then the next hop is selected which pretends to be nearer to the destination junction that may cause packets to be at most favorable node.

Ding, *et al*. (2010) proposed a Static Node Assisted Adaptive Routing Protocol (SADV) in VANETs. In SADV fixed station called static nodes are distributed by scenario, located at intersections points. When there exist no vehicles to distribute the data packets along the most favorable path then the packet is transmitted to the static node. This node is capable to feed the packet and retransmit it when the best possible route becomes available. Adding to this, these fixed stations are responsible for calculating the average delay of forwarding data between each. SADV also dynamically adapts to varying traffic density by allowing each node to measure the amount of time for message delivery. SADV assumes that each vehicle has accessed to external static street map and knows its position through GPS. SADV s operation takes place in two modes: In Road Mode and Intersection Mode .

Ding, *et al*. (2011) proposed an Improved AODV Routing protocol for VANETs. In this improved AODV routing protocol in VANET, two steps optimization is done in route discovery and route selection process to decrease overhead and improve the route stability. For development the information of speed and direction of vehicle are included. In the first phase, the nodes with the stable links are chosen to forward route request packet. Along with that the control overhead is lowered due to the fact that some of the nodes are idle and are not used to forward route request. In the other phase, the route with the highest stability will be used for dataforwarding when the source vehicle obtains variouspaths to destination vehicle. By the two phase optimization, the route selected for transmitting packets is more stable and overhead is decreased.

Tu, Hongyu*et al*. (2014) proposed an improved routing protocol using traditional GPSR protocol that is named as GPSR-MV. It is a routing protocol based on moment of vehicles for VANET.Fastmoving and forwarding efficiency of vehicles has been used in GPSR-MV. Accordingto the GPS installed in vehicles the position information such as, the velocity of the neighbouring nodes will be evaluated in GPSR-MV, and the information of position will be updated accordingly. Ittakes that source node is always horizontal to the destination node and divide the movement of vehicles into two directions one is vertical and the other is horizontal. It then selects the next hop which is furthest to the source node. If the node a s position is (x_1, y_1) at time step t_1, while its position is (x_2, y_2) at time step t_2. t_1 and t_2 are the time when the GPS updates information. GPSR-MV takes the node s position in consideration, to predict the nodes position before data transmission.

The values that can be used to calculate the speed of node a, are as follows.

$$?_? = \frac{?\sqrt{(?_? - ?_?)^? + (?_? - ?_?)^?}}{?_? - ?_?}$$

And the movement direction is:

$$?_? = \tan^{??} \frac{?_? - ?_?}{?_? - ?_?}$$

Soares*et al*. (2014) proposed An Adaptive Data Dissemination protocol With Dynamic Next Hop Selection for Vehicular Networks. It aims to build up a protocol that is simply adjustable to most changing topology scenarios of vehicles, hence designed TODD, an adaptive Traffic-Oriented Data Dissemination protocol. TODD uses real time traffic knowledge to vigorously select the top next vehicles. The process is initiated by evaluating a formula calculated for each participating vehicle, which give inclination to particular vehicle components such as speed, distance to the destination, and traffic density based on the ongoing traffic knowledge. The main contribution of TODD is the Dynamic Next Hop selection technique, which takes in to account the advanced behavior of different traffic scenarios. TODD does not evaluate dissemination routes before sending data packets. Inits place, roads are chosen at every intersection through which packets should be sent, in accordancewith the traffic scenario at every road. Toeliminate broadcast storms problem, TODD also allows a vehicle to vehicle communication along the vehicles on the roads, in order to choose next node for data packetsexchange of RTS and CTS packets also takes place. The carry-and-forward mechanism is needed to tackle the fragmentation problems. Besides that, this paper also proposed a centralized version of TODD (CTODD).CTODD dealswith the deficiency of real-time vehicular information that is stored in the vehicles. For dense and sparse scenarios a study was performed to evaluate the best coefficients.

Equation defines the metric calculation used in this work.

$$?(?, ?, ?) = ? * (1 \quad ?/?_{max}) + ?(?/?_{max}) + ?(?/?_{max})$$

Shen*et al.* (2014) proposed a new routing protocol AODV with Predicting Node Trend (AODV-PNT) that is suitable VANET communication. There are two main enhancement in AODV-PNT, the first one is it evaluates the routing metric improvements of the vehicles and calculate the total weight of the route (TWR). The movement information of the Vehicle including speed, acceleration, direction and link quality is being used as routing metric and on this basis TWR is calculated. The other one is that it predicts node s future TWR and calculate fixed threshold W in an attempt to choose suitable relay node. In short, this paper improves the link quality in between the vehicles. Finally the simulation is done using NS-2, the simulation results shows that AODV-PNT achieves better results than AODV in terms of PDR, average end to end delay and routing overhead.

The TWR to the source node to the next-hop node could be expressed in the following mathematical equation:

$$?? \; ? = ?_? * |?_? - ?_?| + ?_? * |?_? - ?_?| + ?_? * ?$$

This chapter elaborates various techniques and tools that have been employed in the development of the proposed routing protocol.

3.1 Simulation Tool Used

The tools that are being used in the implementation of this thesis including simulation software and hardware have been described below.

3.1.1 NS - version 2:

Network Simulator (Version 2), commonly recognized as NS-2, is basically an event driven simulator that proved to be useful in analyzing the ever changingpersonality of communication networks. NS2 can be used in the simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP). NS-2 is based on two languages: an object oriented simulator, written in C++ and provides a simulation interface through OTcl interpreter, an object-oriented dialect of Tcl, used to execute user s command script. NS-2 has a rich library of protocols and network objects. There exist two classes of hierarchies, one is the complied C++ hierarchy and the other is interpreted OTcl, with one to one correspondence between them. Figure 3.1 shows the architecture of NS-2.

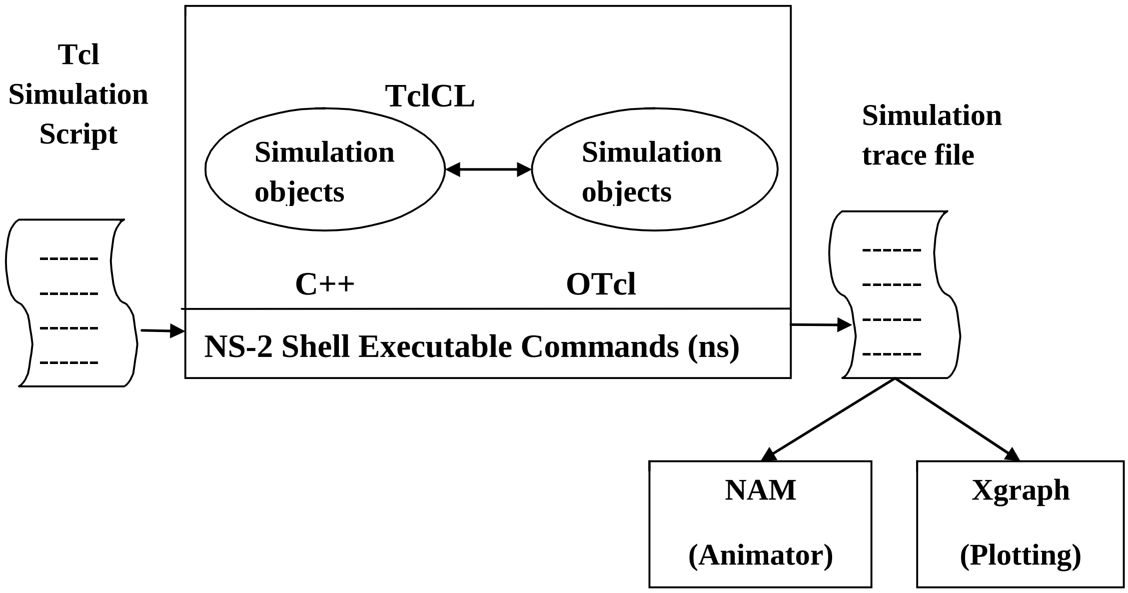

Figure 3.1: Architecture Of NS-2

Redhat linux: Redhatlinux operating system has been used as a platform for NS-2 simulation of the proposed work.

Windows: Windows 7 has been used for documentation and presentation of this work.

3.2 Proposed Work

The work that is being proposed in this thesis is to determine the efficient path from the source to the destination by using the existing on demand routing protocol with the advancement of calculating the density of each node in the network. The density of each node can be calculated by using some real time vehicular information like position (x,y), speed, distance, and transmission power. The purpose of this protocol is to avoid the link breakage problem of AODV using real time traffic information to find the best relay node to which the packet is transmitted. The main aim of the proposed protocol is to reduce the overhead and transmission delay by eliminating the link breakage problem in vehicular ad hoc network.

3.3 Methodology

One of the major problems in routing in VANETs is the link breakage problem that usually increases network overhead and end to end delay. There are many routing protocols as we discussed above in the literature review each of which has its own advantages and disadvantages. The one common drawback of all the work is the link breakage problem; this problem arises when the vehicle carrying the packet changes its route due to which the packet gets lost. For this, a solution that is being proposed in this work is to calculate the node density of each vehicle by using the real time traffic information. The density is being calculated by various vehicular parameters like speed of the vehicle, distance from the destination, transmission range, energy and position of each one of them. The main idea behind this protocol is the next hop selection that can be used to send the packet based on the density calculated. Firstly, the source node, that want to send the packet, sends the beacon message to all the nodes if any node requiresthe packet it sends the reply message to the source along with its position and identity numberin the absence of which the node forwards the packet to the neighbours.This process continues till any node sends a reply messageto the source that it wants the packet. A routing table is maintained at each node containing the node s real time traffic information and its density value. The routing table at each node is responsible to find the node s neighbour nodes by analyzing whether the distance of the node from the current node is less than or greater than its transmission range according to which it stores the neighbouring nodes in the routing table. After finding the neighbour node this protocol dynamically selects the best nexthop by using density calculation technique.

3.3.1 Dynamic next hop selection and density calculation

In case of vehicular ad hoc networks, in order to keep the table up to date the vehicle need to broadcast the control messages which increases overhead as well as the information stored in the table quickly changes due to the dynamic nature of vehicles.

3.3.1.1 Next hop selection

In order to reduce the overhead, RTS (Request To Send) and CTS (Clear To Send) method is used that has been used by some other protocol to find the best next hop. For selecting next hop for the packet to be sent the vehicle starts searching for neighbours by broadcasting RTS message. When a neighbour receives RTS packet, it chooses whether to reply or not based on its real time information such as its direction of movement approaching the destination or if it is closer to the destination than the RTS sender. If it chooses to reply it computes the waiting time to send the CTS packet, this method reduces the overhead. In this proposed NDARP protocol the RTS packet is sent only to that neighbour node whose density value is highest among the selected values of the nodes which are higher than the threshold value (calculated dynamically for each next hop selection). The nodes having lower density value than the threshold density are discarded from the list to which RTS packet is being sent. This process not only reduces the overall routing overhead but also lowers the end to end delay.

The threshold density value of the path is being calculated as half of the density having the highest value or subtracting the lowest density value path from the highest one, whichever is higher. This concept is useful in reducing overhead and delay by sending the RTS packet only to the node which have highest density other than that in case link breakage happen the threshold value is used to find the next optimal to send the packet. Therefore before the link breaks, this protocol is able to predict the next best path to send the packet without losing it.

3.3.1.2 Density calculation

In (**Rodrigo B. Soares, 2014)**, to use the real time traffic information for better routing some empirical experiments has been performed for both dense and sparse scenarios which shows that the average delay is low when the speed and distance coefficient are greater for dense scenario, therefore the vehicle with higher speed and closer to the destination will be more reliable considering this we conclude that speed and distance would be directly proportional to the density metric evaluation, but in this work to avoid the link failure and packet loss we consider that the next hop should be that much close to the source node (within its transmission range) so that it doesn t move out of the coverage area at the time of packet forwarding therefore we subtracted the distance of the next hop from the source node s transmission range in order to make the link stronger and avoid link breakage higher the value of the (TR D) stronger the link between the source node and the next hop. The next parameter we have considered in the proposed formula is the node s current energy. The node s current energy directly affects the density of a node. If the energy of a node is higher that show the node is either idle or sleep i.e. it is not engaged in other activity, hence such kind of node will be more reliable than the node which is already engaged in receiving and transmitting the packets. This is because if we chose a node which is engaged increases the load at that node which in turns may loss the packet so the node which is idle is chosen to transmit the packet further to the destination. The node s energy is calculated by equation (ii).For the sake of simplicity we can say that this parameter is used to identify whether the vehicle is active or inactive at the given point of time in the given scenario.

The GPS information of the vehicle is used to calculate the position and the direction of movement of the neighbouring nodes **(Tu*et al.,* 2014)** and the location information is updated periodically. In this work we have assumed that the direction of source node is always horizontal with respect to the destination node and the direction of movement of all neighbour nodes can be divided into direction one is vertical and other is horizontal assuming source node as the origin. The moment direction (θ) of node is calculated using equation (v), through this equation the source node calculates the direction of motion of its neighbour nodes. This parameter is then placed in the density calculation formula according to explanation given in GSPR-MV **(Tu*et***

***al.*,2014)**, it says smaller the angle the greater the horizontal speed towards the destination node. Therefore as the angle between the source node and the neighbour node decreases the density metric of that node increases which implies that the direction is inversely proportional to the density of that node hence it has been taken as the denomination in the density calculation equation (i).

The mathematical formula for calculating the density of each node in order to find the best relay node is given by,

$$\text{DENSITY} = \frac{?\text{ENERGY} * ?(\text{TRANSMISSIONRANGE} - \text{DISTANCE}) * \text{SPEED}??}{\text{DIRECTION}}$$

It can be written as,

$$? ? ? ??? ? = \frac{(?_? ((?? - ?) * ?)}{?}$$

---------- (i)

Here,

Energy can be defined as

Energy (E_N)= (InitialEnergy   power*time) ---------- (ii)

Here, Power = (Txpower + Rxpower) // when the node is active

Or ---------- (iii)

Power = (Idlepower + Sleeppower) // when the node is inactive

Where the formula parameters are assumed as,

Initial Energy = 100 J,

TxPower (Transmission power) = 0.33 W,

RxPower (Receiving power) = 0.1 W,

Idle Power = 0.05 W,

Sleep Power = 0.03 W

Transmission Range Defined is 250 m.

Distance can be defined as Euclidean distance between two points in the plane with coordinates (x, y) & (a, b) is given by

$$D ?(x, y), (a, b) ? = ? \overline{(x - a)2 + (y - b)2}$$ ---------- (iv)

Speed = 20 m/s. (assumed same for each vehicle in simulation)

Direction (?) = Finding Angle between neighbour nodes till destination. This can be defined as

$$\theta = \tan^{-1} \frac{b - y}{a - x} \qquad \text{---------- (v)}$$

Through the mathematical formation given above we can elaborate how the concept of calculation of density used. Equation (i) show the formula for calculating the density using the real time traffic information of each vehicle in the vehicular scenario. The real time traffic information contains parameters like transmission range, speed, energy of a vehicle, distance to the destination and its direction. Transmission range and speed is assumed to be 250m and 20m/s respectively. Energy of each vehicle can be defined by the formula given by equation (ii), which contains initial energy and the power consumed by the vehicle. The power consumed by the vehicle is given by equation (iii), the power consumed by the vehicle can be in the form of transmission power, receiving power, idle power and sleep power of a vehicle. Equation (iv) defines the distance between the current node and the neighbour node for each node and equation (iv) calculates the direction by calculating the angle between the required nodes.

The further description of the problem can be given by the following block diagram. Figure 3.3 illustrates the same.

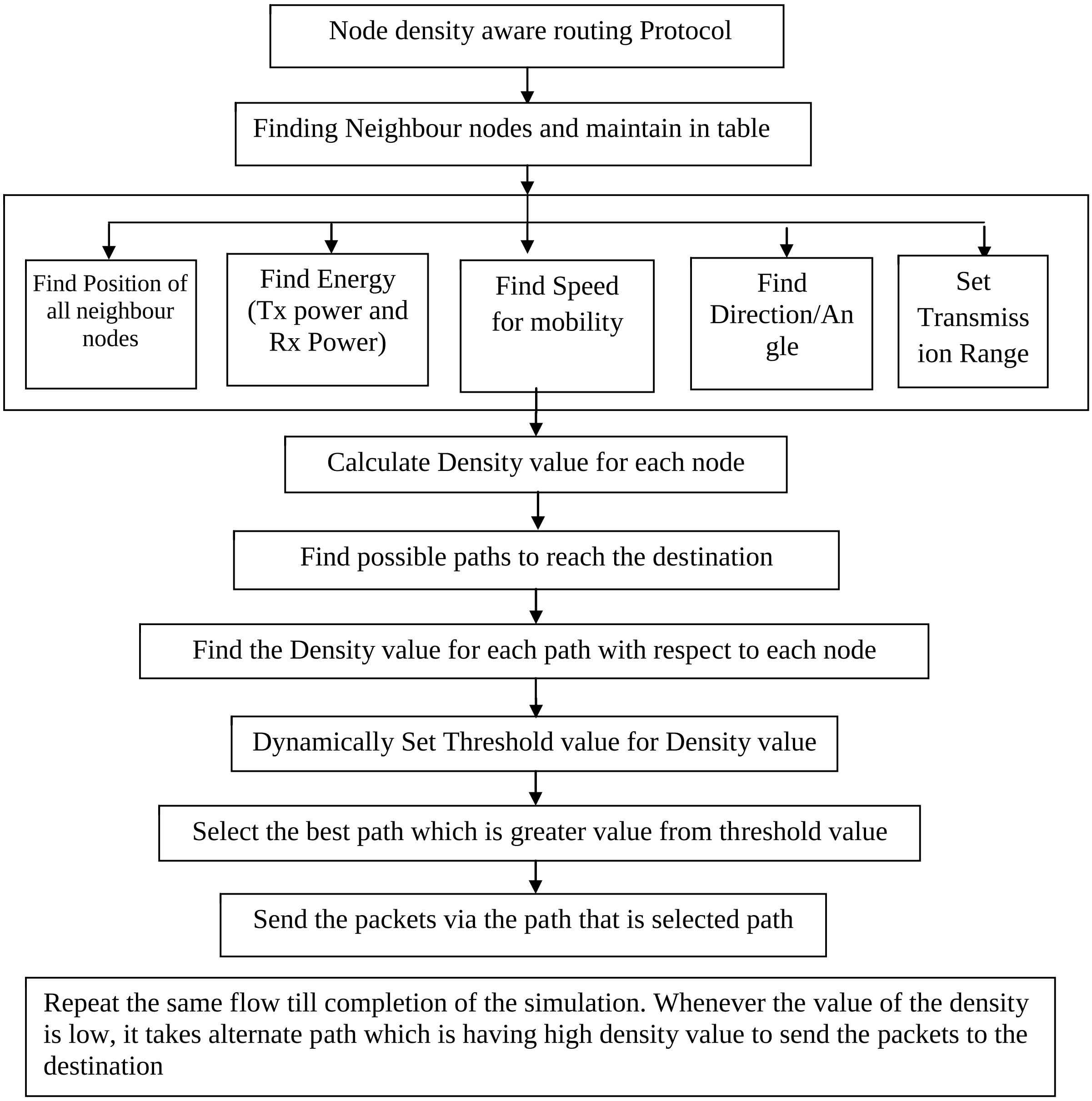

Figure 3.3: Block diagram of the problem stated

CHAPTER 4 RESULTS AND DISCUSSION

This chapter illustrates the experiments and outcomes of simulations operated on NS2. The experimental observations are inscribed, evaluated and discussed systematically in the upcoming section on the basis of various performance matrices.

To analyze the performance of AODV, CTODD, and the proposed NDARP protocol, the following performance metrics have been used during the simulation.

4.1 Performance Metrics

The comparativeanalysis of AODV, CTODD and NDARP protocol in VANETs has been performed based on the End To End delay, Throughputand Packet Delivery ratio. These are described below in the subsequent section.

4.1.1 Packet delivery ratio

Packet delivery ratio is the ratio of the data packets received at the destination node to that sent by the source in percentage.

It can be mathematically represented as

$$PDR = (DATA_{REC}/DATA_{SEN}) \times 100$$

Where,

$DATA_{REC}$ is the no. of packet received.

$DATA_{SEN}$ is the no. of packets sent.

4.1.2 Throughput

Throughput can be defined as the amount of data packet successfully received per unit time. It is the ratio of the packet received to the time over which the transmission has taken place. This is measured as bits/sec. The higher is the throughput the better is the performance.

Mathematically it is represented as

$$\text{Throughput} = \frac{\text{? ?? ????? ????????????????????}}{\text{? ?? ?????????? ?????}}$$

4.1.3 End to end delay

End to EndDelay can be defined as the time taken by the data packet to arrive at the destination node from the source node. It is mathematically calculated by reducing the time at which the packet is sent by the source node to that of it reaches to the destination node.

Mathematically it can be defined as

$$\text{End to end delay} = TIME_{REC} - TIME_{SEN}$$

Where,

$TIME_{REC}$: time at which packet reaches the destination

$TIME_{SEN}$: time at which packet sent by the source

4.1.4 Routing overhead

Routing overhead is important mechanism as it describes how many packets are required for route discovery and route maintenance. Overhead explains the number of packets generated by all nodes in the network for establishing route between sources and destinations. Routing Overhead is measures of the scalability of a protocol, the degree to which it will function in low bandwidth or congested environments. This can be stated as

Routing overhead = total number of packets (control and data packets both)

4.1.5 Packet loss

Packet Loss is defined as the ratio of the number of data packets that do not reached the destination node to that of originated by the source node.

Mathematically it can be shown as

$$\text{Packet Loss} = (DATA_{SEN}-DATA_{REC})/ DATA_{SEN}$$

4.1.6 Link failure

The stability of the route can be defined if the link failure occurs rarely in any connection. This parameter is used to measure the route stability.The route is said to be stable,if there is lower number of broken links per routes. Or else, more control packets are needed for greater number of link failures.

4.2 Simulation Parameters

The parameters used in the simulation of the proposed NDARP protocol are given below in the Table 4.1.

Table 4.1: Simulation Parameters

Parameters	Value
Transmission Range	250m
Number Of Nodes	10-100 (in steps of 10)
Simulation area	1400m × 900m
Channel Type	Wireless
Interface Queue Type	DropTail/Priority Queue
Network Interface Type	Physical Wireless
Transmission mode	UDP
Propagation Model	Two Ray Ground
Speed Of Node	20m/s
Simulation Time	10 sec
Packet Size	512 bytes
Traffic Type	CBR
Initial energy of vehicle	100 J
Routing Protocols	AODV, CTODD, NDARP

4.3 Simulation Results and Discussion

4.3.1 Packet delivery ratio

Table 4.2 : Packet delivery ratio

No. Of nodes	AODV	CTODD	NDARP
10	68.203	71.874	79.434
20	69.203	72.874	80.434
30	70.203	73.874	81.434
40	71.203	74.874	82.434
50	72.203	75.874	83.434
60	73.203	76.874	84.434
70	74.203	77.874	85.434
80	75.203	78.874	86.434
90	76.203	79.874	87.434
100	77.203	80.874	88.434

Figure 4.1 shows the comparison graph of packet delivery ratio over node mobility (No. of nodes) between AODV, CTODD and NDARP. From the Table 4.2 and Figure 4.1 it is shown that the packet delivery ratio of NDARP is much better than CTODD and AODV. This is because in NDARP we are finding route with the highest density that eliminates the possibility of link breakage which ensures packet delivery from source to destination. On the other hand the PDR in case of CTODD is better than AODV due to the metric calculation used in CTODD.

Figure 4.1: No. of nodesVs packet delivery ratio (%)

4.3.2 End to end delay

Table 4.3 : End to end delay

No. Of nodes	AODV	CTODD	NDARP
10	8.29	8	1.99
20	8.12	8	6.36
30	8.18	8	7.28
40	8.09	8	4.87
50	8,18	8	7.34
60	8.05	8	2.76
70	8.19	8	7.76
80	8.10	8	5.55
90	8.18	8	7.43
100	8.13	8	6.82

Figure 4.2 shows the comparison of End to End Delay (in ms) over node mobility between AODV, CTODD, NDARP. From the Table 4.3 and Figure 4.2 it is shown that the end to end delay of NDARP is much better than CTODD and AODV. It also shows that the delay of CTODD and AODV remains approximately same minor differences because of the RTS and CTS packet exchange in CTODD which though reduces overhead but increases delay.

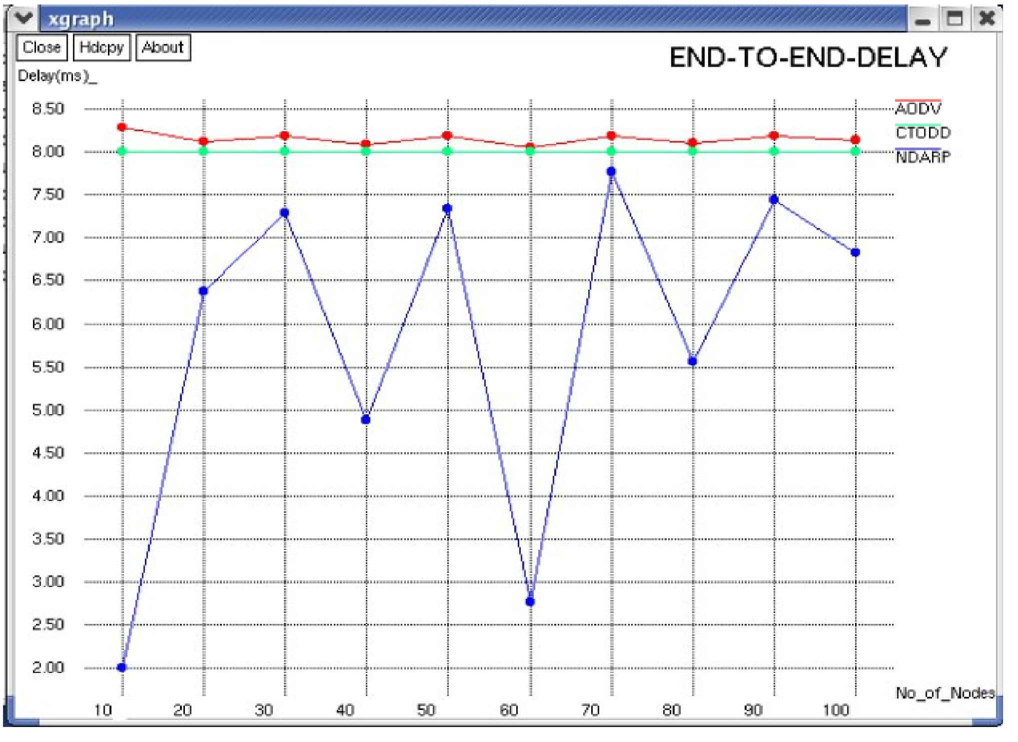

Figure 4.2: No. of nodesVs end to end delay (in ms)

4.3.3 Throughput

Table 4.4 : Throughput

No. Of nodes	AODV	CTODD	NDARP
10	146.96	164.96	250.48
20	145.75	163.75	249.88
30	146.25	164.25	250.12
40	146.02	164.02	250.01
50	145.79	163.79	249.90
60	147.65	165.65	250.83
70	146.78	164.78	250.39
80	146.46	164.46	250.23
90	147.81	165.81	250.90
100	145.06	163.06	250.53

Figure 4.3 shows the comparison of the throughput (measured in bps) over time between AODV, CTODD and proposed NDARP. From the above Table 4.4 and Figure 4.3 it can be clearly shown that the proposed NDARP protocol outperforms the existing AODV and CTODD in terms of throughput. This is because of the methodology used in the proposed NDARP protocol to find the best next hop and hence find the best route from source to destination which ensures the elimination of link breakage problem and hence increases throughput.

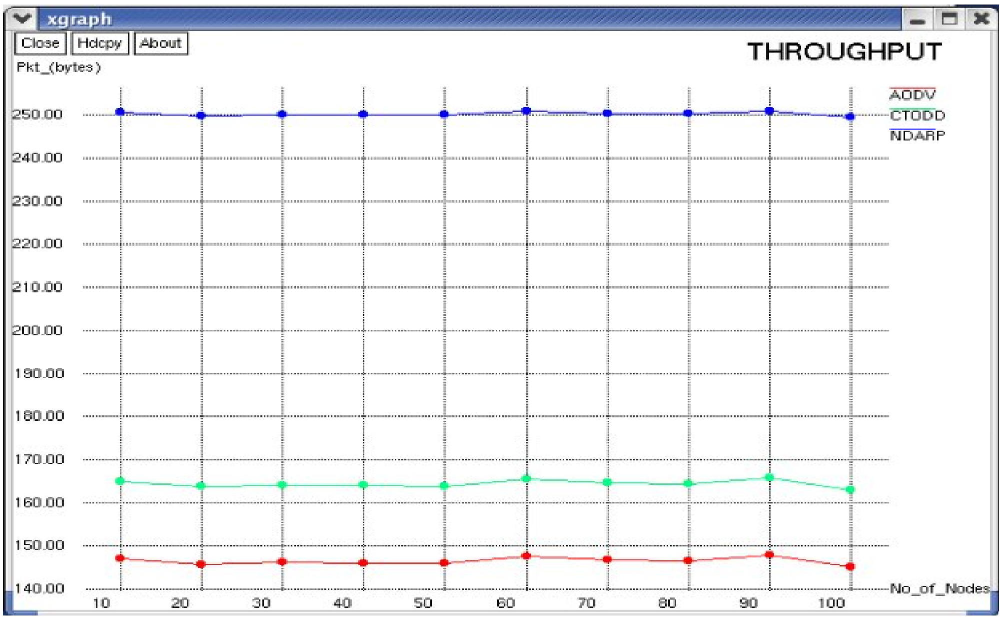

Figure 4.3 No. of NodesVs Throughput (bps)

4.3.4 Routing overhead

Table 4.5: Routing overhead

No. Of nodes	AODV	CTODD	NDARP
10	19.4	17.5	15.3
20	19.5	18.4	15.4
30	19.5	18.7	15.5
40	19.5	18.7	16.5
50	19.5	18.8	16.5
60	20.3	18.8	16.5
70	20.5	18.9	16.5
80	20.5	18.9	16.5
90	20.5	18.9	16.6
100	20.5	19	16.6

Figure 4.4 shows the comparison of routing overhead over node mobility between the proposed NDARP and the existing AODV and CTODD. From the table 4.5 and Figure 4.4 it can be easily shown that the proposed routing protocol NDARP outperforms AODV and CTODD. This is because, the number of control packets sent to establish the route is much less in NDARP than that of CTODD as well as AODV which reduces the overall routing overhead. This is also due to the reduction of broken links problem which is higher in CTODD and AODV.

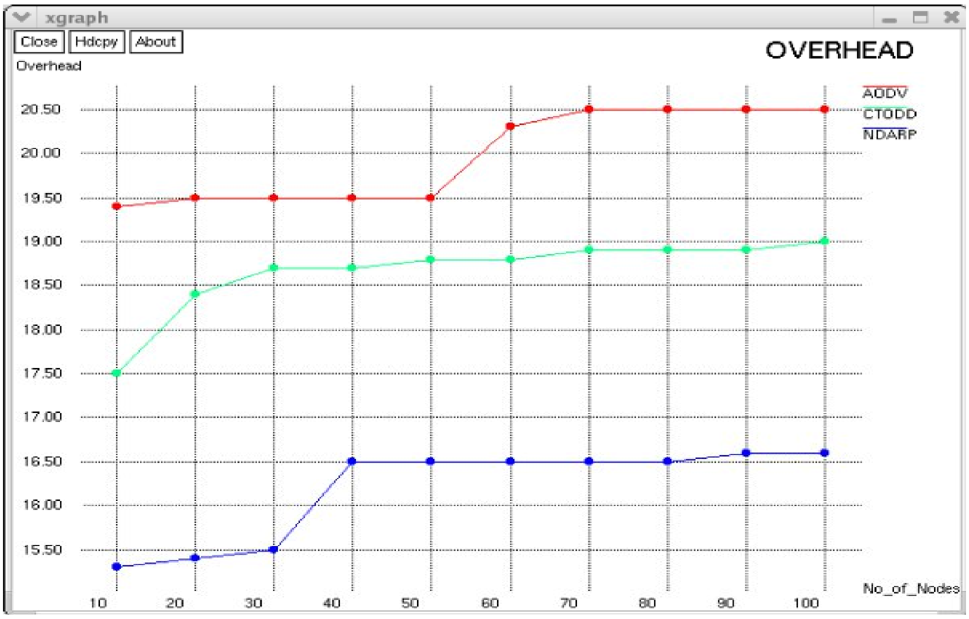

Figure 4.4: No. of nodesVs overhead

4.3.4 Packet loss

Table 4.6: Packet loss

No. Of nodes	AODV	CTODD	NDARP
10	31	29	20
20	30	28	19
30	29	27	18
40	28	26	17
50	27	25	16
60	26	24	15
70	25	23	14
80	24	22	13
90	23	21	12

100	22	20	11

Figure 4.5 shows the comparison of Packet loss over node mobility between the existing routing protocol AODV and CTODD and proposed NDARP. From the table 4.6 and Figure 4.5 this can be analyzed that NDARP shows much improved results than AODV and CTODD, this is because of the density calculation technique used in NDARP to find the next best relay node due to which at any point before the route fails and packet gets lost it finds another reliable path to send the packet to the destination which reduces the packet loss. No such technique is used in AODV and the technique we use is better than that used in CTODD.

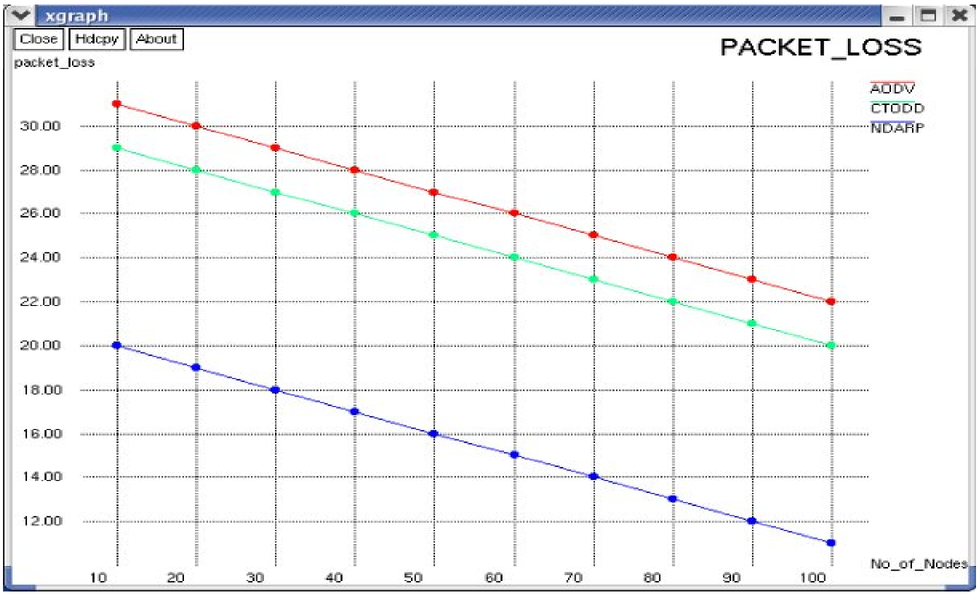

Figure 4.5: No. of nodesVs packet loss

4.3.5 Link failure

Table 4.7: Link Faliure

No. Of nodes	AODV	CTODD	NDARP
10	32	25	17
20	31	24	15
30	28	22	14
40	26	21	12
50	23	20	11
60	21	18	10
70	19	15	8
80	16	13	7
90	13	11	6

100	11	9	5

Figure 4.6 shows the comparison of the link failure metric with the node mobility between the proposed routing protocol NDARP and the existing protocols CTODD and AODV. From the Table 4.7 and Figure 4.6 it is shown that the link failure problem in the proposed NDARP is much less than CTODD and AODV. This is because of the density metric calculation for each node at every single point to find the best relay node and to avoid the link failure.

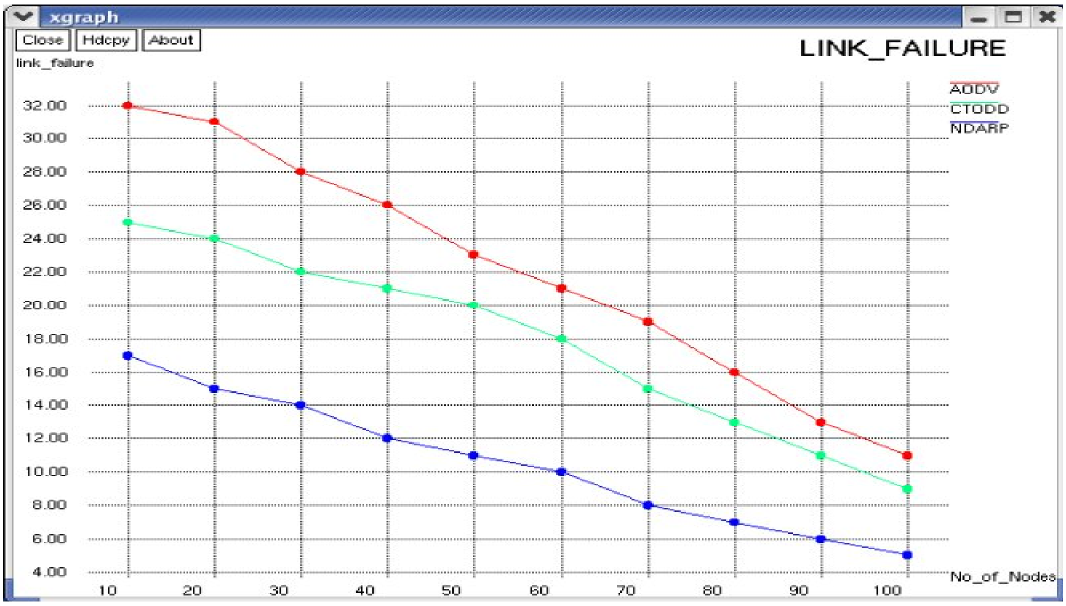

Figure 4.6: No. of nodesVs link failure

Vehicular Ad Hoc Network (VANET) is a subclass of MANETs, in which vehicles act as nodes and each vehicle is equipped with various transmission capabilities through which these vehicles can connect with each other. It uses an advance wireless technology in the field of wireless communication to provide an intelligent transportation system. There are two types of communications that takes place in vehicular ad hoc network one of them is the inter-vehicle communication system that uses only On Board Units (OBU) to communicate and the other is Roadside vehicle communication system in which communication takes place between roadside infrastructure and OBUs. This study focuses on improving the efficiency of routing protocol in VANETs. As we know that VANET have highly dynamic topology due to which the performance of routing protocols plays a very important role. One of the major problems in VANETs routing protocols is link failure because of the broken links problem the routing overhead and end to end delay increases which eventually decreases the throughput and causes packet loss.

5.1 Conclusion

The work that is being proposed in this thesis deals with the above problems and diminishes the demerits of link failure. The proposed routing protocol is named as Node Density Aware Routing Protocol (NDARP) as deals with the calculation of density value of each vehicle in order to find out the best relay node and hence find the most reliable path from source to destination. In NDARP density of each protocol is calculated by using the real time traffic information of each vehicle, and the path with the highest density is used to send the packet to the destination.

Furthermore, to show the reliability of the proposed work we simulate and compare NDARP with the existing AODV and CTODD routing protocols that are designed for VANET scenario. In the comparison we find that packet delivery ratio, throughput, end to end delay, overhead, packet loss and link failure shows much better results for NDARP than CTODD and AODV. This is because of the use of the density calculation technique that we used in NDARP for each vehicle node. This technique allows us to find the best relay node to transmit the packet and improves multi hop, inter- vehicle communication.

5.2 Future Scope

As a future work NDARP can be simulated for different speed of all vehicle to make it more practical in traffic scenario, currently I have simulated it by assuming that each vehicle is moving with a constant speed of 20m/s in highway scenario. It can also be implemented differently for sparse and dense traffic scenario.

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ABSTRACT

Name	:	Priyanka Agrawal	**Id. No.**	:	45553
Sem. & year of admission	:	I, 2013-14	**Degree**	:	Master of Technology
Major	:	Computer Engineering	**Department**	:	Computer Engineering
Thesis Title	:	**Node Density Aware Routing Protocol in VANETs**			
Advisor	:	Pankaj Kumar Mishra			

Vehicular Ad Hoc Network (VANET) is a subclass of MANET, in which vehicles act as nodes and each vehicle is equipped with various wireless transmission capabilities like GPS and Bluetooth through which these vehicles can connect with each other. It uses an advance wireless technology in the field of wireless communication to make it possible to communicate with each other and to provide an intelligent transportation system. VANET is one of the most emerging research fields for researchers due to its highly dynamic topology and link disorder problem. There are various routing protocols developed for routing in VANETs each of which has its own merits and demerits. Out of all the disadvantages, the most common problem is the link breakage problem which occurs due to the high mobility of the nodes. This study is specifically concerned with the link distortion problem and proposes a new method to find the route from source to destination vehicle by ensuring to eliminate the link failure.

In this work, a new methodology is developed to find an efficient path from the source vehicle to the destination vehicle by using the real time traffic information of each vehicle to find the density (or weight) of each node. This methodology is termed as Node Density Aware Routing Protocol (NDARP) in VANETs. The main features of this protocol is that it efficiently calculates the density metric for each node by using some real time vehicular parameters such as vehicle s energy, speed, transmission range, direction and distance between nodes, which is further used to find the best relay node to transmit the data packet and to choose the best path from source to destination. Furthermore, this protocol outperforms the existing AODV routing protocol and CTODD routing protocol in VANETs.

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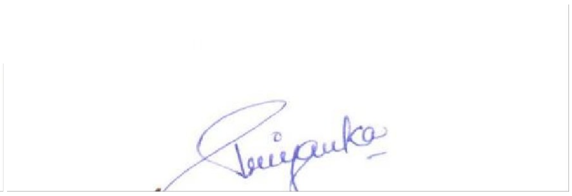
?मुख विषय : कं?यूटर अभियांि?की ?**वभाग**: कं?यूटर अभियांि?की

शोध का शीषक : नोड डसिटी अवेयर ?टिंग ?ोटोकॉल वॅनेट
सलाहकार : पंकज कुमार मि?ा

विहि?युलर आड़हॉक नेटवक(वॅनेट) मॅनेट की एक उपवग?है जिसम?वाहन नो?स के ?प म?काय?करते ह?और ??येक वाहन विभि?न संचरण ?मताओं से सुसि?जत है जिस के मा?यम से इन वाहन? को एक दूसरे के साथ कने?ट कर सकते ह? यह एक बु?धिमान परिवहन ?णाली ?दान करने के लिए वायरलेस संचार के ?े? म?एक अि?म वायरलेस तकनीक का उपयोग करता है। वॅनेट अपने अ?यधिक गतिशील टोपोलॉजी और कड़ी विकार की सम?या की वजह सेशोधकताओं के लिए सबसे उभरते अनुसंधान के ?े? म?से एक है। वॅनेट म?माग?के लिए विकसित किये गये विभि?न माग??ोटोकॉल ह?, जिनम?से ??येक के अपने गुण और दोष है। सारी ?ुटिय? म?सबसे सामा?य सम?या संपक? टूटना है जो की वाहनो की तेज़ गति की वजह से उ?प?न होती है। यह अ?ययन विशेष ?प से संपक? वि?पीकरण सम?या सेसंबंधित है अथवा ?ोत वाहन से गंत?य वाहन तक डाटा पैकेट को पहुचने के लिए एक नवीन ?णाली ??तावित करता है जो कि संपक? टूटने की सम?या को कम करने मे सहायक है।इसके अलावा इस शोध मे ??तावित काय?को मौजूदा अनुमागण ?ोटोकॉ?स के साथ तुलनाकी गयी है।

इस शोध के अंतगत एक नवीन काय?णाली विकसित की गयी है जिसका उ?दे?य ?ोत वाहन से गंत?य वाहन तक निपुण माग?खोज़ना है। इस काय?के लिए ??तावित ?ोटोकॉल मे हर नोड की डसिटी की गणना करने के लिए वा?तविक समय यातायात की जानकारी का उपयोग किया गया है। इस काय?णाली को इस शोध म?नोड डसिटी अवेयर ?टिंग ?ोटोकॉल (एनडीएआरपी) नाम दिया गया है। इस ?ोटोकॉल की मु?य विशेषता यह ह?की यह कुशलतापूवक वा?तविक समय यातायात की जानकारी जैसे की गति, दूरी, दिशा, ऊजा?संचरण सीमा, का उपयोग करते हुए हर नोड की डसिटी

की गणना करता है। आगे यह जानकारी सव??म म?य?थ नोड खोजने के लिए ?योग की जाती है जिस से डेटा पैकेट ?ेषित किया जा सके और ?ोत से गंत?य तक सव??म माग?का चुनाव किया जा सके। इसके अलावा एनडीएआरपी ?ोटोकॉल सेवा की गुणव?ा के अनुसार मौजूदा एओडीवी और टीओडीडी माग??ोटोकॉल से बेहतर ?दशन करता है।



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