EFFICIENT DATA ACCESS IN VEHICULAR ADHOC NETWORKS

Dissertation submitted in fulfilment of the requirements for the Degree of

MASTER OF TECHNOLOGY

in

COMPUTER SCIENCE AND ENGINEERING

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May 2017

ABSTRACT

VANET is a highly movable wireless ad hoc network that is meant to support road safety, monitoring the traffic etc. In VANET environment, each vehicle can go for access to data from RSU or can communicate to any other vehicle. In this scenario, service scheduling becomes an important challenge to provide equal distribution of data access. "Data Scheduling" measured a very important issue in VANET to successful delivery of data item to the vehicle in proper and accurate way. Communication among vehicles are becoming a promising technology for security, management of traffic, monitoring and controlling of pollution, and numerous other road safety and traffic applications. Due to this a lot of data is generated that must be shared between communication parties efficiently. A major load is caused on the network infrastructure because of all this generated data, and the main aim of the network infrastructure is to provide constant services to the users. Thus, in order to manage the load on the network in such situations, a new scheme is proposed which suggests to cache frequently accessed contents at particular locations such as vehicles and RSUs so that data can be accessed from either local cache or RSU cache without the need to flood requests for the required data in the whole network thus reducing the delay and ultimately increasing the throughput.

DECLARATION STATEMENT

I hereby declare that the research work reported in the dissertation entitled "EFFICIENT DATA ACCESS IN VEHICULAR AD HOC NETWORKS" in partial fulfilment of the requirement for the award of Degree for Master of Technology in Computer Science and Engineering at Lovely Professional University, Phagwara, Punjab is an authentic work carried out under supervision of my research supervisor Mr. Mohinder Kumar. I have not submitted this work elsewhere for any degree or diploma.

I understand that the work presented herewith is in direct compliance with Lovely Professional University's Policy on plagiarism, intellectual property rights, and highest standards of moral and ethical conduct. Therefore, to the best of my knowledge, the content of this dissertation represents authentic and honest research effort conducted, in its entirety, by me. I am fully responsible for the contents of my dissertation work.

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SUPERVISOR'S CERTIFICATE

This is to certify that the work reported in the M.Tech Dissertation entitled "**EFFICIENT DATA ACCESS IN VEHICULAR AD HOC NETWORKS"**, submitted by **Anjali** at **Lovely Professional University, Phagwara, India** is a bonafide record of her original work carried out under my supervision and as per my knowledge and belief this work has not been submitted elsewhere for any other degree.

Signature of Supervisor

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   Date: ____________________

ACKNOWLEDGEMENT

I express my gratitude to my thesis guide Mr. Mohinder Kumar of the Department of CSE at Lovely Professional University for his continuous guidance in my study and research, for his encouragement, endurance, inspiration, keenness, and immense knowledge. His guidance helped me a lot during the period of research and preparation of this report. His good self is always ready to help me whenever I had any doubt about my research on the subject. He time and again allowed this research to be my own work, but guided me in the right way whenever he considered I required it. I must also convey my very deep gratefulness to my parents for providing me with constant support and encouragement during my whole years of study and throughout the course of researching and preparing this report. This accomplishment would not have been achievable without their support and guidance.

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INTRODUCTION

1.1 Overview

Recently, as the vehicle industry is flourishing and communication technology in wireless mode, vehicular ad hoc networks are becoming one of the most promising research fields.

VANETs which use vehicles as mobile nodes are a subclass of mobile ad hoc networks (MANETs) to provide communications among nearby vehicles and between vehicles and nearby roadside equipment but apparently differ from other networks by their own characteristics. Specifically, the nodes (vehicles) in VANETs are limited to road topology while moving, so if the road information is available, we are able to predict the future position of a vehicle; what is more, vehicles can afford significant computing, communication, and sensing capabilities as well as providing continuous transmission power themselves to support these functions.

There are multiple challenges in Vehicular AD Hoc Networks for example probable huge level of network and that too with high speed vehicles moving. In Vehicular Ad Hoc Network the vehicles move very fast and their locations also keeps on changing. These fast moving vehicles are the main cause of the changing topology in the network because due to speed the connection between nodes connect and disconnect very often. Also Vehicular Ad Hoc networks works at large scale consisting of a lot of vehicles and that too spread over the whole network of roads.

1.2 Architecture

Vehicular Ad Hoc networks works at large scale consisting of a lot of vehicles and that too spread over the whole network of roads. This part describes the system architecture of vehicular ad hoc networks. Firstly the main components of VANETs architecture from a domain view are introduced. Then, their interactions are explained and the communication architecture is introduced.

1.2.1 Main Components

VANETs system can be divided into three domains: the mobile domain, the infrastructure domain, and the generic domain.

As is shown in Figure 1.1, the mobile domain consists of two parts: the vehicle domain and the mobile device domain. The vehicle domain comprises all kinds of vehicles such as cars and buses. The mobile device domain comprises all kinds of portable devices like personal navigation devices and smart phones.

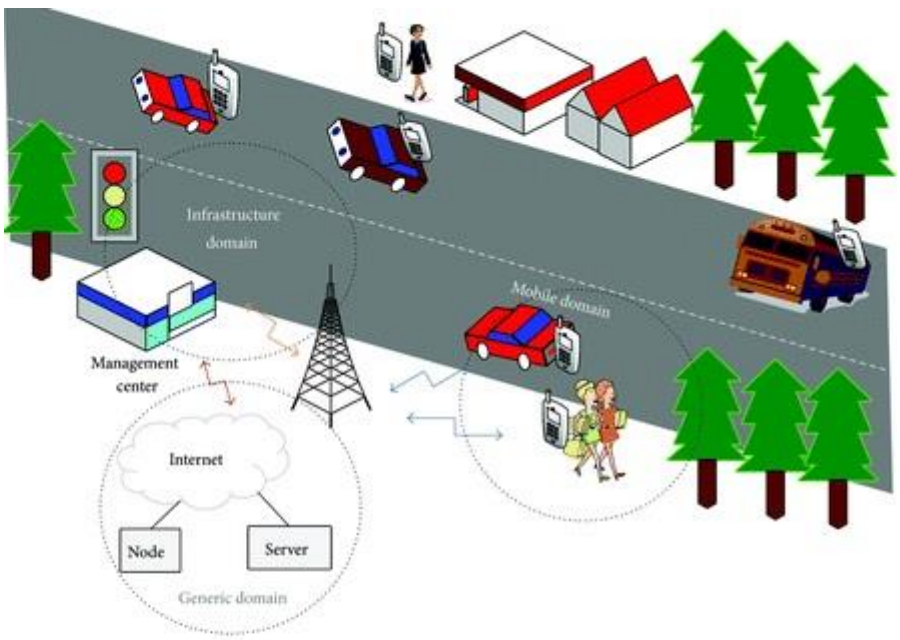

Figure 1.1: VANET System Domains

Within the infrastructure domain, there are two domains: the roadside infrastructure domain and the central infrastructure domain. The roadside infrastructure domain contains roadside unit entities like traffic lights. The central infrastructure domain contains infrastructure management centres such as traffic management centres (TMCs) and vehicle management centres.

1.2.2 C2C-CC Architecture

In Figure 1.2, the in-vehicle domain is shown, composing of an on-board unit (OBU) and one or multiple application units (AUs). The connections between them are usually wired and sometimes wireless. However, the ad hoc domain is composed of vehicles equipped with OBUs and roadside units (RSUs). An OBU can be seen as a mobile node of an ad hoc network and RSU is a static node likewise. An RSU can be connected to the Internet via the gateway; RSUs can communicate with each other directly or via multihop as well. There are two types of infrastructure domain access, RSUs and hot spots (HSs). OBUs may communicate with Internet via RSUs or HSs. In the absence of RSUs and HSs, OBUs can also communicate with each other by using cellular radio networks.

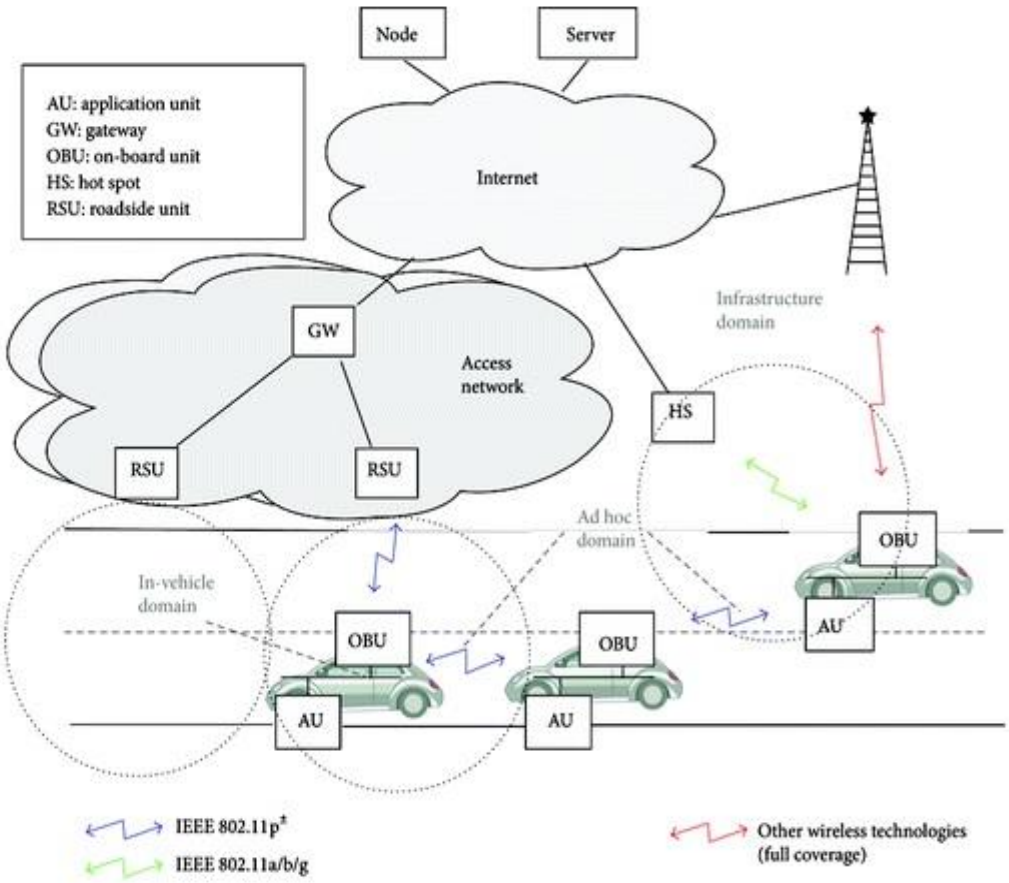

Figure 1.2: VANET Architecture

Vehicular Ad-hoc Networks (VANETs) are going up as is the favourite network plan for intelligent transportation systems. VANETs are based on short range wireless exchange and share of information between vehicles. By installing on-board transceivers in the vehicles, recently growing up VANET facilitates wireless communication among vehicles and roadside units, for internet access using the special DSRC (Dedicated Shortest-Range Communications) radio spectrum.

1.3 Special Characteristics of VANET

Vehicular ad hoc networks are created by applying the principles of mobile ad hoc networks but still they are considered as a separate area of research mainly due the provision of safety. Following are the distinctive features of VANET:

Frequently changing topology: VANET is having frequently changing topology because of frequent building and breaking of connections between vehicles. If it is supposed that there are two vehicles which are moving in the opposite direction from each other and have the speed of 60 km/hr (25 m/sec) and the communication range is nearly 250m, then connection between the vehicles will last only 5 secs (250m). This proves the highly changing topology of VANETs.

Repeated disconnection in the network: Due to the characteristic discussed above it is requires that after every 5 secs, the vehicles need to look for new connection establishment for preserving the seamless link. In the low density areas, where there are fewer vehicles, network links will be disturbed repeatedly. These kinds of problems can be resolved by deploying the relay nodes alongside the roads.

Mobility Model: The knowledge of the position of hosts and their mobility is required in order to establish and maintain the connections among the vehicles. But guessing that information is tough as the character and pattern of movement for every vehicle keeps on changing. Therefore, based on the learning from already known paths and speed of vehicles we can design the network efficiently.

Environment of Communication: There is a huge variation in the motion of vehicles on highways and cities. Therefore plan for host prediction as well as routing protocol requires to get used to for these variations. In case of highway scenarios there is a 1-D model due to that the prediction is easy and simple. But in urban scenario, the arrangement of lanes, changing hosts density, existence of houses and trees act like obstruction even in communications that involve less distance thus making the model very intricate.

Unlimited Transmission Power: There is a nonstop supply of power to all the vehicles involved in the communication.

Delay Conditions: The security feature of Vehicular Ad Hoc Networks permits the delivery of information to appropriate hosts on time. Any kind of latency in delivery of data is not accepted in this view. Thus, the matter of latency is more important to deal with than supplying the vehicles with high rate of data transmission.

Communication among onboard sensor units: For the purpose of routing and maintaining an efficient communication among vehicles, on board sensors are used to give the position of hosts and their mobility.

Frequent change in the topology of network: The topology of network in vehicular ad hoc network has a tendency to vary quickly for the reason that of the fast moving vehicles.

Limitless size of the network: There can be involvement of vehicles from single city to multiple cities or also a country in vehicular ad hoc networks. Therefore an algorithm for vehicular ad hoc networks should be made such that it is scalable.

Unidentified receiver: There must be recognition of the hosts in a particular area in vehicular ad hoc networks. This can help in privacy protection of vehicles.

Transmission of information on time: Many security linked applications are there which need transmission of data on time.

Infrastructure support: In future, vehicular ad hoc networks can in fact get help from infrastructure. This feature can be taken into consideration in order to make better algorithms for vehicular ad hoc networks.

Physically safe nodes: Nodes in vehicular ad hoc networks are more protected than in mobile ad hoc networks. Therefore, compromise of nodes becomes difficult in vehicular ad hoc networks.

Frequently dividing network: There will be frequent divisions in vehicular ad hoc networks. Due to the changing conditions of traffic there can be large gaps between vehicles in thinly populated areas and therefore will lead to multiple isolated group of vehicles.

1.4 Purpose of Vehicular Ad Hoc Networks

There is variety of uses of VANETs like road security related to the moving vehicles. There are various uses in the field of enjoyment and business; therefore a lot of technologies are used. These uses are of two types:

Security linked: These uses are like avoiding the accident and driving in supportive manner. The main objective of this is to avoid accidents in difficult situations and by this use many life threatening accidents can be avoided. Therefore, it is very necessary to stop any kind of attacker to hamper the services

Other uses: It consists of information regarding traffic, features related to payment on toll plazas, services related to position like looking for the nearby petrol pump and services like infotainment for example downloading of songs etc. These kind of services especially the payment needs to be secured.

Security uses crucial to life: VANETs can be used to provide warning whenever there is any collision going to happen. These applications can make use of the control and other channels of DSRC. In this way the warnings can be sent to all the vehicles which are near to the location of possible collision.

Notification regarding security: They consist of caution related to area of work. The dissimilarity between these two uses lies in the fact that how much amount of delay is allowed in both. In the crucial Security uses the notification must be sent to all the near vehicles in 100 ms, while in this the notification can be sent in the time period of 1000 ms. These applications can make use of the control and other channels of DSRC. In this way the warnings can be sent to all the vehicles which are near to the location of possible collision.

Collection of toll electronically: Toll can be paid by the vehicles whenever they cross toll plaza even if does not stops. Electrical License Plate will be scanned by the toll plaza at the OBU installed on the vehicle and a receipt will be issued consisting of the total sum paid, time of payment and position of Toll Plaza.

Access to Internet: In future it is expected that the vehicles will be capable of connecting to the internet. Unlike previous uses, for this purpose service channel of DSRC will be used rather than control channel as this channel has low priority. with the lowest priority comparing with the previous applications.

Communication in clusters: There can be the cases when many vehicles moving in the same direction and on the same road may have some common interests so they can communicate in groups. For this purpose service channel of the DSRC can be used rather than control channel because control channel is mainly used for security related uses. In vehicular ad hoc networks mostly all the vehicles that falls in the same region wants to communicate so implementing communication in cluster is a great possibility. There are multiple examples of such applications like Roadside Service Finders, hotel finders, petrol pump finders within the same region. For this purpose service channel of the DSRC can be used rather than control channel because control channel is mainly used for security related uses. A request can be sent by any vehicle to the RSU and a reply will be sent back to the vehicle.

A VANET is applicable on vehicles moving on road. It is envisaged for usage in multiple areas like safety of road, convenience in moving of vehicles on road, and business purpose. Out of them, data dissemination is a significant kind. Exhaustive investigation is carried out to efficiently disseminate data to many beneficiaries in the network. It is observed that main object of data dissemination applications is to approach to required number of recipients economically.

1.5 Dedicated Short-Range Communication

DSRC (Dedicated Short-Range Communication) [1] provides the ability to efficiently carry out inter-vehicular sharing and exchange of messages etc, that is known as technology of Vehicle Safety Communication. With short-range communication having 5.9 GHz frequency, vehicles will attain ability to communicate with each other and also with their surroundings. Numerous provisions will be provided for networks of vehicles which help to increase the protection of the infrastructure of transportation. For example, the system will achieve ability to synchronize traffic lights in order to make the flow of traffic smooth.

Now, due to the rapid advancements in the internet, it is possible for the hosts to use much kind of services while sitting in their vehicles, such as users can control their household equipments remotely when they are away. This is all due to the development of a new rising technology i.e. vehicular ad hoc networks in which vehicles are equipped with on board units which perform a variety of functions such as collecting the data and forwarding it to the other vehicles.

There are two types of communications in VANETs i.e. vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. Vehicles can access a variety of resources from the nearby RSUs in vehicle to infrastructure (V2I) communications these RSUs act as access routers which establishes connection of the vehicles with the network infrastructure. RSUs are installed along the roads and act as intermediary between the network infrastructure and vehicle for the purpose of data sharing among the vehicles in both the directions. On the other hand there is direct communication between the vehicles in case of vehicle to vehicle (V2V) communication without the involvement of RSUs. While in motion, vehicles share important information such as road traffic, weather conditions, or security alarms with each other either cooperatively or by the installed RSUs.

Basically, there exist two areas of importance for the distribution of data i.e. dense and sparse. As there is less or no infrastructure there in sparse areas, the connection among the vehicles is established for short period of time. Huge quantity of data is shared between the nodes and RSUs in areas which are urban due to the presence of large number of vehicles on the road. Because of which, in these urban areas, vehicles offer a variety of road safety services to each other, such as path changing alert, signal jump alert, and many other disaster related warnings. Not just that, many other traffic related and entertainment related services such as information regarding traffic, location of the nearby petrol pump, and onboard Internet services for entertainment are provided. So there requires a well-organized data sharing between the vehicles and RSUs in order to make data reach to its destination in time and that too error free. Vehicular Ad-hoc

Networks (VANETs) are going up as is the favourite network plan for intelligent transportation systems. VANETs are based on short range wireless exchange and share of information between vehicles. By installing on-board transceivers in the vehicles, recently growing up VANET facilitates wireless communication among vehicles and roadside units, for internet access using the special DSRC (Dedicated Shortest-Range Communications) radio spectrum.

VANET is a highly movable wireless ad hoc network that is meant to support road safety, monitoring the traffic etc. In VANET environment, each vehicle can go for access to data from RSU or can communicate to any other vehicle. In this scenario, service scheduling becomes an important challenge to provide equal distribution of data access. "Data Scheduling" measured a very important issue in VANET to successful delivery of data item to the vehicle in proper and accurate way. Communication among vehicles are becoming a promising technology for security, management of traffic, monitoring and controlling of pollution, and numerous other road safety and traffic applications. Due to this a lot of data is generated that must be shared between communication parties efficiently. A major load is caused on the network infrastructure because of all this generated data, and the main aim of the network infrastructure is to provide constant services to the users. Thus, in order to manage the load on the network in such situations, a new scheme is proposed which suggests to cache frequently accessed contents at particular locations such as vehicles and RSUs so that data can be accessed from either local cache or RSU cache without the need to flood requests for the required data in the whole network thus reducing the delay and ultimately increasing the throughput.

CHAPTER 2

REVIEW OF LITERATURE

Jinhua Guo and Nathan Balon (2014) [1]: They provide the ability to efficiently carry out inter-vehicular sharing and exchange of messages etc that is known as technology of Vehicle Safety Communication. With short-range communication having 5.9 GHz frequency, vehicles will attain ability to communicate with each other and also with their surroundings.

In order to check the traffic jam, sensors will use info arriving from vehicles. Public protection vehicles transmit, by the means of wireless communication, so as to modify traffic indicators to take action hurriedly to a crisis. Vehicles will exchange and share information with one another to drive in a cooperative manner, to avoid accidents and enhance efficiency. With the initiation of the DSRC standard many promising purposes will be achieved. DSRC maintains security of all vehicles communications. The VANET intends to make available a high data rate and also minimize latency within a comparatively small communication region. Due to the distinctive characteristics of Vehicular Ad Hoc Networks, numerous challenges are associated with it.

The major difference between a MANET and a VANET is that, a MANET has no infrastructure whereas VANET is infrastructure-based, as RSUs can be placed along roadside, and thereby, making vehicles avail the services from the RSUs. The main challenge is that the due to the high mobility of vehicles in VANETs, fragmentation in network often occurs.

In addition, protection is essential concern for a VANET. VANETs possess distinctive features in comparison to MANETs. The unique characteristics of a VANET provide opportunities to enhance performance of network, and simultaneously there are significant difficulties. There are a lot of differences between a VANET and a MANET.

First of all, a vehicular ad hoc network is considered to have as a fast changing topology. Secondly, breakage in network occurs often. Thirdly, the reach of a VANET is small. Fourthly, a VANET causes a number of distinctive security and safety challenges.

Due to the high mobility of vehicles in the network, changes in topology occur frequently. Because of that, the time of communication between two vehicles is short. Short lived links in VANET is due to high mobility of vehicles, reaching the speed up to 200 kmph. One alternative to increase the period of a link is to enhance the transmission power. The problem is that if the transmission range of a vehicle is increased in order to maintain a communication link then the throughput in the network will decrease. A short time linkage is maintained among vehicles when they move in direction opposite to each other. At the same time, when vehicles move in the similar direction, the wireless connection between vehicles lasts for about a minute. Due to high speed of vehicles, keeping any kind of membership in cluster is difficult. Example, it is not easy to ascertain an exact record of adjoining vehicles. Protocols based on Group membership are thus difficult to execute on a VANET. The restricted number of vehicles with transceivers will cause heterogeneity of the network, making a segment of the network inaccessible.

A large collection of uses for DSRC are evolved. The uses of DSRC are divided into the below mentioned four categories:

(a) Vehicle-to-Vehicle applications convey messages in between the vehicles.

(b) Vehicle-to/from-Infrastructure applications where communication is carried out either to or from vehicle to an access point.

(c) Vehicle-to-Home is a type of function which is utilized for a vehicle which is there at the residence of the driver/owner, for uses like transmitting info among the vehicles.

(d) Routing Based uses are when the desired addressee is more than one host far.

One of the main problems in VANET is hidden terminal problem which is the chief reason of clash in a wireless network and the same arises when the two hosts not in the transmission range of each other, broadcast to a host that is in the range of both of them.

As shown in figure 2.1, hosts S1 and S2 are not in the transmission range of each other. Therefore, the medium seems to be free to both of them. If both hosts start transmitting to another host R1 simultaneously, collision will happen at R1 host and none of the packets will be received fruitfully. The said problem is tackled with the exchange of RTS/CTS before transmission of data.

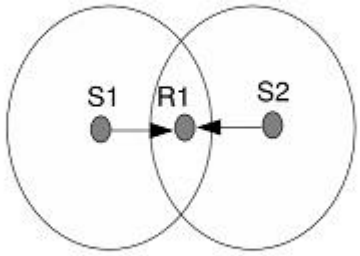

Figure 2.1**:** Hidden Terminal Problem [1]

As shown in figure 2.2. When host S1 intends to send data, whenever it gets the right to use the means, host S1 first sends a RTS (Request to send) to the proposed beneficiary R1. When host R1 gets the RTS, host R1 replies with CTS. At S1, when the CTS is arrived, it will indicate to host S1 that R1 is prepared to collect info. The hidden node problem is mainly removed, when host S2 listens the CTS transmitted from R1. Node S2 will then put off from accessing the wireless medium until the communication between S1and R1 is fulfilled. As S2 listens the ACK which is forwarded from R1 it identifies the communication is done.

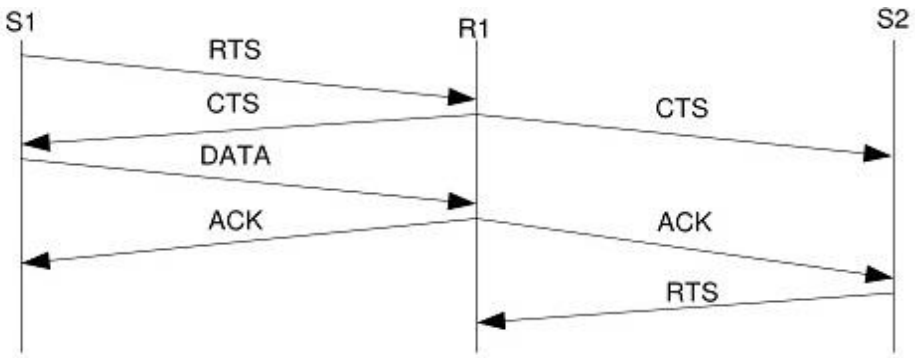

Figure 2.2**:** RTS/CTS Handshake [1]

Yang Zhang, Jing Zhao and Guohong Cao (2007) [2]: In this, some problems related to data access on roads are detected. Due to the high mobility of vehicles, the demands should be handled very fast. As vehicles can both upload and download data to/from the roadside unit, they contend for the same bandwidth. To tackle these problems, several scheduling methods are suggested. A vital scheduling scheme to consider both service deadline and data size, known as D∗S is suggested. It is a scheme of scheduling that offers stability among download and upload demands.

In this scheme, non-handling of requests within a stipulated time will cause the dropping of requests, due to the movement of vehicles outside RSU. As update and download requests contends with other, a few data can become out of date if an update is left, leading to poor quality of service (Qos). Thus, supplying updated data to many vehicles is essential. The following parameters for scheduling vehicle-roadside data access are used.

1) Service Ratio: It is known as the ratio of the served requests prior to the time limit to the entire requests received. A best method of scheduling method should deal with multiple requests at a time.

2) Quality of data: Data turns out to be out of date if there is a new edition of the data with a vehicle but become unsuccessful to upload the data prior to the vehicle travels out of the transmission range of RSU. Due to this, the quality of information for the download service will reduce. Thus, a top method has to bring up to date info at the moment and aim to shun mustiness of data. It is tricky to attain both best ratio of service and first-class data. If extra bandwidth is given to download requirements then download service ratio will be higher, but update ratio will drop significantly and hence it will lead to low data quality. If more bandwidth will be allocated to update requests, then the service ratio decreases. There is always a trade-off between high service ratio and good data quality.

Two metrics to schedule data access among vehicles and RSUs are made out:

(a) Data Size: For how much time a service will stay depends upon the size of the data, if the vehicles can exchange and share information with the RSU at the same data transmission rate.

(b) Deadline: If a request cannot be entertained timely, then it is dropped. Therefore, a request whose deadline is earlier is more urgent.

Following are the three simple schemes:

(a) First Come First Serve (FCFS): first arriving request will be handled first.

(b) First Deadline First (FDF): firstly a most urgent request will be handled.

(c) Smallest Data Size First (SDF): the small size data request will be handled first.

The D∗S Scheduling:

As mentioned above, in FCFS, the request which arrives first will be served first and data size and request deadline is not considered. In FDF, the most urgent requests are given highest priority. SDF considers the size of data but disregard to the importance of a request which result that not any of above mentioned schemes can serve with a high-quality scheduling. Thus, a novel scheduling scheme, called D∗S as proposed above takes into account both the info and time limit when setting up vehicle and road info.

(a) If two queries having identical time limit arrive, the query with little size have to be dole out first.

(b) If two queries enquire for identical sized info, query having prior time limit to expire have to be served first.

As per that each vehicle is given a service value called DS value based on its query's length and time limit expiry.

DS_value = (Deadline−CurrentClock) ∗DataSize..(I)

Every time the D∗S scheme entertains the queries having least DS_value.

<u>Sarita Negi, Smita Singh, Akshay Kumar (2016) [3]:</u> Algorithm D*S/N is the extended form of D*S and makes the broadcast efficiency better; because it first deals with awaiting queries. For this, another metric has been added i.e., the amount of queries that are pending for the data (N).

The DSN _value = (Deadline − CurrentClock)*S/N..(II)

Three metrics deadline (D), data size (S) and pending requests (N) are used. The values of S and N are united to make a single S/N list so that when a fresh request arrives, the S/N value of the related data item updated. This modification does not carry much maintenance overhead as compared to D*S algorithm.

<u>Hao, Jin Tang, and Yu Cheng (2013) [4]:</u> In this, a framework is suggested in Vehicular Ad Hoc Networks (VANETs) for secure cooperative data downloading. In this framework, data is downloaded by vehicles when they cross a Road Side Unit (RSU), exchange the info once moves away from the exposure of RSUs. The primary concern of supportive info loading is of nodes efficiently exchange data with one another. A data input procedure is proposed where nodes cooperatively transmit data as per their location. With this cooperative exchange of data among nodes, collisions and the hidden terminal problem in communication are avoided. The suggested protocol assures the delivery of the demanded info for every vehicle crossing a Road Side Unit.

Xu Liya, Deng Anyuan, Gao Guanyong, Jiujiang University, Yang Wenzhong, Cheng Yong (2016) [5]: The main objective of the same is to make available a robust routing in urban environments. A situation is considered in which many ITS (Intelligent Transportation System) applications are set up in a city, for offering both inter-vehicular communication services as well as infrastructure-based ITS services. To ensure efficiency to various types of applications, many significant matters has to be handled, the link is easy to break, road hinders the mobility of vehicles, the topology of VANET varies quickly etc. VANET is disconnected many a times, due to the constraints faced by vehicles on roads which lead to many topology setbacks in the network. Here the main point for consideration is to create a robust routing with the assistance of static-nodes. In this, whenever a route is established, every static host in the path gathers the details of other static nodes. The path in which static nodes are back bone nodes and the vehicles are the relaying nodes can be survived.

Further, in the path, vehicle within the transmission range of static nodes can transmit data packets through the path during the period. Thus, this idea can enhance the Packet Delivery Ratio and diminish the delay of packets.

Tan Yan, Wensheng Zhang and Guiling Wang (2014) [6]: A VANET consisting two parts i.e. the set V consisting of every mobile vehicle and the set SN consisting of every static node is taken. In the said paper, it is assumed that every vehicle is furnished with GPS device that enables the nodes to get its location and speed. With the digital maps, vehicles can find out the location of their neighbouring intersections. In each intersection the static nodes are placed. Vehicles send the information regarding the traffic in real time about connected roads to the particular static host. The source knows the location of the target node in order to make a routing decision. It is assumed that the position of SN is given and their locations are set. The location of node is varying with time. When the distance between two nodes is lesser than the transmission range, the two nodes can share and exchange messages with one another. Every vehicle produces packets of data time to time. Unicast delivery of data is considered, i.e. each packet ‘pa’ has sole source, s (pa), and sole destination d (pa).

Data dissemination to desired number of receivers in VANET is a new issue with least work done over it. Inspired by processor scheduling in this scheme roads are treated as processors with different processing capabilities. Each road is assigned with delegation task thus distributing the dissemination tasks among various roads and hence providing better dissemination than traditional dissemination algorithms like flooding, one hop broadcasting etc.

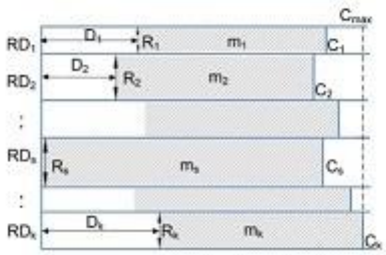

Figure 2.3**:** Data Dissemination Task [6]

A sender requires distributing data to M recipients in a concerned area comprising of k roads. RD_i (i = 1... k) is used to represent the roads. RD_s particularly signify the roads where the sender is positioned. R_i denotes the density of traffic on road RD_i, that indicates the amount of fresh receivers a distributor be able to contact on RD_i per unit time. R_i is taken as the processing capacity of implicit processor RD_i. m_i is the amount of receivers that have to be arrived at in RD_i. m_i represents the job allocated to implicit processor RD_i. D_i is used to represent the start functioning time of implicit processor RD_i, D_i represents the period when RD_i is assigned the dissemination task. C_i denotes the completion period of a implicit processor’s job i.e. the point at which receivers on road RD_i have received the data. In Figure 2.3, each road RD_i depicted by a rectangle, is a virtual processor. R_i denotes width which is the processing capacity and the length stand for time. The void space signifies the inoperative period of the processor, it indicates that the distribution job is not allocated to road RD_i due to some space between RD_i and the dispatcher, and it requires a little time for RD_i to allocate a duty. The shaded region is the functioning time of the processors, and m_i is area. m_i is the obtained by multiplying the processing capability R_i with its working time (C_i –D_i). The rule is as below:

m=R*(C-D)..(III)

Further, C_{max} is used to represent a point at which processor in the last completes its work. C_{max} is the distribution latency of the complete job.

There are many data dissemination techniques in VANETS already but in DOVE, data is disseminated to desired no of receivers because there is some pre defined budget of the number of nodes to which data should be disseminated. For example: A store wants to distribute a certain no. of free tickets depending upon the budget, so these kind of data dissemination requires a control over the nodes to whom data is disseminated. In this roads are treated as processors and each road is delegated with dissemination task. A shortest path tree is formed using dijkstra algorithm and root node A starts the delegation task.

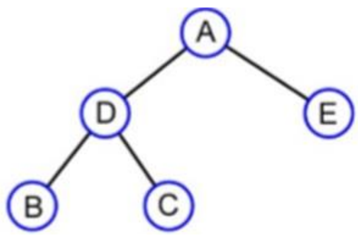

Figure 2.4**:** Delegation Tree [6]

In this tree nodes represent roads and edges between them tell that roads are connected i.e. for example: there is a path between road A and road D, E.

Neeraj Kumar and Jong-Hyouk Lee (2014) [7]: In order to mitigate the burden over the network infrastructure, vehicles distribute data among each other in a cooperative manner with the use of Markov chain model having three states. Stale data is replaced to hold fresh data in a probabilistic manner. The period to live in a waiting state, the number of times information is accessed in a certain time is used to calculate the probability. If two vehicles want to access the frequently used data, they can do so by using cooperative caching without the need to put burden on network infrastructure. They will ask the server for data if the required information is not there in their local cache. This scheme has increased the hit ratio, decreased the delay in accessing the data and improved the collision problem to great extent. This approach had lowered the jam and latency by 30% and increased the hit ratio by 20%.

Su and Zhang (2007) [8]: A cluster-based message passing is proposed among vehicles. On receiving a legitimate invitation from the head of the cluster within a particular time, a vehicle can become the part of cluster. Otherwise, it will turn out to be a head of cluster by itself. Upon receiving the legitimate invitation from a cluster having more members, it can be merged into that. In this approach delivery of both the public safety messages and entertainment messages are supported. Both the contention based and contention free mediums are combined together in this approach. Contention free is used within the cluster and contention based is for delivery of safety messages among the heads of clusters. This approach works well in the delivery of both real and non real time data.

Xia Shen, Xiang Cheng, Liuqing Yang, Rongqing Zhang, and Bingli Jiao (2014) [9]: Discussed the main challenge that how best to assign the transmission opportunity to nodes with maximum dissemination utility and to avoid the collision problem. They then propose a novel and practical relay selection strategy and adopt the space–time network coding (STNC) with low detection complexity and space–time diversity gain to improve the dissemination efficiency. Basically there are three phases of data scheduling: relay selection, transmission and feedback phase. In relay selection a central server selects the nodes that will be used for relaying. In transmission, all the nodes will transmit as per the scheduling results given in previous phase. In feedback phase vehicles will update their speed and location to the RSU.

Namboordiri and Gao (2007) [10]: A prediction-based routing protocol is proposed in which a path is calculated between a source and destination with the help of wireless local area network. The life span of the path can be also predicted if the location and speed of the vehicle is provided. Basically routes are predicted based on the scenario, for example in highway scenario the vehicles will move relatively and the connection between them will last long because of that. The traditional schemes used to calculate new path when the previous one breaks. But in this approach, based on the scenario, paths are predicted even before a failure occurs thus saving a lot of time.

Wischhof et al. A. Ebner, H. Rohling, M. Lott, and R. Halfmann (2003) [11]: For knowing the traffic information a vehicular communication model is explained. In this the idea of timestamp is used to find out the newness of the message sent and received by the vehicles.

Korkmaz et al. (2004) [12]: A proposal for VANET is given by Korkmaz *et al.* This new proposal helps resolving the problems of the already existing schemes such as broadcast storm, hidden terminal problem etc. The new proposed scheme sends/receives the messages from/to one vehicle to/from another in a particular area of interest, without knowing the topology of the network. This scheme provides high packet delivery ratio and better use of channel than the already existing schemes.

Shafiee and Leung (2009) [13]: A better mechanism to distribute data among vehicles is proposed by Shafiee and Leung, in which urgent messages are kept at an intersection for long time in order to make sure that all the intersecting road segments have received the messages.

Naumov and Gross (2007) [14]: A location-based routing protocol called connectivity aware routing is proposed by Naumov and Gross. This protocol suggests the procedure to discover a complete route from start to end. The path found out by the protocol consists of a set of fix points that are created by the values of the speed of the moving vehicles on the road which is a combination of location and topology-based protocols for routing and is capable of searching the position of the target and at the same time looking for the linked route amid the sender and receiver.

Wisitpongphan et al. (2007) [15]: The use of an experimental vehicle traffic data to build up a complete framework for studying the behaviour of disjointed network and its features is proposed by Wisitpongphan et al. This study says that the connection of the vehicles with the network can be broken for a second to several minutes, depending upon the number of the vehicles on a road.

Namboordiri and Gao (2007) [16]: A prediction-based routing protocol is proposed by Namboordiri and Gao in which a path is calculated between a source and destination with the help of wireless local area network. The life span of the path can be also predicted if the location and speed of the vehicle is provided.

He et al. (2008) [17]: An on-demand consistent routing protocol is proposed by He et al. In this, multiple disjoint links are found for each application so that reliability is assured and RSUs are used in order to balance the load, enhancing the chances of link establishment successfully.

Su and Zhang (2007) [18]: A cluster supported message passing is proposed among vehicles by Su and Zhang. On receiving a legitimate invitation from the head of the cluster within a particular time, a vehicle can become the part of cluster. Otherwise, it will turn out to be a head of cluster by itself. Upon receiving the legitimate invitation from a cluster having more members, it can be merged into that.

Bronsted and Kristensen (2006) [19]: Zone flooding and zone diffusion these two protocols are proposed by Bronsted and Kristensen to effectively distribute data among the vehicles. These schemes collected and distributed the data to the vehicles that fall in the same geographic region. These two protocols have found a great usage in open part of uses in VANETs.

K. Ibrahim and M. C. Weigle (2007) [20]: Ibrahim and Weigle proposed a data dissemination scheme in which it is assumed that clusters are formed on roads among the vehicles by interchanging the information regarding speed and location of vehicles within the group. When transmitting the data to a destination, it goes from node to node which increases the chances of redundancy in the network. In this approach, it is checked that there is no redundant data; otherwise it will unnecessarily consume bandwidth.

K. Ibrahim and M. C. Weigle (2008) [21]: Along with the above mentioned applications of transmitting the data to a destination, a new stringent mechanism of missing is applied by Ibrahim and Weigle for eliminating the stale data in the cache in order to make space for fresh arriving data. Redundancy is checked just as in their already defined approach.

H. Wu, R. Fujimoto, R. Guensler, and M. Hunter (2004) [22]: An approach to make use of the mobility in vehicles has been discussed. The motion in vehicles has been combined with the idea to disseminate the info by forwarding the data through vehicles. MDDV is discussed which chooses mobility in vehicles as a tool to forward data and a message head is chosen which contains info about its creation and its location. How close a message has reached from source towards destination is calculated by message head's location.

T. Nadeem, S. Dashtinezhad, C. Liao, and L. Iftode (2014) [23]: Basically in this, a model is discussed about how to disseminate data about traffic among vehicles into the network so that for example in the days of fog it will helpful for drivers to already know the road condition.

L.Wischhof, A. Ebner, H. Rohling, M. Lott, and R. Halfmann (2003) [24]: As it is already known that in case of vehicular ad hoc networks the main challenge is to distribute data among the vehicles. So an approach is discussed such that there is no central control where data is stored. Rather data is stored in decentralized manner.

L. Wischhof, A. Ebner, and H. Rohling (2005) [25]: Further this approach is refined and applied in real life scenario to check its success and possibility when applied on real traffic. In this approach vehicles communicate directly with each other thus decreasing the communication delay. Therefore this approach can be used to distribute time critical data. Here no service provider is there hence the service charge is also absolutely nothing. So it can be used in various comfort and security applications.

Khaleel Mershad and Hassan Artail (2013) [26]: With the emerging technology, threats also increase. So in order to safely access the data from RSU security mechanisms are discussed in this. As there are various threats especially in accessing of data in ad hoc wireless environment so it is necessary to develop a system capable of securing against privacy attacks. A set of fresh safety methods are introduced and its working is judged.

Adler et al. (2006) [27]: A data distribution algorithm for VANETs is proposed by Adler *et al*. A data dissemination framework is proposed which is able to combine the features of already known routing protocols. Choice of the message depends upon the function that uses the present situation and the contents of the messages.

Yang et al. (2007) [28]: A multi hop communication scheme is proposed by Yang et al. In this, a node which can't transmit its message direct to RSU, transmit packet to another nodes in a cooperative style in order to make the data reach the RSU. This scheme is known as coordinated external peer communication (CEPEC). For accessing the internet, this scheme ensures throughput as well as reasonable bandwidth utilization among roads. In this approach the road is divided into sections of same length. A head is chosen in every section that collects and forwards the packets. This scheme outperforms in fairly allocating bandwidth to every section on the road.

Biswas et al. (2006) [29]: He suggested a data distribution scheme in vehicular network. The author has shown a new data distribution mechanism for sending the data among the vehicles. This new scheme is known as cooperative collision avoidance where security related data is given preference over the other non real time data. The traditional Mobile Ad Hoc networks cannot work well to improve the problem of collision.

Khaled Ibrahim (2011) [30]: Basically he tells about how to provide data to a vehicle according to its choice. When transmitting the data to a destination, it goes from node to node which increases the chances of redundancy in the network. In this approach, it is checked that there is no redundant data; otherwise it will unnecessarily consume bandwidth. Therefore techniques of data collection and forwarding known as cluster-based accurate syntactic compression of aggregated data in VANETs (CASCADE) are discussed.

Brij Bihari Dubey, Naveen Chauhan and Prashant Kumar (2010) [31]: In VANET communication among vehicles sometimes take place using multihops, so whom should be chosen as next hop depending upon speed, stability etc is described. Also various techniques of data dissemination in vehicular ad hoc networks is discussed based on network topology. Pull based and push based techniques are discussed. In pull based, vehicles request for data from RSU and their requests are served by RSU. In push based, RSU periodically forwards data to vehicles passing through it. Various road scenarios and how to disseminate data on different scenarios are discussed like on highway scenario vehicles move in straight line and a vehicle or RSU wants to transmit data will simply use greedy approach in which as soon as they find any vehicle moving in the direction of destination they pass the packet to it.

CHAPTER 3
PRESENT WORK

3.1 Problem Formulation

Communication among vehicles are becoming a promising technology for security, management of traffic, monitoring and controlling of pollution, and numerous other road safety and traffic applications. Due to this a lot of data is generated that must be shared between communication parties efficiently. A major load is caused on the network infrastructure because of all this generated data, and the main aim of the network infrastructure is to provide constant services to the users. Thus, in order to manage the load on the network in such situations, a new scheme is proposed which suggests to cache frequently accessed contents at particular locations such as vehicles and RSUs so that data can be accessed from either local cache or RSU cache without the need to flood requests for the required data in the whole network thus reducing the delay and ultimately increasing the throughput. As the speed of vehicles moving on the road is high and number of the vehicles in the particular area is less, therefore putting all the data on the existing infrastructure is not possible, and it may happen that important information does not reach the end user. In order to deal with this matter, an innovative peer-to-peer (P2P) cooperative caching mechanism is suggested. In order to mitigate the burden over the network infrastructure, vehicles distribute data among each other in a cooperative manner with the use of Markov chain model having three states.

Stale data is replaced to hold fresh data in a probabilistic manner. The period to live in the state of wait and the number of times a data is accessed in a certain period is used to calculate the probability. If two vehicles want to access the frequently used data, they can do so by using cooperative caching without the need to put burden on network infrastructure. They will ask the server for data if it is not there in their local cache. This scheme has increased the hit ratio, decreased the delay in accessing the data and improved the collision problem to great extent. This scheme has lowered the jam and latency by 30% and increased the hit ratio by 20%. In order to mitigate the burden over the network infrastructure, vehicles distribute data among each other in a cooperative manner with the use of Markov chain model having three states.

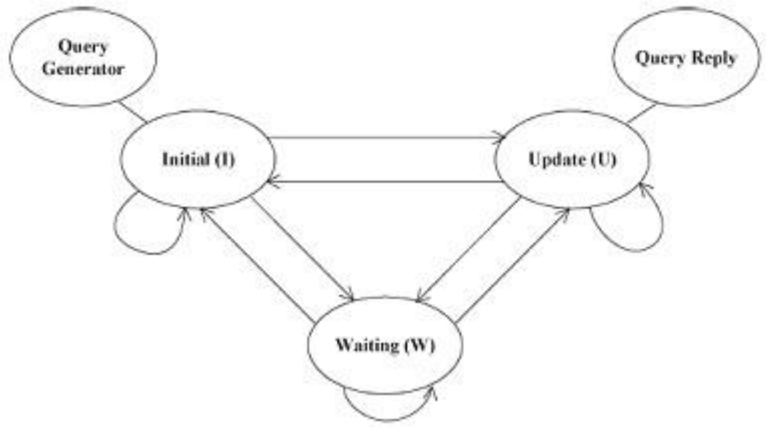

Figure 3.1**:** Markov Chain Model with three States

In figure 3.1, it is shown that the state of every vehicle has a probability to either make the query stay back in the same position or move from one state to another. By exchanging the query with each other, the vehicles can disseminate the data among each other cooperatively. Depending upon the probability, the state of a vehicle may remain the same or it may transit from one state to another state for example waiting state or update state. The caching of data attained from other vehicles depends on the probability.

Initially, a query generator generates the query which is accepted and this query generator can be a client in this scenario. Based on the query, it is possible that the data asked in the query is present in the local cache of the vehicle. If the info is there in cache, the result for the request is given to the client at once, and the process ends. But if the requested data is not present in the local cache of the vehicle, then the query is forwarded to other vehicles, and a reply is awaited for the query received from other vehicles, due to which the state of the vehicle reaches the waiting state. As soon as the result of request is sent to the node which initially generated the query, the system's state either move to the initial state or to the update state in order to accept the next query.

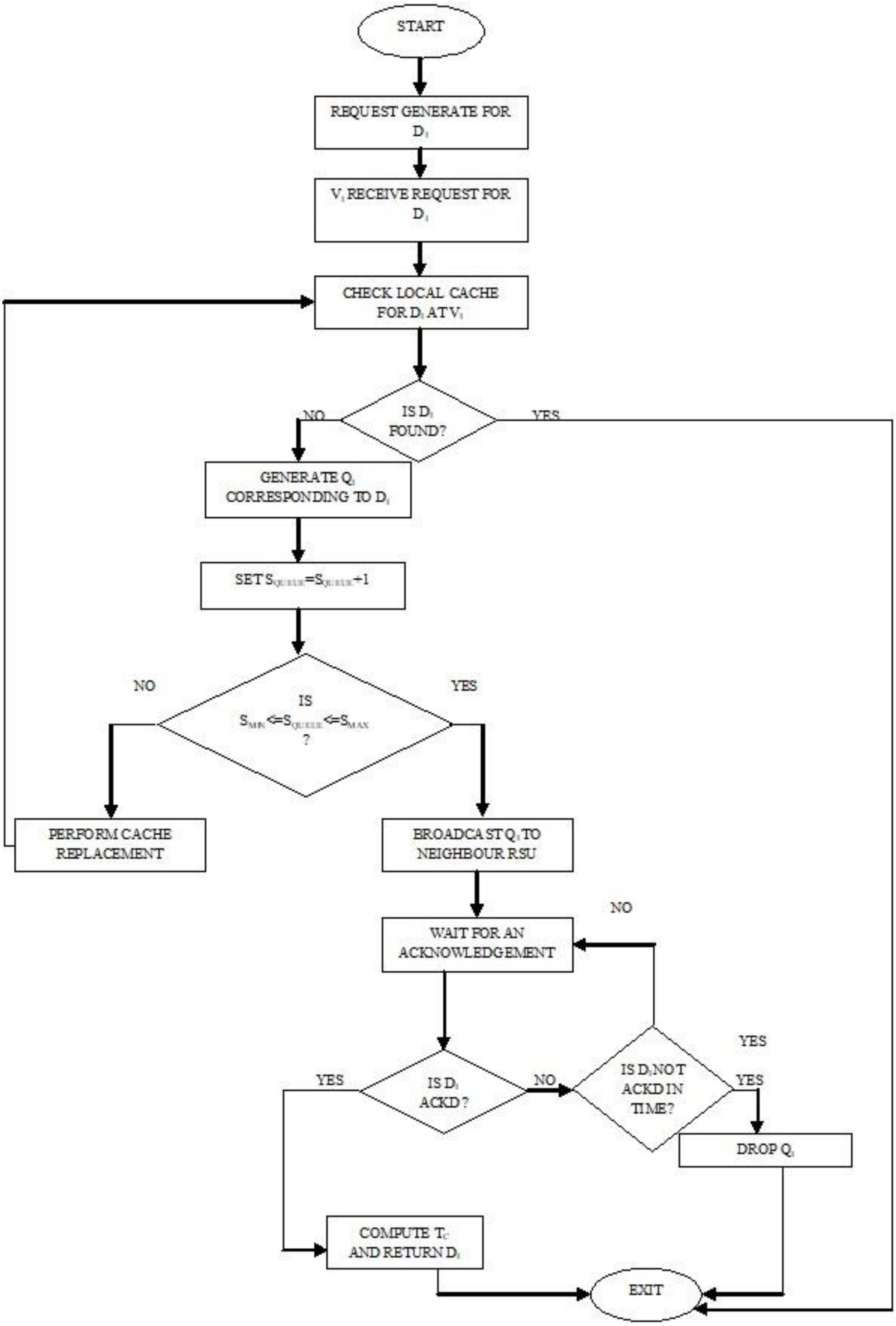

Figure 3.2: Flow chart of Existing Scheme

Algorithm of existing scheme:

if Request to find D_i arrived at V_i **then**
    Check the local cache of V_i
    if D_i found **then**
        Return D_i found
        Exit
    else
        Generate Q_i corresponding to D_i
        Set $S_{queue} \leftarrow S_{queue} + 1$

        if ($S_{min} \leq S_{queue} \leq S_{max}$) is not satisfied **then**
            Perform a cache replacement with π
            Continue
        else
            Broadcast Q_i to all other vehicles
            while Wait for an acknowledgement with D_i **do**
                if D_i acknowledged **then**
                    Compute t_C
                    Return D_i acknowledged
                    Exit
                end if

                if D_i not acknowledged in a given time **then**
                    Drop Q_i
                    Exit
                    end if
            end while
        end if
    end if
end if

As shown in Figure 3.1, the probability with respect to each state is calculated. For getting a reply in real time, requested data is generally looked for in the cache of closer vehicle, in accordance of which, the setting of query's characteristics are done, for example ID of the vehicle, begin and finish time, and ID of the requested data. Firstly, a query for the requested data id is generated by the user. A queue is maintained, in which the upper and lower values are set for every vehicle, in order to keep track of all the requests created either for same data ID or different data ID. Depending upon the length of queue i.e. if the length is between the upper and lower fixed value, the queue is accepted and the data item for which the query is generated is searched and the point to start the request is set. If the vehicle could not find the searched data item in its local cache then it disseminates the query generated for particular information to all the vehicles and waits for a particular time of the acknowledgement from other vehicles.

Following are the steps of the algorithm: A request is transmitted to all the vehicles along with the ID of the vehicle and an acknowledgement is waited. In case, if there is no reply received then the request is discarded, otherwise every intermediary vehicle looks into the cache which every vehicle maintains locally, for searching the requested data in it. If the data is found then the vehicle replies back, or transmit the results on vehicle to another in a cooperative manner. In a particular region, all the vehicles are searched for the data. Now, in the second phase after receiving the acknowledgement, space is made available for new data. If there is not enough space to accommodate the new data, then the nearby RSU is requested. If the nearby RSU responds to the request sent then the message is transmitted to the requesting vehicle. Else the vehicle enters into the update state and the value of time is incrementing. In this way the queries are replaced in the cache of vehicle. If the size of the queue is larger than the threshold value, then it gets into the state of waiting and few data items in the cache are replaced with the ID of vehicle, rate of use and ID of data. The replacement of cache needs the ID of vehicle, rate of data use, and ID of the data. For every data, probability is computed using (IV), and data item with a least probability is replaced as computed in (IV).

$$\pi = \frac{1}{t_w D_i \theta \tau_{\text{interval}}} \quad \text{(IV)}$$

3.2 Objectives of the Study

Let $V = \{V1, V2, \ldots, Vn\}$ denote the vehicles in the network. $D = \{D1, D2, \ldots, Dn\}$ and $Q = \{Q1, Q2, \ldots, Qn\}$ are respectively the identifiers for the data (IDs) and requests made for particular information which can be cached during the period of communication. Every request for a particular information has the following metrics $\{V_i, D_i, \theta, \rho, \tau_{\text{interval}}\}$, where ρ and θ respectively are rate of use and chance of accessibility of the information in a time interval τ_{interval}. The request is sent to RSU under which a vehicle V_i falls. When RSU receives the request for a particular data, it looks into its local cache for the requested data. If the requested data is there in its local cache, then the RSU replies. Else, the request enters into a waiting state. If after some time the requested data is available, the request is responded to the vehicle which sent it, by the time RSU will send same query to other RSU to find and locate data item D_i. Every request's progress is observed by start time τ_{start} and update time τ_{update}. The period for handling the request is considered as the subtraction of τ_{start} and τ_{update}.

As the number of vehicles increase on the road, collecting the information and distributing it becomes a cumbersome task in order to deliver the packets in time because of the network congestion. A wise move is therefore required to pick the finest path which offers least delay for the efficient delivery of information. Hosts containing both the RSU and hosts needs transmit the data in a P2P fashion to the neighbouring nodes in order to rapidly adopt the road conditions. Instead of establishing inter node communication where any data unit D_i get searched from one node to other, we can establish and involve RSU to achieve the same aim. This will cause reduction in communication delay as well as network congestion. Because of the fact that RSU units are much more capable to communicate and deliver information in long distance so we can take use of this feature. All this should not overburden the network as the ultimate aim of the network is to provide the continuous services to all the vehicles in motion. Therefore a specific method is required to make the vehicles share the data with each other without overburdening the network.

To deal with the said matters and to make the vehicles use the data while in motion, caching of the data can be used. In this, commonly used information is placed at some nearby site in order to decrease the burden of the server. As the queries are now responded from the nearby sites, the latency to access the information is decreased. But at the same time, managing the data in the cache for supplying it to the vehicles in vehicular ad hoc environment is a great challenge. The information renewed on the vehicles must also be supplied to the nearby storage area for example cache so that, always the latest data is supplied to the user whenever the user requests so.

The main objectives of the study are:

1. To deploy a new Fast Interacting Ad Hoc on demand Distance Vector routing (FIAODV) algorithm.
2. To develop an analytical model in order to establish communication between the vehicles and RSUs by placing cache at both RSU and vehicles. So that data

requests can be served more quickly than when there is no cache either on vehicle or RSUs (i.e. AODV protocol).

3. To do performance analysis of newly proposed protocol i.e. FIAODV and to show that FIAODV performs better than existing AODV with respect to time delay, packet delivery ratio and throughput.

3.3 Research Methodology

Traffic Model

2-D traffic model is considered in our scheme. In this scheme, clients can go bidirectional and frequently used information can be located at vehicles, RSU. A gateway is used in to offer a variety of services to the moving vehicles for example users can either send or receive the data while in motion.

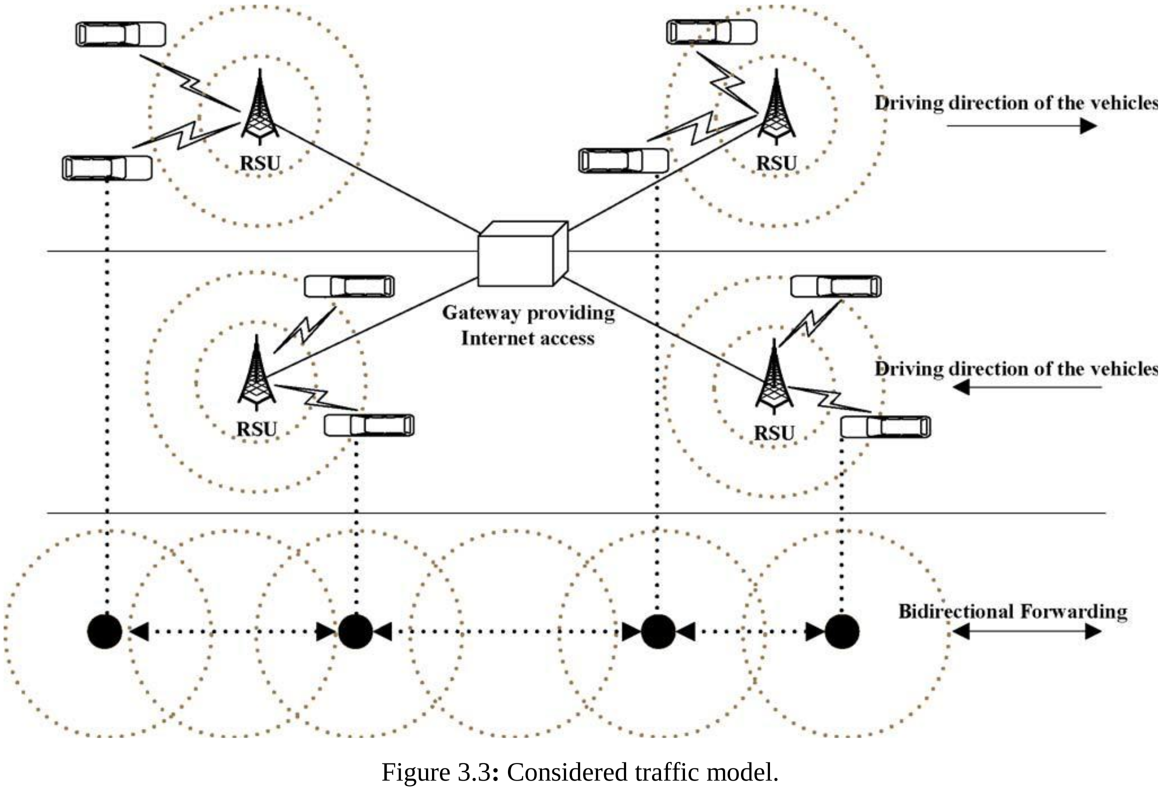

Figure 3.3**:** Considered traffic model.

RSUs are fixed in multiple locations in the case of vehicle to infrastructure communication. The data is sent or received to the server constantly or after some fixed time intervals. In case of vehicle to vehicle communication, every vehicle sends and receives data from one another cooperatively. In the proposed scenario first kind of communication is considered in which there is communication of vehicles among themselves as well as with RSU for information sharing without burdening the server due to which throughput of the system is improved to great extent.

Instead of P2PCC in V2V communication P2PCC in V2I communication is adopted, i.e. cache will now also be maintained at RSU and vehicle V_i demanding for data D_i will first search for data in its local cache, in case it does not have that data, it will ask for RSU_i under whose range vehicle V_i comes to provide with the data, if the data will be available in the cache of RSU_i it will send it back otherwise, will perform RSU to RSU communication to ask for the data D_i from other RSUs, as the data will be received by query generating RSU i.e. RSU_i it will serve the demand of vehicle V_i demanding for it.

In this manner, load on the network infrastructure will be reduced as V2I communication will help serving more requests per unit time than V2V because RSUs will be having more processing speed than a vehicle, large-sized cache than a vehicle and much more battery power, thus if more number of data requests will be served per unit time, dissemination task will be done faster leading to lower dissemination delay and thus increasing the throughput w.r.t. Packet Delivery Ratio.

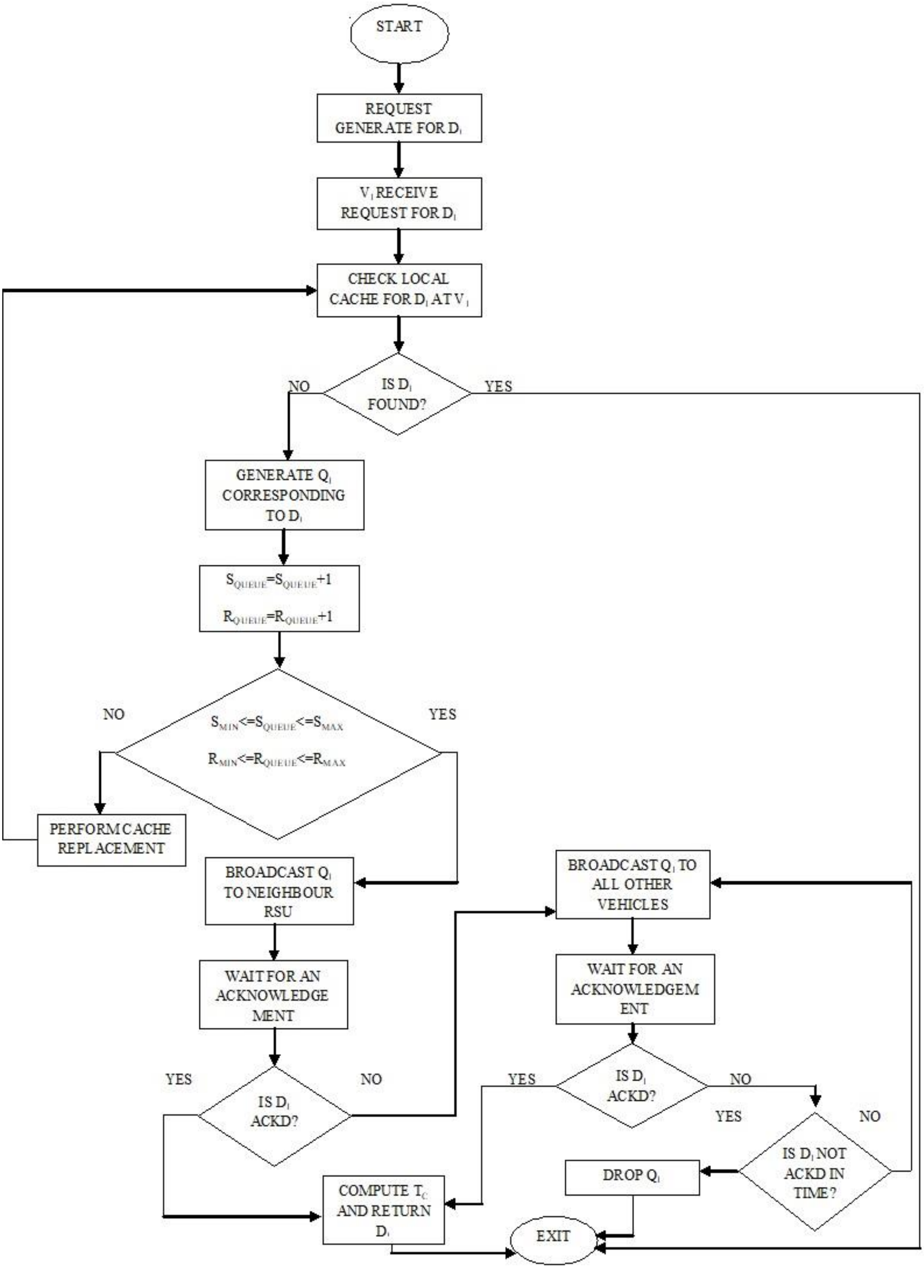

Figure 3.4: Flow Chart of Proposed Scheme

Algorithm of Proposed Scheme (FIAODV):

```
if Request to find Di arrived at Vi then
    Check the local cache of Vi
    if Di found then
        Return Di found
        Exit
    else
        Generate Qi corresponding to Di
        Set Squeue ← Squeue + 1
        Set Rqueue ← Rqueue + 1

        if (Smin ≤ Squeue ≤ Smax || Smin ≤ Rqueue ≤ Smax) is not satisfied then
            Perform a cache replacement with π
            Continue
        else
            Broadcast Qi to Neighbour RSU
            while Wait for an acknowledgement with Di do
                if Di acknowledged then
                    Compute tC
                    Return Di acknowledged
                    Exit
                else
                    Broadcast Qi to all other vehicles
                    while Wait for an acknowledgement with Di do
                        if Di acknowledged then
                            Compute tC
                            Return Di acknowledged
                            Exit
                        end if
                        if Di not acknowledged in a given time then
                            Drop Qi
                            Exit
                        end if
                    end while
                end if
                if Di not acknowledged in a given time then
                    Drop Qi
                    Exit
                end if
            end while
        end if
    end if
end if
```

Firstly, a query for the requested data id is generated by the user. A queue is maintained, in which the upper and lower values are set for every vehicle, in order to keep track of all the requests created either for same data ID or different data ID. Depending upon the length of queue i.e. if the length is between the upper and lower fixed value, the queue is accepted and the data item for which the query is generated is searched and the point to begin the request is set. If host could not find searched data item in its local cache then it disseminates the query generated for particular information to all the vehicles and waits for a particular time of the acknowledgement from other vehicles.

Following are the steps of the algorithm: A request is transmitted to the all RSUs along with the ID of the vehicle and an acknowledgement is waited. In case, if there is no reply received then the request is discarded, otherwise every intermediary RSU looks into the cache which every RSU maintains locally, for searching the requested data in it. If the data is found then the RSU replies back, or transmit the results from one RSU to another in a cooperative manner. In a particular region, all the RSUs are searched for the data.

Now, in the second phase after receiving the acknowledgement, space is made available for new data. If there is not enough space to accommodate the new data, then the nearby RSU is requested. If the nearby RSU responds to the request sent then the message is transmitted to the requesting vehicle. Else the vehicle enters into the update state and the value of time is incrementing. In this way the queries are replaced in the cache of vehicle. If the size of the queue is larger than the threshold value, then it goes in the state of waiting and few data items in the cache are replaced with the ID of vehicle, rate of use and ID of data. The replacement of cache needs the ID of vehicle, rate of data use, and ID of the data. For every data, probability is calculated using (IV), and that data item with a least probability is replaced as computed in (IV).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Experimental Results

The tool used for simulating and evaluating the proposed scheme is Network Simulator 2. Network Simulator 2 is an open source and very famous simulator. NS2 is an object-oriented, event driven network simulator. It uses C++ and Tcl. These two programming languages are used for a reason. The interior features of these two programming languages are the main reason of why they are used. C++ is capable of implementing the proposed scheme, but showing the results visually and graphically is not easy in C++. In the field of research in networks, organizing a complete test environment consisting of many connected computers, data connections and routers will become very expensive to verify the results of a protocol or algorithm. In these situations, network simulators can help completing this task that too in cost and time efficient manner. Network simulator also allows the designers of networks to test the existing or changed protocols in a managed way. In general, real world networks are tried to be modelled by the network simulators. The basic idea is that by creating a model of the system, its characteristics can be altered and the consequent results can be examined. The metrics of simulation are provided in Table 4.1.

PARAMETER	VALUE
NUMBER OF VEHICLES (NODES)	500
AVERAGE VELOCIIY OF VEHICLES	20-40 miles/h
PERIOD OF TRAFFIC LIGHTS	60 sec
WIRELESS COMMUNICATION RANGE	300 m
QUERY INTERVAL	10 sec
SIZE OF NODE CACHE	4 MB
SIZE OF RSU CACHE	8 MB

Table 4.1: Used Parameters and values

Figure 4.1 shows the variation of the packet loss in AODV and FIAODV, Figure 4.2 shows the variation in the throughput of both the schemes and Figure 4.3 shows the variation in the delay of both the schemes.

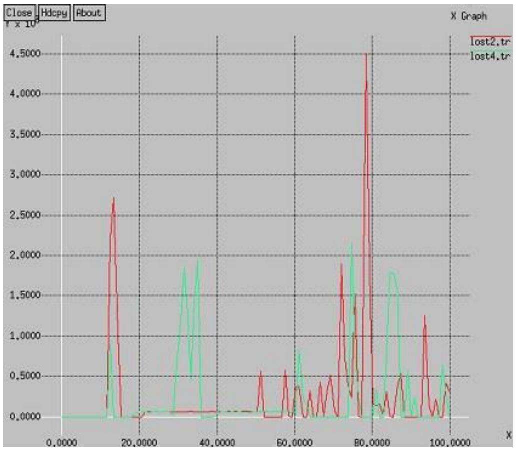

Figure 4.1: Packet Loss

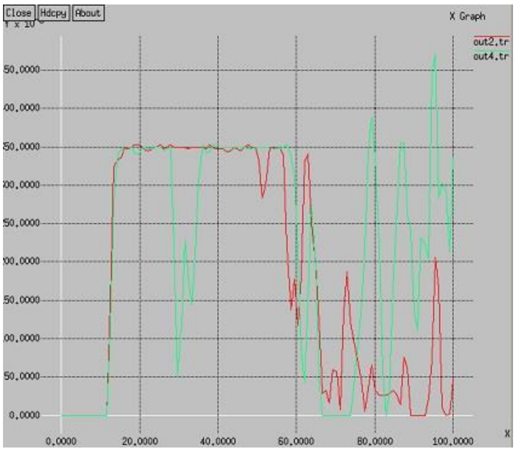

Figure 4.2: Throughput

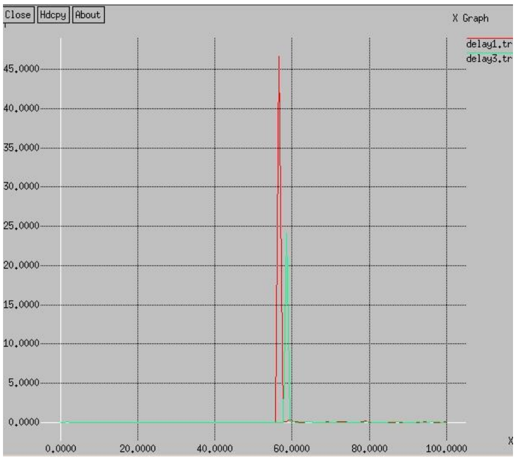

Figure 4.3: Delay

Packet Loss: As the data will be accessed from either local cache or nearby RSU's cache in FIAODV so the request will not be flooded in the whole network due to which medium will not be congested and less collisions will occur thus leading to less packet loss.

Throughput: In FIAODV, the amount of data delivered from the source to the destination in a particular amount of time is more because there is less congestion in the network which means less collision that ultimately leads to high throughput.

Delay: Delay is reduced in FIAODV because the request is served from either local cache or nearby RSU's cache.

4.2 Comparison with Existing Technique

We have evaluated the proposed scheme and performed the comparison with the existing AODV protocol in terms of Packet Delivery Ratio, throughput, delay. As shown, the proposed scheme, FIAODV, has better performance in terms of all the above mentioned parameters as matched with the AODV. For illustration, as the time passes, the average packet loss of AODV is more than the proposed scheme i.e. FIAODV, as the propossed scheme suggests for caching and probing of info in the local cache and if data not found in local cache then searching on RSU. So there is no requirement of calling the server. This will help to balance the load in the network, ultimately leading to less packet drop and hence enhancing the throughput with the reduced access time.

AODV Vs FIAODV (at multiple iterations)

At multiple iterations AODV is compared with FIAODV with respect to throughput, packet delivery ratio and delay. The results are captured in the tables, for every iteration and graphs are plotted.

SERIAL NO.	AODV(in gbps)	FIODV(in gbps)
1	3.31	4.41
2	3.54	3.74
3	4.52	4.41
4	3.93	3.42
5	4.18	3.98
6	3.16	4.05
7	3.97	3.99
8	3.12	3.24
9	3.26	3.82
10	3.44	4.28

Table 4.2: Throughput (At Iterations)

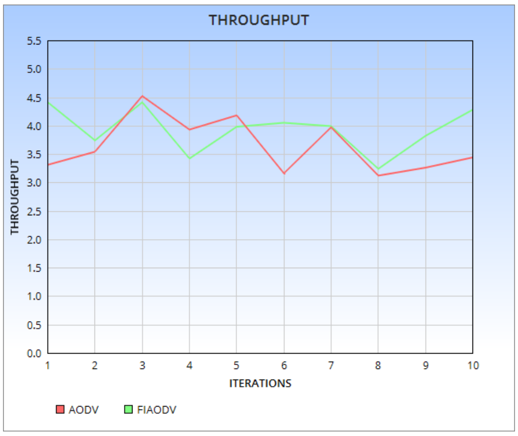

Figure 4.4: Graph of Throughput (At Iterations)

SERIAL NO.	AODV	FIODV
1	30.64	29.93
2	26.55	23.01
3	27.91	26.46
4	21.32	27.13
5	29.84	28.41
6	27	28.62
7	24.49	22
8	21.74	26.34
9	26.59	27.42
10	25.67	29.69

Table 4.3: Packet delivery ratio (At Iterations)

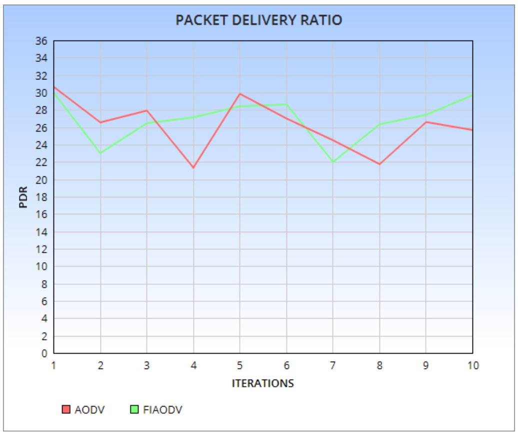

Figure 4.5: Graph of Packet Delivery Ratio (At Iterations)

SERIAL NO.	AODV	FIODV
1	55.65	52.22
2	54.92	53.85
3	54.60	52.49
4	53.92	53.54
5	56.18	54.42
6	55.40	54.63
7	54.81	54.75
8	53.39	52.91
9	55.95	55.45
10	55.48	52.82

Table 4.4: Delay (At Iterations)

Figure 4.6: Graph of Delay (At Iterations)

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

Now a day, maintaining of cache is greatly applied in order to mitigate collision problem and to balance the load on the network. A novice scheme is suggested for communication among vehicles in vehicular ad hoc environment. The data is disseminated among the vehicles using local cache as well as RSU's cache. Whatever data that vehicles share with each other for example routing information etc, is cached efficiently in the given proposal. So whenever any vehicle in a particular area request for that particular data, it is made readily available to that vehicle. This info is utilized at any time a request is made in any area. The new proposed scheme is compared with AODV with respect to the parameters such as packet delivery ratio, throughput and delay. The results show that the proposed scheme has reduced the congestion and increased the packet delivery ratio and throughput significantly.

5.2 Future Scope

This scheme can further be enhanced by using a proxy server that will access the data for the vehicles while they are in motion. A proxy server will behave like a mediator between a user who is requesting and a server. Whenever a request will be received by a proxy server from the vehicle for a data it will check into its local cache for the data. If the data is found, the proxy server sends it back to the vehicle and will not forward the request ahead to any RSU. But if the data will not be there in its local cache, then the proxy server, on behalf of the moving vehicle, will request the data from other RSUs. When the request is served, the proxy server will check the original request and forward the reply back to the requesting user.

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