OPTIMAL ROUTING PROTOCOL FOR VEHICULAR AdHoc NETWORKS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE
OF

MASTER OF TECHNOLOGY

IN

SOFTWARE ENGINEERING

Submitted By:

RAJIV KUMAR

(2K18/SWE/14)

Under the supervision of
Dr. Vinod Kumar

DEPARTMENT OF COMPUTER SCIENCE
DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
Bawana Road, Delhi-110042

JUNE, 2020

CANDIDATE'S DECLARATION

I, Rajiv Kumar, Roll No. 2K18/SWE/14 student of M.Tech Software Engineering, hereby declare that the project Dissertation titled "Optimal Routing Protocol for Vehicular AdHoc Networks" which is submitted by me to the Department of Computer Science, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any degree, Diploma Associateship, Fellowship or other similar title or recognition.

Place: Delhi

Date: 26/06/20

Rajiv Kumar

CERTIFICATE

I hereby certify that the Project Dissertation titled “Optimal Routing Protocol for Vehicular AdHoc Networks” which is submitted by Rajiv Kumar, Roll No. 2K18/SWE/14,Software Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi

Date: 06/08/20

Dr. Vinod Kumar

SUPERVISOR

ACKNOWLEDGEMENT

I express my gratitude to my major project guide Dr. Vinod Kumar, Dept. of CSE, Delhi Technological University, for the valuable support and guidance he provided in making this major project. It is my pleasure to record my sincere thanks to my respected guide for his constructive criticism and insight without which the project would not have shaped as it has.

I humbly extend my words of gratitude to other faculty members of this department for providing their valuable help and time whenever it was required.

RAJIV KUMAR

Roll No. 2K18/SWE/14

M.Tech (Software Engineering)

ABSTRACT

.

Through this research work,I propose an optimised routing protocol which significantly reduces packet transfer time and can be used for faster communication in real life scenario.The existing routing algorithms demand optimization for the purpose of Vehicular Ad-Hoc Networks as traffic congestion increase rate over powers the rate of infrastructure development and a millisecond error in traffic management network could lead to disastrous outcomes..Therefore,there is a need for developing a improved algorithm which reduces run time and help the existing ones.Various relevant data is retrieved by multiple run up of the algorithms and graphs are plotted to show the comparison results.

.

CONTENTS

List of Figures

List of Tables

CHAPTER 1 INTRODUCTION

Vehicular AdHoc networks(VANETs) is now seen as the epitome of vehicular communication. Early usage of VANETs were recorded in 2001 under ”car-to-car ad-hoc mobile communication and networking” applications, where forming networks is a prime requirement alongside cars relaying the information amongst each other.The communication between one vehicle to the other is required on the same scale as that of communication between the roads and the vehicles These communication methodologies combine together in the VANET ecosystem to provide an array of services on the road and easing transportation system.

Various possibilities are already being investigated to explore the future potential of this technology.Early preparation and research work is also being carried on simultaneously to make the future model highly sustainable by improving energy efficiency in localization accuracy of wireless sensor networks.

A major portion of the transmission is likely to be occupied by various overheads, since they are periodically transmitted by all vehicles. As a result, many routing algorithms focus on the optimization of the transmission parameters of them. Various routing protocols are well established already for Mobile AdHoc Networks(MANETs) but VANETs need a complete different set of framework for optimized usage.We are proposing a Re-Route Routing Protocol which is made possible by a dynamic density graph of vehicles present.Once the vehicles have an idea of the traffic density,these same algorithms are able to perform with higher efficiency as number of redundant packet transfers are reduced.

CHAPTER 2 ROUTING PROTOCOLS

Routing is the central issue in networks where transfer of data between network nodes is of prime requirement.Routing protocols are a continuous area of research and development and new routing protocols keep emerging as an improvement to the already established routing protocols

.

2.1. Ad-Hoc On Demand Distance Vector

In AODV, networks do nothing and wait for connections to be established.Network nodes requiring to connect broadcast a request for connection.Nodes which are not a part of a specific route are not supposed to keep information regarding the specific route. Hence,these nodes are not able to enable flow of topology-update packet or in other words,these nodes only contain the details of the route they stand in. In a scenario,where the originator node currently has some information data ready for transmission to a destination presently not known, it scatters a packet Route Request (RREQ) throughout the network.For every intervening nodes, when an R-REQ is received,it identifies the presence and location of the source node and is able to predict a traceback path to the source . If the receiving node finds out that it has received a unique R-REQ and it further identifies that the final sink node must be somewhere else and it is not the sink node for this specific packet and therfore it just floods the network with this packet so that it could reach where it was aimed for.Types of R-REQ are - R (Repair flag),G (Gratuitous RREP flag),D(Destination only flag),U(Unknown sequence number). However,if the final recipient node confirms itself to be the sink node or it knows the path to the final destined node , then a Route-REPLY(R-REP) is simultaneously generated as the output.The R-REP acts as a unicast packet and follows a network trend of hop-to-hop to the source where the information is received by each intermediate nodes in the backtracking path. As the R-REP is slated to reach each of them, they create a route to the destination. When the R-REP is received by the destination, the path to the destination is recorded and hence now it can start to send data. Types of R-REP are - R(Repair flag),A (Acknowledgement required) and Reserved(Sent as 0). The Route Reply Acknowledgment (RREP-ACK) message is delivered as a reply to a RREP message by setting a bit which is mostly done when single direction links hinders the process of route discovery.

In cases of a failure of link , a R-ERR(Route Error) packet is sent. Its types are - N(no delete flag),Reserved(Sent as 0),DestCount(No. of destinations not reachable,sent as 1),IP address and Sequence number of unreachable address

2.2. Destination Sequenced Distance Vector Routing

In DSDV packet delivery rate decreases significantly and one of the major causes for it is the use of already stalled routes in case of links being broken. In DSDV the presence of stalled routes does not necessarily mean that path upto the destination could now not be figured out. Various other neighbours that could have a recorded path to the destination can be put to use in such a scenario.

DSDV routing needs every node to maintain a table comprising all the other nodes which it may have known directly or could have been introduced by one or more of its neighbours. Every node has a single entry in the routing table. This entry contains all the necessary information about the node such as its IP address, last known sequence number and the hop count to reach that node.From the table only detail of its neighbour which would form the next hop in current route will be retrieved.

2.3 Optimized Link State Routing Protocol

OLSR is different from the above distance vector routing protocols. OLSR declares a predefined methodology for transfer of messages to other nodes, using the process of optimizing to reduce the overhead as well as transfer time. For the purpose of synchronization, jitter could be used while a message is forwarded.For fulfilling this purpose,a random time period is selected to cache the message,only then it is forwarded. The Optimized Link State Routing Protocol is in particular developed for adhoc networks like mobile or vehicular.It uses a table and is involved in constant exchange of information with other nodes such that all the nodes of the system form a proactive mode of communication.

2.4 Dynamic Source Routing

One of the better on demand protocol that is in extensive use currently is DSR.This routing mechanism takes extra efforts in order to reduce the overall consumption bandwidth.It does so with the use of control packets.A significant advantage that it holds over the other routing protocols is that it does not need to update the routing table at each of the nodes dynamically and frequently.

In DSR the network is given the freedom to be organize and configure itself as it suits, without the demand of any additional facilities to the network. The protocol primarily consists of two major methods i.e. ”Route Discovery” and ”Route Maintenance”, both of which perform the task handin-hand facilitating in finding newer paths within the network to the destination or,if the path is already found,then maintain those paths to random destinations.If this kind of routing is not used ,then there may be unnecessary creation of loops in the paths.Also,this helps in cases where the current nodes does not have the latest information by using to its advantage the property of packets to store a bit of routing information within themselves.

CHAPTER 3 NETWORK MODEL SETUP

3.1 SUMO(Simulator for Urban Mobility) Software

It is an open source software licensed under EPLv2 which provides an easy platform for simulating the land mode of transportation .It creates a simulation wherein the vehicles will be treated as nodes and with pedestrians in view,a network is created.It comes with an improvised tools setup which provide a very handy platform for creating various scenarios which a researcher could think for their experiment.

For the purpose of our experiment and due to power and memory limitations,we selected a sample area in New Delhi, using open street maps.We have used osmWebWizard python file to generate the following scenario with a run on firefox browser..For implementing our manual routing algorithm, we needed an external API TraCI(Traffic Control Interface) which uses a TCP based Client/Server architecture and provides us with additional command line options.Using this API, multiple clients are able to connect at a time and more than one command will run in an automated sequence which sets up our changing number of vehicles and route map.

Fig. 3.1: A snapshot of area selection in open street maps

3.2 ns3.30

We have used network simulator version 3.30 for the purpose of simulating the network and generating required data for analysis.Under this,we included the module for NetAnim 3.108 for the purpose of animating our network scenario and observing the packet flow in the network while our simulated vehicles communicate among each other.Using ns 3.30 we have simulated vehicle movements by uploading the map and vehicles setup first.

We have taken use of the mobility-trace.cc file from the ns 3.30 directory to incorporate the Net-Anim simulator code to be run directly from the ns-3.30 simulator.We have further created a object.tcl file in the same directory which would help us in creating our own defined scenarios for each of the protocols we have used from the same source file with just a simple creation of a new object instance.

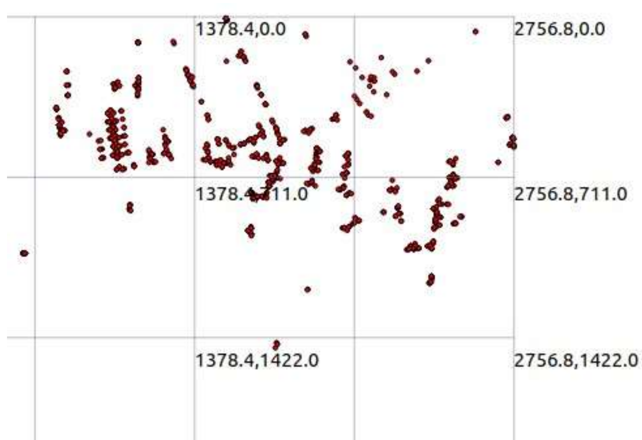


Fig. 3.2: NetAnim snapshot showing vehicle movement and communication through one of the routing protocols

CHAPTER 4 EXPERIMENTAL PROCEDURE

We develop a smart routing protocol using network flow graph as our base and dynamic updation of vehicles is attempted using density parameters.

4.1 Design

The development of this protocol firstly requires the property of vehicles to identify itself on whichever surroundings it is present.This can be done with the help of GPS system in vehicles.Also,each vehicle can transfer the information of its starting and ending point so that two predefined nodes can be setup beforehand.The proposed model can be implemented using a central cloud server.Once each vehicle is aware of its location,we now need a central weighted network graph where data of each vehicle is put up and using these data as node points the graph can be updated in real time.As soon as the traffic density reaches a predefined threshold, the vehicle will be notified to try an alternate route for packet transfer so that at a time one vehicle would not be loaded with multiple receive requests and waiting time for packets could be significantly reduced.

4.2 Implementation

Suppose a route that vehicle takes consists of different roads. R=R1,R2....Rn where R1 will be the starting point of the vehicle and Rn will be the ending point.On each street change the declared set of parameters for a vehicle- V_i,R_i,P_i is simultaneously updated ,where V_i is the unique vehicle identity number ,R_i is the current road on which the vehicle is travelling and P_i is the receive/request status of the packet transfer between two vehicles. This information is stored in a central database and as soon as a new set of parameters appear for a given vehicle identity number the old set is accordingly replaced with the new one ,so that at any give time there is only one real time entry for each vehicle present on the network.

The roads are represented using a directed weighted graph with each node representing an intersection point in the street and each directed edge represents a vehicle along with its direction.

Parameters	Values
Simulation Map	New Delhi
Simulation Area	2200*25 m^2
Simulation Time	10000 seconds
Speed of vehicles	5-60 km/h
Density of Vehicles	2000-8000

Table 4.1 Configuration parameters of the proposed model

At any time flow(x) of vehicles on a street needs to be determined using the below equation

$$x = dln(\frac{D}{d}) \quad (1)$$

where D is the max density of vehicles on the street, and d is the current density of vehicles in the street.

A threshold flow value (X_0) is set to decide when the flow of vehicles is increased to an extent such that packet transfer efficiency gets reduced significantly.

We further define a function which assigns value to parameter on the basis of density and flow.For our experiment, function

f = 0(If d=0) ,

else f = 1 (if 0<D <0.4*N)

where N is the maximum number of vehicles at all times. Depending on f, we update our edge weights in the weighted graph.This is done continuously to ensure packet transfer efficiency is maintained throughout

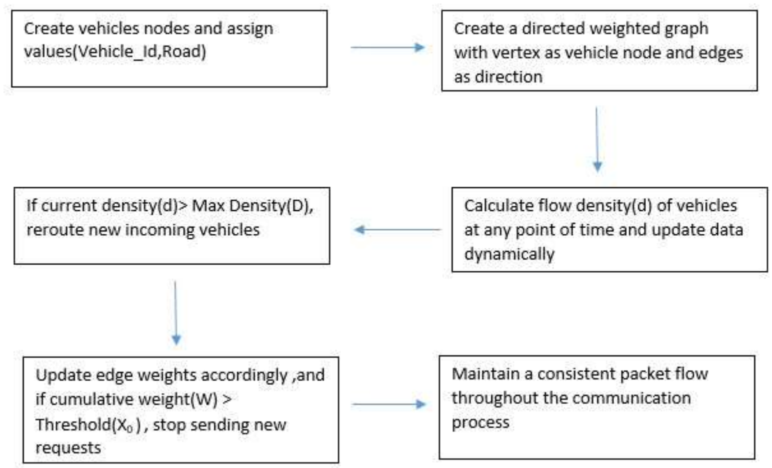
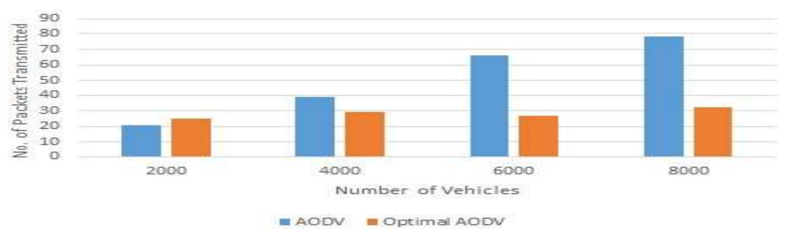


Fig 4.1 Flowchart depicting implementation process

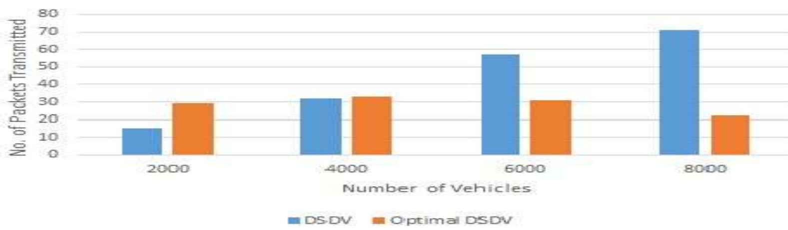
CHAPTER 5 EXPERIMENTAL RESULTS

5.1 Number of Packets Transmitted

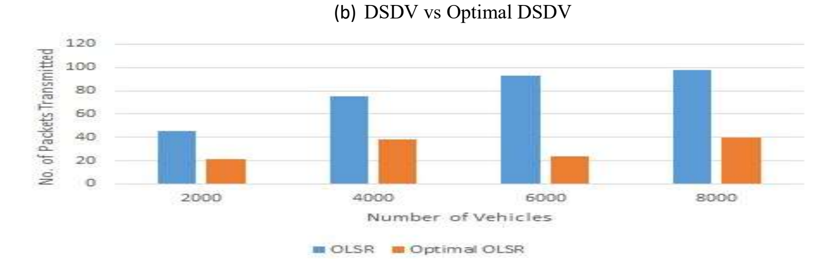
The number of packets transmitted varies depending upon network characteristics and the number of vehicles.However, the optimal routing protocol is able to maintain a constant packet transfer ratio across conditions.As we see in Fig 3, the number of packets transmitted keeps on increasing for the original algorithms.With very high number of vehicles this would create a lot of network constraints and would certainly breach the network capacity limit at some point of time.The working of optimal algorithm is such that it quickly distributes the network load to other edges in the graph , which translates to switching network packets to other vehicles having lower request/receive accumulation.The optimal protocol maintains a consistent number of packets being transmitted for all cases.Even when the number of vehicles is increased,the optimal protocol quickly identifies the receive/request status of multiple vehicles and does not allow stacking of large number of packets at a single node.Through efficient distribution of packets throughout the network,it ensures that a practical transmission rate is achievable.We see that without the use of optimal algorithm ,the number of packets transmitted keeps on increasing as we increase the number of vehicles.In a VANET ,there will be huge number of vehicles in a single route and hence these protocols are bound to get slower and increase traffic resistance.



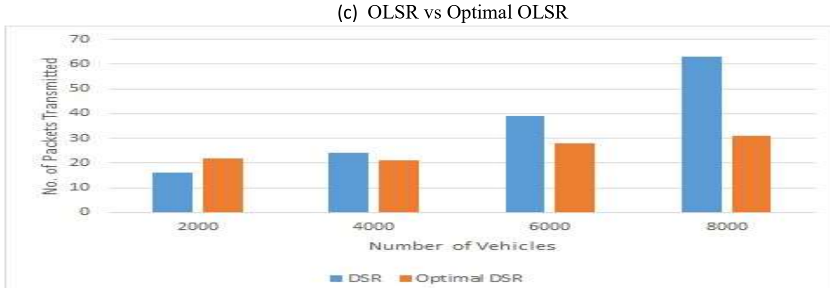
(a) AODV vs Optimal AODV



(b) DSDV vs Optimal DSDV



(c) OLSR vs Optimal OLSR



(d) DSR vs Optimal DSR

Fig. 5.1: Number of Packets Transmitted

5.2 Mac/Phy Overhead

PHY layer provides the maximum throughput achievable for a given channel and PHY parameters. It could be far from the speed and user experience. MAC layer throughput tales into account the MAC overheads and inefficiencies in accessing the channel when there are a lot of nodes/CPEs communicating to an AP. The best algorithm should have very less overhead as more overhead means more time,memory and power utilization.As seen in the graph,the DSDV protocol is found to have the most overhead,while DSR protocol has the lowest and hence could be called as the best on this attribute.Other two protocols have average performance on this regard.The optimal protocol simulation shows that it can lead to lower Mac/Phy overhead which could improve network efficiency.

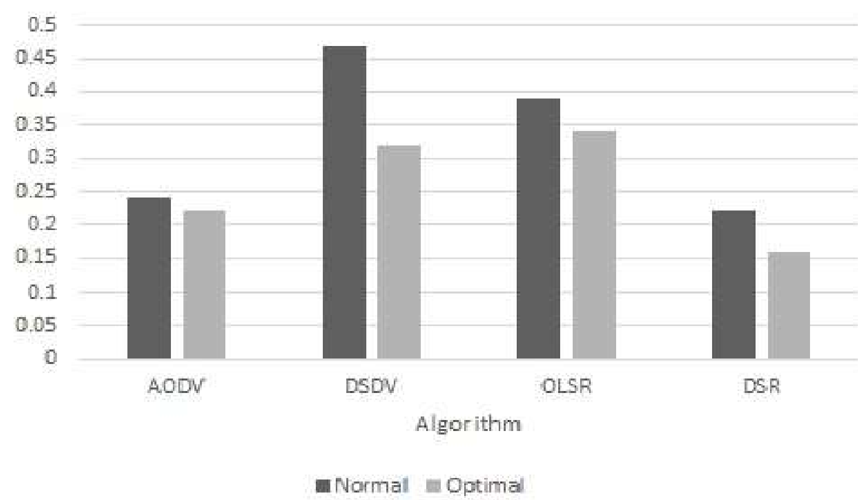


Fig. 5.2: Mac/Phy Overhead of the routing protocols

5.3 Average Routing Goodput

Goodput is calculated when the original data is divided by the transfer time. For example, a 50 megabyte file may require 3000 kilobytes of header information and acknowledgements to be sent during the data transfer process. Therefore, the goodput would be roughly 50 megabytes divided by the transfer time and throughput would be 53 megabytes divided by the transfer time.Goodput is different from throughput as throughput is concerned with the overall data whereas goodput is concerned only with the good data i.e. the data which is useful,and the other overheads such as header,checksum data etc.In this factor ,OLSR and DSDV protocol are comparable whereas the other two protocols are worse than these.The running of optimal protocol leads to average routing goodput significantly higher than when used without the optimality.As every microsecond is equally precious in case of vehicular adHoc networks,therefore our optimal protocol achieves better result in this regard.

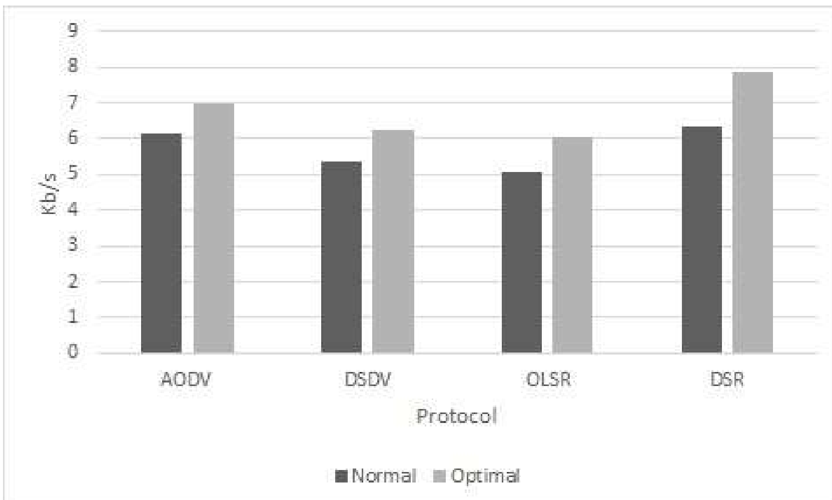
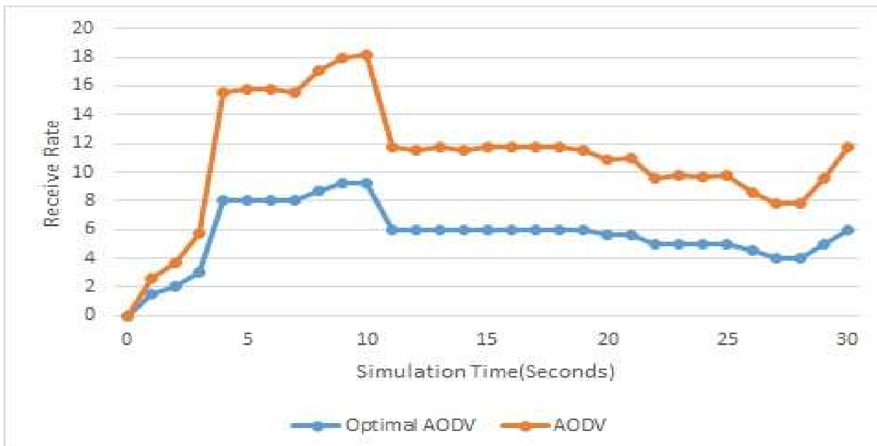


Fig. 5.3: Average Routing Goodput of the routing protocols

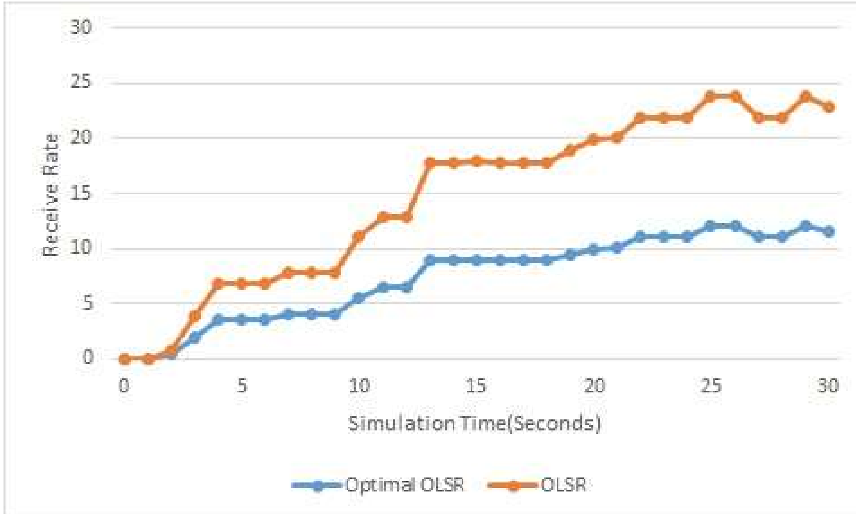
5.4 Receive Rate Comparison

The average simulation time for each protocol was about 30 seconds.For 30 seconds,receiving and sending of packets was observed and data was extracted to calculate the receive rate of each.It was then plotted on the graph,to draw a comparison between the routing protocols.As we can see from the following graph,OLSR protocol has little deviation from the other two during start of the simulation whereas in the middle phase,each of the protocols are observed to have a similar receive rate.After about 20 seconds,stark and visible variations start to occur in the graph where AODV protocol begins to show higher receive rate than other two protocols.Overall it seems that DSDV would be a good choice on this attribute with its lower overall receive rate.The optimal DSR protocol does not give any conclusive evidence that it works superior than the DSR protocol ,but on observing the average receive rate ,it can be clearly deduced that it holds significant advantage.For the other three protocols there is stark variation in receive rate of the optimal protocol wherein it shows reduced rate throughout the simulation of 30 seconds.The optimal OSLR routing gives an overall best performance in this regard.

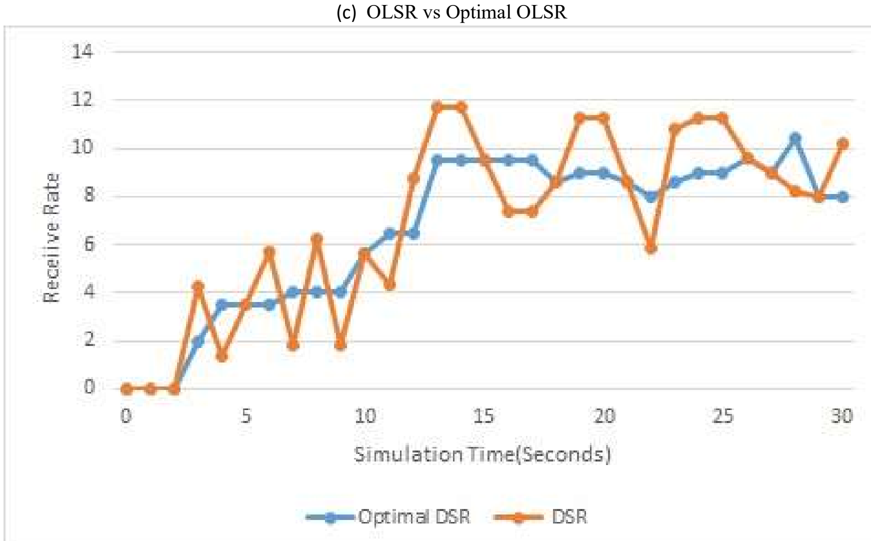


(a) AODV vs Optimal AODV

(b) DSDV vs Optimal DSDV



(c) OLSR vs Optimal OLSR



(d) DSR vs Optimal DSR

Fig. 5.4: Receive Rate Comparison

CHAPTER 6 CONCLUSION AND FUTURE SCOPE

As we can see from the above observations,there are some protocols which perform very good on some aspect whereas at the same time is quite average in some other aspect.We can state that OLSR could be declared as overall winner by leading others in most of the aspects we have taken but still we cannot be sure it will definitely outperform others everytime. A more suitable conclusion that can be derived is that we should select our routing protocols depending on our network,memory and other constraints.Therefore,we definitely need an improved routing protocol and our proposed protocol definitely provides some highly desired improvements and we hope this could improve network efficiency to a great extent in VANETs.Looking at the constraints we can derive which aspect is more important for us.For example, if we have very low bandwidth available then we cannot have a large overhead to deal with and therefore our prime concern should be to select a protocol which has very low Phy overhead.In a similar we can approach as per our requirements.

For further research on this topic, a combination of routing protocols could be used wherein at different times of packet transfer process ,different routing protocols could be used to find an overall optimized structure.Therefore, we have tried a newer approach where all the vehicles will act as smart agents and will have knowledge of their surroundings and nearby vehicles.

A lot of improvement is still possible along the lines of this paper such as we have used a static threshold in our protocol ,where it is already predecided based on manual calculations about the network scenario and number of vehicles.Instead of this,one can use a dynamic threshold by defining the rules to declare to calculate a network threshold every time there is a change in the parameters of the network.Of course ,that would increase the time complexity of the algorithm and would need further optimizations.Also, we have proposed a central cloud server for information processing.This selection is equally debatable and a potential replacement would be installing multiple Roadside Units(RSUs) and enabling information sharing htrough them.

References

[1]. Y. Xi, K. Sha, W. Shi, L. Schwiebert, and T. Zhang, "Enforcing privacy using symmetric random key-set in vehicular networks," in Proc. IEEE ISADS, Sedona, AZ, USA, Mar. 21–23, 2007, pp. 344–351 [5] Sarkar Narul I, Lol Wilford G., "A study of MANET Routing Protocols: Joint node density, packet length and mobility", Computers and Communications (ISCC), 2010 IEEE Symposium on, pp. 515-520, 2010.

[2]. Bin Hu, Gharavi H, "DSR- Based Directional Routing Protocol for Ad Hoc networks", Global Telecommunications Conference GLOBECOM 2007 IEEE, pp. 4936-4940, 2007.

[3]. Sivaganesan, D. "EFFICIENT ROUTING PROTOCOL WITH COLLISION AVOIDANCE IN VEHICULAR NETWORKS." Journal of Ubiquitous Computing and Communication Technologies (UCCT) 1, no. 02 (2019): 76-86

[4]. S.-H. Sun, J.-L. Hu, Y. Peng, X.-M. Pan, L. Zhao, and J.-Y. Fang, ''Support for vehicle-to-everything services based on LTE,'' IEEE Wireless Commun., vol. 23, no. 3, pp. 4–8, Jun. 2016.

[5]. K. Abboud, H. A. Omar, and W. Zhuang, ''Interworking of DSRC and cellular network technologies for V2X communications: A survey,'' IEEE Trans. Veh. Technol., vol. 65, no. 12, pp. 9457–9470, Dec. 2016.

[6]. S. Wang, S. Djahel, and J. Mcmanis, ''An adaptive and VANETs-based next road re-routing system for unexpected urban traffic congestion avoidance,'' in Proc. IEEE Veh. Netw. Conf. (VNC), Dec. 2015, pp. 196–203.