

SIMULATION-BASED PERFORMANCE ANALYSIS OF VANET ROUTING PROTOCOLS IN URBAN TRAFFIC ENVIRONMENTS USING SUMO AND NS3

Wasif Muhai-ud-Din¹, Imtiaz Hussain^{*2}

¹Department of Computer Science, University of Sialkot, Pakistan

²Department of Computer Science, University of Management and Technology Sialkot Campus, Pakistan

¹wasiitp1@gmail.com, ²imtiaz.hussain@skt.umt.edu.pk

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Corresponding Author: *

Imtiaz Hussain

Abstract

Vehicular Ad Hoc Networks (VANETs) represent an emerging subset of Mobile Ad Hoc Networks (MANETs) specifically applied within the traffic sector. VANETs are becoming a crucial component of intelligent transportation systems due to their capability to enhance road safety and facilitate efficient vehicle-to-vehicle (V2V) communication. This study uses Simulation of Urban Mobility (SUMO) and Network Simulator 3 (NS3) simulator to provide an extensive performance study of VANETs routing protocols. Three well-known routing protocols are the subject of this study: ad hoc on-demand distance vector (AODV), destination-sequenced distance vector (DSDV) and optimized link state routing (OLSR) in terms of two different Friis and Two Ray Ground (TRG) propagation loss model that are used to analyze these protocols. A thorough industrial estate map of the city Sialkot, Pakistan, is obtained from OpenStreetMap and utilized in the SUMO simulator to create vehicular traffic scenarios in order to replicate genuine traffic circumstances. The routing protocols performance evaluated using the NS3 simulator, taking into account important parameters including, packets received receive rate, overhead, packet delivery ratio, and goodput. The findings show that for every parameter examined, the OLSR technique performs better as compare to DSDV and AODV. In particular, with Friis propagation model it performs better in terms of goodput and packet delivery ratio. The research demonstrate how crucial propagation models are to the effectiveness of routing methods in VANETs. The research also offers useful advice on how to use routing protocols and propagation models strategically in order to maximize VANETs performance.

1. Introduction

Sialkot is an industrial hub of sports, Hosiery, leather, surgical goods, etc. in Pakistan. This city exports such articles to fulfill the requirements of other countries all over the world. It is a very congested city with huge traffic volume. With the increase in business volume and the innovation of technologies, an intelligent transport system is required for this type of city. VANETs are one of the notable technological trends that are gaining significant attention and

greatly benefiting the development of intelligent transportation systems [1]. The amazing thing about the development is the new role of the innovation system in promoting road safety and providing protection to drivers and passenger's **Error! Reference source not found.**

In recent years, extensive research has focused on VANETs, primarily aiming to enhance communication systems between vehicles and Vehicle-to-Infrastructure (V2I) connectivity. The unique characteristics of VANETs, compared to

other MANETs, have been a central focus for many researchers. They have examined various issues such as road safety, intelligent transportation systems, quality of service, and network layers [1]. As VANETs are formed in a dynamic topology, they can be considered lively. A highly dynamic topology is a network that consists of nodes whose pattern of connection frequently changes at high speeds [1][4]. User speed and how VANETs are designed affect the frequency of accident detection and traffic management. However, VANETs communication is heterogeneous, and trip durations not only vary between urban and remote locations but can also be affected by the density of vehicles and trees [5].

Through the establishment of a V2V communication system, the VANETs provide an environment for intra-vehicle communication and coordination thereby preventing unpleasant conditions like traffic congestion and accidents. Apart from security, this capability can be used for comfort apps and security services, for example, internet access and free space in the parking area. Figure 1.1 highlights the different modes of communication within VANETs, such as Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Infrastructure-to-Infrastructure (I2I), and Infrastructure-to-Trusting Unit (TU), which represent the overall architecture of VANETs [6].



Figure 1.1. VANETs model architecture

Despite this, the research community faces several challenges in the field of VANETs, namely the high mobility of vehicles and the change in network topology due to mobility, especially on highways; the probability of the network being overloaded during transportation accidents; issues related to network security; and the difficulties associated with message routing.

1.1 Routing Protocols Overview

Routing protocols are required for the functioning of VANETs as vehicles can exchange messages with each other through them. These protocols are arranged in five categories to indicate traits and cases that are to be applied to a particular field or a use. Topology, Position, Cluster, Geocast, and Broadcast Routing Protocols are the five main group's **Error! Reference source not found.**

1.1.1 Routing Protocols based on Topology

Topology-based Routing Protocols forward packets using the network's pre-existing connections. Three further categories are created out of them: Protocols that are Proactive, Reactive, and Hybrid **Error! Reference source not found.**[7].

Proactive Routing Protocols (PRP): These routing protocols entail keeping routing data up to date in the background, independent of communication demands. For real-time applications, it may lead to minimal latency even while route discovery is eliminated. Proactive procedures include WRP, TBRPF, OLSR, DSDV, CGSR, and FSR.

Reactive Routing Protocols (RRP): These protocols, which establish routes only when needed for nodes to communicate, include DSR,

TORA, JARR, PGB, and AODV. Ad Hoc based routing bombards the network with inquiry packets during the route discovery phase.

Hybrid Protocols: It is the combination of PRP and RRP. These protocols reduce control overhead in proactive routing and lower the initial route discovery time in reactive routing. These are the goals of hybrid protocols. Two examples of hybrid procedures are ZRP and HARP [7].

1.1.2 Routing Protocols based on Position

Geographic location data is used by position-based routing protocols to identify the subsequent forwarding hop. Further, they are divided into two categories: delay-tolerant and position-based greedy V2V routing protocols [7].

1.1.3 Routing Protocols based on Cluster

Cluster-based routing works well with clustered networks, where a group of nodes forms a cluster and a designated cluster head broadcasts packets

to the cluster. Examples include TIBCRPH, CDBRP, LORA-CBF, and COIN [9]

1.1.4 GeoCast Routing Protocols

The goal of location-based multicast routing used in GeoCast Routing Protocols is to transmit packets to each node inside the source node to a designated geographic area (Zone of Relevance, or ZOR). IVG, DG-CASTOR, and DRG are a few examples **Error! Reference source not found.**[9].

1.1.5 Routing Protocols based on Broadcast

In VANETs, broadcast-based routing is commonly utilized to share traffic, weather, emergency information, road conditions, and announcements as well as ads. BROADCAST, V-TRADE, UMB and DV-CAST are a few examples. These protocols solve issues with mobility and real-time communication by meeting a variety of communication demands in the dynamic and mobile VANETs environment **Error! Reference source not found.**[9].

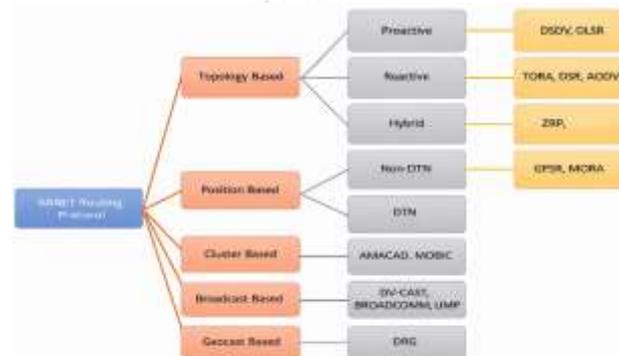


Figure 1.2. VANET Routing Protocols

1.2 Problem Statement

VANETs, a developing technology subset within MANETs in the traffic domain, are of interest to academics and the automotive industry. Uncertainty about the performance and adaptability of VANETs in real-world settings is caused by a dearth of research specifically designed for Sialkot's roads, which makes it difficult to install and optimize them for an industrial urban context. VANET has a dynamic topology property. VANETs routing protocols performance vary with the number of vehicles. The performance of VANETs is greatly impacted by routing protocols, making the

selection of the optimal one difficult. However, the study only supports two ray propagation loss models and less than 50 cars **Error! Reference source not found.** In another study, the impact of vehicle density on the performance of VANET routing protocols including OLSR, AODV, and DSDV are examined. However, the research does not support propagation loss model [7]. By assessing and contrasting the effectiveness of VANETs routing protocols in Sialkot, this study seeks to close this knowledge gap and offer useful suggestions for the creation of smart transportation networks.

1.3 Research Objective

- Assess the routing protocols of VANETs in terms of message transmission performance.
- Perform comparison analysis on VANETs Routing Protocols in real-time traffic under propagation loss models (Friis and TRG).

1.4 Research Questions

These given questions for research are those I have developed and will be further explored in this thesis.

1.4.1 Question 1:

In V2V Communication how message transmit under various VANETs routing protocols?

1.4.2 Question 2:

How propagation loss models (Friis and TRG) affect the transmission of message between V2V in real time traffic?

1.5 Motivation

This research is motivated by the understanding that will be essential to the development of intelligent transportation systems in the future. Even if previous research has made a substantial contribution to the knowledge, it is still necessary to assess and contrast how well ad-hoc routing protocols methods function in actual use cases in city Sialkot. The Sialkot, an industrial city with distinct characteristics, is a perfect place to conduct this kind of assessment. This project is intended to study the development of an efficient VANETs operating on industrial settings. To achieve this, this research will attempt to gather a lot of information through field experiments on the roads of Sialkot city. With the completion of the projects, it is considered that the results will lead to the enhancement in the reliability, safety, and proficiency of the car communication systems, stimulating innovative solutions in the intelligent transport sector.

The study advances the creation of dependable and energy efficient VANETs, supporting more general sustainability objectives in intelligent transportation networks. The study establishes the foundation for developing VANETs that reduce energy consumption, improve information transmission, and eventually lead to

safer and more sustainable transportation solutions by assessing radio propagation models.

2. Literature Review

Previous studies have been conducted on the VANETs Ad Hoc Routing Protocol. VANETs are a promising Intelligent Transportation System technology that facilitates V2V communication on the road, infrastructure communication across the road, and RSUs communicating with other RSUs. VANETs have unique properties due to specific protocols for communication.

2.1 Related Work

Academics and the automobile sector are interested in VANETs, an emerging technological subset within MANETs applications in the traffic arena [14]. This discipline is appealing because it offers greater prospects for progress and requires less money for experiments than other fields. Vehicular ad hoc networks employ a variety of modeling tools to assess the topology of various vehicle-based ad hoc networks that use routing protocols.

Three performance analysis factors are considered by the author of this study [14] while assessing the efficacy of VANET routing protocols: average delay, packet delivery ratio (PDR), and normalized routing load. Four distinct topology-based routing protocols were used: three reactive routing protocol protocols (DSR, TORA, and AODV) and one proactive (DSDV) routing protocol. The middleware application Tracl is utilized in the routing protocol evaluation, along with NS3 and SUMO. The author concludes that all protocols operate efficiently with different topologies and settings. This paper uses Packet Loss Rate (PLR) as a performance analysis indicator in addition to PDR and AEED. The author claims that in urban settings, OLSR and DSDV perform better in terms of end-to-end latency, whereas AODV protocol performs well in terms of PDR and PLR. The routing protocol performance in the Melaka City real-time traffic scenario is tested using the NS3 and SUMO simulators. Other performance measures can be taken into account by the road scenario and propagation loss model when analyzing VANETs routing protocols for future research [7].

Mobile ad hoc networks have evolved over time and are now used in practical situations. The primary issue is designing and configuring complex systems using simulation tools. The author in [17] evaluates the propagation loss model using NS3, and standard parameter values are given for other scholars to use in their comparative investigations.

The author of [18] investigated Nepal's real-time traffic circumstances using NS3 and SUMO network simulators. Using the two-ray ground (TRG) propagation loss model, the authors evaluated the efficacy of VANET routing protocols, including AODV, DSR and DSDV. According to the author, if the PDR is utilized as the performance analysis criterion, then AODV is a superior protocol than DSDV and DSR. However, the results indicate that DSR outperformed other routing protocols when Average End-to-End Delay (AEED) is used as the performance analysis metric. Only two performance analysis elements are taken into consideration by the study's author.

In the vehicle manufacturing sector, VANETs are becoming more and more popular because of their capacity to increase driver and passenger convenience and safety. The unique properties of mobile ad hoc networks provide substantial challenges to protocol design. Using the SUMO and MOVE simulators, the author examined the effectiveness of several topology-based VANETs routing protocols in various urban settings. According to this study's findings, the optimal protocol in terms of performance was AODV [19].

VANETs are a fascinating area for research because of their remarkable dependability and ability to alter topology quickly. The Central Jakartan roadways were utilized by the authors of this study [20], who employed OpenStreetMap and SUMO to generate the map and NS3 to test several protocols and propagation loss models. The authors used several propagation loss models to evaluate each protocol's efficacy. According to the results, OLSR fared well while using the Friis loss model [20]. The study found that the propagation loss model affected protocol performance, while vehicle speed had no discernible influence.

A suggested strategy aims to prioritize

emergency cars on the road and lessen traffic congestion. This model depicts the flow of traffic in Shanghai. The model aims to decrease traffic bottlenecks, enhance the realistic mobility model, and control intelligent traffic signals. In this model [21], TraCI and NS3 were utilized in tandem to execute simulations, while SUMO was employed to generate traffic. Amina and Mohamed et al. [22] with vehicular ad hoc networks, every car has an OBU of its own, connects to a reliable OBU, and forms a network. The creation of routing protocols that offer security and high service quality is the primary difficult problem in VANETs. Apply the routing protocols on the Hay-Alquds-Oujda, Morocco map using SUMO and NS3. This paper's authors examine how vehicle density affects the efficiency of routing protocols. Researchers and the automotive industry are paying increasing attention to VANETs in an effort to increase vehicle safety. The DSR and OLSR procedures are assessed by the authors in three distinct situations, which were created using SUMO NETEDITOR and simulated using NS3. VANETs are special because of their intricate design protocol tailored to a changing environment [23].

Sarkar et al. [24] used the routing protocols for vehicular ad hoc networks in Dhaka, a real traffic model city in Bangladesh. Sarkar et al. employ the Friis and TRG propagation loss model in conjunction with the SUMO and NS3 simulation tools to test the various protocols for VANETs. After executing the simulation on the recommended model, the authors conclude that AODV performs better than alternative protocols under the Friis propagation loss model. Conversely, all protocols have lower performance values than the Friis model; nonetheless, AODV also demonstrates strong performance in the Two Ray model. Additionally, packets received, packet reception rate, packet loss ratio, and PDR are metrics used to evaluate the effectiveness of routing protocols for VANETs.

A study was conducted to examine the routing protocols performance in the real-time traffic scenario of Bouria city, Algeria, using SUMO. As traffic density increased, the effectiveness of VANET routing protocols (AODV, DSDV, OLSR, and GPSR) was investigated. The study's

findings demonstrate how changes in topology and vehicle density affect VANET performance. The effectiveness of the protocols was assessed using three metrics: overhead, goodput, and PDR at a vehicle speed of 10 m/s **Error! Reference source not found.**

In order to ascertain which routing protocols functioned best in circumstances with high traffic, the study of O. Sbyti et al. [25] examined the routing protocols of VANETs by increasing the vehicle density. Three performance analysis matrices are used to evaluate the effectiveness of VANETs topology-based routing protocols (AODV, DSDV, and OLSR): packet loss rate (PLR), throughput, and network overhead. To simulate, NS3 and SUMO are utilized. The study's result is that AODV performs better in terms of throughput when the number of cars exceeds 60. When it comes to network overhead, cars above 75 should use OLSR, while those under 75 should use AODV. In terms of PLR, OLSR protocols perform better, while DSDV is not appropriate for VANETs.

2.1.1 Comparative Analysis Using SUMO and NS3

This study focuses on the important problem of constructing resilient and effective routing techniques for VANETs. VANETs, which are a sub-class of MANETs, have an occurrence of dynamic topologies, widely varying communication environments, and networks usually disconnected because of high speed of movement. This research aims at evaluating and juxtaposing five of the most popular routing protocols in the case of an urban area such as the Haye E1 Qods neighborhood in Oujda, Morocco [22]. The tested protocols involve AODV, DSDV, OLSR, GPCR, and GPSR algorithms, which the report describes in detail. The methodology follows and two types of the routing protocols will be introduced in detail while the simulation setup as well as the NS-3 and SUMO simulators will be described. The simulation exercises and the outcomes analysis will give a clear understanding on the performance of each routing protocol, taking into account quantities indicators such as PDR, AEED, average throughput and overhead. Reference to the results, the author's emphasis to OLSR shows the best performance in terms

of PDR and throughput for the presented case. While over and AEED, GPSR and GCRP are clearly dominant as they take the advantage of the position-based routing to minimize the overhead and intelligent routing of packets. The paper concludes by acknowledging the present status of VANET routing protocol research and outlining potential directions for the future, including accounting for additional metrics like propagation models and map sizes [26].

2.1.2 Performance analysis and comparison of DSDV, AODV and OLSR

VANETs, which consist of V2V, V2R and V2P communications, give rise to new approaches for smart transport systems. It is vital to have multi pass routing protocols that facilitate data transfer with smoothness, given the dynamic topology, as well as the complex radio environment. A work of recent had unified VANETs with the IEEE 802.11p/WAVE protocol stack, as a result of which research has gone on the adaptation of MANET routing protocols in view of VANETs. The previous research has actually taken a stride in implementing the MANET routing protocols within the context of VANETs. The simulation experiments have been the key approach thus far. The commonalities in these studies are AODV, DSDV and OLSR routing protocols with the realization that there are some changes from AODV to OLSR and DSDV [27]. Table 2.1 shows what the most important research related to it is. Factors like PDR, AEED, goodput, and routing overhead metrics are the keys.

This research is aimed at providing a complete analysis of the AODV, OLSR, and DSDV routing protocols for the IEEE802.11p/WAVE stack in the VANETs scenarios. The metrics to be assessed includes PDR, Gdp, RO, and E2E D. The study uses the Bonn Motion mobility simulator and NS3 to simulate more complicated VANET scenarios with varying densities, trajectories, and speeds. In the study, NS3 and BonnMotion are used for VANETs simulating and investigating the performance of AODV, OLSR and DSDV protocols. The simulations run through multiple situations that include: the density of the network, nodes' velocity, and mobility patterns. Performance

indicators are diligently reviewed to understand how each algorithm reacts to a different environmental factor.

The results unequivocally demonstrate that, in sparse and moderately moving nodal networks, the OLSR algorithm performs significantly better than both the DSDV and AODV routing techniques. Another OLSR advantage is the fact that performance is kept stable even when the number of nodes or node velocity increases. This edge mainly derives from the MPR technique, which shows high routing advancement through aggregation and organization, resulting in a relay that is sustainable and grows [28]. Consequently, the paper reveals the impact of the routing protocol choice in VANETs and shows that OLSR stands better than OSDV and DDSV in various sorts of cases.

2.1.3 Performance Analysis of VANETs Routing Protocols Using SUMO and NS2

It provides a context for the VANETs routing protocol and emphasize the role of protocol selection in primary to secondary traffic conditions. The current research acts as a precursor for other studies employing Sumo and NS3 as simulation tools, targeting critical areas to ensure the highest level of network performance.

The paper considers the detailed analysis of the VANETs properties and difficulties in comparison with MANETs. VANETs feature extremely fast speeds of motion, dynamic topology, and immeasurable situations which enhance the routing protocol tailor-made for it. Routing algorithms based on graph theory, like AODV, OLSR, DSDV, ZRP, and DSR have been developed, but their application in VANETs has failed to deliver due to problematic adjustments in the topology. In contrast to these position-based protocols such as GPSR, LAR, and GSR that are able to scale to the dynamic VANETs environments because they use spatial data for that purpose. The choice of a routing protocol, nevertheless, depends on all these real-time variables as traffic, speed, and density of vehicles [28]. The purpose of this study is to evaluate and contrast the effectiveness of the AODV, DSR, and LAR routing protocols in various VANET settings. The evaluation metrics include Throughput, Packet Delivery Ratio, and

Routing Overhead. Different traffic scenarios, characterized by varying vehicle density and speed, are considered to assess protocol performance comprehensively.

The given environment is relied on which the NS2 toolkits represent the network simulator and the SUMO toolkits refer to the traffic simulator. AODV, DSR, and LAR, three routing protocols will be analyzed in view of critical performance aspects accruing to various traffic scenarios. The more important of metrics is throughput, and the others are PDR and Routing overhead which give us a measure of efficacy of the protocol in different conditions. The research stresses that a good routing algorithm must be based on the traffic conditions improvement. AODV, DSR, and LAR protocols are examined, but LAR shows the best mileage in the circumstances when vehicles travel close to each other in a dense city traffic. Future work will focus on analyzing the performance of the protocols on metrics such as hop-count, delays, and path duration within urban environments that are realistic, as well as integrating vehicle flow data in real-time.

2.1.4 Performance Analysis of VANETs Routing Protocols Using NS2 Simulation

A lot of research has been done on VANETs routing protocols, and many of the proposals made have been aimed to counteract the challenges that arise from the volatile vehicular environments. VANETs and MANETs have certain similarities, but VANETs have other characteristics such as the fact that they are very dynamic in its topology, there are frequent disconnections and sometimes constrained mobility. Since routing protocols are the linkages in the VANETs they must be considered for efficiency in data transmission and addressing the safety applications that are relevant. Studies that have been undertaken to analyze the performance of 802.11p/WAVE in VANETs become rare with time, leaving few of them that can be used in vehicular mobility simulations.

This study targets the performance of reactive routing protocols such as DSDV, AODV, and DSR under the experimental conditions of a VANETs model that has been simulated under NS2. The main emphasis is on evaluating

routing protocols efficiencies in urban surroundings - the qualities to be taken into account, among others, are throughput characteristics, packet losses, and modulation schemes. The aim is to figure out and then implement the best routing protocol for traffic in urban areas. The experiment which is conducted using the NS2 network simulator is a simulated scenario that incorporates IEEE 802.11 MAC and PHY models that makes 802.11p VANETs message transmission possible. The comparison of the three DSDV, AODV and DSR routing protocols performance is made using packet delays, modulation schemes and packet loss. In accordance with the methods of real experiments that would take place in an urban test bed, safety applications in VANETs would be investigated to find out the possibility for each one [29].

The VANETs routing protocols like DSDV, AODV, and DSR were used in NS2 simulation for comparing them in the aspects of efficiency. This reveals the importance of selecting suitable routing protocols for vehicular communication. The concluded statement reveals that the reactive routing protocols, namely AODV combined with IEEE 802.11p, perform much better in urban environments in comparison to one another. This trait points to the importance of protocol efficiency in the VANETs communication design for safety and passenger focused apps.

2.1.5 Implementation and Analysis Using NS3 and SUMO

With the introduction of VANETs, the development of mobile ad-hoc networks has ushered in a new era in which network topologies may alter rapidly. The need to evaluate the performance of various VANET routing protocols—AODV, OLSR, DSDV, and DSR—in the context of VANET intersections makes this study topic significant.

VANET is a group of MANETs in which vehicles with on board unit (OBUs) and Roadside Units (RSUs) are the mobile nodes and they are deployed for the sake of: transmitting, receiving, and sharing data. VANETs research subject involves diverse communication method, from V2V, V2I, and Vehicle-to-anything (V2X), with main focus on

security, superiority and network layer protocol. Nevertheless, VANETs feature specific attributes compared to MANETs such as frequent network topology changes, a diverse communication environment, various connectivity environments, frequent disconnections, and strict time constraints which makes them different and unique [5]. Researchers have proposed several solutions to the problems posed by VANETs, and they have used the simulation tools such as SUMO (Simulation of Urban Mobility) and NS3 (Network Simulator 3). SUMO is used for developing the creation of realistic traffic scenarios, whereas NS3 simulates the network environment in which network protocols' performance is evaluated. By exploiting these instruments, the realization of routing algorithms that meet an efficient packet routing in the VANETs environments turned out to be possible. Various routing algorithms and protocols have been scrutinized looking at their benefits and shortcomings. The DSDV protocol works preemptively keeping the distance vectors of routes with numbers as route discovery indicator despite the degree of overhead due to topology changes. On the other hand, in case of a proactive routing protocol which is OLSR based on the principles of MPR (Multiple Link States) it can eliminate overhead and boost email [30].

Discussing another protocol AODV, which takes a method called reaction, building up routes when needed while DSR uses source routing based on request for routes. The designed protocols use various techniques of traffic flow management for the different features that put the VANETs traffic in delay, overhead as well as packet delivery efficiency. Research further directions include the use of new metrics such as propagation models and scale of maps to build end to end data collection and evaluation process of the VANETs network performance. By further exploring these issues, researchers aspire to give the students and practitioners in the domain of VANETs research and development, not only deep insights, but also advanced tools that will help them in their further work for the cause of innovation in this dynamic domain.

2.1.6 LIMoSim's Lightweight Approach

The literature related to VANETs addresses the need of robust and effective communication in turbulent transportation management systems for city-wide adoption of autonomous vehicles and man-made intelligent transportation systems (ITSs). As vehicles inevitably give way V2X communicate, sharing mobility information for optimal handling, handover, as well as resource allocation becomes incredibly important. The simulation tools are a leverage that greatly adds to the opportunities of research and development in this sector by presenting a truthful reflection of vehicular movement and communication settings. This Literature review sheds light on the existing techniques used to develop vehicular networks and introduces a new lightweight framework, LIMoSim that shows how integrating vehicular mobility and communications simulations can be done.

The focus of the recent research has been on simulation tools which can capture all vehicle motion and constantly changing topologies and cooperate being narrow resources. Usual techniques in nowadays utilize IPC communication linked to the coupling of specific simulators with intricate numerous runs at each synchronized time. Apart from that, this disconnection of moving things and devices in transmission fails a development of smart mobility linked models, as one can't study interdependencies between the both [31].

Whereas conventional paradigms are based on vehicular mobility modeling, which is the action of vehicles, LIMoSim provides a communication-oriented approach of mobility simulation that offers an easier and integrated infrastructure for simulating vehicular mobility and communication. Through adhering to a common codebase for mobility, and communication parts, LIMoSim lowers the dependency on IPC and thus implements simplicity of simulations' set ups and adds interoperability between mobility and communication simulations. Putting up map data based on OpenStreetMap (OSM) as the real feature of simulations provides a complete depiction of simulations that researchers can apply to analyze integrated transport management systems in urban regions.

The suggested framework would be

demonstrated on its abilities with the proof-of-concept evaluation by means of efficiently furnishing with realistic representations of vehicular mobility. OMNeT++ network simulation tool is getting embedded into LIMoSim mobility simulation kernel to perform the simulations; thus, developing advanced algorithms for exploring the synergies between the communication and motion becomes easier. The aim of future efforts concerning LIMoSim is to make it integrate with other communication simulator frameworks, including NS3, which will improve its functionality in the VANETs research domain significantly. Lastly, efforts are exerted to integrate LIMoSim into existing VANETs frameworks, like Veins which is IEEE 802.11p simulation for mobile robot networks, and not only limited to urban vehicular scenarios, but also covers indoor logistic contexts [31].

2.1.7 RSU Based Approach

What this paper focuses on is the critical issue of routing problems related to VANETs and proposes a novel approach that involves deployment of RSUs in order to overcome these challenges. To see VANETs in this way as the area of transportation is changing is a sort of mess for the routing system and precise transmission of data packets between vehicles and infrastructure. Routing protocols as the basis for building the routing framework for data transmission in VANETs closely associated with the optimal choice of transit ways for vital data the problem that calls for a deep-rooted analysis and further exploratory researches.

The investigation starts with the elaboration of VANETs, which are considered as a subsystem of MANETs, based on mobility of the nodes that consist of vehicles and RSUs as mobile nodes whose high-speed data communications is delivered through data packets. Here we mention the intrinsic difficulties of VANETs among which high speeds of vehicles, additional variations in wireless network topologies, and diversification of traffic scenarios could be listed as the most remarkable ones. Robust routing protocols that are dynamic in nature by design and respond to variable conditions as they occur are crucial to the provision of dependable data transfer [32].

By the means of in-depth comparative analysis of known geo-routing and position-based routing protocols in a range of traffic situations we attempt to evaluate the most optimal routing protocol within VANETs framework. Regarding routing protocols, we sort them into groups of proactive, reactive, and hybrid, and rate them based upon their effectiveness in solving problems that happen along the line of city, highway, and rural areas in VANETs. Our findings conclude that certain its routing protocols are more efficient and useful than others for particular scenarios where some others not match performance.

We provide a spatial route RSU base way routing system for VANETs based on our study and designed to alleviate the transportation-related issues that arose from his thorough investigation. By relaying data packets between cars, RSUs appear to be a means of improving the routing capabilities of vehicles by acting as a

wireless napping ground. In order to significantly improve reliability and latency of data transmission, we introduce a strategy based on the utilization of RSUs to overcome teething problems related to dynamic changes of topology, channel congestion, or problems typical for urban environments [32].

Ultimately, the article demonstrates that dealing with routing difficulties in VANETs is integral in maintaining the level of trustworthiness and performance of communication in mobile vehicular networks. In conclusion, our RSU-based technique is a reliable solution for both traffic degradation problems and an improvement of routing performances for future work in this area. Technologically by trying to accomplish analysis and innovative techniques, we intend to get to the square root of what VANETs can achieve in atomizing the machines.

Table 1.1. Summary of Related Work on Routing Protocol of VANETs

Paper	Tools	Protocol	Propagation model/Technology	Parameter
M. Jan et al. [5]	SUMO and NS3	AODV, OLSR, DSDV, DSR	Two-Ray Ground	PDR, Maximum EED, Power Consumption, Average Throughput, Overhead
Yang et al. [14]	SUMO, TraCI, NS3	AODV, DSR, TORA, DSDV	-	Packet Delivery Ratio, AD, NRL
Benin et al. [17]	NS3	-	Fading, Log Distance, Nakagami, Two Ray	-
Jha and Baral et al. [18]	SUMO, NS3	DSR, AODV, DSDV	Two Ray	Packet Delivery Ratio, AEED
Salman et al. [19]	SUMO, NS3, MOVE	AODV, DSR, OLSR, DSDV	-	Packet Delivery Ratio, AD and Jitter
pratama et al. Error! Reference source not found.	SUMO, NS3	AODV, OLSR, DSR, DSDV	Friis, Two Ray Ground, Nakagami	Throughput, Goodput
Su et al. [21]	SUMO, TraCI, NS3	-	-	-

Aminaet al. [22]	NS-3, SUMO, and BonnMotion mobility simulator	AODV, OLSR, and DSDV	Two-Ray Ground	PDR, Goodput, Overhead, EED
Shihab et al. [23]	SUMO, Net Editor, NS3	OLSR, DSR	-	Overhead, Goodput, Packet Receives Ratio
Sarkar et al. [24]	SUMO, NS3	AODV, DSDV, DSR, OLSR	Friis, Two-Ray	Receive Rate, Packet Received Rate, PLR, PDR
Kang et al. [26]	SUMO, NS3	AODV, DSDV, DSR	Friis	Throughput
Sallum et al. [27]	NS3 and SUMO Simulators	OLSR, DSDV, AODV, GPCR and GPSR	Two-Ray Ground	Overhead, Average throughput, PDR, AEED
Pandey K et al. [28]	NS2 (Network Simulator 2) for Network Simulation and SUMO	AODV, DSR, and LAR	Two-Ray ground	Throughput, Packet Delivery Ratio (PDR), Routing Overhead
Ali et al. [29]	NS2	DSDV, AODV, and DSR	IEEE 802.11P	Throughput, Packet Loss, Modulation
B. Saliwa et al. [31]	LIMoSim, OMNeT++	AODV, DSR, OLSR	IDM, MOBIL	Mobility and Communication Integration, Realistic Representation, Interoperability
K Jain et al. [32]	RSU Deployment	Geo-Routing and Position-Based		Dynamic Topology Changes, Channel Congestion
Proposed Work	OSM, SUMO and NS3	AODV, DSDV and OLSR	Friis and TRG Propagation Loss Model	Goodput, Overhead, PDR, Received Rate, Packet Received.

2.2 Topology based VANETs Routing Protocols

2.2.1 AODV

It is a reactive routing approach that is widely used in ad hoc networks and offers efficient unicast and multicast communication. AODV simplify the process by just needing node information for the next hop, in contrast to systems that keep copious amounts of route information. By using techniques for route discovery and management, AODV avoids

tracking routes to inactive nodes during communication by dynamically locating routes as needed [33].

A lot of studies on the AODV routing protocol done in the VANETs and MANETs context are very focused on its ability to respond to the high dynamic's situation, the low government and memory cost, and the use of destiny sequence numbers to avoid loops. Researchers' inspections show that this device performs well by setting pathways and fixing networks thereby

reducing the amount of processing requirements. Employing the green features of AODV, which enables to interconnection of tens to thousands of portable or wireless devices, is a complementary approach to creating routes for saving energy in mobile ad-hoc networks. But, on the other hand, constant information security issues have drawn more attention to these transient hosts as they are vulnerable to other harmful attacks. Nevertheless, the limitations of AODV such as the vulnerability to compromising nodes, path instability, and excessive network overhead in comparison to other routing protocols should serve as purposeful input for future improvement. The remarkable aptitude of AODV for diverse MANETs configurations makes the protocol applicable for deployment. The up-coming efforts put in research are intended to overcome these challenges and make the protocol as suitable as possible to situations with rapidly changing situations and limited resources [34]. We go into the AODV protocol in the article, which is intended for a suitable, dynamic routing in mobile ad-hoc networks (MANETs) and based on self-ordering. AODV is particularly obvious for case in point when the environment is climatic, and the network paths could be lost or new ones opened. Therefore,

AODV can track new road links for destinations in a short time.

The sequence number, which prevents loops and is used for route discovery with range requests and range replies – is AODV's key feature. Route maintenance is also a part of the protocol. When a connection breaks up or topology changes, the protocol will send Route Errors (RERRs) to do route invalidation immediately [35].

Route Table management of AODV actively does a fundamental job of keeping up-to-date records of destination IP addresses, sequence numbers, hop counts, and next hops to ensure smooth routing. Also, the protocol binds the allowance of assistance for multicast routing, for use by the original nodes though they may not be multicast protocols conversant too.

In the future, research concentrations in AODV scalability optimization, routing protocol overhead reduction, and security in the MANETs sphere will be mainly developed. Next developments will aim at improving its overall competency and making it applicable to the most diverse locations and networking situations; this will include integration with new and up to date technologies, such as edge computing and the Internet of Things (IoT) [35].

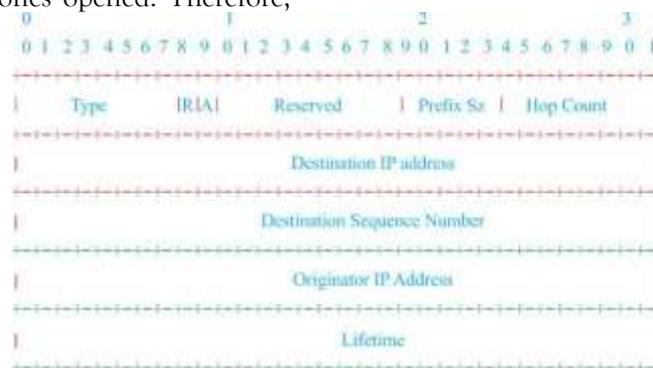


Figure 2.1. Route Reply Message Format

2.2.2 DSDV

The DSDV protocol differs from other algorithms in two respects. It has two tables; a routing table that tracks the latest routing ads, and a time settings table, which is used to keep time of the updates of the routing ads. On one hand, the DSDV protocol endows non-looping paths with destination sequence numbers, but

the selection criterion may result in network fluctuations in routing. Research, consequently, has been initiated as the problem of unidirectional associations is the focus of research, as they imply two-way communications in relationships [36].

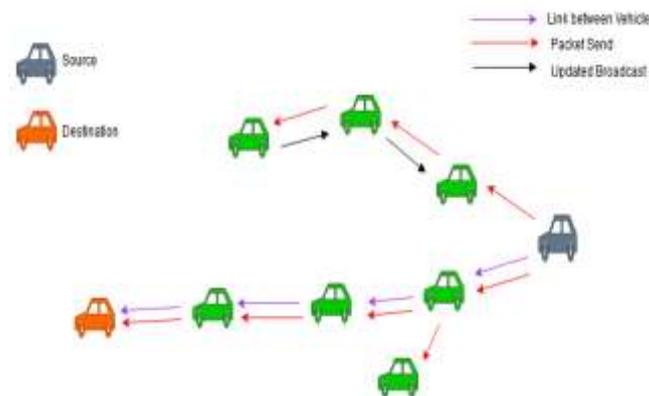


Figure 2.2. DSDV Working Process

Proactive, this protocol, delivers possibly useful QoS enhancements, keeping routing tables up-to-dated, ensuring there are no looping. Current efforts suggest improvements to overcome constraints, and it is anticipated that recently suggested protocols developed from DSDV may find useful uses in real-world situations. The literature emphasizes DSDV advantages as well as disadvantages, and there is ongoing work to improve and modify it for changing ad hoc network situations [37]. The DSDV proactive routing protocol for VANETs and MANETs uses a distance vector approach to update a routing table for each destination node [38]. By giving routing entries sequence numbers, DSDV is made to manage extremely dynamic topologies and enables nodes to identify and fix discrepancies in their routing tables. Numerous studies have been conducted on the DSDV protocol in the literature, with an emphasis on its effectiveness and applicability for MANETs. The size and frequency of routing table changes, node mobility, network structure, and other factors all impact DSDV performance [38]. According to research, DSDV performs better in high-density, low-mobility networks because there are more neighbors and more frequent routing table updates. As another research indicated, DSDV proves to be good in coping with dynamic topologies and high mobility, although periodical routing table updates may be tied to performance degradation, states different research.

Some improvements have been suggested such as sequence number suppression and triggered updates. The first one is in charge of upgrading the network whenever a node detects a change

in its neighborhood, however, the latter broadcast only updates whenever the sequence number of a destination alters [38].

Finally, it is concluded that sequence numbers in DSDV which help in building its routing table integrities, are indeed a well-researched technology in MANETs routing. DSDV has given a lower level of packet latency and routing overhead compared to others and has been shown to perform well in a particular set of circumstances. However, there are node mobility and network topology that affect the DSDV performance. Plenty of changes like the suppression of sequence numbers and the initiation of regular updates have been provided to improve DSDV function on MANETs.

2.2.3 OLSR

A reactive routing protocol that works with linking state in an optimized way is referred to as Optimized Link State Routing. Each alteration of one of the network's links causes the routing table to be created anew and updated regularly. Route discovery is a technique for constructing the network. It is characterized by a routing protocol that makes sure that the nodes can communicate with one another beforehand. To join each node in the network, RREQ (route request) packets are sent to nearby nodes using the OLSR protocol's route discovery procedure. Each node is in charge of figuring out which other node nearby will relay messages to it. We call these particular nodes Multi-Point Relays (MPRs). To compute Multi-Point Relays (MPRs), each pair of adjacent hops from the MPRs has to have a bidirectional connection to the MPR set. Therefore, MPR nodes need to be

linked to at least two surrounding nodes. The message that the node sends is a part of the MPR, and it is selected such that the node will keep the data inside an MPR set [12][39].

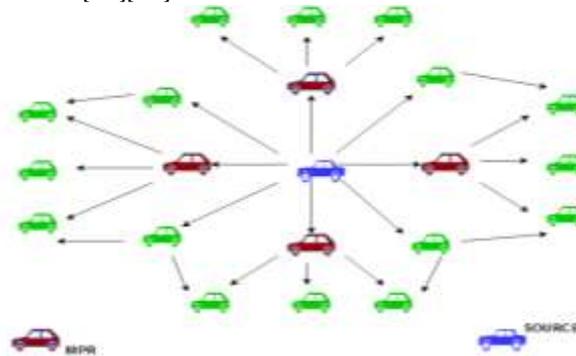


Figure 2.3. MPR mechanism in OLSR

A comprehensive analysis of many routing strategies applied to vehicle ad hoc networks (VANETs) has been provided [40]. We investigate V2V routing techniques in this work. In the category of V2V communication, the routing protocols include those used by automobiles to communicate information about their position, speed, and other details. It is verified that the most important primary parameter is related to the system that is used to create routes between automobiles.

The OLSR protocol which is a critical approach for the realization of VANETs. But it is affected by the wireless connectivity features and node mobility approach which is the other way around for cellular networks. The researchers have performed experiments of how the OLSR parameters might be optimized to tackle the challenges [41].

It has been shown that the parameter setting affect the OLSR contribution to the VANETs and as a result manual parameter adjustment is needed to take commonly available vehicular connectivity at higher level. Studies have suggested making a connection of motion information with the routing protocols so as to decrease the interlink disruption in very dynamic VANETs. Further on, evolutionary algorithm that can be used (i.e. differential evolution (DE) and genetic algorithms (GA) for optimal OLSR parameters. Particle swarm optimization is a widely used evolutionary technique that combines simplicity of implementation with quick convergence. The

particles in this method are updated according to the following Equations and have two attributes: location and velocity:

$$v_i^{t+1} = w \times v_i^t + c_1 \times r_1 \times (pbest_i^t - p_i^t) + c_2 \times r_2 \times (gbest^t - p_i^t)$$

$$p_i^{t+1} = p_i^t + v_i^{t+1}$$

Where v_i^t and p_i^t are the velocity and position of particle at the t^{th} iteration.

But, frequently, currently used optimization procedures that do not take into account the routing traffic load into consideration. Subsequently, to handle the two conflicting objectives of fast delivery and money saving efficiency in VANETs, a particle swarm (PSO) based multi-objective optimization framework has been formulated. This framework has two components; QoS metrics and routing load. The goal of this approach is to find a better balance in performance and cost through a trade-off between the QoS and routing load. In the simulations experiments show good results to confirm the efficiency of the obtained parameters of OLSR in both theoretical and real circumstances of VANETs [41].

Briefly, optimizing OLSR in VANETs can help perfect the communication integrity as well as quality characterizing the dynamic vehicle environments. Integration of evolutionary algorithms and multi-objective optimization techniques will be able to improve performances of OLSR with the minimum routing versus high network traffic load which will be the best way of implementing VANETs under ITS applications in future.

2.2.4 DSR

The DSR, or dynamic source routing, is a reactive routing protocol that is known to be the most widely used in the VANETs because of its adaption to dynamic topology changes and its efficient route discovery mechanism. The present paper focuses on summarizing the results and implications of the DSR method's performance and use in VANET networks.

Safety on road is of critical importance, and this is beneficial technology which provides information through V2V and V2I communications. VANETs provide a sharing platform through which vehicles can exchange critical information that is related to the current situation of the road and the presence of dangers, thus enabling situation awareness and driver safety. Efficient routing protocols play a pivotal role and provide a framework for the deployment of the communication channels in VANETs [42]. In VANETs, routing protocols selection is most typically estimated into topology-based and position-based routing protocols. DSR certainly goes a long way in terms of optimization due to its proactive nature by means of route choices and eliminating overhead amidst conservation of network resources.

A carried-out experiment analyzed DSR in some different situations like alteration the number of nodes, velocity of node and variations on size of packet. DSR was able to show strength and efficiency across the experiments by using lot of simulations. These strengths helped DSR being well adapted and suitable for real life VANETs deploy environment which has unpredictable and dynamic network conditions [42].

The Simulation evaluation under different scenarios enabled us to draw valuable conclusions pertaining its performance under

diverse scenarios. DSR showed best results when used as an indicator for throughput, that is, the amount of data transferred per unit time, and end-end delay, which means the time taken by the broadcast on average to reach its destination. This conclusion notifies the DSR efficiency in enabling time-delay and an added reliability to the VANETs process and therefore bring about the enhancement of road safety and overall traffic management.

All things considered, the studies done on DSR in relation to VANETs confirm its feasibility as a routing protocol to provide effective and flexible communication between automobiles and infrastructure elements. More research may look into hybrid and optimization strategies to better utilize DSR's advantages in meeting certain needs and obstacles in VANETs deployments.

The DSR uses on-demand routing, AODV-like, which creates routes on demand. DSR sets itself apart by using source routing, in which the transmitting computer determines the path instead of depending on the routing tables of intermediary devices. Subsequent improvements, such as DSRFLOW, have improved its performance.

During route discovery in DSR, gathering the addresses of devices between the destination and source is important to determine source routes. Nodes aid in effective routing by caching this path information for use in ensuing route discovery packets. However, for lengthy routes or big addresses, like IPv6, source routing may result in significant overhead. To overcome this, DSR adds a flow ID option that can be used, allowing hop-by-hop forwarding independent of source routing [43].

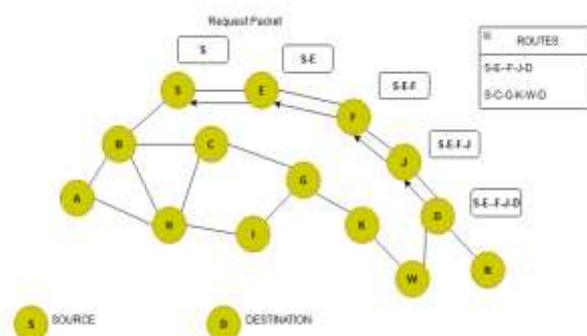


Figure 2.4. DSR Route Discovering Mechanism

This protocol is based on source routing, enabling mobile nodes to continuously update their routing information. It has two main phases: Route Discovery and Route Maintenance. When the message reaches the intended destination node, a route reply is generated, which includes the route record from the route request. To send the route reply back to the source node, the destination node needs a path; it can either use its route cache or retrace the route using the route record from the route reply [44].

2.3 Network Simulation Tools

2.3.1 OpenStreetMap (OSM)

OSM is an editable, publicly available map of the entire globe. It provides thorough graphical depictions of parks, buildings, highways, and bodies of water. When necessary, researchers can import OSM information from the internet to concentrate on particular city regions, roads, or other sites. Additionally, users are able to create traffic simulations for pedestrians, cars,

trucks, trains, buses, and ships. Open Street Map (OSM) can be accessed online at <https://www.openstreetmap.org>.

2.3.2 Simulation of Urban Mobility (SUMO)

With the introduction of SUMO by the German Aerospace Center, the research field on transportation and mobility has widened up now [45]. One significant task of SUMO is to enable the development of different traffic network models, where researchers can implement investigations on driving scenarios, traffic control strategies, and vehicle communications. As for improving features and customization, the product will provide a Netgen and Netconv suite app. As it is linked to OpenStreetMap (OSM), its simulations are based on real maps of roads, and the level of realism is greatly enhanced. It serves as a useful tool in urban analysis and traffic dynamics, particularly with the emulator's in-built network topology, configurable traffic scenarios, and SMO compatibility.

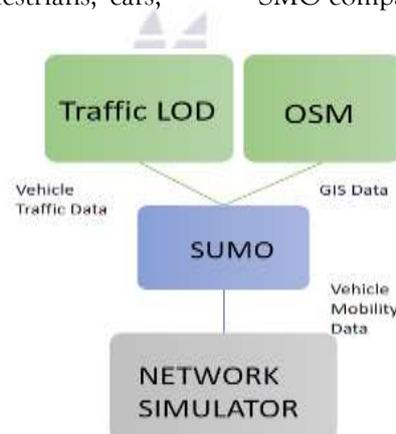


Figure 2.5. SUMO Classification

2.3.3 NS3

NS-3 is a tool for discrete event simulations that allows for flexible and open-source network research aiming at the domain of communication networks. The simulation package NS3 was developed in C++ and is

certified under GNU GPLv2 which permits researchers to adjust their simulations in a way that meets their needs **Error! Reference source not found..**

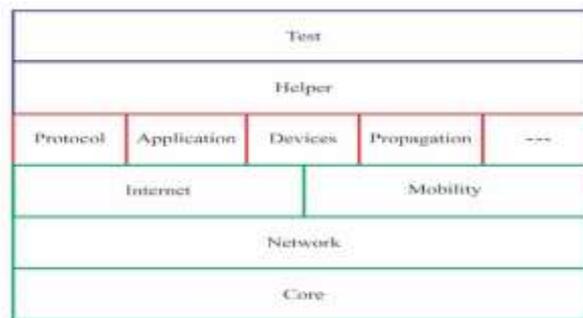


Figure 2.6. Software architecture of NS3

NS3 core features involve modules to manage system variables, network simulations, node mobility, and high-level scripting. These modules allow researchers to precisely simulate and analyze different facets of communication networks, such as basic system functions, complex mobility patterns, and protocol configurations.

2.4 Propagation Loss Model

We can determine how signals can spread across various environments, distances, and obstacles by using the propagation loss model. The propagation loss model's path loss may be computed using the following equation **Error! Reference source not found.** This equation is also called the link budget equation.

$$P_r = P_t + G_t + G_r + P_l - L_t - L_r$$

P_r = Show the received power of vehicle or node

P_t = Transmitted power of vehicle or node

G_t = Represent gain transmitting antenna

G_r = Represent receiving transmitting antenna

P_l = Show the path loss

L_t = Losses of transmitting system (cable connector etc.)

L_r = Losses of receiving system (cable connector etc.)

A medium or channel plays a vital role in VANETs for V2V and V2I applications. Number of factors that reason for path loss in propagation loss model.

- **Spreading:** Signals dispersed evenly in a vacuum surrounding the source during communication. Inverse square law states that the strength of signals decreases with increasing distance from the source.

- **Attenuation:** The process by which signals change in intensity and form as they go from their source to their destination. We refer to

this process as attenuation. Even in space, no medium can deliver a signal without attenuation.

- **Fading:** In wireless communication, attenuation varies based on radio frequency, time, and location, among other aspects.
- **Shadowing:** Received signal strength varies as a result of interactions between the broadcast and received electromagnetic signals.
- **Doppler Effect:** The frequency varies continuously with the speed of the node in the Doppler Effect since both the sender and receiver are usually mobile and in motion.

2.4.1 Propagation loss model type

In VANETs simulations, where vehicular mobility, heterogeneous terrains, and variable communication circumstances present special problems, propagation loss models become essential. These models, which address different facets of VANETs communication, can be classified as deterministic, empirical, or statistical [48].

2.4.1.1 Friis Model:

In wireless communication, records the loss of free space paths. Widely utilized in outdoor situations, especially where direct line-of-sight communication is common [48]. Nothing in the Friis permits communication to be sent and received through the line of sight and surrounding objects to reflect or diffraction. The path loss and received power may be computed using the Friis Equation that follows.

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2 L}$$

P_r = Output power of available receiving antenna.

P_t = Input power transmitting antenna.

- G_t = Represent gain transmitting antenna
- G_r = Represent receiving transmitting antenna
- λ = Wavelength of radio frequency.
- L = Length of antenna.
- d = Distance between antenna.

2.4.1.2 Two-Ray Ground Model (TRG):

TRG propagation loss model was designed by Rappaport. Takes into consideration signal refraction from the ground in open spaces. Appropriate in situations when signal propagation is considerably impacted by ground reflections [48]. In TRG we consider data packets are transferred from one vehicle to another vehicle via two paths, a line-of-sight path without any interference, and in the second path we consider data packet signal change his path

due to interference reflection like roads, trees, buildings, etc. TRG can be calculated through the following Equation.

$$P_r = \frac{P_t * G_t * G_r * (H_t^2) * (H_r^2)}{(d^4 * L)}$$

P_r = Output power of available at receiving antenna

P_t = Input power of transmitting antenna

G_t = Represent gain transmitting antenna

G_r = Represent receiving transmitting antenna

H_t = Height of gain transmitting antenna

H_r = Height of receiving transmitting antenna

d = Distance between antenna

L = Length of antenna

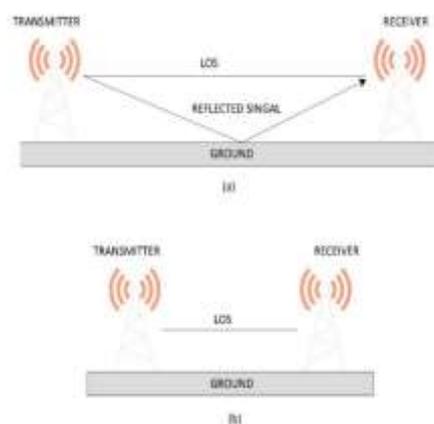


Figure 2.7. (a) Two-Ray Ground propagation models and (b) Frii

2.4.2 Propagation loss model type overview

This study examines the operation of radio propagation models including Friis, TRG and Nakagami models for VANETs. RPMs are crucial in VANETs because they are used to find out the path loss for different work environments, especially the modern road infrastructures. The VANETs technology is purposed for V2V and vehicle-to-roadside interaction that assists in improving safety,

following route, and providing roadside services. The paper shows that RPMs in VANETs are necessary for forecasting radio wave propagation domineering features, especially in the dynamic environment, such as a modern road infrastructure. It starts by presenting the Free Space, TRG and Nakagami propagation models as the choice for performance assessment [49].

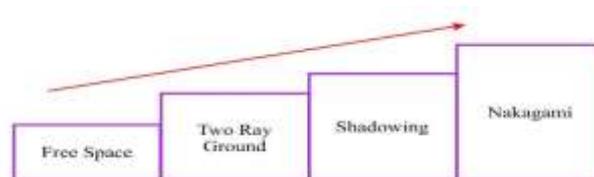


Figure 2.8. Evolution of Propagation loss models

It tackles the broader scope of on-demand networks, while diving into their decentralization and potential benefits in scenarios like natural disasters and emergency operations. The architecture of VANETs, consisting of inters vehicle communication (IVC) and communication with RSUs, is described. Propagation models play a major role in the estimation of path loss parameter in VANETs, especially for the complex propagation environment such as that of the modern road infrastructures. Among other things, this study focuses on the role of RPMs to accurately predict roads' behavior and ensure more effective interacting between V2V and V2I. It guides a method that is used in the evaluation of performance of Friis and TRG as well as Nakagami propagation models in VANETs. Throughput, packet loss and EED metrics among others are considered when comparing the performances. The simulation has been conducted by the utilizing various software tools such as JOSM, SUMO, MOVE,

NS-2 on Ubuntu operating system [49][50]. The process of the simulation also includes several stages, such as the map generation by JOSM, road generation in SUMO, and real-time vehicle movement in MOVE, and the final simulation in NS-2. The simulated location will be Rangka Besar Selayang Baru, Selangor, and an area measuring 2 km by 2 km. The flow chart in the paper shows all simulation process stages; hence it is a good one.

3. Proposed Methodology

This methodology provides a structured approach to evaluate VANETs routing protocols, incorporating realistic data from OSM, traffic scenarios from SUMO, and communication simulations from NS-3. By considering the working principles of routing protocols and propagation loss models, the study goal is to contribute valuable insights into the domain of intelligent transportation systems. Figure 3.1 depicts the proposed methodology to evaluate the performance of routing protocols under two different propagation loss models.

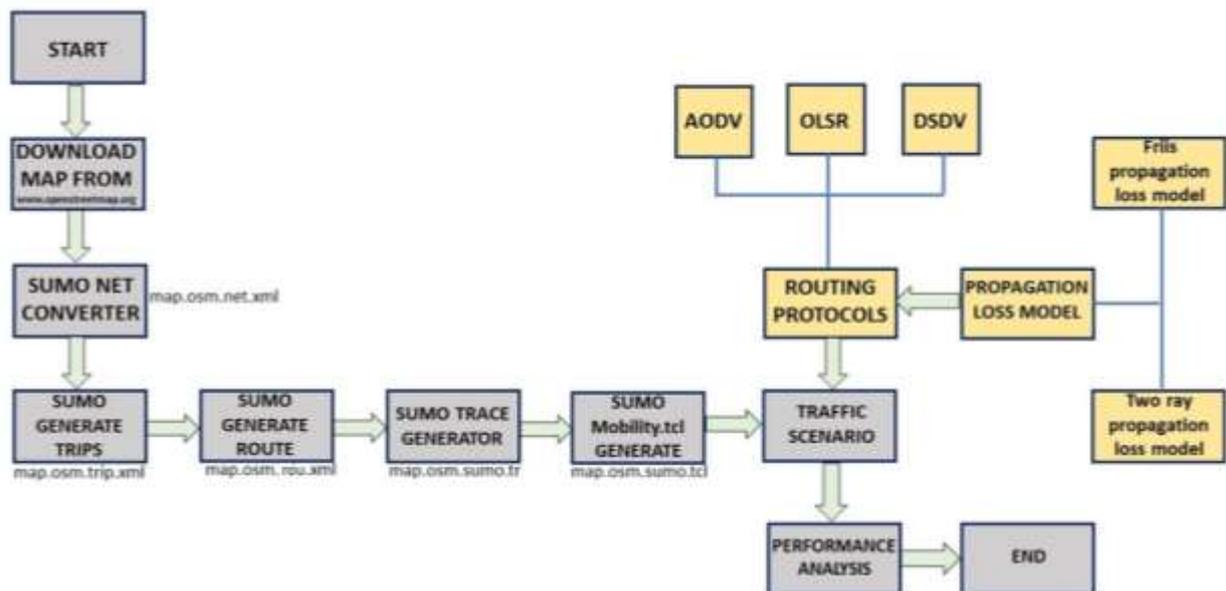


Figure 2.5. Proposed Methodology

3.1 Map Data Acquisition and Processing

We use the state-of-the-art traffic simulator OSM for data collecting and analysis. Researchers can conveniently access OSM's data through its API. By using this API the traffic scenarios particularly designed for the VANETs research may be made as accurate as possible. The API

makes it easy to include certain geographic data in simulation frameworks because researchers can extract the data. Also because the OSM is collaborative, contributors constantly modify and contribute to the dynamic map so that the simulations are always based on the most current

and accurate data **Error! Reference source not found..**



Figure 2.6. Open Street View. (Sialkot Industrial Estate)

As per methodology as shown in Figure 3.1, The first step in the evaluation is to get the Sialkot city map road (Industrial Estate Sialkot) data from the OSM, click on the export button, and

save selected map as map.osm file in the download folder. "Open street map > select industrial estate Sialkot area > export as map.osm"



Figure 2.7. The Map of the Industrial City Sialkot using SUMO

OSM works seamlessly with traffic simulators such as SUMO making the process of creating scenarios that have accurate and realistic traffic parameters using real-world map data easier [30]. To conduct VANET communication in every tested scenario, the traffic data generated on the traffic simulator was imported by the network simulator. The SUMO Net Converter is used to process the gathered data. To use SUMO Net Converter, create a working folder and copy the map.osm file into this folder. Copy the "osmNetconvert.typr.xml" file from "C:\Programe Files (x86)\Eclipse\Sumo\data\typemap" and paste this file in the working folder to run the netconvert command. The command "netconvert -osmmmap.osm -o map.osm.net.xml" at the Windows command line was then used to convert the map.osm file

into a network simulator file, resulting in a file of the format "map.osm.net.xml". This step ensures that the selected road network is properly represented for further simulation. A lot of information is lost when the map.osm file is transformed into a net.xml file, including information on buildings, trees, parks, water, and points of interest. To add additional helpful information, this command "polyconvert -net-file test.net.xml -osm-files map.osm -type-file typemap.xml -o map.poly.xml -xml-validation never" is used with "typemap.xml". Now additional information is available in the form of the file name "map.poly.xml".

3.2 Trip and Route Generation

Once the map data has been processed, SUMO is used for the generation of realistic trip data utilizing the created network. The objectives of

points of interest and major traffic within the industrial estate in Sialkot city are considered. The trip generation process aims at simulating the natural movements of vehicles and traffic patterns. Additionally, SUMO produces routes for vehicles by considering the designated destinations and the main streets. For trip and route generating, copy the file "randomTripy.py" from "C:\Program Files (x86)\Eclipse\Sumo\tools" in the working folder and then run the command "randomTrips.py -n map.osm.net.xml -e 100 -r map.osm.rou.xml" to create a trip and route file using the map.osm.net.xml file once polyconvert is finished. This finally creates the map.osm.rou.xml file with 100 vehicles.

3.3 Trace Generation

The SUMO Trace Generator is used to further process the collected trip data and create trace files. Now that the "trac.xml" file is required for further proceeding or evaluation, use the

following command: "sumo -c myconfig.sumocfg -FCD-output sumoTrace.xml" to obtain the "sumoTrace.xml" file. The SUMO "mobility.tcl" files generated from these trace data allow precise modeling of vehicle movements inside the network.

3.4 Integration with NS3

We are utilizing NS3, and the sumoTrace.xml file is not directly compatible with it. The file "sumoTrace.xml" was converted to "ns2mobility.tcl" using the command "traceExporter.py -FCD-input sumoTrace.xml -ns2mobility-output ns2mobility.tcl". After generating ns2mobility.tcl, it is referenced within the VANETs file for execution.

3.5 Simulation Configuration

Set all the settings required for our requirements before executing the file. The setting for the simulation is shown in Table 3.1.

Table 3.1. Configuration for Simulation

Parameters	Values
Simulator	NS-3.26, SUMO 1.10
Operating System	Windows 10, Ubuntu
System Description	Hp 8 th Gen Core i5, G5, 16 GB RAM, 512 SSD Hard,CPU 1.70 and 1.90 GHz
Number of Vehicles (Node)	100
Simulation Time (Sec)	300
Speed (km/h)	20
Transmission Power (dBm)	7.5
Protocols	OLSR, DSDV, AODV
Propagation Loss Model	Friis, TRG
MAC Protocol	802.11 P
Packet Size	200B
Carrier Frequency	9GHz

3.6 Simulation

An important part of the experimental setup is propagation loss models in addition to routing protocols incorporated into SUMO simulation. Both systems are connected for messaging between the traffic (SUMO) and the simulation network (NS3). This integration brings better simulation of the behavior of the vehicles and the networks, which occur simultaneously in real time [45].By generating traffic scenarios, the traffic flow of industrial estate Sialkot city's

actual circumstances is mirrored in the simulation. The scenarios are employed for a thorough assessment of vehicle communication systems taking aspects such as node density, traffic pattern, and environment into consideration. The traffic density, the traffic flow patterns, and the road architecture network where all these scenarios are conceived are changed. Traffic scenarios in Sialkot city are simulated as the highways with NS3 in the SUMO platform [5].

3.6.1 Integration of Protocols and Models

Along the vehicle network, routing protocols such as AODV, OLSR, and DSDV are included to specify data packet transmission and routing. In addition to wireless communication simulations, propagation models like the Friis and TRG Propagation Loss Model are being applied in network performance evaluation and communication reliability.

3.6.2 Evaluation Parameter

Prior to and throughout the simulation runs, critical metrics like packet delivery ratio, latency, and throughput are collected for a range of traffic scenarios and node densities. These processes allow us to determine if route algorithms and simulation models are compatible with the actual values of the urban vehicle network.

3.7 Performance Analysis

Hence, the purpose of performance analysis is to determine how efficient and productive vehicle network systems function inside the simulated situations. With the focus on the relationships between the routing protocols and the propagation loss models on the one hand and the network performance and reliability on the other, the main metrics from the network setup stage are analyzed.

3.7.1 Ratio of Packet Delivery

The packet delivery ratio [51] is not only the most prominent operational parameter but also the basis on which the network evaluates its performance level. The percentage of successful data transfer from the source to the destination vehicle is represented by the packet delivery ratio. Use Equation 3.1 to get the packet delivery ratio.

$$PDR = \frac{TSRP}{TTP}$$

TSRP = Total successful packet received

TTP = Total transmitted packet

3.7.2 Overhead Transmission

When source to destination sends data, add some extra bits on the Physical and MAC layers to understand the receiver. If the overhead value is low, it needs only a few extra bits for data packets and sent more data on the link Equation 3.2 guide how to calculate the overhead transmission [25].

$$Overhead = \frac{TNOM}{TTDP}$$

TNOP = Total number of overhead messages

TTDP = Total transmitted data packets

3.7.3 Average Goodput

According to [52][53] goodput is the throughput value determined at the application layer. It solely takes into account the Basic Safety Message (BSM) or the pertinent data for processing, as opposed to throughput. The most useful data in VANETs is thought to be BSM. b/s, mbp/s or kbp/s are units of measurement. The performance of the network improves with increasing Goodput. The average goodput may be calculated using Equation 3.3

$$Goodput_{avg} = \frac{TPR * 8}{TST}$$

TRP = Total packets received

TST = Total simulation time

8 = 1 byte included 8 bits

4. Outcomes and Discussion

This section includes the simulation results for the previously indicated scenario, together with the performance of three routing protocols in the real-time mobility of autos. The performance indicators include goodput, Mac PHY overhead, PDR, amount of received packets, and reception rate. The two propagation loss models used in this study are Friis and TRG.

4.1 Friis Propagation Loss Model-based analysis

The performance comparison of three protocols—AODV, OLSR, and DSDV—with an emphasis on average goodput and overhead is shown in Figure 4.1.

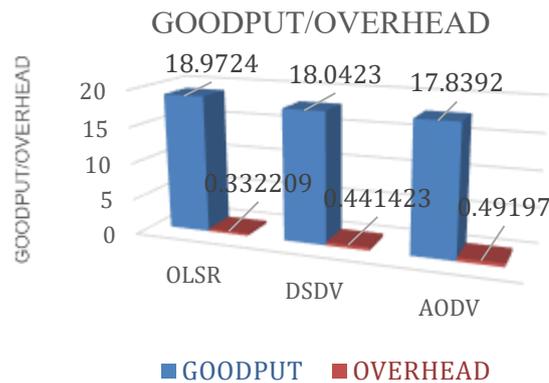


Figure 0.1. Goodput/Overhead Performance

Analysis for Friis Propagation Loss Model

Goodput_{avg}: OLSR > DSDV > AODV

Overhead_{avg}: OLSR < DSDV < AODV

The performance of various routing protocols according to the received rate is shown in Figure 4.2.

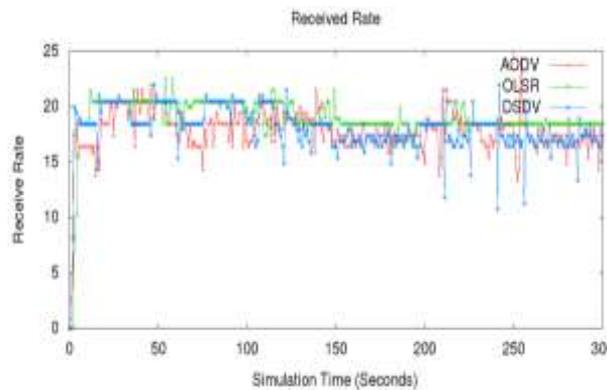


Figure 0.2. Received Rate Performance

Analysis for Friis Propagation Loss Model

Received Rate: OLSR > AODV > DSDV

The performance of different routing protocols is shown in Figure 4.3 according to the quantity of received packets.

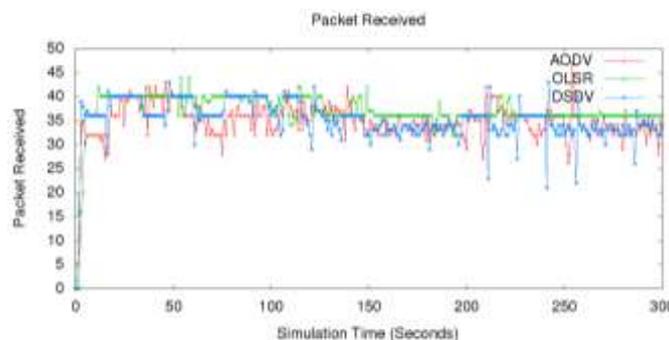


Figure 0.3. Packets Receives Performance

Analysis under Friis Propagation Loss Model

Packets Received: OLSR > AODV > DSDV

The efficiency of several routing strategies for MAC PHY overhead-based vehicular ad hoc networks (VANETs) is shown in Figure 4.4.

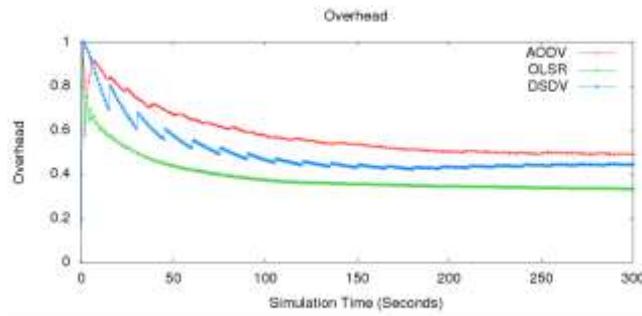


Figure 0.4. Overhead Performance

Analysis under Friis

Overhead: AODV > DSDV > OLSR

Using the Friis propagation loss model, Figure 4.5 shows the packet delivery ratio over the course of the transmission. Initially, the OLSR protocol exhibits the highest packet delivery

ratio compared to other protocols. However, within a few seconds, AODV starts outperforming DSDV. Overall, OLSR maintains a superior packet delivery ratio.

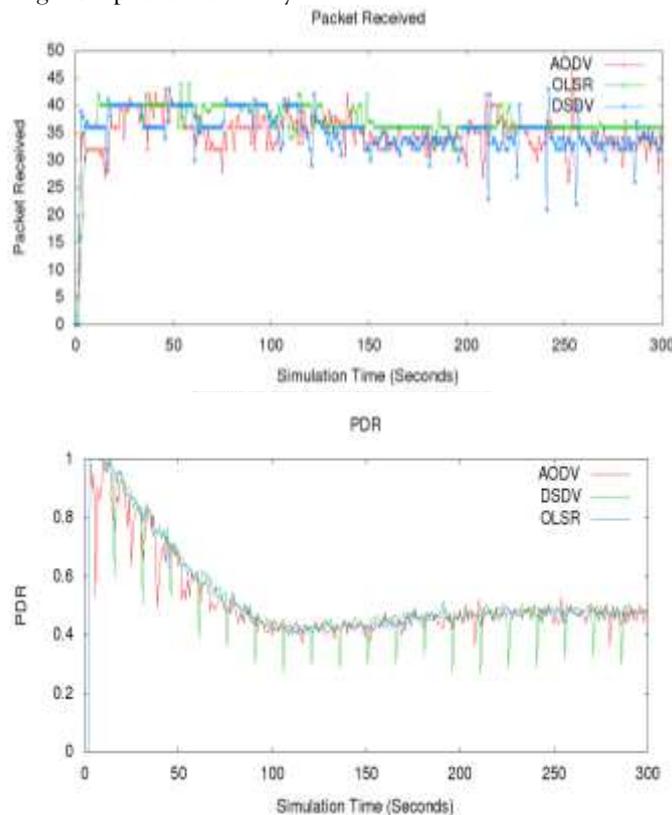


Figure 0.5. Packet Delivery Ratio Performance under Friis Propagation Loss Model

Packet Delivery Ratio: OLSR > AODV > DSDV

4.2. Analysis Based on Two Ray Ground Propagation Model

In Figure 4.6 the average goodput and Mac PHY overhead performance of three VANETs

routing protocols—AODV, DSDV, and OLSR—is shown. OLSR outperforms both AODV and DSDV in terms of performance.

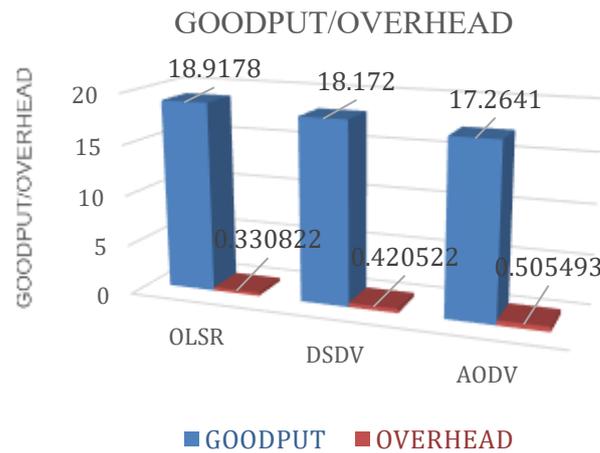


Figure 0.6. Goodput/Overhead Performance

Analysis under TRG Propagation Loss Model

Goodput_{avg}: OLSR > DSDV > AODV

Overhead_{avg}: OLSR < DSDV < AODV

The efficiency of various routing strategies based on the reception rate is shown in Figure 4.7. The

data shows that OLSR achieves a higher reception rate compared to both AODV and DSDV.

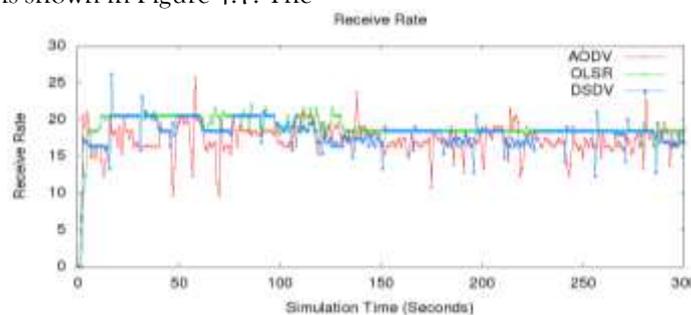


Figure 0.7. Receive Rate Performance

Analysis under Two Ray Ground Propagation Loss Model

Received Rate: OLSR > DSDV > AODV

The performance of routing protocols in response to received packets is depicted in Figure 4.8. Compared to AODV and DSDV,

OLSR delivers a better rate of reception. The DSDV routing protocol performs better at receiving packets than the AODV routing protocol when using the two-ray ground propagation loss model.

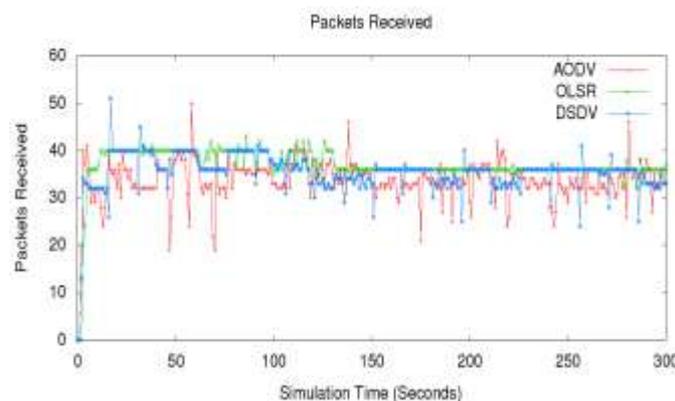


Figure 0.8. Packets Received under Two Ray Ground Propagation Loss Model

Packets Received: OLSR > DSDV > AODV

The efficacy of overhead-based routing techniques for VANETs is seen in Figure 4.9. While DSDV has less overhead than AODV, OLSR also has less overhead when compared to both. In particular, OLSR's proactive approach guarantees that the routing tables are constantly current, which minimizes the need for frequent route discoveries and, as a result, overhead. However, because DSDV is a table-driven

protocol, it constantly updates its routing tables, which also helps to reduce overhead. On the other hand, because of its route discovery method, AODV runs on an on-demand basis, which results in increased overhead. The findings show that OLSR and DSDV offer more effective solutions than AODV in situations when lowering overhead is essential.

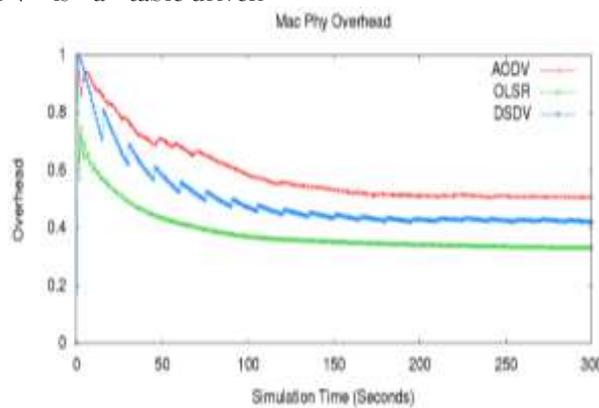


Figure 0.9. Overhead Performance Analysis under Two Ray Ground Propagation Loss Model

Overhead: AODV > DSDV > OLSR

The PDR during the transmission duration is displayed in Figure 4.10 using the Two Ray Ground propagation loss model. The packet

delivery ratio of the OLSR protocol is initially the best when compared to other protocols; however, AODV surpasses DSDV in a couple of seconds.

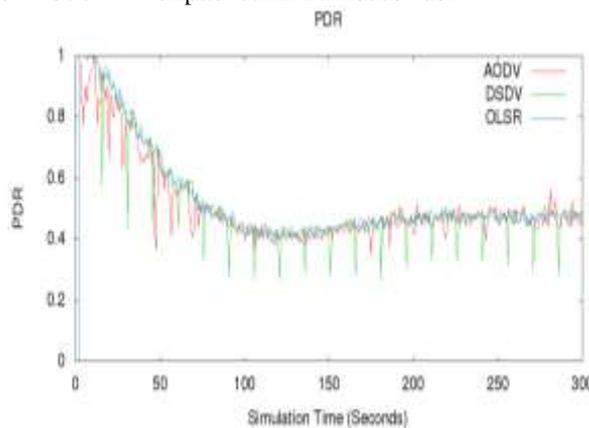


Figure 0.10. PDR under Two Ray Ground Propagation Loss Model

Packet Delivery Ratio: OLSR > AODV > DSDV

4.3 Research Finding

We selected the industrial region of Sialkot, Pakistan, for our study. This research aims to raise awareness of the issue of traffic congestion caused by a breakdown in communication in conventional ways of moving finished goods

from production to the warehouse. We conduct tests using NS3 and SUMO to determine the optimal algorithm for V2V message transmission. According to the research, autonomous cars are a better option for moving items from a factory to a warehouse than carts or other conventional techniques like using trucks or other vehicles. This is especially true for the

business sector in Sialkot. In our research, we ran simulations utilizing the same situation but with several vehicular ad hoc network communication protocols and propagation loss models. The conclusions of our study present the role of autonomous cars in industrial settings, together with the various strategies for improving the efficiency of the process whereby the goods from assembly lines are sent to warehouses. The adoption of the technology encourages businesses to reduce pollution and exploit the limited resources of the environment.

The SUMO and NS3 simulators have been utilized to investigate how vehicles exchange data within VANETs. This research focuses on assessing the performance of three routing protocols: OLSR, DSDV, and AODV. The evaluation is carried out using two propagation loss models: the Friis free-space model and the Two-Ray Ground (TRG) model. During the data-sharing process, various performance metrics are analyzed, including goodput, overhead, PDR, packets received, and received rate. The findings from this evaluation reveal an important insight: the performance of routing protocols varies significantly depending on the propagation loss model used. This variation underscores the necessity of understanding the

specific characteristics of the propagation environment when analyzing and selecting routing protocols for VANETs. Such knowledge is essential for developing more efficient and reliable vehicular communication systems, ensuring optimal data sharing, and maintaining robust network performance across different environments. Further, it is concluded that, based on a comparison between previous studies and the present study on routing protocols, the performance of these protocols varies not only with propagation loss models but also with different traffic and road scenarios. This comprehensive analysis highlights that factor such as traffic density, vehicle speed, and road topology significantly impact the effectiveness and efficiency of routing protocols in VANETs. Consequently, it is crucial to consider these variables when designing and implementing routing strategies to ensure robust and reliable vehicular communication. Understanding the interplay between these factors can lead to the development of adaptive protocols that can dynamically adjust to varying conditions, thereby enhancing overall network performance and data sharing efficiency in diverse vehicular environments.

Table 4.1. Comparison of Base/Existing and Current Study

Area	Routing Protocols	Propagation Loss Model	Performance Metrics	Results
Bouira City Algeria [7].	AODV, DSDV, OLSR		PDR, Overhead, Goodput	Performance of Routing protocols varies with Traffic Density
Melaka City Malaysia [11].	AODV, DSDV, OLSR	Two Ray Ground	PDR, PLR, EED	AODV outstanding in terms of PDR and PLR
Sialkot City Pakistan	AODV, DSDV, OLSR	Friis, Two Ray Ground	Goodput, Overhead, PDR, Packets Received, Receive Rate.	OLSR Perform better as compare to others in all aspects.

5. Conclusion and Future Directions

5.1 Conclusion

In this article, traffic in the industrial sector of Sialkot, Pakistan is analyzed in the current times. Originating in Sialkot, the industrial hub of Pakistan, sports goods, surgical instruments, and leather goods are distributed worldwide. OSDV,

DSDV and OLSR are studied with Friis and Two Ray Ground propagation loss models that we will account for in the simulation. Different models of propagation loss will manifest different levels of accuracy on the specifications of performance. Received rate, received packets, overhead, and goodput are the corresponding

parameters evaluated. Above said protocols perform better with Friis as compare to Two Ray Ground model, especially OLSR routing protocols.

Meanwhile, with both propagation loss models, OLSR performs better than DSDV and AODV. AODV performs better than DSDV in the Friis loss model in terms of packets received and received rate, although having a greater overhead. While other protocols perform better than the Two-Ray Ground propagation loss model, DSDV outperforms it in terms of packet received and received rate. Overall, the study shows that propagation loss model shave effect on the performance of routing protocols is in vehicle ad hoc networks. In this study, topology-based routing protocols perform better with the Friis propagation loss model as compare to Two-Ray Ground propagation loss model especially when using OLSR routing protocol.

5.2 Future Direction

In this study, we use simulation tools SUMO and NS3 to analyze the effectiveness of message transmission between vehicles in the Sialkot industrial region. We research using many VANETs routing protocols utilizing the Friis and Two-Ray ground propagation loss model. We went over earlier studies and examined how the propagation loss model functions for different protocols. In the future, the entire world industry is moving towards autonomous vehicles, and this study can be useful in Sialkot Industrial Estate to implement autonomous vehicles to transport goods from factory to warehouse and from one place to another. According to our analysis, for VANET routing protocols, the Friis propagation loss model is suitable as compared to the TRG propagation loss model in industrial estate Sialkot. The commercial sector would be better served by using the technology for freight. We will investigate ways to improve message security during vehicle transmission as a future research topic. Additionally, use VANETs to examine how technology is affecting the business industry's logistics sector while concurrently trying to improve the performance of algorithms for dependable and quick communication.

Author Contributions

Wasif Muhai-ud-Din: conceptuality, literature, methodology, writing original draft, simulation, visualization, investigation.

Imtiaz Hussain: supervision, review and testing.

Compliance with Ethical Standards

The authors declare that they have no conflict of interest. This study does not involve the use, access, or processing of any private or personally identifiable information at any stage of the research. All data used in this work are generated through simulation-based environments rather than collected from human participants or real-world personal sources. Simulation tools such as SUMO were employed for real-time traffic generation, while NS-3 was used for system visualization and network performance analysis. The use of these platforms ensures a controlled, ethical, and risk-free research environment. Moreover, these tools contribute to maintaining accuracy, improving system performance evaluation, and supporting transparency and reproducibility of the results.

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