

TRAFFIC CONGESTION MANAGEMENT IN VANET NETWORK

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Computer Science and Engineering

By

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(DEEMED TO BE UNIVERSITY)**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **TUPRAN NISHANTH KUMAR (40111360)** and **THIRAKALA SRITEJA (40111336)** who carried out the Project work entitled "Traffic congestion management in VANET Networks" under my supervision from Nov 2023 to April 2024.

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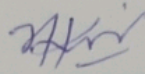
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I, TUPRAN NISHANTH KUMAR (Reg No: 40111360), hereby declare that the Project Report entitled "Traffic congestion management in VANET Networks" done by me under the guidance of Dr.N.S Usha,M.E.,Ph.D is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Computer Science and Engineering.

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ABSTRACT

Traffic congestion is a persistent and multifaceted challenge in urban areas, exacerbating travel times, fuel consumption, and environmental degradation. In response, this study proposes an innovative approach to alleviate congestion through advanced traffic management strategies. By harnessing real-time data from Vehicular Ad hoc Networks (VANETs), informed decision-making becomes feasible, enabling dynamic adjustments to traffic signal timings and consequent improvements in traffic flow. The overarching objective of this project is to develop a resilient and adaptable congestion management system, fostering enhanced urban transportation efficiency and ultimately resulting in reduced traffic congestion, shorter commutes, and a more sustainable urban environment. Beyond congestion management, the study delves into various facets of traffic pattern analysis, including intelligent vehicle detection, route prediction, and vehicle path monitoring. While existing research predominantly focuses on utilizing VANETs for congestion detection, this project explores the integration of data mining techniques to develop a comprehensive mechanism for detecting, controlling, and predicting both recurrent and nonrecurrent traffic congestions within a unified system framework. Moreover, the study aims to address the inherent challenges associated with developing such an integrated system, including the optimization of detection algorithms, control mechanisms, and predictive models. Through meticulous identification, optimization, and algorithm development, the project seeks to advance the state-of-the-art in traffic congestion management within VANETs. Leveraging simulation tools such as NS3 and SUMO, the project aims to evaluate the performance of different network protocols and traffic management strategies under various traffic scenarios. By synthesizing insights from simulation results with real-world data, the project endeavors to provide actionable recommendations for the deployment of effective congestion management solutions in urban environments. Ultimately, the research contributes to the broader goal of enhancing urban mobility, reducing environmental impact, and improving overall quality of life in urban areas through innovative traffic management approaches enabled by VANET technologies.

TABLE OF CONTENTS

Chapter No	TITLE	Page No.
	ABSTRACT	iv
	LIST OF FIGURES	vii
	LIST OF ABBREVIATIONS	viii
1	INTRODUCTION	1
2	LITERATURE SURVEY	3
	2.1 Inferences from Literature Survey	2
	2.2 Existing System	7
	2.3 Open Problems in Existing System	8
	2.4 Proposed System	9
3	AIM AND SCOPE OF THE PRESENT INVESTIGATION	
	3.1 Aim	9
	3.2 Objective	10
	3.3 Scope of The Present Investigation	11
	3.4 Risk Analysis of Project	12
	3.5 Hardware Requirements	16
4	EXPERIMENTAL OR METHODS, ALGORITHMS USED	17
	4.1 Selected Methodology or Process Model	18
	4.2 Architecture / Overall Design of Proposed System	19
	4.3 Model Architecture Design/Algorithm	24
	4.4 Description of Software Implementation and Testing Plan	26

	4.5	Routing in VANET	29
	4.6	ADHOC Routing Protocols	31
5		IMPLEMENTATION DETAILS	38
	5.1	Data Collection	38
	5.2	Routing Protocols Implementation	39
	5.3	Traffic Congestion Algorithms Evaluation	41
	5.4	Real-Time Map Designing	42
	5.5	Conversion of SUMO to Ns3	43
6		RESULTS AND DISCUSSIONS	45
7		CONCLUSION AND FUTURE WORK	
	7.1	Conclusion	48
	7.2	Future Enhancement	48
		REFERENCES	50
		APPENDIX	
		A. SOURCE CODE	52
		B. SCREEN SHOTS	63
		C. RESEARCH PAPER	64
		D.CERTIFICATE	71

LIST OF FIGURES

FIGURE NO.	FIGURE NAME	PAGE NO.
4.1	VANET Overview	20
4.2	Components of VANET	21
4.3	VANET Architecture	22
4.4	Table Architecture	23
4.5	VANET Communication Architecture	24
4.6	Elements of VANET	26
4.7	ADHOC Protocols	32
4.8	DSDV routing	34
4.9	AODV Routing	35
4.10	AODV vs DSDV	37
6.1	SUMO CMD	46
6.2	Open Street Maps (OSM)	46
6.3	SUMO Simulation	47

LIST OF ABBREVIATIONS

VANET	Vehicular Adhoc Network
SUMO	Simulation of Urban Mobility
NS3	Network Simulator 3
AODV	Adhoc On-Demand Distance Vector
DSDV	Destination Sequence Distance Vector Routing
CMD	Command Prompt
DSR	Distance Signal Repository
V2V	Vehicle to Vehicle Communication
V2I	Vehicle to Infrastructure Communication
DSRC	Dedicated Short Range Communication
RREQ	Route Request Packet

CHAPTER 1

INTRODUCTION

Traffic congestion is a major problem in many urban areas, affecting the environment, economy and quality of life of the citizens. One of the possible solutions to mitigate this problem is to use vehicular ad hoc networks (VANETs), which are self-organized networks of vehicles that communicate with each other and with roadside infrastructure. VANETs can provide various applications and services, such as traffic information dissemination, route guidance, accident warning, parking management and entertainment. In this project, we aim to design and implement a traffic congestion management system using VANETs, which can collect and analyze real-time traffic data, optimize traffic flow and reduce travel time and emissions. We will use simulation tools and testbeds to evaluate the performance and feasibility of our proposed system. We will also address the challenges and issues related to VANETs, such as security, privacy, scalability and reliability.

V2I and V2V communication are two types of wireless technologies that enable vehicles to communicate with each other and with the infrastructure. V2I stands for vehicle-to-infrastructure communication, which allows vehicles to exchange information with traffic signals, road signs, parking meters, and other roadside devices. V2V stands for vehicle-to-vehicle communication, which allows vehicles to share data such as speed, position, direction, and braking status with nearby vehicles. These technologies can improve road safety, traffic efficiency, and environmental sustainability by providing drivers with real-time information and warnings, coordinating traffic flow, and reducing fuel consumption and emissions.

The recent advancements in wireless networking are responsible for entire change in communication model as seen today. This is because it is easy to deploy and setup. These wireless networks can be classified either mobile infrastructure or ad-hoc depending on how they are deployed. Mobile infrastructure has fixed deployment model while adhoc have flexible mobile model. The fixed mode requires an infrastructure to be deployed before devices (called nodes) start to communicate with each other. The devices in this model communicate with infrastructure as well as with each other.

CHARACTERISTICS OF VANET

VANET is an application of MANET but it has its own distinct characteristics which can be summarized as:

- i. **High Mobility:** The nodes in VANETs usually are moving at high speed. This makes harder to predict a node's position and making protection of node privacy.
- ii. **Rapidly changing Network topology:** Due to high node mobility and random speed of vehicles, the position of node changes frequently. As a result of this, network topology in VANETs tends to change frequently.
- iii. **Unbounded network size:** VANET can be implemented for one city, several cities or for countries. This means that network size in VANET is geographically unbounded.
- iv. **Frequent exchange of information:** The ad hoc nature of VANET motivates the nodes to gather information from the other vehicles and road side units. Hence the information exchange among node becomes frequent.
- v. **Wireless Communication:** VANET is designed for the wireless environment. Nodes are connected and exchange their information via wireless. Therefore, some security measure must be considered in communication.
- vi. **Time Critical:** The information in VANET must be delivered to the nodes with in time limit so that a decision can be made by the node and perform action accordingly.
- vii. **Sufficient Energy:** The VANET nodes have no issue of energy and computation resources. This allows VANET usage of demanding techniques such as RSA, ECDSA implementation and also provides unlimited transmission power.
- viii. **Better Physical Protection:** The VANET nodes are physically better protected. Thus, VANET nodes are more difficult to compromise physically and reduce the effect of infrastructure attack.
- ix. **High computational capability:** Operating vehicles can afford significant computing, communication and sensing capabilities.
- x. **Partitioned network:** Vehicular networks will be frequently partitioned. The dynamic nature of traffic may result in large inter vehicle gaps in sparsely populated scenarios and hence in several isolated clusters of nodes.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE SURVEY

The following papers were referenced and studied for the project.

[1] R. Hussain, J. Lee, and S. Zeadally, "Trust in VANET: a survey of current solutions and future research opportunities" IEEE Transactions on Intelligent Transportation Systems, 2021.

This study [1] examines, evaluates few of the most recent trust management and establishing techniques for automobile networks. Along with discussing the drawbacks and restrictions of current methods, it also makes some recommendations for potential future research areas. This paper discusses entity trust and data trust, two concepts that are critical to dependable and safe communication in vehicular ad hoc networks (VANETs).

[2] Facchina, C. Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control (Doctoral dissertation, University of Windsor (Canada),2020).

In this paper [2], Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control is the dissertation's description of a novel algorithm that modifies the transmission power of beacon messages in Vehicular Ad Hoc Networks (VANETs) in response to vehicle speed and density. The algorithm's objectives are to lessen network congestion and enhance the dependability and promptness of safety messages. The dissertation compares and evaluates the algorithm with other approaches through simulation, and it is concluded that the algorithm performs better in terms of communication overhead and congestion control.

[3] N. Lyamin, B. Bellalta, and A. Vinel, "Age-of-informationaware decentralized congestion control in vanets," IEEE Networking Letters, vol. 2, no. 1, 2020

This research [3] presents a unique approach based on the age of information (Aol) metric to maximize the transmission rate of automobiles in a Vehicular Ad-hoc Network (VANET). The technique attempts to prevent packet collisions and channel congestion while minimizing the network's average area of overlap. The strategy is assessed using simulations in the paper and compared to other current methods.

[4] Sharma, S., Chahal, M., & Harit, S. (2019, February). Transmission Rate-based Congestion Control in Vehicular Ad Hoc Networks. In 2019 Amity International Conference on Artificial Intelligence (AICAI). IEEE

A Rate adaptation and priority modeling are two unique ways of controlling network congestion in vehicular ad hoc networks (VANETs) that are discussed in the paper [4]. Vehicle Ad Hoc Networks, or VANETs, are networks of automobiles that use wireless technology to communicate with infrastructure and one another. They are used in many different areas, including traffic management, infotainment, and safety. But because of the large number of cars and the regular exchange of safety alerts, they also have to deal with network congestion. In order to regulate the transmission rate of the beacon signals—periodic communications containing vehicle status information—the study suggests the use of the Decentralized Congestion Control (DCC) algorithm.

[5] de Sousa, R. S., Boukerche, A., & Loureiro, A. A. DisTraC: A Distributed and Low-Overhead Protocol for Traffic Congestion Control Using Vehicular Networks IEEE Symposium on Computers and Communications (ISCC). IEEE, 2019.

This study [5] introduces DisTraC, a novel protocol that cuts down on travel times and traffic jams in cities by utilizing V2V communication. Based on traffic density, DisTraC adjusts the beacon message transmission rate and prioritizes emergency

alerts. In terms of communication overhead and congestion control, the paper's simulated evaluation of DisTraC demonstrates its superior performance over current techniques

[6] Akinlade, O., Saini, I., Liu, X., & Jaekel, A. Traffic Density Based Distributed Congestion Control Strategy for Vehicular Communication, 2019.

This research [6] suggests a novel method for modifying the vehicles' transmission power in a Vehicular Ad Hoc Network (VANET) according to the network's vehicle density. Reducing network channel congestion and enhancing network performance are the objectives. In comparison to current technologies, the paper's simulated evaluation of the suggested solution demonstrates its ability to lower packet loss and inter-packet delay.

[7] R. Chhabra, C. Rama Krishna, and S. Verma, "Context-aware hybrid adaptive beaconing for driver behavior dissemination in VANETs," IETE Journal of Research, 2021.

This [7] study aims to enhance communication in Vehicular Ad hoc Networks (VANETs) by improving beaconing mechanisms. The proposed method adapts beaconing based on contextual factors such as vehicle density, road conditions, and driver behavior. It combines both periodic and event-triggered beaconing to optimize information dissemination while minimizing network overhead. By tailoring beaconing to specific scenarios, this approach enhances safety-critical messages (e.g., collision warnings) in VANETs. Their research aims to make VANETs smarter and more efficient by dynamically adjusting beaconing strategies based on real-world context

[8] P. Rajput, M. Chaturvedi, and V. Patel, "Opportunistic sensing-based detection of crowdedness in public transport buses," Pervasive and Mobile Computing, 2020.

Opportunistic sensing-based Detection aims to address the challenge of assessing crowdedness levels in buses. The authors propose an opportunistic sensing-based

approach. They leverage data from accelerometers and Global Positioning System (GPS) sensors available in smartphones carried by commuters. By analyzing sensor data, the system identifies crowded conditions within buses. This technology is used to improve public transportation services by providing real-time information on bus occupancy.

[9] A. U. Haq, K. Liu, and M. B. Latif, "A Location-and Mobility-Aware Clustering-Based TDMA MAC Protocol for Vehicular Ad-hoc Networks," 28th Wireless and Optical Communications Conference (WOCC), 2019.

Location and Mobility aware clustering enhance communication in Vehicular Ad hoc Networks (VANETs) by improving Medium Access Control (MAC) protocols. The proposed protocol is location-aware and mobility-aware. It leverages clustering techniques to optimize time division multiple access (TDMA) scheduling. By adapting to real-world context, this protocol enhances data exchange efficiency in VANETs. Vehicles are grouped into clusters based on their proximity and mobility patterns. Time slots are allocated dynamically to clusters, considering their location and movement.

[10] G. H. Alsuhli, A. Khattab, and Y. A. Fahmy, "Double-head clustering for resilient VANETs," Wireless Communications and Mobile Computing, vol. 2019.

The study addresses the challenges of Vehicular Ad Hoc Networks (VANETs), including scalability and highly dynamic topology. The authors introduce a general-purpose resilient double-head clustering (DHC) algorithm for VANETs. DHC leverages relevant mobility metrics (such as vehicle speed, position, and direction) and communication link quality metrics (like link expiration time and signal-to-noise ratio). DHC exhibits enhanced performance and stability during cluster maintenance phases. The algorithm's effectiveness is validated through extensive evaluations, comparing it with other algorithms under various mobility scenarios and radio channel models.

Inference from the above study

The referenced studies encompass innovative approaches to enhance vehicular communication and congestion control in VANETs. They explore trust management, adaptive transmission power, age-of-information metrics, congestion control algorithms, and novel protocols like DisTraC. Context-aware beaconing and opportunistic sensing further refine VANET efficiency. Location and mobility-aware clustering protocols, along with resilient clustering algorithms, address scalability and dynamic topology challenges. Collectively, these advancements contribute to safer, more efficient vehicular communication systems, paving the way for intelligent transportation networks capable of dynamically adapting to real-world conditions, enhancing road safety, traffic flow, and overall urban mobility.

2.2 EXISTING SYSTEM

VANETs can be used to disseminate real-time traffic information to vehicles. This information can include traffic conditions, road closures, accidents, and alternative routes. By providing drivers with up-to-date information, they can make informed decisions to avoid congested areas, thus reducing overall traffic congestion. VANETs can be integrated with traffic signal control systems to optimize traffic signal timings based on real-time traffic conditions. By adjusting signal timings dynamically, traffic flow can be improved, reducing congestion at intersections. VANETs enable vehicles to communicate with each other to share traffic information and collectively plan routes. Using this information, vehicles can dynamically adjust their routes to avoid congested areas, leading to more efficient traffic flow. Some systems use real-time data from VANETs to detect and control traffic congestion. For instance, the Congestion Detection and Control Algorithm (CDCA) leverages V2V (vehicle-to-vehicle) and V2I (vehicle-to-infrastructure) communication networks to manage congestion effectively.

- 1) Cooperative Adaptive Cruise Control (CACC):** CACC systems utilize VANET technology to enable vehicles to communicate with each other and maintain safe following distances automatically. By coordinating acceleration and braking among vehicles, CACC systems can improve traffic flow and

reduce congestion, especially on highways.

- 2) **Dynamic Lane Assignment:** VANETs can be used to dynamically assign lanes to vehicles based on traffic conditions. By directing vehicles to less congested lanes, overall traffic flow can be improved, reducing congestion.
- 3) **Parking Management:** VANETs can be utilized for smart parking management systems. Vehicles can communicate with parking infrastructure to find available parking spaces more efficiently, reducing congestion caused by drivers searching for parking.

2.3 OPEN PROBLEMS IN THE EXISTING SYSTEM

Addressing traffic congestion in modern urban environments presents several challenges, including the development of dynamic traffic flow models capable of accounting for real-time factors such as weather conditions and accidents, the implementation of adaptive traffic signal control systems, integration of multi-modal transportation options, and fostering sustainable transportation practices. Additionally, optimizing freight transportation routes, improving public transportation accessibility, and integrating real-time traffic data from various sources are essential to reduce congestion. Smart city initiatives leveraging technology, influencing driver behavior for responsible driving, and effective governance and policies are central to congestion management. Furthermore, addressing issues related to emergency and evacuation planning, data privacy, urban planning, and land use, as well as raising public awareness about congestion's impact, play key roles in reducing traffic congestion and creating more efficient, sustainable urban transportation systems.

1. **Dynamic Traffic Flow Modeling:** Developing more accurate and dynamic models for traffic flow that can account for various factors, such as weather conditions, special events, and accidents, in real-time.
2. **Effective Traffic Signal Control:** Designing intelligent traffic signal control systems that can adapt to changing traffic conditions, prioritize public transportation, and optimize traffic flow to reduce congestion.
3. **Multi-Modal Transportation Integration:** Creating seamless integration between various modes of transportation, including buses, subways, rideshares, and cycling, to provide commuters with efficient and convenient options for reducing congestion.

4. **Sustainable Transportation:** Encouraging the adoption of sustainable and eco-friendly transportation methods, such as electric vehicles and public transportation, to reduce the environmental impact of congestion.
5. **Route Optimization for Freight Transportation:** Developing route optimization strategies for freight transportation that reduce the impact of truck traffic on congestion and improve logistics efficiency.

2.4 PROPOSED SYSTEM

The proposed system leverages Vehicular Ad Hoc Networks (VANETs) and intelligent algorithms to dynamically manage traffic congestion. By integrating Dedicated Short-Range Communication (DSRC) technology with machine learning-based traffic prediction and dynamic tolling, the system aims to optimize traffic flow and reduce congestion in urban areas. Key components include edge computing for real-time data processing, cooperative communication among vehicles, and adaptive control mechanisms for traffic signals. Additionally, the system provides drivers with dynamic route suggestions based on real-time traffic data, contributing to reduced travel times and environmental impact while prioritizing road safety. Overall, the proposed system offers a resilient and effective solution for addressing traffic congestion in urban environments.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 AIM

The aim of the project is to analyze and evaluate different network protocols within Vehicular Ad hoc Networks (VANETs) to effectively manage and alleviate traffic congestion. By conducting comprehensive assessments of various routing, congestion control, and traffic management techniques, the project aims to identify strategies that optimize VANET performance in congested environments. The ultimate goal is to contribute to the development of efficient VANET systems capable of enhancing road safety, reducing delays, and improving overall traffic flow in urban and highway settings. Through empirical testing and analysis, the project seeks to provide valuable insights into the design and implementation of VANET solutions that address the challenges posed by dynamic vehicular environments.

3.2 OBJECTIVE

The objective of the project on traffic congestion management in Vehicular Ad hoc Networks (VANETs) is to investigate and demonstrate the effectiveness of different network protocols in alleviating traffic congestion. VANETs play a crucial role in enhancing road safety and traffic efficiency by enabling communication among vehicles and infrastructure. However, the dynamic nature of vehicular environments poses significant challenges, such as congestion, which can lead to delays, accidents, and inefficient use of road resources.

Through this project, we aim to evaluate various network protocols, including routing, congestion control, and traffic management techniques, to optimize the performance of VANETs in congested scenarios. The key objectives include:

1. Assessing the performance of different routing protocols (e.g., AODV, DSR, and OLSR) in terms of packet delivery ratio, end-to-end delay, and network overhead under varying traffic densities.
2. Investigating congestion control mechanisms, such as rate control and admission control, to mitigate congestion and improve network efficiency.
3. Implementing and testing traffic management strategies, such as traffic signal optimization and route guidance, to alleviate congestion hotspots and enhance traffic flow.

By achieving these objectives, we aim to contribute to the development of efficient and reliable VANET systems capable of effectively managing traffic congestion, thereby improving overall road safety and mobility.

3.3 SCOPE OF THE PRESENT INVESTIGATION

The scope of the present investigation encompasses several key aspects related to traffic congestion management in Vehicular Ad Hoc Networks (VANETs).

i) Utilization of VANETs for Traffic Management

The investigation focuses on leveraging VANETs to address traffic congestion challenges in urban areas. It aims to harness the real-time data collected from VANETs to implement innovative traffic management strategies.

ii) Innovative Strategies for Congestion Management

The project proposes the implementation of advanced traffic management techniques, including dynamic adjustment of traffic signal timings based on real-time data analysis. These strategies aim to improve traffic flow and reduce congestion in urban environments.

iii) Exploration of Traffic Patterns

The investigation delves into the study of traffic patterns using VANETs, encompassing intelligent vehicle detection, route prediction, vehicle path monitoring, and other related features. By analyzing traffic patterns, the project seeks to develop effective congestion detection, control, and prediction mechanisms.

iv) Integration of Data Mining Techniques

While previous studies have primarily focused on using VANETs for detecting traffic congestion, the present investigation explores the deployment of data mining techniques to enhance congestion management. The project aims to develop an efficient mechanism that combines congestion detection, control, and prediction into a single system.

v) Examination of Traffic Congestion Algorithms

The investigation involves the identification, optimization, and analysis of algorithms for traffic congestion management in VANETs. It explores various approaches to optimize traffic flow and mitigate congestion using VANET-based systems.

vi) Evaluation of VANET Protocols

The project evaluates different VANET protocols, including NS3 and SUMO, to assess their effectiveness in managing traffic congestion. It aims to analyze the performance of these protocols under various traffic conditions and scenarios.

3.4 RISK ANALYSIS OF THE PROJECT

Risk analysis for the project "Traffic Congestion Management in VANET Networks" involves identifying potential risks that could impact the successful completion of the project and developing strategies to mitigate or manage these risks. Here are some key risk factors and mitigation strategies:

1. Technical Risks

Complexity of VANET Systems: VANETs are complex systems with numerous interacting components. The integration of various technologies such as DSRC, edge computing, and machine learning algorithms may introduce technical challenges. Thorough testing and validation of each component, utilizing simulation tools like SUMO and NS-3 to identify and address potential integration issues. **Data Accuracy and Reliability:** Real-time traffic data collected from VANETs may be prone to errors or inconsistencies, affecting the accuracy of congestion detection and management algorithms. Implement data validation and error-checking mechanisms, calibrate sensors regularly, and incorporate redundancy in data collection methods to ensure reliability.

2. Operational Risks

Network Stability and Performance: VANETs operate in dynamic and unpredictable environments, leading to potential issues with network stability, connectivity, and performance. Conduct extensive testing in diverse scenarios to evaluate network performance, implement robust communication protocols, and deploy redundant communication channels to mitigate the impact of network failures. **Privacy and Security Concerns:** The transmission of sensitive data in VANETs raises privacy and security concerns, including unauthorized access, data breaches, and malicious attacks. Employ encryption techniques to secure data transmission, implement access control mechanisms, and deploy intrusion detection systems to detect and respond to security threats proactively.

3. Resource Risks

Budget Overruns: Unexpected expenses or cost overruns may occur due to unanticipated equipment purchases, software licensing fees, or additional manpower requirements. Develop a detailed budget plan, regularly monitor expenses, and allocate contingency funds to address unforeseen costs. **Resource Constraints:** Limited availability of skilled personnel, hardware, or software resources may hinder project progress and impact deliverable timelines. Identify resource constraints early, prioritize

tasks, and consider outsourcing certain activities or collaborating with external partners to supplement internal resources.

4. External Risks

A) Regulatory Compliance: Changes in regulatory requirements or legal frameworks governing VANETs may necessitate adjustments to project plans and technical specifications. Stay updated on relevant regulations, engage legal experts to assess compliance requirements, and maintain flexibility in project timelines to accommodate regulatory changes. Vendor Dependence: Dependency on third-party vendors for hardware, software, or services may introduce risks related to product availability, support, and vendor reliability. Conduct thorough vendor assessments, establish clear contractual agreements, and diversify vendor partnerships to minimize reliance on any single vendor. By proactively identifying and addressing these risks, the project team can enhance the likelihood of project success and mitigate potential negative impacts on project objectives, timelines, and outcomes. Regular monitoring and reassessment of risks throughout the project lifecycle are essential to adapt to evolving circumstances and ensure project resilience.

3.5 SOFTWARE REQUIREMENTS SPECIFICATION DOCUMENT

Python

Python is the primary programming language for machine learning and neural network development. Python serves as the primary scripting language for implementing custom algorithms, data analysis, and visualization tasks within the research framework. Its simplicity, versatility, and extensive libraries make it well-suited for rapid prototyping and experimentation. Researchers can develop traffic prediction models, congestion detection algorithms, and optimization techniques using Python's rich ecosystem of scientific computing libraries such as NumPy, Pandas, and Matplotlib. Python's integration with SUMO and NS-3 enables seamless interaction with simulation environments, facilitating the implementation and testing of the proposed congestion management system.

SUMO (Simulation of Urban Mobility)

SUMO is a powerful traffic simulation tool designed for modeling and analyzing traffic flows in urban environments. It offers a comprehensive platform for simulating various traffic scenarios, including vehicle movements, traffic signals, and road networks. SUMO enables researchers and practitioners to evaluate traffic management strategies, study the impact of infrastructure changes, and optimize transportation systems for enhanced efficiency and safety.

OSM (OpenStreetMap) Maps

OSM maps provide a rich source of geospatial data that can be utilized for various mapping and navigation applications. With its open and collaborative nature, OSM allows users to access detailed maps of roads, buildings, and points of interest worldwide. OSM maps are particularly valuable for developing location-based services, route planning, and geographic analysis. By leveraging OSM data, developers can create customized maps tailored to specific requirements and integrate them into their applications seamlessly.

NS-3 (Network Simulator 3)

NS-3 is a widely-used discrete-event network simulator capable of modeling various communication networks and protocols. It provides a flexible and extensible framework for simulating network behavior, including wired, wireless, and Internet protocols. NS-3 enables researchers and developers to evaluate the performance of networking algorithms, study protocol interactions, and assess the impact of network configurations on overall system behavior. With its modular design and extensive library of models, NS-3 is an invaluable tool for simulating and analyzing complex network scenarios.

Operating System

The software tools you choose should be compatible with your preferred operating system, such as Windows or Linux. For this project, we are utilizing Ubuntu, a popular Linux distribution, so the selected software is compatible with this operating system.

3.5 HARDWARE REQUIREMENTS

- Operating system : Linux
- Processor : minimum intel i3
- Ram : minimum 4 gb
- Hard disk : minimum 250gb
- Input Device : Keyboard, Mouse, Camera

CHAPTER 4

DISCRIPTION OF PROPOSED SYSTEM

System Overview

The proposed system aims to address traffic congestion in urban areas by leveraging Vehicular Ad Hoc Networks (VANETs) and advanced traffic management techniques. By collecting and analyzing real-time data from vehicles within the network, the system dynamically adjusts traffic signal timings to optimize traffic flow and reduce congestion. Key components of the system include VANET communication protocols, traffic simulation tools, and data analysis algorithms.

Key Components

1. VANET Communication Protocols

The system relies on communication protocols such as Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) to facilitate real-time data exchange among vehicles and roadside infrastructure. These protocols enable the transmission of traffic information, including vehicle speed, location, and traffic conditions. By using the Vehicle-to-infrastructure technology, drivers can be warned of dangers such as red-light violations and any stop signs they may not notice.

2. Traffic Simulation Tools

- a. SUMO (Simulation of Urban Mobility):** SUMO is utilized for simulating realistic traffic scenarios based on OpenStreetMap (OSM) data. It allows researchers to define vehicle parameters, simulate traffic flow, and evaluate congestion management strategies.
- b. NS-3 Simulator:** NS-3 serves as a network simulator for modeling VANET communication and evaluating routing protocols. It provides a platform for

analyzing network performance, congestion control algorithms, and the impact of varying traffic densities.

3. System Architecture

The system architecture includes components such as OpenStreetMap (OSM) for map data extraction, SUMO simulator for traffic simulation, NS-3 simulator for network modeling, and data analysis modules for processing traffic data and optimizing traffic signal timings.

4. Routing Protocols

Various routing protocols are evaluated for their suitability in VANET environments, including DSDV, DSR, and AODV. These protocols facilitate efficient communication among vehicles and infrastructure, contributing to congestion management and traffic optimization.

4.1 SELECTED METHODOLOGY

The selected methodology for addressing traffic congestion in urban areas involves the utilization of Vehicular Ad Hoc Networks (VANETs) and advanced traffic management techniques. VANETs facilitate real-time communication between vehicles and roadside infrastructure, enabling the collection and processing of traffic data. This data is then analyzed using machine learning algorithms and data mining techniques to dynamically adjust traffic signal timings, thereby optimizing traffic flow and reducing congestion.

The methodology leverages simulation tools like SUMO (Simulation of Urban Mobility) and network simulators like NS-3 to model and evaluate the proposed traffic management system. OpenStreetMap (OSM) data is utilized to create realistic simulations of urban road networks, while routing protocols such as DSDV, DSR, and AODV are employed to simulate network traffic and congestion scenarios.

The proposed system architecture involves the integration of edge computing, machine

learning-based traffic prediction, dynamic tolling, and smart traffic lights to enhance congestion management. Additionally, the system provides drivers with dynamic route suggestions based on real-time traffic data, contributing to reduced travel times and environmental impact.

The selected methodology emphasizes the importance of utilizing VANETs and advanced traffic management techniques to address the persistent challenge of traffic congestion in urban areas. Through simulation and evaluation, the effectiveness and viability of the proposed system are rigorously analyzed to provide insights for future research and implementation.

4.2 ARCHITECTURE / OVERALL DESIGN OF PROPOSED SYSTEM

VANET – ARCHITECTURE

VANETs are an emerging wireless communication technology under intelligent transportation system (ITS). These are the distributed self-organized system which includes a wireless communication system equipped in vehicles to communicate with each other and relay the information from one node to another. These types of networks are devised to bring significant improvement the transportation system. Nodes are expected to communicate by means of Dedicated Short-Range Communication (DSRC) standard that employs the IEEE 802.11p standard for wireless communication. To allow communication with participants out of radio range, messages have to be forwarded by other nodes (multi-hop communication).

Vehicles are not subject to the strict energy, space and computing capabilities restrictions normally adopted for MANETs. More challenging is the potentially very high speed of the nodes (up to 250 km/h) and the large dimensions of the VANET. The primary VANET's goal is to increase road safety. To achieve this, the vehicles act as sensors and exchange warnings or more generally telematics information (like current speed, location) that enables the drivers to react early to abnormal and potentially dangerous situations like accidents, traffic jams or glaze. The information provided by

other vehicles and stationary infrastructure might also be used for driver assistant systems like adaptive cruise control (ACC) or breaking assistants.

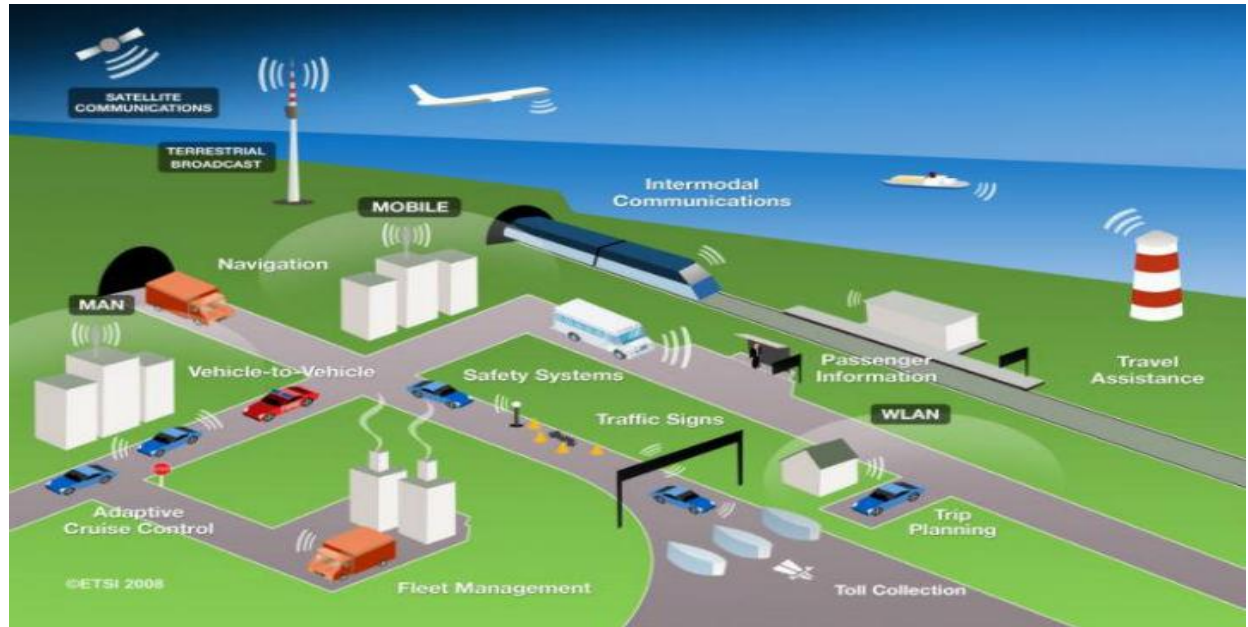


Fig 4.1 VANET-Overview

In addition, authorized entities like police or firefighters should be able to send alarm signals and instructions e.g. to clear their way or stop other road users. Besides that, the VANET should increase comfort by means of value-added services like location-based services or Internet on the road.

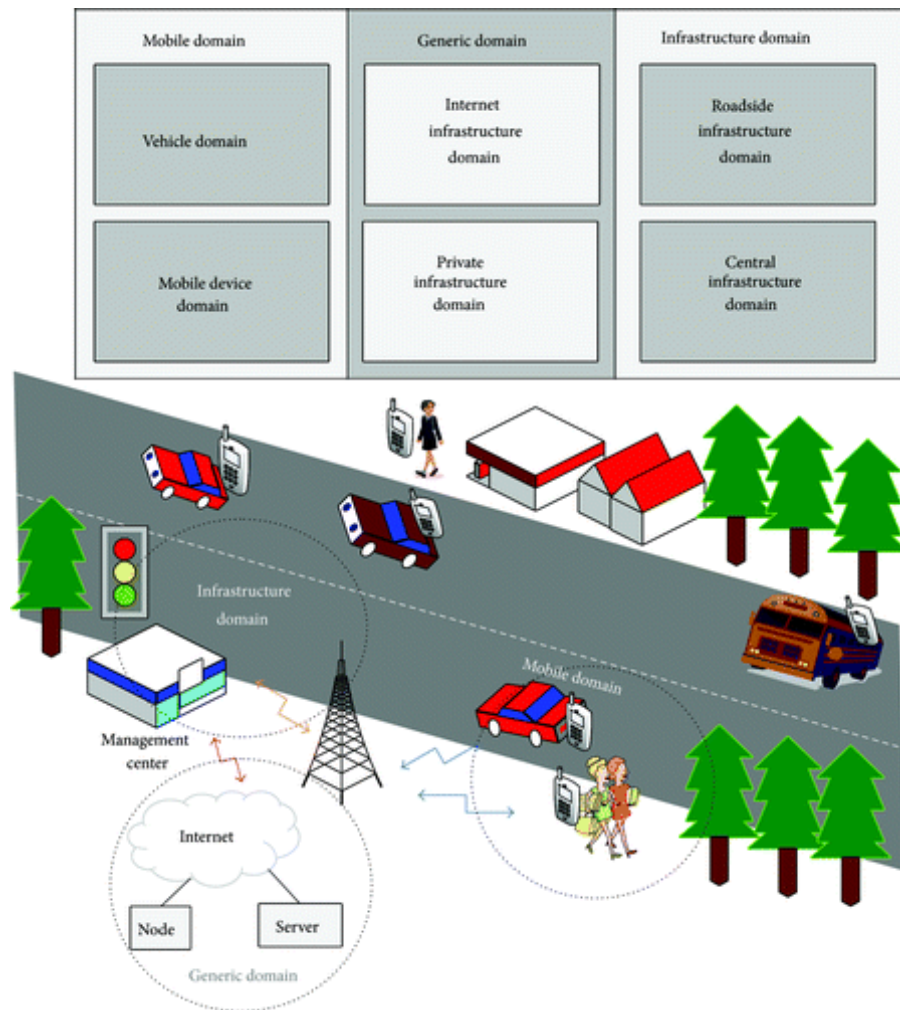


Fig 4.2 Components of VANET

According to the IEEE 1471-2000 and ISO/IEC 42010 architecture standard guidelines, we are able to achieve the VANETs system by entities which can be divided into three domains: the mobile domain, the infrastructure domain, and the generic domain.

The mobile domain consists of two parts: the vehicle domain and the mobile device domain. The vehicle domain comprises all kinds of vehicles such as cars and buses. The mobile device domain comprises all kinds of portable devices like personal navigation devices and smartphones.

Within the infrastructure domain, there are two domains: the roadside infrastructure domain and the central infrastructure domain. The roadside infrastructure domain

contains roadside unit entities like traffic lights. The central infrastructure domain contains infrastructure management centres such as Traffic Management Centres (TMCs) and vehicle management centres.

However, the development of VANETs architecture varies from region to region. In the V2X communication system which is pursued by the V2V communication consortium, the reference architecture is a little different. V2V communication consortium is the major driving force for vehicular communication. This system architecture comprises three domains: in-vehicle, ad hoc, and infrastructure domain.

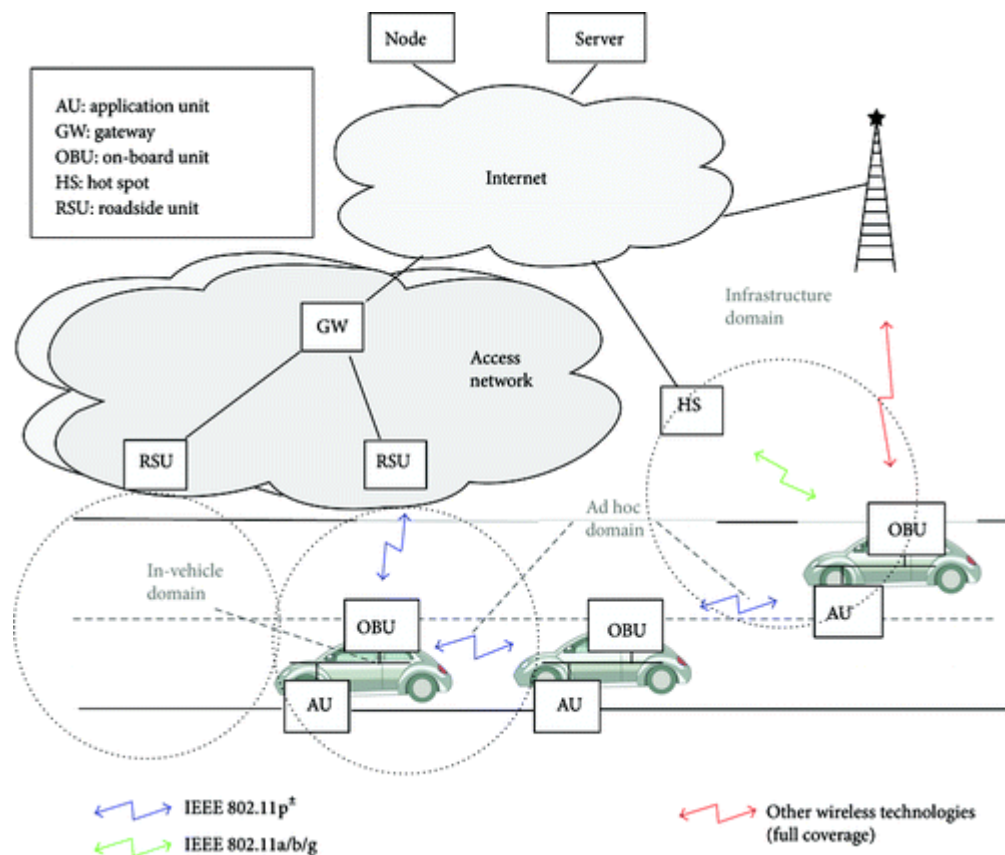


Fig 4.3 VANET-Architecture

The in-vehicle domain is composed of an on-board unit (OBU) and one or multiple application units (AUs). The connections between them are usually wired and

sometimes wireless. However, the ad hoc domain is composed of vehicles equipped with OBUs and roadside units (RSUs). An OBU can be seen as a mobile node of an ad hoc network and RSU is a static node likewise. An RSU can be connected to the Internet via the gateway; RSUs can communicate with each other directly or via multi-hop as well. There are two types of infrastructure domain access, RSUs and hot spots (HSs). OBUs may communicate with Internet via RSUs or HSs. In the absence of RSUs and HSs, OBUs can also communicate with each other by using cellular radio networks (GSM, GPRS, UMTS, WiMAX, and 4G).

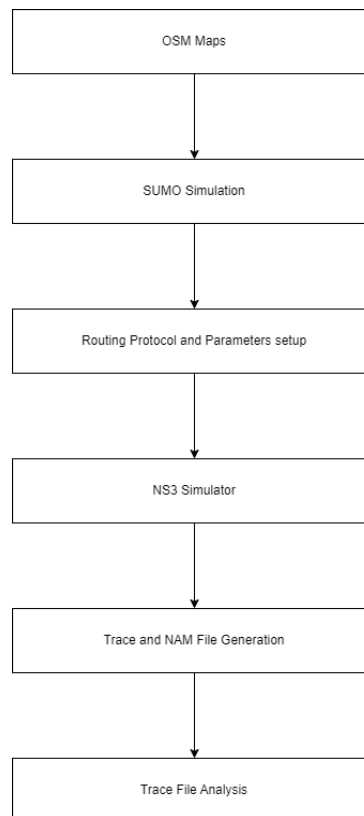


Fig 4.4 System Architecture

4.3 Model Architecture Design/ Algorithm:

COMMUNICATION ARCHITECTURE

Communication types in VANETs can be categorized into four types. The category is closely related to VANETs components as described above.

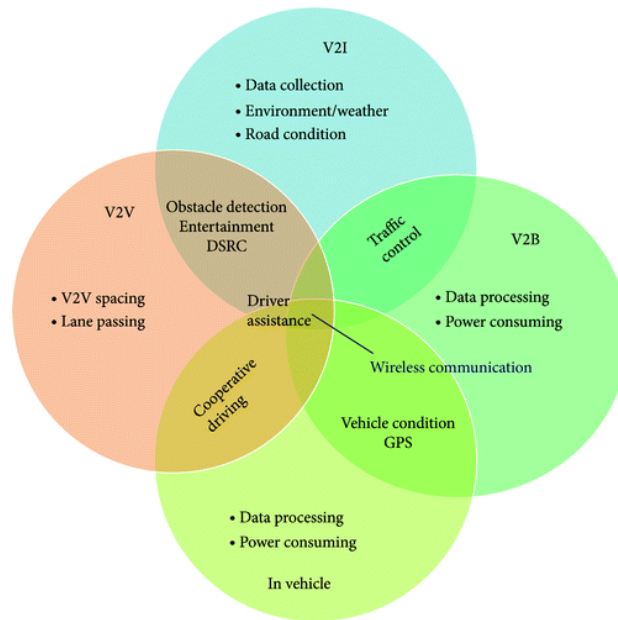


Fig 4.5 VANET-Communication Architecture

In-vehicle communication, which is more and more necessary and important in VANETs research, refers to the in-vehicle domain. In-vehicle communication system can detect a vehicle's performance and especially driver's fatigue and drowsiness, which is critical for driver and public safety.

Vehicle-to-vehicle (V2V) communication can provide a data exchange platform for the drivers to share information and warning messages, so as to expand driver assistance.

Vehicle-to-road infrastructure (V2I) communication is another useful research field in VANETs. V2I communication enables real-time traffic/weather updates for drivers and

provides environmental sensing and monitoring.

Vehicle-to-broadband cloud (V2B) communication means that vehicles may communicate via wireless broadband mechanisms such as 3G/4G. As the broadband cloud may include more traffic information and monitoring data as well as infotainment, this type of communication will be useful for active driver assistance and vehicle tracking.

Generally, the architecture of VANETs may differ from region to region, and thus the protocols and interfaces are also different among them. DSRC is specifically designed for automotive use and a corresponding set of protocols and standards. The US FCC has allocated 75 MHz of spectrum for DSRC communication, from 5.850 GHz to 5.925 GHz. Different protocols are designed to use at the various layers; some of them are still under active development now. The IEEE 802.11p, an approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE), is focused primarily on the PHY layer and MAC sublayer of the stack. IEEE 1609 is a higher layer standard based on the IEEE 802.11p. IEEE 1609 represents a family of standards that function in the middle layers of the protocol stack to flexibly support safety applications in VANETs, while non-safety applications are supported through another set of protocols. In particular, network layer services and transport layer services for non-safety applications are provided by three quite stable protocols: IPv6, TCP, and UDP.

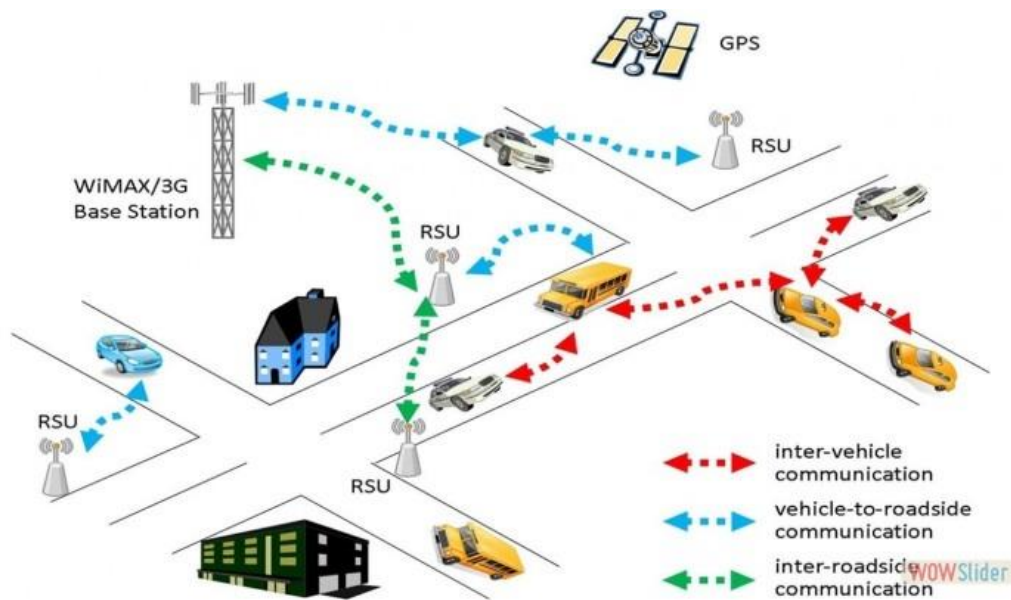


Fig 4.6 Elements of VANET

4.4 Description of Software for Implementation and Testing Plan

For the implementation and testing of the proposed traffic congestion management system in VANETs, a comprehensive suite of software tools and platforms will be employed. These software components will facilitate the development, simulation, and evaluation of the system's performance under various traffic scenarios and network conditions. The software stack encompasses both simulation environments and development frameworks tailored to VANET applications, ensuring robustness, scalability, and accuracy in the assessment of the proposed system.

1. SUMO (Simulation of Urban Mobility)

SUMO serves as the primary simulation platform for modeling vehicular traffic dynamics in urban environments. It provides a versatile framework for creating realistic traffic scenarios, simulating vehicle movements, and evaluating the impact of congestion management strategies. SUMO's rich feature set includes support for road network definition, traffic flow modeling, and integration with external tools such as

OpenStreetMap for importing real-world map data. Leveraging SUMO, researchers can conduct extensive simulations to validate the effectiveness of the proposed congestion management algorithms and assess their performance metrics.

2. NS-3 (Network Simulator 3)

NS-3 is a discrete-event network simulator renowned for its accuracy and extensibility in modeling various networking protocols and architectures. In the context of VANETs, NS-3 enables the simulation of wireless communication protocols, including Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication. Researchers can develop custom network models, implement routing protocols, and analyze network performance metrics such as packet loss, latency, and throughput. NS-3's modular design facilitates the integration of different congestion control mechanisms and traffic management strategies, allowing for comprehensive evaluation under diverse traffic scenarios.

3. OpenStreetMap (OSM)

OpenStreetMap provides a valuable source of geospatial data for creating detailed maps of road networks, traffic signals, and infrastructure elements. Researchers can extract OSM data to generate realistic urban environments for simulation purposes, ensuring the fidelity of traffic simulations conducted in SUMO and NS-3. OSM's collaborative nature and extensive coverage make it an indispensable tool for acquiring real-world map data, enabling researchers to replicate actual traffic conditions and evaluate congestion management strategies in a realistic context.

4. Python Programming Language

Python serves as the primary scripting language for implementing custom algorithms, data analysis, and visualization tasks within the research framework. Its simplicity, versatility, and extensive libraries make it well-suited for rapid prototyping and experimentation. Researchers can develop traffic prediction models, congestion detection algorithms, and optimization techniques using Python's rich ecosystem of scientific computing libraries such as NumPy, Pandas, and Matplotlib. Python's

integration with SUMO and NS-3 enables seamless interaction with simulation environments, facilitating the implementation and testing of the proposed congestion management system.

Testing Plan

The testing plan encompasses a series of rigorous evaluations aimed at validating the functionality, performance, and scalability of the proposed traffic congestion management system in VANETs. The testing process will involve simulated experiments conducted in SUMO and NS-3, complemented by real-world data analysis and validation where applicable. The key components of the testing plan include:

Functional Testing

Functional testing will verify that the system components perform as intended and meet the specified requirements. This includes testing the implementation of congestion detection algorithms, traffic prediction models, and dynamic traffic signal control mechanisms. Functional testing will ensure the correctness and reliability of the system's core functionalities under different traffic scenarios and network conditions.

Performance Testing

Performance testing will assess the system's efficiency, scalability, and resource utilization under varying traffic loads and network configurations. Researchers will measure key performance metrics such as throughput, latency, packet loss, and CPU/memory usage to evaluate the system's responsiveness and scalability. Performance testing will identify potential bottlenecks, optimize resource allocation, and ensure the system's ability to handle high volumes of traffic while maintaining optimal performance.

Simulation-based Testing

Simulation-based testing in SUMO and NS-3 will simulate realistic traffic scenarios to evaluate the system's behavior and performance in a controlled environment.

Researchers will design experiments to assess congestion management strategies, analyze traffic flow patterns, and measure the effectiveness of dynamic traffic signal control mechanisms. Simulation-based testing will provide insights into the system's behavior under different traffic conditions and enable iterative refinement of congestion management algorithms.

Validation with Real-world Data

Validation with real-world data involves comparing the results obtained from simulations with actual traffic data collected from urban environments. Researchers will validate the accuracy and reliability of the system's predictions, congestion detection algorithms, and traffic management strategies using real-world traffic data. Validation with real-world data will enhance the credibility and applicability of the research findings, ensuring that the proposed congestion management system performs effectively in real-world scenarios.

4.5 Routing in VANET

For communication Ad-hoc networks are used. Ad-hoc Network is initially used for the MANETs but now they are used for the VANETs also. VANET utilizes this location based and topology-based steering conventions obliges that each of the partaking hubs be allocated a novel location. This intimates that we require an instrument that can be utilized to appoint interesting locations to vehicles yet these conventions don't promise that the copy locations are doled out in a system or not. Consequently, existing circulated tending to calculations utilized as a part of versatile specially appointed systems are significantly less suitable in a VANET environment. Particular VANET-related issues, for example, system topology, portability designs, thickness of vehicles at diverse times of the day, fast changes in vehicles arriving and leaving the VANET and the way that the width of the street is regularly littler than the transmission run all make the utilization of these routine specially appointed directing conventions lacking.

Protective routing protocol

Proactive steering conventions utilize standard separation vector directing methodologies (e.g., Destination-Sequenced Distance-Vector (DSDV) steering) or connection state directing techniques (e.g., Optimized Link State Routing convention (OLSR) and Topology Broadcast-focused around Reverse-Path Forwarding (TBRPF)). They keep up and overhaul data on directing to all hubs that being said additionally when the way is not utilized. Course overhauls are occasionally performed paying little heed to system load, data transmission imperatives, and system size.

Reactive routing protocol

Touchy directing conventions, for example, Dynamic Source Routing (DSR), and Ad hoc On-Demand Distance Vector (AODV) steering execute course determination on an interest or need premise and keep up just the courses that are right now being used, in this manner lessening the load on the system when just a subset of accessible courses is being used and this breaking point the data transfer capacity wastage.

Position-based routing

Position-based directing conventions oblige that data about the physical position of the taking part hubs be accessible. This position is made accessible to the immediate neighbours as intermittently transmitted reference points. A sender can ask for the position of a recipient with the assistance of an area administration.

Forwarding

A geographic unicast transports bundle between two hubs through various remote jumps. At the point when the asking for hub needs to send a unicast parcel, it discovers the position of the goal hub by taking a gander at the area table. An avaricious sending calculation is then used to send the bundle to the neighbouring vehicle or hubs,

rehashes enumerating the base remaining separation to the end of the line vehicle and this methodology at each vehicle along the sending way until the parcel achieves its goal.

4.6 AD-HOC ROUTING PROTOCOLS

Wireless networks is an emerging new technology that will allow users to access information and services electronically, regardless of their geographic position. Wireless networks can be classified in two types: Infrastructured network and Infrastructure-less (**ad hoc**) networks. Infrastructured network consists of a network with fixed and wired gateways. A mobile host communicates with a bridge in the network (called base station) within its communication radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed.

In contrast to infrastructure-based networks, in ad hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. Ad hoc networks are very useful in emergency search-and-rescue operations, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrain.

Ad hoc routing protocols can be divided into two categories:

- i. Table-driven
- ii. On-demand routing
- iii. Hybrid

based on when and how the routes are discovered. In table driven routing protocols, consistent and up-to-date routing information to all nodes is maintained at each node whereas in on-demand, routing the routes are created only when desired by the source

host. Next two sections discuss current table-driven protocols as well as on-demand protocols.

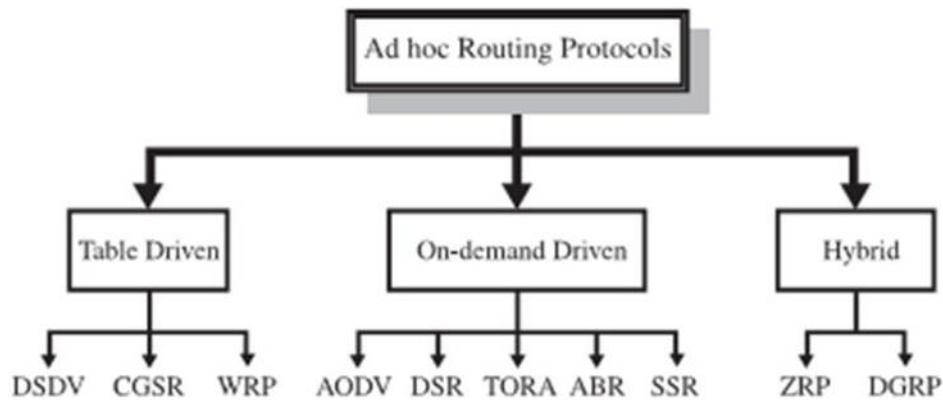


Fig 4.7 Ad hoc Protocols

4.6.1 TABLE DRIVEN ROUTING PROTOCOLS – PROACTIVE

In Table-driven routing protocols each node maintains one or more tables containing routing information to every other node in the network. All nodes update these tables so as to maintain a consistent and up-to-date view of the network. When the network topology changes the nodes propagate update messages throughout the network in order to maintain a consistent and up-to-date routing information about the whole network. These routing protocols differ in the method by which the topology change information is distributed across the network and the number of necessary routing-related tables. The following sections discuss some of the existing table-driven ad hoc routing protocols.

Destination-Sequenced Distance-Vector Routing Protocol

The Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm is based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements.

Every mobile station maintains a routing table that lists all available destinations, the number of hops to reach the destination and the sequence number assigned by the destination node. The sequence number is used to distinguish stale routes from new ones and thus avoid the formation of loops. The stations periodically transmit their routing tables to their immediate neighbours. A station also transmits its routing table if a significant change has occurred in its table from the last update sent. So, the update is both time-driven and event-driven. The routing table updates can be sent in two ways: a "full dump" or an incremental update. A full dump sends the full routing table to the neighbours and could span many packets whereas in an incremental update only those entries from the routing table are sent that has a metric change since the last update and it must fit in a packet. If there is space in the incremental update packet then those entries may be included whose sequence number has changed. When the network is relatively stable, incremental updates are sent to avoid extra traffic and full dump are relatively infrequent. In a fast-changing network, incremental packets can grow big so full dumps will be more frequent. Each route update packet, in addition to the routing table information, also contains a unique sequence number assigned by the transmitter. The route labelled with the highest (i.e. most recent) sequence number is used. If two routes have the same sequence number then the route with the best metric (i.e. shortest route) is used. Based on the past history, the stations estimate the settling time of routes. The stations delay the transmission of a routing update by settling time so as to eliminate those updates that would occur if a better route were found very soon.

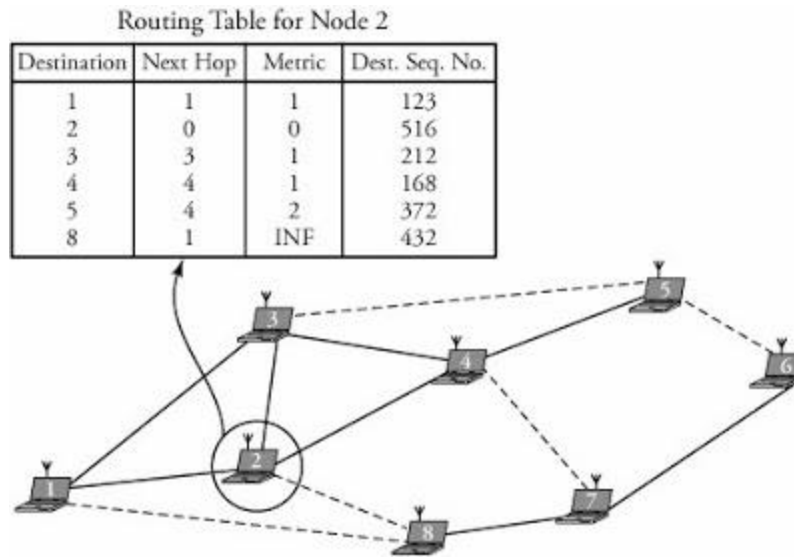


Fig 4.8 DSDV Routing

4.6.2 ON-DEMAND ROUTING PROTOCOLS – REACTIVE

These protocols take a lazy approach to routing. In contrast to table-driven routing protocols all up-to-date routes are not maintained at every node, instead the routes are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination. The route remains valid till the destination is reachable or until the route is no longer needed.

AODV ROUTING

AODV is a well-known topology routing protocol which has a very high packet delivery ratio and low routing overhead. AODV works as follows:

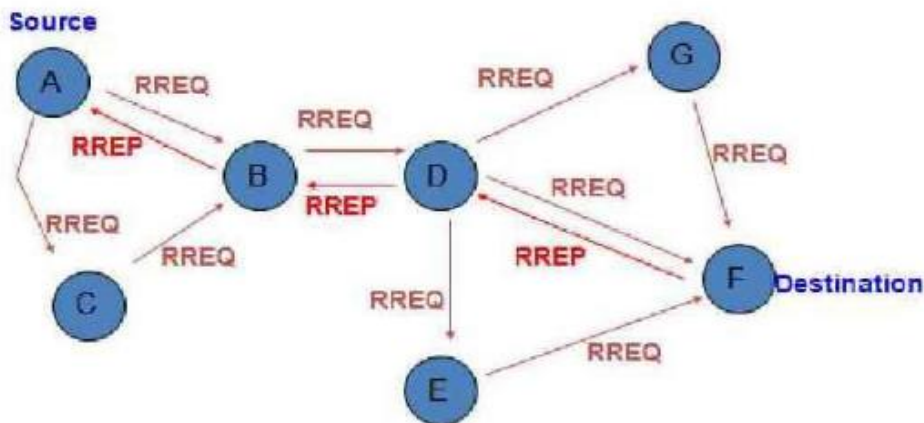


Fig 4.9 AODV Routing

Whenever a node wants to communicate with another node, it checks in local routing table to find an available path to the destination node. If there is no path available, then it broadcasts a route request (RREQ) message to its neighbourhood. The node that receives RREQ looks its table for a path leading to the destination node. If there is no path then, the RREQ message is re-broadcasted and a path to the originating node is formed that has sent RREQ message. This helps in establishing the end-to-end path when the same node receives route reply (RREP) message as shown in Figure.

All the node in the network follows this process until this RREQ message reaches a node which has a suitable path to the destination Node. At the end of this request-reply process a path between source and destination node is created and is available for further communication. In this way, the originating node that generated RREQ receives an RREP message.

To maintain a connection with the sink node is a crucial issue to collect data from networks without any interruption. While networks are typically deployed in abundance, losing the connectivity with the sink node due to frequent path break eventually reduces the quality and efficiency of the network operation.

4.6.3 HYBRID (BOTH PROACTIVE AND REACTIVE)

This type of protocol combines the advantages of proactive and reactive routing. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding. The choice of one or the other method requires predetermination for typical cases. The main disadvantages of such algorithms are:

1. Advantage depends on number of other nodes activated.
2. Reaction to traffic demand depends on gradient of traffic volume.

4.6.4 COMPARISON OF AODV AND DSDV

Following review of two protocols - AODV and DSDV

- i. Both protocols used the concept of sequence number to update latest routing information.
- ii. The bandwidth is wasted in case of DSDV, because of periodic broadcasting of updated information. In AODV, nodes only propagate hello messages to its neighbours.
- iii. In DSDV, routes information which are maintained in routing table can be stale as DSDV cannot handle nodes movement at high speeds due to lack of alternative routes. But in case of AODV, the routes are find out on demand only, so the routes information cannot be stale.
- iv. In DSDV, throughput decreases because of periodic routes information updates and if the node mobility is at high speed. In AODV, throughput is stable because it doesn't broadcast any routing information.

Also, the End-to-End delay is calculated for both DSDV and AODV routing protocols.

End to End Delay: The average time from the beginning of a packet transmission at a source node until packet delivery to a destination. This includes delays caused by buffering of data packets during route discovery, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

On Calculating E2E for both DSDV and AODV, it is found that AODV betters DSDV, having lower delay.

Since, DSDV dynamically checks for the shortest path at every instant even when the established route exists, the delay is higher and also thereby throughput is less.

While AODV protocol uses an already established route until the nodes move out of range. Hence the delay is lower and throughput is high.

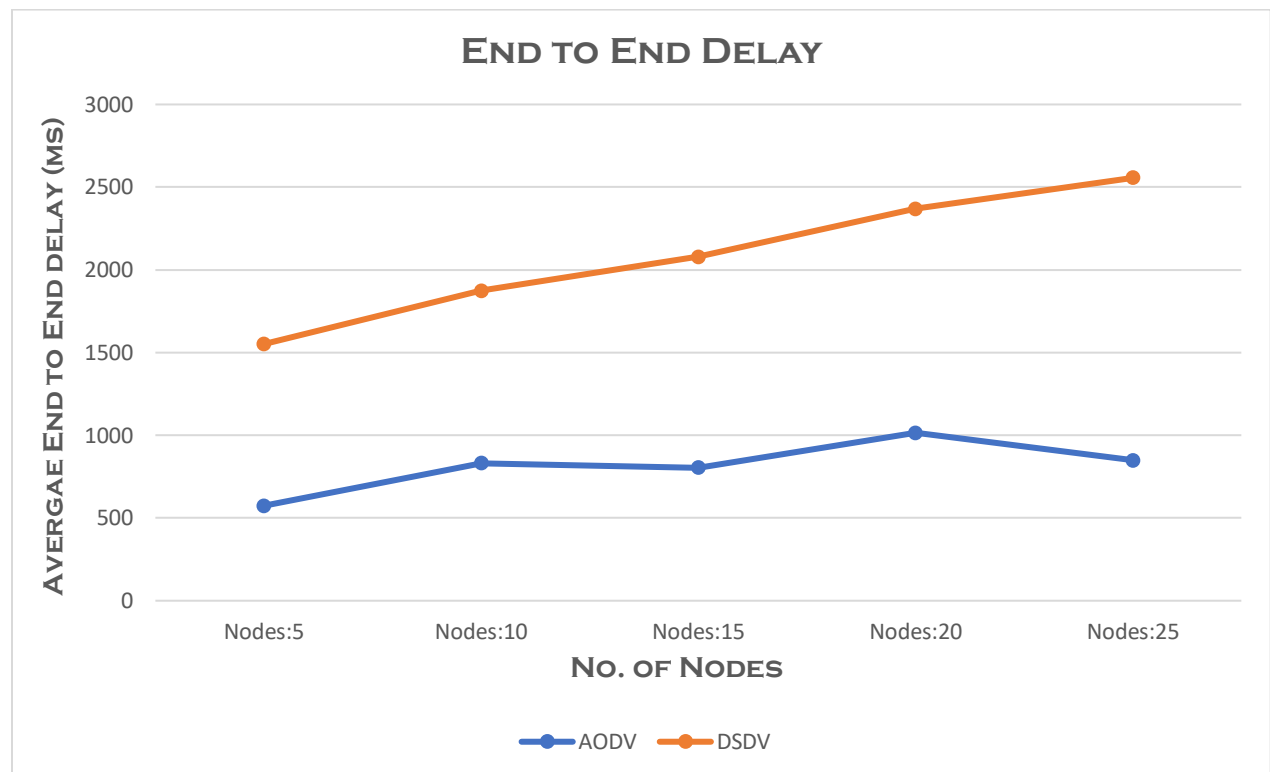


Fig 4.10 AODV vs DSDV

From the Analysis, it is found that AODV protocol provides a lower delay in every case. Since the delay is lower, more number of packets can be communicated between the nodes and thereby throughput is higher.

Throughput = (Received Data Size/Transmission Time)*8

Hence in our project, which requires a demanding routing protocol with high throughput and lower delay as vehicles keep moving at high speeds, AODV is more preferred and used for Vehicular communication.

CHAPTER 5

IMPLEMENTATION DETAILS

Implementing VANET-based traffic management involves several essential steps, each crucial for the system's effectiveness. Below is a detailed outline of the implementation process:

5.1 Data Collection

The data collection phase of our project involved the simulation of real-world traffic scenarios using SUMO (Simulation of Urban Mobility) with OpenStreetMap (OSM) maps. Leveraging SUMO's capabilities allowed us to recreate intricate urban road networks, complete with various traffic elements such as vehicles, traffic signals, and infrastructure. By importing OSM maps into SUMO, we were able to simulate realistic traffic conditions representative of actual urban environments.

Utilizing SUMO for Realistic Simulations

SUMO provided us with a versatile platform for conducting simulations that closely mimic real-world traffic dynamics. The integration of OSM maps ensured that our simulated environments accurately reflected the layout of urban road networks, including intersections, lanes, and traffic flow patterns. This level of detail was crucial for generating realistic traffic scenarios and collecting data representative of actual urban traffic conditions.

Generating Real-Time Traffic Data

During the simulation runs, SUMO generated real-time traffic data capturing various parameters such as vehicle speed, density, location, and route choices. This data was collected at regular intervals throughout the simulation, providing a comprehensive snapshot of traffic dynamics within the simulated environment. By analyzing this data,

we gained valuable insights into traffic patterns, congestion hotspots, and the effectiveness of routing protocols.

Validation and Calibration

To ensure the accuracy and validity of our simulated data, we performed validation and calibration exercises. This involved comparing simulated traffic data against real-world traffic data from reliable sources to validate the fidelity of our simulations. Additionally, we fine-tuned simulation parameters and traffic behavior models to calibrate the simulations to closely match observed real-world traffic patterns.

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By simulating real-world traffic scenarios, we were able to generate comprehensive datasets capturing various traffic parameters. This data serves as a crucial foundation for the subsequent phases of our project, including algorithm development, model training, and performance evaluation.

5.2 Routing Protocols Implementation

Routing protocol selection is a critical aspect of designing a vehicular ad hoc network (VANET)-based traffic management system. The choice of routing protocol directly impacts the efficiency, reliability, and scalability of communication within the network. In our project, we undertook a comprehensive evaluation of several prominent routing protocols, including Destination-Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR), and Ad-hoc On-Demand Distance Vector (AODV), to determine the most suitable protocol for our VANET-based traffic management system.

One of the key factors considered during the evaluation process was the control overhead associated with each routing protocol. Control overhead refers to the amount of signaling traffic required for route discovery, maintenance, and updating. Low control overhead is essential for minimizing communication latency and conserving network resources, particularly in high-density VANET environments. We meticulously analyzed

the control overhead of each protocol under varying network densities and traffic conditions to assess their suitability for real-time traffic management applications.

Another crucial consideration in routing protocol selection was adaptability to dynamic network topology changes. VANETs are inherently dynamic networks characterized by frequent node mobility and topology changes. As such, the selected routing protocol must possess robust mechanisms for quickly adapting to topology changes and maintaining reliable communication paths between vehicles and infrastructure nodes. We evaluated the adaptability of each protocol through simulation experiments simulating node mobility and network topology changes, closely monitoring their performance under dynamic conditions.

Scalability was also a key performance metric used to evaluate routing protocols. Scalability refers to the ability of the routing protocol to efficiently handle increasing network size and traffic load without significant degradation in performance. In urban environments, VANETs may encompass thousands of vehicles and infrastructure nodes, necessitating routing protocols capable of scaling to accommodate large networks. We conducted scalability tests on each protocol, progressively increasing the network size and traffic load to assess their performance under varying network scales.

Based on the simulation results and performance metrics analysis, we identified the most suitable routing protocol for our VANET-based traffic management system. The selected protocol demonstrated low control overhead, robust adaptability to dynamic network topology changes, and scalable performance across varying network sizes and traffic conditions. Our rigorous evaluation process ensures that the chosen routing protocol meets the stringent requirements of real-time traffic management applications in urban environments, laying a solid foundation for the subsequent phases of our project implementation.

5.3 Traffic Congestion Algorithms Evaluation

In our project, the evaluation of congestion management algorithms constitutes a pivotal phase aimed at gauging the efficacy of different approaches in mitigating traffic congestion within urban environments. Two primary algorithms under scrutiny are adaptive transmission power control and dynamic route suggestions, both integral to the overarching objective of enhancing traffic flow and reducing congestion.

Experimental Methodology

The evaluation process unfolds through a series of meticulously designed simulation experiments conducted within the SUMO (Simulation of Urban Mobility) framework. Leveraging SUMO's capabilities, we simulate real-world traffic scenarios incorporating various congestion management algorithms. These simulations replicate urban road networks, vehicles, traffic signals, and infrastructure, ensuring a high degree of realism in our experimental setup.

Metrics and Analysis

Central to our evaluation is the analysis of key performance metrics to quantify the effectiveness of the implemented algorithms. These metrics encompass communication overhead, congestion control, and network performance, providing comprehensive insights into the algorithm's impact on traffic management within VANETs.

Communication Overhead

Communication overhead serves as a critical indicator of the efficiency of congestion management algorithms in minimizing the burden on the VANET communication infrastructure. Lower communication overhead signifies optimized communication protocols, facilitating seamless data exchange among vehicles and infrastructure nodes without imposing unnecessary strain on the network.

Congestion Control

The ability of congestion management algorithms to effectively alleviate traffic congestion forms the crux of our evaluation. We scrutinize the algorithms' capability to detect congestion hotspots, implement proactive measures to mitigate congestion, and dynamically adapt to changing traffic conditions. By assessing congestion levels and congestion dissipation rates, we ascertain the algorithms' effectiveness in improving traffic flow within the simulated urban environment.

Network Performance

Lastly, we delve into an in-depth analysis of network performance metrics to evaluate the overall efficiency and reliability of the congestion management algorithms. This entails assessing parameters such as packet loss, latency, and throughput to gauge the algorithms' impact on VANET communication and network stability.

5.4 Real-Time Map Designing

Steps followed to implement Real-Time Map Designing:

- i. Download the OSM file from www.openstreetmap.org – “map.osm”
- ii. Open the terminal in the required work directory
- iii. Command: `netconvert --osm-files map.osm -o map.net.xml`

The osm file is then into a xml file and thereby the roads and paths are created as a network.

- iv. Command: `polyconvert --osm-files map.osm --net-file map.net.xml --type-file osmPolyconvert.typ.xml -o map.poly.xml`

Using the osm file and network file every object in the network is converted in the form of polygons for a 2D view.

- v. Command: `python randomTrips.py -n map.net.xml -r map.rou.xml -e 50 -l`

Random route trips are generated for a required number of vehicles.

- vi. Finally, the files created are incorporated as a configuration file which is the mother file used for simulation – “map.sumo.cfg”

All the required network, polygon, route files are provided as child files inside the configuration file.

- vii. The simulation can then be run in ‘GUI’ format by typing command: `sumo-gui map.sumo.cfg`

5.5 Conversion of SUMO to Ns3

Using SUMO, we generated the traffic model. We need to transfer the traffic model information to Ns3 in order to establish communication between them.

The conversion is done as follows:

- i. Command: `sumo -c map.sumo.cfg --fcd-output map.sumo.xml`
- ii. The SUMO configuration file is converted into a XML file format.
- iii. Command: `python traceExporter.py --fcd-input map.sumo.xml --ns2config-output map.tcl --ns2mobility-output mobility.tcl --ns3activity-output activity.tcl`
- iv. Using Trace Exporter, the SUMO xml file is converted into TCL file. Thereby three different files are created:
 - a. Activity file: Various start and stop time of vehicle movements are stored in the ‘activity.tcl’ file.
 - b. Mobility file: The routes to be followed by various vehicles are stored in the ‘mobility.tcl’ file
 - c. Base tcl file: The information about the topography, number of vehicles and the simulation start and stop time are stored in the ‘map.tcl’ file

Thereby, Ns2 executable files are obtained.

Establishing Real-time VANET scenario:

- i. Once the executable files are obtained, add a simple wireless scenario using AODV protocol.
- ii. Enable communication links between every vehicle and observe performance

and movements of vehicles (nodes).

- iii. Based on various movements of vehicles, place RSUs wherever needed in order to achieve maximum coverage.
- iv. Enable I2I communication and V2I communication and design for complete connectivity of all nodes present in the topography.

Thereby, a complete VANET model is designed for real-time scenarios and the performance is checked.

CHAPTER 6

RESULTS AND DISCUSSIONS

The research findings underscore the significance of utilizing VANETs for congestion management, emphasizing the effectiveness of real-time data processing and dynamic traffic signal adjustments in alleviating congestion. Through meticulous simulations using tools like SUMO and the ns-3 network simulator, the study demonstrates the feasibility of VANET-based solutions in replicating real-world traffic scenarios and evaluating congestion management strategies.

In particular, the choice of routing protocols plays a pivotal role in determining the efficacy of traffic congestion management in VANETs. The study evaluates protocols such as DSDV, DSR, and AODV, considering factors like network density, mobility patterns, and traffic load. Results indicate that while DSDV may be suitable for low to moderate congestion scenarios due to its ability to maintain up-to-date routing information, on-demand protocols like DSR and AODV exhibit better adaptability to highly dynamic and congested environments. Notably, AODV emerges as a promising choice for managing traffic congestion in VANETs, thanks to its efficient route discovery and maintenance mechanisms.

Furthermore, the integration of OSM data enhances the realism of simulations, providing greater geographical precision and accuracy in evaluating congestion management strategies. The research highlights the potential of VANET-based traffic management systems in optimizing traffic flow, reducing emissions, and enhancing overall transportation efficiency. However, challenges related to communication reliability and network scalability must be addressed for practical implementation in real-world scenarios.

Overall, the results and discussions underscore the promise of VANETs in addressing traffic congestion challenges, while also emphasizing the importance of ongoing research efforts to refine protocols, optimize communication mechanisms, and ensure

Fig 6.1 SUMO cmd

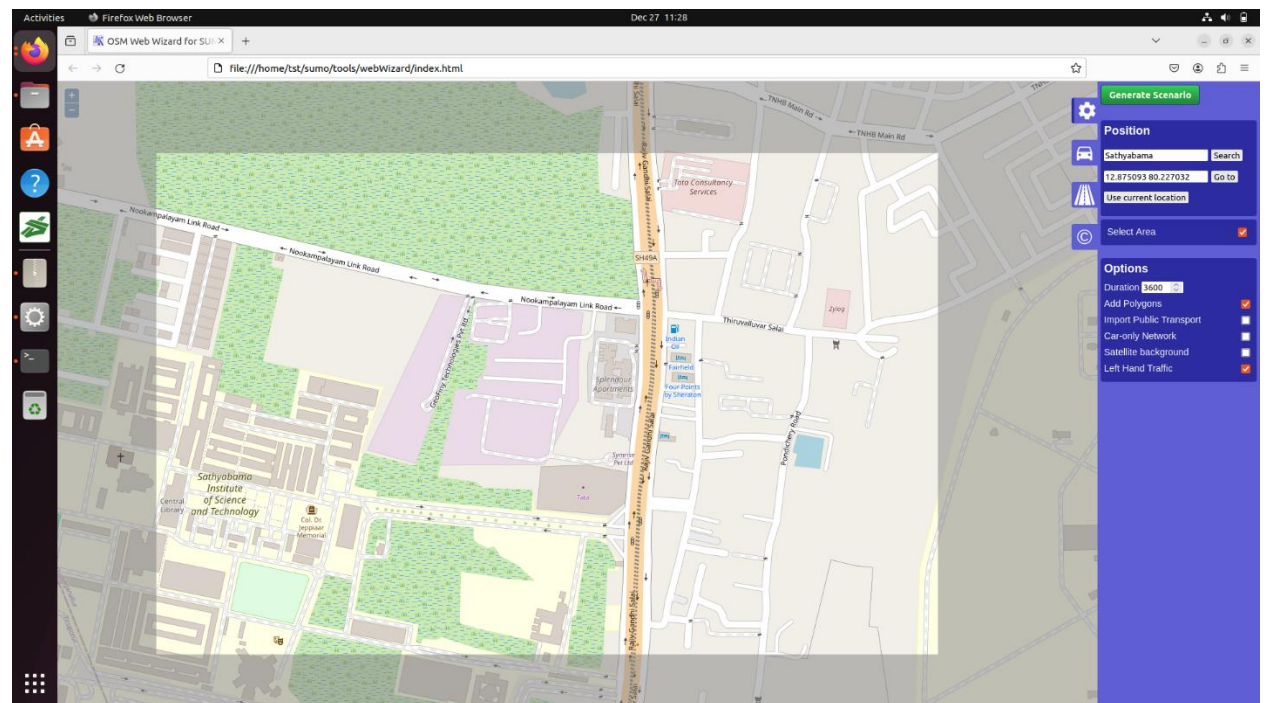


Fig 6.2 Open Street Map

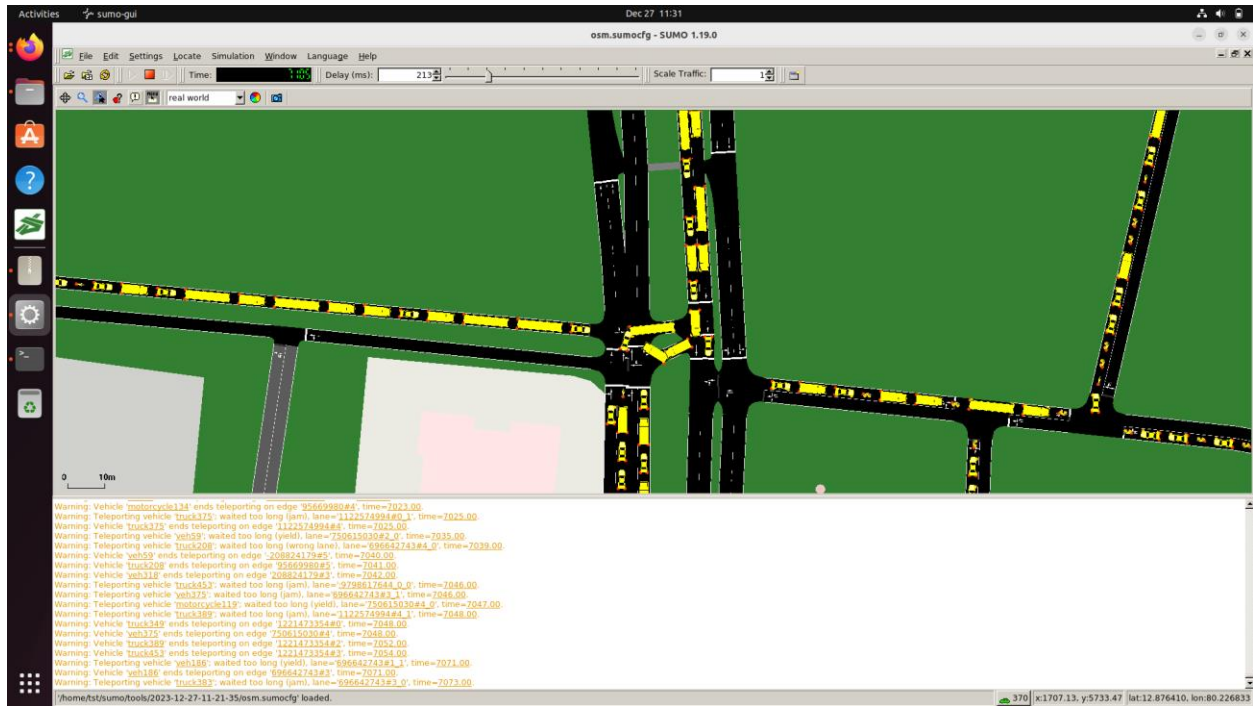


Fig 6.3 SUMO Simulation

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

In conclusion, the study underscores the potential of Vehicular Ad Hoc Networks (VANETs) as a promising solution for effectively managing traffic congestion in urban environments. By leveraging real-time data from VANETs and employing advanced traffic management strategies, the project aims to address the persistent challenges posed by congestion, including increased travel times, fuel consumption, and environmental pollution. Through meticulous simulation and analysis using tools such as SUMO and NS-3, the research demonstrates the feasibility and effectiveness of VANET-based congestion management systems in optimizing traffic flow and reducing congestion levels.

However, it is essential to acknowledge the inherent challenges and limitations associated with VANETs, including concerns related to stability, scalability, security, and privacy. Addressing these challenges is crucial to ensure the seamless deployment and operation of VANET-based systems. Moreover, ongoing efforts are needed to refine VANET protocols, optimize communication mechanisms, and enhance the reliability of vehicular communication networks. By overcoming these challenges and continuously improving VANET technologies, the research aims to contribute to the development of resilient and efficient urban traffic management solutions within the framework of intelligent transportation systems.

7.2 FUTURE ENHANCEMENT

Moving forward, the research identifies several avenues for enhancing the effectiveness and efficiency of VANET-based traffic congestion management systems. One prospective enhancement involves the incorporation of clustering algorithms to facilitate the efficient formation of vehicle clusters in VANETs. By dynamically grouping vehicles based on proximity, speed, or destination, clustering algorithms have the potential to

improve communication efficiency and reduce congestion levels. However, challenges such as dynamic cluster memberships and communication overhead need to be addressed to realize the full benefits of this enhancement.

Furthermore, the research emphasizes the importance of ongoing research and development efforts to refine VANET protocols, optimize communication mechanisms, and address emerging challenges in urban traffic management. Collaboration between academia, industry, and government stakeholders is essential to drive innovation and advance the state-of-the-art in VANET technologies. By fostering interdisciplinary collaboration and leveraging emerging technologies such as edge computing and machine learning, future enhancements aim to create more resilient, flexible, and effective VANET-based traffic congestion management systems, ultimately leading to less traffic, shorter commutes, and a more sustainable urban environment.

REFERENCES

- [1] R. Hussain, J. Lee, and S. Zeadally, "Trust in VANET: a survey of current solutions and future research opportunities" IEEE Transactions on Intelligent Transportation Systems, 2021.
- [2] Facchina, C. Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control (Doctoral dissertation, University of Windsor (Canada),2020).
- [3] N. Lyamin, B. Bellalta, and A. Vinel, "Age-of-informationaware decentralized congestion control in vanets," IEEE Networking Letters, vol. 2, no. 1, 2020
- [4] Sharma, S., Chahal, M., & Harit, S. (2019, February). Transmission Rate-based Congestion Control in Vehicular Ad Hoc Networks. In 2019 Amity International Conference on Artificial Intelligence (AICAI). IEEE
- [5] de Sousa, R. S., Boukerche, A., & Loureiro, A. A. DisTraC: A Distributed and Low-Overhead Protocol for Traffic Congestion Control Using Vehicular Networks IEEE Symposium on Computers and Communications (ISCC). IEEE, 2019.
- [6] Akinlade, O., Saini, I., Liu, X., & Jaekel, A. Traffic Density Based Distributed Congestion Control Strategy for Vehicular Communication, 2019.
- [7] R. Chhabra, C. Rama Krishna, and S. Verma, "Context-aware hybrid adaptive beaconing for driver behavior dissemination in VANETs," IETE Journal of Research, vol. 68, 2021.
- [8] P. Rajput, M. Chaturvedi, and V. Patel, "Opportunistic sensing-based detection of crowdedness in public transport buses," Pervasive and Mobile Computing, vol. 68, 2020
- [9] A. U. Haq, K. Liu, and M. B. Latif, "A Location-and Mobility-Aware Clustering-Based

TDMA MAC Protocol for Vehicular Ad-hoc Networks," 28th Wireless and Optical Communications Conference (WOCC), 2019.

[10] G. H. Alsuhli, A. Khattab, and Y. A. Fahmy, "Double-head clustering for resilient VANETs," *Wireless Communications and Mobile Computing*, vol. 2019.

[11] Jie Cui, Lu Wei, Hong Zhong, Jing Zhang, Yan Xu, and Lu Liu. Edge computing in vanets-an efficient and privacy-preserving cooperative downloading scheme. *IEEE Journal on Selected Areas in Communications*, 2020.

[12] Ikram Ali and Fagen Li. An efficient conditional privacy-preserving authentication scheme for Vehicle-To-Infrastructure communication in VANETs. *Vehicular Communications*, 2020.

[13] Jie Cui, Wenyu Xu, Yibo Han, Jing Zhang, and Hong Zhong. Secure mutual authentication with privacy preservation in vehicular ad hoc networks. *Vehicular Communications*, 2020.

[14] Baidaa Hamza Khudayer, Mohammed Anbar, Sabri Hanshi, and TatChee Wan. Efficient route discovery and link failure detection mechanisms for source routing protocol in mobile ad-hoc networks. *IEEE Access*, 2020.

[15] Mahmood A, Al-Shareedha and Selvakumar Manickam,A. Systematic Literature Review on Security of Vehicular Ad-Hoc Network (VANET) Based on VEINS Framework, *IEEE Access*,2023.

Appendix

A. SOURCE CODE

```
#include "ns3/aodv-module.h"
#include "ns3/applications-module.h"
#include "ns3/core-module.h"
#include "ns3/dsdv-module.h"
#include "ns3/dsr-module.h"
#include "ns3/flow-monitor-module.h"
#include "ns3/internet-module.h"
#include "ns3/mobility-module.h"
#include "ns3/network-module.h"
#include "ns3/olsr-module.h"
#include "ns3/yans-wifi-helper.h"

#include <fstream>
#include <iostream>

using namespace ns3;
using namespace dsr;

NS_LOG_COMPONENT_DEFINE("manet-routing-compare");

class RoutingExperiment
{
public:
    RoutingExperiment();

    void Run();

    void CommandSetup(int argc, char** argv);
```

```

private:
    Ptr<Socket> SetupPacketReceive(Ipv4Address addr, Ptr<Node> node);

    void ReceivePacket(Ptr<Socket> socket);

    void CheckThroughput();

    uint32_t port{9};
    uint32_t bytesTotal{0};
    uint32_t packetsReceived{0};

    std::string m_CSVfileName{"vanet-routing.output.csv"};
    int m_nSinks{10};
    std::string m_protocolName{"AODV"};
    double m_txp{7.5};
    bool m_traceMobility{false};
    bool m_flowMonitor{false};
};

RoutingExperiment::RoutingExperiment() {}

static inline std::string PrintReceivedPacket(Ptr<Socket> socket, Ptr<Packet> packet,
Address senderAddress)
{
    std::ostringstream oss;

    oss << Simulator::Now().GetSeconds() << " " << socket->GetNode()->GetId();

    if (InetSocketAddress::IsMatchingType(senderAddress))
    {

```

```

        InetSocketAddress addr = InetSocketAddress::ConvertFrom(senderAddress);
        oss << " received one packet from " << addr.GetIpv4();
    }
    else
    {
        oss << " received one packet!";
    }
    return oss.str();
}

void RoutingExperiment::ReceivePacket(Ptr<Socket> socket)
{
    Ptr<Packet> packet;
    Address senderAddress;
    while ((packet = socket->RecvFrom(senderAddress)))
    {
        bytesTotal += packet->GetSize();
        packetsReceived += 1;
        NS_LOG_UNCOND(PrintReceivedPacket(socket, packet, senderAddress));
    }
}

void RoutingExperiment::CheckThroughput()
{
    double kbs = (bytesTotal * 8.0) / 1000;
    bytesTotal = 0;

    std::ofstream out(m_CSVfileName, std::ios::app);

    out << (Simulator::Now()).GetSeconds() << "," << kbs << "," << packetsReceived <<
    ","

```

```

    << m_nSinks << "," << m_protocolName << "," << m_txp << "" << std::endl;

    out.close();
    packetsReceived = 0;
    Simulator::Schedule(Seconds(1.0), &RoutingExperiment::CheckThroughput, this);
}

Ptr<Socket> RoutingExperiment::SetupPacketReceive(Ipv4Address addr, Ptr<Node>
node)
{
    TypeId tid = TypeId::LookupByName("ns3::UdpSocketFactory");
    Ptr<Socket> sink = Socket::CreateSocket(node, tid);
    InetSocketAddress local = InetSocketAddress(addr, port);
    sink->Bind(local);
    sink->SetRecvCallback(MakeCallback(&RoutingExperiment::ReceivePacket, this));

    return sink;
}

void RoutingExperiment::CommandSetup(int argc, char** argv)
{
    CommandLine cmd(__FILE__);
    cmd.AddValue("CSVfileName", "The name of the CSV output file name",
m_CSVfileName);
    cmd.AddValue("traceMobility", "Enable mobility tracing", m_traceMobility);
    cmd.AddValue("protocol", "Routing protocol (OLSR, AODV, DSDV, DSR)",
m_protocolName);
    cmd.AddValue("flowMonitor", "enable FlowMonitor", m_flowMonitor);
    cmd.Parse(argc, argv);

    std::vector<std::string> allowedProtocols{"OLSR", "AODV", "DSDV", "DSR"};

```

```

        if (std::find(std::begin(allowedProtocols), std::end(allowedProtocols),
m_protocolName) ==
            std::end(allowedProtocols))
        {
            NS_FATAL_ERROR("No such protocol:" << m_protocolName);
        }
    }
}

```

```

int main(int argc, char* argv[])
{
    RoutingExperiment experiment;
    experiment.CommandSetup(argc, argv);
    experiment.Run();

    return 0;
}

```

```

void RoutingExperiment::Run()
{
    Packet::EnablePrinting();

    std::ofstream out(m_CSVfileName);
    out << "SimulationSecond,"
        << "ReceiveRate,"
        << "PacketsReceived,"
        << "NumberOfSinks,"
        << "RoutingProtocol,"
        << "TransmissionPower" << std::endl;
    out.close();
}

```

```

int nWifis = 50;

double TotalTime = 70.0;
std::string rate("2048bps");
std::string phyMode("DsssRate11Mbps");
std::string tr_name("manet-routing-compare");
int nodeSpeed = 20;
int nodePause = 0;

Config::SetDefault("ns3::OnOffApplication::PacketSize", StringValue("64"));
Config::SetDefault("ns3::OnOffApplication::DataRate", StringValue(rate));

Config::SetDefault("ns3::WifiRemoteStationManager::NonUnicastMode",
StringValue(phyMode));

NodeContainer adhocNodes;
adhocNodes.Create(nWifis);

WifiHelper wifi;
wifi.SetStandard(WIFI_STANDARD_80211b);

YansWifiPhyHelper wifiPhy;
YansWifiChannelHelper wifiChannel;
wifiChannel.SetPropagationDelay("ns3::ConstantSpeedPropagationDelayModel");
wifiChannel.AddPropagationLoss("ns3::FriisPropagationLossModel");
wifiPhy.SetChannel(wifiChannel.Create());

WifiMacHelper wifiMac;
wifi.SetRemoteStationManager("ns3::ConstantRateWifiManager",
                             "DataMode",
                             StringValue(phyMode),

```

```

        "ControlMode",
        StringValue(phyMode));

wifiPhy.Set("TxPowerStart", DoubleValue(m_txp));
wifiPhy.Set("TxPowerEnd", DoubleValue(m_txp));

wifiMac.SetType("ns3::AdhocWifiMac");
NetDeviceContainer adhocDevices = wifi.Install(wifiPhy, wifiMac, adhocNodes);

MobilityHelper mobilityAdhoc;
int64_t streamIndex = 0;

ObjectFactory pos;
pos.SetTypeId("ns3::RandomRectanglePositionAllocator");
pos.Set("X", StringValue("ns3::UniformRandomVariable[Min=0.0|Max=300.0]"));
pos.Set("Y", StringValue("ns3::UniformRandomVariable[Min=0.0|Max=1500.0]"));

Ptr<PositionAllocator> taPositionAlloc = pos.Create()-
>GetObject<PositionAllocator>();
streamIndex += taPositionAlloc->AssignStreams(streamIndex);

std::stringstream ssSpeed;
ssSpeed << "ns3::UniformRandomVariable[Min=0.0|
Max=" << nodeSpeed << "]";
std::stringstream ssPause;
ssPause << "ns3::ConstantRandomVariable[Constant=" << nodePause << "]";
mobilityAdhoc.SetMobilityModel("ns3::RandomWaypointMobilityModel",
        "Speed",
        StringValue(ssSpeed.str()),
        "Pause",

```

```

        StringValue(ssPause.str()),
        "PositionAllocator",
        PointerValue(taPositionAlloc));
mobilityAdhoc.SetPositionAllocator(taPositionAlloc);
mobilityAdhoc.Install(adhocNodes);
streamIndex += mobilityAdhoc.AssignStreams(adhocNodes, streamIndex);

```

```

AodvHelper aodv;
OlsrHelper olsr;
DsdvHelper dsdv;
DsrHelper dsr;
DsrMainHelper dsrMain;
Ipv4ListRoutingHelper list;
InternetStackHelper internet;

```

```

if (m_protocolName == "OLSR")
{
    list.Add(olsr, 100);
    internet.SetRoutingHelper(list);
    internet.Install(adhocNodes);
}
else if (m_protocolName == "AODV")
{
    list.Add(aodv, 100);
    internet.SetRoutingHelper(list);
    internet.Install(adhocNodes);
}
else if (m_protocolName == "DSDV")
{
    list.Add(dsdv, 100);
    internet.SetRoutingHelper(list);
}

```

```

        internet.Install(adhocNodes);
    }
    else if (m_protocolName == "DSR")
    {
        internet.Install(adhocNodes);
        dsrMain.Install(dsr, adhocNodes);
        if (m_flowMonitor)
        {
            NS_FATAL_ERROR ("Error: FlowMonitor does not work with DSR.
Terminating.");
        }
    }
    else
    {
        NS_FATAL_ERROR("No such protocol:" << m_protocolName);
    }

    Ipv4AddressHelper addressAdhoc;
    addressAdhoc.SetBase("10.1.1.0", "255.255.255.0");
    Ipv4InterfaceContainer adhocInterfaces;
    adhocInterfaces = addressAdhoc.Assign(adhocDevices);

    OnOffHelper onoff1("ns3::UdpSocketFactory", Address());
    onoff1.SetAttribute("OnTime",
StringValue("ns3::ConstantRandomVariable[Constant=1.0]"));
    onoff1.SetAttribute("OffTime",
StringValue("ns3::ConstantRandomVariable[Constant=0.0]"));

    for (int i = 0; i < m_nSinks; i++)
    {
        Ptr<Socket> sink = SetupPacketReceive(adhocInterfaces.GetAddress(i),

```

```

adhocNodes.Get(i));

    AddressValue remoteAddress(InetSocketAddress(adhocInterfaces.GetAddress(i),
port));
    onoff1.SetAttribute("Remote", remoteAddress);

    Ptr<UniformRandomVariable> var = CreateObject<UniformRandomVariable>();
    ApplicationContainer temp = onoff1.Install(adhocNodes.Get(i + m_nSinks));
    temp.Start(Seconds(var->GetValue(100.0, 101.0)));
    temp.Stop(Seconds(TotalTime));
}

std::stringstream ss;
ss << nWifis;
std::string nodes = ss.str();

std::stringstream ss2;
ss2 << nodeSpeed;
std::string sNodeSpeed = ss2.str();

std::stringstream ss3;
ss3 << nodePause;
std::string sNodePause = ss3.str();

std::stringstream ss4;
ss4 << rate;
std::string sRate = ss4.str();

AsciiTraceHelper ascii;
MobilityHelper::EnableAsciiAll(ascii.CreateFileStream(tr_name + ".mob"));

```

```

FlowMonitorHelper flowmonHelper;
Ptr<FlowMonitor> flowmon;
if (m_flowMonitor)
{
    flowmon = flowmonHelper.InstallAll();
}

CheckThroughput();

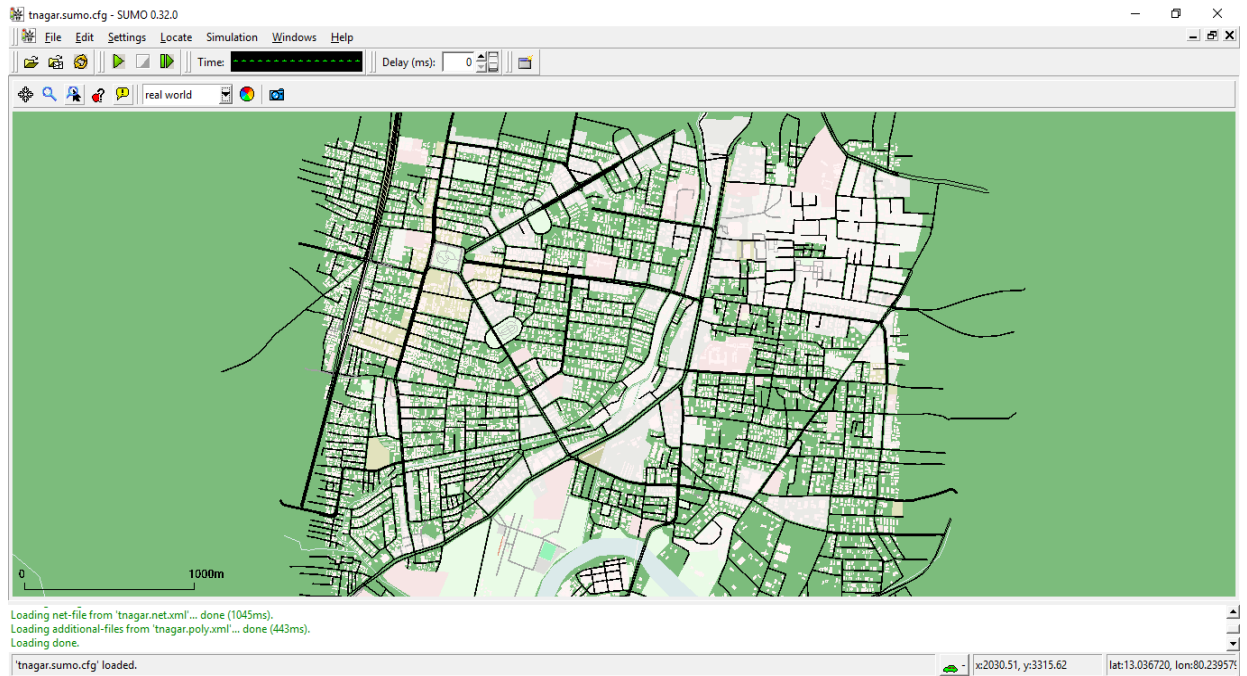
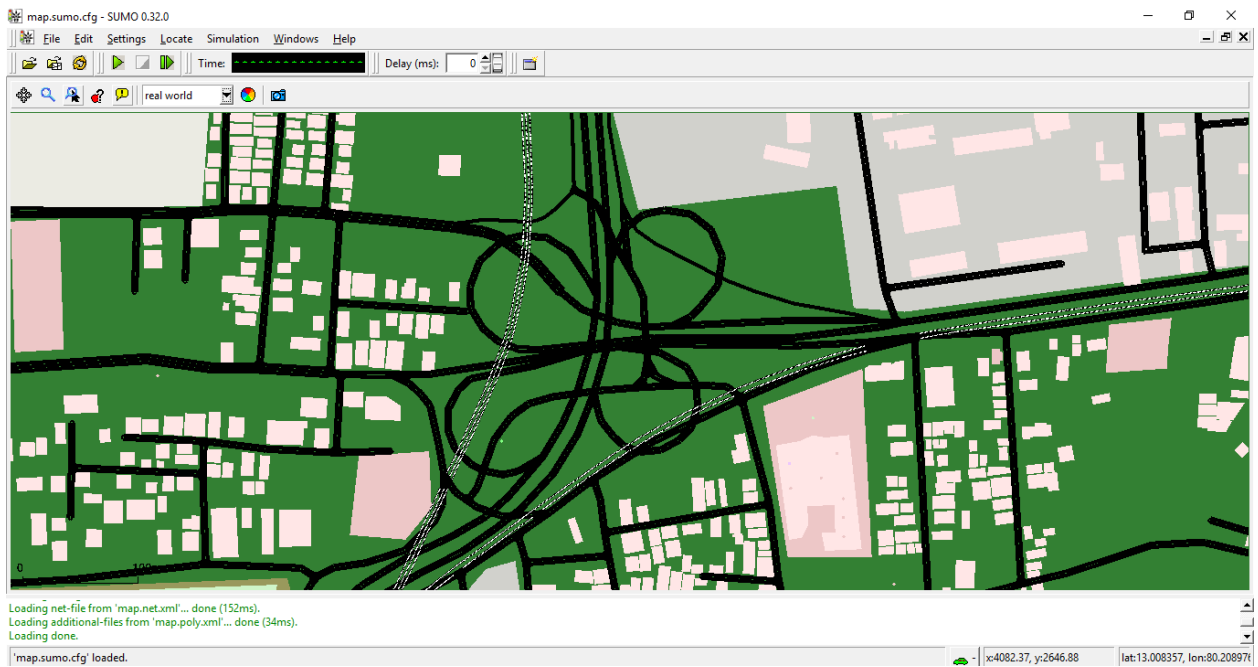
Simulator::Stop(Seconds(TotalTime));
Simulator::Run();

if (m_flowMonitor)
{
    flowmon->SerializeToXmlFile(tr_name + ".flowmon", false, false);
}

Simulator::Destroy();
}

```

B. SCREENSHOTS



C. RESEARCH PAPER

TRAFFIC CONGESTION MANAGEMENT IN VANET NETWORKS

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Abstract— Traffic congestion is a persistent challenge in urban areas, leading to increased travel times, fuel consumption, and environmental pollution. This study presents an innovative strategy for addressing congestion by utilizing advanced traffic management. Sensitive decision-making is made possible by the collection and processing of real-time data from vehicular ad hoc networks (VANETs). By using these methods to analyze the data, traffic signal timings are dynamically adjusted, improving traffic flow and reducing congestion. The goal of the project is to create a resilient, flexible, and effective congestion management system that enhances urban transportation and, in the end, results in less traffic, shorter commutes, and a more sustainable urban environment. The study of traffic patterns is among the most fascinating fields of research. This includes a host of other features including intelligent vehicle detection, route prediction, vehicle path monitoring, and much more. The majority of the studies that has been done using a vehicular ad-hoc network (VANET) to detect traffic congestion, but as of late, data mining techniques have been deployed. Even if the majority of the suggested work has been successful in detecting traffic congestion, developing an efficient mechanism that combines the detection, control, and prediction of both recurrent and nonrecurrent traffic congestions into a single system is difficult. This paper examines the identification, optimization, and algorithms of traffic congestion in VANET.

Keywords— VANET, NS3, SUMO.

INTRODUCTION

Urban areas grapple with the persistent issue of traffic congestion, a multifaceted challenge impacting economic vitality, environmental sustainability, and the overall standard of living. Offering a potential remedy to this predicament

are Vehicular Ad Hoc Networks (VANETs), dynamic networks that autonomously connect vehicles with both roadside infrastructure and fellow vehicles. The versatility of VANETs is exemplified through their ability to furnish a spectrum of services, encompassing route guidance, parking management, accident alerts, and the real-time distribution of traffic information. This project is dedicated to harnessing the capabilities of VANETs to engineer and implement a sophisticated traffic congestion management system. The overarching aim is to optimize traffic flow, curtail emissions, and diminish travel times by leveraging the real-time analysis of traffic data. The effectiveness and viability of this proposed system will be meticulously scrutinized through the utilization of testbeds and simulation tools.

However promising, VANETs are not without their share of challenges, including concerns related to stability, scalability, security, and privacy. Tackling these challenges head-on is imperative to ensure the seamless deployment and operation of VANET-based systems. Stability becomes paramount for ensuring the reliability of communication, scalability is a prerequisite for accommodating an expanding vehicular network, and robust security measures are essential for safeguarding sensitive data.

In the realm of wireless technologies, VANETs rely on two pivotal communication modes: Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V). V2I facilitates communication between vehicles and various roadside infrastructure elements such as parking meters, road signs, and traffic signals. Concurrently, V2V empowers vehicles to engage in real-time information exchange concerning their position,

speed, direction, and brake conditions. The integration of these wireless technologies aims to enhance road safety, traffic efficiency, and the overarching goal of environmental sustainability.

The transformative shift observed in contemporary communication models can be attributed to recent strides in wireless networking technologies. These networks can be broadly categorized into ad hoc and mobile infrastructure setups. Ad hoc networks epitomize flexibility and mobility, while mobile infrastructure adopts a more fixed deployment approach. VANETs, being a subset of Mobile Ad Hoc Networks (MANETs), are characterized by nodes constrained in their movement, with a focal emphasis on prioritizing passenger comfort and safety.

Amidst the intricate tapestry of challenges in bustling metropolises such as Delhi, Mumbai, and Bangalore, traffic congestion stands out prominently. VANETs, equipped with the capability to disseminate real-time information, emerge as a beacon of hope by empowering drivers with alternatives when congestion looms. Informed drivers can exercise discretion, opting to alter routes or patiently wait until the bottleneck dissipates, thereby localizing the issue for more effective management. Augmenting this informational exchange, the presentation of data on dashboards or through visual representations of impacted areas serves to heighten passenger awareness, contributing tangibly to improved decision-making and the overall efficacy of traffic management initiatives.

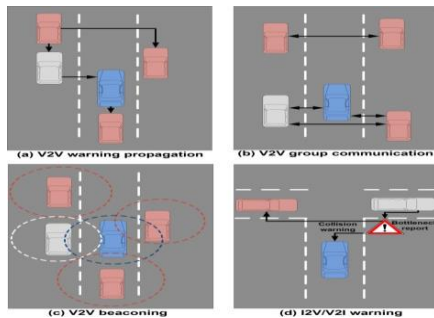


Fig 1: VANET Working

II. LITERATURE REVIEW

This study [1] examines, evaluates few of the most recent trust management and establishing techniques for automobile networks. Along with discussing the drawbacks and restrictions of current methods, it also makes some recommendations for potential future research areas. This paper discusses entity trust and data trust, two concepts that are critical to dependable and safe communication in vehicular ad hoc networks (VANETs).

In this paper [2], Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control is the dissertation's description of a novel algorithm that modifies the transmission power of beacon messages in Vehicular Ad Hoc Networks (VANETs) in response to vehicle speed and density. The algorithm's objectives are to lessen network congestion and enhance the dependability and promptness of safety messages. The dissertation compares and evaluates the algorithm with other approaches through simulation, and it is concluded that the algorithm performs better in terms of communication overhead and congestion control.

This research [3] presents a unique approach based on the age of information (AoI) metric to maximize the transmission rate of automobiles in a Vehicular Ad-hoc Network (VANET). The technique attempts to prevent packet collisions and channel congestion while minimizing the network's average area of overlap. The strategy is assessed using simulations in the paper and compared to other current methods.

A Rate adaptation and priority modeling are two unique ways of controlling network congestion in vehicular ad hoc networks (VANETs) that are discussed in the paper [4]. Vehicle Ad Hoc Networks, or VANETs, are networks of automobiles that use wireless technology to communicate with infrastructure and one another. They are used in many different areas, including traffic management, infotainment, and safety. But because of the large number of cars and the regular exchange of safety alerts, they

also have to deal with network congestion. In order to regulate the transmission rate of the beacon signals—periodic communications containing vehicle status information—the study suggests the use of the Decentralized Congestion Control (DCC) algorithm.

This study [5] introduces DisTraC, a novel protocol that cuts down on travel times and traffic jams in cities by utilizing V2V communication. Based on traffic density, DisTraC adjusts the beacon message transmission rate and prioritizes emergency alerts. In terms of communication overhead and congestion control, the paper's simulated evaluation of DisTraC demonstrates its superior performance over current techniques.

This research [6] suggests a novel method for modifying the vehicles' transmission power in a Vehicular Ad Hoc Network (VANET) according to the network's vehicle density. Reducing network channel congestion and enhancing network performance are the objectives. In comparison to current technologies, the paper's simulated evaluation of the suggested solution demonstrates its ability to lower packet loss and inter-packet delay.

III. EXISTING SYSTEM

In the present urban infrastructure, the orchestration of traffic flow primarily depends on conventional traffic signal coordination, GPS-based navigation applications, surveillance cameras, and centralized traffic management systems. Despite their widespread use, these existing systems are frequently characterized by shortcomings in terms of adaptability, responsiveness, and scalability. Addressing these limitations is critical for the advancement of traffic management solutions, and exploring innovative approaches becomes imperative to create a more efficient and sustainable urban mobility landscape.

IV. PROPOSED SYSTEM

The paper advocates for a shift towards VANET-based traffic information systems,

utilizing DSRC and intelligent algorithms for dynamic traffic signal adjustments. The integration of edge computing, machine learning-based traffic prediction, dynamic tolling, and smart traffic lights is explored to enhance congestion management, emphasizing decentralized systems, cooperative communication, and adaptive control mechanisms. The overarching goal is to create a resilient traffic management framework addressing the dynamic nature of urban traffic patterns and effectively mitigating congestion.

The proposed system also provides drivers with dynamic route suggestions based on real-time traffic data, employing machine learning and data analytics for congestion forecasting and detection. This approach aligns with sustainability and environmental concerns, contributing to increased road safety by prioritizing emergency vehicles. The system aims for reduced environmental impact, enhanced energy efficiency, and considers implications for policy and public acceptance.

V. ROUTING PROTOCOLS

Wireless ad hoc networks facilitate free-roaming stations with a dynamically changing network topology. The relocation of stations leads to the loss of some network ties and the potential formation of new ones, necessitating new routing techniques.

1. Ad Hoc Routing Systems

Ad hoc routing systems come in two types: table-driven and on-demand. The focus of this research is on three protocols – DSDV, DSR, and AODV. DSDV employs sequence numbers to avoid loops and selects the most recent routes. DSR allows nodes to dynamically find source routes through "Route Discovery" and "Route Maintenance" processes. AODV, a well-known topology routing protocol, initiates route requests and establishes end-to-end paths between nodes.

2. DSDV Protocol

DSDV is an improved version of the Bellman-

Ford Routing Algorithm, using sequence numbers to avoid loops. Stations periodically broadcast routing tables, and updates can be either full or incremental. The route with the highest sequence number (or the shortest route if equal) is chosen. Stations estimate settling times to reduce unnecessary updates.

3. DSR Protocol

DSR allows nodes in an ad hoc network to find source routes through "Route Discovery" and "Route Maintenance" processes. Caches of routes reduce control messaging costs. DSR route recovery can happen more quickly compared to other on-demand protocols.

4. AODV Protocol

AODV operates by broadcasting route request (RREQ) messages when a node needs to communicate. Nodes forward RREQ messages to establish a reverse path, and a path is created when the source node receives a route reply (RREP) message. Maintaining a connection with the sink node is critical for uninterrupted data collection.

5. IEEE 802.11p/DSRC Protocol

IEEE 802.11p/DSRC is a wireless protocol for vehicular ad hoc networks, addressing challenges in high mobility, topological changes, and ensuring reliability and low latency. Operating in the 5.9 GHz band, it supports safety and non-safety applications, with WAVE (802.11p) improving PHY and MAC layers for DSRC.

VI. SYSTEM ARCHITECTURE

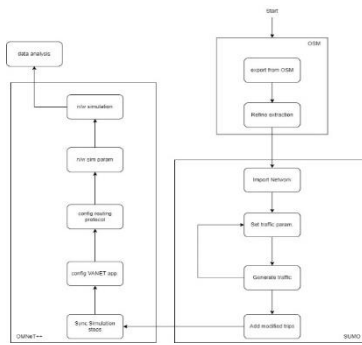


Fig 2: System architecture

A. OpenStreetMap (OSM)

OpenStreetMap (OSM) is a collaborative project that creates freely editable and open-source maps using contributions from volunteers worldwide. These maps offer detailed geographic information and are utilized in various applications and services. In our research, we will leverage OSM to extract maps for simulating real-world traffic conditions.

B. SUMO Simulator

The extracted OSM map data is imported into the SUMO simulator, where we define the vehicle count and types before the simulation begins. Additionally, we set various parameters within SUMO to configure the simulation environment according to our research needs.

C. Routing Protocols and Initialization Parameters

We will employ specific routing protocols to simulate network traffic, developing code to analyze the outcomes of these protocols within the network simulation. Initialization parameters are crucial for configuring the initial state of the network and its components.

D. NS-3 Simulator

NS-3 is a discrete-event network simulator developed in C++, featuring a Python binding for enhanced flexibility. It serves as a robust platform for simulating various networking protocols and environments, providing a wide array of modules catering to different networking technologies. The extensibility, flexibility, and accuracy of NS-3 make it a preferred choice in academia and research for simulating and evaluating network protocols, algorithms, and architectures.

E. Trace and Nam Files Generation

During simulation in NS-3, trace and nam files are generated to capture and record various aspects of the simulated network behavior. These files contain detailed information about the network's performance, traffic patterns, and other relevant metrics, enabling in-depth analysis and evaluation.

F. Trace File Analysis:

Following simulation, the trace files are

analyzed to extract meaningful insights into the network's behavior and performance. This analysis involves examining various parameters and metrics recorded in the trace files, providing valuable data for evaluating the effectiveness of the simulated routing protocols and network configurations.

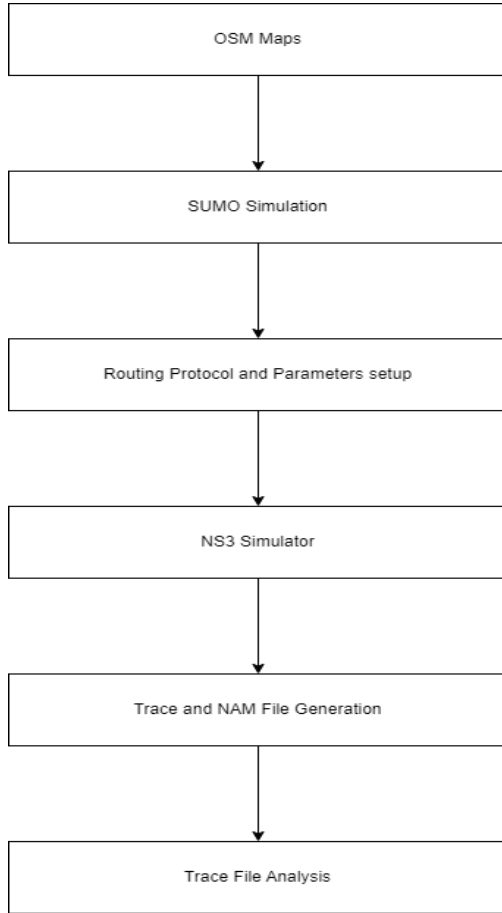


Fig 3: Process

VII. RESULTS AND DISCUSSION

The research findings are a result of a meticulous use of open-source tools, specifically the Simulation of Urban Mobility (SUMO) and the ns-3 network simulator, combined with geospatial data from OpenStreetMap (OSM). In the context of SUMO, the simulations demonstrated a high degree of realism,

effectively replicating real-world traffic scenarios and showcasing its versatility in analyzing vehicular dynamics. The incorporation of OSM data enhanced the simulations by providing greater geographical precision, strengthening the authenticity of the virtual road network, and significantly improving the accuracy of congestion management evaluations.

The choice of the most suitable routing protocol for traffic congestion management in VANETs depends on various factors, including network density, mobility patterns, traffic load, and application requirements.

According to the simulation scenarios with low to moderate traffic congestion and relatively stable network conditions, DSDV may be a suitable choice due to its ability to maintain up-to-date routing information and quickly adapt to topology changes. However, in highly dynamic and congested environments, on-demand routing protocols like DSR and AODV may be more appropriate due to their lower control overhead and better adaptability to frequent route changes.

AODV, in particular, has shown promising results in managing traffic congestion in VANETs due to its efficient route discovery and maintenance mechanisms. It strikes a balance between the proactive nature of DSDV and the reactive approach of DSR, making it a popular choice for various VANET applications.

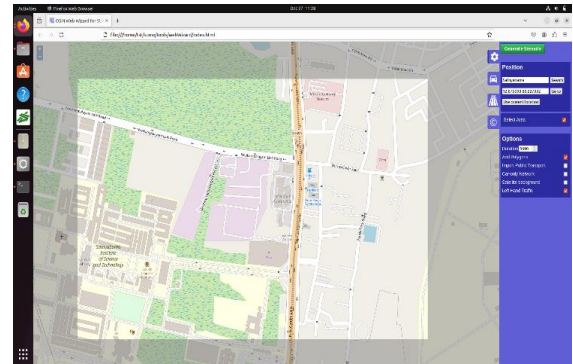


Fig 4: OSM

Moving beyond tool application, the research delved into the intricate interplay of vehicular

communication protocols within the realm of Vehicle Ad-Hoc Networks (VANETs). The ns-3 network simulator played a pivotal role in facilitating a detailed examination of these protocols. Its open-source architecture, coupled with inherent extensibility, positioned ns-3 as a central instrument in elucidating the nuanced implications of diverse networking strategies on the overall performance of VANETs.



Fig 5: Terminal

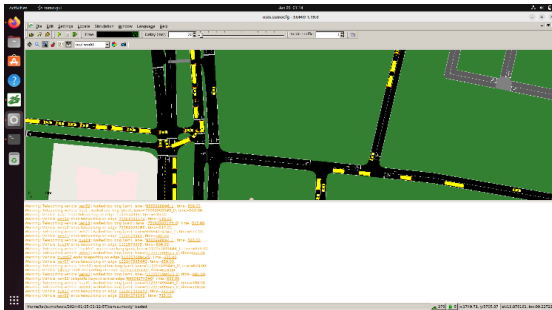


Fig 6: SUMO

VIII. FUTURE ENHANCEMENT

A prospective enhancement for the research involves incorporating clustering algorithms for efficient formation of vehicle clusters in Vehicle Ad-Hoc Networks (VANETs). Utilizing algorithms like K-means or hierarchical clustering could dynamically group vehicles based on proximity, speed, or destination, improving communication efficiency and reducing congestion. The implementation of clustering algorithms has the potential to optimize resource allocation and enhance scalability. However, challenges like dynamic

cluster memberships and communication overhead need consideration. This addition would further refine VANET-based traffic management systems, offering potential benefits in terms of smoother traffic flow and network performance.

IX. CONCLUSION

In conclusion, our simulation study highlights the potential of Vehicle Ad-Hoc Networks (VANETs) in effectively managing traffic congestion. Through meticulous consideration of factors such as communication latency and network stability, the results demonstrate the real-time adaptability of VANET-based congestion management systems. However, challenges related to communication reliability must be addressed for practical implementation in real-world scenarios. This research emphasizes the need for ongoing efforts to refine VANET protocols and optimize communication mechanisms, contributing valuable insights to the development of resilient and efficient urban traffic management solutions within the realm of intelligent transportation systems.

REFERENCES

- [1] R. Hussain, J. Lee, and S. Zeadally, "Trust in VANET: a survey of current solutions and future research opportunities" IEEE Transactions on Intelligent Transportation Systems, 2021.
- [2] Facchina, C. Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control (Doctoral dissertation, University of Windsor (Canada),2020).
- [3] N. Lyamin, B. Bellalta, and A. Vinel, "Age-of-informationaware decentralized congestion control in vanets," IEEE Networking Letters, vol. 2, no. 1, 2020
- [4] Sharma, S., Chahal, M., & Harit, S. (2019, February). Transmission Rate-based Congestion Control in Vehicular Ad Hoc Networks. In 2019 Amity International Conference on Artificial

Intelligence (AICAI). IEEE

[5] de Sousa, R. S., Boukerche, A., & Loureiro, A. A. DisTraC: A Distributed and Low-Overhead Protocol for Traffic Congestion Control Using Vehicular Networks. IEEE Symposium on Computers and Communications (ISCC). IEEE, 2019.

[6] Akinlade, O., Saini, I., Liu, X., & Jaekel, A. Traffic Density Based Distributed Congestion Control Strategy for Vehicular Communication, 2019.

[7] R. Chhabra, C. Rama Krishna, and S. Verma, "Context-aware hybrid adaptive beaconing for driver behavior dissemination in VANETs," IETE Journal of Research, vol. 68, 2021.

[8] P. Rajput, M. Chaturvedi, and V. Patel, "Opportunistic sensing-based detection of crowdedness in public transport buses," Pervasive and Mobile Computing, vol. 68, article 101246, 2020

[9] A. U. Haq, K. Liu, and M. B. Latif, "A Location-and Mobility-Aware Clustering-Based TDMA MAC Protocol for Vehicular Ad-hoc Networks," 28th Wireless and Optical Communications Conference (WOCC), 2019.

[10] G. H. Alsuhli, A. Khattab, and Y. A. Fahmy, "Double-head clustering for resilient VANETs," Wireless Communications and Mobile Computing, vol. 2019.

TRAFFIC CONGESTION MANAGEMENT IN VANET NETWORK

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Computer Science and Engineering

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **THIRAKALA SRITEJA (40111336)** and **TUPRAN NISHANTH KUMAR (40111360)** who carried out the Project work entitled "Traffic congestion management in VANET Networks" under my supervision from Nov 2023 to April 2024.

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DECLARATION

I, THIRAKALA SRITEJA (40111336) hereby declare that the Project Report entitled "Traffic congestion management in VANET Networks" done by me under the guidance of Dr.N.S Usha,M.E.,Ph.D is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Computer Science and Engineering.

DATE:

PLACE: Chennai



SIGNATURE OF THE CANDIDATE

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I convey my sincere thanks to **Dr.T.Sasikala, M.E.,(Ph.D.) Dean** of School of Computing **Dr. L. Lakshmanan M.E., Ph.D.**, Head of the Department of Computer Science and Engineering for providing me necessary support and details at the right time during the progressive reviews.

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ABSTRACT

Traffic congestion is a persistent and multifaceted challenge in urban areas, exacerbating travel times, fuel consumption, and environmental degradation. In response, this study proposes an innovative approach to alleviate congestion through advanced traffic management strategies. By harnessing real-time data from Vehicular Ad hoc Networks (VANETs), informed decision-making becomes feasible, enabling dynamic adjustments to traffic signal timings and consequent improvements in traffic flow. The overarching objective of this project is to develop a resilient and adaptable congestion management system, fostering enhanced urban transportation efficiency and ultimately resulting in reduced traffic congestion, shorter commutes, and a more sustainable urban environment. Beyond congestion management, the study delves into various facets of traffic pattern analysis, including intelligent vehicle detection, route prediction, and vehicle path monitoring. While existing research predominantly focuses on utilizing VANETs for congestion detection, this project explores the integration of data mining techniques to develop a comprehensive mechanism for detecting, controlling, and predicting both recurrent and nonrecurrent traffic congestions within a unified system framework. Moreover, the study aims to address the inherent challenges associated with developing such an integrated system, including the optimization of detection algorithms, control mechanisms, and predictive models. Through meticulous identification, optimization, and algorithm development, the project seeks to advance the state-of-the-art in traffic congestion management within VANETs. Leveraging simulation tools such as NS3 and SUMO, the project aims to evaluate the performance of different network protocols and traffic management strategies under various traffic scenarios. By synthesizing insights from simulation results with real-world data, the project endeavors to provide actionable recommendations for the deployment of effective congestion management solutions in urban environments. Ultimately, the research contributes to the broader goal of enhancing urban mobility, reducing environmental impact, and improving overall quality of life in urban areas through innovative traffic management approaches enabled by VANET technologies.

TABLE OF CONTENTS

Chapter No	TITLE	Page No.
	ABSTRACT	iv
	LIST OF FIGURES	vii
	LIST OF ABBREVIATIONS	viii
1	INTRODUCTION	1
2	LITERATURE SURVEY	3
	2.1 Inferences from Literature Survey	2
	2.2 Existing System	7
	2.3 Open Problems in Existing System	8
	2.4 Proposed System	9
3	AIM AND SCOPE OF THE PRESENT INVESTIGATION	
	3.1 Aim	9
	3.2 Objective	10
	3.3 Scope of The Present Investigation	11
	3.4 Risk Analysis of Project	12
	3.5 Hardware Requirements	16
4	EXPERIMENTAL OR METHODS, ALGORITHMS USED	17
	4.1 Selected Methodology or Process Model	18
	4.2 Architecture / Overall Design of Proposed System	19
	4.3 Model Architecture Design/Algorithm	24
	4.4 Description of Software Implementation and Testing Plan	26

	4.5	Routing in VANET	29
	4.6	ADHOC Routing Protocols	31
5		IMPLEMENTATION DETAILS	38
	5.1	Data Collection	38
	5.2	Routing Protocols Implementation	39
	5.3	Traffic Congestion Algorithms Evaluation	41
	5.4	Real-Time Map Designing	42
	5.5	Conversion of SUMO to Ns3	43
6		RESULTS AND DISCUSSIONS	45
7		CONCLUSION AND FUTURE WORK	
	7.1	Conclusion	48
	7.2	Future Enhancement	48
		REFERENCES	50
		APPENDIX	
		A. SOURCE CODE	52
		B. SCREEN SHOTS	63
		C. RESEARCH PAPER	64
		D.CERTIFICATE	71

LIST OF FIGURES

FIGURE NO.	FIGURE NAME	PAGE NO.
4.1	VANET Overview	20
4.2	Components of VANET	21
4.3	VANET Architecture	22
4.4	Table Architecture	23
4.5	VANET Communication Architecture	24
4.6	Elements of VANET	26
4.7	ADHOC Protocols	32
4.8	DSDV routing	34
4.9	AODV Routing	35
4.10	AODV vs DSDV	37
6.1	SUMO CMD	46
6.2	Open Street Maps (OSM)	46
6.3	SUMO Simulation	47

LIST OF ABBREVIATIONS

VANET	Vehicular Adhoc Network
SUMO	Simulation of Urban Mobility
NS3	Network Simulator 3
AODV	Adhoc On-Demand Distance Vector
DSDV	Destination Sequence Distance Vector Routing
CMD	Command Prompt
DSR	Distance Signal Repository
V2V	Vehicle to Vehicle Communication
V2I	Vehicle to Infrastructure Communication
DSRC	Dedicated Short Range Communication
RREQ	Route Request Packet

CHAPTER 1

INTRODUCTION

Traffic congestion is a major problem in many urban areas, affecting the environment, economy and quality of life of the citizens. One of the possible solutions to mitigate this problem is to use vehicular ad hoc networks (VANETs), which are self-organized networks of vehicles that communicate with each other and with roadside infrastructure. VANETs can provide various applications and services, such as traffic information dissemination, route guidance, accident warning, parking management and entertainment. In this project, we aim to design and implement a traffic congestion management system using VANETs, which can collect and analyze real-time traffic data, optimize traffic flow and reduce travel time and emissions. We will use simulation tools and testbeds to evaluate the performance and feasibility of our proposed system. We will also address the challenges and issues related to VANETs, such as security, privacy, scalability and reliability.

V2I and V2V communication are two types of wireless technologies that enable vehicles to communicate with each other and with the infrastructure. V2I stands for vehicle-to-infrastructure communication, which allows vehicles to exchange information with traffic signals, road signs, parking meters, and other roadside devices. V2V stands for vehicle-to-vehicle communication, which allows vehicles to share data such as speed, position, direction, and braking status with nearby vehicles. These technologies can improve road safety, traffic efficiency, and environmental sustainability by providing drivers with real-time information and warnings, coordinating traffic flow, and reducing fuel consumption and emissions.

The recent advancements in wireless networking are responsible for entire change in communication model as seen today. This is because it is easy to deploy and setup. These wireless networks can be classified either mobile infrastructure or ad-hoc depending on how they are deployed. Mobile infrastructure has fixed deployment model while adhoc have flexible mobile model. The fixed mode requires an infrastructure to be deployed before devices (called nodes) start to communicate with each other. The devices in this model communicate with infrastructure as well as with each other.

CHARACTERISTICS OF VANET

VANET is an application of MANET but it has its own distinct characteristics which can be summarized as:

- i. **High Mobility:** The nodes in VANETs usually are moving at high speed. This makes harder to predict a node's position and making protection of node privacy.
- ii. **Rapidly changing Network topology:** Due to high node mobility and random speed of vehicles, the position of node changes frequently. As a result of this, network topology in VANETs tends to change frequently.
- iii. **Unbounded network size:** VANET can be implemented for one city, several cities or for countries. This means that network size in VANET is geographically unbounded.
- iv. **Frequent exchange of information:** The ad hoc nature of VANET motivates the nodes to gather information from the other vehicles and road side units. Hence the information exchange among node becomes frequent.
- v. **Wireless Communication:** VANET is designed for the wireless environment. Nodes are connected and exchange their information via wireless. Therefore, some security measure must be considered in communication.
- vi. **Time Critical:** The information in VANET must be delivered to the nodes with in time limit so that a decision can be made by the node and perform action accordingly.
- vii. **Sufficient Energy:** The VANET nodes have no issue of energy and computation resources. This allows VANET usage of demanding techniques such as RSA, ECDSA implementation and also provides unlimited transmission power.
- viii. **Better Physical Protection:** The VANET nodes are physically better protected. Thus, VANET nodes are more difficult to compromise physically and reduce the effect of infrastructure attack.
- ix. **High computational capability:** Operating vehicles can afford significant computing, communication and sensing capabilities.
- x. **Partitioned network:** Vehicular networks will be frequently partitioned. The dynamic nature of traffic may result in large inter vehicle gaps in sparsely populated scenarios and hence in several isolated clusters of nodes.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE SURVEY

The following papers were referenced and studied for the project.

[1] R. Hussain, J. Lee, and S. Zeadally, "Trust in VANET: a survey of current solutions and future research opportunities" IEEE Transactions on Intelligent Transportation Systems, 2021.

This study [1] examines, evaluates few of the most recent trust management and establishing techniques for automobile networks. Along with discussing the drawbacks and restrictions of current methods, it also makes some recommendations for potential future research areas. This paper discusses entity trust and data trust, two concepts that are critical to dependable and safe communication in vehicular ad hoc networks (VANETs).

[2] Facchina, C. Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control (Doctoral dissertation, University of Windsor (Canada),2020).

In this paper [2], Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control is the dissertation's description of a novel algorithm that modifies the transmission power of beacon messages in Vehicular Ad Hoc Networks (VANETs) in response to vehicle speed and density. The algorithm's objectives are to lessen network congestion and enhance the dependability and promptness of safety messages. The dissertation compares and evaluates the algorithm with other approaches through simulation, and it is concluded that the algorithm performs better in terms of communication overhead and congestion control.

[3] N. Lyamin, B. Bellalta, and A. Vinel, "Age-of-informationaware decentralized congestion control in vanets," IEEE Networking Letters, vol. 2, no. 1, 2020

This research [3] presents a unique approach based on the age of information (AoI) metric to maximize the transmission rate of automobiles in a Vehicular Ad-hoc Network (VANET). The technique attempts to prevent packet collisions and channel congestion while minimizing the network's average area of overlap. The strategy is assessed using simulations in the paper and compared to other current methods.

[4] Sharma, S., Chahal, M., & Harit, S. (2019, February). Transmission Rate-based Congestion Control in Vehicular Ad Hoc Networks. In 2019 Amity International Conference on Artificial Intelligence (AICAI). IEEE

A Rate adaptation and priority modeling are two unique ways of controlling network congestion in vehicular ad hoc networks (VANETs) that are discussed in the paper [4]. Vehicle Ad Hoc Networks, or VANETs, are networks of automobiles that use wireless technology to communicate with infrastructure and one another. They are used in many different areas, including traffic management, infotainment, and safety. But because of the large number of cars and the regular exchange of safety alerts, they also have to deal with network congestion. In order to regulate the transmission rate of the beacon signals—periodic communications containing vehicle status information—the study suggests the use of the Decentralized Congestion Control (DCC) algorithm.

[5] de Sousa, R. S., Boukerche, A., & Loureiro, A. A. DisTraC: A Distributed and Low-Overhead Protocol for Traffic Congestion Control Using Vehicular Networks IEEE Symposium on Computers and Communications (ISCC). IEEE, 2019.

This study [5] introduces DisTraC, a novel protocol that cuts down on travel times and traffic jams in cities by utilizing V2V communication. Based on traffic density, DisTraC adjusts the beacon message transmission rate and prioritizes emergency

alerts. In terms of communication overhead and congestion control, the paper's simulated evaluation of DisTraC demonstrates its superior performance over current techniques

[6] Akinlade, O., Saini, I., Liu, X., & Jaekel, A. Traffic Density Based Distributed Congestion Control Strategy for Vehicular Communication, 2019.

This research [6] suggests a novel method for modifying the vehicles' transmission power in a Vehicular Ad Hoc Network (VANET) according to the network's vehicle density. Reducing network channel congestion and enhancing network performance are the objectives. In comparison to current technologies, the paper's simulated evaluation of the suggested solution demonstrates its ability to lower packet loss and inter-packet delay.

[7] R. Chhabra, C. Rama Krishna, and S. Verma, "Context-aware hybrid adaptive beaconing for driver behavior dissemination in VANETs," IETE Journal of Research, 2021.

This [7] study aims to enhance communication in Vehicular Ad hoc Networks (VANETs) by improving beaconing mechanisms. The proposed method adapts beaconing based on contextual factors such as vehicle density, road conditions, and driver behavior. It combines both periodic and event-triggered beaconing to optimize information dissemination while minimizing network overhead. By tailoring beaconing to specific scenarios, this approach enhances safety-critical messages (e.g., collision warnings) in VANETs. Their research aims to make VANETs smarter and more efficient by dynamically adjusting beaconing strategies based on real-world context

[8] P. Rajput, M. Chaturvedi, and V. Patel, "Opportunistic sensing-based detection of crowdedness in public transport buses," Pervasive and Mobile Computing, 2020.

Opportunistic sensing-based Detection aims to address the challenge of assessing crowdedness levels in buses. The authors propose an opportunistic sensing-based

approach. They leverage data from accelerometers and Global Positioning System (GPS) sensors available in smartphones carried by commuters. By analyzing sensor data, the system identifies crowded conditions within buses. This technology is used to improve public transportation services by providing real-time information on bus occupancy.

[9] A. U. Haq, K. Liu, and M. B. Latif, "A Location-and Mobility-Aware Clustering-Based TDMA MAC Protocol for Vehicular Ad-hoc Networks," 28th Wireless and Optical Communications Conference (WOCC), 2019.

Location and Mobility aware clustering enhance communication in Vehicular Ad hoc Networks (VANETs) by improving Medium Access Control (MAC) protocols. The proposed protocol is location-aware and mobility-aware. It leverages clustering techniques to optimize time division multiple access (TDMA) scheduling. By adapting to real-world context, this protocol enhances data exchange efficiency in VANETs. Vehicles are grouped into clusters based on their proximity and mobility patterns. Time slots are allocated dynamically to clusters, considering their location and movement.

[10] G. H. Alsuhli, A. Khattab, and Y. A. Fahmy, "Double-head clustering for resilient VANETs," Wireless Communications and Mobile Computing, vol. 2019.

The study addresses the challenges of Vehicular Ad Hoc Networks (VANETs), including scalability and highly dynamic topology. The authors introduce a general-purpose resilient double-head clustering (DHC) algorithm for VANETs. DHC leverages relevant mobility metrics (such as vehicle speed, position, and direction) and communication link quality metrics (like link expiration time and signal-to-noise ratio). DHC exhibits enhanced performance and stability during cluster maintenance phases. The algorithm's effectiveness is validated through extensive evaluations, comparing it with other algorithms under various mobility scenarios and radio channel models.

Inference from the above study

The referenced studies encompass innovative approaches to enhance vehicular communication and congestion control in VANETs. They explore trust management, adaptive transmission power, age-of-information metrics, congestion control algorithms, and novel protocols like DisTraC. Context-aware beaconing and opportunistic sensing further refine VANET efficiency. Location and mobility-aware clustering protocols, along with resilient clustering algorithms, address scalability and dynamic topology challenges. Collectively, these advancements contribute to safer, more efficient vehicular communication systems, paving the way for intelligent transportation networks capable of dynamically adapting to real-world conditions, enhancing road safety, traffic flow, and overall urban mobility.

2.2 EXISTING SYSTEM

VANETs can be used to disseminate real-time traffic information to vehicles. This information can include traffic conditions, road closures, accidents, and alternative routes. By providing drivers with up-to-date information, they can make informed decisions to avoid congested areas, thus reducing overall traffic congestion. VANETs can be integrated with traffic signal control systems to optimize traffic signal timings based on real-time traffic conditions. By adjusting signal timings dynamically, traffic flow can be improved, reducing congestion at intersections. VANETs enable vehicles to communicate with each other to share traffic information and collectively plan routes. Using this information, vehicles can dynamically adjust their routes to avoid congested areas, leading to more efficient traffic flow. Some systems use real-time data from VANETs to detect and control traffic congestion. For instance, the Congestion Detection and Control Algorithm (CDCA) leverages V2V (vehicle-to-vehicle) and V2I (vehicle-to-infrastructure) communication networks to manage congestion effectively.

- 1) Cooperative Adaptive Cruise Control (CACC):** CACC systems utilize VANET technology to enable vehicles to communicate with each other and maintain safe following distances automatically. By coordinating acceleration and braking among vehicles, CACC systems can improve traffic flow and

reduce congestion, especially on highways.

- 2) **Dynamic Lane Assignment:** VANETs can be used to dynamically assign lanes to vehicles based on traffic conditions. By directing vehicles to less congested lanes, overall traffic flow can be improved, reducing congestion.
- 3) **Parking Management:** VANETs can be utilized for smart parking management systems. Vehicles can communicate with parking infrastructure to find available parking spaces more efficiently, reducing congestion caused by drivers searching for parking.

2.3 OPEN PROBLEMS IN THE EXISTING SYSTEM

Addressing traffic congestion in modern urban environments presents several challenges, including the development of dynamic traffic flow models capable of accounting for real-time factors such as weather conditions and accidents, the implementation of adaptive traffic signal control systems, integration of multi-modal transportation options, and fostering sustainable transportation practices. Additionally, optimizing freight transportation routes, improving public transportation accessibility, and integrating real-time traffic data from various sources are essential to reduce congestion. Smart city initiatives leveraging technology, influencing driver behavior for responsible driving, and effective governance and policies are central to congestion management. Furthermore, addressing issues related to emergency and evacuation planning, data privacy, urban planning, and land use, as well as raising public awareness about congestion's impact, play key roles in reducing traffic congestion and creating more efficient, sustainable urban transportation systems.

1. **Dynamic Traffic Flow Modeling:** Developing more accurate and dynamic models for traffic flow that can account for various factors, such as weather conditions, special events, and accidents, in real-time.
2. **Effective Traffic Signal Control:** Designing intelligent traffic signal control systems that can adapt to changing traffic conditions, prioritize public transportation, and optimize traffic flow to reduce congestion.
3. **Multi-Modal Transportation Integration:** Creating seamless integration between various modes of transportation, including buses, subways, rideshares, and cycling, to provide commuters with efficient and convenient options for reducing congestion.

4. **Sustainable Transportation:** Encouraging the adoption of sustainable and eco-friendly transportation methods, such as electric vehicles and public transportation, to reduce the environmental impact of congestion.
5. **Route Optimization for Freight Transportation:** Developing route optimization strategies for freight transportation that reduce the impact of truck traffic on congestion and improve logistics efficiency.

2.4 PROPOSED SYSTEM

The proposed system leverages Vehicular Ad Hoc Networks (VANETs) and intelligent algorithms to dynamically manage traffic congestion. By integrating Dedicated Short-Range Communication (DSRC) technology with machine learning-based traffic prediction and dynamic tolling, the system aims to optimize traffic flow and reduce congestion in urban areas. Key components include edge computing for real-time data processing, cooperative communication among vehicles, and adaptive control mechanisms for traffic signals. Additionally, the system provides drivers with dynamic route suggestions based on real-time traffic data, contributing to reduced travel times and environmental impact while prioritizing road safety. Overall, the proposed system offers a resilient and effective solution for addressing traffic congestion in urban environments.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 AIM

The aim of the project is to analyze and evaluate different network protocols within Vehicular Ad hoc Networks (VANETs) to effectively manage and alleviate traffic congestion. By conducting comprehensive assessments of various routing, congestion control, and traffic management techniques, the project aims to identify strategies that optimize VANET performance in congested environments. The ultimate goal is to contribute to the development of efficient VANET systems capable of enhancing road safety, reducing delays, and improving overall traffic flow in urban and highway settings. Through empirical testing and analysis, the project seeks to provide valuable insights into the design and implementation of VANET solutions that address the challenges posed by dynamic vehicular environments.

3.2 OBJECTIVE

The objective of the project on traffic congestion management in Vehicular Ad hoc Networks (VANETs) is to investigate and demonstrate the effectiveness of different network protocols in alleviating traffic congestion. VANETs play a crucial role in enhancing road safety and traffic efficiency by enabling communication among vehicles and infrastructure. However, the dynamic nature of vehicular environments poses significant challenges, such as congestion, which can lead to delays, accidents, and inefficient use of road resources.

Through this project, we aim to evaluate various network protocols, including routing, congestion control, and traffic management techniques, to optimize the performance of VANETs in congested scenarios. The key objectives include:

1. Assessing the performance of different routing protocols (e.g., AODV, DSR, and OLSR) in terms of packet delivery ratio, end-to-end delay, and network overhead under varying traffic densities.
2. Investigating congestion control mechanisms, such as rate control and admission control, to mitigate congestion and improve network efficiency.
3. Implementing and testing traffic management strategies, such as traffic signal optimization and route guidance, to alleviate congestion hotspots and enhance traffic flow.

By achieving these objectives, we aim to contribute to the development of efficient and reliable VANET systems capable of effectively managing traffic congestion, thereby improving overall road safety and mobility.

3.3 SCOPE OF THE PRESENT INVESTIGATION

The scope of the present investigation encompasses several key aspects related to traffic congestion management in Vehicular Ad Hoc Networks (VANETs).

i) Utilization of VANETs for Traffic Management

The investigation focuses on leveraging VANETs to address traffic congestion challenges in urban areas. It aims to harness the real-time data collected from VANETs to implement innovative traffic management strategies.

ii) Innovative Strategies for Congestion Management

The project proposes the implementation of advanced traffic management techniques, including dynamic adjustment of traffic signal timings based on real-time data analysis. These strategies aim to improve traffic flow and reduce congestion in urban environments.

iii) Exploration of Traffic Patterns

The investigation delves into the study of traffic patterns using VANETs, encompassing intelligent vehicle detection, route prediction, vehicle path monitoring, and other related features. By analyzing traffic patterns, the project seeks to develop effective congestion detection, control, and prediction mechanisms.

iv) Integration of Data Mining Techniques

While previous studies have primarily focused on using VANETs for detecting traffic congestion, the present investigation explores the deployment of data mining techniques to enhance congestion management. The project aims to develop an efficient mechanism that combines congestion detection, control, and prediction into a single system.

v) Examination of Traffic Congestion Algorithms

The investigation involves the identification, optimization, and analysis of algorithms for traffic congestion management in VANETs. It explores various approaches to optimize traffic flow and mitigate congestion using VANET-based systems.

vi) Evaluation of VANET Protocols

The project evaluates different VANET protocols, including NS3 and SUMO, to assess their effectiveness in managing traffic congestion. It aims to analyze the performance of these protocols under various traffic conditions and scenarios.

3.4 RISK ANALYSIS OF THE PROJECT

Risk analysis for the project "Traffic Congestion Management in VANET Networks" involves identifying potential risks that could impact the successful completion of the project and developing strategies to mitigate or manage these risks. Here are some key risk factors and mitigation strategies:

1. Technical Risks

Complexity of VANET Systems: VANETs are complex systems with numerous interacting components. The integration of various technologies such as DSRC, edge computing, and machine learning algorithms may introduce technical challenges. Thorough testing and validation of each component, utilizing simulation tools like SUMO and NS-3 to identify and address potential integration issues. **Data Accuracy and Reliability:** Real-time traffic data collected from VANETs may be prone to errors or inconsistencies, affecting the accuracy of congestion detection and management algorithms. Implement data validation and error-checking mechanisms, calibrate sensors regularly, and incorporate redundancy in data collection methods to ensure reliability.

2. Operational Risks

Network Stability and Performance: VANETs operate in dynamic and unpredictable environments, leading to potential issues with network stability, connectivity, and performance. Conduct extensive testing in diverse scenarios to evaluate network performance, implement robust communication protocols, and deploy redundant communication channels to mitigate the impact of network failures. **Privacy and Security Concerns:** The transmission of sensitive data in VANETs raises privacy and security concerns, including unauthorized access, data breaches, and malicious attacks. Employ encryption techniques to secure data transmission, implement access control mechanisms, and deploy intrusion detection systems to detect and respond to security threats proactively.

3. Resource Risks

Budget Overruns: Unexpected expenses or cost overruns may occur due to unanticipated equipment purchases, software licensing fees, or additional manpower requirements. Develop a detailed budget plan, regularly monitor expenses, and allocate contingency funds to address unforeseen costs. **Resource Constraints:** Limited availability of skilled personnel, hardware, or software resources may hinder project progress and impact deliverable timelines. Identify resource constraints early, prioritize

tasks, and consider outsourcing certain activities or collaborating with external partners to supplement internal resources.

4. External Risks

A) Regulatory Compliance: Changes in regulatory requirements or legal frameworks governing VANETs may necessitate adjustments to project plans and technical specifications. Stay updated on relevant regulations, engage legal experts to assess compliance requirements, and maintain flexibility in project timelines to accommodate regulatory changes. Vendor Dependence: Dependency on third-party vendors for hardware, software, or services may introduce risks related to product availability, support, and vendor reliability. Conduct thorough vendor assessments, establish clear contractual agreements, and diversify vendor partnerships to minimize reliance on any single vendor. By proactively identifying and addressing these risks, the project team can enhance the likelihood of project success and mitigate potential negative impacts on project objectives, timelines, and outcomes. Regular monitoring and reassessment of risks throughout the project lifecycle are essential to adapt to evolving circumstances and ensure project resilience.

3.5 SOFTWARE REQUIREMENTS SPECIFICATION DOCUMENT

Python

Python is the primary programming language for machine learning and neural network development. Python serves as the primary scripting language for implementing custom algorithms, data analysis, and visualization tasks within the research framework. Its simplicity, versatility, and extensive libraries make it well-suited for rapid prototyping and experimentation. Researchers can develop traffic prediction models, congestion detection algorithms, and optimization techniques using Python's rich ecosystem of scientific computing libraries such as NumPy, Pandas, and Matplotlib. Python's integration with SUMO and NS-3 enables seamless interaction with simulation environments, facilitating the implementation and testing of the proposed congestion management system.

SUMO (Simulation of Urban Mobility)

SUMO is a powerful traffic simulation tool designed for modeling and analyzing traffic flows in urban environments. It offers a comprehensive platform for simulating various traffic scenarios, including vehicle movements, traffic signals, and road networks. SUMO enables researchers and practitioners to evaluate traffic management strategies, study the impact of infrastructure changes, and optimize transportation systems for enhanced efficiency and safety.

OSM (OpenStreetMap) Maps

OSM maps provide a rich source of geospatial data that can be utilized for various mapping and navigation applications. With its open and collaborative nature, OSM allows users to access detailed maps of roads, buildings, and points of interest worldwide. OSM maps are particularly valuable for developing location-based services, route planning, and geographic analysis. By leveraging OSM data, developers can create customized maps tailored to specific requirements and integrate them into their applications seamlessly.

NS-3 (Network Simulator 3)

NS-3 is a widely-used discrete-event network simulator capable of modeling various communication networks and protocols. It provides a flexible and extensible framework for simulating network behavior, including wired, wireless, and Internet protocols. NS-3 enables researchers and developers to evaluate the performance of networking algorithms, study protocol interactions, and assess the impact of network configurations on overall system behavior. With its modular design and extensive library of models, NS-3 is an invaluable tool for simulating and analyzing complex network scenarios.

Operating System

The software tools you choose should be compatible with your preferred operating system, such as Windows or Linux. For this project, we are utilizing Ubuntu, a popular Linux distribution, so the selected software is compatible with this operating system.

3.5 HARDWARE REQUIREMENTS

- Operating system : Linux
- Processor : minimum intel i3
- Ram : minimum 4 gb
- Hard disk : minimum 250gb
- Input Device : Keyboard, Mouse, Camera

CHAPTER 4

DISCRIPTION OF PROPOSED SYSTEM

System Overview

The proposed system aims to address traffic congestion in urban areas by leveraging Vehicular Ad Hoc Networks (VANETs) and advanced traffic management techniques. By collecting and analyzing real-time data from vehicles within the network, the system dynamically adjusts traffic signal timings to optimize traffic flow and reduce congestion. Key components of the system include VANET communication protocols, traffic simulation tools, and data analysis algorithms.

Key Components

1. VANET Communication Protocols

The system relies on communication protocols such as Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) to facilitate real-time data exchange among vehicles and roadside infrastructure. These protocols enable the transmission of traffic information, including vehicle speed, location, and traffic conditions. By using the Vehicle-to-infrastructure technology, drivers can be warned of dangers such as red-light violations and any stop signs they may not notice.

2. Traffic Simulation Tools

- a. SUMO (Simulation of Urban Mobility):** SUMO is utilized for simulating realistic traffic scenarios based on OpenStreetMap (OSM) data. It allows researchers to define vehicle parameters, simulate traffic flow, and evaluate congestion management strategies.
- b. NS-3 Simulator:** NS-3 serves as a network simulator for modeling VANET communication and evaluating routing protocols. It provides a platform for

analyzing network performance, congestion control algorithms, and the impact of varying traffic densities.

3. System Architecture

The system architecture includes components such as OpenStreetMap (OSM) for map data extraction, SUMO simulator for traffic simulation, NS-3 simulator for network modeling, and data analysis modules for processing traffic data and optimizing traffic signal timings.

4. Routing Protocols

Various routing protocols are evaluated for their suitability in VANET environments, including DSDV, DSR, and AODV. These protocols facilitate efficient communication among vehicles and infrastructure, contributing to congestion management and traffic optimization.

4.1 SELECTED METHODOLOGY

The selected methodology for addressing traffic congestion in urban areas involves the utilization of Vehicular Ad Hoc Networks (VANETs) and advanced traffic management techniques. VANETs facilitate real-time communication between vehicles and roadside infrastructure, enabling the collection and processing of traffic data. This data is then analyzed using machine learning algorithms and data mining techniques to dynamically adjust traffic signal timings, thereby optimizing traffic flow and reducing congestion.

The methodology leverages simulation tools like SUMO (Simulation of Urban Mobility) and network simulators like NS-3 to model and evaluate the proposed traffic management system. OpenStreetMap (OSM) data is utilized to create realistic simulations of urban road networks, while routing protocols such as DSDV, DSR, and AODV are employed to simulate network traffic and congestion scenarios.

The proposed system architecture involves the integration of edge computing, machine

learning-based traffic prediction, dynamic tolling, and smart traffic lights to enhance congestion management. Additionally, the system provides drivers with dynamic route suggestions based on real-time traffic data, contributing to reduced travel times and environmental impact.

The selected methodology emphasizes the importance of utilizing VANETs and advanced traffic management techniques to address the persistent challenge of traffic congestion in urban areas. Through simulation and evaluation, the effectiveness and viability of the proposed system are rigorously analyzed to provide insights for future research and implementation.

4.2 ARCHITECTURE / OVERALL DESIGN OF PROPOSED SYSTEM

VANET – ARCHITECTURE

VANETs are an emerging wireless communication technology under intelligent transportation system (ITS). These are the distributed self-organized system which includes a wireless communication system equipped in vehicles to communicate with each other and relay the information from one node to another. These types of networks are devised to bring significant improvement the transportation system. Nodes are expected to communicate by means of Dedicated Short-Range Communication (DSRC) standard that employs the IEEE 802.11p standard for wireless communication. To allow communication with participants out of radio range, messages have to be forwarded by other nodes (multi-hop communication).

Vehicles are not subject to the strict energy, space and computing capabilities restrictions normally adopted for MANETs. More challenging is the potentially very high speed of the nodes (up to 250 km/h) and the large dimensions of the VANET. The primary VANET's goal is to increase road safety. To achieve this, the vehicles act as sensors and exchange warnings or more generally telematics information (like current speed, location) that enables the drivers to react early to abnormal and potentially dangerous situations like accidents, traffic jams or glaze. The information provided by

other vehicles and stationary infrastructure might also be used for driver assistant systems like adaptive cruise control (ACC) or breaking assistants.

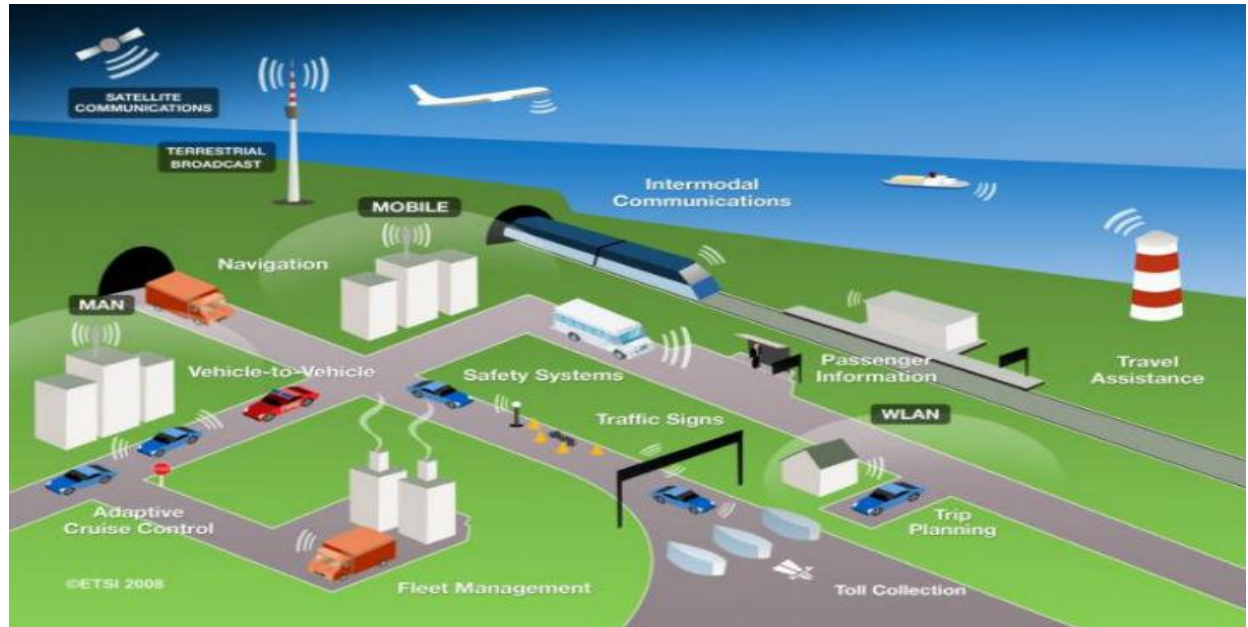


Fig 4.1 VANET-Overview

In addition, authorized entities like police or firefighters should be able to send alarm signals and instructions e.g. to clear their way or stop other road users. Besides that, the VANET should increase comfort by means of value-added services like location-based services or Internet on the road.

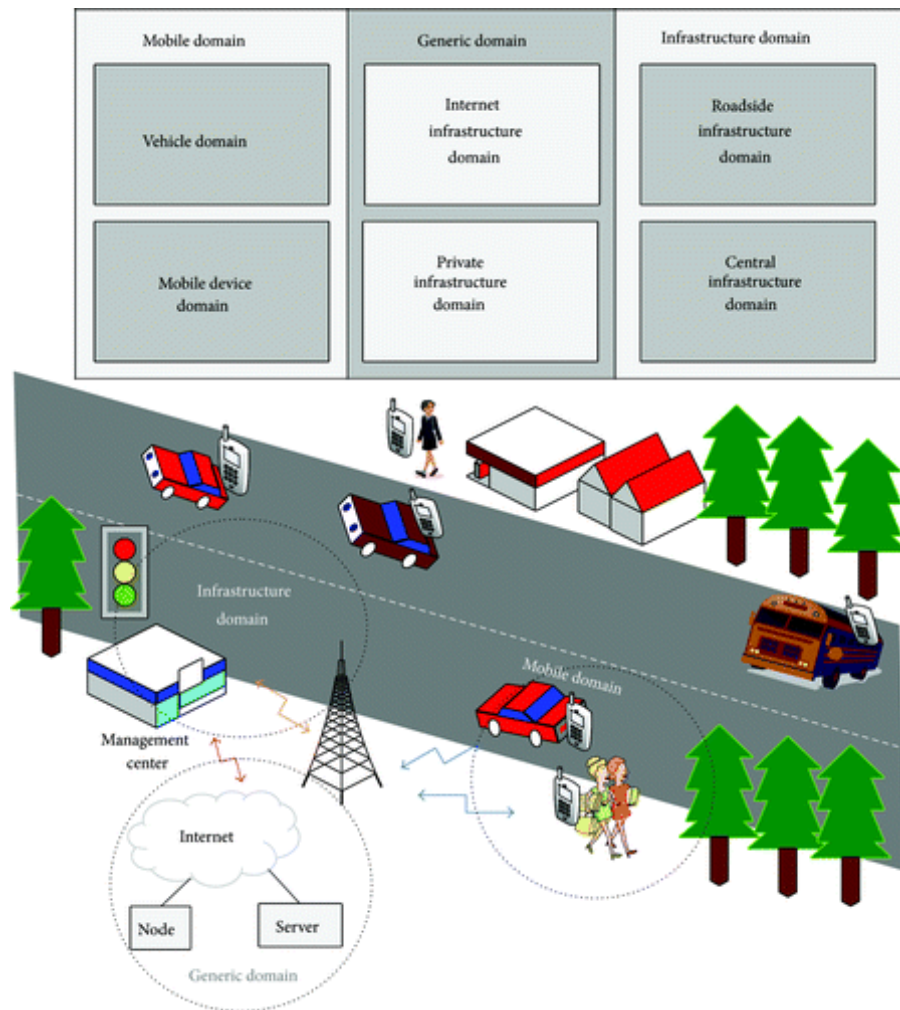


Fig 4.2 Components of VANET

According to the IEEE 1471-2000 and ISO/IEC 42010 architecture standard guidelines, we are able to achieve the VANETs system by entities which can be divided into three domains: the mobile domain, the infrastructure domain, and the generic domain.

The mobile domain consists of two parts: the vehicle domain and the mobile device domain. The vehicle domain comprises all kinds of vehicles such as cars and buses. The mobile device domain comprises all kinds of portable devices like personal navigation devices and smartphones.

Within the infrastructure domain, there are two domains: the roadside infrastructure domain and the central infrastructure domain. The roadside infrastructure domain

contains roadside unit entities like traffic lights. The central infrastructure domain contains infrastructure management centres such as Traffic Management Centres (TMCs) and vehicle management centres.

However, the development of VANETs architecture varies from region to region. In the V2X communication system which is pursued by the V2V communication consortium, the reference architecture is a little different. V2V communication consortium is the major driving force for vehicular communication. This system architecture comprises three domains: in-vehicle, ad hoc, and infrastructure domain.

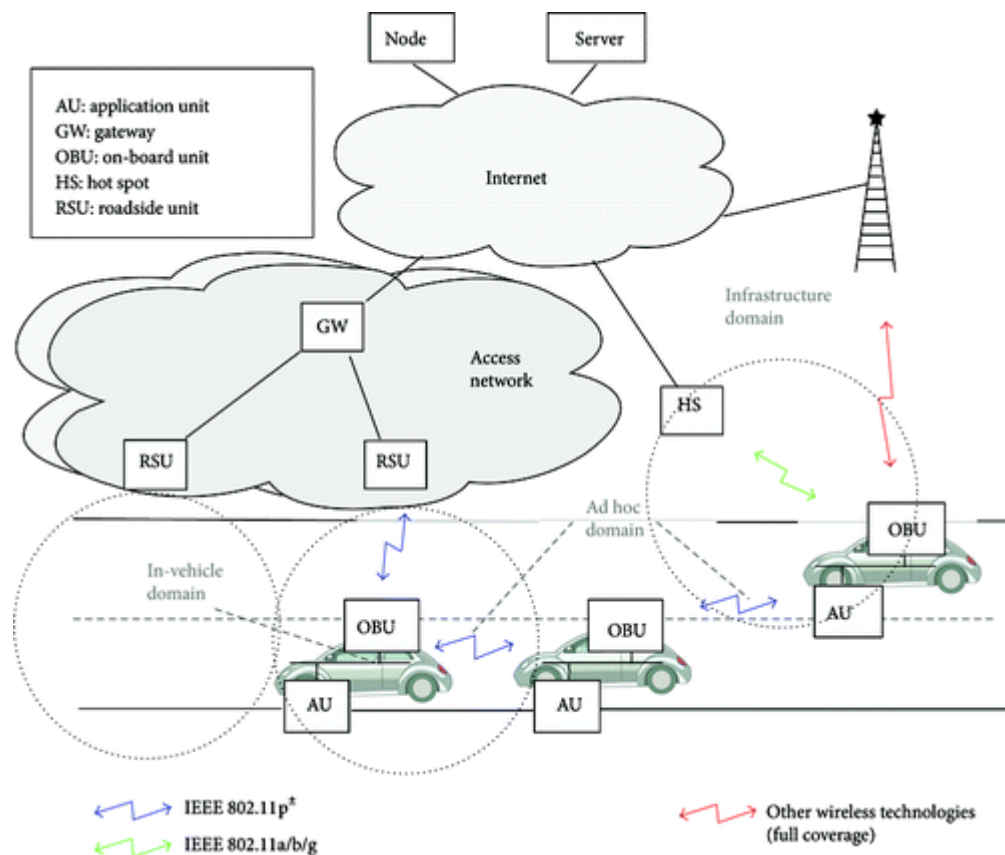


Fig 4.3 VANET-Architecture

The in-vehicle domain is composed of an on-board unit (OBU) and one or multiple application units (AUs). The connections between them are usually wired and

sometimes wireless. However, the ad hoc domain is composed of vehicles equipped with OBUs and roadside units (RSUs). An OBU can be seen as a mobile node of an ad hoc network and RSU is a static node likewise. An RSU can be connected to the Internet via the gateway; RSUs can communicate with each other directly or via multi-hop as well. There are two types of infrastructure domain access, RSUs and hot spots (HSs). OBUs may communicate with Internet via RSUs or HSs. In the absence of RSUs and HSs, OBUs can also communicate with each other by using cellular radio networks (GSM, GPRS, UMTS, WiMAX, and 4G).

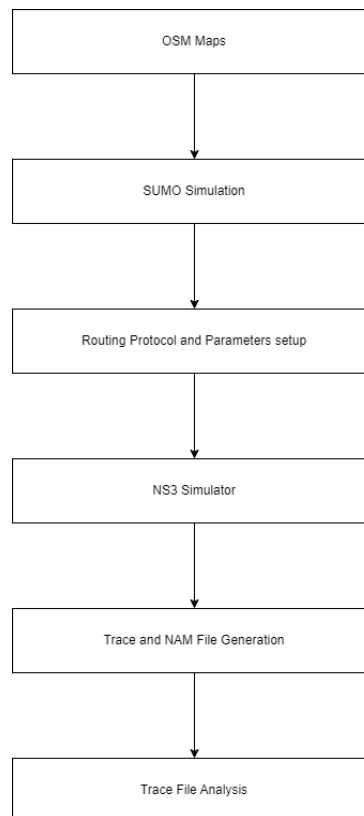


Fig 4.4 System Architecture

4.3 Model Architecture Design/ Algorithm:

COMMUNICATION ARCHITECTURE

Communication types in VANETs can be categorized into four types. The category is closely related to VANETs components as described above.

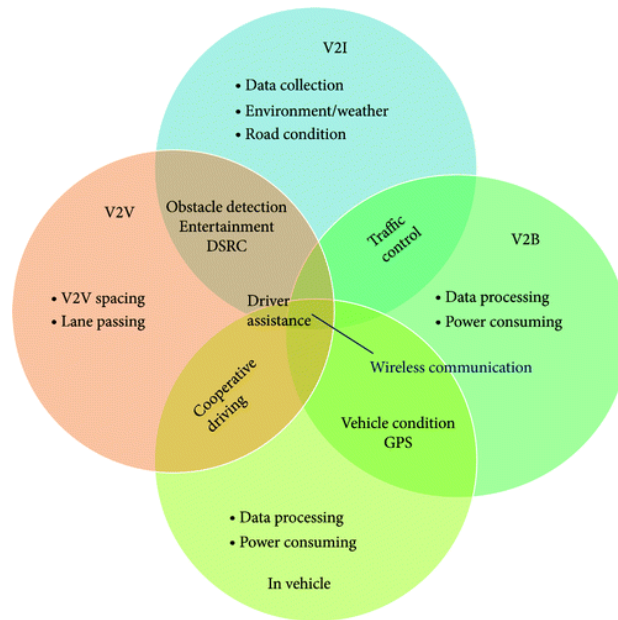


Fig 4.5 VANET-Communication Architecture

In-vehicle communication, which is more and more necessary and important in VANETs research, refers to the in-vehicle domain. In-vehicle communication system can detect a vehicle's performance and especially driver's fatigue and drowsiness, which is critical for driver and public safety.

Vehicle-to-vehicle (V2V) communication can provide a data exchange platform for the drivers to share information and warning messages, so as to expand driver assistance.

Vehicle-to-road infrastructure (V2I) communication is another useful research field in VANETs. V2I communication enables real-time traffic/weather updates for drivers and

provides environmental sensing and monitoring.

Vehicle-to-broadband cloud (V2B) communication means that vehicles may communicate via wireless broadband mechanisms such as 3G/4G. As the broadband cloud may include more traffic information and monitoring data as well as infotainment, this type of communication will be useful for active driver assistance and vehicle tracking.

Generally, the architecture of VANETs may differ from region to region, and thus the protocols and interfaces are also different among them. DSRC is specifically designed for automotive use and a corresponding set of protocols and standards. The US FCC has allocated 75 MHz of spectrum for DSRC communication, from 5.850 GHz to 5.925 GHz. Different protocols are designed to use at the various layers; some of them are still under active development now. The IEEE 802.11p, an approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE), is focused primarily on the PHY layer and MAC sublayer of the stack. IEEE 1609 is a higher layer standard based on the IEEE 802.11p. IEEE 1609 represents a family of standards that function in the middle layers of the protocol stack to flexibly support safety applications in VANETs, while non-safety applications are supported through another set of protocols. In particular, network layer services and transport layer services for non-safety applications are provided by three quite stable protocols: IPv6, TCP, and UDP.

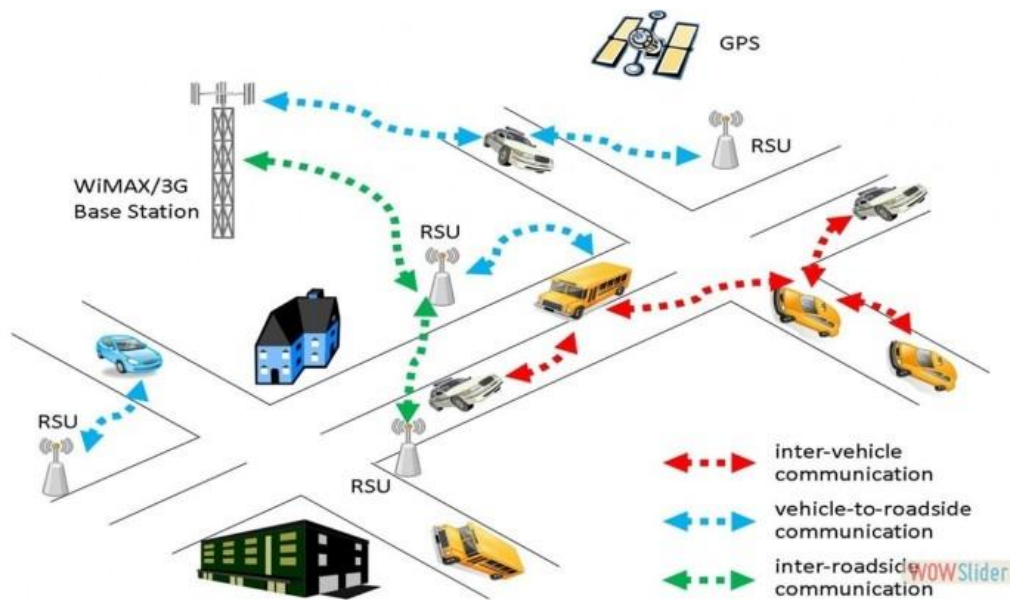


Fig 4.6 Elements of VANET

4.4 Description of Software for Implementation and Testing Plan

For the implementation and testing of the proposed traffic congestion management system in VANETs, a comprehensive suite of software tools and platforms will be employed. These software components will facilitate the development, simulation, and evaluation of the system's performance under various traffic scenarios and network conditions. The software stack encompasses both simulation environments and development frameworks tailored to VANET applications, ensuring robustness, scalability, and accuracy in the assessment of the proposed system.

1. SUMO (Simulation of Urban Mobility)

SUMO serves as the primary simulation platform for modeling vehicular traffic dynamics in urban environments. It provides a versatile framework for creating realistic traffic scenarios, simulating vehicle movements, and evaluating the impact of congestion management strategies. SUMO's rich feature set includes support for road network definition, traffic flow modeling, and integration with external tools such as

OpenStreetMap for importing real-world map data. Leveraging SUMO, researchers can conduct extensive simulations to validate the effectiveness of the proposed congestion management algorithms and assess their performance metrics.

2. NS-3 (Network Simulator 3)

NS-3 is a discrete-event network simulator renowned for its accuracy and extensibility in modeling various networking protocols and architectures. In the context of VANETs, NS-3 enables the simulation of wireless communication protocols, including Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication. Researchers can develop custom network models, implement routing protocols, and analyze network performance metrics such as packet loss, latency, and throughput. NS-3's modular design facilitates the integration of different congestion control mechanisms and traffic management strategies, allowing for comprehensive evaluation under diverse traffic scenarios.

3. OpenStreetMap (OSM)

OpenStreetMap provides a valuable source of geospatial data for creating detailed maps of road networks, traffic signals, and infrastructure elements. Researchers can extract OSM data to generate realistic urban environments for simulation purposes, ensuring the fidelity of traffic simulations conducted in SUMO and NS-3. OSM's collaborative nature and extensive coverage make it an indispensable tool for acquiring real-world map data, enabling researchers to replicate actual traffic conditions and evaluate congestion management strategies in a realistic context.

4. Python Programming Language

Python serves as the primary scripting language for implementing custom algorithms, data analysis, and visualization tasks within the research framework. Its simplicity, versatility, and extensive libraries make it well-suited for rapid prototyping and experimentation. Researchers can develop traffic prediction models, congestion detection algorithms, and optimization techniques using Python's rich ecosystem of scientific computing libraries such as NumPy, Pandas, and Matplotlib. Python's

integration with SUMO and NS-3 enables seamless interaction with simulation environments, facilitating the implementation and testing of the proposed congestion management system.

Testing Plan

The testing plan encompasses a series of rigorous evaluations aimed at validating the functionality, performance, and scalability of the proposed traffic congestion management system in VANETs. The testing process will involve simulated experiments conducted in SUMO and NS-3, complemented by real-world data analysis and validation where applicable. The key components of the testing plan include:

Functional Testing

Functional testing will verify that the system components perform as intended and meet the specified requirements. This includes testing the implementation of congestion detection algorithms, traffic prediction models, and dynamic traffic signal control mechanisms. Functional testing will ensure the correctness and reliability of the system's core functionalities under different traffic scenarios and network conditions.

Performance Testing

Performance testing will assess the system's efficiency, scalability, and resource utilization under varying traffic loads and network configurations. Researchers will measure key performance metrics such as throughput, latency, packet loss, and CPU/memory usage to evaluate the system's responsiveness and scalability. Performance testing will identify potential bottlenecks, optimize resource allocation, and ensure the system's ability to handle high volumes of traffic while maintaining optimal performance.

Simulation-based Testing

Simulation-based testing in SUMO and NS-3 will simulate realistic traffic scenarios to evaluate the system's behavior and performance in a controlled environment.

Researchers will design experiments to assess congestion management strategies, analyze traffic flow patterns, and measure the effectiveness of dynamic traffic signal control mechanisms. Simulation-based testing will provide insights into the system's behavior under different traffic conditions and enable iterative refinement of congestion management algorithms.

Validation with Real-world Data

Validation with real-world data involves comparing the results obtained from simulations with actual traffic data collected from urban environments. Researchers will validate the accuracy and reliability of the system's predictions, congestion detection algorithms, and traffic management strategies using real-world traffic data. Validation with real-world data will enhance the credibility and applicability of the research findings, ensuring that the proposed congestion management system performs effectively in real-world scenarios.

4.5 Routing in VANET

For communication Ad-hoc networks are used. Ad-hoc Network is initially used for the MANETs but now they are used for the VANETs also. VANET utilizes this location based and topology-based steering conventions obliges that each of the partaking hubs be allocated a novel location. This intimates that we require an instrument that can be utilized to appoint interesting locations to vehicles yet these conventions don't promise that the copy locations are doled out in a system or not. Consequently, existing circulated tending to calculations utilized as a part of versatile specially appointed systems are significantly less suitable in a VANET environment. Particular VANET-related issues, for example, system topology, portability designs, thickness of vehicles at diverse times of the day, fast changes in vehicles arriving and leaving the VANET and the way that the width of the street is regularly littler than the transmission run all make the utilization of these routine specially appointed directing conventions lacking.

Protective routing protocol

Proactive steering conventions utilize standard separation vector directing methodologies (e.g., Destination-Sequenced Distance-Vector (DSDV) steering) or connection state directing techniques (e.g., Optimized Link State Routing convention (OLSR) and Topology Broadcast-focused around Reverse-Path Forwarding (TBRPF)). They keep up and overhaul data on directing to all hubs that being said additionally when the way is not utilized. Course overhauls are occasionally performed paying little heed to system load, data transmission imperatives, and system size.

Reactive routing protocol

Touchy directing conventions, for example, Dynamic Source Routing (DSR), and Ad hoc On-Demand Distance Vector (AODV) steering execute course determination on an interest or need premise and keep up just the courses that are right now being used, in this manner lessening the load on the system when just a subset of accessible courses is being used and this breaking point the data transfer capacity wastage.

Position-based routing

Position-based directing conventions oblige that data about the physical position of the taking part hubs be accessible. This position is made accessible to the immediate neighbours as intermittently transmitted reference points. A sender can ask for the position of a recipient with the assistance of an area administration.

Forwarding

A geographic unicast transports bundle between two hubs through various remote jumps. At the point when the asking for hub needs to send a unicast parcel, it discovers the position of the goal hub by taking a gander at the area table. An avaricious sending calculation is then used to send the bundle to the neighbouring vehicle or hubs,

rehashes enumerating the base remaining separation to the end of the line vehicle and this methodology at each vehicle along the sending way until the parcel achieves its goal.

4.6 AD-HOC ROUTING PROTOCOLS

Wireless networks is an emerging new technology that will allow users to access information and services electronically, regardless of their geographic position. Wireless networks can be classified in two types: Infrastructured network and Infrastructure-less (**ad hoc**) networks. Infrastructured network consists of a network with fixed and wired gateways. A mobile host communicates with a bridge in the network (called base station) within its communication radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed.

In contrast to infrastructure-based networks, in ad hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. Ad hoc networks are very useful in emergency search-and-rescue operations, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrain.

Ad hoc routing protocols can be divided into two categories:

- i. Table-driven
- ii. On-demand routing
- iii. Hybrid

based on when and how the routes are discovered. In table driven routing protocols, consistent and up-to-date routing information to all nodes is maintained at each node whereas in on-demand, routing the routes are created only when desired by the source

host. Next two sections discuss current table-driven protocols as well as on-demand protocols.

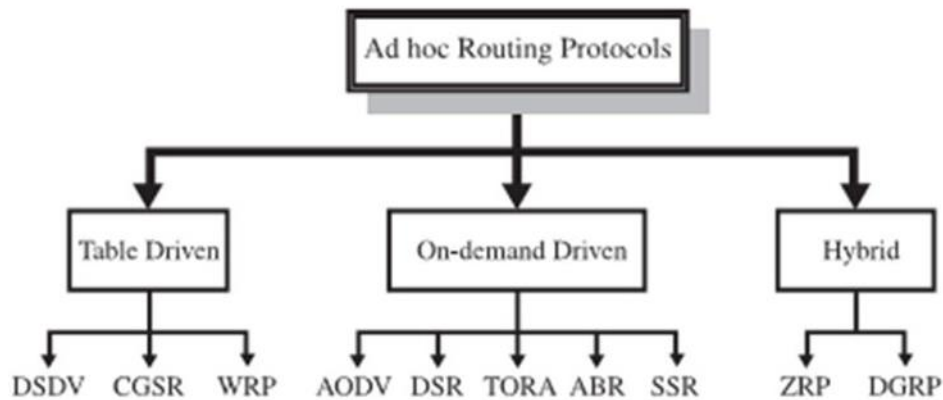


Fig 4.7 Ad hoc Protocols

4.6.1 TABLE DRIVEN ROUTING PROTOCOLS – PROACTIVE

In Table-driven routing protocols each node maintains one or more tables containing routing information to every other node in the network. All nodes update these tables so as to maintain a consistent and up-to-date view of the network. When the network topology changes the nodes propagate update messages throughout the network in order to maintain a consistent and up-to-date routing information about the whole network. These routing protocols differ in the method by which the topology change information is distributed across the network and the number of necessary routing-related tables. The following sections discuss some of the existing table-driven ad hoc routing protocols.

Destination-Sequenced Distance-Vector Routing Protocol

The Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm is based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements.

Every mobile station maintains a routing table that lists all available destinations, the number of hops to reach the destination and the sequence number assigned by the destination node. The sequence number is used to distinguish stale routes from new ones and thus avoid the formation of loops. The stations periodically transmit their routing tables to their immediate neighbours. A station also transmits its routing table if a significant change has occurred in its table from the last update sent. So, the update is both time-driven and event-driven. The routing table updates can be sent in two ways: a "full dump" or an incremental update. A full dump sends the full routing table to the neighbours and could span many packets whereas in an incremental update only those entries from the routing table are sent that has a metric change since the last update and it must fit in a packet. If there is space in the incremental update packet then those entries may be included whose sequence number has changed. When the network is relatively stable, incremental updates are sent to avoid extra traffic and full dump are relatively infrequent. In a fast-changing network, incremental packets can grow big so full dumps will be more frequent. Each route update packet, in addition to the routing table information, also contains a unique sequence number assigned by the transmitter. The route labelled with the highest (i.e. most recent) sequence number is used. If two routes have the same sequence number then the route with the best metric (i.e. shortest route) is used. Based on the past history, the stations estimate the settling time of routes. The stations delay the transmission of a routing update by settling time so as to eliminate those updates that would occur if a better route were found very soon.

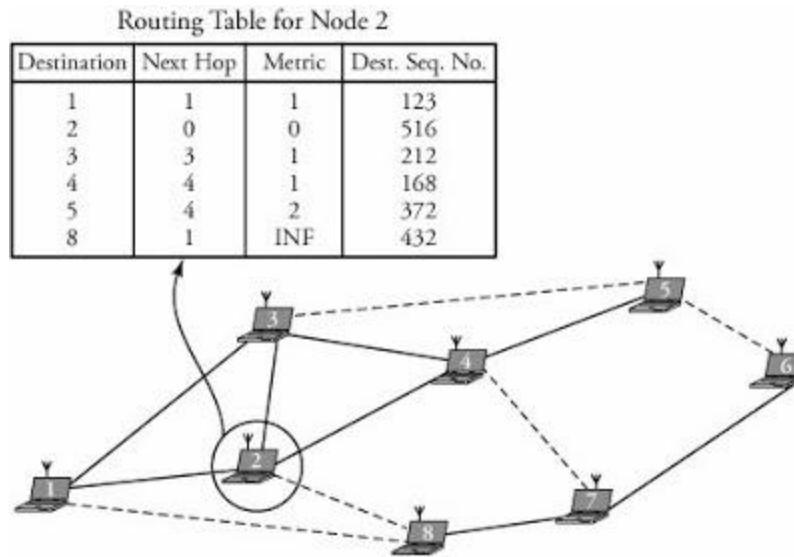


Fig 4.8 DSDV Routing

4.6.2 ON-DEMAND ROUTING PROTOCOLS – REACTIVE

These protocols take a lazy approach to routing. In contrast to table-driven routing protocols all up-to-date routes are not maintained at every node, instead the routes are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination. The route remains valid till the destination is reachable or until the route is no longer needed.

AODV ROUTING

AODV is a well-known topology routing protocol which has a very high packet delivery ratio and low routing overhead. AODV works as follows:

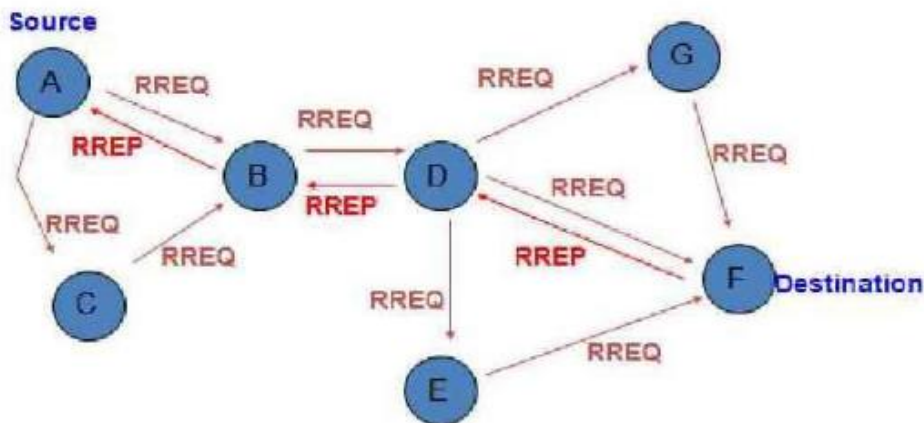


Fig 4.9 AODV Routing

Whenever a node wants to communicate with another node, it checks in local routing table to find an available path to the destination node. If there is no path available, then it broadcasts a route request (RREQ) message to its neighbourhood. The node that receives RREQ looks its table for a path leading to the destination node. If there is no path then, the RREQ message is re-broadcasted and a path to the originating node is formed that has sent RREQ message. This helps in establishing the end-to-end path when the same node receives route reply (RREP) message as shown in Figure.

All the node in the network follows this process until this RREQ message reaches a node which has a suitable path to the destination Node. At the end of this request-reply process a path between source and destination node is created and is available for further communication. In this way, the originating node that generated RREQ receives an RREP message.

To maintain a connection with the sink node is a crucial issue to collect data from networks without any interruption. While networks are typically deployed in abundance, losing the connectivity with the sink node due to frequent path break eventually reduces the quality and efficiency of the network operation.

4.6.3 HYBRID (BOTH PROACTIVE AND REACTIVE)

This type of protocol combines the advantages of proactive and reactive routing. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding. The choice of one or the other method requires predetermination for typical cases. The main disadvantages of such algorithms are:

1. Advantage depends on number of other nodes activated.
2. Reaction to traffic demand depends on gradient of traffic volume.

4.6.4 COMPARISON OF AODV AND DSDV

Following review of two protocols - AODV and DSDV

- i. Both protocols used the concept of sequence number to update latest routing information.
- ii. The bandwidth is wasted in case of DSDV, because of periodic broadcasting of updated information. In AODV, nodes only propagate hello messages to its neighbours.
- iii. In DSDV, routes information which are maintained in routing table can be stale as DSDV cannot handle nodes movement at high speeds due to lack of alternative routes. But in case of AODV, the routes are find out on demand only, so the routes information cannot be stale.
- iv. In DSDV, throughput decreases because of periodic routes information updates and if the node mobility is at high speed. In AODV, throughput is stable because it doesn't broadcast any routing information.

Also, the End-to-End delay is calculated for both DSDV and AODV routing protocols.

End to End Delay: The average time from the beginning of a packet transmission at a source node until packet delivery to a destination. This includes delays caused by buffering of data packets during route discovery, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

On Calculating E2E for both DSDV and AODV, it is found that AODV betters DSDV, having lower delay.

Since, DSDV dynamically checks for the shortest path at every instant even when the established route exists, the delay is higher and also thereby throughput is less.

While AODV protocol uses an already established route until the nodes move out of range. Hence the delay is lower and throughput is high.

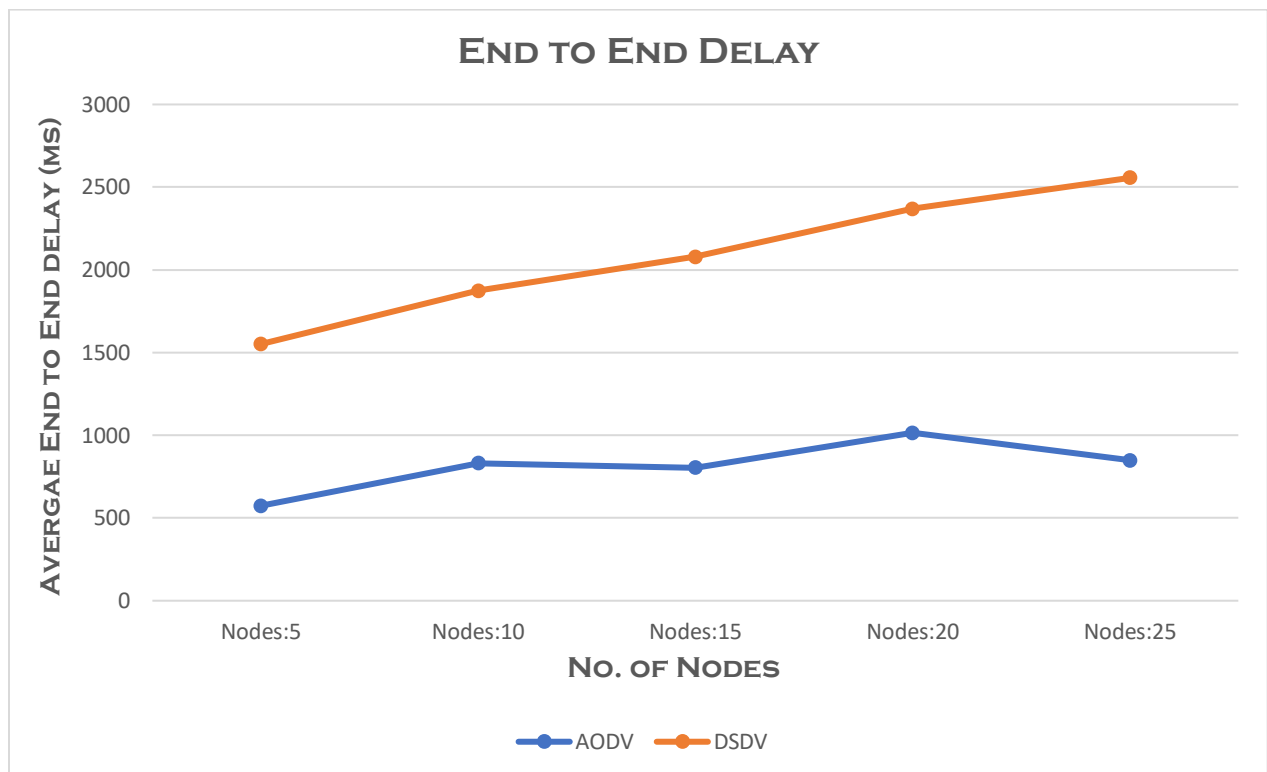


Fig 4.10 AODV vs DSDV

From the Analysis, it is found that AODV protocol provides a lower delay in every case. Since the delay is lower, more number of packets can be communicated between the nodes and thereby throughput is higher.

Throughput = (Received Data Size/Transmission Time)*8

Hence in our project, which requires a demanding routing protocol with high throughput and lower delay as vehicles keep moving at high speeds, AODV is more preferred and used for Vehicular communication.

CHAPTER 5

IMPLEMENTATION DETAILS

Implementing VANET-based traffic management involves several essential steps, each crucial for the system's effectiveness. Below is a detailed outline of the implementation process:

5.1 Data Collection

The data collection phase of our project involved the simulation of real-world traffic scenarios using SUMO (Simulation of Urban Mobility) with OpenStreetMap (OSM) maps. Leveraging SUMO's capabilities allowed us to recreate intricate urban road networks, complete with various traffic elements such as vehicles, traffic signals, and infrastructure. By importing OSM maps into SUMO, we were able to simulate realistic traffic conditions representative of actual urban environments.

Utilizing SUMO for Realistic Simulations

SUMO provided us with a versatile platform for conducting simulations that closely mimic real-world traffic dynamics. The integration of OSM maps ensured that our simulated environments accurately reflected the layout of urban road networks, including intersections, lanes, and traffic flow patterns. This level of detail was crucial for generating realistic traffic scenarios and collecting data representative of actual urban traffic conditions.

Generating Real-Time Traffic Data

During the simulation runs, SUMO generated real-time traffic data capturing various parameters such as vehicle speed, density, location, and route choices. This data was collected at regular intervals throughout the simulation, providing a comprehensive snapshot of traffic dynamics within the simulated environment. By analyzing this data,

we gained valuable insights into traffic patterns, congestion hotspots, and the effectiveness of routing protocols.

Validation and Calibration

To ensure the accuracy and validity of our simulated data, we performed validation and calibration exercises. This involved comparing simulated traffic data against real-world traffic data from reliable sources to validate the fidelity of our simulations. Additionally, we fine-tuned simulation parameters and traffic behavior models to calibrate the simulations to closely match observed real-world traffic patterns.

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By simulating real-world traffic scenarios, we were able to generate comprehensive datasets capturing various traffic parameters. This data serves as a crucial foundation for the subsequent phases of our project, including algorithm development, model training, and performance evaluation.

5.2 Routing Protocols Implementation

Routing protocol selection is a critical aspect of designing a vehicular ad hoc network (VANET)-based traffic management system. The choice of routing protocol directly impacts the efficiency, reliability, and scalability of communication within the network. In our project, we undertook a comprehensive evaluation of several prominent routing protocols, including Destination-Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR), and Ad-hoc On-Demand Distance Vector (AODV), to determine the most suitable protocol for our VANET-based traffic management system.

One of the key factors considered during the evaluation process was the control overhead associated with each routing protocol. Control overhead refers to the amount of signaling traffic required for route discovery, maintenance, and updating. Low control overhead is essential for minimizing communication latency and conserving network resources, particularly in high-density VANET environments. We meticulously analyzed

the control overhead of each protocol under varying network densities and traffic conditions to assess their suitability for real-time traffic management applications.

Another crucial consideration in routing protocol selection was adaptability to dynamic network topology changes. VANETs are inherently dynamic networks characterized by frequent node mobility and topology changes. As such, the selected routing protocol must possess robust mechanisms for quickly adapting to topology changes and maintaining reliable communication paths between vehicles and infrastructure nodes. We evaluated the adaptability of each protocol through simulation experiments simulating node mobility and network topology changes, closely monitoring their performance under dynamic conditions.

Scalability was also a key performance metric used to evaluate routing protocols. Scalability refers to the ability of the routing protocol to efficiently handle increasing network size and traffic load without significant degradation in performance. In urban environments, VANETs may encompass thousands of vehicles and infrastructure nodes, necessitating routing protocols capable of scaling to accommodate large networks. We conducted scalability tests on each protocol, progressively increasing the network size and traffic load to assess their performance under varying network scales.

Based on the simulation results and performance metrics analysis, we identified the most suitable routing protocol for our VANET-based traffic management system. The selected protocol demonstrated low control overhead, robust adaptability to dynamic network topology changes, and scalable performance across varying network sizes and traffic conditions. Our rigorous evaluation process ensures that the chosen routing protocol meets the stringent requirements of real-time traffic management applications in urban environments, laying a solid foundation for the subsequent phases of our project implementation.

5.3 Traffic Congestion Algorithms Evaluation

In our project, the evaluation of congestion management algorithms constitutes a pivotal phase aimed at gauging the efficacy of different approaches in mitigating traffic congestion within urban environments. Two primary algorithms under scrutiny are adaptive transmission power control and dynamic route suggestions, both integral to the overarching objective of enhancing traffic flow and reducing congestion.

Experimental Methodology

The evaluation process unfolds through a series of meticulously designed simulation experiments conducted within the SUMO (Simulation of Urban Mobility) framework. Leveraging SUMO's capabilities, we simulate real-world traffic scenarios incorporating various congestion management algorithms. These simulations replicate urban road networks, vehicles, traffic signals, and infrastructure, ensuring a high degree of realism in our experimental setup.

Metrics and Analysis

Central to our evaluation is the analysis of key performance metrics to quantify the effectiveness of the implemented algorithms. These metrics encompass communication overhead, congestion control, and network performance, providing comprehensive insights into the algorithm's impact on traffic management within VANETs.

Communication Overhead

Communication overhead serves as a critical indicator of the efficiency of congestion management algorithms in minimizing the burden on the VANET communication infrastructure. Lower communication overhead signifies optimized communication protocols, facilitating seamless data exchange among vehicles and infrastructure nodes without imposing unnecessary strain on the network.

Congestion Control

The ability of congestion management algorithms to effectively alleviate traffic congestion forms the crux of our evaluation. We scrutinize the algorithms' capability to detect congestion hotspots, implement proactive measures to mitigate congestion, and dynamically adapt to changing traffic conditions. By assessing congestion levels and congestion dissipation rates, we ascertain the algorithms' effectiveness in improving traffic flow within the simulated urban environment.

Network Performance

Lastly, we delve into an in-depth analysis of network performance metrics to evaluate the overall efficiency and reliability of the congestion management algorithms. This entails assessing parameters such as packet loss, latency, and throughput to gauge the algorithms' impact on VANET communication and network stability.

5.4 Real-Time Map Designing

Steps followed to implement Real-Time Map Designing:

- i. Download the OSM file from www.openstreetmap.org – “map.osm”
- ii. Open the terminal in the required work directory
- iii. Command: `netconvert --osm-files map.osm -o map.net.xml`

The osm file is then into a xml file and thereby the roads and paths are created as a network.

- iv. Command: `polyconvert --osm-files map.osm --net-file map.net.xml --type-file osmPolyconvert.typ.xml -o map.poly.xml`

Using the osm file and network file every object in the network is converted in the form of polygons for a 2D view.

- v. Command: `python randomTrips.py -n map.net.xml -r map.rou.xml -e 50 -l`

Random route trips are generated for a required number of vehicles.

- vi. Finally, the files created are incorporated as a configuration file which is the mother file used for simulation – “map.sumo.cfg”

All the required network, polygon, route files are provided as child files inside the configuration file.

- vii. The simulation can then be run in ‘GUI’ format by typing command: `sumo-gui map.sumo.cfg`

5.5 Conversion of SUMO to Ns3

Using SUMO, we generated the traffic model. We need to transfer the traffic model information to Ns3 in order to establish communication between them.

The conversion is done as follows:

- i. Command: `sumo -c map.sumo.cfg --fcd-output map.sumo.xml`
- ii. The SUMO configuration file is converted into a XML file format.
- iii. Command: `python traceExporter.py --fcd-input map.sumo.xml --ns2config-output map.tcl --ns2mobility-output mobility.tcl --ns3activity-output activity.tcl`
- iv. Using Trace Exporter, the SUMO xml file is converted into TCL file. Thereby three different files are created:
 - a. Activity file: Various start and stop time of vehicle movements are stored in the ‘activity.tcl’ file.
 - b. Mobility file: The routes to be followed by various vehicles are stored in the ‘mobility.tcl’ file
 - c. Base tcl file: The information about the topography, number of vehicles and the simulation start and stop time are stored in the ‘map.tcl’ file

Thereby, Ns2 executable files are obtained.

Establishing Real-time VANET scenario:

- i. Once the executable files are obtained, add a simple wireless scenario using AODV protocol.
- ii. Enable communication links between every vehicle and observe performance

and movements of vehicles (nodes).

- iii. Based on various movements of vehicles, place RSUs wherever needed in order to achieve maximum coverage.
- iv. Enable I2I communication and V2I communication and design for complete connectivity of all nodes present in the topography.

Thereby, a complete VANET model is designed for real-time scenarios and the performance is checked.

CHAPTER 6

RESULTS AND DISCUSSIONS

The research findings underscore the significance of utilizing VANETs for congestion management, emphasizing the effectiveness of real-time data processing and dynamic traffic signal adjustments in alleviating congestion. Through meticulous simulations using tools like SUMO and the ns-3 network simulator, the study demonstrates the feasibility of VANET-based solutions in replicating real-world traffic scenarios and evaluating congestion management strategies.

In particular, the choice of routing protocols plays a pivotal role in determining the efficacy of traffic congestion management in VANETs. The study evaluates protocols such as DSDV, DSR, and AODV, considering factors like network density, mobility patterns, and traffic load. Results indicate that while DSDV may be suitable for low to moderate congestion scenarios due to its ability to maintain up-to-date routing information, on-demand protocols like DSR and AODV exhibit better adaptability to highly dynamic and congested environments. Notably, AODV emerges as a promising choice for managing traffic congestion in VANETs, thanks to its efficient route discovery and maintenance mechanisms.

Furthermore, the integration of OSM data enhances the realism of simulations, providing greater geographical precision and accuracy in evaluating congestion management strategies. The research highlights the potential of VANET-based traffic management systems in optimizing traffic flow, reducing emissions, and enhancing overall transportation efficiency. However, challenges related to communication reliability and network scalability must be addressed for practical implementation in real-world scenarios.

Overall, the results and discussions underscore the promise of VANETs in addressing traffic congestion challenges, while also emphasizing the importance of ongoing research efforts to refine protocols, optimize communication mechanisms, and ensure

The screenshot shows a terminal window titled "tst@tst-VirtualBox: ~/sumo/tools" with a dark purple background. The terminal displays the following commands and their outputs:

```
tst@tst-VirtualBox: ~/sumo/tools$ ls
assign                devel                findAllRoutes.py      generateRouters.py    osmGet.py             README_Contributing.md  stateReply.py         traceExporter.py
averageTripStatistics.py  district            hRouter.py            import                osmWebWizard.py       req_test_server.txt    sumolib              trigger
contributed             dds                generateBddDistricts.py  router.py             osmapi                requirements.txt        tileGet.py           turn-defs
countEdgeUsage.py        edgesInDistricts.py omniaLane             generateContinuousRouters.py  plot_trajectories.py  routes                 tlcCoordinator.py    visualization
createScreenshotSequence.py  evacuateAreas.py  extractTrace.py        generateParkingAreas.py    ptlines2flows.py      runSeeds.py            tlcCycleAdaptation.py webWizard
createEdgeTypeDistribution.py  fcdReplay.py      generateParkingLots.py  generateRailSignalConstraints.py  pypject.tonl          shows                  tools.pyproj         xml
distances               fcdReplay.py      generateRailSignalConstraints.py  osmBuild.py          randomTrips.py        simple

tst@tst-VirtualBox: ~/sumo/tools$ python osm
osmBuild.py  osmGet.py  osmWebWizard.py
tst@tst-VirtualBox: ~/sumo/tools$ python osm
osmBuild.py  osmGet.py  osmWebWizard.py
tst@tst-VirtualBox: ~/sumo/tools$ python osmWebWizard.py
Command 'python' not found, did you mean:
  command 'python3' from deb python3
  command 'python' from deb python-is-python3
tst@tst-VirtualBox: ~/sumo/tools$ python3 --version
Python 3.10.12
tst@tst-VirtualBox: ~/sumo/tools$ python2 osmWebWizard.py
Command 'python2' not found, but can be installed with:
sudo apt install python2
tst@tst-VirtualBox: ~/sumo/tools$ python3 osmWebWizard.py
Building scenario in '/home/tst/sumo/tools/2023-12-27-11-21-35'.
Downloading map data
200 OK
Converting map data
Warning: Ignoring restriction relation '6020379' with unknown from-way.
Warning: Ignoring restriction relation '6020379' with unknown to-way.
Warning: Not joining junctions 2198181869, 654220816 (parallel outgoing 18410953591, 69644274263).
Warning: Not joining junctions 7111510099, 7111516916 (parallel incoming 112257499483, 69644274260).
Warning: Ambiguity in turnarounds computation at junction 'cluster_11050393883_11050393893'.
Success.
Written configuration to 'osm_polycfg'
Parsing network projection from 'osm.net.xml.gz' ... done (7ms).
Parsing nodes from osm-file 'osm_bbox.osm.xml.gz' ... done (6ms).
Parsing relations from osm-file 'osm_bbox.osm.xml.gz' ... done (4ms).
Parsing edges from osm-file 'osm_bbox.osm.xml.gz' ... done (5ms).
Success.
Processing Bus
Success.
Processing Motorcycles
Success.
Processing Cars
Success.
Processing Trucks
Success.
Generating configuration file
Written configuration to 'osm_sumocfg'
Calling SUMO
```

Fig 6.1 SUMO cmd

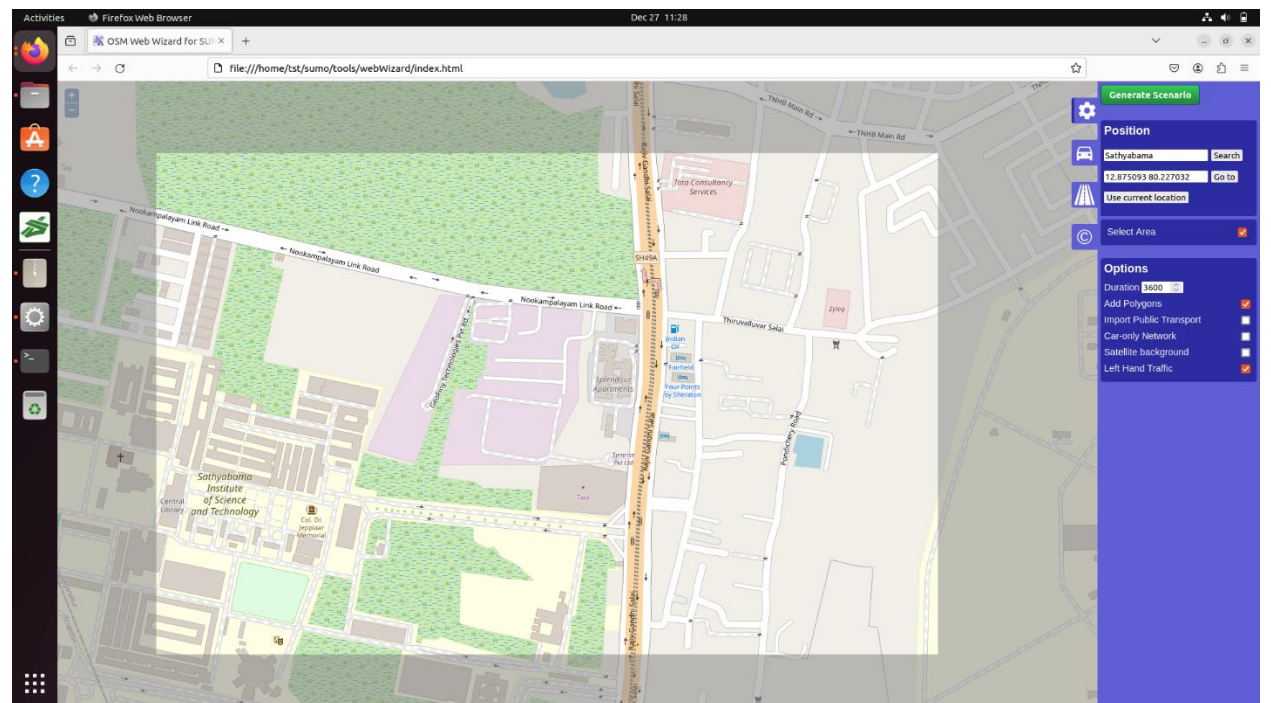


Fig 6.2 Open Street Map

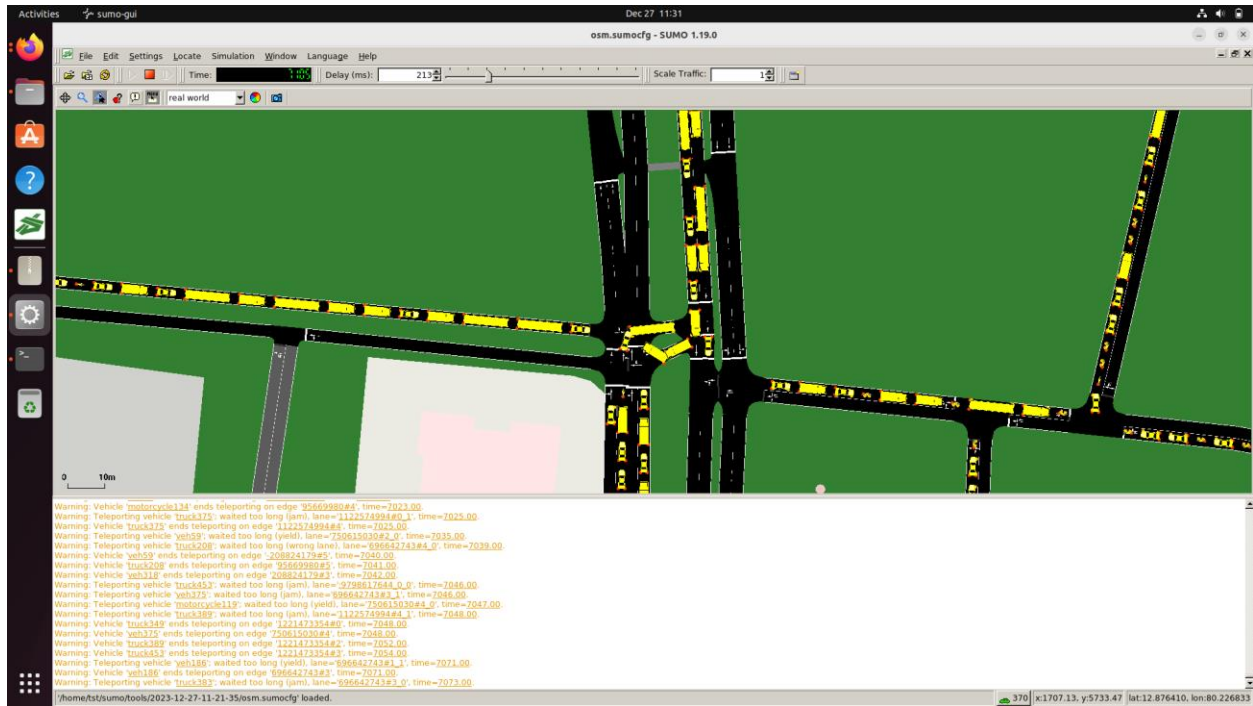


Fig 6.3 SUMO Simulation

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

In conclusion, the study underscores the potential of Vehicular Ad Hoc Networks (VANETs) as a promising solution for effectively managing traffic congestion in urban environments. By leveraging real-time data from VANETs and employing advanced traffic management strategies, the project aims to address the persistent challenges posed by congestion, including increased travel times, fuel consumption, and environmental pollution. Through meticulous simulation and analysis using tools such as SUMO and NS-3, the research demonstrates the feasibility and effectiveness of VANET-based congestion management systems in optimizing traffic flow and reducing congestion levels.

However, it is essential to acknowledge the inherent challenges and limitations associated with VANETs, including concerns related to stability, scalability, security, and privacy. Addressing these challenges is crucial to ensure the seamless deployment and operation of VANET-based systems. Moreover, ongoing efforts are needed to refine VANET protocols, optimize communication mechanisms, and enhance the reliability of vehicular communication networks. By overcoming these challenges and continuously improving VANET technologies, the research aims to contribute to the development of resilient and efficient urban traffic management solutions within the framework of intelligent transportation systems.

7.2 FUTURE ENHANCEMENT

Moving forward, the research identifies several avenues for enhancing the effectiveness and efficiency of VANET-based traffic congestion management systems. One prospective enhancement involves the incorporation of clustering algorithms to facilitate the efficient formation of vehicle clusters in VANETs. By dynamically grouping vehicles based on proximity, speed, or destination, clustering algorithms have the potential to

improve communication efficiency and reduce congestion levels. However, challenges such as dynamic cluster memberships and communication overhead need to be addressed to realize the full benefits of this enhancement.

Furthermore, the research emphasizes the importance of ongoing research and development efforts to refine VANET protocols, optimize communication mechanisms, and address emerging challenges in urban traffic management. Collaboration between academia, industry, and government stakeholders is essential to drive innovation and advance the state-of-the-art in VANET technologies. By fostering interdisciplinary collaboration and leveraging emerging technologies such as edge computing and machine learning, future enhancements aim to create more resilient, flexible, and effective VANET-based traffic congestion management systems, ultimately leading to less traffic, shorter commutes, and a more sustainable urban environment.

REFERENCES

- [1] R. Hussain, J. Lee, and S. Zeadally, "Trust in VANET: a survey of current solutions and future research opportunities" IEEE Transactions on Intelligent Transportation Systems, 2021.
- [2] Facchina, C. Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control (Doctoral dissertation, University of Windsor (Canada),2020).
- [3] N. Lyamin, B. Bellalta, and A. Vinel, "Age-of-informationaware decentralized congestion control in vanets," IEEE Networking Letters, vol. 2, no. 1, 2020
- [4] Sharma, S., Chahal, M., & Harit, S. (2019, February). Transmission Rate-based Congestion Control in Vehicular Ad Hoc Networks. In 2019 Amity International Conference on Artificial Intelligence (AICAI). IEEE
- [5] de Sousa, R. S., Boukerche, A., & Loureiro, A. A. DisTraC: A Distributed and Low-Overhead Protocol for Traffic Congestion Control Using Vehicular Networks IEEE Symposium on Computers and Communications (ISCC). IEEE, 2019.
- [6] Akinlade, O., Saini, I., Liu, X., & Jaekel, A. Traffic Density Based Distributed Congestion Control Strategy for Vehicular Communication, 2019.
- [7] R. Chhabra, C. Rama Krishna, and S. Verma, "Context-aware hybrid adaptive beaconing for driver behavior dissemination in VANETs," IETE Journal of Research, vol. 68, 2021.
- [8] P. Rajput, M. Chaturvedi, and V. Patel, "Opportunistic sensing-based detection of crowdedness in public transport buses," Pervasive and Mobile Computing, vol. 68, 2020
- [9] A. U. Haq, K. Liu, and M. B. Latif, "A Location-and Mobility-Aware Clustering-Based

TDMA MAC Protocol for Vehicular Ad-hoc Networks," 28th Wireless and Optical Communications Conference (WOCC), 2019.

[10] G. H. Alsuhli, A. Khattab, and Y. A. Fahmy, "Double-head clustering for resilient VANETs," *Wireless Communications and Mobile Computing*, vol. 2019.

[11] Jie Cui, Lu Wei, Hong Zhong, Jing Zhang, Yan Xu, and Lu Liu. Edge computing in vanets-an efficient and privacy-preserving cooperative downloading scheme. *IEEE Journal on Selected Areas in Communications*, 2020.

[12] Ikram Ali and Fagen Li. An efficient conditional privacy-preserving authentication scheme for Vehicle-To-Infrastructure communication in VANETs. *Vehicular Communications*, 2020.

[13] Jie Cui, Wenyu Xu, Yibo Han, Jing Zhang, and Hong Zhong. Secure mutual authentication with privacy preservation in vehicular ad hoc networks. *Vehicular Communications*, 2020.

[14] Baidaa Hamza Khudayer, Mohammed Anbar, Sabri Hanshi, and TatChee Wan. Efficient route discovery and link failure detection mechanisms for source routing protocol in mobile ad-hoc networks. *IEEE Access*, 2020.

[15] Mahmood A, Al-Shareedha and Selvakumar Manickam,A. Systematic Literature Review on Security of Vehicular Ad-Hoc Network (VANET) Based on VEINS Framework, *IEEE Access*,2023.

Appendix

A. SOURCE CODE

```
#include "ns3/aodv-module.h"
#include "ns3/applications-module.h"
#include "ns3/core-module.h"
#include "ns3/dsdv-module.h"
#include "ns3/dsr-module.h"
#include "ns3/flow-monitor-module.h"
#include "ns3/internet-module.h"
#include "ns3/mobility-module.h"
#include "ns3/network-module.h"
#include "ns3/olsr-module.h"
#include "ns3/yans-wifi-helper.h"

#include <fstream>
#include <iostream>

using namespace ns3;
using namespace dsr;

NS_LOG_COMPONENT_DEFINE("manet-routing-compare");

class RoutingExperiment
{
public:
    RoutingExperiment();

    void Run();

    void CommandSetup(int argc, char** argv);
```

```

private:
    Ptr<Socket> SetupPacketReceive(Ipv4Address addr, Ptr<Node> node);

    void ReceivePacket(Ptr<Socket> socket);

    void CheckThroughput();

    uint32_t port{9};
    uint32_t bytesTotal{0};
    uint32_t packetsReceived{0};

    std::string m_CSVfileName{"vanet-routing.output.csv"};
    int m_nSinks{10};
    std::string m_protocolName{"AODV"};
    double m_txp{7.5};
    bool m_traceMobility{false};
    bool m_flowMonitor{false};
};

RoutingExperiment::RoutingExperiment() {}

static inline std::string PrintReceivedPacket(Ptr<Socket> socket, Ptr<Packet> packet,
Address senderAddress)
{
    std::ostringstream oss;

    oss << Simulator::Now().GetSeconds() << " " << socket->GetNode()->GetId();

    if (InetSocketAddress::IsMatchingType(senderAddress))
    {

```

```

        InetSocketAddress addr = InetSocketAddress::ConvertFrom(senderAddress);
        oss << " received one packet from " << addr.GetIpv4();
    }
    else
    {
        oss << " received one packet!";
    }
    return oss.str();
}

void RoutingExperiment::ReceivePacket(Ptr<Socket> socket)
{
    Ptr<Packet> packet;
    Address senderAddress;
    while ((packet = socket->RecvFrom(senderAddress)))
    {
        bytesTotal += packet->GetSize();
        packetsReceived += 1;
        NS_LOG_UNCOND(PrintReceivedPacket(socket, packet, senderAddress));
    }
}

void RoutingExperiment::CheckThroughput()
{
    double kbs = (bytesTotal * 8.0) / 1000;
    bytesTotal = 0;

    std::ofstream out(m_CSVfileName, std::ios::app);

    out << (Simulator::Now()).GetSeconds() << "," << kbs << "," << packetsReceived <<
    ","

```

```

    << m_nSinks << "," << m_protocolName << "," << m_txp << "" << std::endl;

    out.close();
    packetsReceived = 0;
    Simulator::Schedule(Seconds(1.0), &RoutingExperiment::CheckThroughput, this);
}

Ptr<Socket> RoutingExperiment::SetupPacketReceive(Ipv4Address addr, Ptr<Node>
node)
{
    TypeId tid = TypeId::LookupByName("ns3::UdpSocketFactory");
    Ptr<Socket> sink = Socket::CreateSocket(node, tid);
    InetSocketAddress local = InetSocketAddress(addr, port);
    sink->Bind(local);
    sink->SetRecvCallback(MakeCallback(&RoutingExperiment::ReceivePacket, this));

    return sink;
}

void RoutingExperiment::CommandSetup(int argc, char** argv)
{
    CommandLine cmd(__FILE__);
    cmd.AddValue("CSVfileName", "The name of the CSV output file name",
m_CSVfileName);
    cmd.AddValue("traceMobility", "Enable mobility tracing", m_traceMobility);
    cmd.AddValue("protocol", "Routing protocol (OLSR, AODV, DSDV, DSR)",
m_protocolName);
    cmd.AddValue("flowMonitor", "enable FlowMonitor", m_flowMonitor);
    cmd.Parse(argc, argv);

    std::vector<std::string> allowedProtocols{"OLSR", "AODV", "DSDV", "DSR"};

```

```

        if (std::find(std::begin(allowedProtocols), std::end(allowedProtocols),
m_protocolName) ==
            std::end(allowedProtocols))
        {
            NS_FATAL_ERROR("No such protocol:" << m_protocolName);
        }
    }
}

```

```

int main(int argc, char* argv[])
{
    RoutingExperiment experiment;
    experiment.CommandSetup(argc, argv);
    experiment.Run();

    return 0;
}

```

```

void RoutingExperiment::Run()
{
    Packet::EnablePrinting();

    std::ofstream out(m_CSVfileName);
    out << "SimulationSecond,"
        << "ReceiveRate,"
        << "PacketsReceived,"
        << "NumberOfSinks,"
        << "RoutingProtocol,"
        << "TransmissionPower" << std::endl;
    out.close();
}

```

```

int nWifis = 50;

double TotalTime = 70.0;
std::string rate("2048bps");
std::string phyMode("DsssRate11Mbps");
std::string tr_name("manet-routing-compare");
int nodeSpeed = 20;
int nodePause = 0;

Config::SetDefault("ns3::OnOffApplication::PacketSize", StringValue("64"));
Config::SetDefault("ns3::OnOffApplication::DataRate", StringValue(rate));

Config::SetDefault("ns3::WifiRemoteStationManager::NonUnicastMode",
StringValue(phyMode));

NodeContainer adhocNodes;
adhocNodes.Create(nWifis);

WifiHelper wifi;
wifi.SetStandard(WIFI_STANDARD_80211b);

YansWifiPhyHelper wifiPhy;
YansWifiChannelHelper wifiChannel;
wifiChannel.SetPropagationDelay("ns3::ConstantSpeedPropagationDelayModel");
wifiChannel.AddPropagationLoss("ns3::FriisPropagationLossModel");
wifiPhy.SetChannel(wifiChannel.Create());

WifiMacHelper wifiMac;
wifi.SetRemoteStationManager("ns3::ConstantRateWifiManager",
                             "DataMode",
                             StringValue(phyMode),

```

```

        "ControlMode",
        StringValue(phyMode));

wifiPhy.Set("TxPowerStart", DoubleValue(m_txp));
wifiPhy.Set("TxPowerEnd", DoubleValue(m_txp));

wifiMac.SetType("ns3::AdhocWifiMac");
NetDeviceContainer adhocDevices = wifi.Install(wifiPhy, wifiMac, adhocNodes);

MobilityHelper mobilityAdhoc;
int64_t streamIndex = 0;

ObjectFactory pos;
pos.SetTypeId("ns3::RandomRectanglePositionAllocator");
pos.Set("X", StringValue("ns3::UniformRandomVariable[Min=0.0|Max=300.0]"));
pos.Set("Y", StringValue("ns3::UniformRandomVariable[Min=0.0|Max=1500.0]"));

Ptr<PositionAllocator> taPositionAlloc = pos.Create()-
>GetObject<PositionAllocator>();
streamIndex += taPositionAlloc->AssignStreams(streamIndex);

std::stringstream ssSpeed;
ssSpeed << "ns3::UniformRandomVariable[Min=0.0|
Max=" << nodeSpeed << "]";
std::stringstream ssPause;
ssPause << "ns3::ConstantRandomVariable[Constant=" << nodePause << "]";
mobilityAdhoc.SetMobilityModel("ns3::RandomWaypointMobilityModel",
        "Speed",
        StringValue(ssSpeed.str()),
        "Pause",

```

```

        StringValue(ssPause.str()),
        "PositionAllocator",
        PointerValue(taPositionAlloc));
mobilityAdhoc.SetPositionAllocator(taPositionAlloc);
mobilityAdhoc.Install(adhocNodes);
streamIndex += mobilityAdhoc.AssignStreams(adhocNodes, streamIndex);

```

```

AodvHelper aodv;
OlsrHelper olsr;
DsdvHelper dsdv;
DsrHelper dsr;
DsrMainHelper dsrMain;
Ipv4ListRoutingHelper list;
InternetStackHelper internet;

```

```

if (m_protocolName == "OLSR")
{
    list.Add(olsr, 100);
    internet.SetRoutingHelper(list);
    internet.Install(adhocNodes);
}
else if (m_protocolName == "AODV")
{
    list.Add(aodv, 100);
    internet.SetRoutingHelper(list);
    internet.Install(adhocNodes);
}
else if (m_protocolName == "DSDV")
{
    list.Add(dsdv, 100);
    internet.SetRoutingHelper(list);
}

```

```

        internet.Install(adhocNodes);
    }
    else if (m_protocolName == "DSR")
    {
        internet.Install(adhocNodes);
        dsrMain.Install(dsr, adhocNodes);
        if (m_flowMonitor)
        {
            NS_FATAL_ERROR ("Error: FlowMonitor does not work with DSR.
Terminating.");
        }
    }
    else
    {
        NS_FATAL_ERROR("No such protocol:" << m_protocolName);
    }

    Ipv4AddressHelper addressAdhoc;
    addressAdhoc.SetBase("10.1.1.0", "255.255.255.0");
    Ipv4InterfaceContainer adhocInterfaces;
    adhocInterfaces = addressAdhoc.Assign(adhocDevices);

    OnOffHelper onoff1("ns3::UdpSocketFactory", Address());
    onoff1.SetAttribute("OnTime",
StringValue("ns3::ConstantRandomVariable[Constant=1.0]"));
    onoff1.SetAttribute("OffTime",
StringValue("ns3::ConstantRandomVariable[Constant=0.0]"));

    for (int i = 0; i < m_nSinks; i++)
    {
        Ptr<Socket> sink = SetupPacketReceive(adhocInterfaces.GetAddress(i),

```

```

adhocNodes.Get(i));

    AddressValue remoteAddress(InetSocketAddress(adhocInterfaces.GetAddress(i),
port));
    onoff1.SetAttribute("Remote", remoteAddress);

    Ptr<UniformRandomVariable> var = CreateObject<UniformRandomVariable>();
    ApplicationContainer temp = onoff1.Install(adhocNodes.Get(i + m_nSinks));
    temp.Start(Seconds(var->GetValue(100.0, 101.0)));
    temp.Stop(Seconds(TotalTime));
}

std::stringstream ss;
ss << nWifis;
std::string nodes = ss.str();

std::stringstream ss2;
ss2 << nodeSpeed;
std::string sNodeSpeed = ss2.str();

std::stringstream ss3;
ss3 << nodePause;
std::string sNodePause = ss3.str();

std::stringstream ss4;
ss4 << rate;
std::string sRate = ss4.str();

AsciiTraceHelper ascii;
MobilityHelper::EnableAsciiAll(ascii.CreateFileStream(tr_name + ".mob"));

```

```

FlowMonitorHelper flowmonHelper;
Ptr<FlowMonitor> flowmon;
if (m_flowMonitor)
{
    flowmon = flowmonHelper.InstallAll();
}

CheckThroughput();

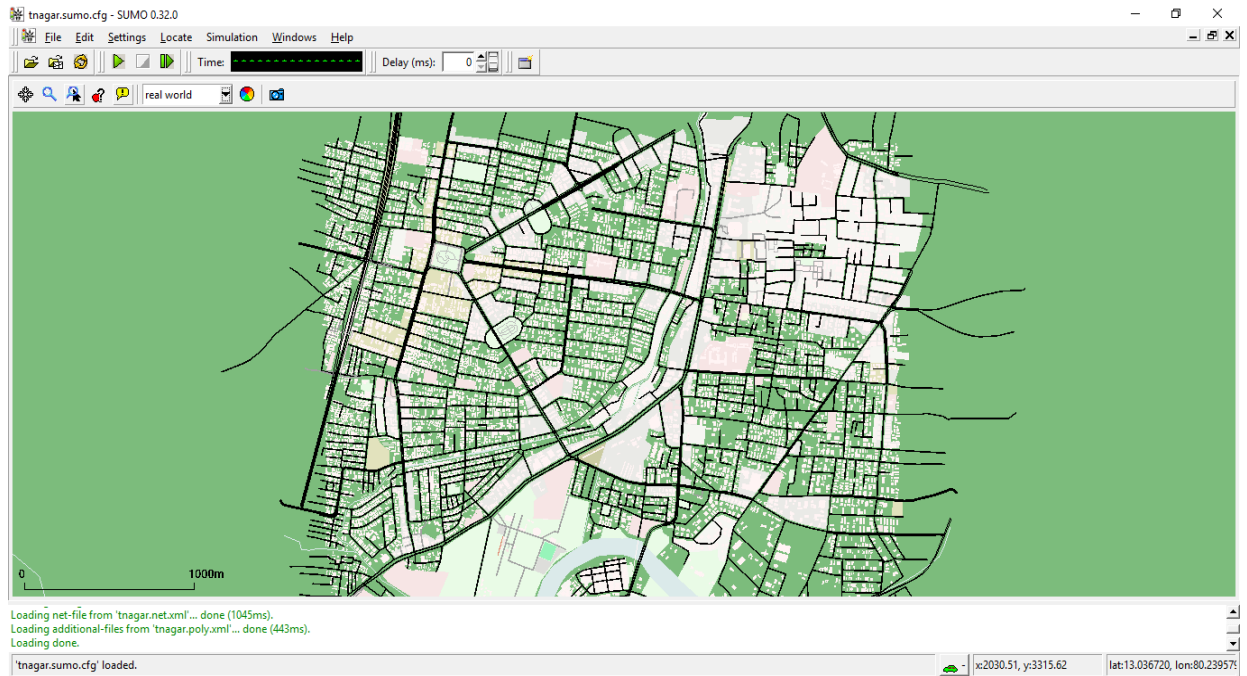
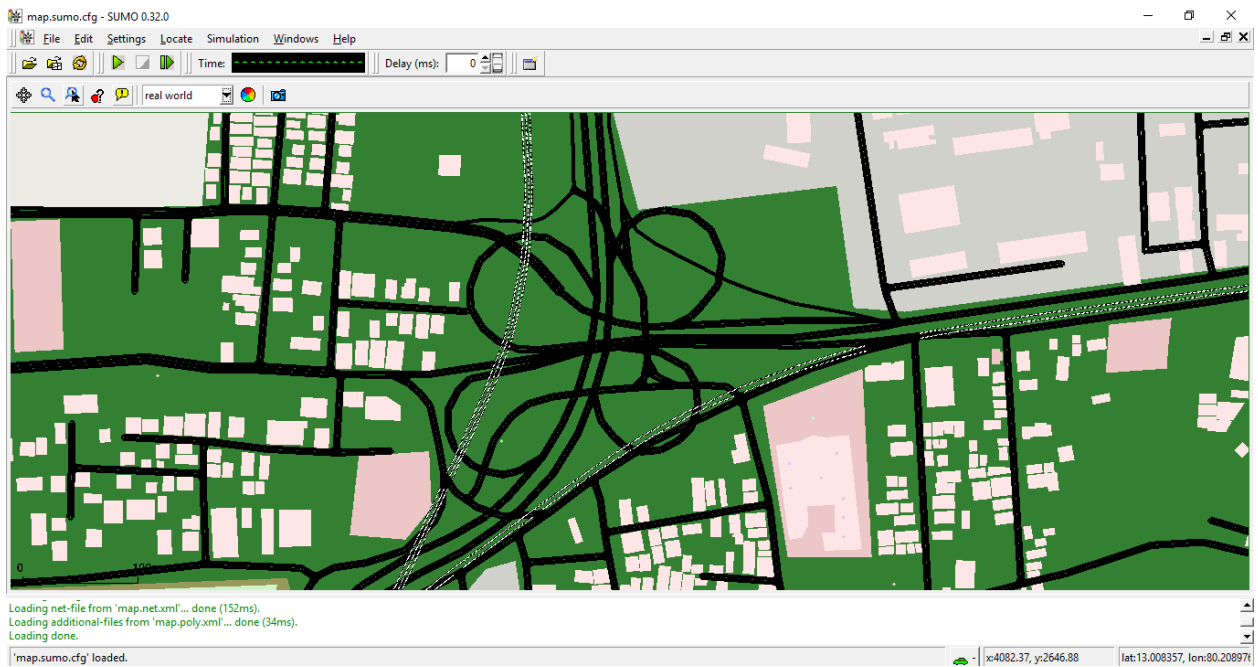
Simulator::Stop(Seconds(TotalTime));
Simulator::Run();

if (m_flowMonitor)
{
    flowmon->SerializeToXmlFile(tr_name + ".flowmon", false, false);
}

Simulator::Destroy();
}

```

B. SCREENSHOTS



C. RESEARCH PAPER

TRAFFIC CONGESTION MANAGEMENT IN VANET NETWORKS

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Abstract— Traffic congestion is a persistent challenge in urban areas, leading to increased travel times, fuel consumption, and environmental pollution. This study presents an innovative strategy for addressing congestion by utilizing advanced traffic management. Sensitive decision-making is made possible by the collection and processing of real-time data from vehicular ad hoc networks (VANETs). By using these methods to analyze the data, traffic signal timings are dynamically adjusted, improving traffic flow and reducing congestion. The goal of the project is to create a resilient, flexible, and effective congestion management system that enhances urban transportation and, in the end, results in less traffic, shorter commutes, and a more sustainable urban environment. The study of traffic patterns is among the most fascinating fields of research. This includes a host of other features including intelligent vehicle detection, route prediction, vehicle path monitoring, and much more. The majority of the studies that has been done using a vehicular ad-hoc network (VANET) to detect traffic congestion, but as of late, data mining techniques have been deployed. Even if the majority of the suggested work has been successful in detecting traffic congestion, developing an efficient mechanism that combines the detection, control, and prediction of both recurrent and nonrecurrent traffic congestions into a single system is difficult. This paper examines the identification, optimization, and algorithms of traffic congestion in VANET.

Keywords— VANET, NS3, SUMO.

INTRODUCTION

Urban areas grapple with the persistent issue of traffic congestion, a multifaceted challenge impacting economic vitality, environmental sustainability, and the overall standard of living. Offering a potential remedy to this predicament

are Vehicular Ad Hoc Networks (VANETs), dynamic networks that autonomously connect vehicles with both roadside infrastructure and fellow vehicles. The versatility of VANETs is exemplified through their ability to furnish a spectrum of services, encompassing route guidance, parking management, accident alerts, and the real-time distribution of traffic information. This project is dedicated to harnessing the capabilities of VANETs to engineer and implement a sophisticated traffic congestion management system. The overarching aim is to optimize traffic flow, curtail emissions, and diminish travel times by leveraging the real-time analysis of traffic data. The effectiveness and viability of this proposed system will be meticulously scrutinized through the utilization of testbeds and simulation tools.

However promising, VANETs are not without their share of challenges, including concerns related to stability, scalability, security, and privacy. Tackling these challenges head-on is imperative to ensure the seamless deployment and operation of VANET-based systems. Stability becomes paramount for ensuring the reliability of communication, scalability is a prerequisite for accommodating an expanding vehicular network, and robust security measures are essential for safeguarding sensitive data.

In the realm of wireless technologies, VANETs rely on two pivotal communication modes: Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V). V2I facilitates communication between vehicles and various roadside infrastructure elements such as parking meters, road signs, and traffic signals. Concurrently, V2V empowers vehicles to engage in real-time information exchange concerning their position,

speed, direction, and brake conditions. The integration of these wireless technologies aims to enhance road safety, traffic efficiency, and the overarching goal of environmental sustainability.

The transformative shift observed in contemporary communication models can be attributed to recent strides in wireless networking technologies. These networks can be broadly categorized into ad hoc and mobile infrastructure setups. Ad hoc networks epitomize flexibility and mobility, while mobile infrastructure adopts a more fixed deployment approach. VANETs, being a subset of Mobile Ad Hoc Networks (MANETs), are characterized by nodes constrained in their movement, with a focal emphasis on prioritizing passenger comfort and safety.

Amidst the intricate tapestry of challenges in bustling metropolises such as Delhi, Mumbai, and Bangalore, traffic congestion stands out prominently. VANETs, equipped with the capability to disseminate real-time information, emerge as a beacon of hope by empowering drivers with alternatives when congestion looms. Informed drivers can exercise discretion, opting to alter routes or patiently wait until the bottleneck dissipates, thereby localizing the issue for more effective management. Augmenting this informational exchange, the presentation of data on dashboards or through visual representations of impacted areas serves to heighten passenger awareness, contributing tangibly to improved decision-making and the overall efficacy of traffic management initiatives.

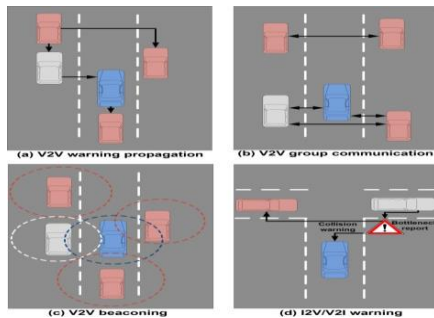


Fig 1: VANET Working

II. LITERATURE REVIEW

This study [1] examines, evaluates few of the most recent trust management and establishing techniques for automobile networks. Along with discussing the drawbacks and restrictions of current methods, it also makes some recommendations for potential future research areas. This paper discusses entity trust and data trust, two concepts that are critical to dependable and safe communication in vehicular ad hoc networks (VANETs).

In this paper [2], Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control is the dissertation's description of a novel algorithm that modifies the transmission power of beacon messages in Vehicular Ad Hoc Networks (VANETs) in response to vehicle speed and density. The algorithm's objectives are to lessen network congestion and enhance the dependability and promptness of safety messages. The dissertation compares and evaluates the algorithm with other approaches through simulation, and it is concluded that the algorithm performs better in terms of communication overhead and congestion control.

This research [3] presents a unique approach based on the age of information (AoI) metric to maximize the transmission rate of automobiles in a Vehicular Ad-hoc Network (VANET). The technique attempts to prevent packet collisions and channel congestion while minimizing the network's average area of overlap. The strategy is assessed using simulations in the paper and compared to other current methods.

A Rate adaptation and priority modeling are two unique ways of controlling network congestion in vehicular ad hoc networks (VANETs) that are discussed in the paper [4]. Vehicle Ad Hoc Networks, or VANETs, are networks of automobiles that use wireless technology to communicate with infrastructure and one another. They are used in many different areas, including traffic management, infotainment, and safety. But because of the large number of cars and the regular exchange of safety alerts, they

also have to deal with network congestion. In order to regulate the transmission rate of the beacon signals—periodic communications containing vehicle status information—the study suggests the use of the Decentralized Congestion Control (DCC) algorithm.

This study [5] introduces DisTraC, a novel protocol that cuts down on travel times and traffic jams in cities by utilizing V2V communication. Based on traffic density, DisTraC adjusts the beacon message transmission rate and prioritizes emergency alerts. In terms of communication overhead and congestion control, the paper's simulated evaluation of DisTraC demonstrates its superior performance over current techniques.

This research [6] suggests a novel method for modifying the vehicles' transmission power in a Vehicular Ad Hoc Network (VANET) according to the network's vehicle density. Reducing network channel congestion and enhancing network performance are the objectives. In comparison to current technologies, the paper's simulated evaluation of the suggested solution demonstrates its ability to lower packet loss and inter-packet delay.

III. EXISTING SYSTEM

In the present urban infrastructure, the orchestration of traffic flow primarily depends on conventional traffic signal coordination, GPS-based navigation applications, surveillance cameras, and centralized traffic management systems. Despite their widespread use, these existing systems are frequently characterized by shortcomings in terms of adaptability, responsiveness, and scalability. Addressing these limitations is critical for the advancement of traffic management solutions, and exploring innovative approaches becomes imperative to create a more efficient and sustainable urban mobility landscape.

IV. PROPOSED SYSTEM

The paper advocates for a shift towards VANET-based traffic information systems,

utilizing DSRC and intelligent algorithms for dynamic traffic signal adjustments. The integration of edge computing, machine learning-based traffic prediction, dynamic tolling, and smart traffic lights is explored to enhance congestion management, emphasizing decentralized systems, cooperative communication, and adaptive control mechanisms. The overarching goal is to create a resilient traffic management framework addressing the dynamic nature of urban traffic patterns and effectively mitigating congestion.

The proposed system also provides drivers with dynamic route suggestions based on real-time traffic data, employing machine learning and data analytics for congestion forecasting and detection. This approach aligns with sustainability and environmental concerns, contributing to increased road safety by prioritizing emergency vehicles. The system aims for reduced environmental impact, enhanced energy efficiency, and considers implications for policy and public acceptance.

V. ROUTING PROTOCOLS

Wireless ad hoc networks facilitate free-roaming stations with a dynamically changing network topology. The relocation of stations leads to the loss of some network ties and the potential formation of new ones, necessitating new routing techniques.

1. Ad Hoc Routing Systems

Ad hoc routing systems come in two types: table-driven and on-demand. The focus of this research is on three protocols – DSDV, DSR, and AODV. DSDV employs sequence numbers to avoid loops and selects the most recent routes. DSR allows nodes to dynamically find source routes through "Route Discovery" and "Route Maintenance" processes. AODV, a well-known topology routing protocol, initiates route requests and establishes end-to-end paths between nodes.

2. DSDV Protocol

DSDV is an improved version of the Bellman-

Ford Routing Algorithm, using sequence numbers to avoid loops. Stations periodically broadcast routing tables, and updates can be either full or incremental. The route with the highest sequence number (or the shortest route if equal) is chosen. Stations estimate settling times to reduce unnecessary updates.

3. DSR Protocol

DSR allows nodes in an ad hoc network to find source routes through "Route Discovery" and "Route Maintenance" processes. Caches of routes reduce control messaging costs. DSR route recovery can happen more quickly compared to other on-demand protocols.

4. AODV Protocol

AODV operates by broadcasting route request (RREQ) messages when a node needs to communicate. Nodes forward RREQ messages to establish a reverse path, and a path is created when the source node receives a route reply (RREP) message. Maintaining a connection with the sink node is critical for uninterrupted data collection.

5. IEEE 802.11p/DSRC Protocol

IEEE 802.11p/DSRC is a wireless protocol for vehicular ad hoc networks, addressing challenges in high mobility, topological changes, and ensuring reliability and low latency. Operating in the 5.9 GHz band, it supports safety and non-safety applications, with WAVE (802.11p) improving PHY and MAC layers for DSRC.

VI. SYSTEM ARCHITECTURE

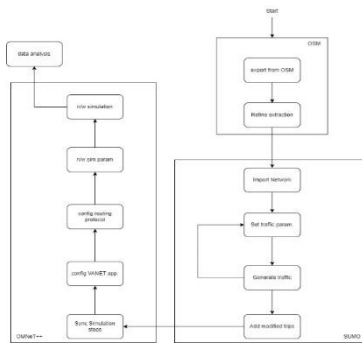


Fig 2: System architecture

A. OpenStreetMap (OSM)

OpenStreetMap (OSM) is a collaborative project that creates freely editable and open-source maps using contributions from volunteers worldwide. These maps offer detailed geographic information and are utilized in various applications and services. In our research, we will leverage OSM to extract maps for simulating real-world traffic conditions.

B. SUMO Simulator

The extracted OSM map data is imported into the SUMO simulator, where we define the vehicle count and types before the simulation begins. Additionally, we set various parameters within SUMO to configure the simulation environment according to our research needs.

C. Routing Protocols and Initialization Parameters

We will employ specific routing protocols to simulate network traffic, developing code to analyze the outcomes of these protocols within the network simulation. Initialization parameters are crucial for configuring the initial state of the network and its components.

D. NS-3 Simulator

NS-3 is a discrete-event network simulator developed in C++, featuring a Python binding for enhanced flexibility. It serves as a robust platform for simulating various networking protocols and environments, providing a wide array of modules catering to different networking technologies. The extensibility, flexibility, and accuracy of NS-3 make it a preferred choice in academia and research for simulating and evaluating network protocols, algorithms, and architectures.

E. Trace and Nam Files Generation

During simulation in NS-3, trace and nam files are generated to capture and record various aspects of the simulated network behavior. These files contain detailed information about the network's performance, traffic patterns, and other relevant metrics, enabling in-depth analysis and evaluation.

F. Trace File Analysis:

Following simulation, the trace files are

analyzed to extract meaningful insights into the network's behavior and performance. This analysis involves examining various parameters and metrics recorded in the trace files, providing valuable data for evaluating the effectiveness of the simulated routing protocols and network configurations.

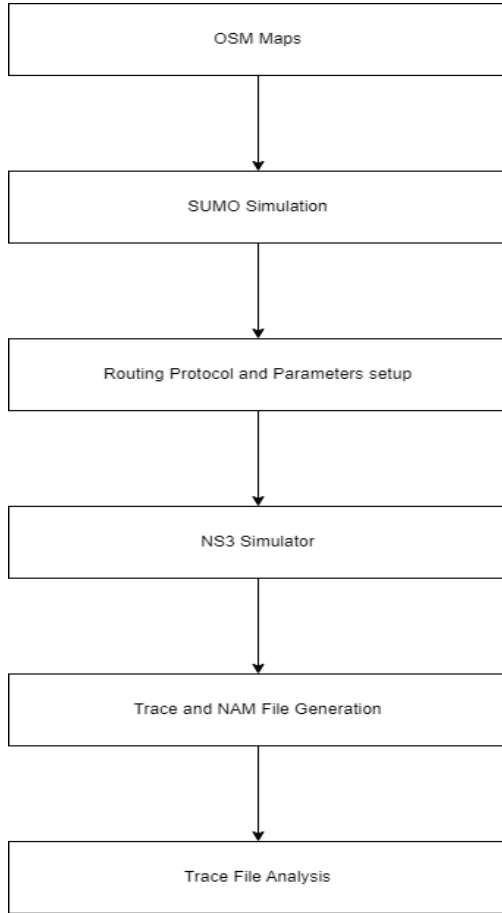


Fig 3: Process

VII. RESULTS AND DISCUSSION

The research findings are a result of a meticulous use of open-source tools, specifically the Simulation of Urban Mobility (SUMO) and the ns-3 network simulator, combined with geospatial data from OpenStreetMap (OSM). In the context of SUMO, the simulations demonstrated a high degree of realism,

effectively replicating real-world traffic scenarios and showcasing its versatility in analyzing vehicular dynamics. The incorporation of OSM data enhanced the simulations by providing greater geographical precision, strengthening the authenticity of the virtual road network, and significantly improving the accuracy of congestion management evaluations.

The choice of the most suitable routing protocol for traffic congestion management in VANETs depends on various factors, including network density, mobility patterns, traffic load, and application requirements.

According to the simulation scenarios with low to moderate traffic congestion and relatively stable network conditions, DSDV may be a suitable choice due to its ability to maintain up-to-date routing information and quickly adapt to topology changes. However, in highly dynamic and congested environments, on-demand routing protocols like DSR and AODV may be more appropriate due to their lower control overhead and better adaptability to frequent route changes.

AODV, in particular, has shown promising results in managing traffic congestion in VANETs due to its efficient route discovery and maintenance mechanisms. It strikes a balance between the proactive nature of DSDV and the reactive approach of DSR, making it a popular choice for various VANET applications.

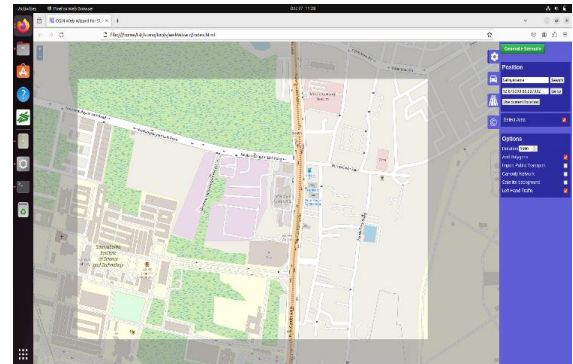


Fig 4: OSM

Moving beyond tool application, the research delved into the intricate interplay of vehicular

communication protocols within the realm of Vehicle Ad-Hoc Networks (VANETs). The ns-3 network simulator played a pivotal role in facilitating a detailed examination of these protocols. Its open-source architecture, coupled with inherent extensibility, positioned ns-3 as a central instrument in elucidating the nuanced implications of diverse networking strategies on the overall performance of VANETs.



Fig 5: Terminal

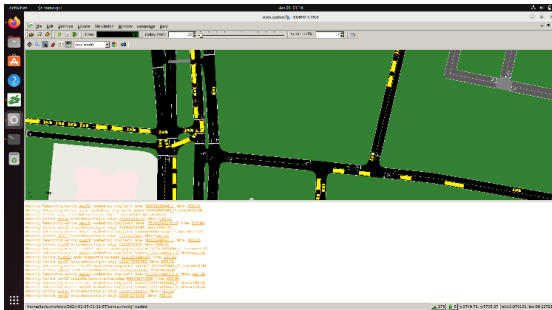


Fig 6: SUMO

VIII. FUTURE ENHANCEMENT

A prospective enhancement for the research involves incorporating clustering algorithms for efficient formation of vehicle clusters in Vehicle Ad-Hoc Networks (VANETs). Utilizing algorithms like K-means or hierarchical clustering could dynamically group vehicles based on proximity, speed, or destination, improving communication efficiency and reducing congestion. The implementation of clustering algorithms has the potential to optimize resource allocation and enhance scalability. However, challenges like dynamic

cluster memberships and communication overhead need consideration. This addition would further refine VANET-based traffic management systems, offering potential benefits in terms of smoother traffic flow and network performance.

IX. CONCLUSION

In conclusion, our simulation study highlights the potential of Vehicle Ad-Hoc Networks (VANETs) in effectively managing traffic congestion. Through meticulous consideration of factors such as communication latency and network stability, the results demonstrate the real-time adaptability of VANET-based congestion management systems. However, challenges related to communication reliability must be addressed for practical implementation in real-world scenarios. This research emphasizes the need for ongoing efforts to refine VANET protocols and optimize communication mechanisms, contributing valuable insights to the development of resilient and efficient urban traffic management solutions within the realm of intelligent transportation systems.

REFERENCES

- [1] R. Hussain, J. Lee, and S. Zeadally, "Trust in VANET: a survey of current solutions and future research opportunities" IEEE Transactions on Intelligent Transportation Systems, 2021.
- [2] Facchina, C. Adaptive Transmission Power Level with Vehicle Speed Approximation of Density for VANET Congestion Control (Doctoral dissertation, University of Windsor (Canada),2020).
- [3] N. Lyamin, B. Bellalta, and A. Vinel, "Age-of-informationaware decentralized congestion control in vanets," IEEE Networking Letters, vol. 2, no. 1, 2020
- [4] Sharma, S., Chahal, M., & Harit, S. (2019, February). Transmission Rate-based Congestion Control in Vehicular Ad Hoc Networks. In 2019 Amity International Conference on Artificial

Intelligence (AICAI). IEEE

[5] de Sousa, R. S., Boukerche, A., & Loureiro, A. A. DisTraC: A Distributed and Low-Overhead Protocol for Traffic Congestion Control Using Vehicular Networks. IEEE Symposium on Computers and Communications (ISCC). IEEE, 2019.

[6] Akinlade, O., Saini, I., Liu, X., & Jaekel, A. Traffic Density Based Distributed Congestion Control Strategy for Vehicular Communication, 2019.

[7] R. Chhabra, C. Rama Krishna, and S. Verma, "Context-aware hybrid adaptive beaconing for driver behavior dissemination in VANETs," IETE Journal of Research, vol. 68, 2021.

[8] P. Rajput, M. Chaturvedi, and V. Patel, "Opportunistic sensing-based detection of crowdedness in public transport buses," Pervasive and Mobile Computing, vol. 68, article 101246, 2020

[9] A. U. Haq, K. Liu, and M. B. Latif, "A Location-and Mobility-Aware Clustering-Based TDMA MAC Protocol for Vehicular Ad-hoc Networks," 28th Wireless and Optical Communications Conference (WOCC), 2019.

[10] G. H. Alsuhli, A. Khattab, and Y. A. Fahmy, "Double-head clustering for resilient VANETs," Wireless Communications and Mobile Computing, vol. 2019.