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Performance Evaluation of Routing Protocols for Vehicle Re-Routing in ITS-based Vehicular Networks

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Abstract— This study aims to assess the performance of routing protocols in Intelligent Transportation System (ITS)-based vehicular networks, specifically in accident and highway scenarios. The effective management of traffic flow in these situations is crucial for ensuring the safety and smooth operation of vehicular networks. Therefore, it is imperative to evaluate routing protocols to identify the most suitable one for these scenarios. The evaluation considers various commonly used routing protocols in vehicular networks, including Ad hoc On-Demand Distance Vector (AODV), Ad hoc On-Demand Multipath Distance Vector (AOMDV), and Destination-Sequenced Distance Vector (DSDV). The evaluation is based on several performance metrics, such as packet delivery ratio, end-to-end delay, network throughput, normalized routing load, and routing overhead. These metrics provide insights into the effectiveness and efficiency of the routing protocols in handling re-routing in accident and highway scenarios. The research is divided into two modules, Module I and Module II, to evaluate the effectiveness of routing protocols in these distinct scenarios using the NS2 simulation tool. The simulation results are analyzed and compared to determine the performance of the routing protocols in each module. The findings indicate that AODV consistently achieves the highest throughput, packet delivery ratio, and lowest end-to-end delay, routing overhead, and normalized routing load, followed by AOMDV and then DSDV. The findings of this study contribute to the understanding of the strengths and weaknesses of different routing protocols in accident and highway scenarios. This knowledge can assist in the development of more efficient and reliable routing protocols for vehicular networks.

Keywords- Accident scenario, Highway Scenario, Intelligent Transportation System (ITS), Routing protocol, Re-routing, SUMO Simulator, NS-2 Simulator, VANET.

I. INTRODUCTION

Traffic congestion is a pervasive problem in the 21st century, posing a significant challenge to people and policymakers. The number of automobiles on roads is increasing, leading to major traffic issues. This concern is more pressing in developing nations such as India and China, where traffic growth outpaces road infrastructure development. Focusing solely on improving transportation infrastructure is not the optimal solution to address this problem. Therefore, policymakers and countries must seek ways to minimize, optimize, and control the significant costs of traffic congestion while also ensuring safe, fast, and convenient transportation. These objectives require a holistic approach that involves improving transportation infrastructure, promoting public transportation, regulating vehicle usage, encouraging carpooling, and deploying innovative technologies such as intelligent transportation systems (ITS). By embracing these measures, countries can alleviate traffic congestion and achieve sustainable transportation solutions. [1]

One of the most innovative solutions to traffic control and prevention is the intelligent transportation system (ITS). ITS comprises a variety of state-of-the-art technologies designed to assess, track, and analyze traffic, while also integrating various technologies to achieve objectives such as traffic quality, cost savings, energy efficiency, environmental protection, and time reduction. The term "intelligent transportation system" encompasses various systems, including portable systems, standalone systems installed on vehicles, systems that enable vehicle-to-vehicle and vehicle-to-infrastructure communication, and cooperative systems. These systems enable traffic managers and operators to make informed decisions in real-time, helping to alleviate traffic congestion and reduce travel times. In addition, ITS can support various transportation modes, such as public transportation and non-motorized transportation, to achieve sustainable mobility. As such, ITS is an indispensable tool for developing smart and sustainable transportation systems that meet the evolving needs of modern society.[2]

In previous research, various types of ad hoc networks exist, one of which is VANET or Vehicular Ad-hoc NETwork, which is a subset of MANET or Mobile Ad-Hoc NETwork. Both share similar features, such as low bandwidth, self-organization, and mutual radio transmission. VANET's primary purpose is to provide wireless connectivity between vehicles and vehicle infrastructure communication without requiring central access. Vehicle-to-Vehicle Ad-Hoc Network (VANET) facilitates the transmission of data between automobiles and their surroundings. This technology has both protective and non-protective applications, such as improved routing, location-based services, traffic management, media usage, and vehicle safety. While the primary goal of VANET is to provide information on accident prevention, the network topology changes too quickly, and auto-organization of the network causes link breakages, which can result in severe injuries if the link is broken or the package is delayed. To address this, researchers and practitioners are exploring new routing protocols and communication mechanisms to improve the reliability and stability of VANET. [3]

Efficient routing in Vehicular Ad-Hoc Networks (VANETs) holds significant importance as it is responsible for establishing and maintaining multi-hop communication routes.

However, the dynamic nature of VANETs, characterized by high node mobility and frequent topology changes, introduces challenges in terms of increased overhead in exchanging and updating topology information, thereby making routing a complex task. Additionally, the varying node density and the presence of obstacles with different shapes and sizes further complicate the performance of routing protocols. Consequently, enhancing the efficiency of routing protocols in VANETs becomes imperative. In the context of VANET routing, several major challenges need to be addressed. Firstly, the issue of node mobility necessitates the development of routing protocols that can effectively handle the movement of vehicles. Secondly, reducing connectivity overhead is crucial to minimize the amount of information exchanged and updated, thereby optimizing the routing process. Furthermore, the ability to adapt to changing topology is essential in order to maintain efficient communication routes in the face of dynamic network conditions. Additionally, the varying node densities encountered in VANETs pose a challenge that needs to be addressed by routing protocols. Lastly, the presence of obstacles with diverse shapes and sizes requires routing protocols to be capable of effectively navigating around such obstacles. Addressing these challenges is of utmost importance in order to enhance the performance of VANET routing protocols. Figure 1 illustrates the communication model for VANET architecture, wherein various types of communication, such as vehicle-to-vehicle, vehicle-to-RSU, and vehicle-to-infrastructure, are attempted to be established over the internet with the objective of obtaining real-time information from all types of vehicles.

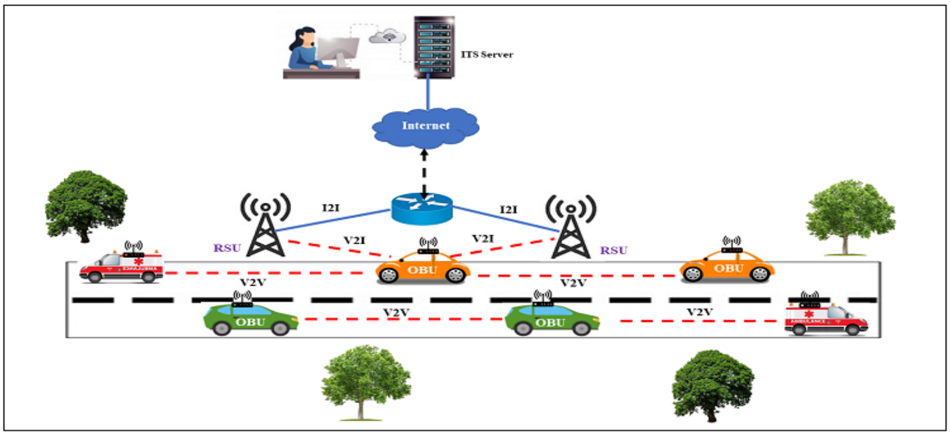


Figure 1: VANET Communication Model [26]

The performance evaluation of routing protocols for vehicle re-routing in Intelligent Transportation System (ITS)-based vehicular networks is a crucial aspect in ensuring efficient and reliable communication in vehicular environments. This evaluation becomes particularly significant in accident scenarios and highway scenarios, where the timely and accurate dissemination of information is essential for ensuring the safety and well-being of drivers and passengers. Accidents on roadways are unfortunate events that can lead to severe consequences, including injuries, fatalities, and traffic congestion. In such scenarios, the ability to quickly and effectively reroute vehicles is of utmost importance to minimize the impact of the accident and facilitate the smooth flow of traffic. Routing protocols play a vital role in determining the most appropriate alternative routes for vehicles, considering factors such as road conditions, traffic congestion, and the availability of alternative paths. Highway scenarios, on the other hand, present unique challenges due to the high-speed nature of vehicles and the need for seamless communication between vehicles and infrastructure. Efficient routing protocols are necessary to ensure reliable and low-latency communication, enabling timely dissemination of information such as traffic updates, road conditions, and emergency alerts. These protocols must consider the dynamic nature of highway environments, where vehicles are constantly moving at high speeds and may encounter various obstacles or congestion points.

The remainder of this paper is organized as follows: Section 2 presents literature survey in relevant proposed research topic and comparison between ns 2 and ns 3 simulators. Section 3 describes the proposed methodology about the modules considered, describes the routing protocols and performance parameters considered for the research work. Section 4 describes the result analysis about the modules and finally the paper is concluded in sections 5.

II. RELATED WORK

The In recent years, VANETs and MANETs have exhibited many similar characteristics, with the absence of infrastructure being the only difference in the case of MANET [4]. Therefore, this paper surveys the routing protocols of VANETs such as AODV, DSDV, and DSR protocols, and implements them in network and traffic simulators, as well as a traffic control interface module [5]. Managing and utilizing communication methods in VANETs can be challenging due to their dynamic structure and mobile nodes. While extensive research has been conducted on MANET-guidance protocols in relevant and similar fields, only a few studies have focused on systematic comparisons and performance appraisals between VANETs and MANETs. [6-8]

Author in [9] analyzed the performance of different routing protocols in a vehicle scenario. The study measured key performance metrics such as Average Goodput and the BSM PDR. Author in [10] found that ACO-IBR protocol minimizes delay, enhances successful delivery ratio, and improves throughput for all real mobility patterns. Author in [11] analyzed that STRWP yields satisfactory performance across all three routing protocols, with respect to metrics such as packet delivery ratio, throughput, and end-to-end delay. Author in [12] compared various classes of VANET protocols provides valuable guidance, concluding that among AODV, OLSR, and DSDV, AODV is the most optimal method for the model. Author in [13] proposed two VANET routing protocols, Dynamic MANET On-Demand (DYMO), and Optimized Link State Routing version 2 (OLSRv2).

Author in [14] evaluated the impact of black hole attacks on VANETs in a realistic urban traffic scenario in Panama City. Four major routing protocols were analyzed under normal and black hole attack conditions using ns-3 and SUMO simulation tools. The study aimed to investigate the performance impact of black hole attacks on VANETs. Author in [15] analyzed DSDV emerged as the most viable option due to its low average end-to-end delay. Author in [16] assessed the effectiveness of routing protocols in Vehicular Ad-hoc Networks (VANETs) through the use of the ns-3 simulation tool. The study compares the performance of DSDV, OLSR, and AODV routing protocols based on metrics such as throughput, packet delivery ratio, and overhead. The objective is to identify the most suitable routing protocol for VANETs in both Grid and Random deployment scenarios.

Author in [17] analyzed the classical Cluster Based Routing Protocol (CBRP) and an optimized version of CBRP that utilizes a particle swarm optimization (PSO) technique. The optimized CBRP demonstrates improved accuracy and efficiency of the protocol. Author in [18] examined the impact of vehicle density on the performance of popular routing protocols. Quantitative metrics such as overhead, packet delivery ratio, average throughput, and average end-to-end delay are evaluated using the Network Simulator NS-3 and SUMO. Author in [18] evaluated the performance of three reactive mobile ad hoc routing protocols in Mobile Ad Hoc Network (MANET) environments with varying (non-uniform) node density. The study shows that an increase in node speed results in a decrease in performance of the AODV, DSR, and CBRP protocols.

III. METHODOLOGY ADOPTED

SAAQ The present study aims to evaluate the performance of routing protocols for vehicle re-routing in Intelligent Transportation System (ITS)-based vehicular networks, specifically focusing on accident and highway scenarios. The methodology employed in this research involves the implementation of these scenarios in the NS-2 simulation environment. To begin with, the accident scenario is simulated to assess the effectiveness of routing protocols in handling unexpected events on the road. This scenario involves the introduction of a sudden accident on a particular road segment, which disrupts the normal flow of traffic. The routing protocols under investigation are then evaluated based on their ability to efficiently reroute vehicles and minimize the impact of the accident on overall network performance. The NS-2 simulation environment allows for the accurate representation of various parameters such as vehicle density, speed, and communication range, which are crucial in assessing the performance of routing protocols in such scenarios.

Furthermore, the highway scenario is implemented to evaluate the routing protocols' performance in a high-speed, high-density vehicular network environment. This scenario aims to replicate the conditions typically encountered on highways, where vehicles are traveling at high speeds and frequently changing lanes. The routing protocols are assessed based on their ability to maintain reliable and efficient communication among vehicles, considering factors such as packet loss, delay, and throughput. By implementing this scenario in NS-2, it becomes possible to analyze the impact of different routing protocols on network performance under realistic highway conditions. The NS-2 simulation environment offers several advantages for conducting this research. Firstly, it provides a platform for accurately modeling the behavior of vehicles and their interactions in a vehicular network. This allows for the replication of real-world scenarios and the evaluation of routing protocols in a controlled environment. Secondly, NS-2 enables the manipulation of various network parameters, facilitating the investigation of different scenarios and their impact on routing protocol performance. Lastly, NS-2 provides comprehensive performance metrics, allowing for a thorough analysis of the routing protocols' efficiency and effectiveness in the given scenarios.

This methodology outlines the stages followed during the study, as depicted in Figure 2. The three routing protocols tested in this research include AODV and AOMDV, both reactive protocols, and one proactive protocol, DSDV.

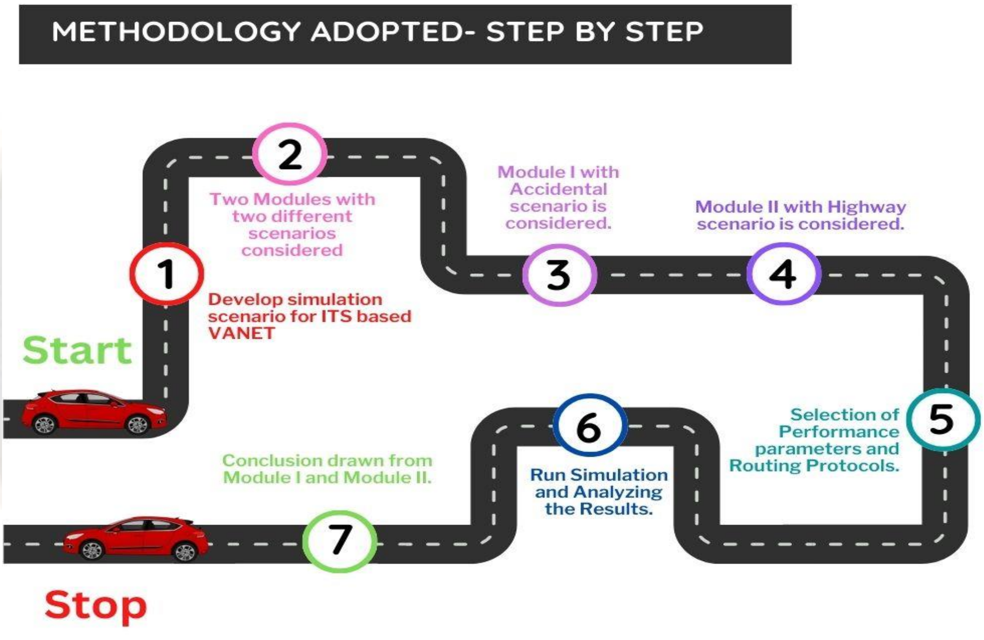


Figure 2: Methodology Adopted for Proposed Research

Step 1: Develop a simulation scenario of the ITS based VANET network

In the first step it is important to decide the simulation scenario for ITS based VANET network. Since ITS application is to be used widely in VANET kind of network and also vehicles in ITS system are distributed, so two scenarios are considered which are accidental and highway where vehicular nodes are distributed randomly.

Step 2: Two Modules with two different scenarios considered

In the second step, it is important to initiate the research work with some kind of simulation tool, so it is decided that start with lightweight simulation with small network which is done in Module I and then do simulation slightly deeper with larger network in Module II.

Step 3: Module I with Accidental scenario is considered.

In the third step, Module I is decided to execute with less number of nodes in ITS based VANET network using the simulation tool NS-2 with objective set as to identify the right routing protocol for accidental scenario. This includes identifying the right routing protocols according to desired levels of reliability, availability, and latency. In the first module three routing protocols like AODV, AOMDV and DSDV are compared. Their evaluation is done based on basic three parameters like Throughput, Packet Delivery Ratio and End to End Delay. In the first module, the primary focus is to make understanding about the working of various routing protocols, how they act upon VANET networks and how they affect the different parameters. Since Network Simulator 2 is quite tough to learn and it takes much time to implement and to understand the concept of creating VANET networks, so only few parameters with less number of vehicular nodes are considered for the study in module 1.

Step 4: Module II with Highway scenario is considered.

In the fourth step, Module II is decided to execute with more number of vehicular nodes in ITS based VANET network using the simulation tool NS-2 with objective set as to identify the factors that can affect various parameters in the ITS network at Highway scenario. This includes the number of vehicles connected to the road-side-unit network, the type of data being transferred, and the network infrastructure. In the second module AODV, DSDV and AOMDV routing protocols are tested based on scenario where number of vehicle nodes varies from 10 nodes to 100 vehicle nodes. In this module scalability factor of routing protocols are kept in mind that how they perform when number of vehicle nodes would increase in wireless ITS based VANET networks.

Step 5: Selection of QoS parameters and Routing Protocols.

In the fifth step, routing protocols have been considered are AODV, AOMDV and DSDV since they are implemented in NS-2, so there is only need to know their performances in different networks. Routing protocols are used to determine the best path for data to travel between nodes in a network. Wireless routing protocols are designed to operate in wireless networks, which have unique characteristics such as limited bandwidth, high error rates, and dynamic topology. There are three routing protocols which are considered in both, Module I and Module II.

Step 6: Run Simulation and Analyzing the Results.

In the sixth step, simulation is conducted for both modules one by one and the performances of routing protocols are recorded. In Module I, five simulation scenarios are conducted for 20,25,30,35 and 40 nodes while in Module II, six simulation scenarios are conducted for nodes varying from 10 nodes to 100 nodes. The results obtained are exported to MS-excel files & appropriate graphs are formed for different parameters for both the Modules I and II.

Step 7: Conclusion drawn from Module I and Module II.

After plotting graph, it is easier to find the performances of routing protocols according to the set parameters for the study. This step clears the view that which protocols is well suited for ITS based VANET networks and which can adopt dynamically when number of vehicle nodes increases in the network.

IV. RESULTS AND DISCUSSION

The objective of this study is to evaluate the performance of various routing protocols in vehicular networks when faced with accident and highway scenarios. Vehicular networks, based on Intelligent Transportation Systems (ITS), have gained significant attention due to their potential to enhance road safety and traffic efficiency. In these networks, vehicles communicate with each other and with infrastructure nodes to exchange information and make informed decisions. Accidents and highway scenarios are critical situations that require efficient routing protocols to ensure timely and reliable communication among vehicles. Therefore, it is crucial to assess the performance of routing protocols in such scenarios. The NS-2 simulator is employed to create a realistic simulation environment that accurately represents the behavior of vehicular networks. The simulation analysis focuses on evaluating the performance of different routing protocols in terms of key performance metrics such as packet delivery ratio, end-to-end delay, and throughput. These metrics provide insights into the effectiveness and efficiency of the routing protocols under investigation.

Table 1 provides an overview of the system environment, including details of the parameters used for simulation. The simulation tool, NS-2 (version 2.35) is used in Ubuntu OS 16.04 for both Modules I and Module II. Table 1 enlists some of the simulative parameters executed in the experiments. The Simulation area is distributed in 1000mx1000m area and simulation time is set to be around for 300 seconds.

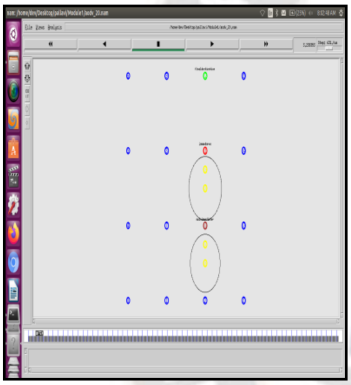
Table 1: Parameters for Simulation

SN	***Parameters***	***Specification***
1	MAC Type	Mac/802.11
2	Antenna Model	Omni Antenna
3	Type of Channel	Wireless Channel
4	Routing Protocol	AODV, DSDV & AOMDV
5	No. of Nodes	Module I: 20-40 nodes Module II:10 to 100 nodes
6	Transmission Protocol	UDP
7	Interface Queue Type	DropTail/PriQueue

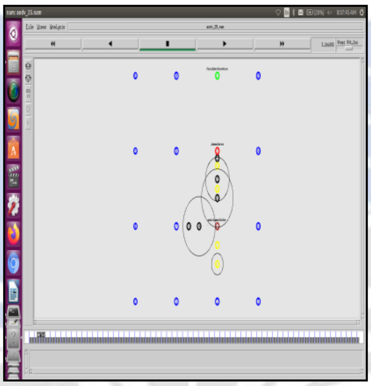
8	Radio Propagation Model	Propagation /TwoRayGround
9	Parameters	Module I: PDR, Throughput & Delay Module II: PDR, Throughput, Delay, RO & NRL
10	Time end for simulation	300 seconds

In Module I, there are five scenarios where the number of nodes is kept between 20 to 40 vehicle nodes. These scenarios are dynamic, meaning that the nodes move around. Module 1 is focused on checking the performance of three routing protocols namely; AODV, AOMDV, and DSDV routing protocols. Since the NS 2 simulator took a lot of time to set for a VANET-based environment, only a few parameters are considered for the experiment. There is an accidental scenario at the intersection, after getting a successful message that there is an accident occurred at the intersection, other vehicles re-route themselves to reach their destinations.

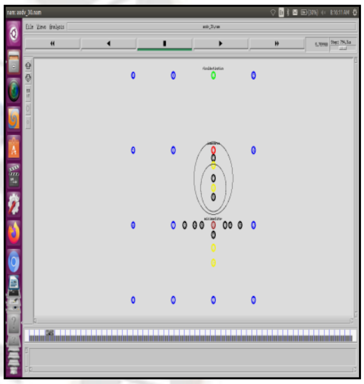
Figure 3 (a) shows the simulation snapshot for scenario 1 of Module I. In this scenario 1, there are only two vehicular nodes that re-route themselves when they receive the accident warning message at the intersection of the single-lane scenario. Figure 3 (b) and figure 3 (c) show the simulation snapshot for scenario 2 and scenario 3 of Module I respectively. In this scenario 2 & 3, there are four & six vehicular nodes that re-route themselves when they receive the accident warning message at the intersection of the single-lane scenario. Figure 3 (d) and Figure 3 (e) show the simulation snapshot for Scenario 4 and Scenario 5 of Module I respectively. In this scenario 4 & 5, there are eight & ten vehicular nodes that re-route themselves when they receive the accident warning message at the intersection of single-lane scenario.



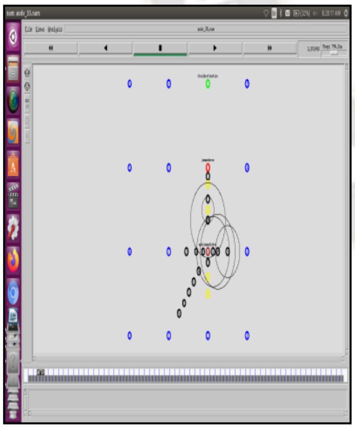
(a) Scenario 1



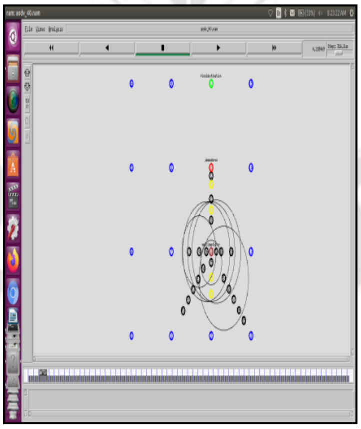
(b) Scenario 2



(c) Scenario3



(d) Scenario 4



(e) Scenario 5

Figure 3 (a) to (e): Module 1- Simulation Analysis

In Module II, there are six scenarios where the number of nodes is kept at 10, 20, 30, 50, 75 and 100 nodes. There are some sender and receiver nodes for communication, which sets up an environment for VANET. The Module 2 is focused to check the performance of three routing protocols namely; AODV, AOMDV and DSDV routing protocols in scalable manner. Since NS 2 simulator took lot of time to setup for VANET based environment, so few more parameters than module 1 are considered for the experiment. Figure 4(a) shows the simulation snapshot for scenario 1 of Module II. In this scenario 1, there are four lanes at Highway scenario where nodes move in both directions. Vehicle nodes may be here car, bike, ambulance etc. Since vehicular nodes are communicating with each other, so network overhead increase in such kind of

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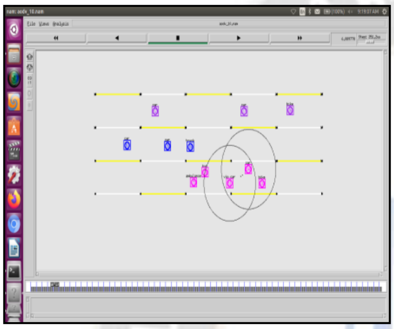
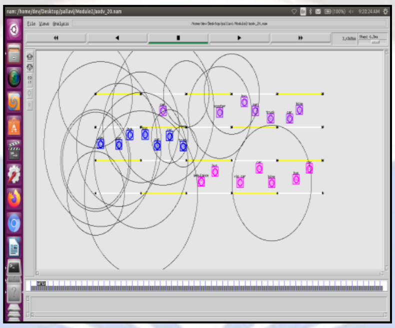
network due to variation of speed and dynamic positions of vehicular nodes. This makes untrustworthy kind of communication among vehicles. In this scenario, only 10 nodes are deployed in VANET architecture forming (Vehicle to Vehicle) V-V communication.

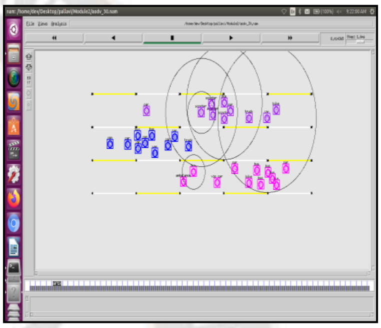
Figure 4(b) and figure 4(c) show the simulation snapshot for scenario 2 and scenario 3 of Module II respectively. In this scenario 2 & 3, there are four lanes at Highway scenario where nodes move in both directions. In these scenarios, only 20 & 30 nodes are deployed in VANET architecture forming (Vehicle to Vehicle) V-V communication respectively. Figure 4(d) and figure 4(d) show the simulation snapshot for scenario 4 and scenario 5 of Module II respectively. In this scenario 4 & 5, there are four lanes at Highway scenario where nodes move in both directions. In these scenarios, only 50 & 75 nodes are deployed in VANET architecture forming (Vehicle to Vehicle) V-V communication respectively. Figure 4(e) shows the simulation snapshot for scenario 6 of Module II. In this scenario 6, there are four lanes at Highway scenario where nodes move in both directions. Vehicle nodes may be here car, bike, ambulance etc. Since vehicular nodes are communicating with each other, so network overhead increase in such kind of network due to variation of speed and dynamic positions of vehicular nodes. This makes untrustworthy kind of communication among vehicles. In this scenario, 100 nodes are deployed in VANET architecture forming (Vehicle to Vehicle) V-V communication. There is no accidental condition is considered in this Module II.



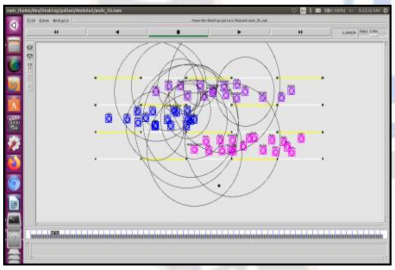
(a) Scenario 1



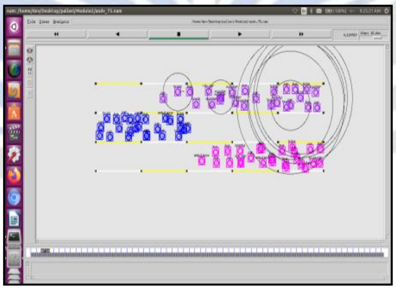
(b) Scenario 2



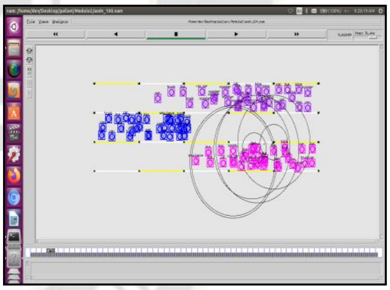
(c) Scenario 3



(d) Scenario 4



(e) Scenario 5



(f) Scenario 6

Figure 4 (a) to (f): Module 2- Simulation Analysis

The simulation was conducted with different numbers of vehicular nodes ranging from 20 and 40 in Module I. The data obtained via awk scripts have been drawn to MS Excel to draw the graphs. Regarding the three parameters considered in Module I, it can be found that AODV performs better than the other routing protocols namely AOMDV and DSDV routing protocols.

Figure 5(a) to 5(c) shows the graph obtained for routing protocols performance in Module 1. Figure 5(a) shows the throughput parameter graph for three routing protocols which is measured in kbps. The results of the simulation show that AODV consistently achieves the highest throughput, followed by AOMDV and then DSDV. Figure 5(b) shows the packet delivery ratio parameter graph for three routing protocols which is measured in percentage. The results of the simulation show that AODV consistently achieves the highest packet delivery ratio, followed by AOMDV and then DSDV. Figure 5(c) shows the end-to-end delay parameter graph for three routing protocols which is measured in milliseconds. The results of the simulation show that AODV consistently achieves the lowest end-to-end delay, followed by AOMDV and then DSDV.

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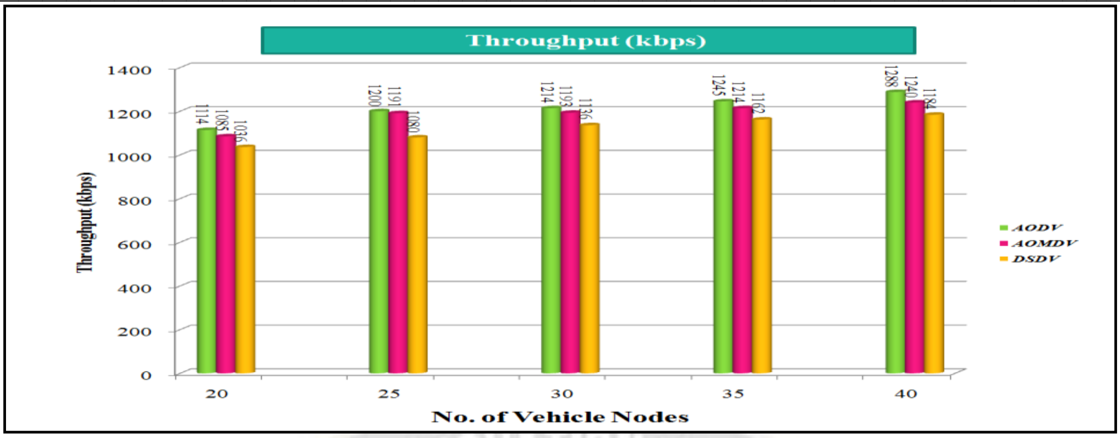
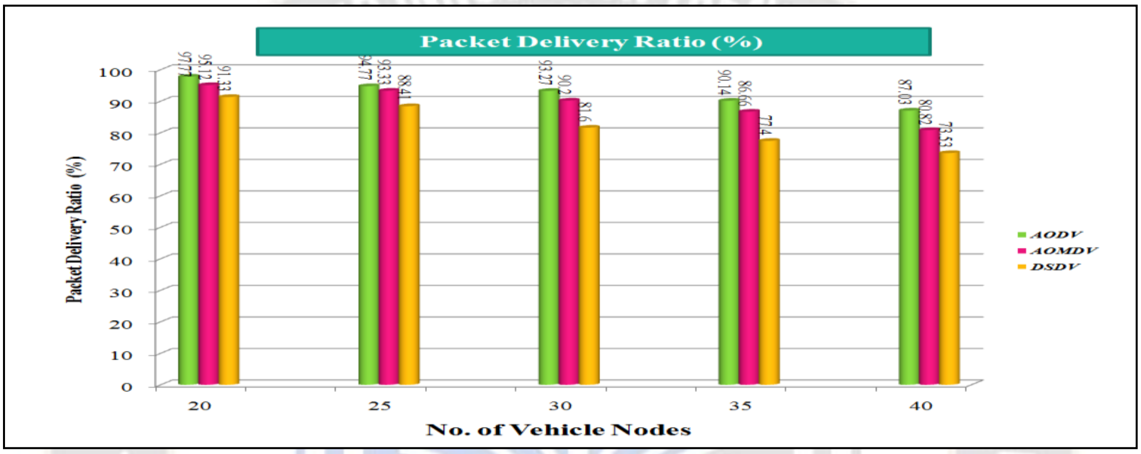
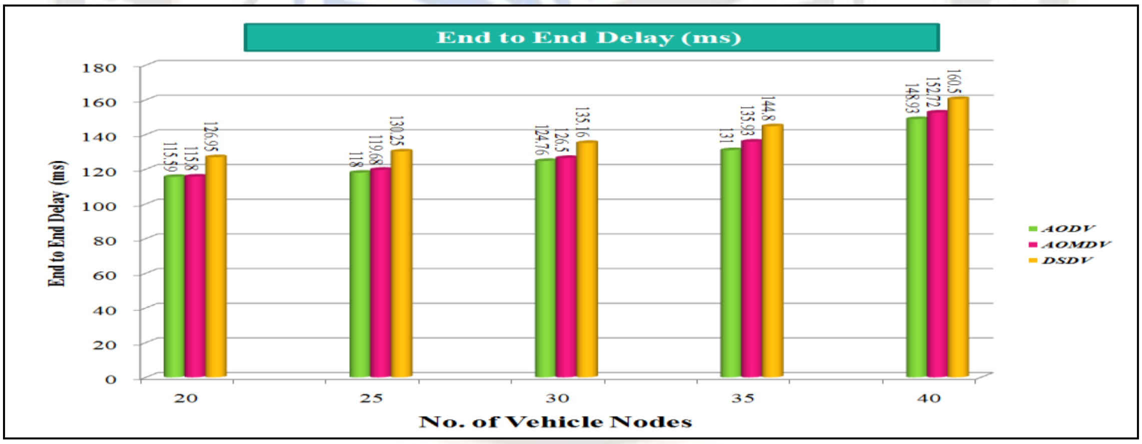


(a) Module 1- Throughput



(b) Module 1- Packet Delivery Ratio



(c) Module 1- End-to-End Delay

Figure 5 (a) to (c): Module 1- Result Analysis

The simulation was conducted with different numbers of nodes from 10 to 100 in Module II. Figure 6(a) to 6(e) shows the graph obtained for routing protocols performance in Module II. Figure 6(a) shows the packet delivery ratio parameter graph for three routing protocols which is measured in percentage. The results of the simulation show that AODV consistently achieves the highest packet delivery ratio, followed by AOMDV and then DSDV. Figure 6(b) shows the end-to-end delay parameter graph for three routing protocols which is measured in milliseconds. The results of the simulation show that AODV consistently achieves the lowest end-to-end delay, followed by AOMDV and then DSDV. Figure 6(c) shows the throughput parameter graph for three routing protocols which is measured in kilobits per second. The results of the simulation show that AODV consistently achieves the highest throughput, followed by AOMDV and then DSDV. Figure 6(d) shows the routing overhead parameter graph for three routing protocols which is measured in ratio. The results of the simulation show that AODV consistently achieves the lowest routing overhead, followed by AOMDV

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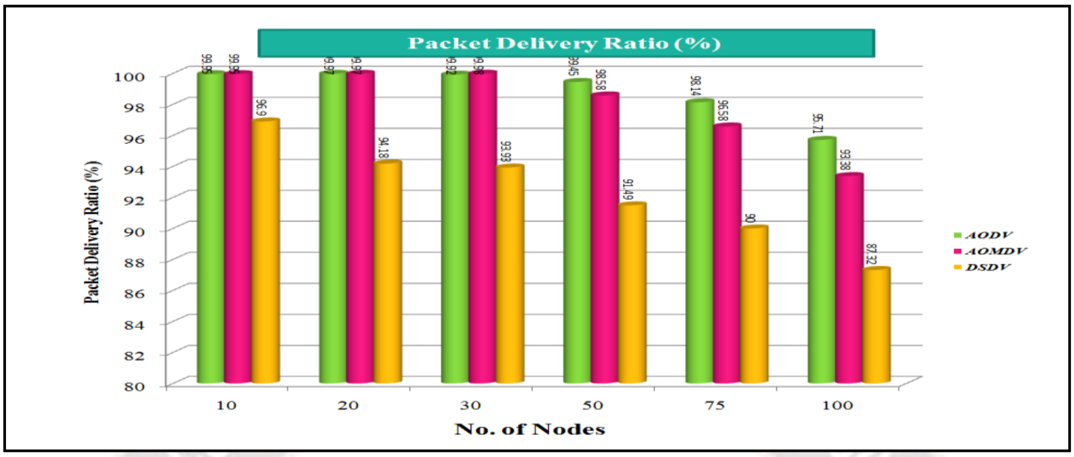
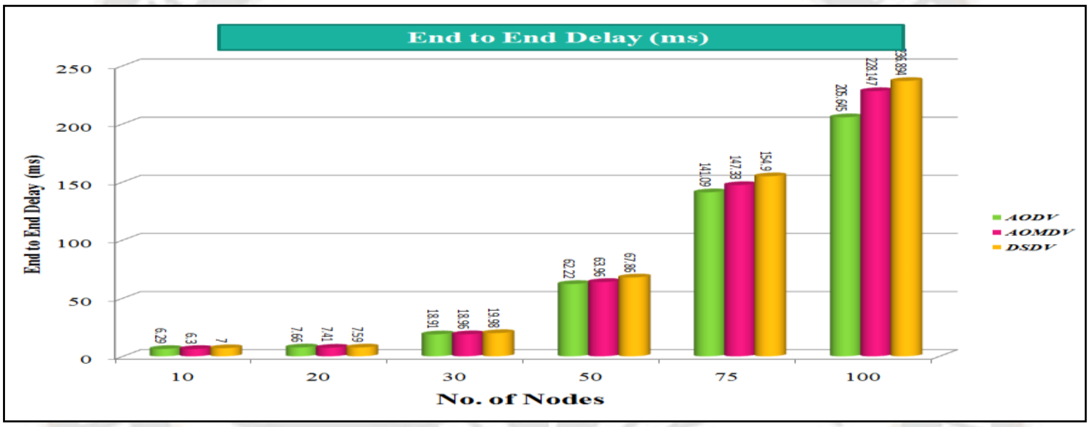
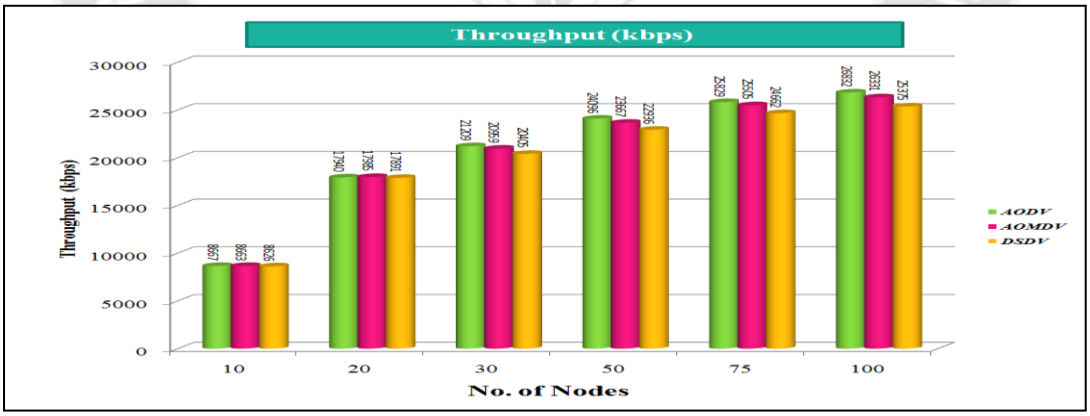
and then DSDV. Figure 6(e) shows the normalized routing load parameter graph for three routing protocols which is measured in ratio. The results of the simulation show that AODV consistently achieves the lowest normalized routing load, followed by AOMDV and then DSDV.



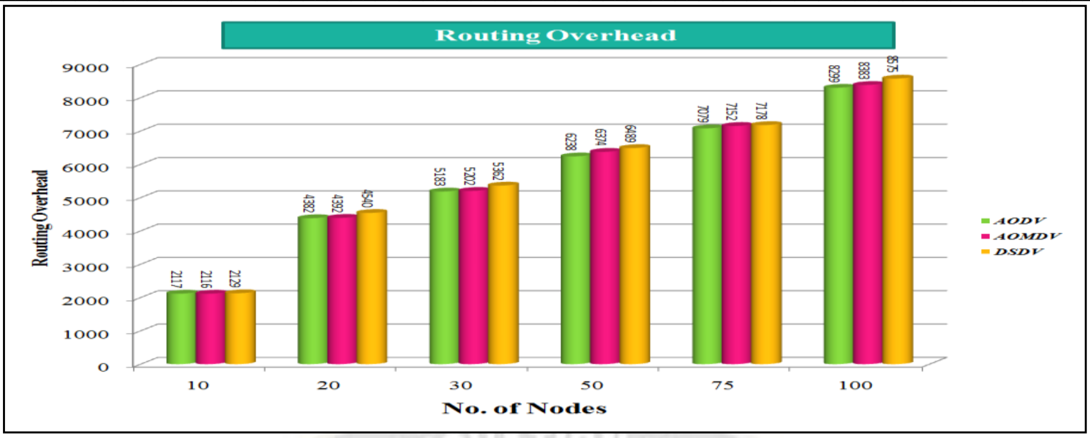
(a)Module 2- Packet Delivery Ratio



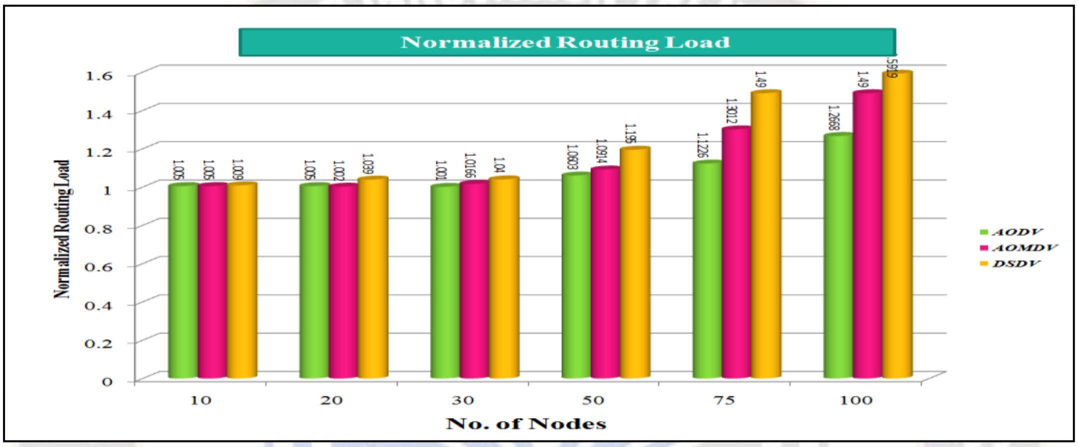
(b) Module 2- End-to-End Delay



(c)Module 2- Throughput



(d)Module 2- Routing Overhead



(e)Module 2- Normalized Routing Load

Figure 6 (a) to (e): Module 2- Result Analysis

The results of the simulation show that AODV consistently achieves the highest throughput, packet delivery ratio and lowest end to end delay, routing overhead & normalized routing load followed by AOMDV and then DSDV. Module I and Module II shows that AODV is performing well than AOMDV and DSDV routing protocols. The choice of preference of routing protocols should be order of following:

AODV > AOMDV > DSDV

V. Conclusion & Future Directions of Research

In In this research work, two modules, Module I and Module II have been discussed. Module I is focused on finding the right kind of routing protocol that is more suitable for ITS-based VANETs. So, in the initial phase of research work, three routing protocols have been considered which are both proactive and reactive kind in nature. AODV is a reactive kind of routing while DSDV and AOMDV are proactive kinds of routing. Since to carry out simulation, network simulator 2 is chosen which is felt tough at the initial phase only three parameters are tested for re-routing of vehicles at accidental scenario purpose with less number of nodes in Module I. Three parameters namely Packet Delivery Ratio, Throughput, and Average End to End Delay have been evaluated among three routing protocols in Module I and it is found that AODV is a better choice when compared with the other two routing protocols.

Module II is focused on finding the best routing protocol that is scalable in nature i.e. which routing is best suited for ITS-based VANETs at Highway scenario when the number of nodes is increased in a network. So again the same three routing protocols are considered but in Module II, the number of nodes is varied from 10 nodes to 100 nodes. Additionally, two more parameters are evaluated namely Normalized Routing Load and Routing Overhead. Here again, in Module II, AODV routing is found to be a better choice when compared with the other two routing protocols.

The future work is decided to design a new routing protocol that would be capable of sending safety messages and speed information to vehicles in the VANET network. Additionally, future research may explore the use of machine learning and artificial intelligence techniques to improve the performance of routing protocols in vehicular networks.

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