Performance Evaluation of IEEE 802.11p MAC Protocol for VANETs

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Abstract: ***VANETs is an emerging new technology which integrates the capabilities of new generation wireless networks to vehicles. Vehicle safety has always been a major concern for automotive engineers. Information about one vehicle can be forwarded to another vehicle using the IEEE 802.11p standard protocol, providing a driver or autonomous vehicle with information regarding speed and direction of the approaching vehicle. In this paper, The latest NS-2 distribution package version 2.34 supports simulation of IEEE 802.11p and provides significantly high level of VANETs simulation accuracy. This paper evaluates the performance of IEEE 802.11p Mac protocol by comparing performance of two routing protocols AODV and DSDV this is done by analyzing three performance metrics throughput, packet loss and average end to end delay.***

Keywords: VANETs, IEEE 802.11p, VanetMobiSim, NS-2.

1. Introduction

Vehicles are the most popular means of transportation around the world as the number of vehicles are increasing significantly on the road, its popularity has led to serious troubles and concerns these days, for instance: growing the number of road accidents, raising the cost in terms of victims and insured people, Increase in the traffic congestion on the roads, Lack of parking space, Difficulty in predicting the speed of other vehicles and safety distance.

As vehicle industry is moving significantly towards advanced safety, many researchers have been carried out in order to develop solutions aimed at helping driver. Current safety technology systems (e.g. airbag, seatbelts, ABS, EPS) support drivers and passengers in critical condition to avoid or mitigate accident. However, they cannot eradicate problems completely.

One of information and communication technology which has attracted a lot of attention recently is Intelligent Transportation System (ITS). This technology enhances transportation safety, reliability, security and productivity by integrating with existing technology, for example computational, wireless communications, satellite and sensing. With the development and growth of wireless communication, it has recently become the main technology for implementing various kinds of application for future Intelligent Transportation Systems. Accordingly, considerable research effort has been carried out in order to use wireless communication in the area of ITS. One of the outcomes which have improved the deployment of ITS applications is wireless data communication between vehicles.

This communication is divided into two types:

- **Vehicle to Vehicle (V2V)**: vehicles communicate directly with neighbour vehicles,
- **Vehicle to Infrastructure (V2I):** two vehicles communicate indirectly by third party medium (e.g. roadside equipment).

Vehicles are equipped with short-range wireless communication technology (approximately 100 to 300 meters) acting as computer nodes on the road. This is known as vehicular ad hoc network (VANET) technology.

1.1 Vanet Architecture

There are three primary components of the VANET: onboard unit (OBU), roadside unit (RSU), and the backhaul network. and two classifications of the VANET architecture from vehicular communication perspective: the road-vehicle communication (RVC) and inter-vehicle communication (IVC) according to Liu et al. (2009)[14] Liu et al. (2009) noted that the network architecture comprises of the physical layer (PHY), the media access control (MAC) layer, the network layer, the transport layer, and the application layer. Figure 1.1 indicated inter-vehicle and vehicle-base station communication. Each vehicle has its individual on-board units for communication and system interface.

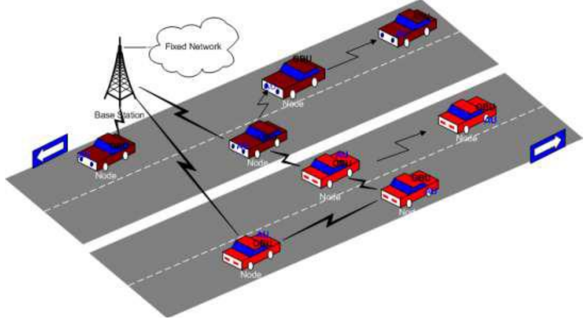

Figure 1.1: Vanet Architecture[15]

2. Challenges and requirements in Vanet

- **Signal fading:** objects between two communicating devices work obstacle and preventing signal from reaching its correct destination and increasing fading.
- **Bandwidth limitations**: It is an important issue in VANET is absence of a central coordinator which controls the communication between nodes and manages bandwidth.
- **Connectivity:** owing to the high mobility and rapid changes of topology causes the NW fragmentation and loose the connectivity. Connectivity is important to increase the transmission power.
- **Security and privacy issue:** keeping privacy and security is one of the most challenge in VANET the receipt of trustworthy information from it source however this trusted information can violate the privacy needs of the sender
- **Routing protocol**: it is a critical challenge to design an efficient protocol that can deliver a packet in minimum period of time. However many researcher have concentrated on designing routing protocol suitable for dense environment that have a high density of vehicle with close distance between them .
- **Effective Protocol:** Enhance the reliability and reduced the extent of interference cause by high building taking scalability into consideration is essential to avoid conflicts delivery of packet into short time specially in emergency.

3. Related Work

The project Co-operative Systems for Intelligent Road Safety [1] focuses on innovative telematics applications for cooperative traffic management. From a communication perspective, it therefore primarily addresses vehicle-to-roadside communications and makes use of CALM (Communication Architecture for Land Mobile environment) standards like the CALM infrared communication interface. CALM is the ISO TC 204 (ITS) Working Group 16 (Communication) on „Continuous Air interface for Long and Medium distance". CALM aims to support continuous communications for vehicles by making use of various media and communication interfaces. The author in [2] was the first tool created for evaluation of VANET performance mainly motivated by vehicular traffic flow and forecasting. The concept of application involves testing the possibilities of real time events as time-critical safety messages. GrooveSim was coded in C++ and Matlab provides GUI for drawing structures and graphs. GrooveSim could operate in five different modes: predetermined, on-road, simulation, hybrid, and research. A group of five vehicles travelling around the city and highway were simulated for recording certain parameters like message penetration, delay, vehicle grouping, packets dropped etc and packet time to live values were calculated in the simulator. GrooveSim did not include any network simulator and also it was unable to create traces for any network simulator. NHTSA (National Highway Traffic Safety Application) [3] provided VANET estimation and focused on a global perception of VANET performance. This platform is a computer-based tool and accepts a text file during vehicular simulation. The NHTSA simulator was designed with networking research in mind and was built on the top of NS-2 simulator. The simulator is platform-independent and is capable to run on both Win32 as well as Linux. It has strong GUI support implemented by C++. The main purpose of NHTSA project was to promote DSRC standardization, and during the test-bed, a GPS receiver, Windows-based notebook and IEEE 802.11a wireless device were used as a hardware module for DSRC standard. The platform is very scalable and flexible for researchers to alter the configuration according to the requirements. This project was aimed to provide a platform based on simulation results from simulation tools and a software prototype called FleetNet Demonstrator FND [4, 5]. The development of this software was aimed to state the problems found in inter-vehicular communication and realistic evaluation of VANET. The focus of this project was primarily on how mobility is achieved with position based routing protocols. The demonstrator of the project performed an outdoor experiment with six vehicles. Each vehicle had two laptops, one as a Linux system for the communication between the vehicles and vehicular to infrastructure through WIFI card. The other laptop had a Windows system to provide a GUI for vehicular communication as well as communication with the GPS receiver. The demonstrator concluded some results by inspecting the vehicular behaviour on highways and in the city, the transmission of data, velocity and distances amongst vehicles. [6] is a German project from the Federal education and research government, founded by automobile manufacturers, telecommunications operators and academia. NOW is the successor of FleetNet Project and supports and strongly cooperates with the Car2Car consortium. One of NOW"s main objectives is the implementation of communication protocols and data security algorithms in vehicular network. Considering the wireless 802.11 technologies and location-based routing in a V2V or vehicle to infrastructure communication context, the goal is to implement a system of reference and to contribute to the standardization of such a solution in Europe in collaboration with the Car2Car consortium. GST (Global System of Telematics) [7] is an EU-funded Integrated Project that is creating an open and standardized end-to-end architecture for automotive telematics services. Participants were major car manufacturer and major Telecom players, altogether around 60 companies. The purpose of GST is to create an environment in which innovative telematics services can be developed and delivered cost-effectively and hence to increase the range of economic telematics services available to manufacturers and consumers. GST has introduced seven service-oriented sub-projects that seek to contribute to achieving the main targets: rescue, safety, payment, safety channel or extended floating car data. The [8] communication group is an organization instigated by European vehicle manufacturers that is open for providers, research associations and other partners. Car2Car uses IEEE 802.11 WLAN technology for the vehicles to correspond with each other within the range of hundred meters and forms an ad hoc network. The routing algorithm verifies the location and speed of a vehicle and is able to oppose changing in the topology if any. In[9] [10] [11] have studied the performance of 802.11p; however, they do not support realistic vehicular mobility simulation. In[12] the authors present a comprehensive evaluation and simulative review of the performance of 802.11p and WAVE protocols supporting realistic vehicular mobility model. In [13] in terms of modelling accuracy, a new model of IEEE 802.11 MAC and PHY, which support IEEE 802.11P, is designed and implemented in NS-2 network simulator version 2.34. This version of NS-2 network simulator is used in this paper.

4. Methodology

Firstly the city scenario must be defined in XML file, this file consists of number of vehicles, traffic lights, seed value, area and simulation time, etc.. Once the scenario file is configured with the entire values next step is to run VanetMobiSim. After the completion of the simulation for a given period of simulation time a file is created this file contains the mobility traces for NS-2 simulation. Then step we should define the communication and network configuration. This file must be defined using Tcl programming language. Then Next step is to run Tcl file in NS-2. After the execution, trace file is created this trace file provides the full detail about the events occurred during the simulation time**.** In order to analyze the events occurred throughout the simulation, extraction of the appropriate information from the trace file is needed. To extract the information from the trace file awk utility script is required. Then we need to run awk file with the trace file to get the result. And the result generated is stored in .txt format.

4.1 Snapshots of the Project Execution

Once the city scenario is configured then next step is to run VanetMobiSim as shown in Fig 4.1(a).

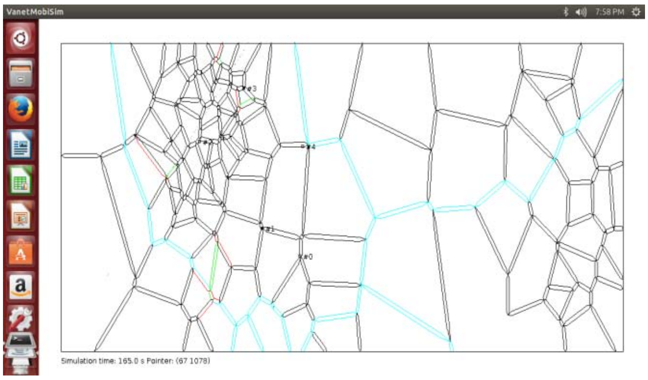

Figure 4.1(a): Screenshot of Node Movements in VanetMobiSim

After the scenario file is generated then step is to define communication and network configuration in Tcl script and run that in NS-2 as shown in figure 4.1(b).

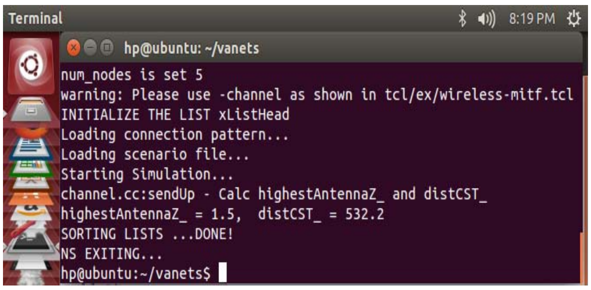

Figure 4.1(b): Screenshot of NS-2 shell launching

After the execution the trace file is created. To extract the values from the trace file awk script is used as shown in the figure 4.1(c).

Figure 4.1(c): Screenshot of AWK shell launching

After running the awk script with trace file The result is generated in .txt format as shown in figure 4.1(d).

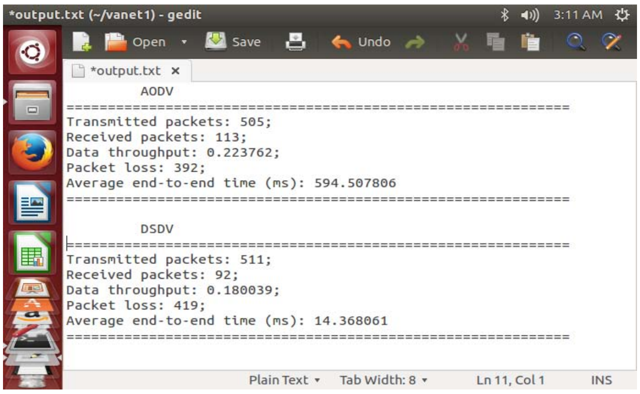

Figure 4.1(d): Screenshot of the generated result

4.2 Proposed System

- To minimize the accidents cases the knowledge of the ongoing traffic is very much necessary. Hereby scenario file is generated from the VanetMobiSim to define vehicle movement to see whether the vehicles are coming from both directions or not.
- By implementing the traffic light signal we want to assure that no two or more vehicles coming from opposite side are on the same Lane causing accident scenario.
- Whenever a vehicle is going in one lane then no other vehicle coming from opposite direction are allowed to use that lane.

5. Results Analysis

5.1 Performance Metrics

- **Throughput -** Throughput is the measure of how fast we can actually send packets through network. The number of packets delivered to the receiver provides the throughput of the network. The throughput is defined as the total amount of data a receiver actually receives from the sender divided by the time it takes for receiver to get the last packet.
- **Packets Loss -** Some of the packets generated by the source will get dropped in the network due to high mobility of the nodes, congestion of the network etc.
- **Average End-to-End Delay –** End-to-End delay indicates how long it took for a packet to travel from the source to the application layer of the destination. I.e. the total time taken by each packet to reach the destination. Average End-to-End delay of data packets includes all possible delays caused by buffering during route discovery, queuing

delay at the interface, retransmission delays at the MAC, propagation and transfer times.

5.2 Simulation Parameters

The following table 5.2 shows the parameters used for the simulation.

Table 5.2: Simulation Parameters

Serial No	Parameters	Values
1	Number of Vehicles	5,10,15,20,25,30
2	Area	3000*1000m2
3	Simulation Time	1000sec
4	Traffic Source	CBR
5	Packet Size	32 bytes
6	Traffic Lights	6
7	Mac Layer	IEEE 802.11p
8	Protocols	AODV,DSDV
9	Maximum Speed	13.89 m/s

5.3 Simulation Analysis

- **Throughput**

In Figure 5.3(a) the throughput of IEEE 802.11p Mac Protocol using AODV and DSDV protocols are specified. Here the number of vehicles varies from 5 to 30. In the graph horizontal axis represents the number of vehicles and vertical axis represents throughput. In the graph AODV exhibited the highest throughput compared to DSDV routing protocol.

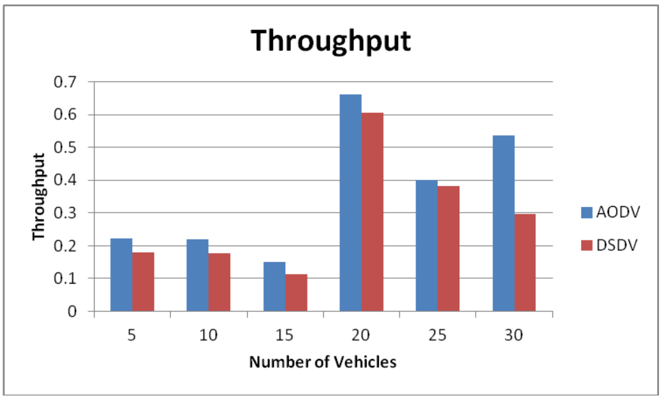

Figure 5.3(a): Throughput versus Number of Vehicles

- **Packet Loss**

In Figure 5.3(b) the packet loss of IEEE 802.11p Mac Protocol for AODV and DSDV protocols are specified. Here the number of vehicles varies from 5 to 30. In the graph horizontal axis represents the number of vehicles and vertical axis represents packet loss. In the graph packet loss is less in AODV compared to DSDV routing protocol.

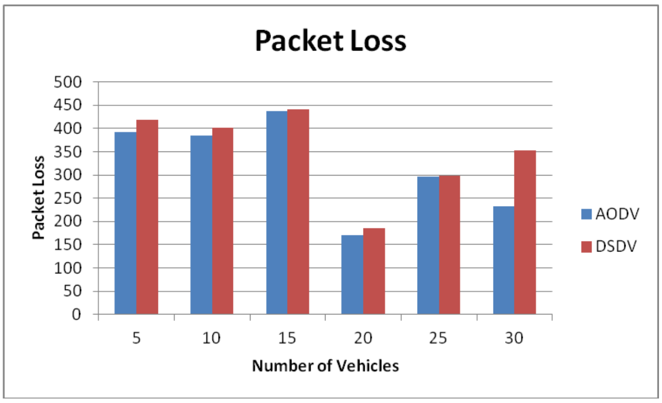

Figure 5.3(b): Packet loss versus Number of Vehicles

- **Average End to End Dealy**

In Figure 5.3(c) the packet loss of IEEE 802.11p Mac Protocol for AODV and DSDV protocols are specified. Here the number of vehicles varies from 5 to 30. In the graph horizontal axis represents the number of vehicles and vertical axis represents Average End to End Delay. In the graph Average End to End Delay is more in AODV compared to DSDV routing protocol.

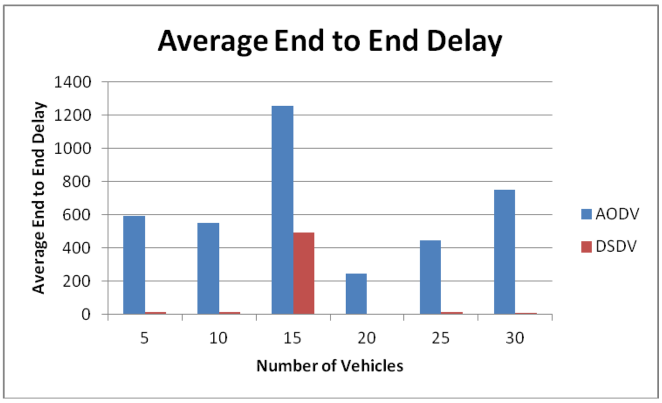

Figure 5.3(c): Average End to End Delay versus Number of Vehicles

6. Conclusion

In this paper we studied the IEEE 802.11p standard for vehicular adhoc networks (VANET). It was mentioned that the fundamental nature of the vehicular safety communication is based on broadcast messages which are exchanged between neighbouring vehicles. This paper evaluates the performance of IEEE 802.11p Mac protocol by implementing the key parameters of 802.11p in NS-2 using realistic vehicular mobility model generated by VanetMobiSim traffic simulator. To evaluate the performance of IEEE 802.11p Mac protocol there are three performance metrics throughput, packet loss and Average end to end delay. After the scenario is implemented these performance metrics are analyzed. Here we have evaluated the performance of IEEE 802.11p Mac Protocol in two different cases one is with the AODV protocol and another case is with the DSDV protocol using the three metrics and compared the performance in two cases. Finally after comparing with the two routing protocols the conclusion is for IEEE 802.11p Mac Protocol throughput is high in AODV compared with DSDV, packet loss is less in AODV compared with DSDV and average end to end delay is high in AODV compared with DSDV.

7. Future Scope

The Vehicular network communication is a wide area and there are still a lot of open problems in this network, for instance security and privacy issues are the most challenging topics in this area. Vehicular safety communications consist of periodic broadcast messages between neighbouring vehicles, so there is a possibility of different security attacks on VANETs. Consequently, it is crucial to develop an appropriate security architecture for vehicular communication.

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