International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 7, Issue 7, July 2017)

Performance Evaluation of IEEE 802.11 And Ieee802.11p for Vehicle to Vehicle Communication using AODV Routing Protocol

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***Abstract*— A Vehicular Ad-Hoc Network (VANET) is an emerging worldwide communication mechanism established between vehicle to vehicle and road-side base stations. A vehicle in VANET is considered to be an intelligent mobile node capable of communicating with its neighbours and other vehicles in the network. High speed and frequent network topology changes are the main characteristics of vehicular networks. These characteristics lead to special issues and challenges in the network design, especially at the medium access control (MAC) layer. Due to high speed of nodes and their frequent disconnections, it is difficult to design a MAC scheme in VANET that satisfies the quality-of-service requirements in all networking scenarios. In this paper, we provide a comprehensive evaluation of the mobility impact on the IEEE 802.11 and IEEE 802.11p MAC performance. To evaluate the efficiency and suitability of mobility models, this paper compares the performance of IEEE 802.11 and IEEE 802.11p standards using AODV protocol. The study is evaluated using the performance metrics Packet Delivery Ratio, Dropped packets, Delay and Routing overhead.**

***Keywords*—VANET, AODV, ITS, AODV, 802.11, 802.1Ip, vehicular communication.**

I. INTRODUCTION

Vehicular Ad Hoc Networks (VANET) is technology that integrates the capabilities of new generation wireless networks to vehicles. In VANET, the communication is established among nearby vehicles and adjacent fixed Road Side Units (RSU). The vehicles in the network have high mobility, and hence they enter and leave the network dynamically VANET can achieve affective communication between moving vehicle by using different ad-hoc networking tools such as IEEE 802.11 b/g, WiMAX IEEE 802.10, Bluetooth, IRA, [1]. Vehicular Ad-hoc is widely finding application in areas such as traffic and road safety, Toll collection, tourist guiding information and natural hazards [2]. VANET is mainly designed at providing safety related information and traffic management. Sample VANET architecture is shown in figure 1.

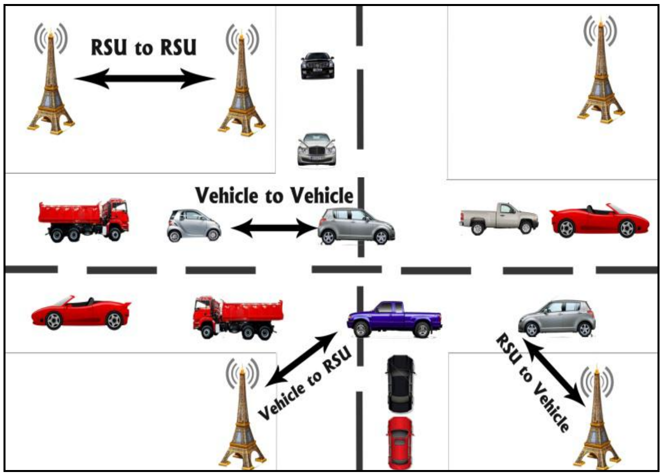


Figure 1 Sample VANET Architecture [3]

The vehicles act as mobile nodes and RSUs act as static nodes. Both the vehicles and RSUs are responsible for communicating the information about the happenings that occurs in the vicinity area. There exist three types of communications.

- Vehicle to Vehicle (V2V) Communication.
- Vehicle to Infrastructure (V2I) Communication.
- Infrastructure to Infrastructure (I2I) Communication.

When the vehicle enters the RSU's vicinity, RSU sends a HELLO message to the vehicle in order to verify the identity. After verifying the identity, it stores the details related to the vehicles for further references. When two vehicles moves apart from each other and if they cannot exchange or share information directly, they use the intermediate vehicles or RSUs for communication. RSU to RSU and Vehicle to RSU communications takes place to cross check the identity of vehicles passing them. Developments in Vehicular Communication pave the way for Intelligent Transportation Systems (ITS). Vehicles in the network can communicate with each other through Inter Vehicle Communication (IVC) as well as with the Road Side Unit (RSU)[4].

Vehicular Ad-hoc Networks is a spontaneous network based on direct vehicle to vehicle communication with continuously altering topology due to high mobility of vehicles on the road. To implement the applications such as safety, driver assistance, entertainment and many other Intelligent Transport System applications in vehicular environment some protocols should be encouraged to take full benefit of the communication between the Vehicle to Vehicle and Vehicle to Infrastructure (V2V or V2I) communications. Hence IEEE has proposed a family of standards called as Wireless Access in the Vehicular Environment (WAVE) that can be used for establishing the vehicle to vehicle communication. Hence in this paper, a sample VANET environment has been created to study the performance of the reactive routing protocol AODV using IEEE 802.11 and IEEE 802.11p standards.

The rest of the paper is organized as follows; Section II provides an overview of the contribution of various researchers towards VANET architecture, their specifications, and protocols used for communication. Section III presents an overview of the IEEE 802.11p standards and compares with IEEE 802.11 standards. Section IV describes the performance evaluation of AODV in VANET using IEEE 802.11 and 802.11p standards and the paper concludes in Section V.

II. REVIEW OF LITERATURE

Fernando A. Teixeira et al [5] presented the performance measurements obtained through off-the-shelf IEEE 802.11p devices. The study conducted various field experiments using the UDP protocol, since it the most suitable transport protocol for driver assistance and road safety applications. The performance measured bit rate, delay, jitter, loss rate and the average time of association between two 802.11p devices. The results showed that IEEE 802.11p with 500 byte frames obtained the best performance, followed by the 150 byte frames, which presented an average bit rate which is about 60% lower. Although the bit rate for 1460 byte frames was higher, the behaviour for 500 bytes was less variable.

B. Ramakrishnan et al [6] discussed the comparative analysis of Cluster based Simple Highway Mobility model with standard 802.11p over the standard 802.11. The VANET MAC layer standard 802.11p is used to measure the Throughput, Packet delivery ratio, Broadcasting time, Normalized routing load for various clusters. These values are compared with the values obtained using 802.11. The simulation result gives that the proposed model with 802.11p has outperformed the result obtained using 802.11.

Ederval Pablo Ferreira da Cruz et al [7] evaluate AODV and OLSR topology-based protocols under 802.11a and802.11p in an urban scenario considering different vehicle density. VANETs have a high dynamic topology, where AODV protocol suffers to maintain routing table constantly updated increasing signalling control messages. For most of the metrics evaluated, it concluded that OLSR has better performance that AODV, mainly when 802.11p is used showing that OLSR can be an alternative to use in VANETs.

N. Mahajan et al [8] describes that the main purpose of VANET is to provide ubiquitous connectivity while on the road to the mobile users. AODV can perform better for IEEE 802.11p than WAVE under high mobility conditions. If number of nodes is increased AODV can perform well. AODV has better Throughput and packet delivery ratio for IEEE 802.11p than WAVE. Link failure requires new route discoveries in AODV as it has almost one route per destination vehicle in its routing table. DSDV is better choice if delay is main concern. And DSDV is worst for dropped packets. The performance degrades with increase in number of nodes. It is concluded that overall performance of AODV with IEEE 802.11p is superior.

Saurabh D. Patil et al[9]describe how to generate the realistic mobility model and test computational experiment based simulations, using NS-2.34, compares the performance of two major routing protocols AODV and DSR under 802.11p (DSRC/WAVE) and 802.11a. The results shows packets delay and packet delivery ratio of AODV and DSR under 802.11p and 802.11a. It was concluded that 802.11p is more suitable than 802.11a for VANET.

Rasha Kaiss Aswed et al [10] compared the analysis of three routing protocols AODV, OLSR and DYMO using two MAC protocols IEEE 802.11p and IEEE 802.11g by varying the number of vehicle. The results show that AODV outperforms OLSR, DYMO in term of average throughput and OLSR has the lowest throughput than AODV and DYMO. In term of end to end delay, AODV has the highest delay. The study was concluded that performance of all routing protocol using 802.11p is higher than IEEE 802.11g in terms of end to end delay. The average throughput of OLSR and DYMO using IEEE 802.11p is higher than DYMO and OLSR using IEEE 802.11g, but the average throughput of AODV using IEEE 802.11g is higher than AODV using IEEE 802.11p.

Prerana Deshmukh et al [11] propose a modification on AODV as MANET routing protocol to make it adaptive for VANET and augmenting to minimize the energy consumption with improved efficiency.

In the proposed methodology, the direction of the node is considered as the most important parameter to select the next hop during a route discovery phase in location based clustering approach. An enhanced AODV protocol that will improves the performance issues on common AODV protocol using location based mechanism so as to improve the route discovery phase and will also contribute to minimize the energy consumption required during the data transmission phase by incorporating two tier mechanisms. The proposed system will enhance protocol to work well in various traffic situations, the overhead of each route in AODV will be less.

III. IEEE 802.11 STANDARDS

The IEEE 802.11 standards used in MANET is also applied in VANET. The main function of IEEE 802.11 standard is that each mobile node checks the transmission of medium before transmitting the packets. If the medium is idle for certain duration of time the node can transmit the packet immediately. If not it retransmits the packets after some time [12].

A. IEEE 802.11p Standard

DSRC refers to Dedicated Short Range of Communication which is medium ranged wireless communication channel particularly designed for the vehicles to communicate. The nodes in the VANETs are mobile and there are numerous challenges to determine the efficiency of the network such as speed of the vehicle, traffic pattern, and mobility. To overcome these challenges IEEE 802.11b was updated to IEEE 802.11p that works on data link and physical layer which can be used for reliable communication between vehicles moving at high speeds. IEEE 802.11p standard uses channels of 10MHz band width in the 5.9GHz band (5.850-5.925 GHz)[13]. The WAVE model and OSI reference model is compared in figure 2.

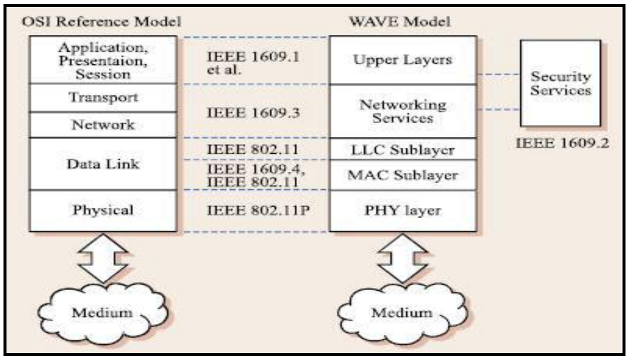


Figure 2 OSI reference Model and WAVE Model[14]

B. Comparison between IEEE 802.11 and IEEE 802.11p

IEE802.11p is the new extension of IEEE 802.11 standards, especially proposed for the high vehicular environment. The WAVE documentation represents enhancements to the MAC and PHY layer of IEEE 802.11 to work efficiently in high vehicular environment. The parameters used in 802.11p is summarized and compared with 802.11 in Table 1.

TABLE 1
Comparison of 802.11 and 802.11p[15]

Parameters	**802.11**	**802.11p**
Bit rate (Mbits/s)	6,9,12,8,24,34,54	3,4,5,9
Modulation model	Bpsk Qpsk 16-QAM 64-QAM	Bpsk Qpsk 16-QAM 64-QAM
Code rate	1/2,2/3,3/4	½,2/3,3/4
No of sub carriers	52	52
Symbol duration(μs)	4	8
Guard time(μs)	0.8	1.6
FFT period(μs)	3.2	6.4
Parameter duration time(μs)	16	32
Sub carrier spacing	0.3125	0.15625

In this paper, the IEEE 802.11p is applied to the reactive protocol AODV and compared with IEEE 802.11 standard to find its suitability in VANET environment. The performance of the AODV is studied using the performance metrics Packet Delivery Ratio, Dropped Packets, Delay and Routing Overhead.

IV. PERFORMANCE EVALUATION

The performance of the AODV protocol has been evaluated by considering 20 vehicles by varying transmission rate as 0.016, 0.032, 0.064, 0.128, 0.512 and 1Mpbs using 802.11 and 80211p Standards. The simulation parameters and simulation layout are shown in Table 2 and figure 3.

TABLE 2
Simulation Parameters

Parameters	Values
Simulator	NS-2
No of vehicle	20
Maximum Vehicle speed	60ms
PHY/MAC	IEEE 802.11/802.11p
Routing protocol	AODV
Traffic source	CBR
Simulation time	300 sec
Area	1000*1000m
Packet size	512 bytes
Transmission rate	0.016, 0.032, 0.064, 0.128, 0.512, 1 Mbps
Mobility model	Random way model

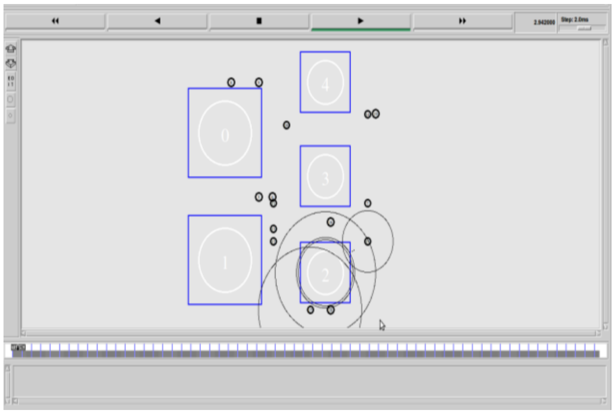


Figure 3 Simulation Layout

A. *Packet Delivery Ratio*

Figure 4 shows the packet delivery ratio for IEEE 802.11 and IEEE802.11p standard for AODV by varying transmission rate as 0.016, 0.032, 0.064, 0.128, 0.512 and 1 Mbps. From the graph it is clear that the AODV shows good results for the transmission rate less than 0.128 Mbps. The ideal range for packet delivery ratio is between the transmission rate 0.032 to 0.064 Mbps irrespective of IEEE standards.

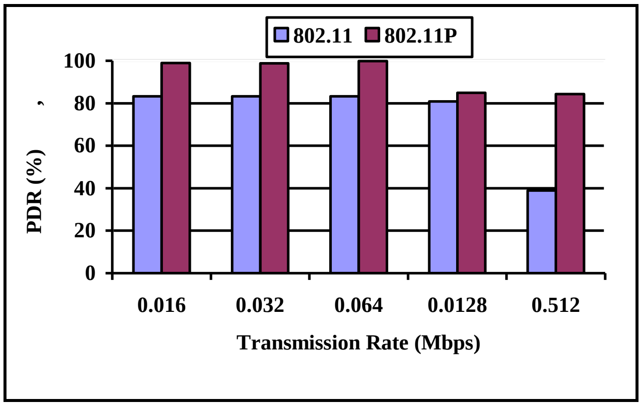


Figure 4 Transmission rate vs PDR (%)

A. *Dropped Packets*

Figure 5 shows the dropped packets for IEEE 802.11 and IEEE802.11p standard with AODV as the routing protocols by varying transmission rate as 0.016, 0.032, 0.064, 0.128, 0.512 and 1 Mbps. From the graph it is clear that the dropped packets value gradually decreases for the transmission rate less than 0.128 Mbps and does not show better results for the transmission rate greater than 0.064 Mbps irrespective of IEEE standards.

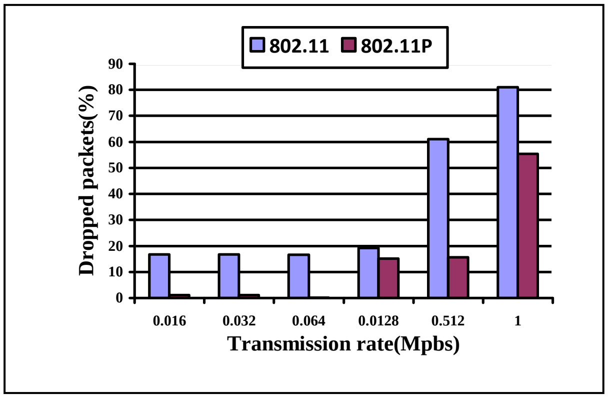
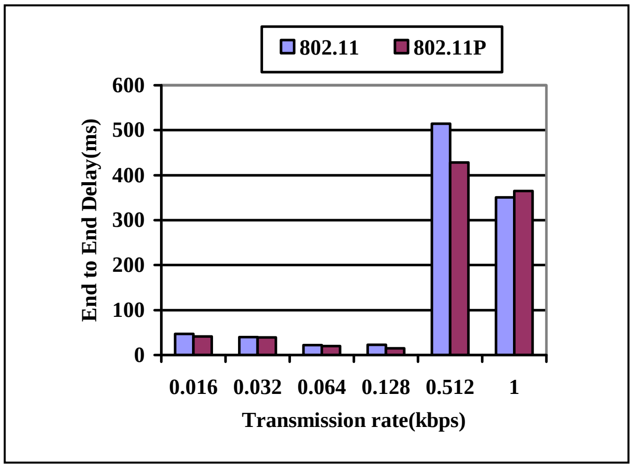


Figure 5 Transmission rate vs Dropped packets

B. End to End Delay

Figure 6 shows the End to End Delay for IEEE 802.11 and IEEE802.11p standard with AODV as the routing protocol by varying transmission rate as 0.016, 0.032, 0.064, 0.128, 0.512 and 1 Mbps. From the graph it is clear that the End-to-End delay gradually decreases for the transmission rate between 0.016 to 0.128 Mbps and does not show better results for the transmission rate greater than 0.128 Mbps irrespective of IEEE standards.



C. Routing Overhead

Figure 7 shows the Routing Overhead for IEEE 802.11 and IEEE802.11p standard with AODV as routing protocol by varying transmission rate as 0.016, 0.032, 0.064, 0.128, 0.512 and 1 Mbps. From the graph it is clear that AODV show acceptable results for the transmission rate less than 0.512 Mbps. The ideal range for Routing Overhead is between the transmission rate 0.032 to 0.128 Mbps irrespective of IEEE standards.

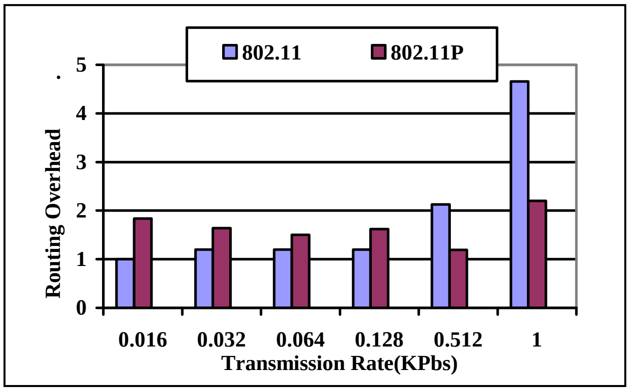


Figure 7 Transmission rate vs Routing Over Head

TABLE 3
Performance Improvement of IEEE 802.11p

Performance Metrics	IEEE 802.11	IEEE 802.11p	% of Improvement
Packet Delivery Ratio	83.33	99.82	19.78
Dropped Packets	16.67	0.18	98.92
End to End Delay	22.43	20.18	10.30
Routing Overhead	1.20	1.50	25

From the Table 3, it is clear that the reactive routing protocol AODV with IEEE 802.11p shows better results compared to 802.11 with 19.78% of increase in PDR, 98% of decrease in Dropped packet, 10.30 % decreased delay and 25 % of increase routing overhead compared to IEEE 802.11.

V. CONCLUSION

In this paper, the reactive routing protocol AODV is used to analyze its suitability in VANET environment using the IEEE 802.11 and IEEE 802.11p standards. The performance of the protocol was studied by varying the transmission rate as16kbps, 32 kbps, 64 kbps, 128 kbps, 512 kbps and 1 Mbps using the performance metrics Packet Delivery Ratio, Dropped Packets, Average End to End Delay and Routing Overhead.

From the obtained the results, it is evident that AODV shows acceptable results with the transmission rate as 64kbps for IEEE 802.11 and IEEE 802.11p standard. While analyzing the suitability of the IEEE standards for VANET, IEEE 802.11p best suits and shows 99.82% of PDR, 0.185 of Dropped Packets, 20.18ms of delay and 1.50 Routing overhead for 64kbps compared to IEEE 802.11 standard

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