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Performance Evaluation of MAC Aware QOS Provisioned Hybrid Routing over VANET

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Abstract

A vehicular ad-hoc network adopts some attributes of MANET and provides communication between high speed vehicles. VANET based communication can be classified into three categories i.e. Vehicle to Vehicle (V2V), Vehicle to Infrastructure and Hybrid which combines both V2V and V2I schemes. VANET has the potential of achieving goals of intelligent transport system (ITS) increasing road safety and transport efficiency. VANET though being a sub-class of MANET has distinguishing features that make routing in VANET a baffling problem. Timely and accurate information dissemination is the primary concern. QoS guaranteed routing with minimum packet collisions will increase the efficiency and throughput of the channel. Back-off algorithms are used to reduce the number of collisions when nodes try to access the channel simultaneously. In this paper, we deployed a back-off method called Modified Back-off algorithm (MBA) in the MAC layer of IEEE 802.11p. The simulations are carried out using NS-2 in order to study the behavior of hybrid routing protocol, ZRP with two different back-off mechanisms utilized at the MAC layer. Evaluations are done using Nakagami propagation model with different vehicle densities and packet sizes. The performance is investigated in terms of throughput, packet delivery ratio, routing load and end to end delay.

Keywords: *MANET, Nakagami, Modulation, MAC*

1. Introduction

VANET provides communication between the vehicles without using centralized scheduling and can be categorized into V2V, V2I and hybrid. In infrastructured networks, the vehicles communicate with a base station called the Road Side unit (RSU). In infrastructure less networks, the vehicles themselves act as transceivers capable of sending and receiving information without any RSU. V2X communication is a hybrid that utilizes both the schemes. It is an approach providing wireless links both between the vehicles as well as between vehicles and infrastructure. VANET supports the various applications related to traffic conditions, safety *etc*. Messages generated by these applications can be delivered by assigning the priorities to each one. These high priority messages are delivered in real time environment. High priority message flooding over VANET leads to collisions, packet loss, and degradation in network performance and also affects the Quality of Experience (QoE). All these issues can be resolved by developing a reliable MAC layer protocol which can easily adopt the dynamic environment. Researchers have enhanced the existing MAC 802.11 standard, called MAC 802.11p/ MAC 802.11e to ensure the QoS constraints. [1]

IEEE 802.11p Standard was developed by revising the existing IEEE 802.11a to provide the QoS support for the VANET based applications related to Intelligent Transportation Systems (ITS), driver's safety and assistance, speed management and

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location services etc. It operates on the channel of 10MHz bandwidth over 5.9 GHz bands [4]. The IEEE 802.11p uses physical layer as communication interface between the MAC layer and the wireless links which are based on OFDM modulation. It provides channel access mechanisms that permit the nodes to share the common channel.[2] The IEEE 802.11p physical layer utilizes the 64 subcarriers which can be modulated using BPSK and QPSK, 16-QAM or 64-QAM modulation schemes under the constraints of channel quality. [11]

VANET applications require accurate and timely delivery of data in order to provide safety and comfort applications. This necessitates QoS provision, high efficiency and throughput requirements. Thus, MAC layer also plays a key role in wireless communication. Most of the previous research done in this area makes use of the default parameters and ideal channel conditions. In this work, in addition to the default conditions, evaluations are also done in different situations involving variations in node density, packet size and modulation schemes. The results are jotted down for default back-off mechanism and the embedded MBA back-off method. Nakagami propagation model is used to provide for high level of realism. The main objective is to explore the impact of several conditions and back-off on the performance of ZRP. The results are obtained for throughput, packet delivery ratio, routing load and end to end delay. Optimum values of MAC and physical layer are identified as the result of the study. Further, achievable bounds for QoS in VANET using ZRP are suggested.

The remainder of the paper is organized as follows. Section 2 presents the related research work done with the objective to gain insight about the current state of art. Section 3 provides a brief description of the back-off methods used in this work. Section 4 presents the simulation environment. Section 5 discusses the results of the study. Section 6 finally concludes the paper.

2. Related Work

In previous research work [5] we did the performance analysis of various routing protocols that fall under different categories of reactive (AODV), proactive (OLSR) and hybrid (ZRP). We have used different constraints of node density variation, packet size variation and modulation variation with the mobility of 10m/s and Nakagami propagation model, in each case. We used NS-2 network simulator for simulation purpose. All the scenarios employed the default back-off method that exists in IEEE 802.11p MAC. From the results, it was inferred that ZRP had overall better performance than AODV and OLSR in the conditions adopted. This paper is an extension of our previous work. The aim is to further explore the hybrid routing protocol, ZRP that proved to be better than AODV and OLSR in our previous work .In this study, performance of ZRP is examined with default back-off method and the embedded MBA algorithm in IEEE 802.11 p MAC.

In order to investigate the present state of art for the suitability of routing protocols in VANET based applications, extensive survey has been done as mentioned below.

Tejpreet Singh *et al.*, [6] analyzed the performance of AODV, OLSR and ZRP protocols in security applications. The parameters –throughput, end to end delay and jitter were considered. Simulations were done in two scenarios: with and without wormhole attack. It was found that OLSR outperforms AODV and ZRP in case of wormhole attack.

Anwar Ul Haque *et al.*, [7] realized the importance of modulation in wireless networks. A model for implementing QPSK in NS-2 was presented. Further comparison between BPSK and QPSK modulation schemes was done to see the effect on data rate, error rate, SNR. QPSK appeared to be a good candidate for different types of topologies from the results obtained.

Pranav Kumar Singh [8] did another effort in assessing the impact of Two Ray Ground and Nakagami Model on the operation of protocols in VANET. AODV and OLSR protocols were evaluated in urban scenario. Packet Delivery ratio and end to end delay were calculated for Two Ray Ground and Nakagami by varying the number of nodes and connections. The authors finally concluded that Nakagami is more realistic and better suited in dynamic VANET scenarios. Lin Zhang *et al.*, [1] developed a solution which utilizes the both CSMA and TDMA together for concurrent channel scheduling and switching. This combination can easily slice the channel control intervals and the service control intervals, thus results in efficient broadcasting. Simulation results show its performance in terms of minimum delay, collision rate and maximum Throughput, as compared to IEEE MAC, SOFT MAC and VeMAC *etc*. Proposed work can be further extended to provide the support for RSU.

Mohammad M. Shurman *et al.*, [2] Proposed back-off mechanism to increase the channel efficiency and throughput and overcome packet collisions in MANET.

Saira Andleeb Gillani *et al.*, [3] explored the issues related to the application of VANETs which can affect the MAC performance. On the basis of requirements, they categorized these applications in to safety applications, User applications and traffic management *etc*. Each of this application type has different impact over the performance of MAC Layer. They explored the different MAC protocols *i.e.*, contention based, contention free and their combination can be termed as Hybrid MAC protocol.

Md. Habibur Rahman *et al.*, [9] explored the behavior of the various reactive and proactive routing protocols, MAC 802.11p etc. using different propagation and mobility models. They used periodic broadcast (PBC) agents to propagate the safety messages over network. Simulation results show that it could not perform well and results in reduction of QoS parameters *i.e.*, delay, jitter, load *etc*., and proposed solution also results in extra overhead over network and it is not suitable for real time VANET's applications and these issues can be explored further.

3. Back-off Algorithms

Back-off algorithms are used to reduce the number of collisions when nodes try to access the channel simultaneously.

3.1 Default Back-off Method

The default MAC back-off algorithm used by MAC 802.11ext, simply increments the contention window size by 1, every time, in constant manner. When it reaches upto CWmax, threshold value, it is reset to CWmin, and after that again incremented one by one in constant manner.

CW = CW+1
if CW > CWmax, then
CW = CWmin

3.2. Modified Back-off Algorithm

In this algorithm, the back-off time is increased exponentially but with a reduced base value (less than 2) after each unsuccessful transmission until prescribed maximum value (CWmax) is reached. Whenever a node transmits a packet successfully, back-off time is reduced to a specified minimum value (CWmin). [10] The CW is exponentially increased and then decreased to CWmin every time a node experiences a packet collision or success.

In case of collision :
CWnew =1.5 * CW * Slot Time
In case channel is idle:
CW= CWmin = 32

4. Simulation Environment

For the purpose of analyzing and evaluating the performance of ZRP to study the effect of back-off procedures, simulations are carried out using a popular discrete event simulator, NS-2 (Version 2.35). Two studies are done. Comparisons are done for ZRP between the default MAC back-off algorithm and Modified Back-off Algorithm (MBA) first under variable node densities, and then with different packet sizes. The following table will summarize the simulation parameters used.

Table 1. Simulation Parameters

Network Simulator	NS-2 (Version 2.35)
Wireless Terrain	1200x1200
Simulation Time	10 min
Routing Protocol	ZRP
Vehicle Density	30, 60, 90
MAC	MAC 802_11 Ext
PHY	WirelessPhyExt
Backoff Algorithms at MAC	Default , MBA back-off
Radio Propagation Model	Nakagami
Data Traffic Source	UDP,CBR
Packet Size	256,512,1024 Bytes
Modulation Scheme	BPSK
Speed of Vehicle	10 m/s

Scenario 1: Varying the number of vehicles as 30, 60, 90

Scenario 2: Varying Packet Size as 256, 512, 1024 Bytes. In this case, the number of nodes taken are 30.

5. Simulation Results and Analysis

The performance of ZRP is analyzed in the presence of default and MBA back-off methods with different variations.

5.1 Scenario 1:

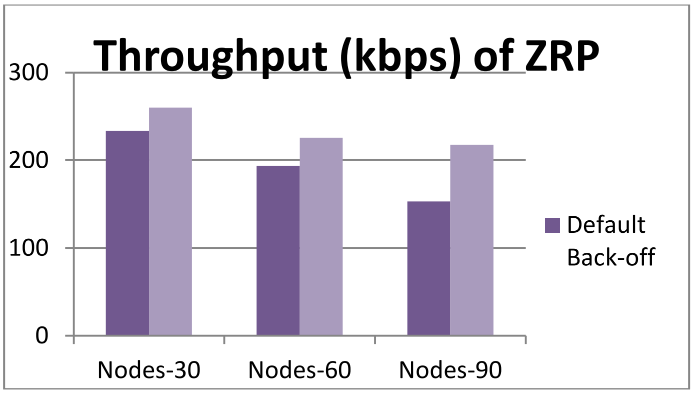

Figure 1. Throughput at 30, 60, 60 Nodes with Default and MBA Back-Off Methods

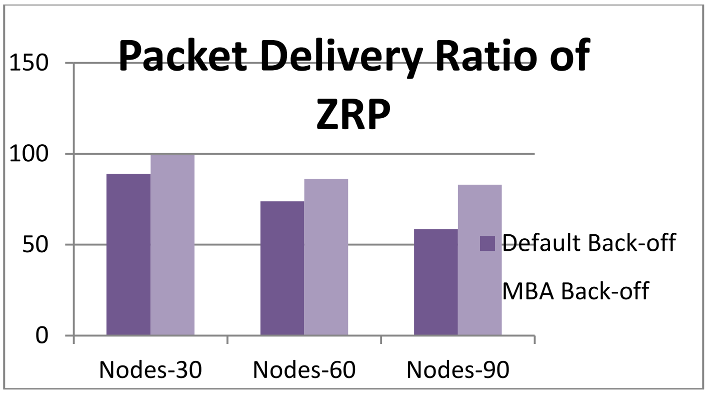

Figure 2. PDR at 30, 60, 60 Nodes with Default and MBA Back-Off Methods

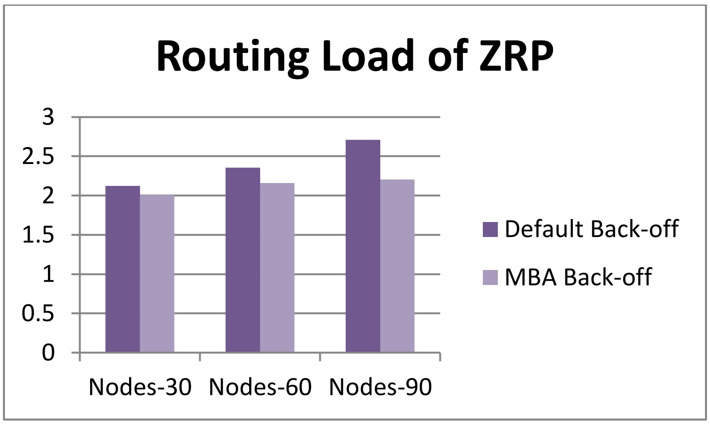

Figure 3. Routing Load at 30, 60, 60 Nodes with Default and MBA Back-Off Methods

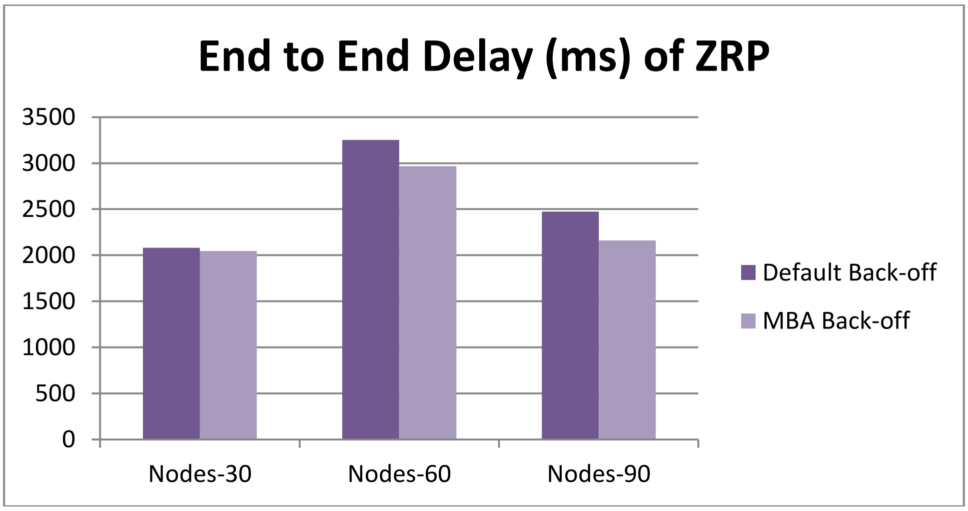

Figure 4. End To End Delay at 30, 60, 60 Nodes with Default and MBA Back-Off Methods

As per the above Figures 1 to 4, it can be observed that with 30 nodes, the throughput and PDR of ZRP is high, routing load and delay is less with MBA back-off method. But when THE node density increases to 60, then throughput and PDR both decrease with the increase in routing load and delay. The results with MBA are still better than the default case. In case of 90 nodes, performance decreases due to increase in the routing load, still

ZRP shows better performance with MBA than the default method because of the former's logic to set the contention window size that results in less collisions and more delivery of packets.

5.2 Scenario 2:

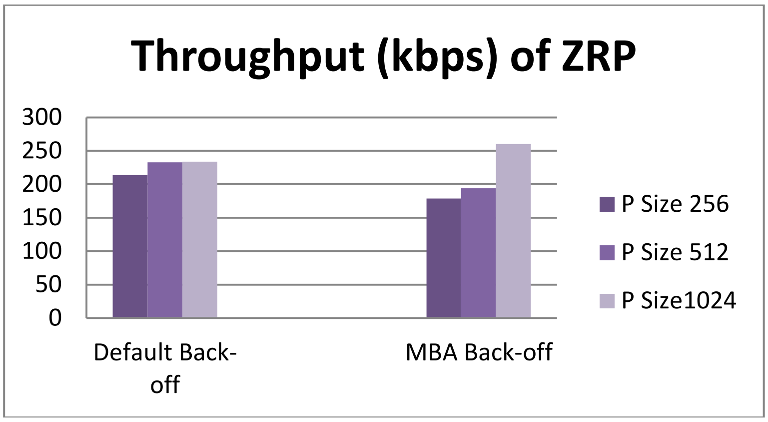

Figure 5. Throughput vs. Back-Off Methods for 256, 512, 1024 Packet Sizes

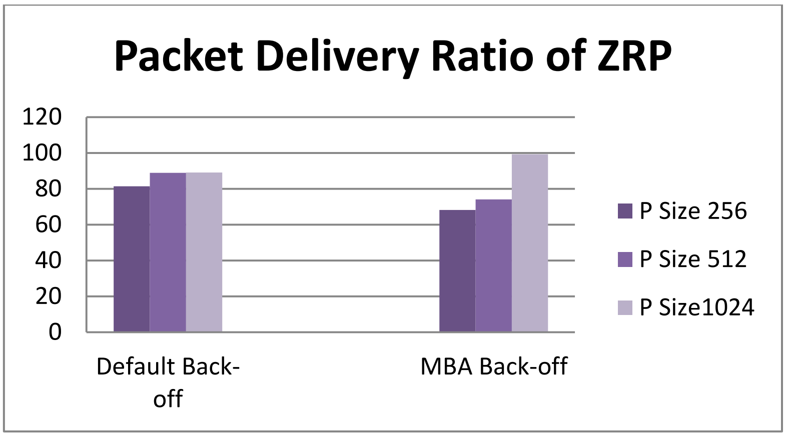

Figure 6. PDR vs. Back-Off Methods with 256, 512, 1024 Packet Sizes

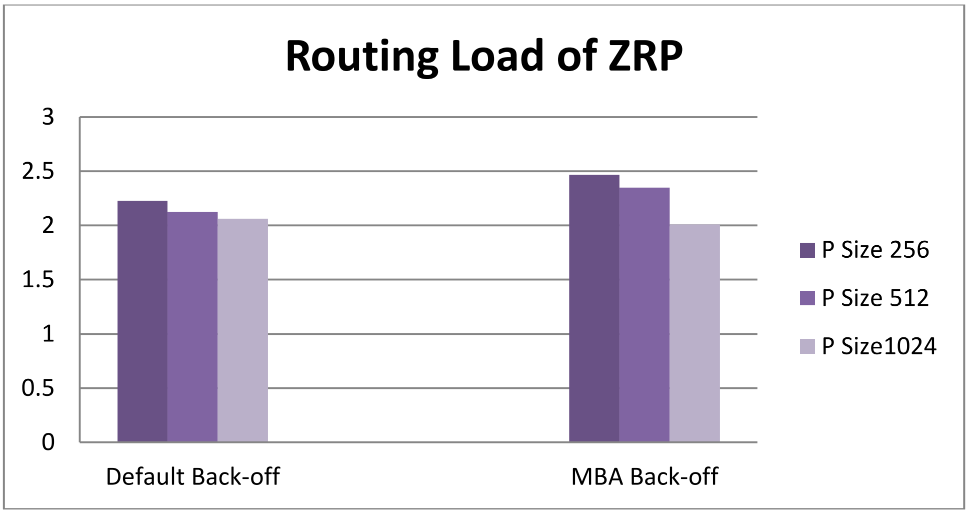

Figure 7. Routing Load vs. Back-Off Methods with 256, 512, 1024 Packet Sizes

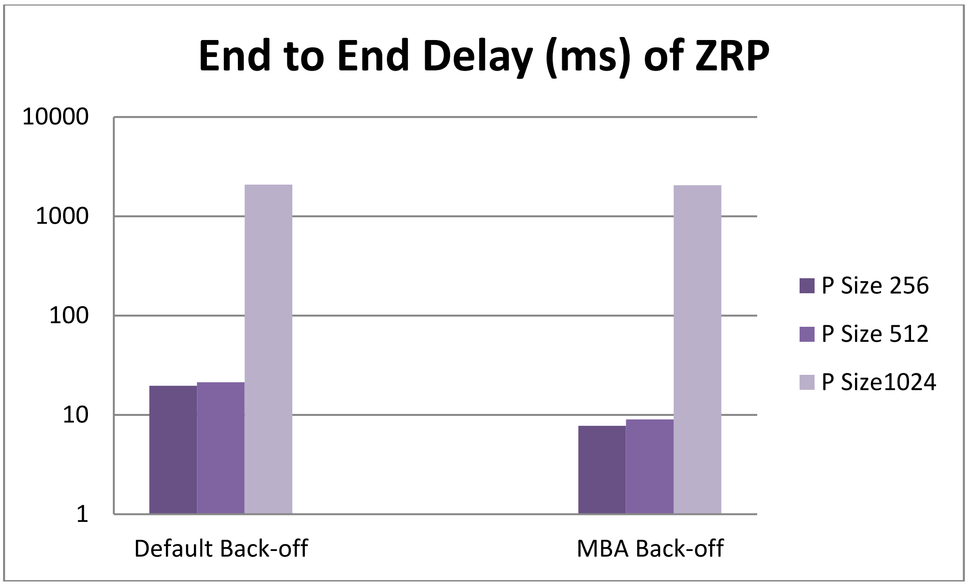

Figure 8. End To End Delay vs. Back-Off Methods with 256, 512, 1024 Packet Sizes

From the above graphs, Figures 5 to 8 it is clear that with the increase in packet size, the throughput and PDR slightly increase in case of default method. With MBA method, there is considerable increase in throughput and PDR with an increase in packet size. Routing load decreases with both the back-off schemes. However, end to end delay of ZRP increase with increasing packet sizes from 256 to 1024 bytes.

6. Conclusion

In this paper, we applied a modified back-off method to the existing MAC 802.11p.We did the variations in node density and packet size for comparing the default and MBA back-off schemes. Performance of ZRP is evaluated under QoS constraints *i.e.*, Throughput, PDR, Routing Load and delay.

The final verdict as per the investigations is as follows:

Using Modified Back-off algorithm, we can observe that performance of ZRP is increased than when the default method is used in terms of Throughput, PDR and Load but end to end delay also increases simultaneously.

As per the results it is observed that with minimum node density, ZRP performed well but if number of nodes increase, throughput and PDR both are decrease because routing load and delay are higher which is inversely proportional to node density.

In case of packet size variations, ZRP protocol has the highest performance using packet size of 1024 bytes in terms of Throughput, PDR, with minimum load while compromising with the end to end delay.

As per the above discussion, finally it can be said that ZRP may be suitable for VANET based network operations as it has high throughput and packet delivery ratio while routing overhead is low. The values of the parameters that can be used to achieve optimum results in case of ZRP are- Packet size of 1024 bytes, BPSK modulation scheme, but vehicle density cannot be certain and not under our control as it depends on the area i.e. city or highway and also on the time of the day, for example rush hours, so its value cannot be suggested/fixed and is variable.

In ZRP, though values of throughput and PDR are high, there is a need to optimize the end to end delay because delay is also an important factor for network based communication. If we cope with the delay factor, in that case ZRP can be used for real time communication over VANET.

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