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802.11p Profile Adaptive MAC Protocol for Non-Safety Messages on Vehicular Ad Hoc Networks

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ABSTRACT

Vehicular Ad hoc Networks (VANET) play a vital Vehicle to Infrastructure (V2I) correspondence frameworks where vehicle are convey by communicating and conveying data transmitted among each other. Because of both high versatility and high unique network topology, congestion control should be executed distributedly. Optimizing the congestion control in term of delay rate, packet delivery ratio (PDR) and throughput could limit the activity of data packet transmissions. These have not been examined altogether so far-but rather this characteristic will be fundamental for VANET system execution and network system performance. This paper exhibits a novel strategy for congestion control and data transmission through Service Control Channel (SCH) in VANET. The Taguchi strategy has been connected in getting the optimize value of parameter for congstion control in highway environment. This idea lessens the pointless activity of data transmission and decreases the likelihood of congested in traffic in view of execution for measuring the delay rate, packet delivery ratio (PDR) and throughput. The proposed execution performance is estimated with the typical VANET environment in V2I topology in highway driving conditions and the simulation results demonstrate and enhance network execution performance with effective data transmission capacity.

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1. INTRODUCTION

Vehicular Ad Hoc Networks (VANET) is a continuosly imperative field in Mobile Ad Hoc Networks (MANETs). Lately, researchers have demonstrated an increased interest in Vehicular communications. As indicated by authors in [1], the VANETs consist of vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications derived from wireless LAN technologies. The typical set of VANET application (e.g., cars accident triggering and local restaurant information for drivers), possessions (driving licensed, rechargeable power outlet), and the surrounding (e.g., highway traffic coditions, security concerns) make the VANET a distinctive area of wireless communication.

The demanding part of VANET is the high mobility of vehicles which influences the high rate of topology changes and the high inconsistency of node intensity. It can be presumed that MANET routing protocols are hard to instigate, eg. Obsolete neighbor data in routing table protocol [2]. The focal point of this study was on value-added applications that were classified as on-request services identified as infotainment, interative media or non-safety applications. Notification triggers for tourists such as hotel and lodging, e-restaurants or e-map downloading shorten the time and thus save fuel utilization.

Figure 1 represented the highway driving environments which clarified the three lanes for each driving direction. These traffic congestion and road safety information can be distributed through various service center in different RSU clusters for broadcasting. Each vehicle contributed in detecting and updating most recent street data.

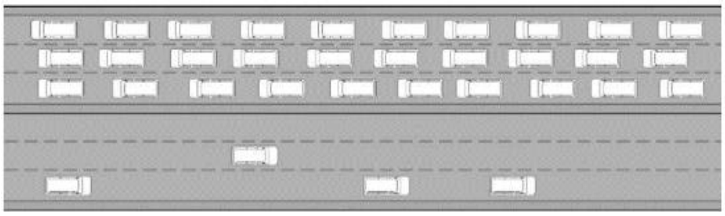

Figure 1. Highway scenario showing the variety of requirements for both moving vehicles

Web correspondence on vehicles, information exchange between OBU (on board unit) in vehicles and RSU (road side unit), depend on wireless remote systems. There are three wireless radio technology measurements set for the vehicle communication [3] such as IEEE 802.11, IEEE 802.15.3 and IEEE 802.15.4.

In order to assist communication in VANETs, the IEEE 802.11p (WAVE) and IEEE 802.11 for Dedicated Short Range Communication (DSRC) were established. The DSRC was composed utilizing a multi-channel framework. The 802.11p standard was proposed for V2V communication [4]. The FCC partitioned the spectrum into seven channels, each with 10 to 20 MHz, in which six were recognized as Service Channels (SCHs), and one as a Control Channel (CCH). The CCH channel is utilized for safety messages while non-safety services (WAVE-mode short messages) adhered to six other SCH service channels that were accessible [5-6].

2. WLAN STANDARD

Table 1 summarized and identified the distinctive functionality of the 802.11 standard in WLAN operation. The 802.11b and 802.11g protocols have been used substansively, which then were revised followed by 802.11n and 802.11p. The 802.11p is another multi-streaming modulation technique. The WLAN standard worked on the 2.4 GHz and 5 GHz Industrial, Science and Medical (ISM) frequency bands.

Table 1. WLAN Modes of Operation [3]

Standard	Ad hoc	Infrastructure	VANETs
802.11 a/b/g/n/p	Yes	Yes	Yes
802.15.1/4/3	Yes	No	Yes
802.16 m/e/d	Yes	Yes	Yes
802.20	Yes	Yes	Yes

From Table 2, numerous standards could be accomplished associated with wireless local area network (WLAN) in VANETs availability. There are different functionalities among all the standards. Security specification, routing, addressing services and interoperability are protocols that affect RSU equipments and OBU communication.

Table 2. Comparison of IEEE Standards [3]

Standard	License/Unlicensed	Lower Range		Higher Range	
		Data rate	Range	Data rate	Range
802.11 a/b/g/n/p	Unlicensed	11-100 Mbps	120-250m	11-100 Mbps	120-250m
802.15.1/4/3	Unlicensed	250Kbps-1 Gbps	2-100m	250Kbps-1 Gbps	10-100m
802.16 m/e/d	Unlicensed	1Gbps	1 km	30Mbps	5-15km
802.20	License	80 Mbps	15 km	80 Mbps	15km

3. CONGESTION CONTROL ALGORITHM DESIGN CRITERIA

The congestion control is complicated due to increase in traffic and data exchange. Plenty of application exchange the data from one user to multiple users, resultant the congestion control became complicated [36]. Congestion control algorithm can be embraced from numerous methods to reduce congestion in VANETs. To avoid congestion, some are depend on broadcasted messages to its neighbors. Table 3 demonstrates the most contemplated congestion control algorithms and parameters by many researchers based on broadcasting cautioning messages.

Table 3. Types of Congestion Control Algorithms and Parameters

Congestion Algorithms	Parameters
TVWS and DSRC Interplay: Optimal Strategy for QoS of Safety Message Dissemination in VANET [7]	Interplay Between TVWS and DSRC
DBFC [8]	Beacon frequency control [35]
A Robust congestion Control Scheme for Safety Messages Dissemination[9]	Priority assignment, transmission power & data rate modification
Emergency Messages in Power-control-based Broadcast Scheme [10]	Boundary nodes selection
Performance Evaluation on Congestion Control Algorithms [11]	Data rate and power control transmission
Event Driven Messages [12]	Messages prioritization
Safety Messaging [13]	Rate and Power Transmission
Optimal Broadcast [14]	Power Transmission
Utility-Based broadcast messages [15]	Data rate transmission
Cooperative Collision Warning [16]	Collision notification
Measurement-based detection and queue freezing techniques [17]	Emergency Messages in VANETs
Distributed beaconing scheme MAC protocol and channel access on SCH [18, 35]	Performance enhancement in MAC protocol
Service channels cooperative scheme in 802.11p/WAVE-based [19]	Proactive & Reactive reservation mechanism
POSTER [20]	Data rate adaptation and packet transmission at SCH
A WAVE MAC protocol for V2I non-safety applications [21]	Channel allocation for QoS
IEEE 802.11p multichannel MAC scheme[22]	Throughput improvement at SCHs and transmission delay reduction
Dynamic carrier sense threshold [23]	Transmission power and packet generation
Multichannel communications [24]	Multichannel architecture enhancement
Dynamic service-channels allocation (DSCA)[6]	Multiple service-channels based on a single transceiver
VEMMAC protocol in VANETs [25]	Multi-channel MAC enhancement

4. SIMULATION AND TESTING PHASE

Experimenting and testing vehicular network requires intensive labor and high expenses. Hence, an alternative solution is to use the simulation before actual implementation [34]. In this project, test-bed efforts were done utilizing OMNeT++ ver 4.6 simulator [28] running under UBUNTU 14.04.2 LTS.

All medium access control (MAC) and routing protocols depended on the INET framework [29], [30] and INET-MANET [31] of the OMNeT++. The mixture of control factors and noise factors are demonstrated in Table III as the experiment parameters. The simulation time for each experiment parameters was 250 seconds and 3 (RNG) random seed generation were conducted [27]. This research optimized the control factors in VANET congestion controls to attain least end-to-end delay, maximum PDR and maximum throughput for highway test condition environment. Simulation parameters for the tested experiments are as expressed in Table 4.

The packet sizes utilized were 25KB up to 125KB and there were five location of RSU distance along the highway. 802.11p was utilized for MAC protocols while the routing protocol AODV was chosen. The control factors level of variations are expressed in Table 5. The noise factors levels of variations of are shown in Table 6. In this experiment, the control factors depends on orthogonal array L8 Taguchi design of experiment which was outlined in five factors and each factor had two levels. For the noise factors, the orthogonal array L1 Taguchi design of experiment was utilized as it had one factors and each had five intervels as summarized in Table 7.

Table 4. Simulation Parameters

Parameter	Values
Number of cars	Up to 60
Number of RSUs	5 points
Distance	1.5 KM
Direction	4 (2 lanes each)
Simulation times	250s
Traffic type	UDP
Routing protocol	AODV
.bitrate	27Mbps
.wlan	802.11p
.message length	512 bytes
Random Number Generator	3 [27]

Table 5. Level of Control Factors for experiments

Parameters	Levels	
	Low	High
wifiPreambleMode	LONG	SHORT
slotTime	5 µs	25µs
rtsThresholdBytes	500 with rts	2346without rts/cts
minSuccessTheshold	5	20
successCoef	2.0	8.0

Table 6. Level of Noise Factors for experiments

	Levels				
Parameters	1	2	3	4	5
Packet generator (KB)	25	50	75	100	125

Table 7. Taguchi's Octagonal Array Experiments Setting

				# exp	1	2	3	4
	Noise Factor/			E	1	1	2	2
	Control Factor			F	1	2	1	2
				G	1	2	2	1
# exp	A	B	C	D				
1	1	1	1	1				
2	1	2	2	2				
3	1	3	3	3				
4	2	1	2	3				
5	2	2	3	1				
6	2	3	1	2				
7	3	1	3	2				
8	3	2	1	3				

To verify the impact each factor had on the yeild, the signal-to-noise (SN) ratio should have been ascertained for each experiment that was performed. The SN value denoting the mean of a process was compared to its variation. Three categories of SN ratio were figured in view of various kinds of execution attributes. In minimizing the attributes of the framework, the following SN ratio, which is called smaller-the-better, was determined applying Equation 1, 2 and 3:

$$SN_i = -10log\left(\sum_{u=1}^{N_i} \frac{y_u^2}{N_i}\right) \tag{1}$$

$$SN_i = -10log\left[\frac{1}{N_i}\sum_{u=1}^{N_i} \frac{1}{y_u^2}\right] \tag{2}$$

$$SN_i = 10log\frac{\bar{y}_i{}^2}{s_i{}^2} \tag{3}$$

Where y = mean response for experiment,
i = number of experiment,
u = number trial run,
Ni = number of trials for experiment i.

The third case is for nominal-the-best situation when a predetermined value is most preferred. To optimize the performance attributes, the following SN ratio, called the larger-the-better was anticipated as follows:

$$\bar{y}_i = \frac{1}{N_i}\sum_{u=1}^{N_i} y_{i,u} \tag{4}$$

$$s_i^2 = \frac{1}{N_i - 1}\sum_{u=1}^{N_i}\left(y_{i,u} - \bar{y}_i\right) \tag{5}$$

For this analysis, the SN proportion larger-the-better was utilized for PDR and throughput assessment. For optimal performance, the larger-the-better performance metric for both PDR and throughput sensitivity was taken to acquire optimal VANETs congestion control plan for non-safety applications. Non-safety applications that require low level quality of service (QoS), are delay sensitive. The investigation concentrated on non-safety applications in VANETs for highway driving situations. Table 8 clarified the execution measurements that were connected to highway experiment environments.

Figure 2, abridges the stream and different stages of the trial procedure in the Taguchi optimization method for minimizing delay, maximizing PDR and maximizing the throughput for highway scenarios.

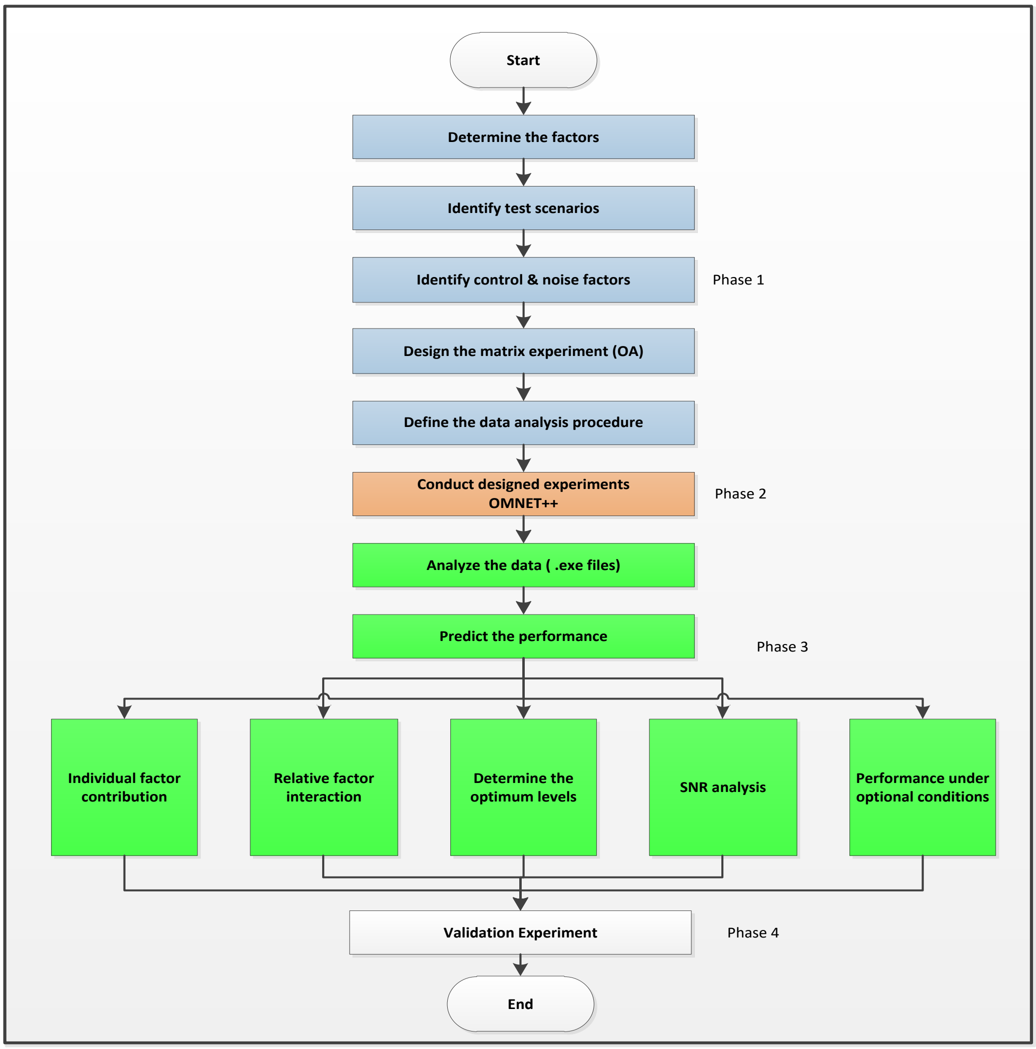

Figure 2. Taguchi optimization method for highway scenario [26]

Table 8. Performance Attributes

Name	Definition
Throughput	Total number of transmitted data packets divided by the total simulation time [32]. $$Throughput = \frac{received\ packets\ in\ bits}{simulation\ time}$$
Packet Delivery Ratio (PDR)	The number of packet received at the destination over the packet generated by the source [33]. $$PDR = \frac{received\ packets}{sent\ packets}$$
Delay	The duration it takes for a data packets transmitted from source to destination [32].

5. RESULTS AND ANALYSIS

This segment shows the outcomes from the optimization design and simulation in OMNeT++. The delay performance attributes is represented in Figure 3 utilizing mean SN Plot for all reaction characters versus control factors. Figure 6 shown the average improvement propagation for delay sensitivity was 15.59% after optimization. At the emphasis purpose of 25KB and 50KB, the network speed expended, there was the likelihood that the data transmission suffered from latency at 50KB to 125KB. Other than that, AODV multi-hop and the point-to-multipoint data transmission of V2I likewise caused extra delay as a packet may need to wait for retransmitting of missing packets during transmission.

Nevertheless, this did not diminish the adequacy of transmission capacity utilization. The charts denoted the S/N ratio smaller is better which depended on the Taguchi method to acquire finest and smaller delay ratio giving it the best fit threshold setting. From the investigation, the optimal congestion control for vehicular system on reducing delay is appeared at 25KB to 50KB of packet size. The packet size demonstrated a little impact to congestion control measurement as expressed before where 15.59% was the average in terms of optimal packet transmission.

This segment will introduce the outcomes from the optimal model in OMNeT++. The PDR and throughput performance attributes is outlined in Figure 4 and Figure 5 utilizing the mean SNR Plot for PDR and throughput response versus control factors. Figure 6 replicates the precision of the framework on the AODV protocol over congestion control towards multimedia applications after optimal packet transmission. Based on Figure 7, there is change after optimal process around 26.4% in viewed of packet delivery ratio (PDR) after optimal process, thus lowering packet loss. From 50KB onwards, the PDR is at a descending pattern that is reduce at a specific time since the modified AODV protocol increased latency of routing activity from the source to the destination.

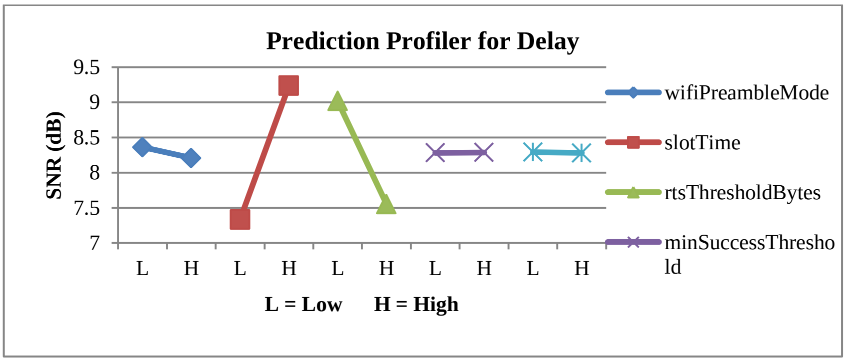

Figure 3. Prediction Profiler for Delay

Fundamentally, the attributes of AODV routing protocol on multimedia applications demonstrated a feasible affect on PDR. Due to an increase in packet size at intervals of 25KB up to 125KB the PDR decresed when there are increase in data traffic activity, topology changes and broken links to the next transmission nodes. Based on the Taguchi method, the graphs in Figure 4, signifies the mean S/N larger is better in getting optimal and higher PDR transmissions with the best fit parameter setting.

Figure 6 and Figure 7 demonstrate the mean SNR larger is better in the Taguchi investigation which is to acquire higher limit of throughput with respect to the best fit parameter setting. Based on Figure 8, when there was changed after optimization of 30.96% on the throughput, packet loss was additionally diminished after the optimization process. From 50KB onwards, the throughput is on upward pattern that is high at a specific time since the adjustment of AODV protocol generates less latency of routing movement from source to the destination. As a result the number of packets that could be broadcasted increased as well.

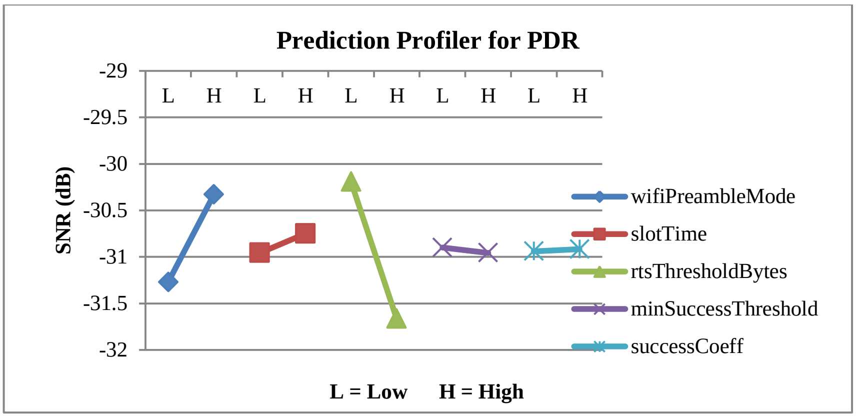

Figure 4. Prediction Profiler for PDR

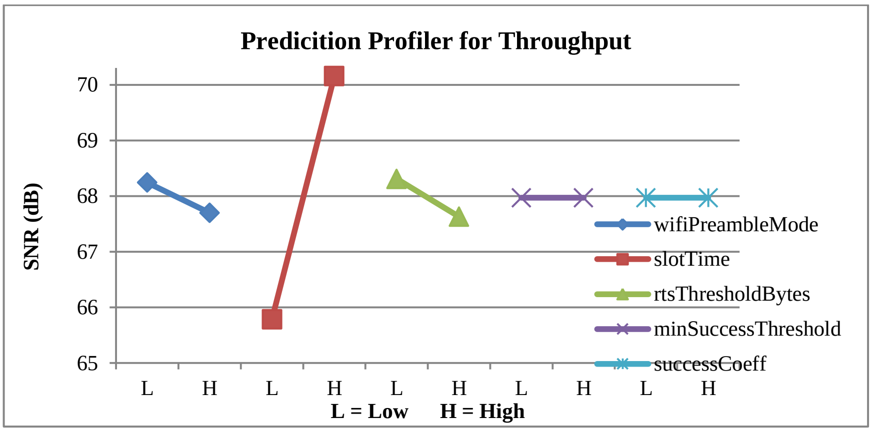

Figure 5. Prediction Profiler for Throughput

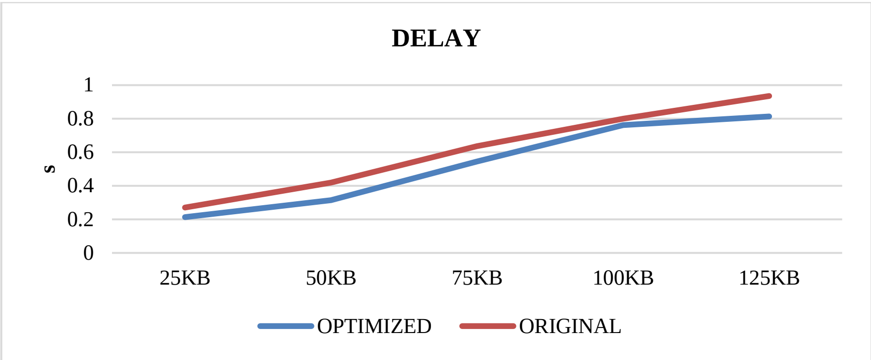

Figure 6. Performance Delay for congestion control

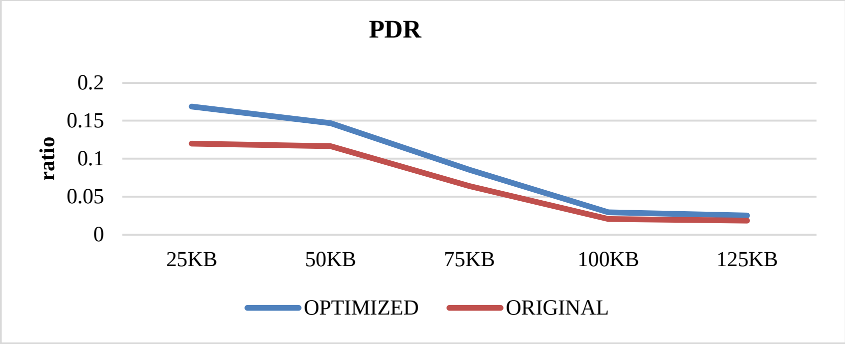

Figure 7. Performance PDR for congestion control

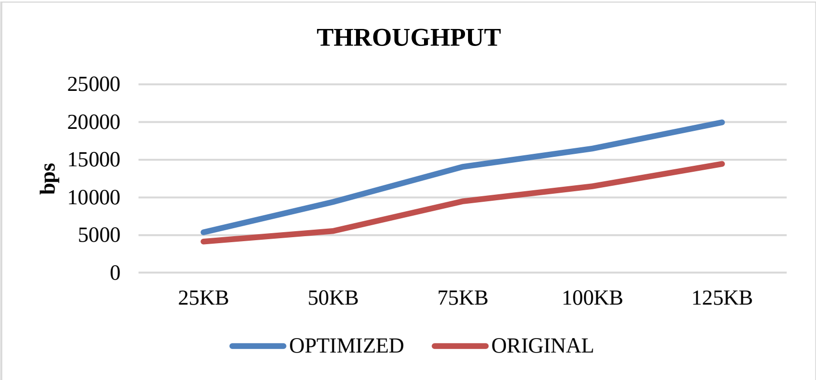

Figure 8. Performance Throughput for congestion control

6. CONCLUSION

In this paper the authors examined innovations and techniques acknowledged by different researchers and proposed a system for congestion control for SCH applications focusing on non-safety applications utilizing the Taguchi optimization scheme. The congestion control approach is one of the better answers to ease congestion in a WLAN communications channel. The authors have featured the algorithm for the non-safety messages mechanism to lessen the channel communications utilization applying to the defined threshold.

Control factors and noise factors have indirect and direct impacts on occurrence of packet broadcasting in VANETs. A vigorous optimization technique is appropriate for various configuration factors, for examples, MAC protocols, routing protocols, networks topology and testbed environments. This paper proposed the Taguchi optimization method for improving the delay sensitivity, PDR sensitivity and throughput sensitivity. For future research trend, more attributes and conditions can be tested for congestion control.

There are various components that have indirect and direct effect on performances for non-safety or multimedia applications. These elements can be categories into twofold, control factors and noise factors. A vigorous optimization technique is appropriate for various configuration factors, for examples, MAC protocols, routing protocols, network topology and test environments. These experiments validated the Taguchi optimization method had enhanced the level of congestion control for multimedia applications in VANETs.

Packet size is a validated element in enhancing throughput and PDR. The distance of RSU also was a key factor in term of occurence in PDR. The simulation results demonstrate the AODV routing deployment has certain outcome in terms of packet transmission toward throughput and PDR. For future work, more parameters can be included for non-safety applications in the optimization process, for example number of nodes, number of vehicles, life time span and RSU distance.

As a conclusion, performance can be accomplished with a reduction in delay sensitive application for mobile user data traffic transmission that plans to maximize the overall effectiveness in transmission of non-safety packets. In this paper, the optimized technique that was setup analyzed the performance of the AODV routing deployment under two unique conditions which is when the changes have been applied in

AODV routing in highway driving scenarios. Our model results demonstrate that the AODV routing deployment has constructive outcomes in terms of delay (number of broadcast packet received). The congestion control of the particular framework enhanced radically after optimization process for the vehicular ad hoc network at client or application level.

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