

## 802.11p Optimization for Delay Sensitive in Non-Safety Messages in VANETs

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### Article Info

#### Article history:

Received Apr 5, 2018

Revised Jun 6, 2018

Accepted Jun 20, 2018

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#### Keywords:

Network optimization

Non-safety applications

Taguchi method

Vehicular ad hoc network

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### ABSTRACT

Vehicle density and high vehicle mobility are variables that measured the performance of Vehicular Ad Hoc Network (VANET) in unpredictable traffic data transmission environment. This paper is focused on non-safety messages transmission mainly for delay in time in test-bed simulation environment. Network optimization is an approach to evaluate the existing congestion control protocols and other network parameters for outlining a newly enhanced congestion control protocols. This paper presents a city and highway traffic data transmission scenarios for optimizing delay sensitivity utilizing the Taguchi method. The average data transmission on delay is performance indicator applying OMNeT++ simulation tools. The optimization process could be achieved once the best fit performance parameters are being identified. The best fit performance values could conclude the optimal and efficient congestion control networks. The packet sizes are the main control factors for this test-bed experiment focusing on non-safety messages which are delay sensitive.

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## 1. INTRODUCTION

Mobile devices are communicated directly among each other without going through any access point. However, Vehicular Ad Hoc Network (VANET) is quite different from other ad hoc networks due to its functionality anticipating the vehicle density, high vehicle mobility, and irregular and severe vehicle communication in traffic environment. In vehicular communications, vehicles function as mobile nodes equipped with on-board units (OBU) and roads are equipped with fixed road side units (RSU). Vehicles with embedded OBU can transmit data to each other are described as inter-vehicle or (vehicle-to-vehicle) V2V communications. Vehicles that communicate with the roadside infrastructure are known as (vehicle-to-infrastructure) V2I communications [1]. VANET is intended to offer a wide range of coverage for comfort or non-safety applications to mobile travelers with vehicles [1]-[4], [22]. VANET is targeted to furnish a communication range of 1000m with roadside units (RSUs) and different vehicles, at velocities of up to 200km/h [5], [6].

Location-based, speed, emergency triggering and travellers point of information are available in VANET [5], [7]. There are two classifications of VANET applications, in particular safety application and non-safety application [4], [8]. The non-safety application is utilized for enhancing driving comfort and the efficiency of the transportation management system which requires more throughput-sensitive instead of delay-sensitive. In [5], it concentrated on a few assessment conditions identified in VANET such as in highway, city and intersectional traffic scenarios and movements.

In the highway scenario, vehicles travel in a line where infrequent RSUs are high while relative speed between vehicles is low. Highway traffic can be evaluated for vehicles moving in the same direction and also in the opposite direction. In contrast, in the city driving scenario vehicles travel at low speed and have a frequent stop-start. There are more numbers of RSU in the city compared to the unpredictable highway scenario. Then, routing in the city is more complex because of all the large obstacles such as buildings and the behavior of car drivers is unpredictable.

Vehicles travel in a straight line in highway scenario which number of RSUs is high while velocity between vehicles is low. Highway traffic can be measured for both vehicles moving in a similar and opposite directions. In contrast, the city drivers travel at low speed and have a continuous stop and start. The numbers of RSU are more in the city contrasted with highway environments. Subsequently, routing in city environment is more complicated due to many buildings and the unpredicted driving movements.

Traffic optimization is one approach to keep up the current congestion control protocols and other traffic parameters for formulating new enhanced congestion control protocols [9]. The data transmission between vehicles and RSUs must be reliable in triggering changes in VANET driving environments. A tool called Multi-Objective Network Optimization and Analysis Tool (MONOPATI) created by [10] utilizing Snealing Algorithm (SA) is as an instrument in optimizing the network in spite the absence of any network topology changes. It does not depend entirely on irregularities exhibit on any changes to the parameters to enhance the mobility execution. Moreover, the system need to be intelligently improved the zero error environments. Consequently, this paper shows an optimization of VANET in delay sensitive applications for both city and highway traffic scenarios using Taguchi method.

## 2. RESEARCH METHOD

In 1960, Dr. Genichi Taguchi initiated the Taguchi method [11] focusing on low cost of producing high quality product while reducing the production process applying a robust experimental design [12]. The Taguchi method is an experimental design to evaluate various factors influencing the characteristics in production process operations. Taguchi's method is an optimization procedure based on orthogonal array (OA) in getting near-optimal settings [13]. OA which is an imperative parameter in Taguchi's method discloses systematically identify the control parameters of the experimental run. Taguchi's method is generally connected to manufacturing production processes and other engineering fields, such as electromagnetic, power electronics and wireless communications [14]. The Taguchi method contains three phases which are clarified in Figure 1[9].

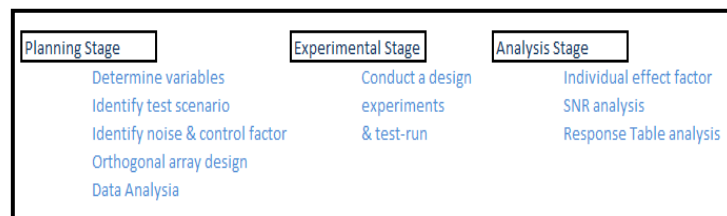


Figure 1. Taguchi method phase [9]

### 2.1. Basic Design Specification

Design of experiment (DOE) in Taguchi method is connected to congestion control in VANETs. This method reduces the variation in congestion control processes. In Figure 2, Taguchi classified variables into two, first the control factors that can be controlled while noise factors which are hard to control. The reason for the Taguchi experimental design is to have the validating factors set at maximum levels and compared with the existing execution. Finally it can be round up as a precise verification experiment with factors set at the maximum levels should be achieved to validate the earlier results.

### 2.2. Methodology over Congestion Control

OMNet++ is an open source software that enables the design of the proposed congestion control framework of traffic system network to the users' viewpoint. Some of the traffic application formats for the traffic generator are UDP, TCP, ViDeo, etc. The selected reference traffic type for this experiment is UDP. The simulation scenario was run over the 250 simulated seconds in a wireless vehicular mobility environment. Table I indicates few parameters for the simulation setup.

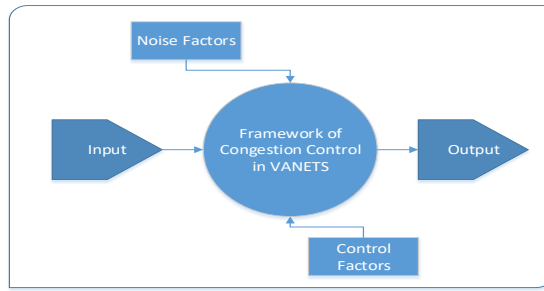


Figure 2. Taguchi approaches design from a robust design perspective

Table 1. Simulation Parameter

Parameter	Values
Number of cars	60
Number of RSUs	5
Simulation times	250s
Traffic type	UDP
Routing protocol	AODV
.bitrate	27Mbps
.wlan	IEEE 802.11p
.message length	512 byte
Random Number Generator	3 [15]

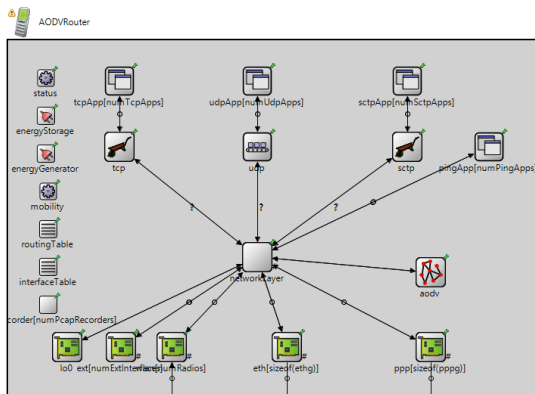


Figure 3. VANETs Base station module implementing the AODV routing supporting wireless VANETs access domain

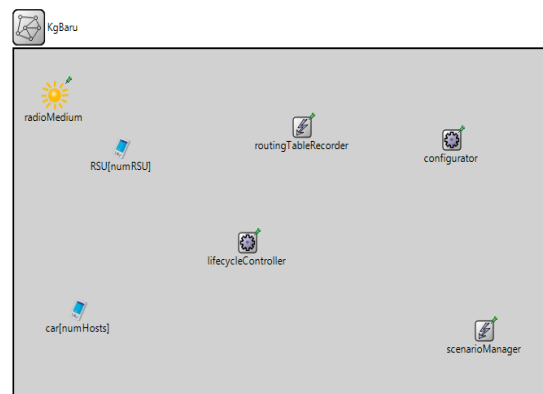


Figure 4. Cars and RSUs modules are implements the hybrid communication depends on the component modules of the neighboring layer which the frame is queued and transmitted



Figure 5. Taguchi methodology phases

### 2.3. Experiments Phase

This experiment concerns maximizing the control factors in VANET congestion controls in accomplishing least end-to-end delay. Next, the control factors that should be maximized are *packet size* and *distance* between RSUs. The three noise factors are *number of cars*, *interval time* of packets generation and cars' *mobility speed*. Levels of variations of control factors are presented in Table II.

Packet sizes are from 25KB up to 125KB. Five levels of RSU distance both for urban and highway scenarios are expressed in Table IV. 802.11p was applied for MAC protocols whereas AODV was identified for routing protocols. Levels of variations of noise factors are displayed in Table 2. The experimental table for control factors is based on orthogonal array L8 Taguchi configuration which is designed for four factors and each factor has three levels. While for noise factors, orthogonal array L4 Taguchi configuration is used which has three factors and each factor has two levels.

Experiment attempts are done utilizing OMNeT++ ver 4.6 simulator [16] running under UBUNTU 14.04.2 LTS operating system. All medium access control (MAC) and routing protocols are based on INET framework [17], [18] and INET-MANET [19] of the OMNeT++ [23]-[24]. All control factors and noise factors are presented in Table 2, Table 3 and Table 4 as the experiments parameter sets. Simulation time of each experiment is set at 250 seconds and 3 (RNG) random network/seed generation is performed [15].

Table 2. Level of Control Factors

Control Factors	Levels				
	1	2	3	4	5
A. Packet size	25KB	50KB	75KB	100KB	125KB
B. Distance of RSUs	1m	500m	750m	1000m	1500m

Table 3. Levels of Noise Factors

Noise Factors	Levels
	1
A. Number of cars	60
B. Time Interval	0.05s

Table 4. Experiments Setting Parameter

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

To determine the impact each factor has on the output, the signal-to-noise (SN) ratio should be figured out for each experiment conducted. The SN value represents the magnitude of the average procedure contrasted with its variation. There are three sorts of SN ratio which can be computed depending on the various types of execution attributes. For maximizing the execution attributes, the following SN ratio, which is called the *larger-the-better* is utilized. In order to minimize the execution of the system, the following SN ratio, which is called *smaller-the-better*, should be calculated utilizing Equation 1, 2 and 3.

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

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

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

Where

y = mean response of the experiment,

i = experiment number,

u = trial number,

Ni = number of trials for experiment i.

The third case is for nominal-the-best situation when a specified value is most desired. The SN ratio should be calculated as follow:

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

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

For this experiment, the SN ratio smaller-the-better is utilized for end-to-end delay evaluation, as shown in Table 5. The experiment is aimed for non-safety applications in VANETs. Essentially there is an interest on non-safety applications for low quality of service (QoS) which are delay sensitive. Therefore, for maximum execution, the larger-the-better execution metric for delay must be considered for non-safety applications. The delay sensitive should be evaluated as execution metrics to end-to-end delay.

Table 5. Performance Metrics

Name	Definition
End-to-end delay (Delay)	The time it takes for a data packets to reach destination from source [20].

### 3. RESULTS AND ANALYSIS

This section will discuss the outcomes from the optimization configuration and simulation in OMNeT++. The end-to-end delay execution attributes is illustrated in Figure 6 utilizing mean SN Plot for end-to-end delay response versus control factors.

Based on Figures 6 and 7, 15.6% on average reduced the delay sensitivity applications after the optimized the traffic congestion control. There is a possibility that the vehicles network connection suffers from latency at point 25KB to 50KB while increased in vehicles speed. ON the top of that, AODV multi-hop data transmission of V2I can lead to extra delay as a packet may need to wait for prior missing packets during data re-transmission. But, this did not reduce the efficiency on traffic capacity usage. The plotted graphs also concluded the S/N smaller is better, applying Taguchi method in order to optimize and reduce end-to-end delay.

Table 6. Simulation Results of Matrix VANETs Experiments

Bitrate	25KB	50KB	75KB	100KB	125KB	S/N
E1	0.239619	0.216577	0.529245	0.395974	0.246035	9.195523
E2	0.239619	0.569094	0.529245	0.395974	0.246035	7.55122
E3	0.207374	0.184337	0.633264	0.460899	0.36741	7.822923
E4	0.207374	0.184337	0.633264	0.460899	0.36741	7.822923
E5	0.266275	0.280519	0.754165	0.672876	0.359889	5.848128
E6	0.266275	0.280519	0.754165	0.672876	0.359889	5.848128
E7	0.184807	0.613109	0.526848	0.35142	0.282432	7.491464
E8	0.184807	0.613109	0.526848	0.35142	0.282432	7.491464

From the experiment, the optimization of congestion control in VANET in minimizing end-to-end delay is high from point of 25KB to 50KB packet size. The packet size has a big impact on optimizing the congestion control performance with 28.37% on average in term of optimization percentage. The effect of parameters in the experiment on the end-to-end delay performance matrix can be seen through the variation percentage of SN ratio values in Table 6.

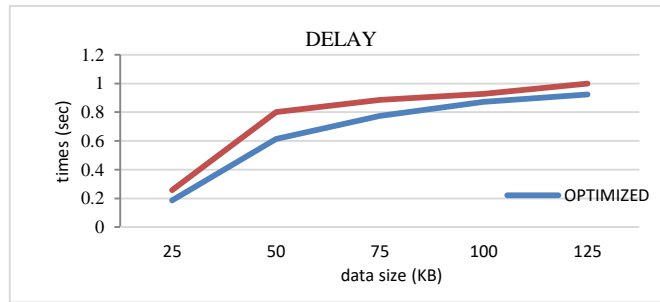


Figure 6. Performance of end-to-end delay framework for before and after optimization of AODV routing over VANETs

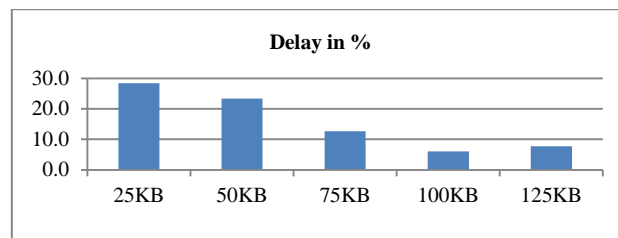


Figure 7. Percentage Plot for Original parameters delay response vs Optimized control factors

#### 4. CONCLUSION

Design or control factors and noise factors which have indirect and direct effect on performances of vehicular networks. A robust optimization technique is applicable for a wide range of design factors such as MAC protocols, routing protocols, network topology and scenarios. This paper proposed the Taguchi optimization method. The factors are optimized for end-to-end delay applications sensitivity. For future research direction, more parameters and scenarios can be involved in the congestion control optimization.

It exhibits the direct and indirect impact on VANET networks performance attributes. A proposed optimization technique is relevant for a various design and control factors such as MAC and routing protocols and VANET topology and environments. Taguchi optimization technique has been proposed in this paper. For future research, more parameters and variables can be associated with congestion control optimization experiments.

It is concluded that seamless performance can be achieved with delay sensitive application in vehicular ad hoc wireless access network of mobile user traffic aiming to maximize the overall effectiveness of non-safety packet transmission and improved network quality services in terms of end-to-end delay sensitivity. In this paper, a typical framework that has been setup examined the performance differences of AODV routing deployment only under two different scenarios that is before and after optimization of AODV routing in urban or city driving conditions. Our simulation results show the AODV routing deployment in the urban or city driving scenario has pros and cons in terms of the end-to-end delay transmission received. However, one positive effect is, the congestion control of the particular framework is improved drastically after optimization for the vehicular ad hoc network of user or application level.

As a conclusion the traffic bandwidth utilization could be materialized in delay sensitive application in VANET environments. These could be optimized the efficiency of non safety data transmission and QoS towards end-to-end delay sensitivity. In this paper, the setup experiments examined the AODV routing performance before and after the proposed optimization in city driving environments. The simulation results shown the impacts in AODV routing deployment in terms of end-to-end delay packet transmission received. Nevertheless, the bandwidth utilization on the network congestion is increased significantly after optimization techniques done for VANET at network application level.

#### ACKNOWLEDGEMENTS

The authors would like to thank the Universiti Teknologi Mara (UiTM) for sponsoring this research under the ARAS Grant (600-IRMI/DANA 5/3/ARAS (0177/2016)) of Research Management Centre, Universiti Teknologi Mara (UiTM).

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