FACTORS AFFECTING THE PERFORMANCE OF AD HOC ON-DEMAND DISTANCE VECTOR PROTOCOL IN SIMULATED MOBILE AD HOC NETWORK SCENARIOS USING TAGUCHI APPROACH

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To my beloved grandmother, Foo Jit Lan,

my mother, Choy Pow Ching,

my father, Tan Guan Kam,

and my brother, Tan Jun Hua.

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ABSTRACT

The performance of ad hoc on demand vector (AODV) protocol is affected hugely by some common major factors. These factors are terrain, network size, node velocity, pause time, transmission range, traffic load, and packet rates. The main purpose of this study is to analyse the effects of those factors and some selected two-way interactions on the performance measure of drop rates and average end-to-end delay. Taguchi approach was used in this study. Initially, L_{16} orthogonal array was used to determine the effects of the seven main factors and eight others two-way interactions between selected factors. The final results revealed that terrain, network size, transmission range, and traffic load have significant effects on drop rates. On the other hand, we discovered that terrain, transmission range, traffic load and interaction between node velocity and pause time have significant effects on average end-to-end. Interaction plot for L_{16} singled out strong interaction between node velocity and pause time for the effect on average end-to-end delay. Furthermore, L_8 orthogonal array was applied to analyse the seven main factors only since most of the interactions effects from L_{16} were largely insignificant to the response. The most influential factors affecting the drop rates (in descending order) were terrain, transmission range, pause time, network size, packet rates, node velocity, and traffic load. For average end-to-end delay, the most influential factors (in descending order) were transmission range, pause time, terrain, network size, traffic load, packet rates, and node velocity. ANOVA results for L_8 shows that terrain and transmission range have significant effects on drop rates. For average end-to-end delay, terrain, pause time and transmission range have significant effects on the response.

ABSTRAK

Prestasi protocol *ad hoc on demand vector* (AODV) dipengaruhi oleh pelbagai factor. Faktor-faktor tersebut adalah luas kawasan rangkaian (LKR), saiz rangkaian, masa berhenti seketika (MBS), halaju nod, had jarak penghantaran (HJP), muatan trafik, dan kadar penghantaran data (KPD). Tujuan utama kajian ini adalah untuk menganalisis kesan factor-faktor tersebut dan beberapa interaksi dua hala terpilih terhadap dua metrik prestasi iaitu kadar penurunan dan purata kelewatan data dari nod ke nod (PKNN). Kaedah Taguchi telah digunakan dalam kajian ini. Pada awal eksperimen, tatasusunan ortogon L_{16} digunakan untuk menentukan kesan daripada tujuh faktor utama dan lapan interaksi dua hala antara faktor yang dipilih. Keputusan mendedahkan bahawa LKR, saiz rangkaian, HJP dan muatan trafik mempunyai kesan yang signifikan terhadap kadar penurunan. Bagi PKNN pula, kami dapati LKR, HJP, muatan trafik dan interaksi antara halaju nod dan MBS mempunyai kesan yang signifikan terhadap respon. Interaksi plot untuk L_{16} mendapati interaksi antara halaju nod dan MBS mempunyai kesan yang kuat terhadap PKNN. Berikutan dari $L_{16,}$ tatasusunan ortogon L_8 digunakan untuk menganalisi tujuk faktor utama sahaja sebab kebanyakan interaksi tidak mempunyai kesan yang signifikan terhadap respon. Kuputusan mendapati bahawa faktor-faktor yang paling berpengaruh terhadap kadar penurunan adalah LKR, diikuti oleh HJP, MBS, saiz rangkaian, KPD, halaju nod, dan muatan trafik. Untuk PKNN pula, faktor yang paling berpengaruh adalah HJP dan diikuti oleh MBS, LKR, saiz rangkaian, muatan trafik, KPD, dan halaju nod. Kuputusan dari ANOVA untuk L_8 menunjukkan bahawa LKR dan HJP mempunyai kesan yang signifikan terhadap kadar penurunan. Untuk PKNN pula, faktor yang signifikan terhadap respon adalah LKR, MBS dan HJP.

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LIST OF SYMBOLS

Df	-	Degrees of freedom
Df_{TOA}	-	Total degrees of freedom for an orthogonal array
Df_r	-	Total degrees of freedom for factors and interactions
Df_A	-	Degrees of freedom for factor *A*
k_A	-	Number of factor levels for factor *A*
$Df_{(A\times B)}$	-	Degrees of freedom for interaction between factor *A* and *B*
S/N	-	Signal to Noise ratio
y_n	-	Response value for *nth* experiment
s^2	-	Variance
$\bar{y}$	-	Mean
y_0	-	Target value
S/N_S	-	Signal to noise ratio for smaller the better
S/N_L	-	Signal to noise ratio for larger the better
S/N_T	-	Signal to noise ratio for nominal the best
N	-	Number of experiments
$\bar{X}_a$	-	Average total response for factor *X* at level *a*
X_{effect}	-	Average effect for factor *X*
f	-	Unique flow id serving as an index
P	-	Fraction of successfully delivered packets
R_f	-	Count of packets received from flow *f*
N_f	-	Count of packets transmitted to *f*
N_p	-	Number of successfully received packets
i	-	Unique packet identifier
r_i	-	Time which a packet with unique id i is received
s_i	-	Time which a packet with unique id i is sent
d	-	Distance between two nodes
r	-	Radius transmission range

F	-	Fisher ratio
Sig	-	Significance value
$F - ratio$	-	Fisher ratio
CF	-	Correlation factor
SS_T	-	Total sum of squares
SS_X	-	Sum of square for factor X
SS_e	-	Sum of square for error
V_X	-	Variance for factor X
V_e	-	Variance for error
SS'_X	-	Pure sum of square for factor X
P_X	-	Percentage of total variation for factor X
P_e	-	Percentage of total variation for error
$y_{predicted}$	-	Predicted response value

LIST OF ABBREVIATIONS

LAN	-	Local Area Network
MANET	-	Mobile Ad Hoc Network
ISP	-	Internet Service Provider
DSDV	-	Destination Sequenced Distance Vector
AODV	-	Ad hoc On-demand Distance Vector
DSR	-	Dynamic Source Routing
TORA	-	Temporary Ordered Routing Algorithms
PDF	-	Packet Delivery Fraction
PAN	-	Personal Area Networking
RREQ	-	Route Request
RREP	-	Route Reply
FUFD	-	Full Factorial Design
FRFD	-	Fractional Factorial Design
MSD	-	Mean Square Deviation
STB	-	Smaller the better
LTB	-	Larger the better
NTB	-	Nominal the best
MSD_{STB}	-	Mean square deviation for smaller the better
MSD_{LTB}	-	Mean square deviation for larger the better
MSD_{NTB}	-	Mean square deviation for nominal the best
ANOVA	-	Analysis of variance
NS2	-	Network Simulator 2
OTcl	-	Object Tool Command Language
NAM	-	Network Animator
NPD	-	Number of packets dropped

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Communication is defined by the exchange of information between two or more mediums. In terms of computing, communication is data transfer between computing devices using a conductor for the linkage in between. Since the first wireless communication device invented by Bell and Tainter in the year 1880, wireless communication between mobile users has become more popular over the years up until now. This is due to the contribution of current technological advancements which have made wireless communication possible on every laptop, mobile phones and even some non-computing devices. These devices usually utilize wireless modem or wireless LAN (Local Area Network) as backbone support.

In next generation of wireless communication, there will be a need for a survivable, efficient, dynamic communication for emergency situations, and even disaster relief efforts. Such network is conceived as applications of Mobile ad hoc networks (MANET) where in Latin, ad hoc means “for this purpose only”. MANET is a wireless network that transmits from nodes to nodes and these nodes are referring to mobile platforms such as mobile phones with built-in wireless connector and laptop, the network is going on without the use of infrastructure such as the cables and the base station. MANET is able to operate on a rough terrain or a spontaneous setup as long as there are nodes present in the range. However, in order to gain access to the internet, one of the nodes must be connected via cable or wireless to an internet service provider (ISP).

MANET is a collection of wireless mobile nodes forming a temporary network. The nodes in a wireless network can move around constantly. Therefore the network topology can change dynamically and unpredictably. For this reason, some protocols must be employed in the system so that any changes in routing will be reflected on the routing algorithm and thus topology can be restructured to repair or update routes.

There had been many studies carried out to design, compare or to improve the MANET protocol algorithm, for example like Destination Sequenced Distance Vector (DSDV), Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Temporary Ordered Routing Algorithms (TORA) [1][2]. However in this dissertation, our aims are to determine and analyse the effects of several factors on the performance of AODV protocol. AODV protocol is chosen because it is one of the reactive protocols that generally use high mobility nodes. Prior to this study, Sarahintu [32] has analysed the DSR protocol.

1.2 Problem Statement

Many researchers have analysed on the performance of certain protocols as well as comparing among the protocols [2] [3]. From past studies, some protocols are found to excel over other protocols in certain scenarios. Therefore, before selecting which protocol to be employed, it has to be tested for its stability and reliability over a certain network configuration and scenario. For AODV protocol, its performance can be analysed by a set of performance metrics such as the packet delivery fraction (PDF) or drop rates, routing overhead and average end-to-end delay [1] [4].

Besides that, there are also some factors that need to be examined such as the terrain, network size, node velocity, transmission range, pause time, and packet rates [5]. These factors are some of the important elements that should be considered in designing specific scenarios in order to examine AODV performance.

The main problem in this study is to determine the effect of each factor mentioned above on the performance of AODV. Hence, we utilize Taguchi's method to examine the effect of factors as well as interactions between some factors correspond to drop rates and average end-to-end delay. This study is able to identify the influential factors that contribute to the performance of AODV protocol. Furthermore, Taguchi approach is also able to rank those factors according to their difference coefficients. In addition of above statement, this study also helped in determining if each factor has significant effect on the performance metrics.

1.3 Research Objectives

The objectives of this research are outlined as follows:

a. To analyse different parameter settings on AODV performance using Taguchi approach.
b. To rank the factors that affect AODC performance.
c. To determine the interaction effects of some factors on AODV performance.
d. To determine the factors that significantly affect AODV performance.
e. To predict the performance of AODV based on the obtained optimum settings.

1.4 Limitations of Study

This study was limited on the analysis of factors with two factor levels and the types of analysis only include the L_{16} orthogonal array which limited to selections of fifteen factors and L_8 orthogonal array which focused on selections of seven factors.

1.5 Scope of the Study

This research focused on the analysis of AODV protocol performance in MANET using the simulation program instead of using real experiments. The simulation setting was based on a group of mobile nodes forming an ad hoc network within a compound relative to a conference hall with sparse distribution and small workload [6]. In terms of nodes mobility, it was assumed that the nodes are moving according to mean speed of walking pedestrian in a commercial area [8][9] and each mobile node had a transmission range limited within 20 meters [10][11].

1.6 Significance of the Study

Results of this study will be helpful for those routing engineers in structuring a new reactive protocol or improving the existing formulation of AODV protocol. By acquiring the knowledge on the significance factors, the engineers will know which parameter should be given higher priority compared to the others and the priority could be ranked accordingly for all the predominance factors. This would help minimizing their workloads and significantly help in time saving.

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