Taguchi based Self-configure Data Rate Optimization AODVUU Routing Parameters in MANET over Optical Network Performances

Adam Wong Yoon Khang, Jamil Abedalrahim Jamil Alsayaydeh, Win Adiyansyah Indra, J. Pusppanathan, Shamsul J. Elias

Abstract: Research and development advancements in the area of wireless technologies give rises of mobile ad hoc networks (MANET) domain but is constrained to the single networks and stand alone. Furthermore, the communication networking applications requirements mostly still depends on fixed infrastructure networks that lead to MANET need to communicate with internet. Consequently, the traditional mobile routing protocols proposed for MANET are inefficient but play an equivalent important role in the performances of mobile wireless network over optical backhaul with focusing of MANET of the wireless domain in access network. Routing protocols procedures are controlled with a set of parameters from being dragged to undesired situations such as un-optimized Quality of Service (QoS) resource consumption. These parameters have a direct impact on the efficiency of a routing protocol and the overall MANET network performances. This paper proposed an offline optimization through simulation design of experiment of the AODV-UU parameters of MANET is evaluated by performing Taguchi signal to noise ratio (SNR) method for fine-tuning the AODV-UU routing parameters using the OMNeT++ software. The work is further extended with self-configure multiple data rates (SCMDR) scheme - a cross-layer-specific technique. AODV-UU with Taguchi tuned under the proposed SCMDR scheme is compared with AODV-UU configuration of oRiG scheme also as respects to previous work is examined based on capacity consumption, end-to-end delay metric and energy consumption metric under the varying speed scenario. The obtained results showed that, AODV-UU with Taguchi configuration outperformed the AODV-UU for the mention performance metrics here. The existing of current access network of the telco operators can benefit from the proposed improvement here.

Index Terms: Taguchi, DOE, QoS, MANET, DCF

I. INTRODUCTION

Mobile Ad Hoc Network (MANET) presents a technological solution to improve digital information systems. MANET consists of mobile devices where information is transferred in a multi hop fashion to a desired destination [1]. The mobile devices are tending to travel random mobility, which implies their engagement to different network topologies and scenarios. This fact conveys the need for robustness in the design of protocols to the adhered multi-scenario phenomenon in MANET. Particularly, this poses a challenge in data dissemination with reqards to Quality of Service (QoS) resource consumption among the mobile peers [2]. Hence, there is a great need for solutions to realize better performance of resource-efficient and reliable wireless mobile networks [3].

Routing protocol behavior describes the protocols mechanism, which is controlled by a set of routing parameters such as link-layer feedback (feedback) and rate limit in AODV-UU. These parameters have a direct impact on the network performances [4]. For example, link-layer feedback incurs explicit extra operations on the network layer information base rather than just sending regular HELLO messages, which need to be fine-tune in a resource efficient manner according to the network scenario [5, 18]. While, Neeta proposed a modification to OLSR routing parameters with modify hello message, and concluded that optimizing modification the OLSR configurations improves MANET performances [6]. This study motivated the works in this paper for further investigate the impact of routing parameters on the network performances under the varying speed scenario based on Taguchi Method [7]. This is to highlight the correlation between these parameters and MANET scenario requirements to propose an optimum configuration of AODVUU to improve its efficiency. Based on brief literature reviews shows that the routing protocol’s parameters are unequally affects the network performances. Other layer solution such as network layer also focuses on MANET QoS in providing the required QoS to each user or application. For example, INORA based on the coupling without interaction between QoS resource reservation of INSIGNIA signaling mechanism with the TORA routing protocol to deliver QoS guarantee [8]. Basically, the signaling mechanism provides QoS reporting to inspect the status information (e.g. bandwidth indicator) and measured delivered QoS (e.g packet loss, throughput etc.) for the TORA routing protocol regarding the route chosen and asks the routing protocol for alternate routes if the route provided does not satisfy the

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QoS requirements. The unfortunate drawback of this scheme is that it does not reserve resources that cause not enough resources before the actual flow. Therefore, it is not suitable for QoS guaranteed services. Thus, the work in this paper proposed the SCMDR scheme by considering the Taguchi optimization AODV-UU routing to connect MANET end users and Internet based on distributed coordination function (DCF) mode of the IEEE 802.11g [9, 10]. Furthermore, the proposed method in this paper is introduced into the FiWi (Fiber-Wireless) area from the wireless domains, which opens the opportunity for adding optimization mechanism to the routing protocols mechanisms. It purposes with consideration of providing QoS-assurance due to limited resource consumption when there is the increase of number of mobile ad hoc nodes. The rest of the paper is organized as follow: the next section describes the proposed method. Section 3 presents the results and their discussion and section 4 concludes this work.

II. METHODOLOGY

There are 2 main steps will be highlighted in subsection that involved in this research. Section A will outlines the simulation planning and cross layer design for integrated optical and wireless domain towards the FiWi-MANET conceptual scheme while section B gives an overview of the proposed algorithm of Taguchi-based design of experiment towards FiWi-MANET network for resource efficient improvement.

A. Proposed algorithm

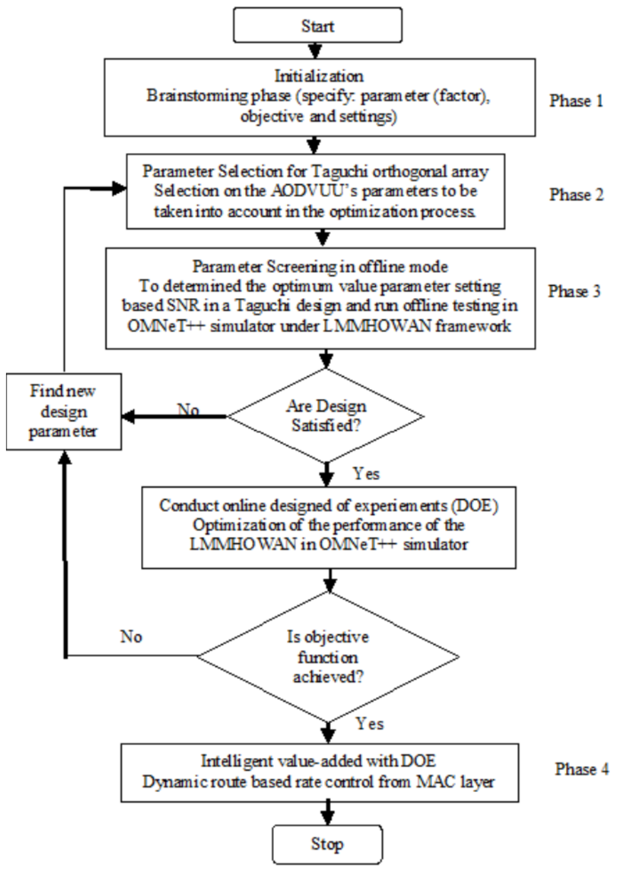

Fig. 1. Systematic optimization processes in framework Architecture

This research relates in identifying factors affecting MANET performance targeting AODV-UU protocol and suggest ways to improve it by connecting it to optical network for reliable transmission. The set of performance factors affecting the protocol capability are beyond the possibility even to be considered here, in this study Taguchi Design of Experiment (DOE) was used to optimize the influence of the factors on the particular network performances. The Figure 1 demonstrate the used of Taguchi method in processing parameters through the optimization process in this paper of the simulated access network. Primarily based on Figure 1, the initial step refers to phase 1 and phase 2 were to formulate the relevant process goal in particular related to ascertain the existing objective setting to be selected for optimization that minimize the effects of the routing process variation. There are 7 identify process parameters are known as control factors such as the rate-limit, llfeedback, optimized_hellos and etc as shown in Table 1.

Table 1 The key routing control factors with respect to its value setting before optimization for designing the Taguchi orthogonal array

Factors \ Levels	L1	L2	L3	L4	L5	L6	L7	L8
ratelimit (ms)	1 (-)	1 (-)	1 (-)	1 (-)	10 (+)	10 (+)	10 (+)	10 (+)
wait_on_reboot (ms)	1 (-)	1 (-)	5 (+)	5 (+)	1 (-)	1 (-)	5 (+)	5 (+)
feedback (true/false)	1 (+)	1 (+)	0 (-)	0 (-)	0 (-)	0 (-)	1 (+)	1 (+)
receive_n_hellos (ms)	5 (+)	1 (-)	1 (-)	5 (+)	1 (-)	5 (+)	1 (-)	5 (+)
optimized_hellos (true/false)	1 (+)	0 (-)	1 (+)	0 (-)	0 (-)	1 (+)	0 (-)	1 (+)
checkNextHop (true/false)	1 (+)	0 (-)	0 (-)	1 (+)	1 (+)	0 (-)	0 (-)	1 (+)
PublicRouting Tables ((true/false))(Optional)	1 (+)	0 (-)	0 (-)	1 (+)	0 (-)	1 (+)	1 (+)	0 (-)

There are two different levels per factor involved are at the low level (-) or the high level (+), the L8 (27) Taguchi design is then chosen according to the standard Orthogonal Arrays [11]. In the L8 (27) Taguchi design, the orthogonal arrays are used instead of the standard factorial design where its factor levels are weighted equally across the entire design [12]. The rate limit was selected because it could put up the edge for the routing with route control messages that buffered the network, which might cause packet drops [13]. It is also assessed that can induce energy efficiency in the integrated MANET domain over optical backhaul framework by creating the rate limit-based approach in the routing of AODV-UU. This work also focuses on proposing the link-layer feedback (feedback) factor from the wireless domain for cross-layer efficient utilization [14].

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It suffers from unambiguous additional operations on the network layer information base due to handful of unsuccessful routes with failed HELLO messages broadcast, which need to be optimized in a resource efficient manner. Follow by that is the screening process of phase 3 of Figure 1 will have a loop back to check on optimized functionality is achieved or not based on the intended networks to obtain the optimize parameters of optimized process. At the parameter screening, the selection of S/N ratio depends on the goal of study either the energy criteria or other utility criteria such as capacity or delay. It can be either minimized or maximized of the network performance metrics. To measure it, the following metrics are used: Total Energy Consumption [19]: Total energy consumption for all mobile ad hoc nodes in bi-directional mode.

$$E(J/s) = \sum (Q(mAh) \times 60 \times 60 \times V(V) \times 1000 \quad (1)$$

Where mobile battery electric charge Q(mAh) in milliampere-hour and mobile battery voltage V(V) in volts.
Total Network Capacity [20]: The throughput metric here measures how well the network can constantly provide data to the user.

$$\text{Capacity} = \sum (\text{Number of packet receive (bit/byte)} / \text{simulation time} \quad (2)$$

End to end delay [21]: This is the average time taken in delivery of all data packets from the source node to reach the same destination node.

$$\text{Delay} = S/N \quad (3)$$

where S is the sum of the time spent to deliver packets for each destination, and N is the number of packets received by all destination nodes.
Unlike other protocols in MANET, an improved AODV-UU protocol with self-configured based optimized routing setting is the key to “coding awareness” in this respective resource efficient effort of radio-and-optical access network as shown in phase 4 of Figure 1. In particular, this protocol takes variable multiple control data rate information from the lower layer that is MAC layer to be processed at the network layer. This SCMDR also adaptively embraces multiple data rate control to avoid the congestion level in the local mobile user nodes. This approach provides a stable mobility wireless condition, which enables the proposed work of constrained data rate mechanism required to offer a better quality of experience for mobile user nodes. Implemented at the mobile station, the predetermined optimized of AODV-UU protocol improves the network performance such as energy consumption, delay and capacity consumption. Therefore, it permits a more efficient bandwidth to be delivered to each mobile nodes client in a resource constraint MANET, which is crucial for getting good IP-Optical streams quality in unpredictable wireless over fiber environments.

B. DOE simulation planning

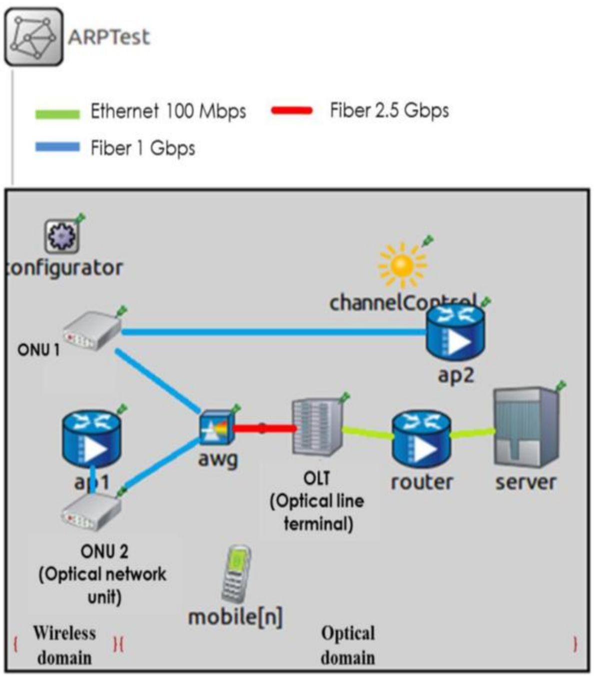

Fig. 2. FiWi-MANET network

Table 2 FiWi-MANET common parameter setting

Parameter	Values
Fiber type	Single mode fiber
Reach (OLT-ONT)	20 km
Number of OLT	1
Number of ONU	2
Number of Nodes	20 to 500
Simulation Area	Max 8kmx6km
Traffic type	UDP
MAC layer	IEEE802.11g with DCF
Carrier Frequency	2.4GHz
Data rate	6Mbps, 24Mbps, 54Mbps

In this paper also, the respective integrated framework design called the FiWi-MANET network was based on combination elements of the optical, mobile and wireless entities. To illuminate it, the Figure 2 showing its main elements of the particular transmission features to form the FiWi-MANET network: from an OLT, splitter and to an ONU at the optical backhaul of downstream direction while from a mobile user to a gateway/ONU in the wireless front-end of upstream direction. To provide better improved capacity wireless transmission while leveraging the growing mobile user demand needs the mobile internet connectivity based on resource utilization distributed approach of optimized multiple data rate link adaptation with self-configure capability.

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The experiments here were carried out using OMNeT++ simulation tools with a number of eight experiments based on this respective integrated framework design. Each of the experiment was run according to Random Network Generator 3, to obtain the accurate and the best parameters value for optimizing the tested variables. The simulation scenario was run in the period of 250 seconds with 50 simulated seconds intervals of getting steady output under dynamic network. For research purpose with the simulation area of 8kmx6km, 2 ONUs integrated with wireless access point is chosen as it is the suitable number of ONUs to be used in FTTH for mall-school areas as reported in [15].

III. RESULTS

This part was to evaluate the performance of the self-configure control data rate based on efficient resource ad hoc routing optimization based on the delay, packet delivery ratio, loss probability, energy consumption and throughput performances. The simulation experiment is governed by a random number generator to uniformly distribute traffic over the routes in a random manner allow reliable predictions of the mobile ad hoc network performance. The performance of the proposed SCMDR scheme improvement based on Taguchi efficient resource AODV-UU routing optimization is compared with the existing works on MANET domain called the oRiG scheme [16]. In the particular paper, the specification for oRiG scheme is based on the revised values parameter of AODV as reported by the author while the design network planning and specification are following the last mile mobile hybrid optical wireless access network scheme in this paper [4].

The impact of quality of services is investigated when the mobility speed of nodes increases with a cross-layer approach towards smart self-configure operation. The simulations were done with unified framework between wireless and optical domain by employing OMNeT++ simulation tool for a mall-school areas topology. The number of speed varies from 5mps to 25mps with an increment of 5mps where there were 30 mobile nodes involved. The sent interval for the whole simulation was fixed to 0.01s with the 1024 bytes fixed message length. The rest of the parameters used for varying of node mobility speeds are described in Table 2.

A. Throughput/Capacity

The graph in Figure 3 is based on the Table 3 shows that oRiG parameter setting scheme was not enough to provide a guarantee of service to the mobile end user. In this scenarios here, the outcome for this metric performance increases with a decrease in node speed [17]. The obvious reason is that the presence of high mobility results in stress for this protocol to forward lots of packets and routing information. Due to mobility also, the link is likely to break and cause nodes failure while using an excessive number of retransmissions. As a result, the data packets are being queued before a new route is discovered. It will cause in large routing overhead. Hence, low throughput is likely to be induced in high mobility in comparison to low mobility.

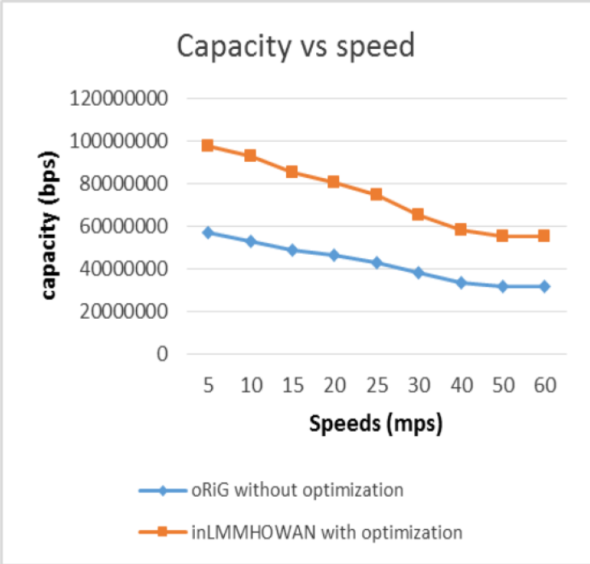

Fig. 3. Performance of capacity for varying speed of oRiG and SCMDR multi-parameter AODVUU routing before and after with self-configure mechanism based on Taguchi optimization

However, the proposed SCMDR scheme had a stronger effect compared to the oRiG scheme as per the Taguchi method for capacity efficiency (the higher value the better) at 71.50% improvement on average. It significantly improves the design parameters by optimizing multiple potential local pieces of information without introducing more additional overhead through the adoption of orthogonal arrays. Furthermore, regardless of speed and individual mobile node, the self-configure routing transmission is introduced according to the multiple data rates it has sent based on the offline optimized predefined best-fit parameters as the transmission delay depends on the data rate.

Table 3 Numerical analysis for network capacity after optimization with self-configure scheme

Capacity			
Speed (mps)	oRiG without optimization	inLMMHOWAN with optimization	% Improvement
5	56764010	97640100	72.01
10	53065530	93065530	75.38
15	49076420	85076420	73.36
20	46586431	80586431	72.98
25	43138742	74387420	72.44
30	38032423	65032423	70.99
40	33507345	58007345	73.12
50	33032762	55033270	66.60
60	33032004	55032004	66.60

B. Energy Consumption

Obviously, high-speed transmission consumes higher energy consumption and moreover, the existing scheme seems to experience a higher unnecessarily overhead given its reactive nature.

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After applying this algorithm, the proposed SCMDR scheme network energy consumption is less and it is ended with 58.37% of average improvement as compared to the prior one (oRiG) as shown in Figure 4 which based on Table 4.

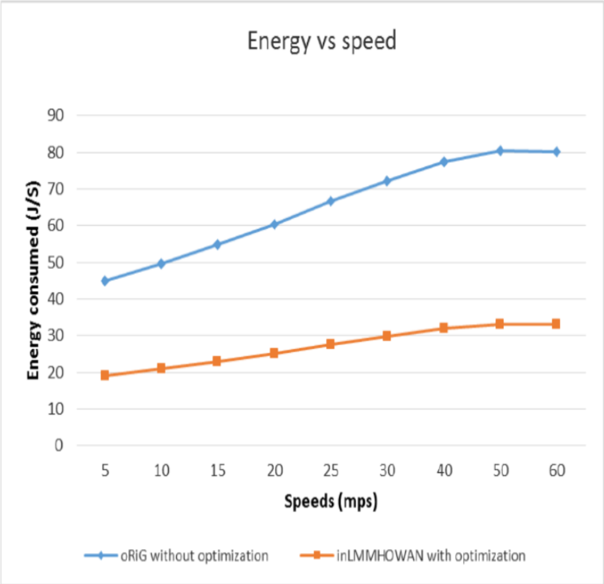

Fig. 4. Performance of energy consumption for varying speeds for both scheme of oRiG and SCMDR multi-parameter AODVUU routing before and after with self-configure mechanism based on Taguchi optimization

Thus, the situation can be explained in SCMDR test scheme the multi data rate link information is dependent on the optimized control factors routing setting in AODV-UU such as HELLO beacon. Each node will obtain the link rate information including the optimal routes driven by a self-configure manner without modifying the HELLO beacon broadcast mechanism of AODVUU, which ultimately makes the process improvement more simplified. This way can effectively broadcast the HELLO messages avoiding the risk transmitting a packet through a broken link that has not been detected by HELLO messaging which minimizes the energy cost.

Table 4 Numerical analysis for energy consumption after optimization with self-configure scheme

Energy Speed (mps)	oRiG without optimization	inLMMHOWAN with optimization	% Improvement
5	44.98	19.07	57.60
10	49.73	21	57.77
15	55	23.06	58.07
20	60.5	25.21	58.33
25	66.7	27.73	58.43
30	72.32	29.92	58.63
40	77.37	31.9	58.77
50	80.39	33	58.95
60	80.2	33	58.85

C. End-to-End Delay

Figure 5 that based on Table 5 shows the average delay comparison between the optimized AODV-UU in the SCMDR scheme and conventional AODV-UU routing in oRiG scheme for every 5mps interval until 60mps mobility speed. In oRiG scheme, 2Mbps data rate is adopted where all data packets, including routing control, are transmitted at that specified data rate of slow packet transmission speed which resulted in the longer delay. This time, the proposed SCMDR scheme has lower delay compared to the normal oRiG in all the scenarios with different moving speeds about 223.27msec, but again they increase considerably for higher speeds. This proposed work, to top it all, is highly configurable over different speed scales with self-configure multiple data rates control of ad hoc routing table using 6 and 54 Mbps. The wireless ad hoc routing is modified to carry the pre-computed set of optimum configurable routing setting in a multi-rate wireless ad hoc network delivering the delay resource efficient next hop. All these happen in the mobile node before the transmission starts so that a mixture of the data rate packet is tuned accordingly in a distributed fashion.

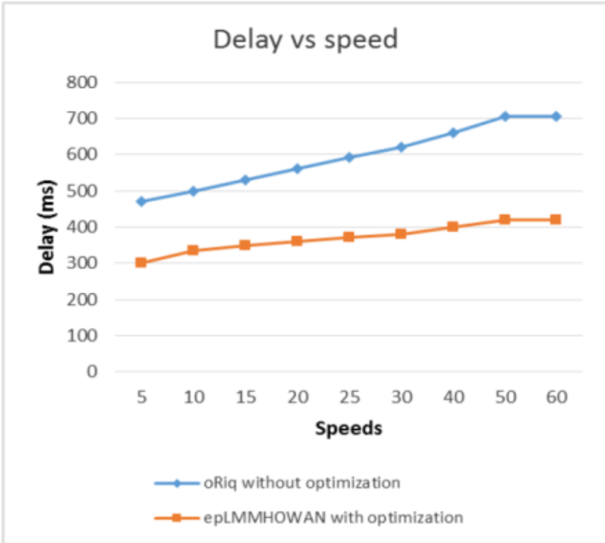

Fig. 5. Performance of end-to-end delay for varying speeds for both schemes of oRiG and SCDMR multi-parameter AODVUU routing before and after with self-configure mechanism based on Taguchi optimization

Table 5 Numerical analysis for end-to-end delay after optimization with self-configure scheme

Delay Speed (mps)	oRiG without optimization	inLMMHOWAN with optimization	% Improvement
5	470.45	300.21	36.19
10	500.49	335.29	33.01
15	530.58	350.14	34.01
20	562.42	360.58	35.89
25	592.18	370.35	37.46
30	620.34	380	38.74
40	660.46	400	39.44
50	704.54	420	40.39
60	704.54	420	40.39

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IV. CONCLUSION

This section discusses the conclusions of this research. The growth of the Internet, its mobile services and applications trend has resulted in an increasing demand. So far, it has been well investigated from the strict layering approach especially focusing either on network layer or transport layer enhancements for MANET. Unfortunately, the convergent layering has not been considered as an all. In this work, the routing challenges especially the aspect of QoS for wireless domain based on MANET in internet integration scenario seem can be addressed by MANET-Optical integration architecture with further routing optimization using Taguchi method in-combination with cross layer approach. The presented results of solution's investigation provide an effective approach to efficient QoS with minimize variation that can serve as alternative last mile mobile internet access to mobile users. Reflecting this broad objective, this paper presents a cross layer conceptual framework with feasible solution simulation framework modelling integrated with the Taguchi multi-criterion objectives optimization in terms of maximize the capacity consumption while minimize the energy consumption and end-to-end delay. It was to overcome the ongoing major open issue associated with bandwidth-constrained-variable wireless capacity link that are showing lower capacity than their hardwired counterparts. It demonstrates remarkable results indicate that 58.37% improvement for energy whereas, 71.50% improvement for capacity, 37.29% improvement for the delay as compared to non-Taguchi AODVUU routing optimization (oRiG) of previous study settings under varying mobility speeds scenario.

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REFERENCES

1. Qussai M. Yaseena, Monther Aldwairi, "An Enhanced AODV Protocol for Avoiding Black Holes in MANET", the 5th International Symposium on Emerging Inter-networks, Communication and Mobility (EICM 2018), Elsevier, 2018.
2. H. Zhou, H. Wang, X. Li, V. Leung, "A survey on mobile data offloading technologies", IEEE Access, vol. 6, no. 1, Jan. 2018, pp. 5101-5111.
3. Mahfuzur Rahman Bosunia and Seong-Ho Jeong, "Efficient Content Delivery for Mobile Communications in Converged Networks," Wireless Communications and Mobile Computing, vol. 2019, Article ID 3170694, 12 pages, 2019.
4. AWY, et al, "Last mile mobile hybrid optical wireless access network routing enhancement", Bulletin of Electrical Engineering and Informatics, vol. 8, no. 1, March 2019, pp. 188~195.
5. N. Javaid, Z. A. Khan, U. Qasim, M. Jamil, M. Ishfaq, and T. A. Alghamdi, "Modeling Routing Overhead of Reactive Protocols at Link Layer and Network Layer in Wireless Multihop Networks," Mathematical Problems in Engineering, vol. 2015, 14 pages, 2015.
6. Neeta T. Tadha, et al, "Route Selection Technique of OLSR based on Energy Parameter and Multipath over MANET", International Journal of Engineering Science and Computing, May 2016.
7. S.E. Nai, Z. Lei, S.H. Wong, Y.H. Chew, "Optimizing radio network parameters for vertical sectorization via Taguchi's method IEEE Trans Veh Technol", 65(2), 2015, pp. 860-869.
8. OrchuAruna, Anil Kumar Prathipati, "Qos Signing and Routing In Manet", International Journal of Engineering Science Invention, 6(9), September 2017.
9. K. Sahithi, S.P.Setty, "Taguchi Design of Experiments for optimizing the Performance of AODV Routing Protocol in MANETS", International Journal of Engineering Research & Technology (IJERT), Vol. 7 Issue 04, April-2018.
10. C. Xu and J. He, "Performance analysis of IEEE 802.11 cognitive radio ad hoc networks," 2015 IEEE/CIC International Conference on Communications in China (ICCC), Shenzhen, 2015, pp. 1-6.
11. Chao-Ton Su. Quality Engineering: Off-Line Methods and Applications. Book Chapter, 2016.
12. Alias, M. S. M., Saad, N. H., Saedon, J., Hassan, N. H., & Harun, S. Analysis on the factors and effects of engine tapping noise by Design of Experiment (DOE). Journal of Mechanical Engineering, 12(2), 2015, pp. 27-48.
13. L. Rivoirard, M. Wahl, P. Sondi, M. Berbineau and D. Gruyer, "Performance evaluation of AODV, DSR, GRP and OLSR for VANET with real-world trajectories," 2017 15th International Conference on ITS Telecommunications (ITST), Warsaw, 2017, pp. 1-7.
14. Xin Yang, Ling Wang, and Jian Xie, "Energy Efficient Cross-Layer Transmission Model for Mobile Wireless Sensor Networks," Mobile Information Systems, vol. 2017, Article ID 1346416, 8 pages, 2017.
15. Asensi Pla, Juan Salvador. Design of Passive Optical Network. Brno Univesity of Technology. Brno, Czech 6 Republic, 2011.
16. Lakshman Naik.L, R.U.Khan & R.B.Mishra. Analysis of Performance Enhancing Parameters of AODV Using NS-3. African Journal of Computing & ICT. Vol 8. No. 2 Issue 2 – August, 2015.
17. Liu Huibin and Zhang, "Intelligent QoS routing algorithm based on improved AODV protocol for Ad Hoc networks", J. Phys.: Conf. Jun 2016.
18. Jamil Abedalrahim Jamil Alsayaydeh, Vadym Shkarupylo, Mohd Saad Bin Hamid, Stepan Skrupsky and Andrii Oliinyk, Stratified Model of the Internet of Things Infrastructure. Journal of Engineering and Applied Sciences, 13: 8634-8638, 2018.
19. Edward Breneiser, Amateur Radio Pedestrian Mobile Handbook: Second Edition, Book chapter, 2014.
20. M. K. Gulati K. Kumar, Performance comparison of mobile adhoc network routing protocol. International Journal of Computer Networks & Communications. 2014, 6(2), 77-84.
21. P. Rohal, R. Dahiya, Dahiya Prashant, "Study and analysis of throughput delay and packet delivery ratio in MANET for topology based routing protocols (AODV DSR and DSDV)", International Journal for Advance Research in Engineering and Technology, vol. 1, no. 2, pp. 54-58, Mar 2013.

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