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Research paper

QoS Support with Taguchi Method in Simulation Modelling Hybrid Architecture of Optical and Multi-Hop Wireless Ad Hoc Networks

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Abstract

Majority of the resource consumption is consumed for their operation in the access network of mobile wireless part because of its dynamic topology and limited wireless transmission range of each mobile user's. This article presents a technique using OMNeT++ software for building a design of experiment simulation model with Taguchi optimization method based on mobile ad hoc network (MANET) of AODVUU communication protocol to in cooperate with multiple layers framework. This particular framework is for deployment over future passive optical network (PON) known as the efficient routing Last Mile Mobile Hybrid optical wireless access network (erLMMHOWAN). It is for performing effective network quality of service evaluation that consider a number of nodes over which the MANET may operate. Its performance is examined on the identified performance metrics like the network capacity and energy consumption. Simulation result shows for the random mobile connectivity in this convergence of heterogeneous optical wireless network can have better performance based on optimized front-end of access network using wireless ad hoc routing.

Keywords: *mobile ad hoc network, Last Mile Mobile Hybrid optical wireless access network, design of experiment, network capacity, energy consumption, taguchi.*

1. Introduction

The access network is also experiencing exponential growth of access demand for the mobile Internet services. Globally, approximately 70% of the total Internet resource consumption were consumes by access networks [1, 2] such as capacity or energy consumption. As a result, telco providers and mobile customers have shifted the mindset towards the idea of eco-friendly technologies society.

Diversity of methods has been exploring to improve the available mobile resource efficiency and availability of wireless domain in access networks. Among today's system networking solutions, upgraded stationary wireless access for instance fiber-wireless (FiWi) architectures based R&F (Radio & Fiber) application provides the most encouraging traffic technology due to its enhanced speed, prosperous capacity resources and low latency and small loss [3].

Apart from that, there are potential issue facing by an important domain in the access networks that is the mobile wireless access network type that evolved rapidly based on few design goals that include mobility, user device re-configurability and flexibility. There are other study that based on MANET network has investigated the topology design for distribution MANET in urban power distribution over fiber link [4]. Thus the goal of this proposed research will concentrate on providing the efficient Internet access to mobile ad hoc users based on IEEE802.11g DCF (Distributed Coordination Function) [5]. Specifically, it is to integrate Taguchi optimization AODVUU routing [6] into the wireless domain of optical fiber-wireless (FiWi) backhaul network architecture. It was carried out with consideration of QoS resource consumption under the varying number of nodes.

Similar background study [7] was conducted for IP networks that was connected to a management server for monitoring the network topology and packet flow in real time of the transmission and reception. It was believed that they had benchmarked the MANET behavior for different performance metrics that are topology and packet flow. However, it did not focus on the effect and interaction of the parameters for the process performance characteristic in MANET which would help them to capture the network condition information.

To the best of the knowledge, not much work on hybrid optical and wireless network planning accounting for multi-hop wireless extensions to the optical segment, further considering the noise factor and control factor for determining minimum variation response of improved quality of service resource consumption at increasing of a number of nodes.

2. Solutions

2.1. erLMMHOWAN modelling setup

The next section carries out the DoE simulation of the erLMMHOWAN using the parameter settings as shown in Table 1. It shows the parameters used in the simulation and their associated values. The input data for the traffic generator is UDP traffic application format only as it did not provide multi-protocol encapsulation. The chosen reference traffic type of this evaluation is UDP [8] because of less overhead and is suitable for achieving the resource-efficient goal to promote an efficient use of networking resources such as capacity or energy consumption. IEEE802.11g with DCF functions at the MAC layer is used because it is a decentralized medium access method operating in both, infrastructure and ad hoc mode while 2 ONUs-Gateway is used due to it is the suitable number of ONUs to be used in FTTH for mall-school areas. The number of nodes is set at 500 nodes due to the high control traffic overhead and the high inefficiency of multi-hop data forwarding to examine the performance impact of network size. There are a total of 8 experiments were done for it with Random Network Generator 3 to obtain the accurate and the best parameters value for optimizing the tested variables.

Table 1: Common main parameters of the LMMHOWAN simulation

Parameter	Values
Simulation times	250s
Fiber type	Single mode Fiber
Reach (OLT-ONT)	20km
Number of OLT	1
Number of ONU	2
Number of nodes	20 to 500
Simulation Area	Max 8kmx6km
Traffic Type	UDP
Routing layer	AODV-UU
MAC Layer	IEEE802.11g with DCF
Carrier Frequency	2.4GHz
Data rate	6Mbps, 24Mbps, 54Mbps
Message Length (Packet Size)	512 byte, 1024 byte
Random number generator (RNG)	3

2.1.1 erLMMHOWAN state of art

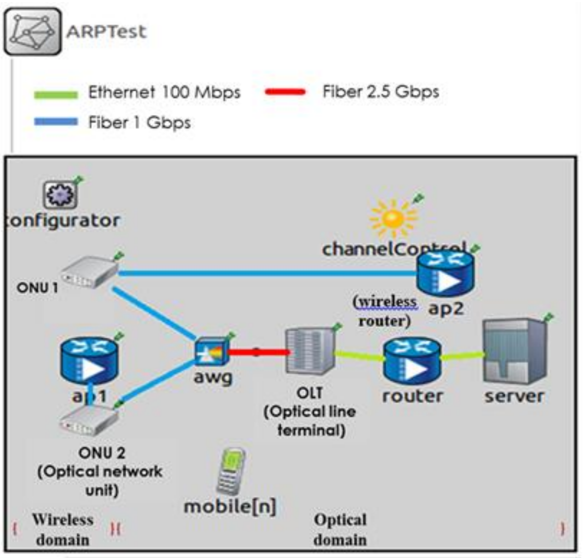

Fig 1: Framework of Multiple Layer Cross Cooperation Solution for erLMMHOWAN

The present study in this paper sets forth erLMMHOWAN framework based on fiber-wireless technology can be extended to MANET radios proposed as a unified analytical framework based on OMNet++ simulation environment [9] for data analysis. An integrated wireless front-end over optical access networks a key supporting technology combined with AODVUU network routing protocol has been proposed here respectively as shown in Figure 1. It is consisting of two main domains with the selected components: ONU, splitter, OLT that reside at the optical backhaul while mobile node, wireless router and wireless gateway in the wireless front end. This is the fundamental approach that based on radio-and-fiber technology with the aggregated optical backbone is to address the mobile wireless access problem. It is to provide efficient resource sharing wireless medium for MANET front-end that consists of independent mobile nodes that are connected to each other. Each participating mobile nodes voluntarily relay the packets to some other mobile nodes using the pre-optimized AODV-UU routing.

2.2. Routing optimization based on Taguchi approach towards LMMHOWAN

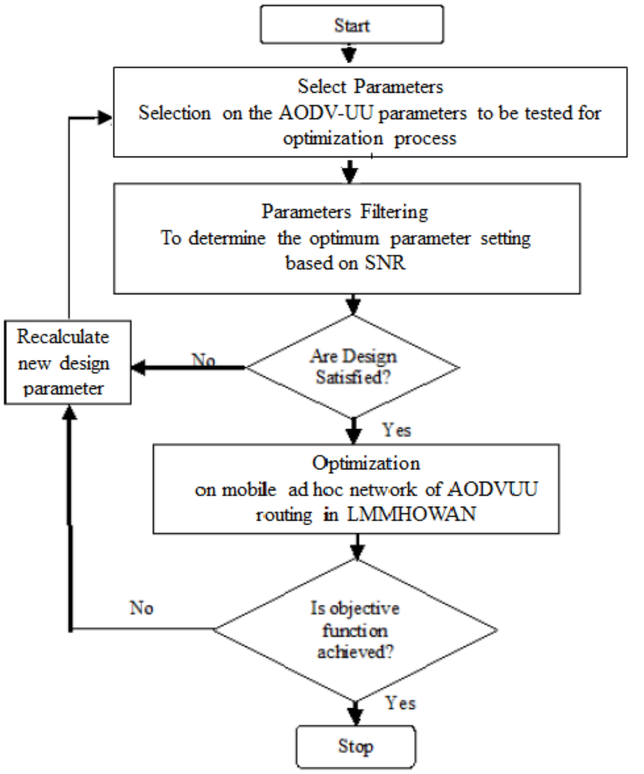

Fig. 2: Optimal design of AODVUU routing in erLMMHOWAN framework based on Taguchi optimization process methodology

This project utilized the Taguchi design method in anticipating the performance of Internet access solutions for AODVUU packet routing design based on MANET network of optimization as shown in the Figure 2 under the framework of erLMMHOWAN. It was for quantitatively identifying just the optimal setting for AODVUU protocol in MANET to go with optical backhaul connection as a wireless-wired backend. To illustrate it, the whole process is about parameter filtering which can be classify into two type of parameters; control and noise factors with respect to the presence variables for quantitatively identifying just the right set of ingredients that go together to make a high-quality product or service is carried out in the offline mode by using Minitab Software, It is where the signal-to-noise (SN) ratios is employs as a quantitative measure for determining the optimum access of wireless mobile ad hoc routes over optical pathway to achieve efficient resources. The SN would identify those control factors that reduce variability. Two categories of SN ratios, namely, “larger-is-better” and “smaller-is-better” [10] in Taguchi Method will be apply in the factor filtering process but it relies on the study goals such as to minimized the energy consumption or maximized the capacity consumption criteria. However, the loop back will have performed if the factor filtering is not satisfied during the optimization process.

2.3. Performance criteria

To measure the network performance metrics, the following metrics are used:

Total Energy Consumption [11]: This is the sum of energy consumed for all individual mobile nodes when the nodes were in the active state (transmit and receive), including the idle mode of its radio usage via the integrated multiple layers framework with an optical backhaul extension. For any data packet, the lower energy consumption by the participating node can improve the network lifespan indirectly to preserve as much as possible the network connectivity.

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

Where mobile battery electric charge Q(mAh) in milliampere-hour and mobile battery voltage V(V) in volts.

Total throughput [12]: The throughput metric here measures how well the network can constantly provide data to the user. To achieve a robust network, it is required that the throughput is at a high-level. Some factors that affect the mobile wireless domain throughput are unreliable communication, changes in topology, limited energy, and bandwidth. Total throughput is the total number of a packet arriving at the destination per simulation time for all participating nodes based on IEEE802.11g DCF wireless router with the client.

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

End to end delay [13]: This is the average time taken in delivery of all data packets from the source node to reach the same destination node. This metric is important in delay sensitive applications such as video or voice transmission. The lower the respective value, the better the network performance will be to signify the lower congestion ultimately in the network, which will reflect the network connectivity.

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

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.

3. Results and Discussion

The simulation setup is evaluated and revealed under the area of a school compound with the improvement scheme called as erL-MMHOWAN with the simulation area of 8kmx6km [14]. It is to be compared with the existing works on MANET domain [15] of its effect of the modified simulation parameters and called as oRir scheme for varying number of nodes in terms of energy consumption, end-to-end delay and network capacity performances.

- Energy consumption

Figure 3 presents the consumption of energy of all nodes while selecting paths from source to destination based on the AODVUU protocol of MANET over HOWAN after optimization (erL-MMHOWAN framework). There is an improvement after optimization at around 26.85% based on its average as compared to prior one (oRir). This is based on the parameter filtering process with selected optimum setting of wait_on_reboot values (1 second). Besides that, the particular parameter main function was to prevent unwanted routing loops for low latency effect, it can have efficient booting time from idle state of its radio usage to active state for better performance of energy consumption as shown in Figure 3.

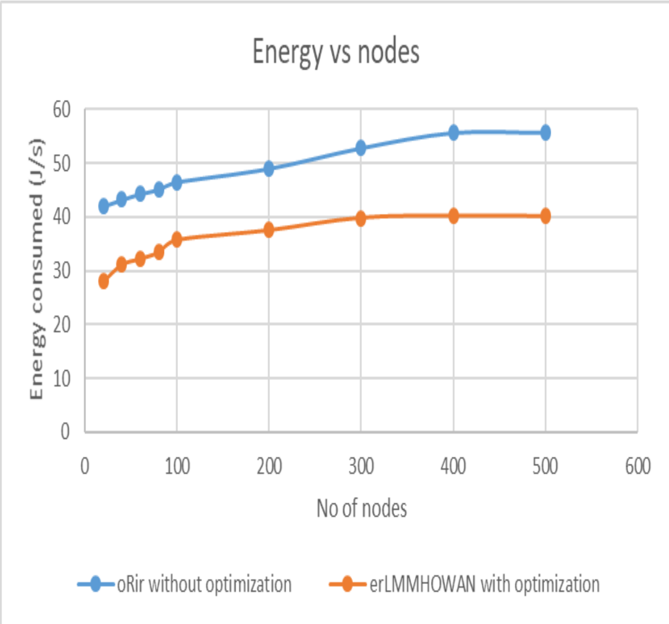

Fig. 3: Energy consumption performance for oRir and erL-MMHOWAN multi-parameter AODVUU routing before and after Taguchi optimization mechanism.

- Throughput/Capacity

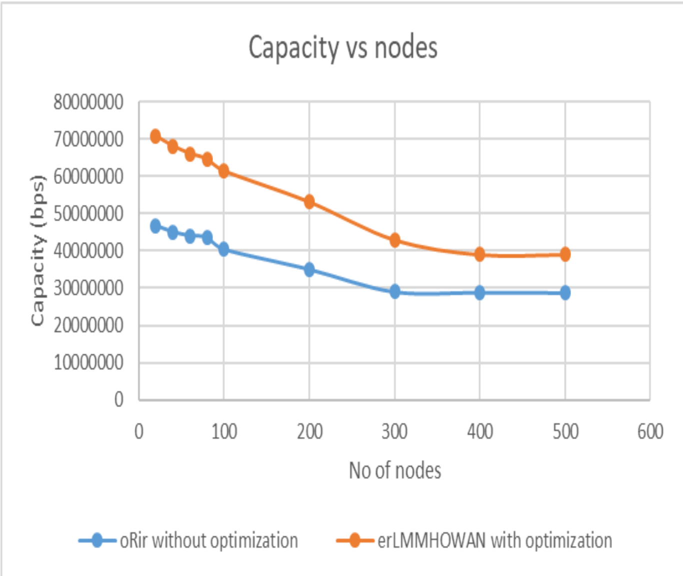

Fig. 4: Capacity performance for oRir and erLMMHOWAN multi-parameter AODVUU routing before and after Taguchi optimization mechanism

After applying this algorithm, our network capacity (erL-MMHOWAN) was better than about 47.07% average improvement as compared to prior one (oRir) as shown in Figure 4. This situation happened mainly because of the better link control with optimized link layer feedback (llfeedback) for detection of nodes congestion occur. It enhances the network awareness of the link condition particular when number of nodes is increased. Performance was improved where it has resulted in better packet service time with delay reduced as shown in Figure 5 and increased in network throughput.

- End-to-end Delay

Figure 5 shows the average performance of end-to-end delay is smaller in our proposed Taguchi scheme of modifying parameter setting than in the previous scheme of parameter setting with 13.44% improvement. As the number of nodes increases, there is high possibility that the wireless front-end suffers from a broken connection resulting in temporal latency (lasting small delay times) due to the high congested route delays the route searching process. So, by obtaining optimum network configurable setting that is available at the network layer can speed up the process searching new path when the number of nodes increase.

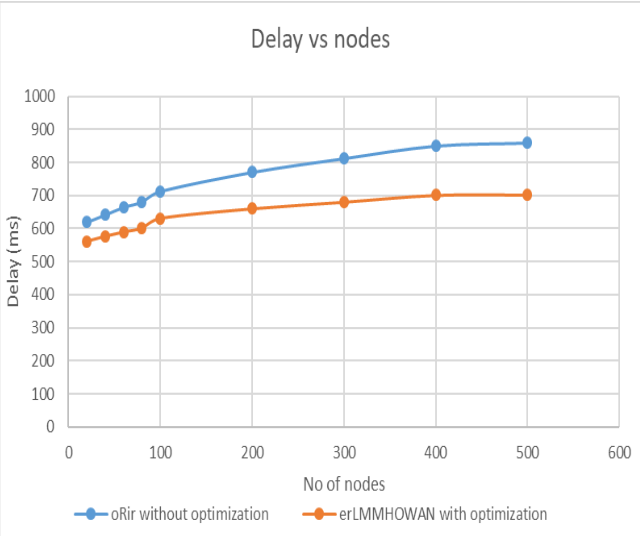

Fig. 5: Delay performance for oRir and erLMMHOWAN multi-parameter AODVUU routing before and after Taguchi optimization mechanism

4. Conclusion

The paper presents the seamless performance can be achieved that is based on the optimum and robust design parameters with the objective of improving the energy resource consumption and maximize the overall effectiveness of wireless packet route transmission capacity. The Taguchi multi-criterion optimization is integrated with the AODV-UU of MANET over optical backhaul can reduce variation in performance across wireless domain by increasing the overall performance in erLMMHOWAN QoS efficiency. It shows that the resource consumption for energy consumption and capacity consumption under Taguchi multi-criterion optimization is integrated with the AODV-UU of MANET over optical backhaul Taguchi optimized AODVUU routing in the erLMMHOWAN scheme has higher quality than the conventional AODVUU routing without Taguchi optimization of the oRir framework. It was to overcome the ongoing major open issue associated with bandwidth-constrained-variable wireless capacity links that are showing lower capacity than their hardwired counterparts.

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