Last mile mobile hybrid optical wireless access network routing enhancement

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ABSTRACT

This study focuses on mobile ad hoc networks (MANETs) that support Internet routing protocol imposing stringent resource consumption constraints of Quality of service (QoS). The mobile Internet causes the on-going issue of inefficient use of the MANET resources due to its random nature of wireless environments. In this paper, the new improved architecture of the last mile mobile hybrid optical-wireless access network (adLMMHOWAN) is proposed and designed to tackle the arised issues. The proposed design is based on a unified wireless-wired network solution required the deployment of MANET-based wireless fidelity (WiFi) technology at the wireless front-end and wavelengths division multiplexing passive optical network (WDM PON) at the optical backhaul. The critical performance metrics such as network capacity and energy consumption based on modified AODVUU routing protocol using OMNeT++ software is analyzed with 2 scenarios, namely the number of nodes and mobility speed. This mode of communication results in better QoS network capacity of 47.07% improvement, with 26.85% reduction of lower energy resource consumption for mobile wireless front-end over passive optical network backhaul architecture when compared with the existing work of oRiq scheme that focus on improvement in MANETs.

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1. INTRODUCTION

The internet traffic has been growing among worldwide subscribers, is likely to have important implications for networking which have been placing a huge demand on quality of service (QoS) telecommunications technologies [1]. Globally, the consumption of the total Internet resource consumption worldwide [2, 3] is about 70% such as capacity or energy consumption have come from access network. The hunger for greater capacity has led telecommunication industry player to become more aggressive to a series of mergers and purchasing wireless spectrum, but even that is not enough. A number of integrated optical and wireless access networks have been study to tackle these contemporary challengers here which can take advantage of their complementary features. It utilize the upper hand of the vast bandwidth and the mobility offered by the optical mobile network, appropriates in accessing mobile applications today [4].

In access network, all around resource consumption such as capacity and energy criteria's will expand beyond expectation because of the fasters growth rates with the number of technology-intelligent users. A robust next generation access network is needed for a deployment flexibility with platform support, large backbone capacity and upgradeability with QoS support [5]. The improved adLMMHOWAN fundamentally based on optical wireless combinations are seen as an promising alternative approaches for a robust access network. It is likely preferred fixed hybrid access and backhaul network solution with reliable broadband and dynamic penetration for users access [6].

In this paper, the front–end of wireless domain in this proposed adLMMHOWAN framework is implemented by using IEEE 802.11 DCF protocol based on WiFi network with the data rate up to 54Mbps. While at optical backend the WDM PON with the maximum up/downstream rate up to 10Gbps is being chosen to be deployed. WDM PON which considered most encouraging technology because of the delivering substantial capacity and service performance [8]. It has few interesting characteristics such as the modulation support for transmission with high data rates and easy deployment in the wireless access network.

Explicitly, the existing works [10, 15] which have brought about subsequent key features and spot the contributions for this paper. Specifically, it provides a heterogeneous unified system communication in terms of its application and protocol that simplifies the performance monitoring process and evaluation study for distributed shared network resources. Other notable contribution to be highlighted was the improvement of integrated cross layer mechanism to achieve rapid and higher performance in wireless domain. It offers a new approach of extensible cross layer access control, based on integrated factor Taguchi optimization of cooperating access protocols. This will result in fast prediction result in identifying the proper design level optimizations.

The organization of the paper where the overview of adLMMHOWAN architecture is briefly described and its whole framework design simulation is shown in Section 2. Further improvement is added to Taguchi optimization integrated modeling with proposed simulation framework based on standard AODV-UU in OMNeT++. In Section 3, the performance evaluation of the optimized adLMMHOWAN is investigated and discussed. Finally, the last section which is the section 4 provides the conclusion for this paper.

2. PROPOSED ALTERNATIVE ROUTING OPTIMIZATION ARCHITECTURE FOR ACCESS NETWORK

The design of experiment (DOE) using Taguchi method [9] with lowest runs is highly recommendable where large number of metrics involved in this respective framework. Basically Taguchi approach is being described based on a robust design method in reducing the variation of a process through the DOE as presented in Figure 1. The Taguchi method involved three main design optimization process where the first part is to develop the top-level system design principally follow by second part, is to identify the right set of control factors and design optimization levels. The last stage would be to obtain the noise factor to reduce the system network variations.

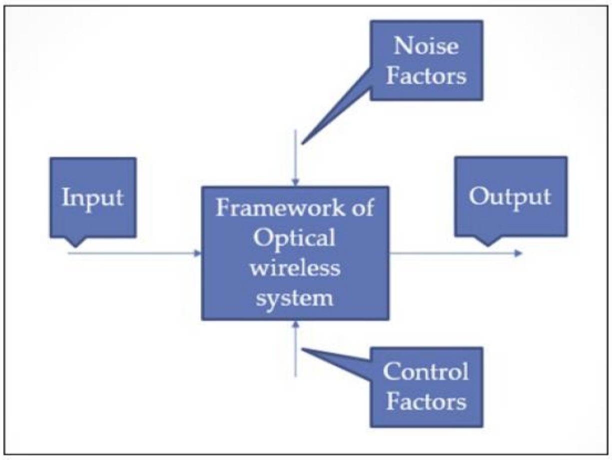

Figure 1. Robust/efficient design perspective in Taguchi method [7]

Based on Figure 2, the key point here when integrated with Taguchi Method is the overall process of optimizing the key variables to the reduced the process variation in the particular framework. The first process would be for screening many factors for routing involved in identifying both the control and noise factors. At the offline mode the proposed work here as a unified wireless-wired network aims to quantify the magnitude effect to the optimum level for several factors in AODVUU routing of MANET over optical backend. The quantitative measure on its performance results is based on Taguchi signal-to-noise (SN) ratios based on two responses, neither a "smaller" or "larger" are better. During this step, the loopback may occur if the factor screening is not fulfilled. As a result, there are seven (7) key variables are selected from the AODVUU's protocol consider as objective parameters such as *wait_on_reboot*, rate limit and etc for the online simulation running.

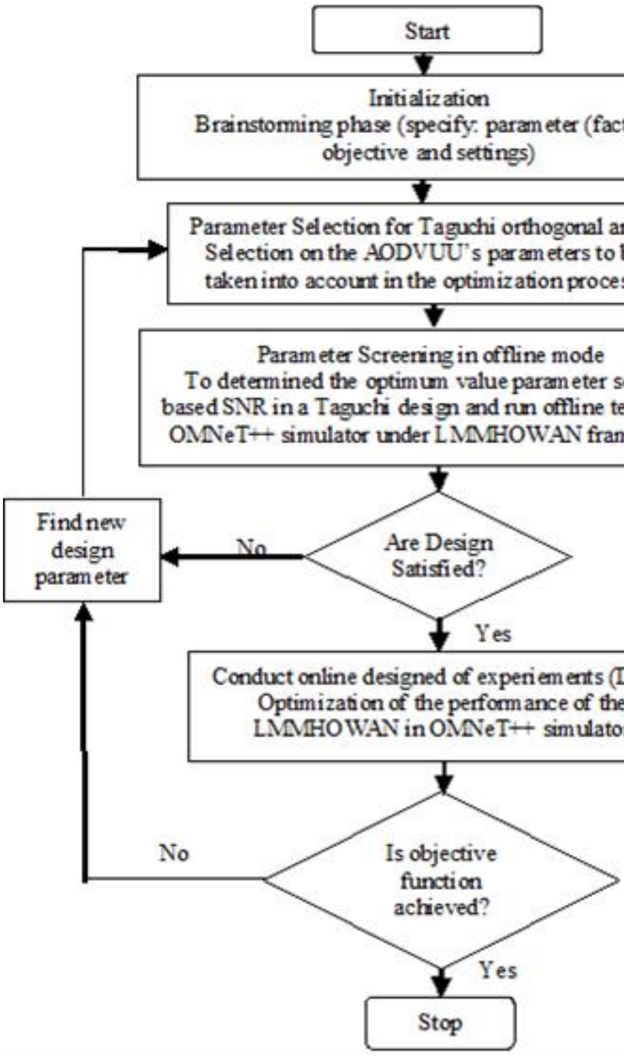

Figure 2. Flow chart for adLMMHOWAN optimal design of AODVUU routing

The proposed adLMMHOWAN architecture framework with integrated cross layer approach and optimal combination of a hybrid WDM-PON scheduling based on fiber-wireless technology that can be extended to MANET radios is shown in Figure 3 [10]. There is the Internet connection take place with the gateway router and the optical backhaul which consists of optical line terminal (OLT) at the backend of the network. Then, a remote node called the arrayed waveguide gratings (AWG) propagates the data to multiple optical network units (ONUs) via an optical fiber. Each router is attached with one ONU connected to the optical backhaul. Instead of using baseband-over-fiber (Radio over Fiber), the R&F (Radio and Fiber) properties based on the IP packets-over-fiber scheme is applied in this study. In the front-end, a set of mobile wireless ad hoc nodes which also a router by itself and at the same act as an end users participate in routing forwarding data to other nodes forms a wireless ad hoc network (MANET). The mobile wireless ad hoc nodes self-establish the upstream traffic (end-user to nearby access point) and maintain the connectivity. It is an alternate resource efficient for mobile Internet access. One or multiple access points are connected to one ONU at the optical domain of the network to create the critical hybrid path of optical fiber [11].

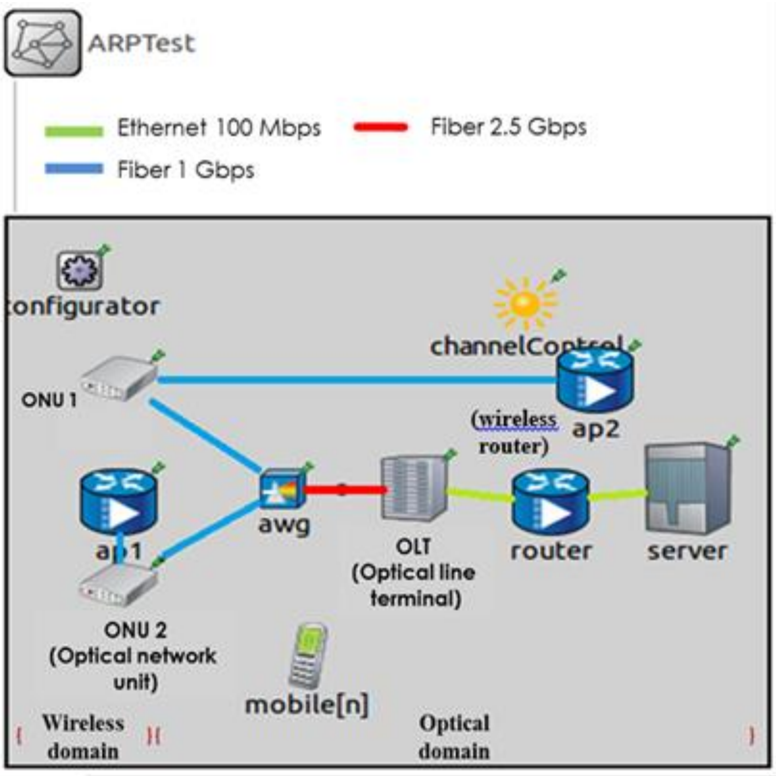

Figure 3. Framework of multiple layer cross cooperation solution for adLMMHOWAN

In this study, the radio-&-fiber scheme with protocol conversion between the optical-wireless domain of Ethernet packet and the optical frame is used to transport the Ethernet packet as a baseband signal over fiber [12]. The integrated connected of ONU/AP are equipped with the protocol conversion for optical and wireless domains. In the upstream direction, the ONU/AP will receive and collect the digitized wireless signals from the MANET nodes and up-convert it to optical signals to be sent to the optical backhaul. While at the downstream transmission, an optical signal was created at OLT and transmitted through the fiber link towards the integrated ONU/AP. The process of down-convert for the optical signal received from the AWG will take place at the ONU/AP converts to a wireless signal at downlink direction to be transmitted into defined MANET network. The OMNeT++ [13] and MiniTab [14] are open source means used to achieve design simulation of performance experiment for the proposed framework. Table 1 show the parameters used in the simulation and their associated values. In this study, 2 ONUs-Gateway is used for deployment the new paradigm optimized framework of Internet access application for mall-school areas following the optical splitters logical ratio of division according to the distributed traffic network topology [18]. To measure the network performance metrics, the following metrics are used:

Total Energy Consumption [16]: 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 [17]: The throughput metric here measures how well the network can constantly provide data to the user.

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

Table 1. Common main parameters of the adLMMHOWAN simulation

Parameter	Values
Simulation time	250s
Fiber type	Single mode fiber
Reach (OLT0ONT)	20 km
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

3. RESULTS AND ANALYSIS

The scenarios of the number of nodes and several mobility speed are identified in different performance metric are shown to evaluate the proposed system performance. Experiments are done based on the comparison with the previous study named as oRiq scheme on MANET domain [15].

3.1. Scenario A: varying mobility speed

As compared to (oRiq) as shown in Figure 4, there is an improvement of the network capacity (adLMMHOWAN) that was about 47.07% average improvement. This is due to the decrease in mobility-related packet loss in rapid changes of the network topology for varying node speeds. The improvement takes place from the perspective of the optimum local connectivity is obtained for link breaks to avoid the undeliverable data packets by the optimized link layer feedback (llfeedback) for detect congestion occurs at the nodes.

Figure 5 shows that after applying this improvement, 26.85% improvement is achieved based on its average as compared to prior (oRiq) with optimality condition of traffic routing according to some optimized configurable parameter such as the checkNextHop metric. The main reason for choosing this parameter setting is to be optimized as if the routing discovery there is no route to transmit due to broken link from several mobility conditions. As a result, the new path needs to be discovered before the traffic can be forwarded and stored in a buffer. This will incur more time and energy as well, which required to be optimized.

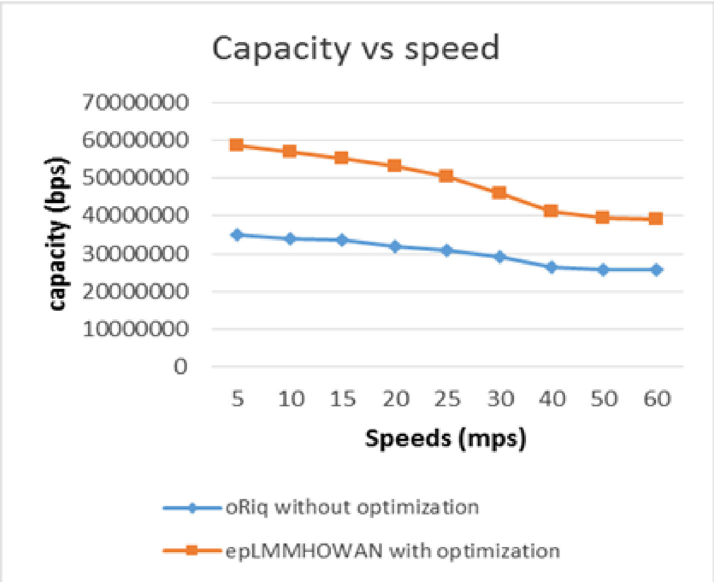

Figure 4. Capacity performance for oRiq and adLMMHOWAN multi-parameter AODVUU routing before and after taguchi optimization mechanism

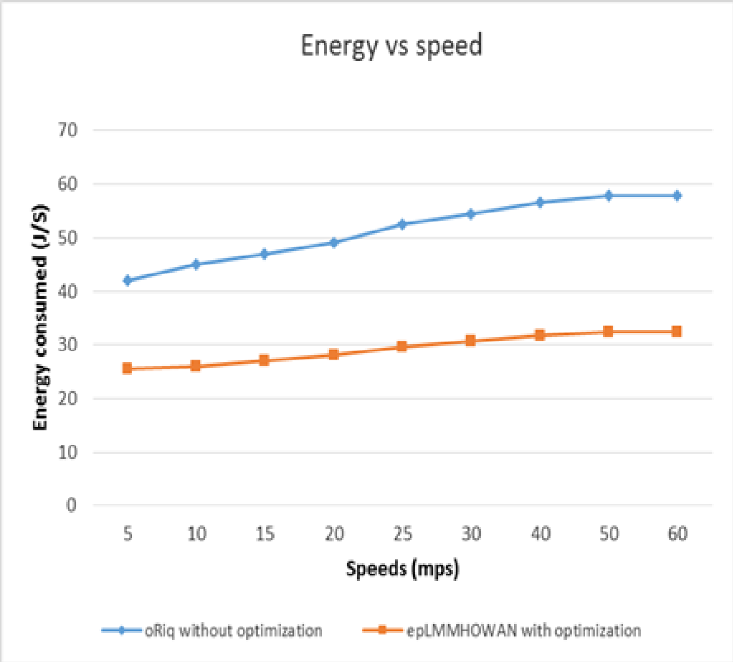

Figure 5. Energy consumption performance for oRiq and adLMMHOWAN multi-parameter AODVUU routing before and after Taguchi optimization mechanism

3.2. Scenario B: effect of the number of mobile nodes increase

Figure 6 shows a good quality of service energy consumption that was about 42.86% energy reduction of average improvement as compared to prior (oRiq). It is due to the unpredictable flooding frequency in data rate based approach in the routing of AODV-UU when the number of nodes was increased which may buffer the network and cause packet loss or a broken link. The optimized data rate limit parameter setting which is available at the network layer can contribute to the QoS best effort path thus leads to energy efficient framework.

About 60.87% average performance improvement was achieved for network capacity when adopting this proposed work here as compared to oRiq scheme as shown in Figure 7. This is due to a drawback in previous scheme (oRiq) that the current sending HELLO messages method to all nodes are not efficient and may degrade the network performance for both medium and large network. It will generate blind flooding that increases link overhead and wireless medium congestion, causing the decrease in the packet delivery as well as the capacity performance.

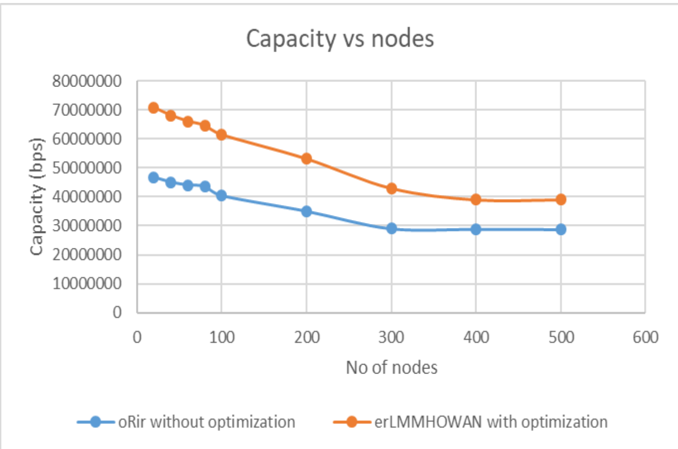

Figure 6. Capacity performance for oRiq and adLMMHOWAN multi-parameter AODVUU routing before and after Taguchi optimization mechanism

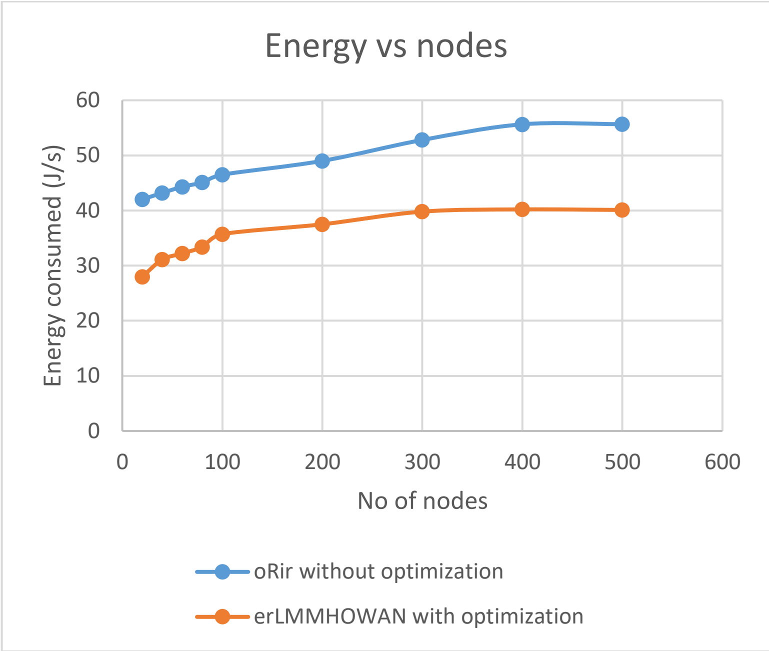

Figure 7. Energy consumption performance for oRiq and adLMMHOWAN multi-parameter AODVUU routing before and after Taguchi optimization mechanism

4. CONCLUSION

In this paper, alternative routing optimization architecture called the LMMHOWAN was properly outlined and introduced for future networks accessibility. Based on the number of nodes and mobility speed scenario, the performance in term of resource consumption was analyzed. In conclusion, the proposed LMMHOWAN framework of routing improvement work when compare to previous (oRiq) scheme achieved the average improvement of 47.07% in network capacity consumption and 26.85% in energy consumption under the scenario of several mobility nodes speed. The increasing number of nodes also improved on average 60.87% in network capacity consumption and 42.86% in energy consumption. For future improvement, the capacity wireless link at the wireless front-end can be further improved with (MIMO) multiple input multiple output system and integrated with the WiFi (IEEE802.11n) technology

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