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Efficient P2P data dissemination in integrated optical and wireless networks with Taguchi method

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Abstract

The Quality of Service (QoS) resource consumption is always the tricky problem and also the on-going issue in the access network of mobile wireless part because of its dynamic nature of network wireless transmissions. It is very critical for the infrastructure-less wireless mobile ad hoc network that is distributed while interconnects in a peer-to-peer manner. Toward resolve the problem, Taguchi method optimization of mobile ad hoc routing (AODVUU) is applied in integrated optical and wireless networks called the adLMMHOWAN. Practically, this technique was carry out using OMNeT++ software by building a simulation based optimization through design of experiment. Its QoS network performance is examined based on packet delivery ratio (PDR) metric and packet loss probabilities (PLP) metric that consider the scenario of variation number of nodes. During the performing stage with random mobile connectivity based on improvement in optimized front-end wireless domain of AODVUU routing, the result is performing better when compared with previous study called the oRia scheme with the improvement of 14.1% PDR and 43.3% PLP in this convergence of heterogeneous optical wireless network.

Keywords*: AODVUU, design of experiment, FiWi, MANET, taguchi*

1. Introduction

A recent consumer survey as shown in Figure 1 has quantified the rising popularity of the mobile Internet of Usage (IoS) of access network, specifically with regard to smart phones and tablets [1, 2]. This has brought about the integration of Internet and MANET nodes associated to key infrastructure of all-IP shared network. Subsequently, total Internet resource consumption worldwide nearly 70% [3] such as delay or packet loss probabilities in the front-end has been consumed by wireless domain of mobile nodes. This poses a challenge in data dissemination among the mobile peers, each having unpredictable mobility [4, 5].

Mobile ad-hoc network (MANET) routing protocols is a self-starting dynamic network comprises a number of intermediate mobile nodes and wireless links connecting them [6]. The MANET considered in this work is distinguish by the unpredictable node movements especially in increase of speed environment and rapidly changes in the node connectivity due to random topology based on multi-hop communication [7, 8]. This will lead to inefficient routing packet and ineffective energy consumption that may cause considerable impact to the environmental sustainability. Hence, there is a great need for solutions to realize better performance of resource-efficient and reliable wireless mobile networks [9, 10].

Several studies of work have been done to gain better performance of MANET. The study of [11] was conducted to provide IP networks framework with connection to the management server. This schemes was for monitoring the real time end-to-end

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communication. It was believed that MANET network behavior was chosen as benchmark study whereby different performance metrics were to be considered that are topology and packet flow. Nevertheless, it was not highlight on the parameters interaction in terms of variation consequence considering the various mobility speed which could bring better quality into the performance characteristic in MANET.

Based on brief literature reviews shows that only a few previous publish works literally associated to our studies. The identify authors investigate the efficiency of certain MANET routing protocols with respect to Taguchi method based on design of experiment (DoE), for example the Dynamic Source Routing (DSR) [12, 13]. The only possible drawback related to this study was that DSR scheme is less efficient in terms of alleviate the negative effect of routing decision and increase the network lifetime when the mobile nodes is at the move [14, 15]. The poor MANET network condition and unreliable nature of mobile ad hoc nodes must be improved to use the resources effectively to ensure high reliable and robust link transmission [16]. Among advanced solutions applied in today's system networking infrastructure to improve both the mobile wireless access networks resource effectiveness and availability, fiber-wireless (FiWi) technologies with respect to enabling Radio & Fiber (R&F) network are one of the most promising alternative network transmission technology because of the unique characteristics like the autonomous mobility, richer in bandwidth resources and low fiber attenuation [17, 18].

Following that, there is other study of MANET connectivity that investigated the topology design in distributed manner for urban power distribution over fiber link [19]. Thus the major concentration of the proposed research study was routing approach of Taguchi optimization AODVUU routing [20] and was also further introduced into the FiWi area from the wireless domains. It aims to provide the alternative method of robust and efficient way to connect MANET end users and Internet based on distributed coordination function (DCF) mode of the IEEE 802.11g [21, 22] with consideration of providing QoS-assurance under limited of resource consumption with respect to increase the number of nodes.

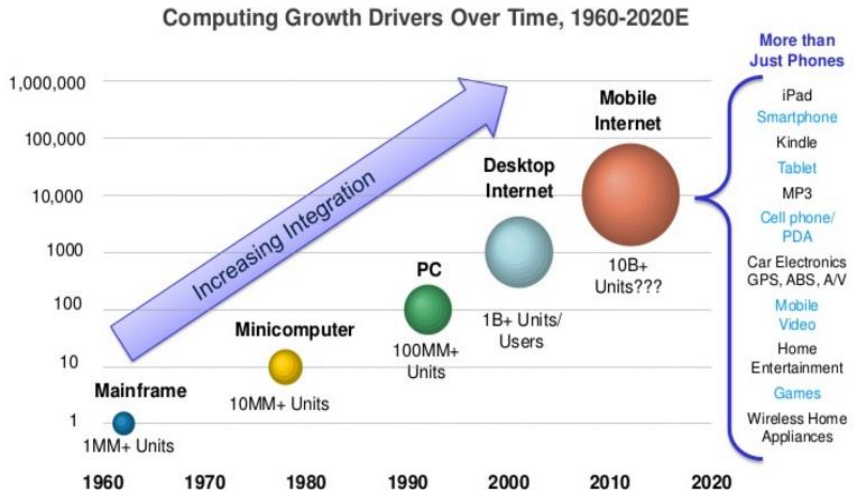

Figure 1. Evolution of mobile wireless access network technology [23]

2. Research Method

Figure 2 shows the optimization process for this particular tested network environments applying Taguchi method. It's start with identifying the parameter (rate-limit, wait_on_reboot, llfeedback, receive_n_hellos, optimized_hellos, checkNextHop and PublicRoutingstables) and noise factors (varying speed and number of nodes) that influencing the tested scenarios based on intelligent multi-rate scheme (6 Mbps, 24 Mbps, 54 Mbps). Then it is to the start parameter filtering processes on the number mobile hosts that run on the intended dimension area thus can specify the tested scenarios environment. Finally, the optimized process will continue until getting the optimize parameters for all the control factors from these experiments.

The component of the proposed improve framework featuring the solution of integrated cooperation layers solution for on-demand resource efficient LMMHOWAN in Figure 3 is adapted associated with the physical layer model of optical fiber connections and dynamic routing protocols for wireless ad-hoc network based on infrastructure [24]. In the study of the LMMHOWAN project with the emphasis more on the efficient utilization of mobile network resources, the pyramid-type layer model optical fiber design is used for efficient network convergence with the wireless domain of MANET network. It is chosen to address the inefficient resource consumption and connectivity problem in both mobile wireless and wired networks. The other key points based on this respective conceptual model are:

- Support for multiple optimizations with the focus on system network resource efficiency.
- Support for multiple scenarios for the coordination of protocol and system components.

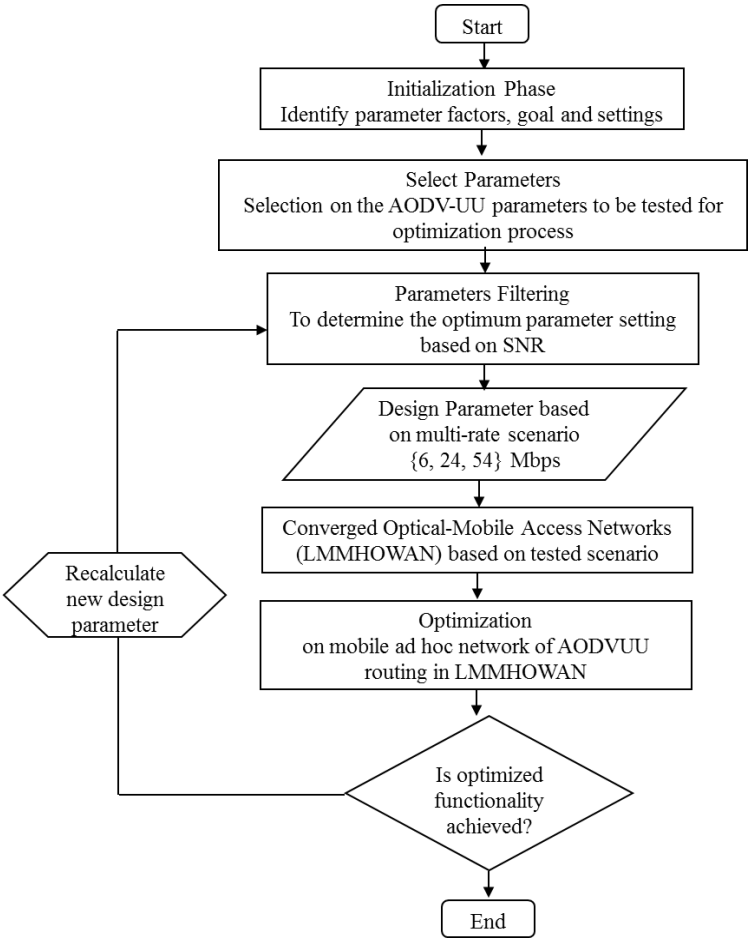

Figure 2. Systematic architecture of optimization processes

LOD (Logical Optimization Database) is the offline process of finding a robust and efficient path for traffic across multiple networks achieved by abstracting the functionality which consists of two components as shown in Figure 3. The converged-layer process component (CPC) is performed in the MANET while the logical component (LC) is executed in the ONU-Wireless Gateway. The logical component (LC) allows designers to identify their converged-layer parameter for optimizations in a very abstract and intuitive way. In this work, a logical component is one "path" of procedural involving integrated optical, wireless and mobile domain functionality. For this purpose, an alternate effective design of experiment through simulation-based customized is proposed for converged-layer design purposes. It is more to user-centered design where the designer engineers have to apply the engineering perspective experience to create a viably functional and efficient design.

The proper realization of the converged-layer parameter optimizations (given by the LC) is realized by the converged-layer process component (CPC) involving user-centric of Robust Design (Taguchi Method). Here the selective tool chosen is Minitab signal-to-noise (SNR) ratio analysis that is used to predict field quality through the design of experiments. The output of the MiniTab software will become the input for the OMNeT simulation. More precisely, the Taguchi signal-to-noise analysis about the main effect plots of mean response factors are extracted, this would be utilized for optimisation purpose in OMNeT++. The system network design phase involves deciding the optimum values/levels based on the signal-to-noise ratio (S/N) goal for the control factors of the AODV-UU routing setting metrics in the identified converged-layer parameter optimizations. The optimum or best values are decided based on the higher value of SNR by depending on the goal when optimizing the selected control factors either to minimize or maximize the performance criteria such as maximize the capacity and PDR.

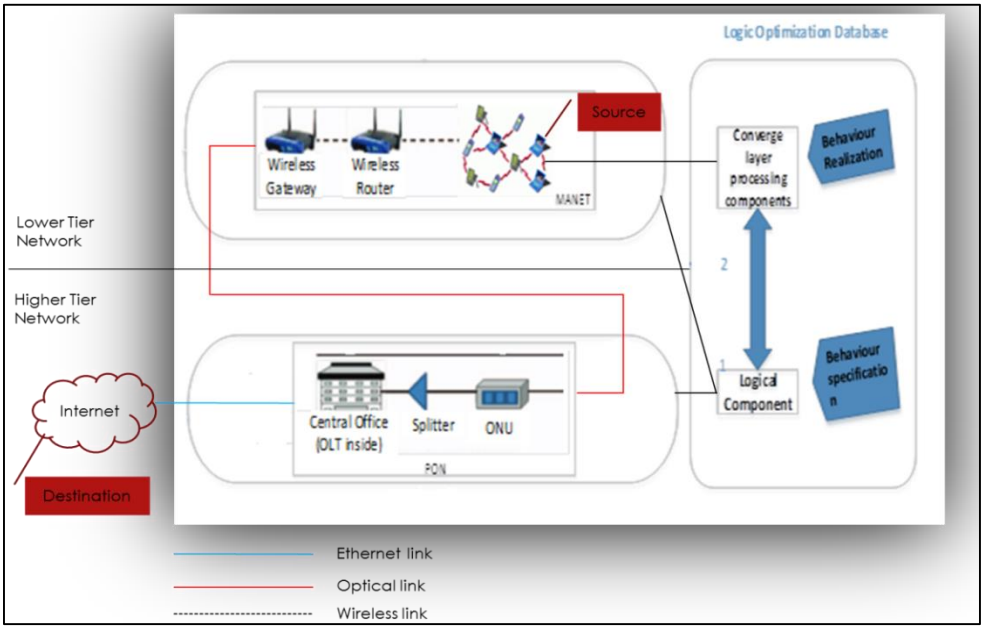

Figure 3. Structure of joint design approach in wired (optical) and wireless for resource optimization in last mile mobile integrated optical and wireless networks

3. Results and Analysis

In this section, the simulation result was compared with the previous study for MANET part [25] known as the oRia system by the use of OMNET++ simulator tool and only focused on 2 performance metrics for evaluation which are PDR and PLP. Figure 4 reflects the strength of the network in terms of accuracy of the data transmission framework for the AODVUU protocol embodies the Taguchi optimization over HOWAN. As depicted in Figure 4, approximately 14.1% of average PDR improvement after the optimization was obtained with reduced of packet loss as compared to the oRia scheme. As the number of nodes increases, routing table in AODVUU of MANET need to be updated intensely causing HELLO messages rapidly multiply broadcast to all the others node which flood in the network where these HELLO message need to be optimized. This may experience bad performance with the unceasingly decrementing value of PDR due to updating these tables takes geometrically increasing amounts of processing power until causing exhaustion of the node's battery power.

While the PLP graph of Figure 5 reflects the occurrences frequency of packet loss happened before reaching the final destination due to frequent link breaks with the increasing of a number of nodes. This has degraded the overall capacity performance. The main reason is that the frequent link breaks would increase the routing overhead such as the internal design routing enabling wait_on_reboot factor for AODVUU. It inccur an extra proccess overhead

called the waiting phase of establishing connection. But with the proposed method here in the evaluation scales better with respect to the number of nodes with 43.31% of average improvement. Thus, it can indirectly improve the mobile nodes transmission guarantee based on the optimum wait_on_reboot value (1 second).

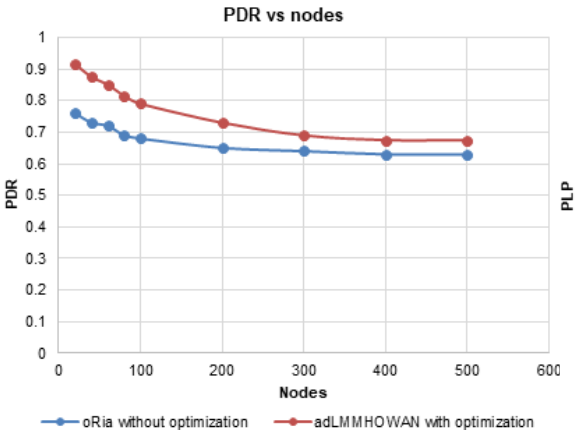

Figure 4. PDR performance for oRia and adLMMHOWAN multi-parameter AODVUU routing before and after Taguchi optimization mechanism

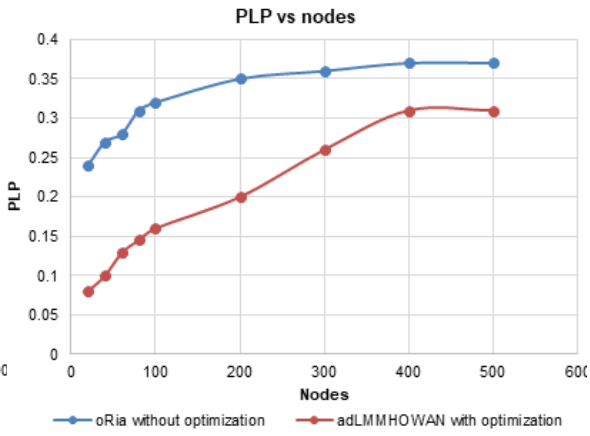

Figure 5. PLP performance for oRia and adLMMHOWAN multi-parameter AODVUU routing before and after Taguchi optimization mechanism

4. Conclusion

In this work, some of the on-going issues in MANET of wireless domain had been addressed to integrate with optical backhaul which then can serve as alternative last mile mobile internet access to mobile users. A feasible simulation framework with the Taguchi multi-criterion optimization has been proposed for a converged wireless MANET with Hybrid Wavelength Division Multiplexing Passive Optical Network (WDM-PON) operated according to the IEEE 802.11g distributed coordination function (DCF) as the medium-access control (MAC) protocol in the link layer. The proposed DoE simulation framework aims to achieved the QoS seamless performance with minimize variation that is depend on the design parameters carry the objective of optimum and robust design criterion while accounting for the specific service requirements (users' traffic) in terms of maximize the PDR and minimize the PLP. It shows that the resource consumption for performance metrics of 14.1% PDR and 43.3% PLP based on Taguchi optimized AODVUU routing in the adLMMHOWAN scheme is more effective than the non-Taguchi AODVUU routing optimization as regards to oRia scheme of previous study settings.

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