Energy-Efficient Passive Optical Local Area Network (POLAN)

Chien Aun Chan, Ka-lun Lee, Jie Li

Department of Electrical and Electronic Engineering, The University of Melbourne, 3010, Victoria, Australia. chienac@unimelb.edu.au

Abstract *We demonstrate through measurements and modelling that a passive optical local area network (POLAN) provides better energy-efficiency for corporate local area networks (LAN) compared to copper Ethernet.*

Introduction

Companies are increasingly challenged in providing sustainable network solutions as corporate LANs are facing disruptive changes caused by the increasing usage of real-time, high bandwidth applications such as video services, teleconference and a diverse range of cloud applications. Furthermore, an increasing focus on corporate social and environmental responsibility has introduced further stringent requirements on enterprise network design. Besides being a future proof technology to support rapid increases in user data rate, enterprise networks have to be energy-efficient and highly secure while minimising the capital and operational expenditures.

Current corporate LANs that are mainly based on copper Ethernet are unable to satisfy all the above requirements of future enterprise networking. In recent years, many companies have introduced POLAN as an alternative LAN solution for corporate networks. Compared to traditional LAN, POLAN enables local area networking with higher bandwidth and security, lower latency, immunity to electromagnetic interference, are highly scalable with large coverage and lower energy consumption. Here, we investigate the power consumption of POLAN experimentally and model the overall power benefit based on the experimental results. In this paper, we use real measurements to construct energy consumption models for different local area network architectures to show that POLAN (GPON-based local area network) could provide the most energy-efficient networking solution. We show that GPON-based POLAN could provide a power saving of up to 82% compared to conventional copper Ethernet LAN.

Energy Consumption of GPON-based LAN

Here, we model the energy consumption of two different network architectures and technologies – conventional copper Ethernet network and Gigabit passive optical network (GPON) in both a small and large enterprise network with 200 and 2000 Ethernet ports, respectively.

The use of optical networking technology in corporate networks has been proposed due to the maturity of GPON standards. A recent study from NOKIA has shown that using optical enterprise networks can provide significant savings over copper Ethernet in terms of capital expenditures (CAPEX), operational expenditures (OPEX), and total costs of ownership (TCO) depending on the network topology[1]:

- 9% to 61% CAPEX savings
- 34% to 54% OPEX savings
- 23% to 58% TCO savings

In this paper, we first measure the power consumption of a POLAN system by varying the traffic load in the system. Then we compare the energy consumption of the POLAN system with conventional copper Ethernet network architecture to demonstrate the savings in total network power consumption.

Fig. 1 shows the experimental setup used to measure the variation of dynamic power consumption of the POLAN system under different traffic loads. In the setup, the POLAN system (model : 7360 FX-4) is manufactured by NOKIA. The FX-4 is equipped with two network terminal (NT) cards and two optical line terminal (LT) cards. The maximum uplink capacity of FX-4 is 40 Gb/s per NT-card. Four personal computers (PC) are connected to four laptops via the POLAN system. The iPerf traffic generating software[2] was used to generate different traffic loads (i.e., from 0 to 1 Gb/s) from a PC on the wide area network to a laptop connected to the LAN via an ONU. We measured the static power (without traffic) as well as the dynamic power (with traffic) of both the OLT and the ONU.

Fig. 2 shows the power consumption measurements of the POLAN. For the OLT, little power variation on traffic loading is observed. However, due to limitation of the traffic generator, we are unable to push the OLT close to the maximum limit in terms of traffic loading. Therefore, higher traffic-loads are required to conclude the OLT dynamic power variation. For the ONU, the maximum power consumption is around 5.9W. When idle, the ONU consumes around 80% of the 5.9W.

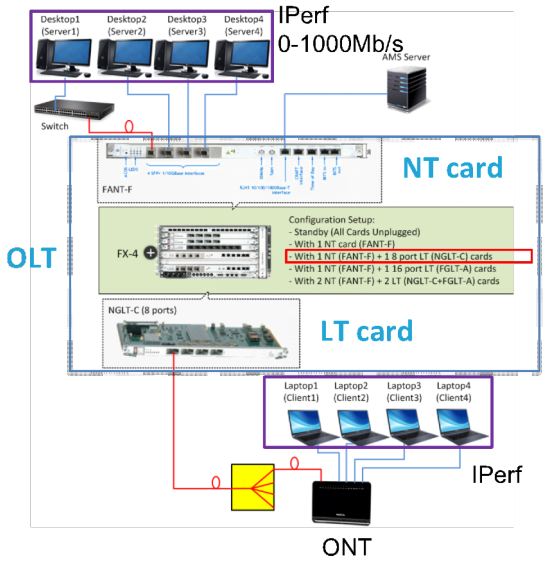

Fig. 1: Experimental setup to measure the static and dynamic power consumption of GPON-based LAN.

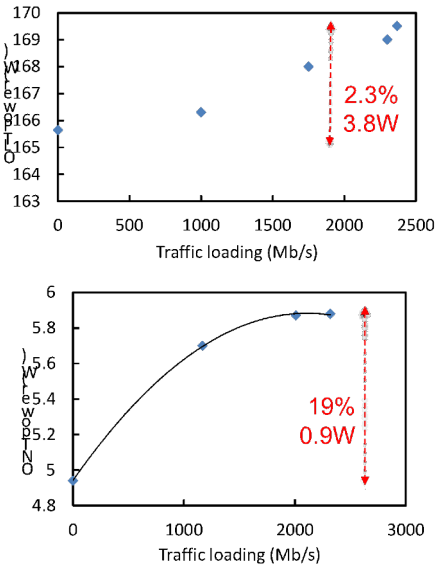

Fig. 2: OLT and ONU power consumption measurements.

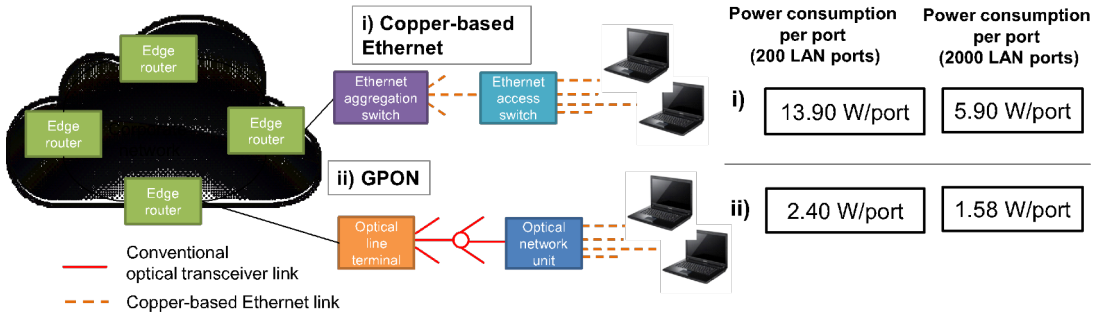

Fig. 3: Comparing per port power consumption of GPON-based LAN and copper Ethernet.

Passive Optical LAN vs. Copper Ethernet

Here we compare the power consumption of the passive optical and copper Ethernet LAN systems. Fig. 3 shows the power consumption per LAN port of the two network architectures for a small enterprise network with 200 LAN ports and a large enterprise network with 2000 LAN ports. For the copper Ethernet LAN, we use Cisco 4506 as the aggregation switch and Cisco 4503 as the access switch for 200-port scenario. For the 2000-port scenario, we use Cisco 4510 and Cisco 4503 as the aggregation and access switches, respectively.

Our results show that conventional copper Ethernet network is not as energy efficient as POLAN, consuming 13.9 W and 5.9 W per port for a 200 and a 2000 port network, respectively. In contrast, the POLAN is a more energy-efficient local area networking solution, at 2.4 W and 1.58 W per port for a 200 and a 2000 port network.

Summary

In this paper, we performed real measurements on the power consumption of a POLAN system and demonstrated that POLAN provides a more energy-efficient local area networking solution for corporate networks compared to conventional copper Ethernet.

References

[1] Bell Labs, “Passive optical LAN versus copper-based Ethernet,” Nokia strategic white paper (2016).

[2] iPerf, https://iperf.fr/