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Performance Analysis of Energy-Aware Load Adaptive Schemes for Optical Communication Networks

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ABSTRACT

Wireless Sensor Network (WSN) is one of the new paradigms which is helping for sharing and disseminating data in the Sensor Networks. Extended Network Lifetime, Scalability, and Traffic Balancing among the Nodes in the Network are significant requirements and challenges for Wireless Sensor Networks which requirements are achieved by clustering that is one of the effectual techniques for achieving these requirements. This research work identifies a few popular Energy Efficient Clustering Protocols namely i. Switch-On, ii. Load Adaptive Sequence Arrangement-Fixed Minimal Transmission Time (LASA-FMT) and iii. Internet Protocol/ Wavelength-Division-Multiplex (IP-WDM) for analysis and studied thoroughly. From the experimental results, it was noticed that the Switch-On model is performing well in term of Routers/ Throughput but however it fails to achieve Throughput, Router Utilization and it is also consuming more Power. The LASA-FMT is outperforming in term of Throughput and the IP-WDM model is outperforming in terms of Router Utilization and Power Consumption, but however this model was incompetent to achieve Throughput.

Keywords: Clustering, Energy Efficiency, Fuzzy Logic, Residual Energy, Ring Routing, Routing Technique, Wireless Sensor Networks

I. INTRODUCTION

Present day administration suppliers confront a large group of difficulties, numerous originating from the mind boggling, dynamic activity examples of mobile, video, and cloud services and expanding interest for transmission capacity with exclusive standards about the nature of service[1,2,3]. The expectations incorporate system availability, more data transfer capacity or bandwidth and a "superior than best exertion" approach.

The expenses for meeting the expectations of the client challenge numerous service supplier income models. They must indeed balance the cost of infrastructure upgrades against the return on investment. To remain competitive as well as profitable, assuredly the service providers must be capable of providing new and developed services while gaining increased efficiencies from the network to lower costs.

The three recently proposed popular models[1,2,3] namely Switch-On, Load Adaptive Sequence Arrangement (LASA) the Fixed Minimal Transmission Time (FMT) and Internet Protocol (IP) / Wavelength-Division-Multiplex (WDM) are here discussed and compared in the following sections.

II. RECENTLY PROPOSED POPULAR MODELS

In the following sections, we have discussed all the above mentioned three models.

A. ILP based Switch-On Schemes[1]

The ILP based Switched-On Scheme was proposed by the author[1,5,6] Marcel Caria and et al. Dynamic transport circuit services are adapted by load adaptive energy saving schemes for backbone IP networks which use to adapt the active network resources to the current traffic demand in order to reduce the network's energy consumption. Although it has been shown that the scheme can notably decreases the network's energy consumption, it is still prone to instabilities in the IP routing service and decreased resilience due to reduced connectivity and they may induce monitoring reconfigurations in fact. To face these challenges, the Switch-On scheme in an IP-over-WDM network, where the network is designed so that the essential IP connectivity is maintained during low traffic periods while dynamic circuits are switched on in the optical layer to boost network capacity during the phases of high traffic demand was indeed proposed.

Switching on the optical links during peak network loads can address some of the challenges still linked with the switching off IP ports and links during the low traffic periods. The already research results perform that the multilayer approaches in IP-over-WDM networks carry remarkable potential for improvement in energy efficiency [1,2,3,4].

In this Switch-On scheme, the network was designed so that the essential IP connectivity is maintained during low traffic periods while dynamic circuits are switched on in the optical layer to boost up the network capacity during the periods of high traffic demand. The Wavelength Division Multiplexed (WDM) layer is provided[1,3,4,5] with the traffic management flexibility and the engineering simplicity of digital transport systems and with the network cost savings of large-scale photonic integration.

The result[1] shows that the Switch-On Technique saves Energy in Optical Networks rather a considerable computational complexity.

B. LOAD ADAPTIVE SEQUENCE ARRANGEMENT (LASA) WITH FIXED MINIMAL TRANSMISSION TIME (FMT)

The Load Adaptive Polling Sequence Arrangement (LASA) Scheme jointly working with Fixed Minimal Transmission Time (LASA-FMT) was proposed[2] by the author Yunxin Lv and et al [2,8,9,10]. An energy-efficient scheme termed as load adaptive sequence arrangement (LASA) is successfully introduced by the authors[2,11,12]. Based on changing the polling sequence of optical network units (ONUs) according to the traffic load, the scheme can successfully develop the energy efficiency of the passive optical access networks. The Flow chart of the LASA scheme that executed at Optical Line Terminal is shown at the Figure 1 and the Flow chart of the LASA scheme that executed at Optical Network Units is shown at the Figure 2

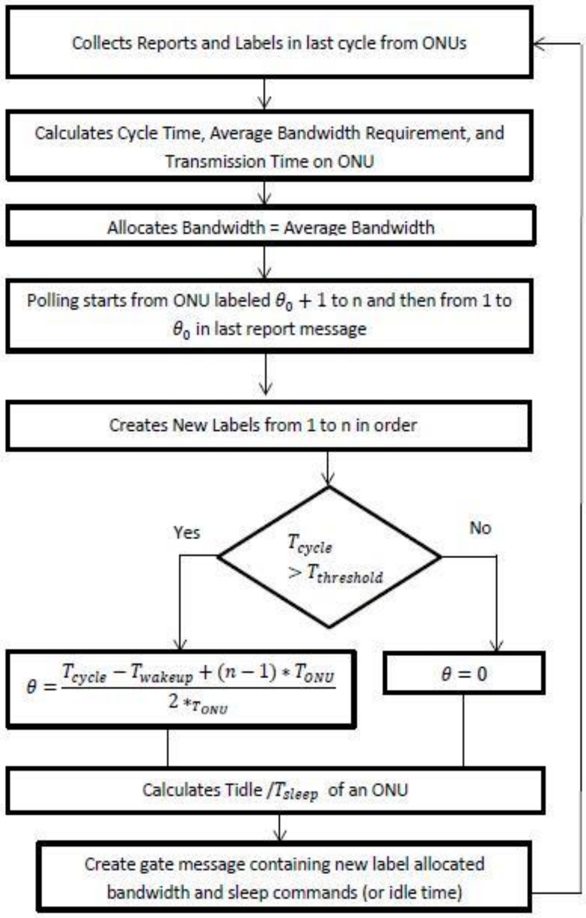

Figure 1. Flow chart of the LASA scheme executed at Optical Line Terminal

The polling sequence arrangement is demonstrated by processing a label that is added in the gate/report message and allocating each ONU an uneven idle time rather. When the polling sequence is changed, the ONUs that have been allocated longer idle times could sleep much longer indeed. Theoretical analysis indicates that the polling sequence arrangement has a remarkable impact on the energy efficiency of the network.

It can provide ONUs longer total sleeping time, and can also barely lengthen the average cycle time. Moreover, to optimize the energy consumption performance under a low-traffic scenario, the LASA scheme as jointly working with the fixed minimal transmission time (FMT) of the ONU scheme, which is called the LASA-FMT scheme, is further investigated in the research. By ensuring the minimal transmission time of an ONU, the LASA-FMT scheme further lengthens the total sleeping time of ONUs and improves the energy efficiency.

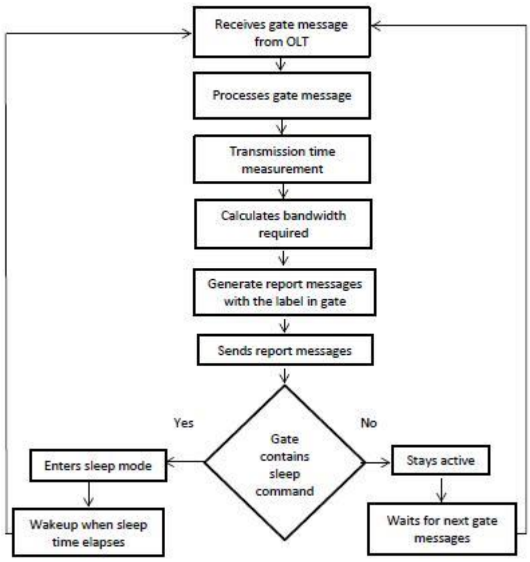

Figure 2. Flow chart of the proposed LASA scheme executed at Optical Network Units

When an energy-efficient scheme termed as load adaptive sequence arrangement (LASA) is introduced, based on changing the polling sequence of optical network units (ONUs) according to the traffic load, the scheme can improve the energy efficiency of passive optical access networks. The polling sequence arrangement is performed by means of processing a label that is added in the gate/report message and allocating each ONU an uneven idle time. When the polling sequence is changed, the ONUs that have been allocated longer idle times could sleep much longer. Theoretical analysis indicates that the polling sequence arrangement has a significant effect on the energy efficiency of the network.

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C. ARCHITECTURE MODELS OF OPTICAL LAYERS

It was considered two types of Optical Layer Architecture Designs such as the ones depending on wavelength conversion capability. Optical Nodes with wavelength conversion can successfully convert the wavelength of an incoming signal to another wavelength channel rather. However, this is not available in all the Optical Nodes. An Optical Node without wavelength conversion depends on the IP layer to provide wavelength conversion to determine the wavelength contention in the process of traffic grooming[3,13,14,15]. Figure 3 shows Optical Node Architecture with (a) and without (b) wavelength conversion. For the IP layer and optical layer interfaces, the Dense WDM (DWDM) ports are connected to SR/Es and E/SRs. In the energy model, the consideration is here for the integrated DWDM ports with SR/E (E/SR) inside an IP line card for the sake of simplicity. Figure 3(a) shows an: All-optical node model employing wavelength switching. The optical layer consists of following 5 major elements; WDM mux, WDM demux, fast tunable wavelength converter (TWC), broadband wavelength converter (WC), and optical cross connector (OXC).

A TWC can tune the output wavelength for an arbitrary WDM [3,16,18] channel to switch the input port to an available output port of an arrayed waveguide grating router (AWGR). In turn, the wavelength is all converted rather to that of the output port WDM channel. Figure 3(b) shows the all-optical node model that provides space switching without any wavelength conversion at all.

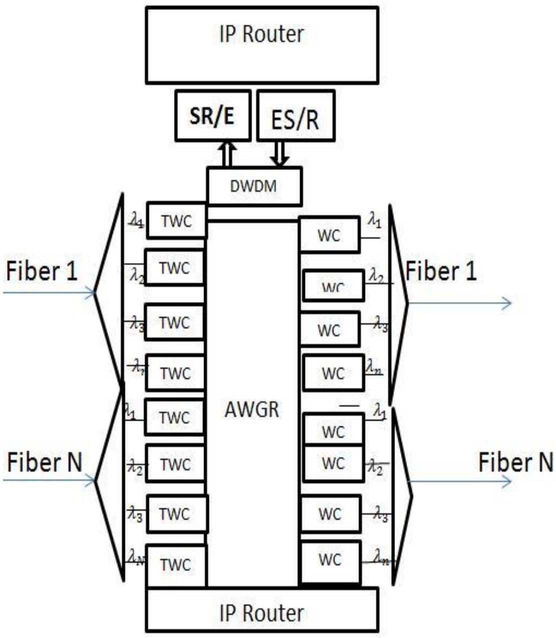

Figure 3. All-Optical Node Schematic Models with IP Router and the AWGR-based Wavelength Switching Optical Node

The Node employs all-optical switching that can connect input ports to output ports only in the same wavelength channel, i.e., Wavelength Layered Switching. Here, an OXC consists of WDM mux, WDM Demux, and slices of passive-medium fiber switch devices.

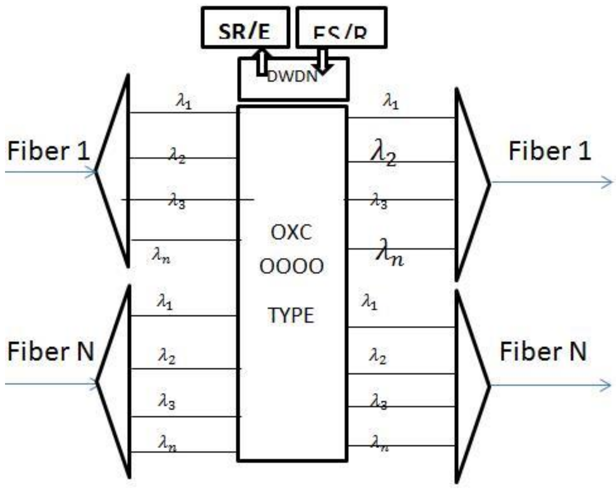

Figure 4. All-Optical Node Schematic Models with IP Router and Space Decision Switching Node without Wavelength Conversion Function

An Amplified Optical Fiber Transmission System Model consists of Erbium-Doped Fiber Amplifiers (EDFAs). Broadband EDFAs are installed at the end of every optical fiber link in order to compensate for the fiber signal attenuation of all WDM channels at once. They employ electro-optic switches for minimal energy consumptions .The total number of the TWCs and WCs in an AWGR wavelength switch is because TWCs and WCs are installed on each side of OXC. An EDFA is installed at every 80 km of a fiber link.

1) Energy Consumption Model[3]

This work[3] considers the static traffic case in order to investigate network dimensions or dimensioning against a worst-case scenario with a maximum traffic demand. Note that this dimensioning objective is different from the dynamic provisioning objective. And it was noted the energy consumption of network as:

$$E_{net} = \sum_{e\in\{\text{network element}\}} p^e(t^e), \quad 0 < t^e \qquad (1)$$

Here, labels each network element, and denote energy consumption of and traffic load at element, respectively. A total energy consumption of a network can be expressed by summation of energy consumptions of all network elements as described in (1). The energy consumption of a network element increases as traffic load increases. That is, more the traffic loads more the energy consumption of a network element. Generalization of the energy consumption of a network element requires consideration of two terms: load-independent power term p_I^e for idle-state power

consumption of element and load-dependent power term of element determined by a product of varying power portion
p_M^e- p_I^e and normalized traffic load on the element, t^e The energy consumption for a given traffic load is expressed as:

$$P^e(t^e) = P^e_I + (P^e_M - P^e_I)\, t^e, \quad 0 \le 1 \qquad (2)$$

This expression in the first-order approximation can model the energy efficiency of a network element: An ideal network element will have a value of zero for and a very small value for p_M^e- p_I^e.

The energy consumptions of IP and optical layers modeled by (2) can be understood as following. In an IP layer, a line card consisting of input and output ports of an IP router performs packet processes to route traffic. These processes include packet framing, forwarding, flow control, and address and class filtering, which are responsible for the major portion of the energy consumption of an IP router indeed. Therefore, the energy consumption of an IP layer can be modeled as the total energy consumption of each IP router port. Hence, employing the EPI model for an IP router port, one can model traffic-dependent IP network energy consumption, and accordingly optimize net-work capacity dimensioning for optimal energy consumption. An optical layer for path switching consumes little energy when compared to that of with the IP layer, since no complicated computing process is required at all in an optical layer. An OXC can be constructed by use of passive medium switch devices and the energy consumption is negligible. We consider the energy consumption of TWC, WC, and EDFA to model the energy consumption of the optical layer. In an optical layer, wavelength converters are turned on if light path is switched by wavelength converters, meaning that there is no traffic dependency in the energy consumption by wavelength converters. Hence, we consider wavelength converters consume energy fully whenever they are turned on.

2) Traffic Grooming With Wavelength Conversion (TGWC)

In a TGWC network, lightpaths consist of connected multiple links were established the constructing virtual topologies. It is a sequence of unidirectional links and those links using different wavelengths. Each IP routing hop is connected by a lightpath and flows that can share a lightpath are groomed at every IP hop. An intermediate node in the middle of the lightpath, which is capable of optical path switching switches the traffic to its next intermediate node. The traffic proceeds in the optical domain until it is received by the end node of the lightpath that terminates the lightpath traffic. This node re-inserts the traffic to another lightpath through an IP layer of the node. Finally the traffic arrives at the destination node as discussed at [3,17].

$$\min \sum_{(i,j)\in Z} \left(P^{IP}_F\, b^{ij} + P^{IP}_V \sum_{(s,d)\in Z} t^{sd}_{ij} \right) + P_{WC} \sum_{l\in L} \sum_{(i,j)\in Z} b^{ij}_l \qquad (3)$$

3) Traffic Grooming Without Wavelength Conversion

In a TG network, lightpaths are established by the same way as in a TGWC network, but a lightpath uses only a single wavelength. Each flow uses virtual links of lightpaths in order to send its traffic. An optical layer of this TG network has no wavelength channel conversion capability. Therefore, wavelength conversion as well as traffic routing occurs in the IP layer

$$\min \sum_{(i,j)\in Z}\left(P_F^{IP}\, b^{ij} + P_V^{IP}\right) + P_{WC} \sum_{(s,d)\in Z} t_{ij}^{sd} \qquad (4)$$

III. RESULTS AND DISCUSSION

The performances of the three identified Energy Efficient Clustering Protocols namely i. Switch-On, ii. Load Adaptive Sequence Arrangement-Fixed Minimal Transmission Time (LASA-FMT) and iii. Internet Protocol/Wavelength-Division-Multiplex (IP-WDM) were studied thoroughly and analyzed in terms of Router Utilization, Throughput and Power Consumption.

Table 1. Comparative Study Analysis

Parameters	Utilization	Throughput	Router/Throughput	PowerConsumption
Switch-On	FAIR	FAIR	BEST	FAIR
LASA+MFT	GOOD	BEST	GOOD	GOOD
IP/WDM	BEST	GOOD	FAIR	BEST

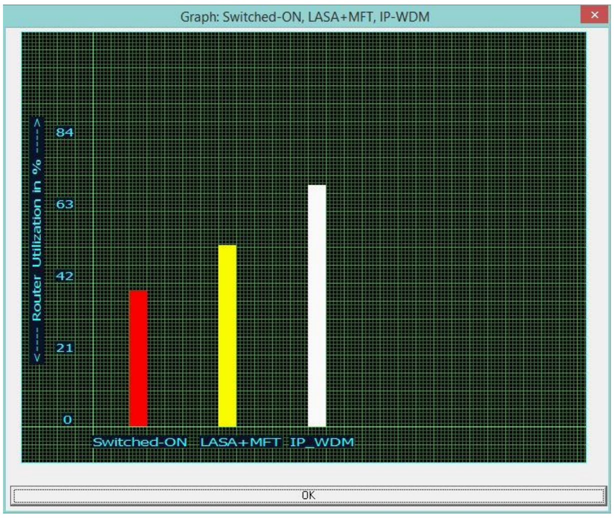

Figure 5. Comparative Study of Models - Router Utilization

A few parameters like Traffic Load, Packet Size, Inter-Frame Gap, Transmission Time, Bandwidth Usage, Packet Delay, Topology were considered to study the above mentioned Models. The Results were discussed and the experimental results of the above Clustering Protocols were shown at the Figures Figure 5 to Figure 8.

As shown at the Figure Figure 5, the IP/WDM is performing well in term of Router Utilization. In other words as IP/WDM doesn't have an efficient Queue Management Scheme, its Throughput is less than that of Switch-On and LASA+MFT Models.

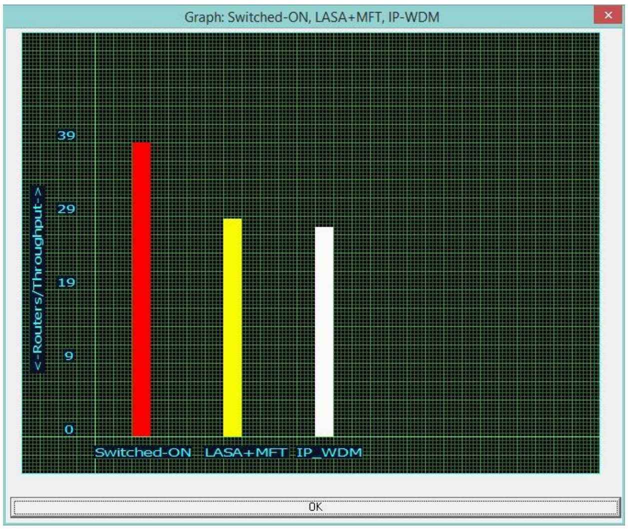

Figure 6. Comparative Study of Models – Routers' Throughput

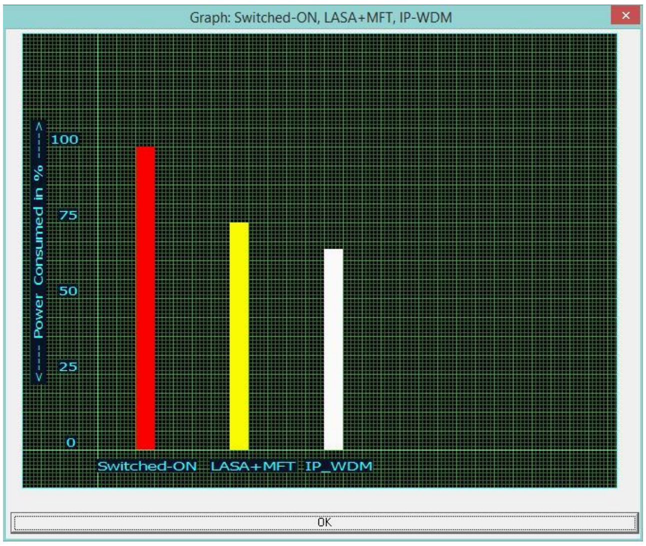

Figure 7. Comparative Study of Models – Power Consumption

As shown at the Figure Figure 6, the Switch-On Model is performing well in term of Router/Throughput. That is as this model Switch Off all the lower usage Routers, its Throughput is higher. In other words as Switch-On permits only higher usage Routers to work, the Network Load is going higher and hence more Packets were dropping which leads more Power Consumption and less Router Utilization. ie more packets need to retransmit by Routers.

As shown at the Figure Figure 7, the IP/WDN is performing well in term of Power Consumption. The LASA+MFT Energy Efficient Model is perming well in term of Throughput as compared with other two models which is shown in the Figure Figure 8.

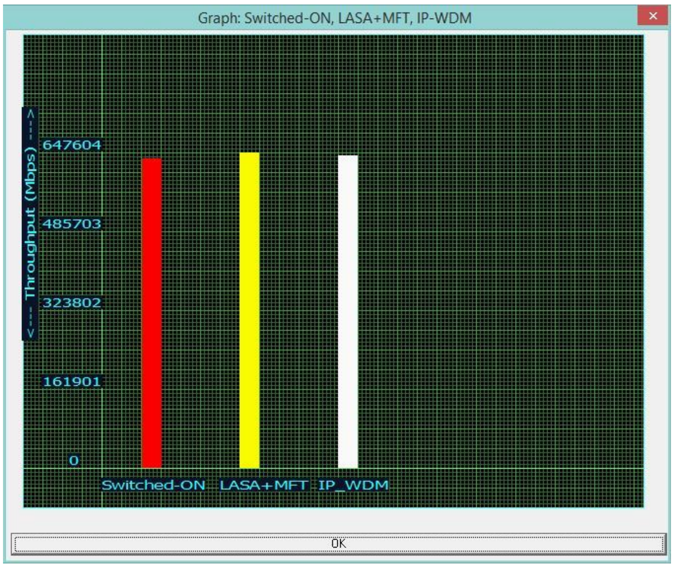

Figure 8. Comparative Study of Models – Throughput

IV. CONCLUSIONS

This research work has implemented the three popular Energy Efficient Clustering Protocols i. Switch-On, ii. LASA-FMT and iii. IP-WDM and studied thoroughly. From the experimental results, it was noticed that the Switch-On model is performing well in term of Routers/ Throughput but however it fails to achieve Throughput, Router Utilization and it is also consuming more Power. The LASA-FMT is outperforming in term of Throughput, but however, it fails to achieve Power Consumption. The IP-WDM model is outperforming in terms of Router Utilization and Power Consumption, but however this model was incompetent to achieve Throughput.

V. REFERENCES

[1]. Marcel Caria,Mohit Chamania,and Admela Jukan,"A Comparative Performance Study of Load Adaptive Energy Saving Schemes for IP-Over- WDM Networks," Journal of Optical Communication Network, Vol. 4, No. 3, 2012.

[2]. Yunxin Lv, Ning Jiang, Kun Qiu, and Chenpeng Xue, "Energy-Efficient Load Adaptive Polling Sequence Arrangement Scheme for Passive Optical Access Networks," Journal of Optical Communication Network, Vol. 7, No. 6, June 2015.

[3]. Yoontae Kim, Chankyun Lee, June-Koo Kevin Rhee, Member, IEEE, and Sangyoum Lee, "IP-Over- WDM Cross-Layer Design for Green Optical Networking With Energy Proportionality Consideration," Journal Of Lightwave Technology, Vol. 30, No. 13, July 1, 2012.

[4]. Annual Cisco Visual Networking Index Forecast Projects Global IP Traffic to Increase More Than Fourfold by 2014, Cisco Press Release Online]. Availble: http://newsroom.cisco.com/dlls/2010/prod_060210.html.

[5]. W. Fisher, M. Suchara, and J. Rexford, "Greening backbone networks: reducing energy consumption by shutting off cables in bundled links," in ACM SIGCOMM Workshop on Green Networking 2010, New York, Aug. 2010.

[6]. A. Coiro, M. Listanti, A. Valenti, and F. Matera, "Reducing power consumption in wavelength routed networks by selective switch off of optical links," IEEE J. Sel. Top. Quantum Electron., vol. 17, no. 2, pp. 428-436, Apr. 2011.

[7]. F. Farahmand, I. Cerutti, M. M. Hasan, and J. P. Jue, "Energy-efficiency of drop-and-continue traffic grooming," in Optical Fiber Communication Conf., 2011.

[8]. C. Lange, D. Kosiankowski, A. Betker, H. Simon, N. Bayer, D. Hugo, H. Lehmann, and A. Gladisch, "Energy efficiency of load-adaptively operated telecommunication networks," J. Lightwave Technol., vol. 32, no. 4, pp. 571-590, Feb. 2014.

[9]. Y. Lv, N. Jiang, K. Qiu, and C. Xue, "Study on the energyefficient scheme based on the interconnection of opticalnetwork-units for next generation optical access network," Opt. Commun., vol. 332, pp. 114-118, Dec. 2014.

[10]. M. P. I. Dias and E. Wong, "Sleep/doze controlled dynamic bandwidth allocation algorithms for energy-efficient passive optical networks," Opt. Express, vol. 21, no. 8, pp. 9931-9946, Apr. 2013.

[11]. A. Dixit, B. Lannoo, D. Colle, M. Pickavet, and P. Demeester, "ONU power saving modes in next generation optical access networks: Progress, efficiency and challenges," Opt. Express, vol.20, no. 26, pp. B52-B63, Dec. 2012.

[12]. M. S. Bazaraa, J. J. Jarvis, and H. D. Sherali, Linear Programming and Network Flows, 4th ed. New York: Wiley, 2010.

[13]. E.Yetginer, Z. Lieu, and G. N. Rouskas, "RWA inWDMrings:An efficient formulation based on maximal independent set decomposition," in Proc. IEEE LANMAN 2010, Long Branch, NJ, May 2010, pp. 1-7.

[14]. W. V. Heddeghem, W. Vereecken, D. Colle, M. Pickavet, and P. Demeester, "Reduction of the energy footprint in optical networks," in Proc. Int. Conf. Photonics in Switching 2010, Energy Efficient Networking and Systems Workshop, Monterey, CA, Jul. 2010.

[15]. M. Jinno, "Energy and spectrally efficient elastic optical path network: Introducing elasticity and adaptation into optical domain," in Proc. Int. Conf. Photonics in Switching, Energy Efficient Networking and Systems Workshop, Monterey, CA, Jul. 2010.

[16]. J.-K. K. Rhee, C. K. Lee, J. Y. Choi, J. H. Kim, Y. H. Won, and J. S. Choi, "Power and cost reduction by hybrid optical packet switching with shared memory buffering," IEEE Commun. Mag., vol. 49, no. 5, pp. 102-110, May 2011.

[17]. S. Zhang, D. Shen, and C. K. Chan, "Energy efficient time-aware traffic grooming in wavelength routing networks," in Proc. IEEE GLOBECOM 2010, Miami, Dec. 2010, pp. 1-5.

[18]. M. Xia, M. Tornatore, Y. Zhang, P. Chowdhury, C. U. Martel, and B. Mukherjee, "Green provisioning for opticalWDM networks," IEEE J. Sel. Topics Quantum Electron., vol. 17, no. 2, pp. 437- 445, Mar. 2011.