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Energy Efficient Partition-Lightpath Scheme for IP over WDM Core Networks

M. N. Mohd Warip[a], I. Andonovic[b], I. Glesk[b], R. Badlishah Ahmad[a], P. Ehkan[a], L. M. Kamarudin[a], M. Elshaikh[a] *

[a]*School of Computer and Communication Engineering, Universiti Malaysia Perlis, Pauh Putra Main Campus, 02600 Arau, Perlis, Malaysia*
[b]*Department of Electronic and Electrical Engineering, University of Strathclyde, 204 George Street, Glasgow G1 1XW, United Kingdom*

Abstract

In this paper, the research focus on the development of energy saving schemes with roots in sleep modes that support the evolution of greener core optical IP networks. The cornerstone of the adopted strategy is partition-lightpath schemes underpinned by the hibernation state implemented through a modification of the intelligent control plane, in particular for transparent network architectures under different scenarios. An enhanced multi-level operational hibernation mode through partition-lightpath was defined including functionality, structure considering its implementation issues. Through the use of appropriate design parameters the impact on blocking probability, wavelengths assignment, LSP connection requests, degree of node connectivity and network utilization can be minimized while also achieving energy savings. Evaluation of this scheme indicates potential reduction in power consumption from 9% up to 17% at the expense of reduced network performance.

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Keywords: Energy Efficiency, IP over WDM networks, Power Consumption, OXC, GMPLS, Partion-Lightpath

1. Introduction

Recent development on power consumption in core telecommunication networks is still expanding. Correspondingly, the global amount of Internet Protocol (IP) traffic is growing every year. While this growth is

* Corresponding author. Tel.: +604-9885461; fax: +604-9885462.
E-mail address: nazriwarip@unimap.edu.my

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gradually slowing down from an earlier Compound Annual Growth Rate (CAGR) of 100% (about 10 years ago) to estimated CAGR of around 20% to 30% at present, this reduced growth still outperforms the annual 13% efficiency increase of new telecommunication equipment in core networks[1]. Accordingly, the sleep mode is the most known energy saving techniques mechanism in core networks.

The key distinction between the sleep mode and hibernation mode is that in the former energy savings are performed manually, for instance by pre-setting configuration or through the manual selection of switch off states for nodes, whilst the latter is a dynamic approach where network equipment or links are placed into sleep modes automatically governed by the state of the traffic flows within the network. Furthermore, previous research has not developed / evaluated hibernation mode techniques for power conservation in core optical IP networks under wavelength continuity. Hibernation modes are proposed based on partition-lightpath schemes to invoke a family of energy conservation options.

Partition-Lightpath hibernation mode relying on balancing energy consumption across network while maintaining wavelength connectivity was proposed and evaluated. The approach lowers power consumption at the expense of a slight increase in blocking probability; maintaining network performance by enhanced traffic utilisation through efficient lightpath establishment.

2. Network Energy Model

In our approach in order to evaluate overall network power consumption and consumed energy per a data bit we used so called equivalent network energy model (see Figure 1) based on multilayer Internet Protocol / Generalized Multi-Protocol Label Switching (IP/GMPLS) over optical layers. In this model, a network carrier bandwidth of OC-192 and average energy consumption of 1019nJ per bit was assumed following[2,3,4].

The parameter G_n denotes a Router's dissipated power of 10kW within its energy consumption of 1000nJ/bit. X_n represents Optical Cross-Connect (OXC) dissipating 100W and consumes 10nJ/bit. W_n denotes Wavelength Division Multiplexing (WDM) part of the node with dissipating power of 120W and energy consumption of 12nJ/bit. A_n represents the consumption owing to Erbium-Doped Fibre Amplifiers (EDFA) within connection spans placed at 70 km intervals, the power consumption is estimated to be 1W with energy of 0.1nJ/bit.

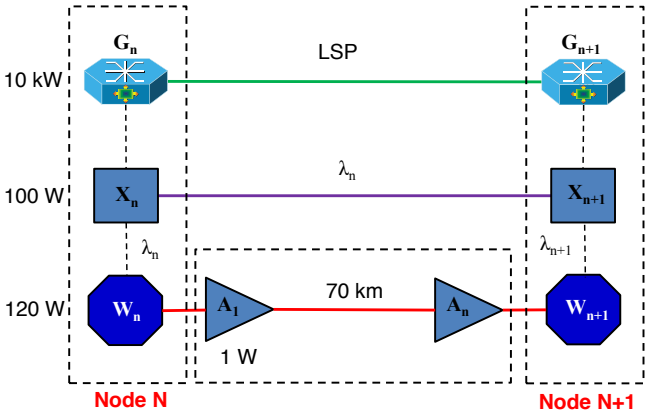

Fig. 1. An Energy Model Design for IP over WDM Networks.