

Design Methodologies for Long-Haul Wavelength-Routed Optical Networks with Awareness of Power Consumption and Cost

Abstract:

Long-haul optical networks employing wavelength-routing nodes are increasingly being deployed for telecommunication backbones to reduce overall transport cost and power consumption. In such optical networks transit traffic at intermediate nodes can be bypassed in optical domain by establishing all-optical paths between node pairs. An all-optical path over a given wavelength (lightpath) is routed through intermediate nodes employing optical crossconnects (OXC), based on wavelength-division multiplexing (WDM) technology. These optical WDM networks using OXC-based wavelength routing are known as wavelength-routed optical networks (WRONs). Lightpath establishment process in WRONs is constrained by limited network resources and various transmission impairments in the physical layer. The maximum length that can be traversed by a lightpath without exceeding a given upper limit of bit-error rate is termed as optical reach (OR). In order to setup a connection over a distance beyond the OR, the network needs to employ optical-electronic-optical (OEO) regeneration at intermediate nodes. The OEO regeneration of an OR-constrained lightpath is not supported in transparent WRONs (all-optical), whereas translucent WRONs can allow such regenerations at intermediate nodes.

In this work, various design issues of WRON-based long-haul networks have been investigated by taking into account of the practical constraints, including line rates, numbers of transceivers and wavelengths and physical-layer constraints from OR. First, we examined the blocking performance of transparent and translucent WRONs for IP-over-WDM settings constrained by OR and available wavelengths. Subsequently, a methodology for determining the required optical transmit power of transceivers to realize a network-wide OR has been explored. Thereafter, similar investigations have been carried out for WRONs with IP-over-MPLS-over-WDM setting. In order to explore the benefits of multiple OR values and multiple/adaptable line rates, further investigations have been carried out for different realizations of WRONs using fixed/mixed OR values and multiple as well as adaptable line rates.

In recent years, carrier-grade-Ethernet (CGE) has become an attractive option for traffic grooming as CGE switch ports can also be used for OEO regeneration. Hence, the design methodologies with awareness of power consumption and cost have also been examined for CGE-over-WRONs employing fixed as well as rate-adaptable transceivers.