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Dynamic service-level-agreement aware shared-path protection in WDM mesh networks

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Abstract

The notion of service level agreements (SLA) has been proposed to capture qualitatively and quantitatively defined performance contracts between service providers and their customers. How to provision satisfiable connections for customers according to their SLA parameters to avoid penalty as well as minimizing cost is one of the main concerns for a service provider. Connection reliability and restoration time are two important SLA parameters for a customer, and should be carefully considered in survivable wavelength-division-multiplexing (WDM) networks. A sound scheme should guarantee customers' reliability and reduce restoration time while benefiting a service provider in resource efficiency. Under the SLA constraints and the assumption of single link failure, we first investigate a partial link-disjoint protection (PLDP) and analyze its availability and average restoration time. We then propose a dynamic constraint shared path protection (DCSP) algorithm in WDM mesh networks. Based on the basic ideas of the *K*-shortest path algorithm and PLDP, DCSP can provide differentiated services for customers according to their SLA parameters while being favorable for reducing average restoration time and optimizing resource utilization. Simulation results show that DCSP can efficiently guarantee the specific SLA requirements of customers with a slight increase in the blocking probability while still achieving spare resource sharing and restoration time optimizations.
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Keywords: Service level agreement (SLA); Availability; Restoration time; Partial link-disjoint protection

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1. Introduction

In optical networks employing wavelength-division-multiplexing (WDM) technology, each wavelength channel has the transmission rate of over a gigabit per second. A single fiber failure can cause the failures of all the lightpaths passing through the fiber, thereby leading to large data and revenue loss. Hence, effective survivability mechanisms are stringent requested to minimize the data loss in optical networks (Ramamurthy et al., 2003; Guo et al., 2004; He et al., 2004; Ou et al., 2004). There has been much effort on survivability against single fiber failure in optical layer. It can be done in two ways, i.e., dynamic restoration and preplanned protection, to recover from a failure. Protection, a proactive procedure in which spare capacity is reserved during lightpath setup, is essential for recovering from such failures in a short time period, which has two main forms: shared protection (SP) and dedicated protection (DP) (Ramamurthy et al., 2003). Because SP has better resource utilization than DP due to multiplexing of the spare capacity, it has been extensively investigated in most of the existing literature (Guo et al., 2004; He et al., 2004; Ou et al., 2004). SP can broadly be classified into shared link protection, shared sub-path protection and shared path protection (He et al., 2004). In order to provide failure-independent protection to a connection from any single link failure, a pair of link-disjoint paths should be computed for each connection. Although some efficient heuristic algorithms (He et al., 2004; Ou et al., 2004) have been proposed to provision protection in optical networks, most of them only consider how to provide 100% protection for all connections, i.e., provisioning a pair of completely link-disjoint paths for each connection without differing their reliable requirements. In fact, different customers need different levels of fault tolerance, and differ in their willingness to pay for a guaranteed service (Fawaz et al., 2004; Zhang et al., 2003a, b; Huang et al., 2004a, b; Song et al., 2005). Moreover, the restoration time is another important performance target and cannot be ignored (Guo et al., 2004). The notion of service level agreement (SLA) (Fawaz et al., 2004) has been proposed to capture qualitatively and quantitatively defined performance contracts between service providers and their customers, which obligates service providers to maintain a certain grade of service that is contractually guaranteed. How to provision satisfiable connections for customers to avoid penalty as well as minimizing cost is one of the main concerns for a service provider. Connection reliability and restoration time are two important SLA parameters of major concerns for a customer in optical networks (Fawaz et al., 2004). Considering different requirements of customers, it is essential to provision services with different levels of reliabilities and reduce restoration time while benefiting a service provider in resource efficiency and service scalability.

In order to achieve the required connection reliability, a service provider needs to carefully provision a connection while considering the availability characteristics of network components. In Fawaz et al. (2004), the authors applied the notion of SLA to the optical domain (O-SLA), and specified the parameters that could be included in this O-SLA. In Zhang et al. (2003a, b), the authors analyzed the availabilities for connections with different protection schemes, and proposed an integer linear program (ILP) based provisioning approach and four cost-effective heuristics. Their work mainly focused on verifying the theoretical availability analysis through simulations, and demonstrating the effectiveness of their ILP-based optimization methods on the assumption of static traffic. In Huang et al. (2004a, b), the authors developed a link-state availability model to form a dynamic link and resource availability parameter, which can be used by a standard

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