Multilayer Quality and Grade of Service Support for High Speed GMPLS IP/DWDM Networks

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Abstract. IP over optical networks controlled by the GMPLS control plane have become the common infrastructure for a variety of services, such as triple play and grid applications. The traffic aggregation requires the services to be differentiated in a multilayer fashion, so as to guarantee higher levels of GoS and QoS to 'gold' traffic. This means that the traditional DiffServ technology needs to be combined with differentiation mechanisms in the optical domain. This paper proposes a framework for multilayer QoS and GoS support in GMPLS based IP/WDM networks. The scheme is based on a multilayer strategy which combines two routing policies that optimize the resource utilization. The system also provides a lightpath differentiation which allows the operator to accommodate sensitive traffic on lightpaths able to guarantee a certain level of transmission quality. The benefits of the scheme are illustrated by a simulation study, discussing blocking probability and resource utilization.

Keywords: GMPLS, DiffServ, QoS, GoS, Multilayer Traffic Engineering, routing, grooming.

1 Introduction

Over the last few years the telecommunications world has considerably evolved towards new challenging scenarios. The increased adoption of broadband access technologies such as Digital Subscriber Line (DSL), cable modem and Ethernet passive optical networks, has lead to the migration of most services towards the Internet Protocol (IP).

Based on the type of application supported, Internet traffic can be roughly divided into two large groups. On the one hand, there is the so called triple play, being the bundle of voice, video, and data services [1, 12]. Due to the fast advance in Voice over IP (VoIP), video on demand, IPTV (IP television) and Web 2.0 technologies, triple play applications have become omnipresent in our daily lives. The second group is the set of the large-scale grid computing services such as e-science applications emerging on a variety of scientific fronts, including geosciences, biomedical informatics and nuclear physics [4]. These applications enhance the understanding of complex systems that share and process data distributed in geographically dispersed locations.

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The traffic change has given rise two phenomena that change the scenario of the telecommunication networks: the massive increase of the bandwidth needs and the migration of the traffic patterns from the predictable and stable behavior of the traditional voice traffic to a self-similar and asymmetric nature of data flows. Consequently, dynamic allocation of resources has become extremely important for the cost effectiveness of a network. In order to satisfy traffic's quantity and quality, network operators have to replace the traditional expensive and statically provisioned networks with dynamic and self adaptive infrastructures. Such networks provide traffic with time-depended application-driven communications paths established by means of near real time signaling.

The fast progress in optical networking and Dense Wavelength Division Multiplexing (DWDM) technologies has made available a huge amount of bandwidth at a lower cost and with predictable performance. DWDM mesh networks provide clients with all-optical high speed channels (i.e. lightpaths) up to 10 Gbps (OC-192) and 40Gbps (OC-768) rates. Lightpaths bypass the electronic switching at intermediate IP routers and improve the communication performance in terms of end-to-end delay, jitter and packet loss. In addition, there has been an effort in providing optical components with a certain grade of automation in order to facilitate intra/inter domain communication by means of an intelligent control plane – called Generalized Multi Protocol Label Switching (GMPLS) [5, 9, 10]. GMPLS eliminates the burden of the human manual intervention b erators need technologies for guaranteeing communications quality and increasing the Return on Investment (ROI). The preferred technology for scalable IP Quality of Service (QoS) deployments is Differentiation Service (DiffServ). DiffServ supports differentiated and assured delay, jitter and loss commitments on the same IP network for different Classes of Service (CoS). However, the massive traffic increase and the flexibility introduced by GMPLS and IP/DWDM networks have made IP layer QoS control mechanisms insufficient. Operators are required to implement new integrated techniques able to satisfy the communication quality on both IP and DWDM layer. The communication quality in IP/DWDM networks encloses two concepts: QoS and Grade of Service (QoS) [6]. The QoS concerns the transmission performance during the data communication phase, such as delay, jitter, Bit Error Rate (BER) and packet loss. The GoS is the set of parameters related to y using sophisticated signaling and routing mechanisms to set up on-demand high speed end-to-end connections in the order of milliseconds. In such a dynamic scenario, the network nodes become intelligent agents able to automatically react to the traffic changes in a multilayer way. This can be thought of as a cooperation between the IP layer (by means of traffic grooming) and the optical layer (by means of dynamic lightpath establishment) in traffic engineering the network and called Multilayer Traffic Engineering (MTE).

When aggregating different traffic types with different Service Level Agreements (SLAs) on the same infrastructure, op the connection establishment, such as blocking probability. Both aspects need to be considered by a network operator to guarantee higher quality communication to high priority sensitive traffic.

This paper proposes and analyzes a framework for multilayer QoS and GoS support in GMPLS based IP/WDM networks. In order to address both QoS and GoS issues, the system differentiates the traffic in two steps. In the first, the traffic differentiation is based on the required bandwidth. High bandwidth applications – likely grid computing