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Title: Multi-layer Traffic Engineering in the New Generation Internet based on IP/MPLS over ASON/GMPLS Networks

Abstract:

The convergence of most services over the Internet Protocol (IP) has triggered the implementation of Multi Protocol Label Switching (MPLS) and Differentiated Service (DiffServ) paradigms. At the same time, the progress of optical technologies has accelerated the standardization of more intelligent optical networks, called Automatically Switched Optical Networks (ASONs). Controlled by the Generalized MPLS (GMPLS) control plane, ASONs have become the preferred infrastructure for broadband communications. The similarity between MPLS and GMPLS paradigms has accelerated the integration between IP and optical layers and the manufacturing of integrated IP/MPLS over optical routers. Integrated IP/MPLS over ASON/GMPLS networks facilitate Multilayer Traffic Engineering (MTE), a technique that combines traditional load balancing in the IP layer with dynamic path establishment in the optical layer.

This dissertation focuses on MTE in IP/MPLS over ASON/GMPLS networks. Firstly, we explore multi-layer routing, a technique that combines the traffic accommodation on the dynamic virtual topology and on the fixed optical infrastructure. We analyze two basic policies widely discussed in literature: one policy prefers the traffic accommodation on the virtual topology while the other prefers the traffic accommodation on the physical topology. We show that both mechanisms do not lead to efficient resource utilization because they tend to congest one layer more than the other one. We propose an adaptive heuristic which combines the advantages of both policies. When accommodating traffic, the proposed approach selects the appropriate layer depending on the resource utilization being experienced on the virtual and physical topology.

Secondly, we explore multi-layer service differentiation and propose a multi-service infrastructure supported by the dynamic virtualization technique enabled by the ASON/GMPLS control plane. The proposed scheme is based on decoupling the physical topology from the virtual one. The virtual layer becomes a service layer consisting of multiple virtual topologies built on top of the same physical (optical) network. The purpose of building several virtual topologies is to map different Classes of Service (CoS) onto separate virtual topologies having different levels of Quality of Service (QoS). The different levels of QoS are achieved by using different processes (routing, virtual topology reconfiguration, resource management, etc.) on the virtual topologies, depending on the CoS being accommodated on them.

Finally, we propose and describe a platform for modeling and simulating MTE in IP/MPLS over ASON/GMPLS networks.