Traffic engineering (TE) is considered one of the hottest topics in the framework of new-generation networks. Basically, the goal of TE is to improve the efficiency and reliability of network operations while optimizing network resource utilization and traffic performance, as stated in Internet Engineering Task Force (IETF) Request for Comments (RFC) 2702. Before introducing the different subjects of TE in optical networks treated in the present special issue, it is meaningful to review the main motivations for TE and the main aspects related to its application in optical networks.

In recent years the amount of traffic due to Internet-based services has become more and more evident. Besides the traditional services carried by the Internet, essentially with no guaranteed quality of service (QoS), a migration to a number of real-time services over Internet Protocol (IP) is foreseen in the near future. Therefore, future network infrastructures will have to handle a huge amount of IP data traffic, including a significant amount of real-time traffic with demands for assured QoS. Moreover, given the fact that Internet traffic is much more variable with time than traditional voice traffic, and thus not easily predictable, such networks have to be flexible enough to react adequately to traffic changes. Future infrastructure must also have multiservice capability, in order to support different types of services with different requirements in terms of QoS. Besides the requirements of flexibility and multiservice capabilities that lead to different levels of QoS requirements, there is another key aspect that needs to be taken into account: cost effectiveness. In fact, a dilemma emerges for carriers and network operators: the cost to upgrade the infrastructure as it is nowadays for fixed and mobile telephone networks is too high to be supported by revenues coming from Internet services. Actually, revenue coming from voice-based services is usually much higher than that derived by current Internet services. Therefore, to obtain cost effectiveness it is necessary to design networks that make effective use of bandwidth or, in a broader sense, of network resources.

TE is a solution that enables the fulfillment of all these requirements, since it allows network resources to be used when necessary, where necessary, and for the desired amount of time. A network with TE capability can dynamically control traffic flows in order to prevent congestion and optimize the availability of resources. More specifically, TE allows a network to choose routes for traffic flows while taking into account traffic loads and network state, to move traffic flows toward less congested paths, and to react to traffic changes or failures in a timely way. In order to adopt TE solutions, it is necessary to create an intelligent control plane that is able to adequately handle network resources. Such an intelligent control plane will require a paradigm shift in the design of network architecture: some features of traditional synchronous digital hierarchy/synchronous optical network (SDH/SONET) or asynchronous transfer mode (ATM) networks have to be imported into the IP world and suitably adapted. A relevant network paradigm considered worldwide is based on the multiprotocol label switching (MPLS) technique and its generalization, GMPLS. In practice, this paradigm consents to the reintroduction of the virtual connection into IP-based networks that are intrinsically connectionless. The GMPLS control plane allows harmonization among the Internet world, based on packet switching, with the optical world, which is intrinsically circuit-switched. Several network architectures and deployment scenarios have been proposed in the literature. Constraint-based routing algorithms are also a key component for realizing TE strategies.

As far as transport technology, it is widely recognized that wavelength-division multiplexing (WDM) optical networks will play a significant role in the realization of the next-generation transport infrastructure, which will have to support both traditional and Internet-based services. Besides the general components, TE in optical networks also includes how routing of lightpaths is achieved, how data flows coming from either a circuit or packet bearer network layer are groomed and routed onto the lightpaths, and how lightpath recovery is performed.

This special issue contains six articles covering the aforementioned topics. In particular, routing and grooming in a multilayer context, failure restoration capabilities, and methods for managing the bandwidth resource in such a context are deeply investigated in this issue.

The first article, from K. Zhu et al., treats the problem of provisioning connections of different bandwidth granularities in a heterogeneous WDM network by means of dynam-
ic traffic grooming schemes in an efficient way, applying TE strategies in order to use only the appropriate amount of network resources.

The issue of traffic grooming in a multilayer network is analyzed in T. Cinkler’s article. This article reports on an overview of grooming in different types of networks (SDH/SONET, ATM, MPLS, and optical networks), discusses advantages and drawbacks of the different grooming methods, and considers applications and future alternative directions.

The article from J. Comellas et al. proposes an integrated IP/WDM routing strategy that takes into account constraints of both the IP and optical layers. In particular, the authors emphasize the implementation requirements of IP/WDM grooming functionality using TE mechanisms based on GMPLS. Simulation results are presented demonstrating the benefits obtained by adopting the reported strategy.

The article authored by P. Iovanna et al. proposes an original GMPLS-based TE approach in multilayer networks, in which network resources are effectively exploited by means of an “elastic” use of bandwidth. The proposed TE system makes use of a hybrid routing approach, based on both offline and online methods, and a bandwidth management system that handles priority among data flows, preemption mechanisms, and traffic rerouting in order to concurrently accommodate the largest amount of traffic and fulfill QoS requirements.

The issue of network resilience is addressed by the last two articles, which treat different failure scenarios. The article authored by A. Chiu and J. Strand proposes a joint IP/optical restoration mechanism to cope with router failures. In this approach the optical layer can assist the IP layer in restoration when a router failure occurs, thus eliminating the need for extra link capacity in the IP layer for protecting router failures. The proposed scheme assumes an IP office architecture of two backbone routers and an optical cross-connect, and is also applicable to restoration for router interface failures as well as to cases with single backbone router office architecture.

Finally, the article from Y. Qin et al. presents an overview of different MPLS-based recovery mechanisms, and proposes a joint two-layer recovery scheme for physical link failures and optical transport equipment failures in IP-centric WDM-based optical networks, where the optical layer takes the recovery actions first and then the upper IP layer initiates its own recovery mechanism if the optical layer does not restore all affected services. The authors report simulation results showing advantages of the proposed scheme with respect to single-layer schemes, and demonstrate the advantages of the finer granularity on IP layer recovery and the effectiveness in speed on the optical layer.

We hope that these articles help readers in understanding the possibilities offered by TE in new-generation optical networks and the different aspects related to the realization of TE.

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