

Reliability Issues in Optical Networks: introduction to the feature issue

Lena Wosinska

Royal Institute of Technology (KTH) / ICT, Sweden

Marco Tacca and Andrea Fumagalli

University of Texas at Dallas, USA

Achim Autenrieth

Nokia Siemens Networks, Germany

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This feature issue of the *Journal of Optical Networking* focuses on the architectures, technologies, and theory for achieving high service availability in optical transport networks.

The rapid growth of IP and multimedia services is driving demand for capacity in the long-haul transport network and subsequently in other parts of the network. Technologies based on dense wavelength division multiplexing (DWDM) systems allow data transmission with bit rates of terabits per second on a single fiber. However, the consequence of the ultrahigh-capacity links is that more traffic will be affected by a single failure. It makes the reliability and fault management aspects of optical networks of great importance in attempting to introduce photonics in a broader context in the networks.

The feature attracted many submissions from which 16 were accepted for publication after revisions. The accepted contributions addressed the following research areas:

- Resilience techniques
- Differentiated survivability
- Access network reliability, including radio over fiber (RoF), gigabit ethernet (GE), and passive optical networks (PONs)
- Resilient traffic grooming.

The following seven papers address resilience techniques.

In "[Multidomain shared protection with limited information via MPP and \$p\$ -cycles](#)," J. Szigeti, L. Gyarmati, and T. Cinkler propose and evaluate the multidomain p -cycles (MDPC) and the multidomain multipath routing with protection (MD-MPP) methods. Special consideration is given to the possibility of sharing resources for multidomain protection if only limited aggregated information is available.

"[Topology-focused availability analysis of basic protection schemes in optical transport networks](#)" by J. Segovia, E. Calle, P. Vila, J. Marzo, and J. Tapolcai presents a study of connection availability under two basic path protection schemes for different network topologies in order to have heterogeneity in geographic coverage, network diameter, link lengths, and average node degree. Results report some useful information to select the suitable protection algorithms according to the network topology features and the required connection availability level.

In "[Combined study on survivability and performance in optical packet switched networks](#)," H. Øverby shows an integrated view of survivability and performance in optical packet switched (OPS) networks by presenting the extended shared packet redundancy scheme, which combines shared packet redundancy with 1+1 path protection functionality.

In "[Approaches to \$p\$ -cycle network design with controlled optical path lengths in the restored network state](#)," D. P. Onguetou and W. D. Grover propose systematically matching shorter working paths with longer protection path segments through p -cycles, and vice versa, with direct consideration of the end-to-end length of paths in the restored network state during the design.

C. Mas Machuca, O. Moe, and M. Jäger evaluate the impact of the protection schemes and the network component's availability on the operational cost. The economic consequences of failures in optical networks with different protection schemes are discussed in "[Impact of protection schemes and network component's availability on operational expenditures](#)."

"[Impact of routing and wavelength selection strategies on GMPLS-controlled distributed restoration](#)" by N. Sambo, I. Cerutti, A. Giorgetti, and P. Castoldi investigates the restorability problem in wavelength-routed networks without wavelength conversion capabilities. The article proposes different routing and wavelength selection strategies that are evaluated by simulations and compared in a detailed performance analysis during restoration of link failures.

"[Lightpath routing for maximum reliability in optical mesh networks](#)" by S. Yuan, S. Varma, and J. P. Jue considers the problem of maximizing the reliability of connections in optical mesh networks against simultaneous failures of multiple fiber links that belong to a shared risk link group (SRLG). The problem instances are defined and formulated as minimum-color lightpath problems for the special case of uniform failure probability of SRLGs. These problems are proven to be NP-hard, and heuristic algorithms are proposed for the general case of different failure probabilities and for larger problem instances. The proposed heuristics are evaluated through simulations.

Differentiated survivability is addressed in the following two papers.

"[Experimental evaluation of GMPLS enhanced routing for differentiated survivability in all-optical networks](#)" by R. Martínez, R. Casellas, and R. Muñoz studies differentiated recovery schemes using dedicated or shared path protection within generalized multiprotocol label switching (GMPLS) all-optical networks. The key contribution of this article is twofold: first, presenting enhanced GMPLS routing approaches for both recovery schemes maximizing resource usage and addressing connection blocking, and second, evaluating these implemented schemes in a real experimental network named the ADRENALINE test bed.

"[Network performance improvement through differentiated survivability services in WDM networks](#)" by G. Markidis and A. Tzanakaki presents a framework based on the backup multiplexing technique in order to facilitate efficient resource sharing and investigates different routing and wavelength assignment (RWA) schemes that considerably enhance the wavelength utilization. Each connection request is assigned to a class of service in order to support different restoration requirements.

The following four papers study access network reliability.

In "[Survivable broadband local access PON architecture: a new direction for supporting simple and efficient resilience capabilities](#)," ASM Delowar Hossain, H. Erkan, A. Hadjiantonis, R. Dorsinville, G. Ellinas, and M. A. Ali propose a two-fiber self-healing ring-based local-access PON architecture that addresses some of the limitations of current tree-based PON architectures, including supporting private networking capability as well as providing simple and cost-effective fully distributed resilience capabilities against most kinds of networking failures.

The article "[High reliability and availability in radio over fiber networks](#)" by G. Castañón, G. Campuzano, and O. Tonguz investigates the potential usefulness of multilevel network topologies for reliability and availability in future RoF networks. The article provides guidelines for network architecture and topology selection in terms of network availability, reliability, and fiber length.

"[Experimental investigation on optical gigabit Ethernet network reliability for high-definition IPTV services](#)" by S. Pompei, L. Rea, F. Matera, and A. Valenti presents an exper-

imental investigation of the quality of service (QoS) of high-definition IPTV applications in a core-access GE/MPLS network test bed. The experimental investigation was carried out in terms of objective as well as subjective QoS measurements using an optical GE network test bed.

In "[Self-protected long-reach 10 Gbits/s EPONs based on a ring architecture](#)," J. Santos, J. Pedro, P. Monteiro, and J. Pires studied the feasibility of a novel network architecture for self-protected long-reach 10 Gbits/s EPONs aiming for a scenario based on a converged access and metro infrastructure.

Finally, resilient traffic grooming is addressed in three papers.

"[Resilient traffic grooming for WDM networks](#)" by A. Jaekel, A. Bari, and S. Bandyopadhyay presents an efficient integer linear program (ILP) formulation for the complete survivable traffic grooming problem, including topology design, traffic routing, and RWA, using both dedicated and shared protection at the lightpath level. It is shown that the proposed ILP is able to generate optimal solutions for practical sized networks with hundreds of traffic requests.

The article "[Optimal multilayer grooming-oriented design for inter-ring traffic protection in DNI multiring WDM networks](#)" by L. C. Resendo, M. R. N. Ribeiro, and J. J. O. Pires proposes optimal approaches integrating traffic grooming, routing, and wavelength assignment for different protection strategies in dual-node interconnection (DNI) multiring translucent networks. A multilayer design matches the optimal solutions from the electronic layer to the available physical topology using a particular DNI RWA formulation.

In "[Design and analysis of partial protection mechanisms in groomed optical WDM mesh networks](#)," M. Sivakumar, J. Fang, K. M. Sivalingam, and A. K. Somani consider the problem of survivable network design in traffic-groomed optical WDM mesh networks that support subwavelength capacity connections. Quality of protection framework is proposed where a connection is provided partial protection. Both static and dynamic traffic scenarios are studied.