Design and analysis of optical packet switching networks

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This PhD dissertation aims at identifying the major issues and difficulties that arise in Optical Packet Switching networks (providing a transport infrastructure for telecommunication traffic), from a logical performance point of view. The latter means that we will not deal so much with physical/technological challenges of OPS, but rather discuss how to handle the optical packets in terms of contention resolution, routing, etc. The work ranges from conceptual studies of OPS node architectures for metro and backbone environments, over packet scheduling strategies, onto network-wide routing strategies and the impact of (re)routing actions on applications.

With respect to node architectures for MANs, we show that a simple architecture without any active switching components in the transit path (followed by traffic passing through a MAN ring node) does not lead to any penalty in terms of transmitter and receiver capacity. For WANs, we show that a Clos-like architecture allows significant reduction of the number of components in a SOA-based architecture.

We study the performance of a generic OPS architecture with a shared feed-back buffer comprising fibre delay lines (FDLs). For the case of fixed length packets and a slotted operation of the switch, we introduce a new Balance algorithm achieving far lower packet losses than previous proposals. For variable length packets, we address the problem of scheduling a train of slots which comprising a single variable length packet. We also assess various alternatives to offering QoS.

On a network-level, we developed a routing algorithm aiming at minimizing the maximal loss rate occurring in a given network carrying a given set of traffic flows. Routing based on careful estimation of the loss rate allows reaching significantly lower loss.

We provide an extensive original study of the effects of protection switching actions on TCP performance, showing detrimental effects of interaction between switched flows and those already present on (part of) the protection route. The effects of changing path lengths and the influence of the speed of protection on TCP goodput are quantified. We culminate the gathered knowledge in a case study comparing MPLS-based protection schemes.