All-Optical Label Swapping in Novel optical network architectures: a network recovery perspective

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ABSTRACT

One of the goals of the GBOU "Optical networking and node architectures" (ONNA) project is to study next-generation optical network architectures. Technological advances such as WDM and fast optical switches as well as protocol standardization have given us flexible high-bandwidth transport networks. This high-bandwidth also introduces the need to study the resilience aspects of such networks. The project both examines automatic circuit-switched optical networks and the longer term solution of optical packet-switched networks. Optical circuits established through optical switching are used in providing on-demand coarse granularity connectivity services. This connectivity is offered between nodes of higher network layers. For example, an IP over optical multi-layer network uses these fast-switching optical networks as a transport layer for carrying data traffic, though the large discrepancy between IP layer traffic flow granularity and optical layer granularity (e.g. wavelength channels) may prove a challenge. Optical packet-switching (OPS) can offer a flexible and bandwidth efficient architecture. Compared to circuit-switched approaches, it provides smaller granularity to the optical layer (on a packet-by-packet basis), while still allowing for optical bypassing of transit nodes (without E/O conversions) for traffic traversing multiple hops. This smaller switching granularity also gives promising opportunities to apply differentiation in recovery techniques. Ideally, we envisage transparent optical networking, where the optical packet can contain an arbitrary client layer protocol. In spite of this, optical packet-switching is still a challenge because of the high bitrates that forces optical technology to switch very fast. To make routing decisions faster and more efficient the Multi Protocol Label Switching (MPLS) routing protocol makes use of local labels. Even though MPLS forms a good solution it yet doesn't cross the chasm between the router's switching speed (i.e. table look-up procedures are time consuming) and the fibre's data speed. In an attempt to overcome this, research starts to focus on all-optical packet-switching by way of All-Optical Label Swapping (AOLS).

AOLS implements the packet-by-packet routing and forwarding functions of MPLS directly at the optical domain. By using optical labels, the IP packets are directed through the optical network without passing them through electronics whenever a forwarding decision is necessary. Ideally this approach has the ability to route packets/bursts independently of bit rate, packet format and packet length. Still AOLS encounters new troubles. The lack of all-optical memory makes the AOLS nodes very complex and resource consuming. Whereas the electronically implemented look-up table was easy to adapt to changing routing demands (i.e. LSPs are set-up, broken down at all possible moments in the network), a big number of optical components need be installed to perform the same functions all-optically. How many components and how they are designed relate directly to the router's ability to accept more or fewer LSPs. This is of great importance when providing the all-optical network with resilience. The ONNA project focused on different protection/restoration schemes (real-time or in advance, local or end-to-end) that could be used in combination with all-optical packet-switching networks. It investigated how the presence of back-up facilities in the network affect the label length and number of labels needed throughout the network (i.e., the router's dimensions).

Keywords: Optical networks, All Optical Label Swapping, Network recovery.

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