Lightpath Provisioning in IP-centric MPλS Optical Networks

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Abstract - *A simulation model of a Multiprotocol Lambda Switching Control framework for the provisioning of wavelength switched paths in IP-centric optical networks is presented. The required extensions to conventional MPLS, OSPF and CR-LDP for implementing Suurballe's Open Shortest Cycle algorithm are also outlined.*

Introduction

The provisioning of lightpaths in an IP-centric wavelength routed network requires a control framework for the establishment and maintenance of optical virtual circuits. This framework should consider scalable protocols required to handle the increasing network complexities/dimensionalities and interact with IP routing and traffic policy management protocols [2]. Moreover, as in conventional IP networks, Optical Cross-Connects are to be considered IP addressable devices, capable of receive and distribute information regarding the different performance parameters relevant to the optical transport network. A self-contained protocol paradigm is no longer valid and co-operation is expected between the upper network layers and the optical layer appended at the bottom of the protocol stack. Hence, a novel Multiprotocol Lambda Switching control framework is proposed based on conventional MPLS Traffic Engineering and QoS Routing using OSPF, thus migrating these concepts into the optical domain.

Multiprotocol Lambda Switching Approach

The use of MPLS in an IP centric optical network raises certain number of concerns regarding the co-existence with other network layer protocols. Particularly, when the optical layer provides protection mechanisms, these have to act in co-ordination with the upper layers avoiding conflicting actions taken as a consequence of the same event, thus leading to topology oscillations and race conditions. Moreover, the Multiprotocol Lambda Switching paradigm dictates that each network element should be treated as an Optical Label Switched Router and therefore include at least one IP address so it can be addressed when routing information is to be shared to obtain a global view of the physical topology of the optical network [3].

The topology is thus discovered using a dynamic routing protocol. The exchange of *hello* and database synchronisation messages allows each core and edge router to create a map of the network where a path between every source and destination pair can be selected following different constraints. OSPF uses the information obtained from other LSRs to obtain the shortest path between every pair of nodes. This, nevertheless, does not consider optical-layer relevant parameters such as wavelength conversion in the cost computation prior to the shortest path selection. Moreover, OSPF does not provide an optimal path when multiple equal-cost paths may exist. Optimised Multipath techniques are required to include other parameters to obtain the optimal path between every source destination pair.

Optical layer protection mechanisms are normally based on spare capacity, either used to carry extra traffic or not, capable of providing similar performance as the protected path where premium traffic is transported. Therefore, even when the physical topology may represent a ring, the logical topology would normally provide different paths between each pair of nodes resembling a mesh, not necessarily fully meshed, topology . Thus the conventional shortest path calculation would not provide the required functionality if the alternative paths are carried over the same fibre. A node disjoint set of routes are desirable where information may be conveyed over different spans not necessarily coinciding with the shortest path but with the optimal shortest cycle. The Shortest Cycle calculation, based on simple modifications to OSPF to include Suurballe's algorithm [1], would then provide a set of nodes the LSP should traverse from a specific Ingress LSR to the corresponding Egress LSR, considering relevant Optical Performance Parameters and providing the required path redundancy.

Traffic Engineering in IP networks has been proposed in combination with both OSPF and MPLS Signalling protocols. Extensions to CR-LDP are proposed to expand the protocol's functionality into the IP centric Optical Network Signalling Protocol (IP-ONSP) in charge of setting up, maintaining and distributing Label information, dynamically setting up explicit routes for the establishment of Optical LSPs between different LSRs. The set of nodes to be included in the explicit route would be provided by the shortest cycle algorithm once data base synchronisation, and therefore convergence, has been reached in the routing domain. At initialisation the Ingress LSR would issue a request to be forwarded to all the nodes in the explicit route, to create bi-directional LSP (contrary to unidirectional paths as in conventional IP MPLS networks) until the message reaches the Egress LSR, in this case, the same source of the original request forming a cycle.

Simulation Work

A simulation model built in OPNET capable of incorporating the salient features of IP-centric optical networks is presented in Fig. 1. The simulation would allow for a modified version of OSPF to run until it signals convergence. The LDP protocol would then initiate the path establishment procedures assigning a wavelength as the label to each cycle with an ingress LSR and intermediate edge LSRs to complete the source-destination pair. The signalling requirements for the propagation of accurate information depends on the OSPF timer settings, as well as the time interval between route computation when significant changes occur in the network or after an indication from the optical layer following a protection event. The link-cost composition as well as the route computation are modified according to Suurballe's algorithm [1] as previously explained.

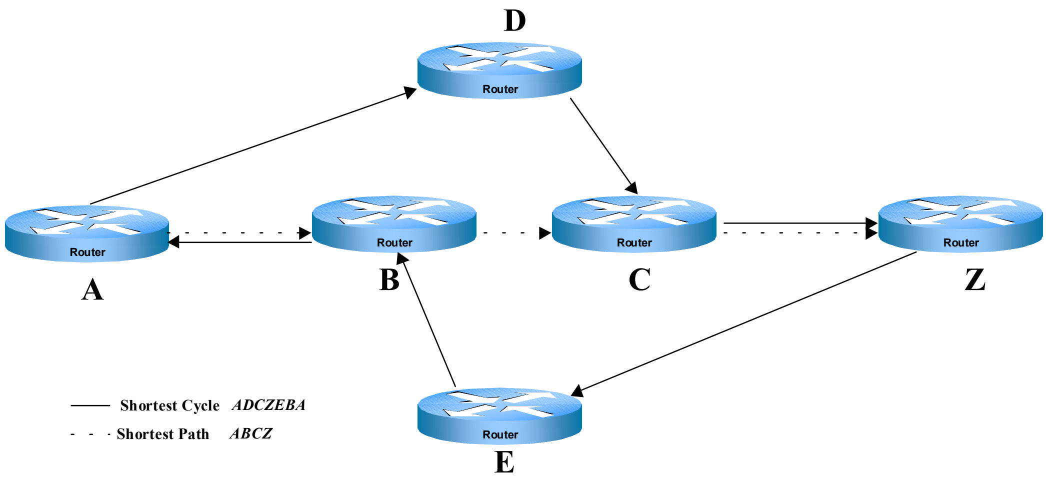

Figure 1. Lightpath Provisioning using the Open Shortest Cycle

Concluding Remarks

IP-centric Lambda Switching Optical Networks may be realised if the different concerns regarding inter-layer co-ordination and escalation strategies are considered. Moreover, a hybrid network provisioning scheme may be feasible if a combined recovery strategy is followed using optical layer protection and alternative node-disjoint path selection considering optical performance parameters.

References

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