ABSTRACT

With proliferation of bandwidth-on-demand services, future transport network will be required to provide highly dynamic connectivity with a wide range of bandwidth requirements to support such heterogeneous services. Elastic optical network (EON) is one of the promising solution for transport optical network for meeting these growing heterogeneous demands. Deployment of advanced control plane is the key to fully exploit the emerging capabilities and flexibilities of the optical network. The control plane functionalities are also constantly evolving with the traffic pattern. Moreover, with increase in data traffic the volume of control traffic in the network also increases. A well designed control plane must take into account the provisioning of this control traffic, i.e. to reserve resources for control traffic on appropriately chosen links of the physical topology, particularly when network is congested. Presently, the two prevalent control architectures are Automatically Switched Optical Network (ASON)/Generalized multi-protocol label switching (GMPLS) based distributed plane and the recently introduced Software defined network (SDN)/OpenFlow based centralized control plane. It is envisioned that a practically deployable control architecture may follow a hybrid combination of both. This thesis has two parts, first part addresses control plane virtual topology design of distributed control plane (Chapter 3) and second part presents control plane virtual topology design of centralized control plane (Chapter 4 & 5).

Resource reservation for control traffic ensures that delay in control plane remains within the service specific delay bound which is imperative for quick set-up and tear-down of such dynamic services. Moreover, data plane and control plane are to be mapped on the same physical topology and share same resources. Therefore, designing one plane without taking into consideration the other, may actually detriment the performance of both the planes. Hence, it is essential to have a combined /comprehensive virtual topology design methodology for control and data planes of the optical backbone network, where the need of both control traffic and data traffic are duly accounted for.

In our first work, we propose a comprehensive design methodology for GMPLS-based control and data planes of wavelength-routed optical networks (WRONs) employing mixed line rate (MLR) transmission for cost-effective resource provisioning. The proposed design approach attempts to minimize the maximum lightpath congestion in network for a given traffic matrix, however, without compromising the network restoration response against link failures.

Centralized control plane architecture of backbone optical network is physically distributed and logically centralized. In the second work, we present an optimization problem and a heuristic algorithm to design control plane virtual topology of Software Defined-EON (SD-EON), wherein dedicated bandwidth is

reserved for control traffic to ensure that delay in control plane links remain within bound and consistent network state is maintained among physically distributed controllers. Results show that propagation delay is the dominant factor when control traffic is low. However, as control traffic increases, queuing delay does not remain negligible. Thus, while designing control plane virtual topology it is important to take into account queuing delay and transmission delay along with propagation delay, especially if control traffic is not negligible.

In the third work, we present an optimization problem to make this control plane virtual topology survivable while minimizing the resources reserved for protection of control traffic subject to the delay bound criteria. Apart from control traffic volume the delay bound is shown to influence the amount of resources that need to be reserved for protection.

Keywords: Optical network, Elastic optical network (EON), Control plane, Data plane, Virtual topology design, Generalized multi-protocol label switching (GMPLS), Software defined network (SDN), Wavelength-division multiplexing (WDM), Wavelength-routed optical networks (WRONs), OpenFlow, queuing delay, restoration time, controller placement problem, survivability, shared protection.