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GMPLS-enabled MPLS-TP/PWE3 node with integrated 10 Gbps tunable DWDM transponders: design and experimental evaluation

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ABSTRACT

In this paper we propose a more cost-efficient alternative to current transport network technologies (SONET/SDH) based on the high-bandwidth transport and deterministic performance of the optical circuit technologies (i.e., WSON) along with the efficient aggregation and statistical multiplexing of a packet transport technology (i.e., MPLS-TP) to support IP and Ethernet services. The purpose is to achieve cost reductions, simplified operations and flexible scalability in transport networks. We present the architectural design, implementation and the performance evaluation of the forwarding capabilities of a MPLS-TP/PWE3 node with integrated 10 Gbps tunable DWDM transponders, extending the GMPLS-enabled WSON transport network of the ADRENALINE Testbed. The node has been implemented using commercial off-the-shelf hardware and the forwarding engine has been implemented using open source software. An evaluation of the node is provided by means of analyzing the obtained throughput and CPU usage in different evaluation scenarios with different traffic grooming and traffic aggregation strategies.

1. Introduction

Historically, backbone transport network architectures have been built on the synchronous optical network/synchronous digital hierarchy (SONET/SDH) technology, which is based on Time Division Multiplexing (TDM), that is, different digital signals can be efficiently multiplexed (in time) within a single frame. SONET/SDH has been designed with specific characteristics such as strictly connection oriented (i.e., coarse-bandwidth, long-lived and manually-provisioned connections), high level of protection and availability, quality of service (QoS), and extended operations and management (OAM) capabilities. However, it is well-known that packet-based services and applications with various bandwidth and QoS requirements are not optimally supported by the coarse bandwidth granularity of SONET/SDH [1]. For example, a 100 Mbit/s Fast Ethernet connection is transported on a 155 Mbit/s STS-3c container, leading to considerable bandwidth waste. To enhance this, Next Generation SONET/SDH (NG–SDH) aims at providing variable and flexible bandwidth granularity by building virtually-concatenated containers of fairly arbitrary size (e.g., 100 Mbit/s), and methods for dynamically changing the bandwidth, but although flexibility and bandwidth occupation are improved, it is not fully optimized.

To achieve cost reduction, simplified operations and flexible scalability, operators want to migrate the SONET/SDH layer to a connection oriented Packet Transport Network (PTN) in order to support packet services while preserving the advantages of such transport infrastructure. In this context, the packet transport technology that is best positioned to replace the SONET/SDH layer due to the majority support from the industry and standardization bodies is the MPLS Transport Profile (MPLS-TP) [2]. This technology is a new solution combining the packet experience of MPLS (e.g., packet switching efficiency, traffic engineering and QoS) with the operational experience of

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SONET/SDH transport networks (e.g., reliability, monitoring and link protection) technologies. MPLS-TP is defined as a profile of the MPLS-TE [3] and the pseudowire emulation edge-to-edge (PWE3) [4] architectures. This combination addresses the design and extension of MPLS functionalities and characteristics, targeted at transport networks.

On the other hand, the development of Wavelength-Switched Optical Networks (WSON), allows the combination of packet transport (i.e., MPLS-TP) and the huge transport capacity supported by optical circuit switching. Reconfigurable and high-bandwidth optical connections (i.e. lightpaths) can be setup entirely within the optical domain to bypass the transit traffic in the core IP/MPLS routers [5]. Consequently, the processing at higher layers is avoided at the intermediate routers, left only at the points where header processing is needed (e.g., the network access edge). The automation of these transport networks can be efficiently encompassed through the deployment of a distributed unified control plane (UCP) [6] based on the Generalized Multi-Protocol Label Switching (GMPLS) architecture [7]. A distributed control plane provides a common set of interconnection mechanisms (e.g., signaling protocol for resource reservation and routing protocol for topology and resource dissemination) and functions such as automated connection provisioning and recovery, traffic engineering or QoS.

The focus of this paper is to present the architectural design, implementation and the packet forwarding performance evaluation of a MPLS-TP/PWE3 node with software-based forwarding and integrated 10 Gbps tunable DWDM transponders to extend the GMPLS-enabled WSON transport network of the ADRENALINE Testbed [8], as shown in Fig. 1. This work extends the first proposed scenarios and results obtained in [9], and is organized as follows: Section 2 describes the architecture of the proposed GMPLS-controlled MPLS-TP/PWE3 node. Section 3 provides the software implementation details of the MPLS-TP/PWE3 label forwarding engine. Section 4 discusses the implementation of a 10 Gbps tunable DWDM transponder. Finally, the experimental performance evaluation of the implemented forwarding engine and the used 10 Gbps tunable DWDM transponder is carried out in Section 5.

2. GMPLS-controlled MPLS-TP/PWE3 node with integrated 10 Gbps tuneable DWDM transponders

Fig. 2 shows the logical architecture of the proposed GMPLS-controlled MPLS-TP/PWE3 node with integrated 10 Gbps tuneable DWDM transponders. In general, the node architecture is divided into two main elements, the control and the data planes.

2.1. Functionalities

The control plane is responsible for handling the establishment, maintenance, deletion, and protection of MPLS-TP connections in a dynamic and on-the-fly fashion, by using the RSVP-TE Connection Controller. Meanwhile, it should also take care the discovering and disseminating the topology and available resources in MPLS-TP and WSON networks, and store the results in the Traffic Engineering

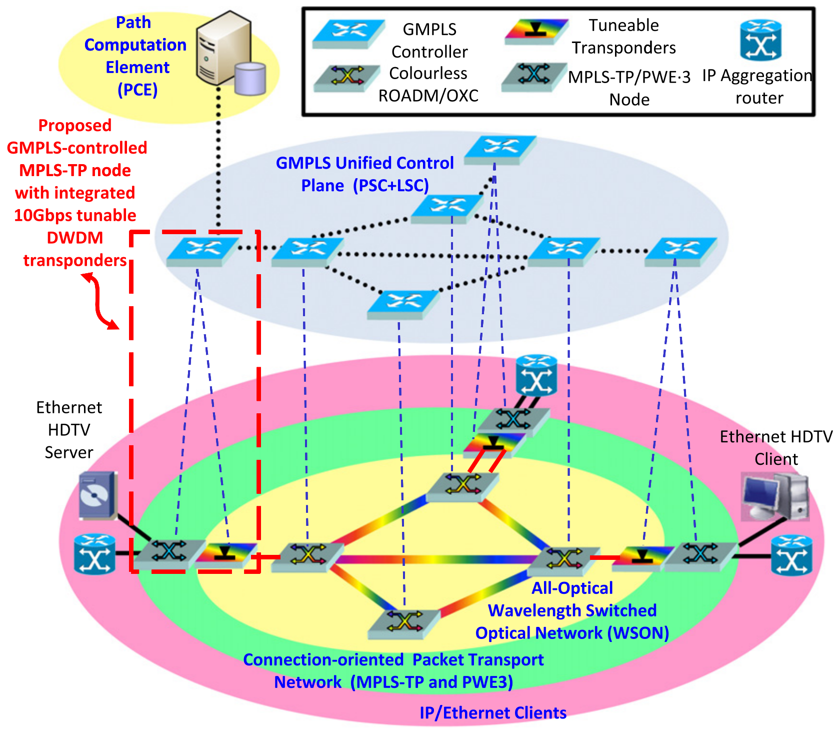

Fig. 1. Architecture of enhanced single-domain dual-region (MPLS-TP and WSON) ADRENALINE Testbed.