Chapter 4
Monitoring Devices for Providing Network Intelligence in Optical Packet Switched Networks

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ABSTRACT

The development of all-Optical Packet Switching (OPS) networks brings about new challenges in the topic of Optical Performance Monitoring (OPM). The objectives of this chapter are addressed to the proposal of new monitoring techniques capable of packet-by-packet monitoring in the optical domain to preserve packet transparency. Moreover, new optical layer functionalities such as dynamic reconfiguration and link level restoration also introduce a level of complexity that may require advanced OPM capabilities. In this chapter, an OSNR monitoring technique and its application for providing network intelligence are explained in detail. In particular, the integration of the monitoring system with the control and management planes is investigated to perform other functions such as quality of service implementation, OSNR-assisted routing, and backup route selection.

INTRODUCTION

To meet the increasing requirements for higher bandwidth and novel services, an evolution from static optical networks to dynamically reconfigurable architectures is expected. This evolution highlights the importance of providing network solutions putting forward scalability and flexibility as most critical specifications. According to these requirements, Optical Packet Switching (OPS) networks provide high throughput, bandwidth efficiency, and excellent flexibility, as well as offering new capabilities to process packets directly at the optical layer (Jourdan et al., 2001; O’Mahony et al., 2001). However, to support OPS at bitrates up to Terabit/s, networks...
should reduce the amount of complex electronics by migrating to an all-optical network, where data is switched and routed transparently in the optical domain. At this scenario, All-Optical Label Switching (AOLS) appears to be a solution to avoid the bottleneck imposed by the nodes based on electronic processing (Blumenthal et al., 2000).

In such an AOLS scenario, all packet-by-packet routing and forwarding functions of Multiprotocol Label Switching (MPLS) are implemented directly in the optical domain. By using optical labels, the IP packets are routed through the core optical networks without requiring O/E/O conversions whenever a routing decision is necessary. This solution allows the network transparency to be improved but at the expense of increasing the complexity of the network management, being necessary to monitor the parameters affecting the network performance directly in the optical layer.

The need of signal quality monitoring at the physical layer has stimulated interest in Optical Performance Monitoring (OPM) as a potential mechanism for improving the control of transmission and the fault management in the physical layer (Kilper et al., 2004). New optical layer functionalities such as dynamic reconfiguration and link level restoration also introduce a level of complexity that may require advanced OPM capabilities. All of these issues bring focus to OPM as an enabling technology for next OPS networks. In such networks, each optical packet may traverse different paths and different optical components; thereby having its own history and quality. Hence, the key goal for OPM is to develop techniques capable of monitoring the physical impairments with fast response and on a packet basis. Related to this topic, the following questions are of special interest:

- How to perform OPM on a packet basis?
- How to develop a monitoring module with fast response time and wide dynamic range?
- How to associate the monitored parameters with the switch controls and header information?
- How to integrate the monitoring information with the control and management planes to provide some kind of network intelligence?

In this chapter, these questions are addressed and an OSNR monitoring technique suitable for next generation OPS networks is discussed. This technique is based on using a specific data word (monitoring field) inserted into the packet header, which is processed in each intermediate node, for monitoring purpose. Moreover, the integration of the monitoring system with other functions in the packet switching node to take real-time decisions based on quality requirements is also envisaged. This will be a great step forward towards the provision of network intelligence inside optical networks.

This paper explores OPM and its potential for enabling higher reconfigurability, and flexibility in an OPS network, including the issues of what parameters should be monitored in the optical signal. Moreover, this chapter describes the importance of signal quality monitoring on a packet-by-packet basis for next OPS networks and proposes a novel technique based on the use of optical correlation to assess the signal quality at the optical domain with relaxed speed requirements. At the end of the chapter, an overview of the main applications of the proposed monitoring technique is presented.

**OPTICAL PERFORMANCE MONITORING**

During the last decades, optical transport systems have become the suitable solution to enable the rapid growth of data traffic in the network backbone. Apart from enhancing the network capac-