OPTICAL NETWORKS

Architecture and Survivability
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This book is intended for use by anyone interested in the development of optical Internet and Metropolitan area networks. As the topics of the book cover a broad spectrum of state-of-the-art optical network design and management schemes, the potential readers may be those working as research & development engineers, graduate students studying wavelength-routed WDM networks, and senior undergraduate students with a background in algorithms and networking. This book may also supplement readings for any graduate course that touches the topics of internetworking, routing, survivability, and network planning algorithms.

We are inspired to write this book by the rapid development and advance in Internet technology, which has revolutionized telecommunications over the past two decades. It is highly possible that progress will maintain this surprisingly speed in the coming future. The lightening fast evolution of Internet makes the cutting-edge research topics a moving target all the time. However, some of the most basic ideas will always hold, and will provide a foundation upon which new research topics may arise.

We believe that the development of algorithms and protocols for resource allocation must cooperate with the control architecture design so that the whole communication systems can be seamlessly integrated. The “optimal” design for network control and management is a function of many network environment parameters and assumptions, which may nevertheless be distorted from the practical situation without a thorough consideration. Many design decisions are based largely on heuristic judgments and tend to be a compromise between alternatives. It is our goal to convey these notations to the readers.

Let us review the topics covered in sequence, chapter by chapter.

Chapter 1 provides opening remarks for the book as well as brief descriptions of the evolution of IP networks and the Multi-Protocol Label Switching (MPLS) based control plane. The design objectives are outlined to provide a basis for further discussions later in this book.

Chapter 2 introduces the control and management architecture for wavelength-routed WDM mesh networks, including the industry and standard setting progresses for the optical Internet. This chapter begins with an overview of the MPLS control plane, in which the most important issues that characterize the newly standardized protocol are provided. Based on the MPLS control plane, the Generalized MPLS control architecture is examined from both the signaling and switching architecture phases. Several models for routing and signaling are given hereafter, which define the interoperability of different protocol constructs.
Chapter 3 provides an overview of the issues surrounding routing and wavelength assignment (RWA), which includes the reported algorithms and heuristics for performing static and dynamic path selection processes.

Chapter 4 considers more practical situations concerning dynamic routing and wavelength assignment problems in which constraints are imposed on the path selection, such as the physical, service and administrative constraints. To improve throughput, a couple of planning algorithms are included.

Chapter 5 discusses routing and wavelength assignment algorithms for networks with multi-granularity traffic in the optical layer. We examine a hardware-based approach to implementing path selection with multi-granularity traffic based on the switching architecture of MG-OXCs provided in Chapter 2.

Chapter 6 introduces the state-of-the-art in protection and restoration in the optical layer, which includes an overview of the ring-based and mesh-based protection schemes. Standardized restoration mechanisms such as the SONET Self-healing Ring and Automatic Protection Switch (APS) are presented. An introduction to the MPLS-based recovery is given, which discusses different types of design originality, including the path-based, link-based, and Short Leap Shared Protection.

Chapter 7 focuses on the spare capacity allocation schemes. Under the assumption that all the working capacity is known to the network control plane, the optimal or near-optimal deployment of spare capacity in the optical networks can be conducted in a static manner. We also provide a framework for improving performance in dynamic networks using the static approaches. Our goal is to fit the time-consuming optimization processes into a dynamic network, where connection requests arrive one after the other without any knowledge of future arrivals.

Chapter 8 introduces survivable routing algorithms with a special focus on optimality in capacity and computation efficiency. Diverse routing algorithms for both dedicated and shared protection are addressed.

Chapter 9 describes a different switching architecture from the wavelength-routed approach – Optical Burst Switching (OBS). The focus is placed on the reservation schemes that have been proposed for the OBS, including Just-In-Time (JIT) and Just-Enough-Time (JET). A comparison is conducted between different switching techniques including Optical Packet Switching, Lambda-Switching, and OBS. Node architectures that implement the OBS are also described.