

# Preface

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In the past decade, we have witnessed the huge success and spectacular growth of the Internet, which has led to the explosion of Internet traffic and has therefore imposed a huge bandwidth demand on its underlying telecommunications infrastructure. To meet the unprecedented demand for bandwidth, fiber optics has brought about a bandwidth revolution in telecommunications networks. At the core of this revolution, optical fiber has proved to be an excellent physical transmission medium because of its huge transmission bandwidth (nearly 50 terabits) as well as a number of other advantages over traditional transmission media, such as low signal attenuation (about 0.2 dB/km), low error bit rate (typically  $10^{-12}$ ), low signal distortion, low power requirement, low space requirement, and low cost. In this revolution, the emergence of wavelength division multiplexing (WDM) technology is a new milestone. WDM allows multiple optical signals to be transmitted independently and simultaneously in multiple optical channels or wavelengths over a single fiber, each operating at a very high rate of a few gigabits per second (Gbps), and can thus more efficiently exploit the usable bandwidth inherent in optical fibers. With recent advances in enabling technologies, WDM systems capable of supporting up to 160 channels at 10 Gbps are commercially available and products with more optical channels are expected to come into the market soon. Therefore, WDM has been widely considered a technology of choice for meeting the huge bandwidth demand in telecommunications networks. Optical networks using WDM technology have become the most promising network infrastructure for next-generation telecommunications networks, not only for wide-area networks but also for metropolitan area networks and local area networks.

Although WDM technology is currently being deployed by many network providers mostly for point-to-point transmission, a large effort from academia, industry, and standardization organizations has been and is being made to enable the transition of WDM from a point-to-point transmission

technology toward a networking technology. Because of this effort, significant research and development progress has been made over the last few years. Advanced optical devices, such as erbium-doped fiber amplifiers (EDFAs), optical cross-connects (OXC), and optical add/drop multiplexers (OADMs) have become commercially available. A number of experimental prototypes and testbeds have already been and are currently being developed and built by many network and service providers. Although there are still a number of challenges for the vision of all-optical networks to be commercially realized, optical WDM networks are indeed coming into the marketplace rapidly.

The purpose of this book is to provide an introduction to basic concepts, major issues, and effective solutions for wavelength-routed WDM networks. Distinguished from other books in optical networks, this book focuses primarily on the networking aspects of such networks and highlights the fundamental concepts and design principles. In addition, the state-of-the-art developments and technologies are introduced. The book is organized into eight chapters and covers the most important networking aspects, such as network control architecture, routing and wavelength assignment, virtual topology configuration and reconfiguration, network control and management, optical-layer protection and restoration, and IP over WDM. To help readers to better understand the contents of each chapter, a number of examples are given to illustrate the concepts, problems, and solutions and a number of problems are included at the end of each chapter. In addition, a list of extensive references is provided in each chapter for those readers who seek a deeper exploration.

This book is intended for graduate students and academic researchers as an introduction to the design of wavelength-routed WDM networks and further their research work. In particular, it is intended as a textbook for graduate students in electrical engineering, computer engineering, or computer science. It can be used as a textbook for a graduate course on optical networks or as a supplementary textbook for a graduate or senior undergraduate course on telecommunications networks, data communication networks, or computer networks. This book may also be of interest to network engineers, designers, planners, operators, and managers in the area of electrical and computer engineering, who would like to learn more about optical networks.

Jun Zheng  
Hussein T. Mouftah  
University of Ottawa