PH PTR

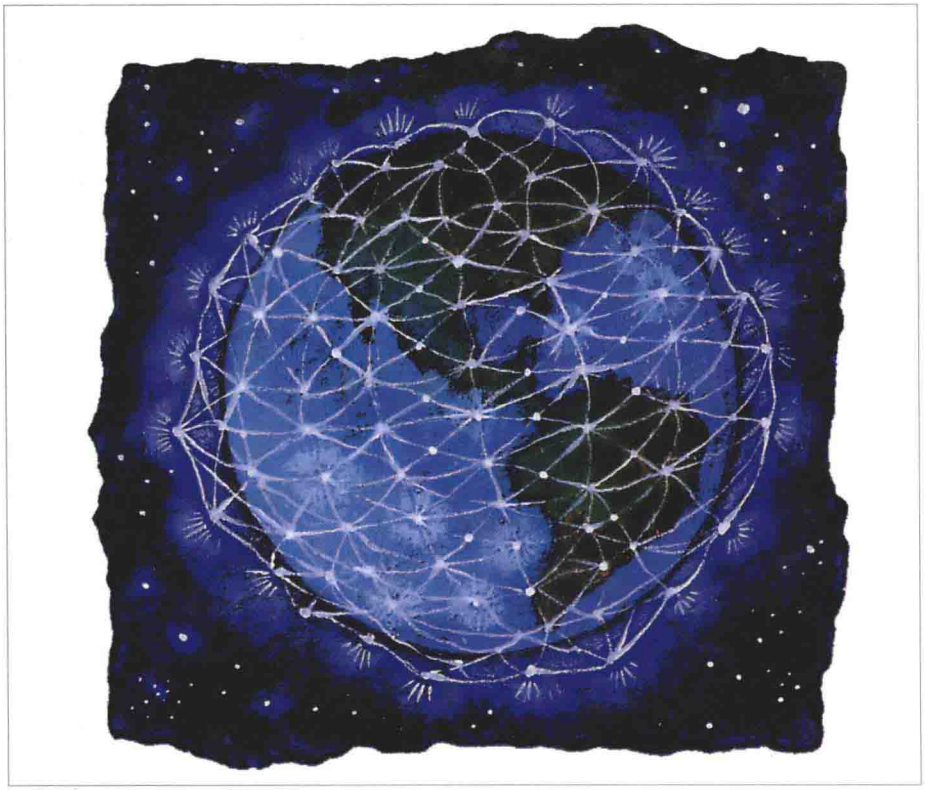
电子工程系列丛书（影印版）

NEXT GENERATION OPTICAL NETWORKS

The Convergence of IP Intelligence and Optical Technologies

下一代光网络

IP智能与光子技术的融合



Peter Tomsu • Christian Schmutzer

http://www.tup.tsinghua.edu.cn

清华大学出版社

内容简介

随着数据业务的快速增长，IP为代表的计算机网络技术与光传送网络技术为代表的电信技术正逐步走向融合。本书着眼于IP技术与光网络技术的交叉点，阐述了下一代光网络的关键技术：实现智能化的IP技术与高速、大容量的光子技术之间融合。本书首先给出了光子技术与数据通信各自的相关基础内容，然后着重讨论了下一代光网络的控制平面的关键技术和未来发展趋势，对静态层叠模式、动态层叠模式和集成对等模式等三种控制平面技术进行了较深入的分析。最后讨论下一代光网络技术的演进趋势，以及它在下一代存贮网络（SAN）、互联网络及电信网络中的解决方案。

下一代光网络技术是涉及面十分宽广的交叉性新技术，本书不仅较系统地总结了下一代光网络技术研究领域中IP over optical 方面的最新成果，而且还阐述了它所涉及的IP技术与光子技术这两方面基础内容。因此，本书是了解或学习下一代光网络技术很好的参考资料，可适用于计算机网络工程师与通信工程师、相关专业的大学高年级、研究生和研究人员。

This edition is authorized for sale in the People's Republic of China only, excluding HongKong, Macao SAR and Taiwan.
此英文影印版仅限在中华人民共和国境内销售，香港、澳门特别行政区及台湾地区除外。

电子工程系列丛书（影印版）

- **The ASIC Handbook 2001**
  Nigel Horspool,Peter Gorman
- **Next Generation Optical Networks 2002**
  Peter Tomsu,Christian Schmutzer
- **The Essential Guide to Telecommunications 3rd ed.2002**
  Annabel Z. Dodd
- **Stream Control Transmission Protocol (SCTP)2002**
  Randall R.Stewart,Qiaobing Xie

ISBN 7-302-06077-0
9 787302 060772 >
定价：42.00 元

PH
PTR

影印版

NEXT GENERATION
OPTICAL NETWORKS

下一代光网络

IP智能与光子技术的融合

清华大学出

电子工程系列丛书（影印版）

NEXT GENERATION OPTICAL NETWORKS

The Convergence of IP Intelligence and Optical Technologies

下一代光网络

IP 智能与光子技术的融合

Peter Tomsu
Christian Schmutzer

清 华 大 学 出 版 社

（京）新登字 158 号

Next Generation Optical Networks: The Convergence of IP Intelligence and Optical Technologies
Peter Tomsu, Christian Schmutzer

Copyright © 2002 by Prentice Hall PTR
Original English Language Edition Published by Prentice Hall PTR
All Rights Reserved.
For sale in Mainland China only.

本书影印版由培生教育出版集团授权清华大学出版社在中国境内独家出版、发行，香港、澳门特别行政区和台湾地区除外。
未经出版者书面许可，不得以任何方式复制或抄袭本书的任何部分。

本书封面贴有培生教育出版集团激光防伪标签，无标签者不得销售。
北京市版权局著作权合同登记号：图字：01-2002-4512

图书在版编目(CIP)数据

下一代光网络：IP 智能与光子技术的融合 = Next Generation Optical Networks: The Convergence of IP Intelligence and Optical Technology / 托姆舒，施穆策著. —影印本. —北京：清华大学出版社，2002
（电子工程系列丛书）
ISBN 7-302-06077-0

Ⅰ. 下… Ⅱ. ①托… ②施… Ⅲ. 光纤通信－通信网－英文 Ⅳ. TN929.11

中国版本图书馆 CIP 数据核字（2002）第 088131 号

出版者：清华大学出版社（北京清华大学学研大厦，邮编 100084）
http:// www.tup.tsinghua.edu.cn
印刷者：清华大学印刷厂
发行者：新华书店总店北京发行所
开　本：787×960 1/16　**印张**：21.5
版　次：2002 年 12 月第 1 版　2002 年 12 月第 1 次印刷
书　号：ISBN 7-302-06077-0/TP・3627
印　数：0001～4000
定　价：42.00 元

此为试读，需要完整PDF请访问：www.ertongbook.com

出 版 前 言

电子工程是信息科学的基础。高等学校新的教学要求指出：计算机专业和电子学专业的学生应相互学习并渗透到彼此的专业领域，拓宽知识面，以适应信息技术飞速发展的时代。培养通晓相关专业领域知识的人才，已成为21世纪理工科教育的迫切要求。为此，我们挑选与信息科学、电子学有关的国外优秀著作，组成“电子工程系列丛书（影印版）”，奉献给国内读者。1999年我们曾推出了奥本海姆的《信号与系统第2版》、奥法尼德斯的《信号处理导论》和拉贝的《数字集成电路》。这三本影印版图书获得了读者的广泛支持。本世纪我们将继续进行这项工作。根据读者的意见，今后我们出版的影印版图书，其开本尺寸不再缩小，基本保持其原版开本尺寸。

我们希望，这套丛书能为国内高校师生、工程技术人员以及科研单位的工作人员提供新的知识和营养，也衷心期待着读者对我们一如既往的支持。

清华大学出版社
计算机教育出版事业部
2002年10月

About the Authors

PETER TOMSU, Ph.D., Senior Consulting Engineer at Cisco Systems, has worked with Cisco since 1996. He is involved in numerous network designs–from service provider backbones to large enterprise backbones–and is significantly driving new technologies during their definition, development, introduction, and final deployment phases. For many years, Tomsu has been a requested speaker at international conferences in the United States and worldwide. He received his Ph.D. from the Technical University of Vienna.

CHRISTIAN SCHMUTZER, M.S., Systems Engineer at Cisco Systems, has been with the company since 1998. He works primarily on the design and deployment of large service provider backbones and concentrates on optical networking as well as routing technologies. As a speaker for technical tutorials throughout Europe, he frequently shares his practical experience. He received his Masters from the Fachhochschule Technikum Wien in Vienna.

Acknowledgments

There are a lot of people we would like to thank. This book would not have been possible without the patience and support of our families. They provided sustained encouragement during the complete period of writing, from the very beginnings of planning this book through the final edits.

A special thanks goes to Mary Franz, who was a significant help in all phases of the project. Radia Perlman deserves a special recognition. She provided encouragement, ideas, guidance, and support throughout the entire effort, giving valuable input in structuring the book.

A very special thanks to our employer, Cisco Systems, for providing great help over the past two years, especially Jane Butler and Rob Lloyd, who supported this book from the very beginning. We also received great support from Gerhard Wieser, David Tsiang, George Suwala, and all others who helped us to finalize this book and are not listed here.

Many of the figures were adapted from Cisco Systems presentations, as well as ITU, IETF, ATM Forum, and other standardization bodies documents.

此为试读,需要完整PDF请访问: www.ertongbook.com

Preface

Why This Book

We had the idea to write this book two years ago, when service providers started commonly thinking about optical technologies such as Wavelength Division Multiplexing (WDM) to increase the capacity of optical transmission systems. The need for higher bandwidth came, of course, from the growing demand generated by the Internet and all of its applications and services.

Historically, there has not been much consensus between service providers and telecommunications camps (on the one side) and Internet service providers (ISPs) and Internet users (on the other side). Obviously, the most important reason for that is that, in the past, telephony companies built Time Division Multiplexing (TDM) networks and delivered voice services to their customers. As the Internet became more popular and generated increasing amounts of traffic, new ISPs started building router networks running IP. These delivered e-mail and World Wide Web (WWW) access and, later, more advanced IP services to their customers. Also at this time, traditional telephone providers started building router networks delivering IP services like their counterparts, the ISPs. From an organizational point of view, this represents two completely separated groups of people, two completely separated business functions, two completely separated areas of responsibility, two completely separated budgets, and—last but not least—two different human generations.

However, time changed quickly and while market deregulation was introduced, a broad range of alternate service providers started to compete in a very

fast-growing market with the incumbent providers. This very competitive situation now forces every single service provider to optimize its network architecture and to streamline its internal organizational structure in order to minimize its operational expenses (OPEX), one of the most important keys to success.

Suddenly, people talking about IP are also talking about WDM and the other way around. Although this is fine and a major step forward, there is still the problem that most people who have worked in the transmission space for years are experts on TDM, WDM, and all other optical transmission technologies. On the other hand, people who have worked for years in the Internet arena are experts in data networking, IP, and IP routing protocols. Both are experts but only in their tightly focused area of technology.

This is where our book is intended to enter the arena—to build a bridge between the two historically separated technology areas. It first outlines the most important technologies of optical transmission space, then focuses on important IP networking technologies. Finally, it concentrates on the convergence of both optical and IP to conclude. We are sure that the reader will obtain a deep understanding of what is really behind the "IP + optical" topic, a topic already of significant interest today and one that will gain even more momentum during the next few years.

Targeted Audience

The target audience for this book includes all people interested and working in the networking arena, service providers, and enterprises that are planning, designing, or deploying advanced optical IP-based infrastructures. The book is structured and written in a way that should be easily understandable for newcomers. It supplies many helpful references to standards and other literature and in-depth explanations, including information for advanced readers who want to get a complete picture of the state of the art of optical networking and the according control and provisioning mechanisms for these networks.

Structure of This Book

Chapter 1 of this book gives an overview about existing and possible future carrier network architectures. The architectural elements of traditional multilayer networks are described, and essential information about applied technologies

such as Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH), Asynchronous Transfer Mode (ATM), or Multiprotocol Label Switching (MPLS), is included.

Chapter 2 focuses on standardization activities in the optical networking arena. A snapshot of what already has been specified by such standardization bodies as International Telecommunications Union (ITU), Institute of Electrical and Electronics Engineering (IEEE), Optical Internetworking Forum (OIF), or Internet Engineering Task Force (IETF) and what kind of proposals are to be finalized soon is provided.

Chapter 3 represents a technology backgrounder delivering in-depth knowledge about optical transmission technologies, data transmission technologies, and network survivability concepts required for understanding how next-generation networks are designed and deployed.

Chapter 4 concentrates on the overall network architecture of advanced optical IP-based infrastructures and describes the three major steps in the evolution, from static IP over optical networks to dynamic and integrated IP + optical networks.

Chapter 5 finally outlines optical end-to-end networking design trends seen in the industry. Three case examples are described to put the theory about the convergence of IP and optical technologies covered in Chapters 1 and 4 into a practical perspective.

Further Information Online

All readers are welcome to consult the Web site www.nextgenzone.net for ongoing updated information related to this book and the authors, as well as for reading about the hot topics in the networking industry. A lot of up-to-date background information, including links to useful Web sites, industry articles, and much more online material can be found.

Contents

Acknowledgments xix

Preface xxi

Chapter 1

Introduction to Carrier Network Architectures 1

IP as Unifying Protocol Infrastructure 1
The Traditional Carrier Network Architecture 2
Achieving Long-Haul Connectivity with Optical Transmission 4
Delivering Multiplexed Services 4
Synchronous Transmission Standards 5
Building a Complex SONET/SDH Carrier Network 7
Multiplexing and Framing Standards 9
Providing Carrier Class Network Availability 13
Adding Versatility with Asynchronous Transfer Mode 14
ATM Reference Model 15
Introducing Statistical Multiplexing 16
Transport Multiple Services across a Single Network 17
AAL1 18
AAL2 19
AAL3/4 20
AAL5 20
ATM Services 22

Permanent Virtual Connection 23
Switched Virtual Connection 23
ATM Virtual Connections 23
ATM Switching Operation 24
ATM Addressing 24
Subnetwork Model of Addressing 25
NSAP-Format ATM Addresses 25
ATM Address Common Components 25
ATM Quality of Service 26
ATM Signaling and Connection Establishment Overview 27
Signaling Standards 28
ATM Connection Establishment Procedure 28
Connection Request Routing and Negotiation 29
Providing Internet Services at the IP Layer 29
Introducing the IP Layer on Top of the ATM Layer 29
Using Multiprotocol Label Switching for Delivering IP Services 31
Scalability Issues of Standard IP Routing Protocols 31
The Concept of Using Labels as Forwarding Information 32
MPLS-Based Applications 36
Next-Generation Carrier Networks 38
Eliminating Intermediate Layers in the Backbone 39
IP over ATM over SONET/SDH over WDM (1) 40
IP over ATM over WDM (2) 41
IP over SONET/SDH over WDM (3) 41
IP over WDM (4) 41
Handling Fiber Capacity Exhaust 41
Adding Intelligence to the Optical Layer 42
Summary 44
Recommended Reading 44

此为试读,需要完整PDF请访问: www.ertongbook.com