Preface

People's insatiable appetite and need for communications, trade, entertainment, and access to information, is as old as humanity itself. In today's society, this manifests itself in an increasingly rich set of *network-based* human-to-human, human-to-machine, and machine-to-machine interactions and applications. Examples of such applications include communications through the intermediary of social networking sites such as FaceBook and MySpace. They include B2C trading as exemplified by Amazon.com and now most brick-and-mortar companies, C2C trading with companies such as eBay as well as free-sharing models such as BitTorrent, and B2B trading with supply-chain integration and algorithmic trading. They have expanded into entertainment with massively multiplayer on-line gaming and virtual worlds such as SecondLife. They encompass access to exponentially growing and increasingly accessible information with new paradigms of on-line encyclopedia such as Wikipedia, and search-based access to the huge amount of information available on-line with tools provided by Google, Yahoo, and others. These types of interactions and applications are more than ever served and delivered over the Web and the underlying telecommunications networks. As the supporting information format has evolved from voice and sound to content-rich data and video, that has driven the need for very large amount of flexible bandwidth at the core of the network and all the way to the end-users and end-computers. And this is most certainly only the beginning.

The information and application explosion that we are currently experiencing, is in large part possible due to the radical progress in optical communications technology over the last few decades. Dense Wavelength Division Multiplexed (DWDM)-based optical mesh networks that route optical connections using optical cross-connects (OXCs) have been proposed as the means to implement the next generation optical networks. Optical mesh network architectures as we envision them will dynamically provide transmission capacities to higher-layer networks, such as inter-router connectivity in an increasingly IP-centric service infrastructure. They will also provide the intelligence required for efficient operations, and control and management at the core of the network.

Optical mesh networks will support a variety of dynamic wavelength services, enabling network services such as bandwidth-on-demand, just-in-time bandwidth and bandwidth scheduling, bandwidth brokering, and optical virtual private networks that open up new opportunities for service providers and their customers alike. At the core of this next generation optical mesh network lies the *intelligence* of the optical network elements and network management platforms required to efficiently provide routing and fast failure recovery. That is precisely the subject of this book.

Most of the books on optical communications or optical networks currently available include a host of subjects – from optical transmission technology to general network architectures, planning, analysis, modeling, and management and control. Contrary to that approach, our book presents an in-depth treatment of a specific class of optical networks, namely path-protection oriented mesh optical networks, and focuses specifically on routing and failure recovery associated with Dedicated Backup Path Protection (DBPP) and Shared Backup Path Protection (SBPP). This book focuses on the routing, recovery, dimensioning, performance analysis, and availability in such networks. This book is intended as a reference for practicing engineers working on the deployment of intelligent fiber-optic networks, and for researchers investigating a host of problems on this subject. This book is not meant for readers interested in fiber-optic communications in general, as it does not provide information about optical transmission at the physical layer, or the technology required for the deployment of such an intelligent optical network. There are a large number of such books in the literature, including, for example, Agrawal[1], Keiser[2] and Palais[3] for the reader seeking a deeper understanding of the underlying optical components and transmission technology, as well as a number of general texts on

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[1] G. P. Agrawal, *Fiber-Optic Communication Systems,* Third Edition (Wiley Series in Microwave and Optical Engineering). New York: John Wiley & Sons, 2002.

[2] G. Keiser, *Optical Fiber Communications,* Third Edition. McGraw-Hill, 2000.

[3] J. C. Palais, *Fiber-Optic Communications,* Fifth Edition. New Jersey: Prentice Hall, 2004.

optical networks (such as books by Stern, Ellinas and Bala[4], by Ramaswami and Sivarajan[5], by Jukan[6] and Mukherjee[7]. In addition, readers who seek a more detailed understanding on the control plane of optical networks have resources such as the book by Bernstein, Rajagopalan and Saha[8] and readers who want a deep understanding of survivability in optical as well as MPLS, SONET and ATM networks are encouraged to read such references as the books by Grover[9], Mouftah and Ho[10] and Zang[11].

Different parts of the book will be appropriate for different audiences. Some chapters will be of more interest to network planners and designers, while others, more forward-looking, will be of more interest to researchers.

Chapters 1, 2, and 3 are suitable for a reader who wants to gain some qualitative knowledge of intelligent optical networks. These chapters give a basic description of mesh optical networks and the basic concepts on routing and restoration in such networks, without treating these subjects in depth. Chapter 1 explains the evolution of optical networks and discusses different network architectures, Chapter 2 describes the numerous survivability techniques that are available for optical networks in general, and Chapter 3 focuses on routing and survivability concepts for shared mesh optical networks in particular.

Detailed discussions on algorithms for routing and Dedicated and Shared Backup Path Protection in mesh optical networks are presented in Chapters 4 through 10 and this material will be of interest to practicing engineers and researchers who are currently deploying or investigating the benefits of intelligent mesh optical networks. Chapter 4 introduces and focuses on the specific routing and recovery framework covered and studied in the reminder of the book: mesh optical networks operated with a path-based protection architecture, in particular Dedicated Backup Path Protection (DBPP) and Shared Backup Path Protection (SBPP). Chapter 5 presents a detailed introduction to and discussion of the algorithmic aspects of routing in path-protected mesh networks, and assesses the corresponding routing complexity. Chapter 6 discusses a number of practical and efficient routing heuristics, Chapter 7 describes advanced cost metrics that can be incorporated in these heuristics to drive certain network behaviors, and Chapter 8 describes ways of controlling and managing the amount of sharing through additional modifications of these heuristics. Chapter 9 takes the problem of routing and recovery in mesh optical networks a step further by investigating techniques for route computation with partial network information. In Chapter 10, we address the problem of reoptimizing the network and rerouting of connections over time as demand changes and the network infrastructure evolves.

Finally, Chapter 11 addresses the dimensioning and recovery performance of mesh optical networks through analytical means, while Chapter 12 covers and studies the service availability of path-protected connections in these networks. These chapters will be of interest to engineers who are interested in the dimensioning and capacity planning aspects of mesh optical networks, and to those who want to understand the availability performance that can be achieved for path-protected connections, and how it relates, or not, to recovery times. This work is also relevant to researchers, as routing with availability objectives or constraints, and network dimensioning, are two subjects that are actively being investigated by researchers in the area of optical networking. The reader is referred to *http://www.eng.ucy.ac.cy/gellinas/book.html* for useful resources such as a web service to apply the mesh routing algorithms described in the book as well as several case studies.

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[4] T. E. Stern, G. Ellinas and K. Bala. *Multiwavelength Optical Networks: Architectural Design and Control,*2nd Edition, Cambridge University Press, 2007.

[5] R. Ramaswami and K. Sivarajan, *Optical Networks: A Practical Perspective,* Second Edition. Morgan Kaufmann, 2002.

[6] A. Jukan, *QoS-based Wavelength Routing in Multi-Service WDM Networks*. Springer, 2001.

[7] B. Mukherjee, *Optical WDM Networks*. Springer, 2006.

[8] G. Bernstein, B. Rajagopalan and D. Saha, *Optical Network Control*. Addison-Wesley, 2004.

[9] W. Grover, *Mesh-Based Survivable Networks*. New Jersey: Prentice Hall, 2004.

[10] H. Mouftah and P-H. Ho, *Optical Networks: Architecture and Survivability*. Kluwer Academic Publishers, 2003.

[11] H. Zang, *WDM Mesh Networks: Management and Survivability*. Kluwer Academic Publishers, 2003.

Acknowledgments. Most of the work presented in this book either originated or was performed when all the authors were part of the Network Routing & Design Group under Jean-Franc¸ois Labourdette, at Tellium Inc. This group was responsible for the development of routing and protection/restoration architectures and algorithms, the design and performance modeling and analysis of mesh optical networks, including comparison with other network and service architectures, as well as numerous customer studies.

We are indebted to our colleagues Sid Chaudhuri and Krishna Bala, the immediate supervisors of the group, for their support, encouragement and expert guidance during the Tellium years. Their broad knowledge of telecommunications networks in general, and of optical networks in particular, was a tremendous resource for us. Their acute understanding and vision gave us valuable insight into several aspects of optical networking and helped us widen our perspectives.

In Tellium, we also had the privilege of interacting with an excellent group of colleagues who were instrumental in the development of the material presented in this book. In particular, we would like to acknowledge the other two members of the group, Ahmet Akyamac¸ and Chris Olzewski. Ahmet Akyamac¸ was instrumental in the work on modeling of mesh optical networks and Chris Olzewski in the work on multi-tier networks. Many fruitful discussions with them provided us with probing criticism, valuable suggestions and comments. It was a pleasure and a privilege working with them both intellectually and personally.

Special thanks also go to a number of other colleagues at Tellium, including Subir Biswas, Ziggy Bogdanomicz, Matt Busche, Samir Datta, Somdip Datta, Evan Goldstein, Nooshin Komaee, Lih Lin, Hang Liu, Dimitris Pendarakis, Bala Rajagopalan, Debanjan Saha, Shahrokh Samieian, Sudipta Sengupta, Bo Tang and James Walker, for the many enlightening discussions on endless technical subjects that have greatly benefited this work.

The quality of this book has significantly improved due to the diligent efforts of a number of unnamed colleagues who took the time to read it and provide valuable comments and suggestions. Our many thanks go out to them. We would also be remiss if we did not extend a thank you to Professor Wayne Grover for taking the time to review early drafts of this book and provide incredibly valuable feedback, and for writing the Foreword for this book.

We also wish to express our thanks to Richard Davies, Birgit Gruber, Sarah Hinton, Rowan January, Joanna Tootill, and Brett Wells, the publishing team at Wiley, for their diligence, and patience while dealing with missed deadlines and last minute changes.

Finally, Georgios Ellinas is greatly indebted to his mother Mary and sister Dorita for their faith and confidence in him, their unyielding emotional support, understanding and patience that have been a source of infinite strength during this undertaking. Jean-Franc¸ois Labourdette wishes to express his profound gratitude to his wife Isabelle and his two children Eric and Thomas for their support throughout this endeavor and for their understanding when he could not spend as much time with them as he would have liked. Eric Bouillet is most indebted to his parents and brothers for their encouragement and support, and to his wonderful wife Shao-i for her love, patience, and the comfort of her unwavering kindness. Ramu Ramamurthy thanks his wife Lakshmi, and his parents for their constant encouragement and support, and his son Shreyas for providing the necessary distraction.

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Georgios Ellinas
Jean-Francois Labourdette
Ramu Ramamurthy

optical fiber â€”â€”-> This type of media is used for high transmission speed and can also transfer data over long distances. coaxial â€”â€”-> Traditionally used for television but can now be used in a network to connect the customer location to the wiring of the customer premises. Explanation: UTP cables are used in wired office environments. Coaxial cables are used to connect cable modems and televisions. Fiber optics are used for high transmission speeds and to transfer data over long distances. STP cables are used in environments where there is a lot of interference. Which statement describe A. Wap Area Network B. Wide Area Network C. Wide Array Net D. Wireless Area Network Ans= (B). 22. What is the main difference between a mainframe and a super computer?Â 29. Coded entries which are used to gain access to a computer system are called_? A. Entry codes B. Passwords C. Security commands D. Code words Ans= (B). 30. Which of the following statements is true about Minicomputer and Microcomputer?Â A. A Mechanical Input device B. Optical input device C. Electronic input device D. Optical output device Ans= (B). 35. UNIVAC is_? A. Universal Automatic Computer B. Universal Array Computer C. Unique Automatic Computer D. Unvalued Automatic Computer Ans= (A). Optical mesh networks will support a variety of dynamic wavelength services, enabling network services such as bandwidth-on-demand, just-in-time bandwidth and bandwidth scheduling, bandwidth brokering, and optical virtual private networks that open up new opportunities for service providers and their customers alike. At the core of this next generation optical mesh network lies the intelligence of the optical network elements and network management platforms required to efficiently provide routing and fast failure recovery. That is precisely the subject of this book. Different parts of the boo...Â Chapters 1, 2, and 3 are suitable for a reader who wants to gain some qualitative knowledge of intelligent optical networks. In this question type, you are given a short text with some blank spaces. You have to fill in the blanks with one or two words taken directly from the passage. To practice this question type effectively, look at the words or phrases just before and after the blank spaces carefully. This may give you some idea about where to look for the answers in the passage. [â€¦] undergraduates and who are studying ____.Â Look at section B where the author speaks about the knowledge learned on the course to its usefulness for students who want to become firefighters. They will be capable of doing the job in a professional and expert way: â€œâ€¦. programs in fire science: they are highly welcome as part of the increasing professionalization of this and many other occupationsâ€. A) network interface. B) connecting lines. C) network nodes.Â 126. What methods of knowledge transfer does not apply to e-learning. A) Internet. B) satellite TV.Â 138. Notes that include the slide as well as key comments and points you may want to emphasis while you present your slide show are know as: A) speaker handouts. B) speaker notes.