Connection-Oriented Networks:

SONET/SDH, ATM, MPLS, OPTICAL NETWORKS

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Preface

This book explores a number of connection-oriented packet-switched networks and circuit-switched networks. These networks, though seemingly different, share common networking principles, and in some cases one network is built on another older one.

The first connection-oriented network is probably the familiar and ubiquitous telephone network. This is a circuit-switched network, whereby a connection is established between the two parties by allocating a channel on each transmission link along the path. The concept of connection, as used in the telephone system, has been emulated for a long time in computer packet-switched networks. In view of this, such networks are known as connection-oriented packet-switched networks.

In this book, we explore two connection-oriented packet-switched networks, namely, *ATM networks* and *Multi-Protocol Label Switched (MPLS) networks*. ATM is a legacy network that was developed in the late 1980s and early 1990s. It is used in the backbone to transport IP traffic, in access networks such as ADSL-based networks and passive optical networks, and also in cellular telephony. The MPLS architecture can be seen as an extension of ATM, and it has be used to introduce quality of service in IP networks.

Two circuit-switched networks, namely *SONET/SDH* and *Optical Wavelength-Routing networks,* are also presented in this book. SONET/SDH has been around for along time, whereas optical wavelength routing networks are relatively new. SONET/SDH is the underlying transport network of the telephone system and it is also used in all modern packet-switched networks, such as IP and ATM. In view of this, it is included in the book as part of the necessary background that the reader should have. Wavelength routing networks are also circuit-switched networks since the transmission of data is done using optical circuit-switched connections, known as *lightpaths*. We also present a new optical networking scheme, which has not as yet been standardized, known as *Optical Burst Switching,* which can be seen as lying between packet switching and circuit switching.

Finally, the book contains a Chapter on access networks, such as ADSL-based networks, cable modems, and ATM passive optical networks, and a Chapter on voice over ATM and voice over MPLS.

The book was written with a view to be used as a text book in a second course on computer networks at the graduate level or senior undergraduate level. Also, it was written for networking engineers out in the field who would like to learn more about connection-oriented packet-switched networks and circuit-switched networks. The book does not deal explicitly with IP networks, and it is not necessary for the reader to have a detailed knowledge of the IP network in order to understand the material presented here. The only pre-requisite for this book is basic knowledge of computer networking principles.

The book consists of twelve Chapters, which cover the following topics:

- *Chapter 1: Introduction*
- *Chapter 2: SONET/SDH*
- *Chapters 3, 4, 5: ATM networks*
- *Chapters 6 and 7: MPLS*
- *Chapters 8, 9, and 10: Optical networks*
- *Chapter 11: Access networks*
- *Chapter 12: Voice over ATM and MPLS.*

How current are the specifications?

Most of this book was written during 2003 and 2004, and therefore the specifications presented in the book have been frozen in that period of time. Since the networking technology is continuously evolving, the reader is strongly encouraged to browse through the web sites of the standard committees for updates.

A note to the students using this book

This book grew out of teaching a course on connection-oriented networks and a course on optical networks for the degree of *Master of Science in Computer Networks* at NC State University. At the beginning of a course, I like to tell my students jokingly that if they

want to get an A they have to read the book five times. If they read it four times, then they will end up with a B, and if they read it three times they will end up with a C, and so on! As the reader can imagine, this statement always gives rise to some lively discussion. However, there is some truth in this statement since the book deals with descriptive material which has been developed over several years by different standards bodies. As a result there are a lot of details to learn and frequently the networking concepts are convoluted and not easy to understand in one or two readings. A good way to test your understanding of a particular networking scheme, is to ask yourself a question, and then try to answer it. If you can answer it immediately without hesitation, then you know it. Otherwise, you need to go back for another reading!!

A note to the instructor

At the end of each Chapter there are problems. Also, at the end of some of the Chapters there is a simulation project designed to help the reader understand better some of the intricacies of the networks presented in this book. Specifically, the following four simulation projects have been included in the book:

- *Chapter 3: A simulation model of AAL 2*
- *Chapter 4: Estimating the ATM traffic parameters of an MPEG video source*
- *Chapter 9: A simulation model of a wavelength routing network*
- *Chapter 10: A simulation model of an optical burst switching network*

Each simulation project contains enough information so that a reader who is unfamiliar with discrete-event simulation techniques can easily write the simulation program.

More information on basic discrete-event simulation techniques can be found in many simulation books including my e-book entitled *Computer Simulation Techniques – The Definitive Introduction,* which is available free of charge from my web page http://www.csc.ncsu.edu/faculty/perros//index.html.

The solution to the problems and the code and results for the simulation projects can be found in a solution manual, available directly from Wiley's web site. Also, a

power point presentation for each Chapter is available from the same Wiley's web site. If you cannot access this web site, please send me an email (hp@csc.ncsu.edu).

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