Internetworking Computer Systems

Interconnecting Networks and Systems

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PRENTICE HALL, Englewood Cliffs, New Jersey 07632

Library of Congress Cataloging-in-Publication Data

McConnell, John
Internetworking computer systems: interconnecting networks and systems/John McConnell.
p. cm.
Bibliography: p.
Includes index.
ISBN 0-13-473976-0
1. Computer networks. I. Title. II. Title: Internetworking computer systems.
TK5105.5M4 1988
004.6—dc19

Editorial/production supervision and interior design: **David Ershun/Nancy Menges**
Cover design: **Karen Stephens**
Manufacturing buyer: **Cindy Grant**

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-473976-0

PRENTICE-HALL INTERNATIONAL (UK) LIMITED, *London*
PRENTICE-HALL OF AUSTRALIA PTY. LIMITED, *Sydney*
PRENTICE-HALL CANADA INC., *Toronto*
PRENTICE-HALL HISPANOAMERICANA, S.A., *Mexico*
PRENTICE-HALL OF INDIA PRIVATE LIMITED, *New Delhi*
PRENTICE-HALL OF JAPAN, INC., *Tokyo*
SIMON & SCHUSTER ASIA PTE. LTD., *Singapore*
EDITORA PRENTICE-HALL DO BRASIL, LTDA., *Rio de Janeiro*

Prentice Hall Advanced Reference Series

JAIN AND DUBES *Algorithms for Clustering Data*
MCCONNELL *Internetworking Computer Systems: Interconnecting Networks and Systems*
SHERE *Software Engineering and Management*

Preface

The advent of large numbers of microcomputer workstations in the workplace has brought the "information age" closer to reality. The productivity of a computer system, and its users, can be augmented when it can communicate with other systems. A networking **environment** that allows easy access to remote resources and easy distribution of information enhances the performance of users and, thus, their organizations. However, interaction and resource sharing among computers is often far from simple or efficient. Creating an environment that supports effective communications among a diverse set of computers is no simple task.

The focus is on the new environment: What are its properties, its challenges, and its unresolved problems? New perspectives and strategies are needed if sophisticated computer communication is to become a commonplace activity. The most important characteristics of this environment are: (1) computer-to-computer communications; (2) internetworking—that is, interconnection of computers attached to different types of networks; (3) interworking—that is, process-to-process interaction, whereby all partners can apply their flexibility and resources to the problem; (4) an infrastructure—that is, an array of management and support services that make the environment easier to use and operate; and (5) heterogeneous computers—that is, different architectures and operating systems that must interwork.

This book examines this challenging area from the perspective of the professional who is dealing with the practical issues of constructing and operating sophisticated networking services. Although theoretical topics such as queueing theory and algorithms have an important place in the field, they

rarely offer any assistance in grappling with large-scale problems of architecture and strategy. Such tools are best employed after specific areas have been defined and a refined analysis can determine specific solutions.

Important internetworking and interworking issues are not necessarily tied to basic communications technology anymore, although a basic knowledge of communications is assumed so that we can focus on these higher-level subjects. At times, reference will be made to basic communications terms, such as *half-duplex* or *twisted pair,* without defining them. Those who are unfamiliar with the topic should have little trouble with this book, since the emphasis here is on *utilizing* basic communications, rather than on understanding a multitude of details. References in the bibliography at the end of the book provide excellent treatments of basic communications technologies and define the common terms.

Interworking environments are complex and require precise orchestration of many diverse elements. **Protocols** assume a fundamental importance, since they are the basic mechanisms for interaction. Environments have a set of protocols—a **suite**—that have a large impact on operational costs and application performance. Currently, organizations with different types of computers encounter a "tower of babel" with sets of proprietary and incompatible protocols for each system. The **Open Systems Interconnection** standards are being widely accepted as the solution to creating better networking environments. However, basic issues and requirements must be kept in mind when evaluating any approach. Practical consideration of such factors as operating costs, performance, management and vendor-dependent alternatives must be included as a means of assessing the suitability of standards—or any other approach.

The open systems interconnection (OSI) model is used as a framework for the five parts of this book. An effort has been made to maintain a balance among the issues, the protocols that address them, and practical considerations. Each of the protocols examined is not broken down to describe each bit; rather the general properties of the protocol and its suitability to the task are discussed. Subjects such as choosing appropriate protocol mechanisms to suit different requirements receive more attention. In addition to the OSI standards, approaches pioneered by ARPANET or provided by some vendors are used as practical examples and alternatives. The OSI model is not followed slavishly, as some chapters deal with areas that have not been addressed by the standards committees at this time. Also, the standards are not considered sacrosanct; poor work is noted in several areas.

The five parts introduce topics of increasing complexity; preceding parts form a foundation for each new part. The first part introduces the material, defines the basic structure of the open systems architecture and discusses common protocol mechanisms. The second part discusses the basic building blocks provided by local area and wide area networks. The third part focuses on

internetworking—the combination of the building blocks discussed in the second section. Interworking issues comprise the fourth part—how to create services needed for process-to-process interaction. The last part discusses examples of interworking applications, some vendor-dependent approaches, and strategic planning.

Acknowledgments

This book turned out to be a larger project than I had expected. At times it was extremely frustrating to think that I understood some topic thoroughly and then see the shambles I made discussing it. The support of my family, friends, and colleagues was essential throughout this period; my colleagues helped clarify the technical contents, and my friends and family supplied the encouragement and sympathetic ears I needed from time to time.

In particular, I would like to acknowledge Kenneth Lini and his group at the U.S. Department of Agriculture, Fort Collins, Colorado. Working with them has been challenging and rewarding. Michael Howard of the Infonetics group of Santa Clara, California, has been invaluable as a sounding board and for valuable insights into many real-world situations. Marianne Rieux of Writers, Ink, in Fort Collins, Colorado, has been a tremendous help with editing and organizational suggestions. Her help is greatly appreciated.

The reviews from Prentice Hall were very helpful. Other perspectives served to clarify details or offer organizational suggestions. I appreciate the time and care they showed.

Finally, a special debt of acknowledgment is owed to Jim Lemmon, the rowing coach at the University of California, Berkeley. Lessons I learned from him while pulling an oar have had more lasting value than any technical material I ever mastered.

Contents

PART ONE

Foundations

This first part introduces the basic environment that the remainder of the book examines in more detail. Chapter 1 gives an overview of the types of networking environments that will be discussed. Chapter 2 introduces the Open Systems Interconnection (OSI) reference model, which is the organizational framework for the following parts. Finally, chapter 3 completes the part with a discussion of the general ideas and mechanisms that underlie a majority of the protocols covered in later chapters.

1
Networking Environments

At the Infonetics Conference on Desktop Communications in 1987, Apple President John Sculley addressed a crucial issue: Although the productivity of our computer technology has increased enormously, the productivity of individuals and organizations has not increased apace. These rapidly changing times require increased productivity if many organizations are to survive.

Computers have steadily increased in speed and capacity while hardware unit costs have decreased. On the Tandem Computer Corporation's "Visions" program, James Martin calculated that the cost for a MIP (million instructions per second) of computing power ranges from $200,000 on a large mainframe to as little as $100 for the new generation of microprocessors. Expanding computational power allows organizations to attack problems that were once too difficult or expensive to confront. At the same time, solutions to present problems are available more quickly.

The advent of microprocessors has made significant computing power available to large numbers of people in many different locations. As with other innovations, microcomputers are being employed in many unforeseen ways. As people grow more accustomed to them and begin to explore their capabilities, more possibilities will be opened.

At the same time, application programs have grown increasingly sophisticated. The current generation of application software has many capabilities that its predecessors lacked. The best new products also supply simpler user interfaces, such as pointing devices, windows, and pull-down menus. In contrast to traditional computing applications, many organizations are depending