FIFTH EDITION

DATA AND COMPUTER COMMUNICATIONS

WILLIAM STALLINGS

PRENTICE HALL
UPPER SADDLE RIVER, NEW JERSEY 07458

Library of Congress Cataloging-in-Publication Data
Stallings, William.
Data and computer communications / William Stallings. —5th ed.
p. cm.
Includes bibliographical references and index.
ISBN (invalid) 0-02-415425-3
1. Data transmission systems. 2. Computer networks. I. Title.
TK5105.S73 1996 96-24419
004.6—dc20 CIP

Publisher: Alan Apt
Editor-in-Chief: Marcia Horton
Production Manager: Bayani Mendoza de Leon
Production Editor: Mona Pompili
Managing Editor: Laura Steele
Design Director: Amy Rosen

Designer: Judy Matz-Coniglio
Cover Designer: Tom Nery
Cover Illustrator: Wendy Grossman
Copy Editor: Chip Lee
Manufacturing Buyer: Donna Sullivan
Editorial Assistant: Shirley McGuire

Simon & Schuster / A Viacom Company
Upper Saddle River, New Jersey 07458

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-02-415425-3

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*

BRIEF CONTENTS

other digital devices. In the latter case, data are usually transmitted in packets. Because the medium is shared, only one station at a time can transmit a packet.

More recently, examples of switched LANs have appeared. The two most prominent examples are ATM LANs, which simply use an ATM network in a local area, and Fibre Channel. We will examine these LANs, as well as the more common broadcast LANs, in Part III.

1.4 PROTOCOLS AND PROTOCOL ARCHITECTURE

When computers, terminals, and/or other data processing devices exchange data, the scope of concern is much broader than the concerns we have discussed in Sections 1.2 and 1.3. Consider, for example, the transfer of a file between two computers. There must be a data path between the two computers, either directly or via a communication network. But more is needed. Typical tasks to be performed are

1. The source system must either activate the direct data communication path or inform the communication network of the identity of the desired destination system.
2. The source system must ascertain that the destination system is prepared to receive data.
3. The file transfer application on the source system must ascertain that the file management program on the destination system is prepared to accept and store the file for this particular user.
4. If the file formats used on the two systems are incompatible, one or the other system must perform a format translation function.

It is clear that there must be a high degree of cooperation between the two computer systems. The exchange of information between computers for the purpose of cooperative action is generally referred to as *computer communications*. Similarly, when two or more computers are interconnected via a communication network, the set of computer stations is referred to as a *computer network*. Because a similar level of cooperation is required between a user at a terminal and one at a computer, these terms are often used when some of the communicating entities are terminals.

In discussing computer communications and computer networks, two concepts are paramount:

- Protocols
- Computer-communications architecture, or protocol architecture

A protocol is used for communication between entities in different systems. The terms "entity" and "system" are used in a very general sense. Examples of

entities are user application programs, file transfer packages, data-base management systems, electronic mail facilities, and terminals. Examples of systems are computers, terminals, and remote sensors. Note that in some cases the entity and the system in which it resides are coextensive (e.g., terminals). In general, an entity is anything capable of sending or receiving information, and a system is a physically distinct object that contains one or more entities. For two entities to communicate successfully, they must "speak the same language." What is communicated, how it is communicated, and when it is communicated must conform to some mutually acceptable conventions between the entities involved. The conventions are referred to as a protocol, which may be defined as a set of rules governing the exchange of data between two entities. The key elements of a protocol are

- **Syntax.** Includes such things as data format and signal levels.
- **Semantics.** Includes control information for coordination and error handling.
- **Timing.** Includes speed matching and sequencing.

Having introduced the concept of a protocol, we can now introduce the concept of a protocol architecture. It is clear that there must be a high degree of cooperation between the two computers. Instead of implementing the logic for this as a single module, the task is broken up into subtasks, each of which is implemented separately. As an example, Figure 1.4 suggests the way in which a file transfer facility could be implemented. Three modules are used. Tasks 3 and 4 in the preceding list could be performed by a file transfer module. The two modules on the two systems exchange files and commands. However, rather than requiring the file transfer module to handle the details of actually transferring data and commands, the file transfer modules each rely on a communications service module. This module is responsible for making sure that the file transfer commands and data are reliably exchanged between systems. Among other things, this module would perform task 2. Now, the nature of the exchange between systems is independent of the nature of the network that interconnects them. Therefore, rather than building details of the network interface into the communications service module, it makes sense to have a third module, a network access module, that performs task 1 by interacting with the network.

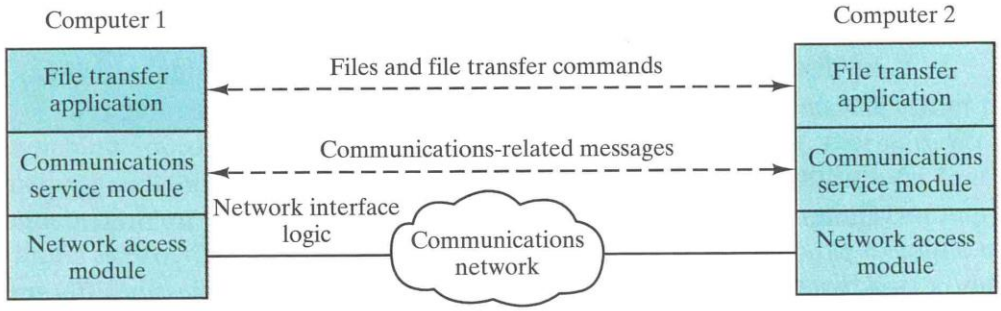

FIGURE 1.4 A simplified architecture for file transfer.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.