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THE

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# HANDBOOK

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OF

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# COMPUTER NETWORKS

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**Distributed Networks, Network Planning,  
Control, Management, and New Trends  
and Applications**

**VOLUME 3**

**Hossein Bidgoli**  
*Editor-in-Chief*

# HANDBOOK OF COMPUTER NETWORKS

**Distributed Networks, Network Planning,  
Control, Management, and New Trends  
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**Volume 3**

江苏工业学院图书馆

**Hossein Bidgoli**

藏书章

Editor-in-Chief

*California State University  
Bakersfield, California*



John Wiley & Sons, Inc.

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Published by John Wiley & Sons, Inc., Hoboken, New Jersey  
Published simultaneously in Canada

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***Library of Congress Cataloging-in-Publication Data:***

Handbook of computer networks / edited by Hossein Bidgoli.

3 v. cm.

ISBN 978-0-471-78458-6 (cloth vol 1 : alk. paper)

ISBN 978-0-471-78459-3 (cloth vol 2 : alk. paper)

ISBN 978-0-471-78460-9 (cloth vol 3 : alk. paper)

ISBN 978-0-471-78461-6 (cloth set : alk. paper)

1. Computer networks Handbooks, manuals, etc. I. Bidgoli, Hossein.

TK5105.5.H32 2008

004.6-dc22

2007012619

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

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To so many fine memories of my mother Ashraf, my father  
Mohammad, and my brother Mohsen, for their uncompromising  
belief in the power of education.

# About the Editor-in-Chief

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**Hossein Bidgoli, Ph.D.**, is professor of Management Information Systems at California State University. Dr. Bidgoli helped set up the first PC lab in the United States. He is the author of 43 textbooks, 27 manuals, and over five dozen technical articles and papers on various aspects of computer applications, information systems and network security, e-commerce, and decision support systems published and presented throughout the world. Dr. Bidgoli also serves as the editor-in-chief of *The Internet*

*Encyclopedia*, *The Handbook of Information Security*, and *The Encyclopedia of Information Systems*.

*The Encyclopedia of Information Systems* was the recipient of one of the Library Journal's Best Reference Sources for 2002 and *The Internet Encyclopedia* was recipient of one of the PSP Awards (Professional and Scholarly Publishing), 2004. Dr. Bidgoli was selected as the California State University, Bakersfield's 2001–2002 Professor of the Year.

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# Preface

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*The Handbook of Computer Networks* is the first comprehensive examination of the core topics in the computer network field. *The Handbook of Computer Networks*, a 3-volume reference work, with 202 chapters, 3400+ pages, is a comprehensive coverage of the computer network field with coverage of the core topics.

**The primary audience** is the libraries of 2-year and 4-year colleges and universities with Computer Science, Computer Engineering, Network Engineering, Telecommunications, Data Communications, MIS, CIS, IT, IS, Data Processing, and Business departments, public and private libraries and corporate libraries throughout the world, and educators and practitioners in the networking and telecommunications fields.

**The secondary audience** is a variety of professionals and a diverse group of academic and professional courses for the individual volumes.

Among industries expected to become increasingly dependent upon the computer networks and telecommunications and active in understanding the many issues surrounding this important and fast-growing field are: government agencies, military, education, libraries, health, medical, law enforcement, accounting firms, law firms, justice, manufacturing, financial services, insurance, communications, transportation, aerospace, energy, biotechnology, retail, and utilities.

Each volume incorporates state-of-the-art core information and computer networks and telecommunications topics, practical applications, and coverage of the emerging issues in the computer networks field.

This definitive 3-volume *Handbook* offers coverage of both established and cutting-edge theories and developments in the computer networks and telecommunications fields. The *Handbook* contains chapters from global experts in academia and industry. The *Handbook* offers the following unique features:

1. Each chapter follows a unique format including Title and Author, Outline, Introduction, Body, Conclusion, Glossary, Cross-References, and References. This unique format assists the readers to pick and choose various sections of a chapter. It also creates consistency throughout the entire series.
2. The *Handbook* has been written by more than 270 experts and reviewed by more than 1000 academics and practitioners chosen from around the world. These diverse collections of expertise have created the most definitive coverage of established and cutting-edge theories and applications of this fast-growing field.
3. Each chapter has been rigorously peer reviewed. This review process assures the accuracy and completeness of each topic.
4. Each chapter provides extensive online and off-line references for additional reading. This will enable the readers to go further with their understanding of a given topic.
5. More than 1000 illustrations and tables throughout the series highlight complex topics and assist further understanding.
6. Each chapter provides extensive cross-references. This helps the readers to read other chapters related to a particular topic, providing a one-stop knowledge base for a given topic.
7. More than 2500 glossary items define new terms and buzzwords throughout the series, assisting in understanding of concepts and applications.
8. The *Handbook* includes a complete table of contents and index sections for easy access to various parts of the series.
9. The series emphasizes both technical as well as managerial issues. This approach provides researchers, educators, students, and practitioners with a balanced understanding and the necessary background to deal with problems related to understanding computer networks and telecommunications issues and to be able to design a sound computer and telecommunications system.
10. The series has been developed based on the current core course materials in several leading universities around the world and current practices in leading computer, telecommunications, and networking corporations. This format should appeal to a diverse group of educators and researchers in the networking and telecommunications fields.

We chose to concentrate on fields and supporting technologies that have widespread applications in academic and business worlds. To develop this *Handbook*, we carefully reviewed current academic research in the networking field in leading universities and research institutions around the world.

Computer networks and telecommunications, network security, management information systems, network design and management, computer information systems (CIS), and electronic commerce curriculums, recommended by the Association of Information Technology Professionals (AITP) and the Association for Computing Management (ACM) were carefully investigated. We also researched the current practices in the networking field carried out by leading networking and telecommunications corporations. Our work assisted us in defining the boundaries and contents of this project. Its chapters address technical as well as managerial issues in the networking and telecommunications fields.

## TOPIC CATEGORIES

Based on our research, we identified nine major topic areas for the Handbook:

- Key Concepts
- Hardware, Media, and Data Transmission
- Digital and Optical Networks
- LANs, MANs, and WANs
- The Internet, Global Networks, and VoIP
- Cellular and Wireless Networks
- Distributed Networks
- Network Planning, Control, and Management
- Computer Network Popular Applications and Future Directions

Although these nine categories are interrelated, each addresses one major dimension of the computer networks and telecommunications fields. The chapters in each category are also interrelated and complementary, enabling readers to compare, contrast, and draw conclusions that might not otherwise be possible.

Though the entries have been arranged logically, the light they shed knows no bounds. The *Handbook* provides unmatched coverage of fundamental topics and issues for successful design and implementation of a computer network and telecommunications systems. Its chapters can serve as material for a wide spectrum of courses such as:

- Grid Computing
- Distributed Intelligent Networks
- Multimedia Networking
- Peer-to-Peer Networks
- Cluster Computing
- Voice over IP
- Storage Area Networks
- Network Backup and Recovery Systems
- Digital Networks
- Optical Networks
- Cellular Networks
- Wireless Networks
- Telecommunications Systems
- Computer Network Management

Successful design and implementation of a sound computer network and telecommunications systems requires a thorough knowledge of several technologies, theories, and supporting disciplines. Networking researchers and practitioners have had to consult many resources to find answers. Some of these sources concentrate on technologies and infrastructures, some on applications and implementation issues, and some on managerial concerns. This *Handbook* provides all of this relevant information in a comprehensive three-volume set with a lively format.

Each volume incorporates core networking and telecommunications topics, practical applications, and coverage of the emerging issues in the networking and telecommunications fields. Written by scholars and practitioners from around the world, the chapters fall into nine major subject areas:

## Key Concepts

Chapters in this group examine a broad range of topics. Fundamental theories, concepts, technologies, and applications related to computer networks, data communications, and telecommunications are discussed. These chapters explain the OSI reference model and then discuss various types of compression techniques including data, image, video, speech, and audio compression. This part concludes with a discussion of multimedia streaming and high definition television (HDTV) as their applications are on the rise. The chapters in this part provide a solid foundation for the rest of the Handbook.

## Hardware, Media, and Data Transmission

Chapters in this group concentrate on the important types of hardware used in network and telecommunications environments and then examine popular media used in data communications including wired and wireless media. The chapters in this part explain different types of modulation techniques for both digital and optical networks and conclude with coverage of various types of multiplexing techniques that are being used to improve the efficiency and effectiveness of communications media.

## Digital and Optical Networks

Chapters in this group discuss important digital and optical technologies that are being used in modern communication and computer networks. Different optical switching techniques, optical devices, optical memories, SONET, and SDH networks are explained.

## LANs, MANs, and WANs

This group of chapters examines major types of computer networks including local, metropolitan, and wide area networks. Popular types of operating systems used in a LAN environment are discussed, including Windows and Linux. The chapters also examine various types of switching techniques including packet, circuit, and message switching. The chapters discuss broadband network applications and technologies and conclude with a discussion of multimedia networking.

## The Internet, Global Networks, and VoIP

Chapters in this group explore a broad range of topics. They review the Internet fundamentals, history, domain name systems, and Internet2. The architecture and functions of the Internet and important protocols including TCP/IP, SMTP, and IP multicast are discussed. The chapters in this group also explain the network and end-system quality of service and then discuss VoIP and its various components, protocols, and applications.

## Cellular and Wireless Networks

Chapters in this group explain cellular and wireless networks. Major standards, protocols, and applications in the cellular environment are discussed. This includes a detailed coverage of GSM, GPRS, UMTS, CDMA, and TDMA. The chapters in this group explore satellite communications



principles, technologies, protocols, and applications in detail. The chapters conclude with coverage of wireless wide area networks and wireless broadband access.

## Distributed Networks

The chapters in this group investigate distributed networks, their fundamentals, architectures, and applications. Grid computing, cluster computing, and peer-to-peer networks are discussed in detail. These chapters also explore storage area networks, fiber channels, and fault tolerant systems. This part concludes with a discussion of distributed algorithms and distributed databases.

## Network Planning, Control, and Management

The chapters in this group discuss theories, methodologies, and technologies that enhance successful network planning, control, and management. After discussion of network capacity planning and network modeling, the chapters concentrate on the identification of threats and vulnerabilities in a network environment. The chapters then present a number of tools and technologies that if properly utilized could significantly improve the integrity of data resources and computer networks by keeping hackers and crackers at bay. This part concludes with a discussion of business continuity planning, e-mail, and Internet use policies, and computer network management.

## Computer Network Popular Applications and Future Directions

Chapters in this group present several popular applications of computer networks and telecommunications systems. These applications could not have been successfully utilized without a sound computer network and telecommunications system. Some of these applications include conferencing, banking, electronic commerce, travel and tourism, and Web-based training and education. This part concludes with a discussion of future trends in computer networking including biologically inspired networking, active networks, and molecular communication.

Specialists have written the *Handbook* for experienced and not so experienced readers. It is to these contributors that I am especially grateful. This remarkable collection of scholars and practitioners have distilled their knowledge

into a fascinating and enlightening one-stop knowledge base in computer networks and telecommunications that “talks” to readers. This has been a massive effort, but one of the most rewarding experiences I have ever had. So many people have played a role that it is difficult to know where to begin.

I should like to thank the members of the editorial board for participating in the project and for their expert advice on help with the selection of topics, recommendations for authors, and reviewing the materials. Many thanks to more than 1000 reviewers who devoted their time by providing advice to me and the authors for improving the coverage, accuracy, and comprehensiveness of these materials.

I thank my senior editor Matt Holt, who initiated the idea of the *Handbook*. Through a dozen drafts and many reviews, the project got off the ground and then was managed flawlessly by Matt and his professional team. Matt and his team made many recommendations for keeping the project focused and maintaining its lively coverage.

Jessica Campilango, our editorial coordinator, assisted our authors and me during the many phases of its development. I am grateful for all her support. When it came to the production phase, the superb Wiley production team took over. Particularly I want to thank Deborah Schindler and Miriam Palmer-Sherman, our production editors. I am grateful for all their hard work. I also want to thank Lynn Lustberg, our project manager from ICC Macmillan Inc. Her thoroughness made it easier to complete the project. I am grateful to all her efforts. I thank Kim Dayman and Christine Kim, our marketing team, for their impressive marketing campaign launched on behalf of the *Handbook*.

Last, but not least, I want to thank my wonderful wife, Nooshin, and my two children, Mohsen and Morvareed, for being so patient during this venture. They provided a pleasant environment that expedited the completion of this project. Mohsen and Morvareed assisted me in sending out thousands of e-mail messages to our authors and reviewers. Nooshin was a great help in designing and maintaining the authors’ and reviewers’ databases. Their efforts are greatly appreciated. Also, my two sisters, Azam and Akram, provided moral support throughout my life. To this family, any expression of thanks is insufficient.

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# Guide to The Handbook of Computer Networks

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*The Handbook of Computer Networks* is a comprehensive coverage of the relatively new and very important field of computer networks and telecommunications systems. This reference work consists of three separate volumes and 202 different chapters on various aspects of this field. Each chapter in the Handbook provides a comprehensive overview of the selected topic, intended to inform a broad spectrum of readers, ranging from computer network professionals and academicians to students to the general business community.

In order that you, the reader, will derive the greatest possible benefit from *The Handbook of Computer Networks*, we have provided this Guide. It explains how the information within it can be located.

## Organization

*The Handbook of Computer Networks* is organized to provide the maximum ease of use for its readers. All of the chapters are arranged logically in these three volumes. Individual volumes could be used independently. However, the greatest benefit is derived if all three volumes are investigated.

## Table of Contents

A complete table of contents of the entire Handbook appears at the front of each volume. This list of chapter titles represents topics that have been carefully selected by the editor-in-chief, Dr. Hossein Bidgoli, and his colleagues on the Editorial Board.

## Index

A Subject Index for each individual volume is located at the end of each volume. This index is the most convenient way to locate a desired topic within the Handbook. The subjects in the index are listed alphabetically and indicate the page number where information on this topic can be found.

## Chapters

The author's name and affiliation are displayed at the beginning of the chapter. All chapters in the Handbook are organized according to a standard format as follow:

### Title and Author

### Outline

### Introduction

### Body

### Conclusion

### Glossary

### Cross References

### References

## Outline

Each chapter begins with an outline indicating the content of the chapter to come. This outline provides a brief overview of the chapter, so that the reader can get a sense of what is contained there without having to leaf through the pages. It also serves to highlight important subtopics that will be discussed within the chapter. For example, the chapter "The Internet Fundamentals" includes sections for Information Superhighway and the World Wide Web, Domain Name Systems, Navigational Tools, Search Engines, and Directories.

The Outline is intended as an overview and thus it lists only the major headings of the chapter. In addition, second-level and third-level headings will be found within the chapter.

## Introduction

The text of each chapter begins with an introductory section that defines the topic under discussion and summarizes the content of the chapter. By reading this section the readers get a general idea regarding a specific chapter.

## Body

The body of each chapter discusses the items that were listed in the outline section of each chapter.

## Conclusion

The conclusion section provides a summary of the materials discussed in a particular chapter. This section leaves the readers with the most important issues and concepts discussed in a particular chapter.

## Glossary

The glossary contains terms that are important to an understanding of the chapter and that may be unfamiliar to the reader. Each term is defined in the context of the particular chapter in which it is used. Thus, the same term may be defined in two or more chapters with the detail of the definition varying slightly from one chapter to another. The Handbook includes approximately 2700 glossary terms. For example, the chapter "The Internet Fundamentals" includes the following glossary entries:

**Extranet** A secure network that uses the Internet and Web technology to connect two or more intranets of trusted business partners, enabling business-to-business, business-to-consumer, consumer-to-consumer, and consumer-to-business communications.

**Intranet** A network within the organization that uses Web technologies (TCP/IP, HTTP, FTP, SMTP, HTML, XML, and its variations) for collecting, storing, and disseminating useful information throughout the organization.



## Cross References

All the chapters in the Handbook have cross references to other chapters. These appear at the end of the chapter, following the chapter text and preceding the References. The cross references indicate related chapters that can be consulted for further information on the same topic. The Handbook contains more than 2000 cross references in all. For example, the chapter “The Internet Fundamentals” has the following cross references:

*Electronic Commerce, Electronic Data Interchange (EDI), Electronic Payment Systems, History of the Internet, Internet2, Internet Domain Name System, Information Retrieval on the Internet.*

## References

The References appears as the last element in a chapter. It lists recent secondary sources to aid the reader in locating more detailed or technical information. Review articles and research papers that are important to an understanding of the topic are also listed. The References in this Handbook are for the benefit of the reader, to provide references for further research on the given topic. Thus, they typically consist of a dozen to two dozen entries. They are not intended to represent a complete listing of all materials consulted by the author in preparing the chapter.