国外计算机科学教材系列

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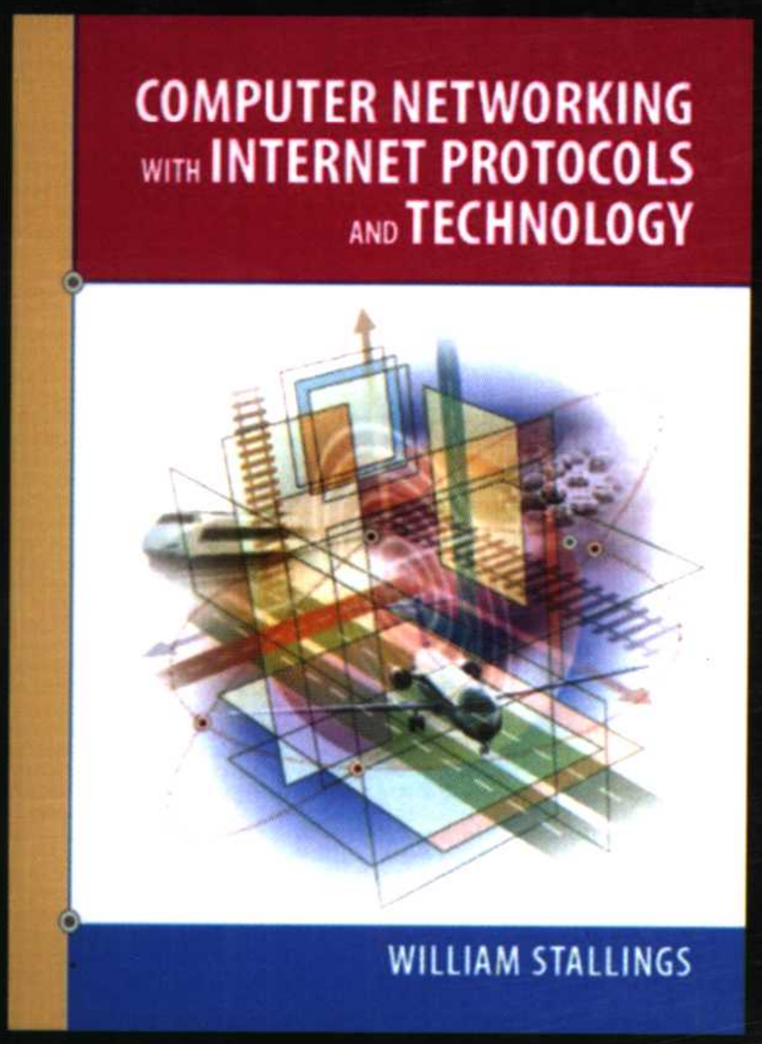
# 计算机网络
## ——互联网协议与技术

# Computer Networking with Internet Protocols and Technology




英文版

[美] William Stallings 著

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## 内 容 简 介

本书采用自顶向下的方法对计算机网络和先进的互联网技术进行了清晰而透彻的讲解。主要内容分为七部分，首先介绍计算机网络和互联网基础，包括互联网历史和现状，OSI和TCP/IP协议等；第二部分介绍互联网上的各种应用；第三部分讲述传输协议，包括TCP和UDP，也介绍了端对端性能和拥塞管理；第四部分集中讲解拥塞控制和服务质量，包括所用到的协议；第五部分讲互联网路由的主要方法；第六部分讲解支持互联网数据传输的网络和链路层的协议和技术；第七部分引入了网络安全和网络管理这两个重要话题。

本书适合作为计算机、信息管理相关专业本科高年级或研究生低年级学生的教材，也是IT相关专业技术人员的有用参考书。



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# 出 版 说 明

21世纪初的5至10年是我国国民经济和社会发展的重要时期，也是信息产业快速发展的关键时期。在我国加入WTO后的今天，培养一支适应国际化竞争的一流IT人才队伍是我国高等教育的重要任务之一。信息科学和技术方面人才的优劣与多寡，是我国面对国际竞争时成败的关键因素。

当前，正值我国高等教育特别是信息科学领域的教育调整、变革的重大时期，为使我国教育体制与国际化接轨，有条件的高等院校正在为某些信息学科和技术课程使用国外优秀教材和优秀原版教材，以使我国在计算机教学上尽快赶上国际先进水平。

电子工业出版社秉承多年来引进国外优秀图书的经验，翻译出版了“国外计算机科学教材系列”丛书，这套教材覆盖学科范围广、领域宽、层次多，既有本科专业课程教材，也有研究生课程教材，以适应不同院系、不同专业、不同层次的师生对教材的需求，广大师生可自由选择和自由组合使用。这些教材涉及的学科方向包括网络与通信、操作系统、计算机组织与结构、算法与数据结构、数据库与信息处理、编程语言、图形图像与多媒体、软件工程等。同时，我们也适当引进了一些优秀英文原版教材，本着翻译版本和英文原版并重的原则，对重点图书既提供英文原版又提供相应的翻译版本。

在图书选题上，我们大都选择国外著名出版公司出版的高校教材，如Pearson Education培生教育出版集团、麦格劳－希尔教育出版集团、麻省理工学院出版社、剑桥大学出版社等。撰写教材的许多作者都是蜚声世界的教授、学者，如道格拉斯·科默（Douglas E. Comer）、威廉·斯托林斯（William Stallings）、哈维·戴特尔（Harvey M. Deitel）、尤利斯·布莱克（Uyless Black）等。

为确保教材的选题质量和翻译质量，我们约请了清华大学、北京大学、北京航空航天大学、复旦大学、上海交通大学、南京大学、浙江大学、哈尔滨工业大学、华中科技大学、西安交通大学、国防科学技术大学、解放军理工大学等著名高校的教授和骨干教师参与了本系列教材的选题、翻译和审校工作。他们中既有讲授同类教材的骨干教师、博士，也有积累了几十年教学经验的老教授和博士生导师。

在该系列教材的选题、翻译和编辑加工过程中，为提高教材质量，我们做了大量细致的工作，包括对所选教材进行全面论证；选择编辑时力求达到专业对口；对排版、印制质量进行严格把关。对于英文教材中出现的错误，我们通过与作者联络和网上下载勘误表等方式，逐一进行了修订。

此外，我们还将与国外著名出版公司合作，提供一些教材的教学支持资料，希望能为授课老师提供帮助。今后，我们将继续加强与各高校教师的密切联系，为广大师生引进更多的国外优秀教材和参考书，为我国计算机科学教学体系与国际教学体系的接轨做出努力。

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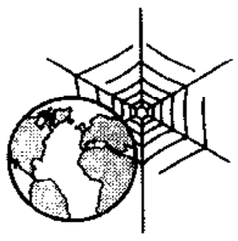
*For my loving wife*
*A*



# WEB SITE FOR COMPUTER NETWORKING WITH INTERNET PROTOCOLS AND TECHNOLOGY

The Web site at WilliamStallings.com/CNIP/CNIP1e.html provides support for instructors and students using the book. It includes the following elements.


**Course Support Materials**

The course support materials include

- Copies of figures from the book in PDF format
- Copies of tables from the book in PDF format
- A set of PowerPoint slides for use as lecture aids
- Computer Science Student Support Site: contains a number of links and documents that the student may find useful in his/her ongoing computer science education. The site includes a review of basic, relevant mathematics; advice on research, writing, and doing homework problems; links to computer science research resources, such as report repositories and bibliographies; and other useful links.
- An errata sheet for the book, updated at most monthly

**CNIP Courses**

The CNIP1e Web site includes links to Web sites for courses taught using the book. These sites can provide useful ideas about scheduling and topic ordering, as well as a number of useful handouts and other materials.

**Useful Web Sites**

The CNIP1e Web site includes links to relevant Web sites, organized by chapter. The links cover a broad spectrum of topics and will enable students to explore timely issues in greater depth.

**Supplemental Documents**

The CNIP1e Web site includes a number of documents that expand on the treatment in the book. Topics include standards organizations, Sockets, TCP/IP checksum, URL/URI, BNF, and ASCII.

**Internet Mailing List**

An Internet mailing list is maintained so that instructors using this book can exchange information, suggestions, and questions with each other and the author. Subscription information is provided at the book's Web site.

**Simulation and Modeling Tools**

The Web site includes links to the *cnet* Web site and the *modeling tools* Web site. These packages can be used to analyze and experiment with protocol and network design issues. Each site includes downloadable software and background information. The instructor's manual includes more information on loading and using the software and suggested student projects. See Appendix B for more information.

# PREFACE

*This book does not pretend to be a comprehensive record; but it aims at helping to disentangle from an immense mass of material the crucial issues and cardinal decisions. Throughout I have set myself to explain faithfully and to the best of my ability.*

—*The World Crisis*, Winston Churchill

## BACKGROUND

Data network communication and distributed applications rely on underlying communications software that is independent of applications and relieves the application of much of the burden of reliably exchanging data. This communications software is organized into a protocol architecture, the most important incarnation of which is the TCP/IP protocol suite. The TCP/IP protocol suite is now dominant, in terms of products, deployment in data networks, and ongoing computer network research. The most prominent incarnation of this suite is in the Internet and its millions of attached computers.

## OBJECTIVES

The objective of this book is to provide an up-to-date survey of developments in the areas of computer networks and Internet-based protocols and algorithms. Central problems that confront the network designer are the need to support multimedia and real-time traffic, the need to control congestion, and the need to provide different levels of quality of service (QoS) to different applications.

The following basic themes serve to unify the discussion:

- **Principles:** Although the scope of this book is broad, there are a number of basic principles that appear repeatedly as themes and that unify this field. Examples are multiplexing, flow control, and error control. The book highlights these principles and contrasts their application in specific areas of technology.
- **Design approaches:** The book examines alternative approaches to meeting specific communication requirements.
- **Standards:** Standards have come to assume an increasingly important, indeed dominant, role in this field. An understanding of the current status and future direction of technology requires a comprehensive discussion of the related standards.

## INTENDED AUDIENCE

This book is intended for both a professional and an academic audience. For the professional interested in this field, the book serves as a basic reference volume and is suitable for self study.

As a textbook, it is suitable for an advanced undergraduate or graduate course. The book treats a number of advanced topics and provides a brief survey of the required elementary topics. After Part One, the parts are relatively independent. Fewer parts could be covered for a shorter course, and the parts can be covered in any order.

## PLAN OF THE BOOK

The book is divided into seven parts:

- Overview
- Internet Applications
- Transport Protocols
- Quality of Service in IP Networks
- Internet Routing
- Network and Link Layers
- Management Topics

In addition, the book includes an extensive glossary, a list of frequently used acronyms, and a bibliography. Each chapter includes a list of key words, review questions, problems, suggestions for further reading, and pointers to relevant Web sites.

The book is intended for both an academic and a professional audience. For the professional interested in this field, the book serves as a basic reference volume and is suitable for self-study. As a textbook, it can be used for a one-semester or two-semester course. It covers the material in the Communication and Networking core course of the joint ACM/IEEE Computing Curricula 2001. The chapters and parts of the book are sufficiently modular to provide a great deal of flexibility in the design of courses.

## TOP-DOWN AND BOTTOM-UP APPROACHES

The book is laid out to present the material in a top-down fashion. This has the advantage of immediately focusing on the most visible part of the material, the applications, and then seeing, progressively, how each layer is supported by the next layer down. This approach makes the most sense for many instructors and students. The application layer is the most visible layer to the student and typically provides the most interest. An understanding of the applications motivates the mechanisms found at the transport layer. The treatment of the application and transport layers enables the student to understand the many design issues at the internet layer, including quality of service and routing issues. Finally, computer networks and data link mechanisms can be treated.

Some readers, and some instructors, are more comfortable with a bottom-up approach. With this approach, each part builds on the material in the previous part, so that it is always clear how a given layer of functionality is supported from below. Accordingly, the book is organized in a modular fashion. After reading Part One, the other parts can be read in a number of possible sequences. See Chapter 0 for a description of each part and for a discussion of the order in which the book can be taught.

## INTERNET SERVICES FOR INSTRUCTORS AND STUDENTS

There is a Web site for this book that provides support for students and instructors. The page includes links to relevant sites, transparency masters of figures and tables in the book in PDF (Adobe Acrobat) format, PowerPoint slides, and sign-up information for the book's Internet

mailing list. The Web page is at WilliamStallings.com/CNIP/CNIP1e.html; see the section, "Web Site for Computer Networking with Internet Protocols and Technology," following this Preface, for more information. An Internet mailing list has been set up so that instructors using this book can exchange information, suggestions, and questions with each other and with the author. As soon as typos or other errors are discovered, an errata list for this book will be available at WilliamStallings.com. Finally, I maintain the Computer Science Student Resource Site at WilliamStallings.com/StudentSupport.html.

## PROJECTS FOR TEACHING COMPUTER NETWORKING

For many instructors, an important component of a computer networks/Internet protocol course is a project or set of projects by which the student gets hands-on experience to reinforce concepts from the text. This book provides an unparalleled degree of support for including a projects component in the course. The instructor's manual not only includes guidance on how to assign and structure the projects, but also includes a set of suggested projects that covers a broad range of topics from the text, including:

- **Sockets programming projects:** The manual includes series of assignments that instruct the student to research a particular topic on the Web or in the literature, and write a report.
- **Simulation projects:** The manual provides support for the use of the *cnet* simulation package: The *cnet* network simulator enables experimentation with various data link layer, network layer, routing and transport layer protocols, and with various network configurations.
- **Performance modeling projects:** An alternative to simulation for assessing the performance of a communications system or networking protocol is analytic modeling. The *tools* package of software serves as the basis for developing such projects.
- **Research projects:** The manual includes series of assignments that instruct the student to research a particular topic on the Web or in the literature, and write a report.
- **Reading/report assignments:** The manual includes a list of papers in the literature, one or more for each chapter, that can be assigned for the student to read and then write a short report.

See Appendix B for details.

## ACKNOWLEDGMENTS

This book has benefited from review by a number of people, who gave generously of their time and expertise. The following people reviewed the original manuscript proposal and made numerous detailed suggestions: Paul Tymann (Rochester Institute of Technology), William Perrizo (North Dakota State), and Kenneth Weber (Mount Union College). The following people reviewed portions of the material in the book: Michael J. Donahoo (Baylor University), Gary Harkin (Montana State University), Larry Owens (California State U. Fresno), S. Hossein Hosseini (U. of Wisconsin—Milwaukee), and Dr. Charles Baker (Southern Methodist University).

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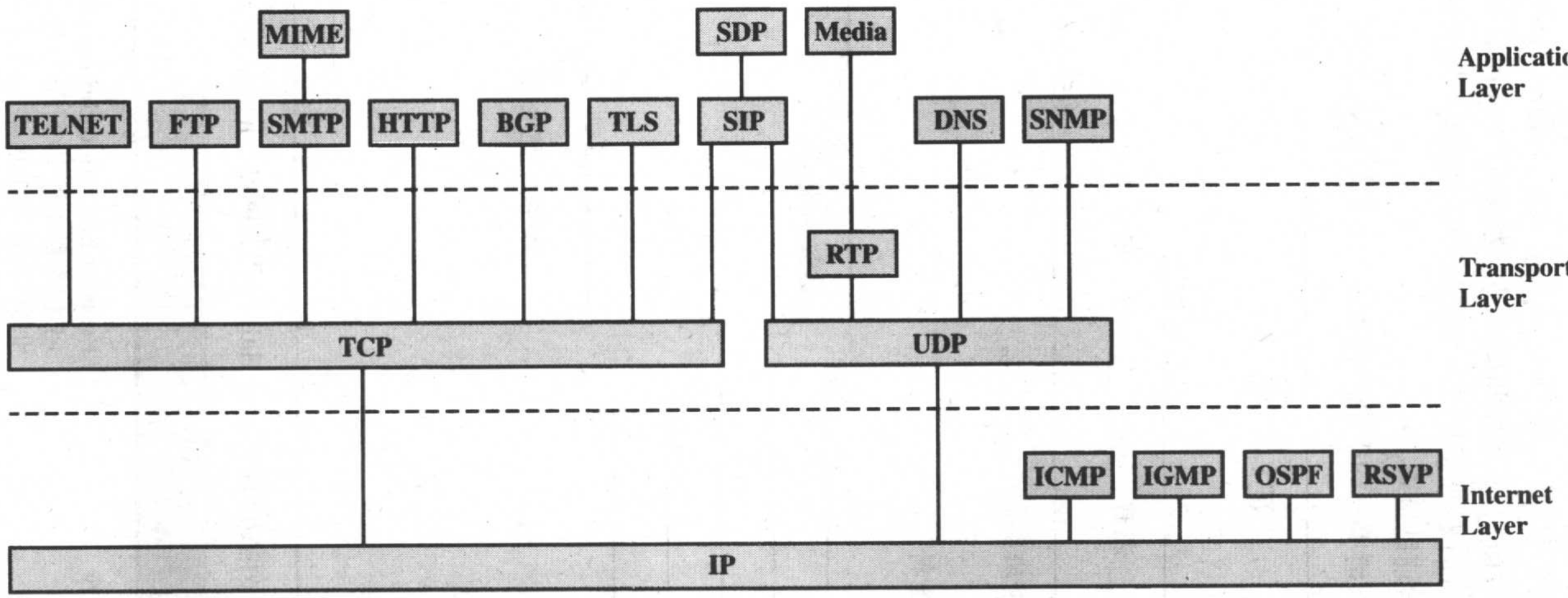


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|---|---|---|---|---|---|
| BGP | = | Border Gateway Protocol | RSVP | = | Resource ReSerVation Protocol |
| DNS | = | Domain Name System | RTP | = | Real-Time Transport Protocol |
| FTP | = | File Transfer Protocol | SDP | = | Session Description Protocol |
| HTTP | = | Hypertext Transfer Protocol | SIP | = | Session Initiation Protocol |
| ICMP | = | Internet Control Message Protocol | SMTP | = | Simple Mail Transfer Protocol |
| IGMP | = | Internet Group Management Protocol | SNMP | = | Simple Network Management Protocol |
| IP | = | Internet Protocol | TCP | = | Transmission Control Protocol |
| MIME | = | Multi-Purpose Internet Mail Extension | TLS | = | Transport Layer Security |
| OSPF | = | Open Shortest Path First | UDP | = | User Datagram Protocol |

**Some Protocols in the TCP/IP Protocol Suite**

# CONTENTS

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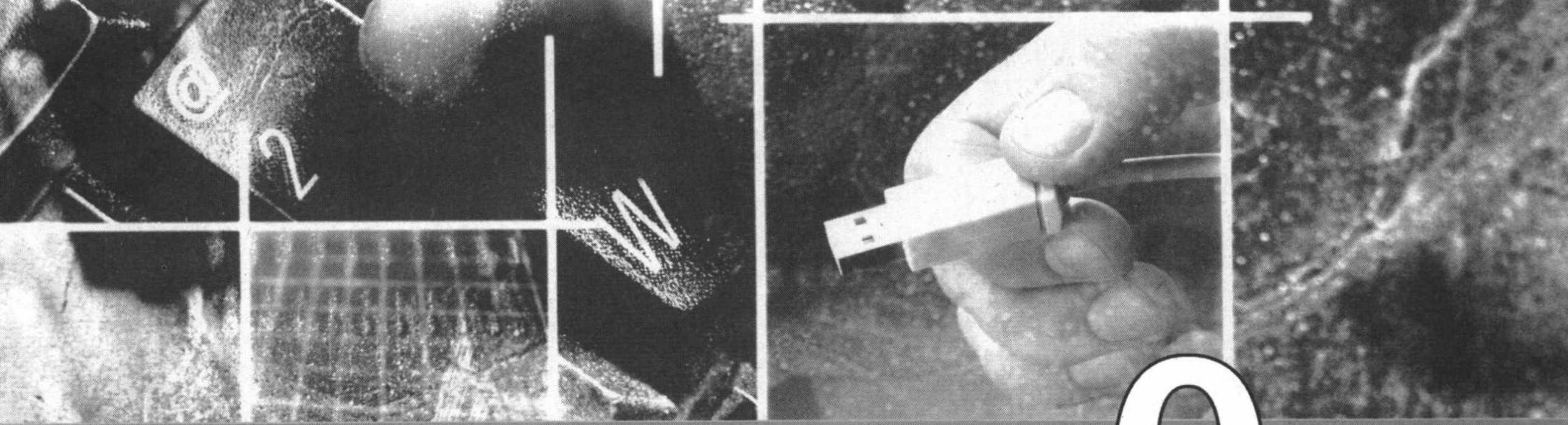

CHAPTER 0

# READER'S GUIDE