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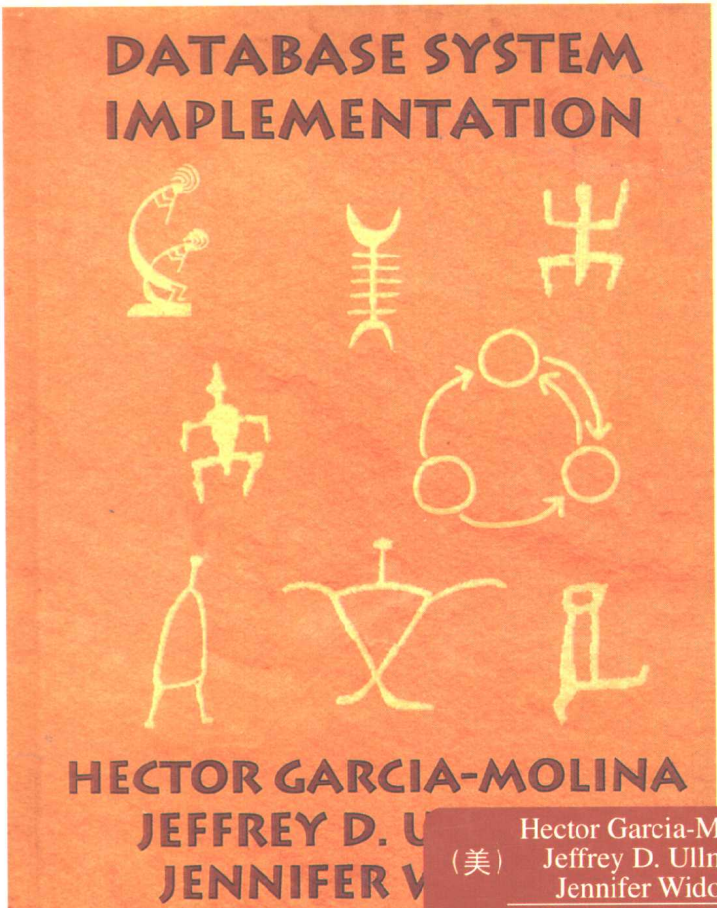
数据库系统实现

（英文版）



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China Machine Press

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Database System Implementation

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出版者的话

文艺复兴以降，源远流长的科学精神和逐步形成的学术规范，使西方国家在自然科学的各个领域取得了垄断性的优势；也正是这样的传统，使美国在信息技术发展的六十多年间名家辈出、独领风骚。在商业化的进程中，美国的产业界与教育界越来越紧密地结合，计算机学科中的许多泰山北斗同时身处科研和教学的最前线，由此而产生的经典科学著作，不仅擘划了研究的范畴，还揭橥了学术的源变，既遵循学术规范，又自有学者个性，其价值并不会因年月的流逝而减退。

近年，在全球信息化大潮的推动下，我国的计算机产业发展迅猛，对专业人才的需求日益迫切。这对计算机教育界和出版界都既是机遇，也是挑战；而专业教材的建设在教育战略上显得举足轻重。在我国信息技术发展时间较短、从业人员较少的现状下，美国等发达国家在其计算机科学发展的几十年间积淀的经典教材仍有许多值得借鉴之处。因此，引进一批国外优秀计算机教材将对我国计算机教育事业的发展起积极的推动作用，也是与世界接轨、建设真正的世界一流大学的必由之路。

机械工业出版社华章图文信息有限公司较早意识到“出版要为教育服务”。自1998年始，华章公司就将工作重点放在了遴选、移译国外优秀教材上。经过几年的不懈努力，我们与Prentice Hall，Addison-Wesley，McGraw-Hill，Morgan Kaufmann等世界著名出版公司建立了良好的合作关系，从它们现有的数百种教材中甄选出Tanenbaum，Stroustrup，Kernighan，Jim Gray等大师名家的一批经典作品，以“计算机科学丛书”为总称出版，供读者学习、研究及庋藏。大理石纹理的封面，也正体现了这套丛书的品位和格调。

“计算机科学丛书”的出版工作得到了国内外学者的鼎力襄助，国内的专家不仅提供了中肯的选题指导，还不辞劳苦地担任了翻译和审校的工作；而原书的作者也相当关注其作品在中国的传播，有的还专诚为其书的中译本作序。迄今，“计算机科学丛书”已经出版了近百个品种，这些书籍在读者中树立了良好的口碑，并被许多高校采用为正式教材和参考书籍，为进一步推广与发展打下了坚实的基础。

随着学科建设的初步完善和教材改革的逐渐深化，教育界对国外计算机教材的需求和应用都步入一个新的阶段。为此，华章公司将加大引进教材的力度，在“华章教育”的总规划之下出版三个系列的计算机教材：针对本科生的核心课程，剔抉外版菁华而成“国外经典教材”系列；对影印版的教材，则单独开辟出“经典原版书库”；定位在高级教程和专业参考的“计算机科学丛书”还将保持原来的风格，继续出版新的品种。为了保证这三套丛书的权威性，同时也为了更好地为学校和老师们服务，华章公司聘请了中国科学院、北京大学、清华大学、国防科技大学、复旦大学、上海交通大学、南京大学、浙江大学、中国科技大学、哈尔滨工业大学、西安交通大学、中国人民大学、北京航空航天大学、北京邮电大学、中山大学、解放军理工大学、郑州大学、湖北工学院、中国国家信息安全测评认证中心等国内重点大学和科研机构在计算机的各个领域的著名学者组成“专家指导委员会”，为我们提供选题意见和出版监督。

“经典原版书库”是响应教育部提出的使用原版国外教材的号召，为国内高校的计算机教学度身订造的。在广泛地征求并听取丛书的“专家指导委员会”的意见后，我们最终选定了这30多种篇幅内容适度、讲解鞭辟入里的教材，其中的大部分已经被M.I.T.、Stanford、U.C. Berkley、C.M.U.等世界名牌大学采用。丛书不仅涵盖了程序设计、数据结构、操作系统、计算机体系结构、数据库、编译原理、软件工程、图形学、通信与网络、离散数学等国内大学计算机专业普遍开设的核心课程，而且各具特色——有的出自语言设计者之手、有的历三十年而不衰、有的已被全世界的几百所高校采用。在这些圆熟通博的名师大作的指引之下，读者必将在计算机科学的宫殿中由登堂而入室。

权威的作者、经典的教材、一流的译者、严格的审校、精细的编辑，这些因素使我们的图书有了质量的保证，但我们的目标是尽善尽美，而反馈的意见正是我们达到这一终极目标的重要帮助。教材的出版只是我们的后续服务的起点。华章公司欢迎老师和读者对我们的工作提出建议或给予指正，我们的联系方法如下：

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Hector Garcia-Molina is the Leonard Bosack and Sandra Lerner Professor in the Computer Science and Electrical Engineering Departments at Stanford University. He has published extensively in the fields of database systems, distributed systems, and digital libraries. His research interests also include distributed computing systems, database systems, and digital libraries.

Jeffrey D. Ullman is the Stanford W. Ascherman Professor of Computer Science at Stanford University. He is the author or co-author of 15 books and 170 technical publications, including *A First Course in Database Systems* (Prentice Hall 1997) and *Elements of ML Programming* (Prentice Hall 1998). His research interests include database theory, database integration, data mining, and education using the information infrastructure. He has received numerous awards such as the Guggenheim Fellowship and election to the National Academy of Engineering. He also received the 1996 Sigmod Contribution Award and the 1998 Karl V. Karstrom Outstanding Educator Award.

Jennifer Widom is an Associate Professor in the Computer Science and Electrical Engineering Departments at Stanford University. She has served on numerous editorial boards and program committees, she has published widely in computer science conferences and journals, and is co-author of *A First Course in Database Systems* (Prentice Hall 1997). Her research interests include database systems for semistructured data and XML, data warehousing, and active database systems.

Preface

This book was designed for CS245, the second course in the database sequence at Stanford. Here, the first database course, CS145, covers database design and programming, for which the book *A First Course in Database Systems* by Jeff Ullman and Jennifer Widom, Prentice-Hall, 1997, was written. The CS245 course then covers implementation of a DBMS, notably storage structures, query processing, and transaction management.

Use of the Book

We're on a quarter system at Stanford, so the principal course using this book — CS245 — is only ten weeks long. In the Winter of 1999, Hector Garcia-Molina used a "beta" version of this book, and covered the following parts: Sections 2.1–2.4, all of Chapters 3 and 4, Sections 5.1 and 5.2, Sections 6.1–6.7, Sections 7.1–7.4, all of Chapter 8, Chapter 9 except for Section 9.8, Sections 10.1–10.3, Section 11.1, and Section 11.5.

The balance of Chapters 6 and 7 (query optimization) is covered in an advanced course, CS346, where students implement their own DBMS. Other portions of the book that are not covered in CS245 may appear in another advanced course, CS347, which talks about distributed databases and advanced transaction processing.

Schools that are on the semester system have the opportunity to combine the use of this book with its predecessor: *A First Course in Database Systems*. We recommend using that book in the first semester, coupled with a database-application programming project. The second semester could cover most or all of the content of this book. An advantage to splitting the study of databases into two courses is that students not planning to specialize in DBMS construction can take only the first course and be able to use databases in whatever branch of Computer Science they enter.

Prerequisites

The course on which the book is based is rarely taken before the senior year, so we expect the reader to have a fairly broad background in the traditional areas

of Computer Science. We assume that the reader has learned something about database programming, especially SQL. It is helpful to know about relational algebra and to have some familiarity with basic data structures. Likewise, some knowledge of file systems and operating systems is useful.

Exercises

The book contains extensive exercises, with some for almost every section. We indicate harder exercises or parts of exercises with an exclamation point. The hardest exercises have a double exclamation point.

Some of the exercises or parts are marked with a star. For these exercises, we shall endeavor to maintain solutions accessible through the book's Web page. These solutions are publicly available and should be used for self-testing. Note that in a few cases, one exercise B asks for modification or adaptation of your solution to another exercise A. If certain parts of A have Web-published solutions, then you should expect the corresponding parts of B to have solutions as well.

Support on the World-Wide Web

The book's home page is

`http://www-db.stanford.edu/~ullman/dbsi.html`

Here you will find solutions to starred exercises, errata as we learn of them, and backup materials. We hope to make available the notes for each offering of CS245 and relevant portions of other database courses, as we teach them, including homeworks, exams, and solutions.

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