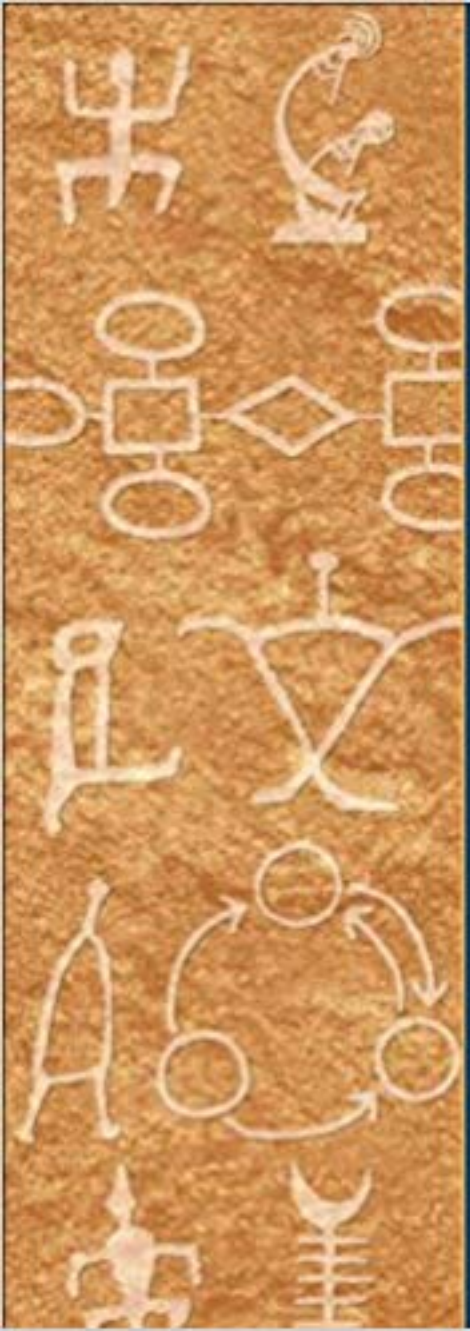

DATABASE SYSTEMS

THE COMPLETE BOOK

SECOND EDITION

Hector Garcia-Molina
Jeffrey D. Ullman
Jennifer Widom

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The Complete Book

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Second Edition

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Preface

This book covers the core of the material taught in the database sequence at Stanford. The introductory course, CS145, uses the first twelve chapters, and is designed for all students — those who want to use database systems as well as those who want to get involved in database implementation. The second course, CS245 on database implementation, covers most of the rest of the book. However, some material is covered in more detail in special topics courses. These include CS346 (implementation project), which concentrates on query optimization as in Chapters 15 and 16. Also, CS345A, on data mining and Web mining, covers the material in the last two chapters.

What's New in the Second Edition

After a brief introduction in Chapter 1, we cover relational modeling in Chapters 2–4. Chapter 4 is devoted to high-level modeling. There, in addition to the E/R model, we now cover UML (Unified Modeling Language). We also have moved to Chapter 4 a shorter version of the material on ODL, treating it as a design language for relational database schemas.

The material on functional and multivalued dependencies has been modified and remains in Chapter 3. We have changed our viewpoint, so that a functional dependency is assumed to have a set of attributes on the right. We have also given explicitly certain algorithms, including the "chase," that allow us to manipulate dependencies. We have augmented our discussion of third normal form to include the 3NF synthesis algorithm and to make clear what the tradeoff between 3NF and BCNF is.

Chapter 5 contains the coverage of relational algebra from the previous edition, and is joined by (part of) the treatment of Datalog from the old Chapter 10. The discussion of recursion in Datalog is either moved to the book's Web site or combined with the treatment of recursive SQL in Chapter 10 of this edition.

Chapters 6–10 are devoted to aspects of SQL programming, and they represent a reorganization and augmentation of the earlier book's Chapters 6, 7, 8, and parts of 10. The material on views and indexes has been moved to its own chapter, number 8, and this material has been augmented with a discussion of

important new topics, including materialized views, and automatic selection of indexes.

The new Chapter 9 is based on the old Chapter 8 (embedded SQL). It is introduced by a new section on 3-tier architecture. It also includes an expanded discussion of JDBC and new coverage of PHP.

Chapter 10 collects a number of advanced SQL topics. The discussion of authorization from the old Chapter 8 has been moved here, as has the discussion of recursive SQL from the old Chapter 10. Data cubes, from the old Chapter 20, are now covered here. The rest of the chapter is devoted to the nested-relation model (from the old Chapter 4) and object-relational features of SQL (from the old Chapter 9).

Then, Chapters 11 and 12 cover XML and systems based on XML. Except for material at the end of the old Chapter 4, which has been moved to Chapter 11, this material is all new. Chapter 11 covers modeling; it includes expanded coverage of DTD's, along with new material on XML Schema. Chapter 12 is devoted to programming, and it includes sections on XPath, XQuery, and XSLT.

Chapter 13 begins the study of database implementation. It covers disk storage and the file structures that are built on disks. This chapter is a condensation of material that, in the first edition, occupied Chapters 11 and 12.

Chapter 14 covers index structures, including B-trees, hashing, and structures for multidimensional indexes. This material also condenses two chapters, 13 and 14, from the first edition.

Chapters 15 and 16 cover query execution and query optimization, respectively. They are similar to the old chapters of the same numbers. Chapter 17 covers logging, and Chapter 18 covers concurrency control; these chapters are also similar to the old chapters with the same numbers. Chapter 19 contains additional topics on concurrency: recovery, deadlocks, and long transactions. This material is a subset of the old Chapter 19.

Chapter 20 is on parallel and distributed databases. In addition to material on parallel query execution from the old Chapter 15 and material on distributed locking and commitment from the old Chapter 19, there are several new sections on distributed query execution: the map-reduce framework for parallel computation, peer-to-peer databases and their implementation of distributed hash tables.

Chapter 21 covers information integration. In addition to material on this subject from the old Chapter 20, we have added a section on local-as-view mediators and a section on entity resolution (finding records from several databases that refer to the same entity, e.g., a person).

Chapter 22 is on data mining. Although there was some material on the subject in the old Chapter 20, almost all of this chapter is new. It covers association rules and frequent itemset mining, including both the famous A-Priori Algorithm and certain efficiency improvements. Chapter 22 includes the key techniques of shingling, minhashing, and locality-sensitive hashing for finding similar items in massive databases, e.g., Web pages that quote substantially

from other Web pages. The chapter concludes with a study of clustering, especially for massive datasets.

Chapter 23, all new, addresses two important ways in which the Internet has impacted database technology. First is search engines, where we discuss algorithms for crawling the Web, the well-known PageRank algorithm for evaluating the importance of Web pages, and its extensions. This chapter also covers data-stream-management systems. We discuss the stream data model and SQL language extensions, and conclude with several interesting algorithms for executing queries on streams.

Prerequisites

We have used the book at the "mezzanine" level, in a sequence of courses taken both by undergraduates and by beginning graduate students. The formal prerequisites for the course are Sophomore-level treatments of:

1. Data structures, algorithms, and discrete math, and
2. Software systems, software engineering, and programming languages.

Of this material, it is important that students have at least a rudimentary understanding of such topics as: algebraic expressions and laws, logic, basic data structures, object-oriented programming concepts, and programming environments. However, we believe that adequate background is acquired by the Junior year of a typical computer science program.

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.

Support on the World Wide Web

The book's home page is

`http://infolab.stanford.edu/~ullman/dscb.html`

You will find errata as we learn of them, and backup materials, including homeworks, projects, and exams. We shall also make available there the sections from the first edition that have been removed from the second.

In addition, there is an accompanying set of on-line homeworks and programming labs using a technology developed by Gradiance Corp. See the section following the Preface for details about the GOAL system. GOAL service

can be purchased at `http://www.prenhall.com/goal`. Instructors who want to use the system in their classes should contact their Prentice-Hall representative or request instructor authorization through the above Web site.

There is a solutions manual for instructors available at

`http://www.prenhall.com/ullman`

This page also gives you access to GOAL and all book materials.

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The remaining errors are ours, of course.

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