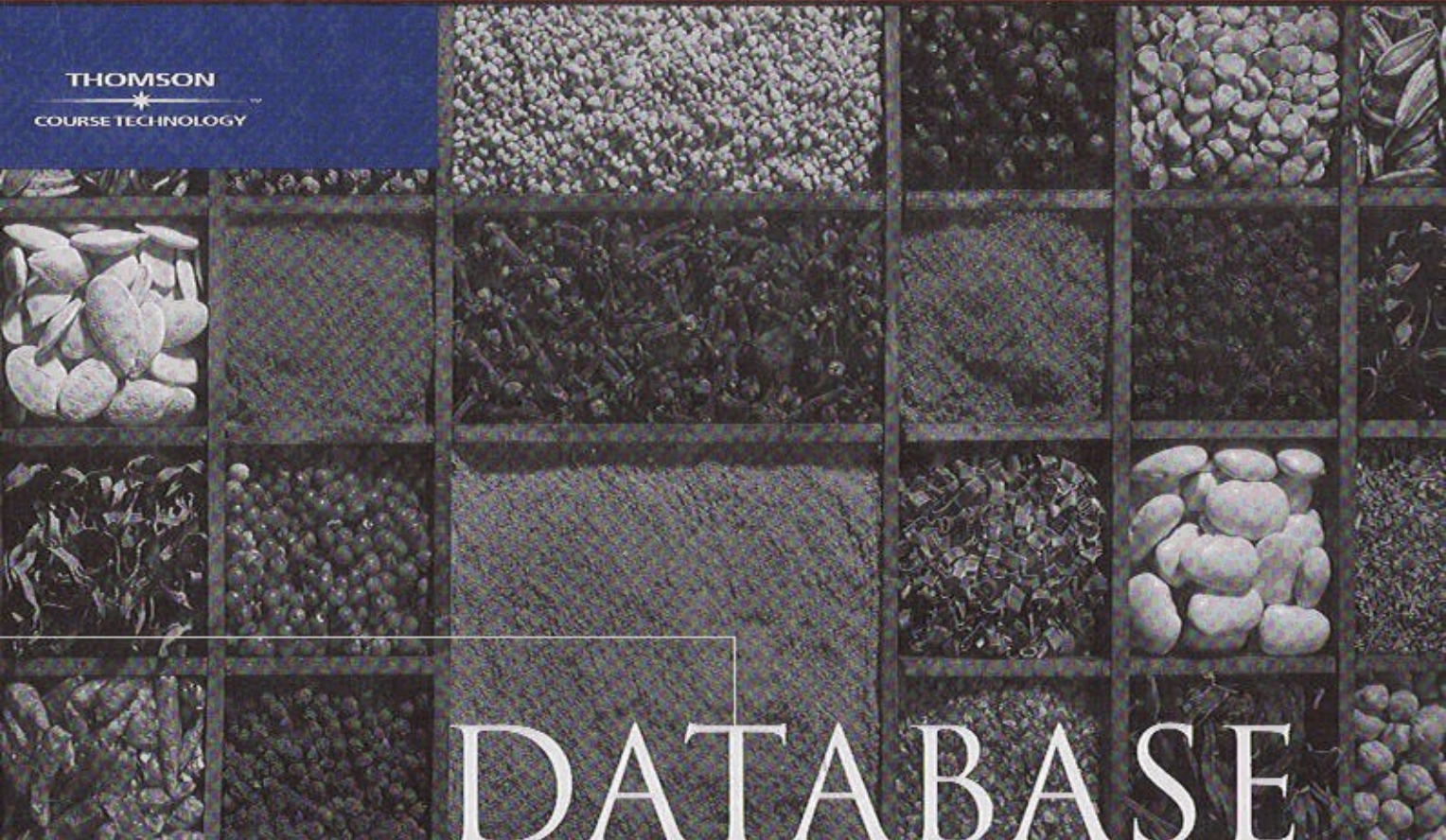


International Student Edition Not for sale in the U.S.

THOMSON
COURSE TECHNOLOGY



DATABASE SYSTEMS

DESIGN, IMPLEMENTATION, AND MANAGEMENT

SEVENTH EDITION

PETER ROB • CARLOS CORONEL

* Includes access code to Web site

PART I DATABASE CONCEPTS

Business Vignette: The Relational Revolution	3
CHAPTER 1 DATABASE SYSTEMS	4
1.1 Data vs. Information	5
1.2 Introducing the Database and the DBMS	6
1.2.1 Role and Advantages of the DBMS	7
1.2.2 Types of Databases	8
1.3 Why Database Design Is Important	9
1.4 Historical Roots: Files and File Systems	10
1.5 Problems with File System Data Management	13
1.5.1 Structural and Data Dependence	15
1.5.2 Field Definitions and Naming Conventions	15
1.5.3 Data Redundancy	16
1.6 Database Systems	17
1.6.1 The Database System Environment	18
1.6.2 DBMS Functions	20
1.6.3 Managing the Database System: A Shift in Focus	23
Summary	24
Key Terms	24
Review Questions	25
Problems	25
 CHAPTER 2 DATA MODELS	 28
2.1 The Importance of Data Models	29
2.2 Data Model Basic Building Blocks	30
2.3 Business Rules	31
2.3.1 Discovering Business Rules	31
2.3.2 Translating Business Rules into Data Model Components	32
2.4 The Evolution of Data Models	32
2.4.1 The Hierarchical Model	33
2.4.2 The Network Model	34
2.4.3 The Relational Model	36
2.4.4 The Entity Relationship Model	38
2.4.5 The Object-Oriented (OO) Model	41
2.4.6 Other Models	43
2.4.7 Database Models and the Internet	43
2.4.8 Data Models: A Summary	43
2.5 Degrees of Data Abstraction	46
2.5.1 The External Model	46
2.5.2 The Conceptual Model	48
2.5.3 The Internal Model	48
2.5.4 The Physical Model	49
Summary	51
Key Terms	51
Review Questions	52
Problems	53

TABLE OF CONTENTS

PART II DESIGN CONCEPTS

Business Vignette: Database Modeling Feeding Children	59
CHAPTER 3 THE RELATIONAL DATABASE MODEL	60
3.1 A Logical View of Data	61
3.1.1 Tables and Their Characteristics	61
3.2 Keys	64
3.3 Integrity Rules	69
3.4 Relational Set Operators	70
3.5 The Data Dictionary and the System Catalog	76
3.6 Relationships Within the Relational Database	78
3.6.1 The 1:M Relationship	78
3.6.2 The 1:1 Relationship	80
3.6.3 The M:N Relationship	81
3.7 Data Redundancy Revisited	86
3.8 Indexes	88
3.9 Codd's Relational Database Rules	89
Summary	91
Key Terms	91
Review Questions	92
Problems	94
CHAPTER 4 ENTITY RELATIONSHIP (ER) MODELING	102
4.1 The Entity Relationship (ER) Model	103
4.1.1 Entities	103
4.1.2 Attributes	103
4.1.3 Relationships	109
4.1.4 Connectivity and Cardinality	109
4.1.5 Existence Dependence	110
4.1.6 Relationship Strength	111
4.1.7 Weak Entities	114
4.1.8 Relationship Participation	116
4.1.9 Relationship Degree	118
4.1.10 Recursive Relationships	120
4.1.11 Composite Entities	122
4.2 Developing an ER Diagram	124
4.3 Database Design Challenges: Conflicting Goals	131
Summary	134
Key Terms	134
Review Questions	135
Problems	136

TABLE OF CONTENTS

CHAPTER 5	NORMALIZATION OF DATABASE TABLES	147
5.1	Database Tables and Normalization	148
5.2	The Need for Normalization	148
5.3	The Normalization Process	151
5.3.1	Conversion to First Normal Form	152
5.3.2	Conversion to Second Normal Form	155
5.3.3	Conversion to Third Normal Form	157
5.4	Improving the Design	158
5.5	Surrogate Key Considerations	162
5.6	Higher-Level Normal Forms	163
5.6.1	The Boyce-Codd Normal Form (BCNF)	164
5.6.2	Fourth Normal Form (4NF)	166
5.7	Normalization and Database Design	168
5.8	Denormalization	172
	Summary	173
	Key Terms	175
	Review Questions	175
	Problems	176
CHAPTER 6	ADVANCED DATA MODELING	183
6.1	The Extended Entity Relationship Model	184
6.1.1	Entity Supertypes and Subtypes	184
6.1.2	Specialization Hierarchy	185
6.1.3	Inheritance	186
6.1.4	Subtype Discriminator	187
6.1.5	Disjoint and Overlapping Constraints	187
6.1.6	Completeness Constraint	189
6.1.7	Specialization and Generalization	189
6.2	Entity Clustering	190
6.3	Entity Integrity: Selecting Primary Keys	191
6.3.1	Natural Keys and Primary Keys	192
6.3.2	Primary Key Guidelines	192
6.3.3	When to Use Composite Primary Keys	193
6.3.4	When to Use Surrogate Primary Keys	194
6.4	Design Cases: Learning Flexible Database Design	196
6.4.1	Design Case #1: Implementing 1:1 Relationships	196
6.4.2	Design Case #2: Maintaining History of Time-Variant Data	197
6.4.3	Design Case #3: Fan Traps	199
6.4.4	Design Case #4: Redundant Relationships	200
6.5	Data Modeling Checklist	201
	Summary	203
	Key Terms	203
	Review Questions	204
	Problems	204

TABLE OF CONTENTS

PART III ADVANCED DESIGN AND IMPLEMENTATION

Business Vignette: Database Systems Managing Nuclear Waste	213
CHAPTER 7 INTRODUCTION TO STRUCTURED QUERY LANGUAGE (SQL)	214
7.1 Introduction to SQL	215
7.2 Data Definition Commands	216
7.2.1 The Database Model	217
7.2.2 Creating the Database	219
7.2.3 The Database Schema	219
7.2.4 Data Types	220
7.2.5 Creating Table Structures	222
7.2.6 SQL Constraints	225
7.2.7 SQL Indexes	229
7.3 Data Manipulation Commands	230
7.3.1 Adding Table Rows	230
7.3.2 Saving Table Changes	232
7.3.3 Listing Table Rows	232
7.3.4 Updating Table Rows	234
7.3.5 Restoring Table Contents	234
7.3.6 Deleting Table Rows	235
7.3.7 Inserting Table Rows with a Select Subquery	235
7.4 Select Queries	237
7.4.1 Selecting Rows with Conditional Restrictions	237
7.4.2 Arithmetic Operators: The Rule of Precedence	241
7.4.3 Logical Operators: And, Or, and Not	241
7.4.4 Special Operators	243
7.5 Advanced Data Definition Commands	247
7.5.1 Changing a Column's Data Type	247
7.5.2 Changing a Column's Data Characteristics	247
7.5.3 Adding a Column	248
7.5.4 Dropping a Column	248
7.5.5 Advanced Data Updates	249
7.5.6 Copying Parts of Tables	250
7.5.7 Adding Primary and Foreign Key Designations	252
7.5.8 Deleting a table from the Database	253
7.6 Advanced Select Queries	253
7.6.1 Ordering a Listing	253
7.6.2 Listing Unique Values	255
7.6.3 Aggregate Functions	255
7.6.4 Grouping Data	260
7.7 Virtual Tables: Creating a View	262
7.8 Joining Database Tables	264
7.8.1 Joining Tables with an Alias	266
7.8.2 Recursive Joins	266
7.8.3 Outer joins	267
Summary	269
Key Terms	270
Review Questions	270
Problems	274

TABLE OF CONTENTS

CHAPTER 8 ADVANCED SQL	285
8.1 Relational Set Operators	286
8.1.1 UNION	286
8.1.2 UNION ALL	288
8.1.3 INTERSECT	288
8.1.4 MINUS	289
8.1.5 Syntax Alternatives	290
8.2 SQL Join Operators	293
8.2.1 Cross Join	294
8.2.2 Natural Join	295
8.2.3 Join USING Clause	296
8.2.4 JOIN ON Clause	297
8.2.5 Outer Joins	298
8.3 Subqueries and Correlated Queries	300
8.3.1 WHERE Subqueries	302
8.3.2 IN Subqueries	303
8.3.3 HAVING Subqueries	304
8.3.4 Multirow Subquery Operators: ANY and ALL	305
8.3.5 FROM Subqueries	306
8.3.6 Attribute List Subqueries	307
8.3.7 Correlated Subqueries	309
8.4 SQL Functions	312
8.4.1 Date and Time Functions	312
8.4.2 Numeric Functions	314
8.4.3 String Functions	315
8.4.4 Conversion Functions	316
8.5 Oracle Sequences	318
8.6 Updatable Views	321
8.7 Procedural SQL	324
8.7.1 Triggers	328
8.7.2 Stored Procedures	338
8.7.3 PL/SQL Processing with Cursors	344
8.7.4 PL/SQL Stored Functions	346
8.8 Embedded SQL	347
Summary	352
Key Terms	353
Review Questions	353
Problems	354
 CHAPTER 9 DATABASE DESIGN	 359
9.1 The Information System	360
9.2 The Systems Development Life Cycle (SDLC)	361
9.2.1 Planning	362
9.2.2 Analysis	363
9.2.3 Detailed Systems Design	363
9.2.4 Implementation	363
9.2.5 Maintenance	364

TABLE OF CONTENTS

9.3 The Database Life Cycle (DBLC)	364
9.3.1 The Database Initial Study	365
9.3.2 Database Design	369
9.3.3 Implementation and Loading	382
9.3.4 Testing and Evaluation	385
9.3.5 Operation	386
9.3.6 Maintenance and Evolution	386
9.4 Database Design Strategies	387
9.5 Centralized vs. Decentralized Design	388
Summary	391
Key Terms	391
Review Questions	391
Problems	392

PART IV ADVANCED DATABASE CONCEPTS

Business Vignette: AT&T's Daytona in the Lead	395
CHAPTER 10 TRANSACTION MANAGEMENT AND CONCURRENCY CONTROL	396
10.1 What is a Transaction?	397
10.1.1 Evaluating Transaction Results	399
10.1.2 Transaction Properties	401
10.1.3 Transaction Management with SQL	402
10.1.4 The Transaction Log	402
10.2 Concurrency Control	404
10.2.1 Lost Updates	404
10.2.2 Uncommitted Data	405
10.2.3 Inconsistent Retrievals	405
10.2.4 The Scheduler	407
10.3 Concurrency Control with Locking Methods	408
10.3.1 Lock Granularity	408
10.3.2 Lock Types	411
10.3.3 Two-Phase Locking to Ensure Serializability	413
10.3.4 Deadlocks	414
10.4 Concurrency Control with Time Stamping Methods	415
10.4.1 Wait/Die and Wound/Wait Schemes	415
10.5 Concurrency Control with Optimistic Methods	416
10.6 Database Recovery Management	416
10.6.1 Transaction Recovery	418
Summary	421
Key Terms	422
Review Questions	422
Problems	423

TABLE OF CONTENTS

CHAPTER 11 DATABASE PERFORMANCE TUNING AND QUERY OPTIMIZATION	425
11.1 Database Performance-Tuning Concepts	426
11.1.1 Performance Tuning: Client and Server	427
11.1.2 DBMS Architecture	427
11.1.3 Database Statistics	429
11.2 Query Processing	430
11.2.1 SQL Parsing Phase	430
11.2.2 SQL Execution Phase	432
11.2.3 SQL Fetching Phase	432
11.3 Indexes and Query Optimization	432
11.4 Optimizer Choices	434
11.4.1 Using Hints to Affect Optimizer Choices	435
11.5 SQL Performance Tuning	436
11.5.1 Index Selectivity	436
11.5.2 Conditional Expressions	437
11.6 Query Formulation	439
11.7 DBMS Performance Tuning	440
11.8 Query Optimization Example	442
Summary	450
Key Terms	451
Review Questions	451
Problems	452
 CHAPTER 12 DISTRIBUTED DATABASE MANAGEMENT SYSTEMS	 455
12.1 The Evolution of Distributed Database Management Systems	456
12.2 DDBMS Advantages and Disadvantages	458
12.3 Distributed Processing and Distributed Databases	459
12.4 Characteristics of Distributed Database Management Systems	461
12.5 DDBMS Components	462
12.6 Levels of Data and Process Distribution	463
12.6.1 Single-Site Processing, Single-Site Data (SPSD)	464
12.6.2 Multiple-Site Processing, Single-Site Data (MPSD)	465
12.6.3 Multiple-Site Processing, Multiple-Site Data (MPMD)	466
12.7 Distributed Database Transparency Features	467
12.8 Distribution Transparency	468
Case 1: The Database Supports Fragmentation Transparency	469
Case 2: The Database Supports Location Transparency	469
Case 3: The Database Supports Local Mapping Transparency	470
12.9 Transaction Transparency	470
12.9.1 Distributed Requests and Distributed Transactions	470
12.9.2 Distributed Concurrency Control	473
12.9.3 Two-Phase Commit Protocol	475
12.10 Performance Transparency and Query Optimization	476

TABLE OF CONTENTS

12.11 Distributed Database Design	477
12.11.1 Data Fragmentation	477
12.11.2 Data Replication	481
12.11.3 Data Allocation	483
12.12 Client/Server vs. DDBMS	483
12.13 C. J. Date's Twelve Commandments for Distributed Databases	484
Summary	485
Key Terms	486
Review Questions	486
Problems	487
 CHAPTER 13 THE DATA WAREHOUSE	 490
13.1 The Need for Data Analysis	491
13.2 Decision Support Systems	492
13.2.1 Operational Data vs. Decision Support Data	493
13.2.2 DSS Database Requirements	497
13.3 The Data Warehouse	499
13.3.1 DSS Architectural Styles	502
13.3.2 Twelve Rules That Define a Data Warehouse	502
13.4 Online Analytical Processing	504
13.4.1 Multidimensional Data Analysis Techniques	504
13.4.2 Advanced Database Support	505
13.4.3 Easy-to-Use End-User Interface	506
13.4.4 Client/Server Architecture	506
13.4.5 OLAP Architecture	507
13.4.6 Relational OLAP	511
13.4.7 Multidimensional OLAP	513
13.4.8 Relational vs. Multidimensional OLAP	515
13.5 Star Schemas	515
13.5.1 Facts	515
13.5.2 Dimensions	516
13.5.3 Attributes	516
13.5.4 Attribute Hierarchies	518
13.5.5 Star Schema Representation	519
13.5.6 Star Schema Performance-Improving Techniques	522
13.6 Implementing a Data Warehouse	525
13.6.1 The Data Warehouse as an Active Decision Support Framework	525
13.6.2 A Company-Wide Effort That Requires User Involvement	526
13.6.3 Satisfy the Trilogy: Data, Analysis, and Users	526
13.6.4 Apply Database Design Procedures	526
13.7 Data Mining	527
13.8 SQL Extensions for OLAP	531
13.8.1 The ROLLUP Extension	532
13.8.2 The CUBE Extension	532
13.8.3 Materialized Views	533
Summary	538
Key Terms	539
Review Questions	539
Problems	540

TABLE OF CONTENTS

PART V DATABASES AND THE INTERNET

Business Vignette: eBay Disaggregates to Stay Competitive	545
CHAPTER 14 DATABASE CONNECTIVITY AND WEB DEVELOPMENT	546
14.1 Database Connectivity	547
14.1.1 Native SQL Connectivity	547
14.1.2 ODBC, DAO, and RDO	547
14.1.3 OLE-DB	551
14.1.4 ADO.NET	553
14.2 Internet Databases	556
14.2.1 Web-to-Database Middleware: Server-Side Extensions	557
14.2.2 Web Server Interfaces	558
14.2.3 The Web Browser	559
14.2.4 Client-Side Extensions	560
14.3 Using a Web-to-Database Production Tool: ColdFusion	561
14.3.1 How ColdFusion Works	562
14.3.2 The RobCor Sample Database	563
14.3.3 Creating a Simple Query with CFQUERY and CFOUTPUT	564
14.3.4 Creating a Simple Query with CFQUERY and CFTABLE	569
14.3.5 Creating a Dynamic Search Page	570
14.3.6 The Web As a Stateless System	574
14.4 Extensible Markup Language (XML)	575
14.4.1 Document Type Definitions (DTD) and XML Schemas	577
14.4.2 XML Presentation	580
14.4.3 XML Applications	583
Summary	585
Key Terms	586
Review Questions	586
Problems	587

PART VI DATABASE ADMINISTRATION

Business Vignette: NASDAQ High-Performance IT	589
CHAPTER 15 DATABASE ADMINISTRATION	590
15.1 Data as a Corporate Asset	591
15.2 The Need for and Role of Databases in an Organization	592
15.3 Introduction of a Database: Special Considerations	593
15.4 The Evolution of the Database Administration Function	594
15.5 The Database Environment's Human Component	597
15.5.1 The DBA's Managerial Role	600
15.5.2 The DBA's Technical Role	605
15.6 Database Administration Tools	611
15.6.1 The Data Dictionary	611
15.6.2 CASE Tools	613
15.7 Developing a Data Administration Strategy	615

TABLE OF CONTENTS

15.8 The DBA at Work: Using Oracle for Database Administration	617
15.8.1 Oracle Database Administration Tools	618
15.8.2 The Default Login	618
15.8.3 Ensuring an Automatic RDBMS Start	619
15.8.4 Creating Tablespaces and Datafiles	620
15.8.5 Managing the Database Objects: Tables, Views, Triggers, and Procedures	621
15.8.6 Managing Users and Establishing Security	622
15.8.7 Customizing the Database Initialization Parameters	625
15.8.8 Creating a New Database	626
Summary	633
Key Terms	634
Review Questions	634

IN THE STUDENT ONLINE COMPANION

APPENDIX A DESIGNING DATABASES WITH VISIO PROFESSIONAL: A TUTORIAL
APPENDIX B THE UNIVERSITY LAB: CONCEPTUAL DESIGN
APPENDIX C THE UNIVERSITY LAB: CONCEPTUAL DESIGN VERIFICATION, LOGICAL DESIGN, AND IMPLEMENTATION
APPENDIX D CONVERTING AN ER MODEL INTO A DATABASE STRUCTURE
APPENDIX E COMPARISON OF ER MODEL NOTATIONS
APPENDIX F CLIENT/SERVER SYSTEMS
APPENDIX G OBJECT-ORIENTED DATABASES
APPENDIX H UNIFIED MODELING LANGUAGE (UML)
APPENDIX I DATABASES IN ELECTRONIC COMMERCE
APPENDIX J WEB DATABASE DEVELOPMENT WITH COLD FUSION
APPENDIX K THE HIERARCHICAL DATABASE MODEL
APPENDIX L THE NETWORK DATABASE MODEL
ANSWERS TO SELECTED QUESTIONS AND PROBLEMS