CONTENTS

Preface xvii
Acknowledgments xxiii
About the Authors xxv

Chapter 1 INTRODUCTION 1

Initial Terminology 1
Steps in the Development of Database Systems 4
  Database Requirements Collection, Definition, and Visualization 5
  Database Modeling 6
  Database Implementation 6
  Developing Front-End Applications 7
  Database Deployment 7
  Database Use 7
  Database Administration and Maintenance 7
The Next Version of the Database 7
Database Scope 8
People Involved with Database Systems 8
  Database Analysts, Designers, and Developers 8
  Front-End Applications Analysts and Developers 9
  Database Administrators 9
  Database End Users 9
Operational versus Analytical Databases 9
Relational DBMS 10
Book Topics Overview 10
  Key Terms 11 • Review Questions 11

Part 1 Operational Databases 13

Chapter 2 DATABASE REQUIREMENTS AND ER MODELING 13

Introduction 13
Basic ER Modeling Constructs 13
Entities 14
Attributes (Unique and Non-Unique) 14
Relationships 15
  Cardinality Constraints 15
Types of Relationships (Maximum Cardinality-Wise) 17
Relationships and Relationship Instances 18
Relationship Attributes 19
Example: Set of Database Requirements and ER Diagram 21
Composite Attributes 22
Composite Unique Attribute 23
Multiple Unique Attributes (Candidate Keys) 24
Multivalued Attributes 25
Derived Attribute 25
Optional Attribute 26
Chapter 3 RELATIONAL DATABASE MODELING 57

Introduction 57

Relational Database Model: Basic Concepts 57

Primary Key 59

Mapping Entities into Relations 59

Mapping Entities with Composite Attributes into Relations 60

Mapping Entities with Unique Composite Attributes into Relations 61

Mapping Entities with Optional Attributes into Relations 62

Entity Integrity Constraint 62

Foreign Key 63

Mapping Relationships into Relational Database Constructs 63

Mapping 1:M Relationships 64

Mapping M:N Relationships 66

Mapping 1:1 Relationships 68

Referential Integrity Constraint 69

Example: Mapping an ER Diagram into a Relational Schema 70

Mapping Entities with Candidate Keys (Multiple Unique Attributes) into Relations 71

Mapping Entities with Multivalued Attributes into Relational Database Constructs 72

Mapping Entities with Derived Attributes into Relations 73

Example: Mapping an Entity Containing Various Types of Attributes into a Relational Schema 74

Mapping Unary Relationships 74

Mapping 1:M Unary Relationships 74

Mapping M:N Unary Relationships 75

Mapping 1:1 Unary Relationships 76

Mapping Multiple Relationships Between the Same Entities 76

Mapping Weak Entities 77

Example: Mapping another ER Diagram into a Relational Schema 78

Relational Database Constraints 78
Chapter 4 UPDATE OPERATIONS, UPDATE ANOMALIES, AND NORMALIZATION 91

Introduction 91

Update Operations 91

Insert Operation Example 91
Delete Operation Example 92
Modify Operation Example 92
Update Operation Terminology Note 93

Update Anomalies 93

Example Scenario 93
Example Relation (Containing Redundant Data) 94
Insertion Anomaly 95
Deletion Anomaly 95
Modification Anomaly 96

Functional Dependencies 97

Functional Dependency Notation 97

Functional Dependencies Example 98

Streamlining Functional Dependencies 99

Augmented Functional Dependencies 100
Equivalent Functional Dependencies 100

Types of Functional Dependencies 101

Partial Functional Dependency 102
Full Key Functional Dependency 102
Transitive Functional Dependency 102

Another Functional Dependencies Example 102

Normalization 104

First Normal Form (1NF) 105
Second Normal Form (2NF) 107
Third Normal Form (3NF) 108
Other Normal Forms 109
Eliminating Redundancy and Resolving Update Anomalies 109

Another Normalization Example 112

A Note About Normalization Exceptions 114

A Note About Denormalization: Normalization versus Performance 115

A Note About ER Modeling versus Normalization 116

A Note About Designer-Added Entities (Tables) and Keys for Streamlining Database Content 117

Key Terms 120 • Review Questions 120 • Exercises 120
Chapter 5 SQL 127

Introduction 127
SQL Commands Overview 127
Data Definition Language (DDL) 127
Data Manipulation Language (DML) 128
Data Control Language (DCL) and Transaction Control Language (TCL) 128
SQL Data Types 128
Brief SQL Syntax Notes 128
CREATE TABLE 129
DROP TABLE 131
INSERT INTO 132
SELECT 134
WHERE 136
DISTINCT 137
ORDER BY 138
LIKE 139
Aggregate Functions 139
GROUP BY 140
HAVING 144
Nested Queries 146
IN 147
JOIN 148
Alias 151
Joining Multiple Relations 152
ALTER TABLE 153
UPDATE 153
DELETE 154
CREATE VIEW and DROP VIEW 154
Set Operators: UNION, INTERSECT, EXCEPT (MINUS) 155
Additional SQL Examples with Additional SQL Commands 157
CREATE TABLE (Additional Example) 157
INSERT INTO (Additional Example) 160
Constraint Management 160
SELECT (Additional Examples) 163
JOIN of a Relation with Itself (Self-JOIN) 163
OUTER JOIN 164
JOIN without Using a Primary Key/Foreign Key Combination 166
IS NULL 166
EXISTS 166
NOT 167
Inserting from a Query 168
Other SQL Functionalities 168
A Note About Inappropriate Use of Observed Values in SQL 168
A Note About SQL Standard and SQL Syntax Differences 169
SQL Syntax Difference Note 1: DATE and TIME Data Types 170
Chapter 6 DATABASE IMPLEMENTATION AND USE 177

Introduction 177
Referential Integrity Constraint: Delete and Update Implementation Options 177
   Delete Options 178
   Update Options 181
   Implementing Delete and Update Options 184

Implementing User-Defined Constraints 185
   CHECK Clause 185
   Other Mechanisms for Implementing User-Defined Constraints 186

Indexing 187
Database Front-End 192
Data Quality Issues 197

A Note About Assertions and Triggers 202
   Key Terms 204 • Review Questions 204 • Exercises 204

Part 2 Analytical Databases 207

Chapter 7 DATA WAREHOUSING CONCEPTS 207

Introduction 207
Analytical versus Operational Information 207
   Data Makeup Differences 208
   Technical Differences 209
   Functional Differences 210

The Data Warehouse Definition 212
   Structured Repository 213
   Integrated 213
   Subject Oriented 213
   Enterprise-Wide 213
   Historical 213
   Time Variant 213
   Retrieval of Analytical Information 213
   Detailed and/or Summarized Data 214

Data Warehouse Components 214
   Source Systems 215
   Data Warehouse 215
   ETL 216
   Data Warehouse Front-End (BI) Applications 216
Chapter 8 DATA WAREHOUSE AND DATA MART MODELING 225

Introduction 225

Dimensional Modeling: Basic Concepts 225

Initial Example: Dimensional Model Based on a Single Source 226

Characteristics of Dimensions and Facts and the Analysis of the Initial Example 229

Expanded Example: Dimensional Model Based on Multiple Sources 231

Additional Possible Fact Attributes 234

Transaction Identifier in the Fact Table 235

Transaction Time in the Fact Table 237

Multiple Fact Tables in a Dimensional Model 240

Detailed versus Aggregated Fact Tables 243

Detailed Fact Table 243

Aggregated Fact Table 245

Detailed versus Aggregated Fact Table 248

Granularity of the Fact Table 248

Line-Item versus Transaction-Level Detailed Fact Table 249

Slowly Changing Dimensions and Timestamps 250

Type 1 Approach 250

Type 2 Approach 251

Type 3 Approach 252

Additional Dimensional Modeling Issues 253

Snowflake Model 254

Cubes 254

Data Warehouse (Data Mart) Modeling Approaches 255

Normalized Data Warehouse 255

An Example of a Normalized Data Warehouse 256

Dimensionally Modeled Data Warehouse 259

An Example of a Dimensionally Modeled Warehouse 260

Independent Data Marts 263

A Note About Comparing Dimensional Modeling and ER Modeling as Data Warehouse/Data Mart Design Techniques 264

Key Terms 265 • Review Questions 265 • Exercises 266 • Mini Cases 272
Chapter 9  DATA WAREHOUSE IMPLEMENTATION AND USE  273

Introduction  273
Creating a Data Warehouse  273
ETL: Extraction, Transformation, Load  275
Online Analytical Processing (OLAP)  280
OLAP/BI Tools  281
OLAP/BI Tools Functionalities  282
  Slice and Dice  283
  Pivot (Rotate)  285
  Drill Down and Drill Up  286
  Additional OLAP/BI Tools Functionality Notes  288
OLAP/BI Tools Purpose  288
Data Warehouse/Data Mart Front-End (BI) Applications  289
Executive Dashboard  292
Data Warehouse Deployment  292
A Note About OLAP/BI Tools Database Models  293
A Note About OLAP/BI Tools Data Architecture Options  295
  MOLAP  295
  ROLAP  296
  HOLAP  297

Key Terms  297  •  Review Questions  297  •  Exercises  299

Part 3  Other Topics  301

Chapter 10  OVERVIEW OF DBMS FUNCTIONALITIES AND DATABASE ADMINISTRATION  301

Introduction  301
DBMS Components  301
Database Administration Overview  302
Monitoring and Maintaining the Database System  302
  Data Dictionary  303
Securing the Database Against Unauthorized Access  305
Provisioning Database Backup and Recovery  306
Ensuring Database Integrity  307
Optimizing Database Performance  307
Developing and Implementing Database Policies and Standards  308

Key Terms  309  •  Review Questions  309

Appendices

Appendix A  ENHANCED ER  311
Appendix B  FURTHER NOTES ON NORMALIZATION AND HIGHER NORMAL FORMS  317
Appendix C  ENTERPRISE RESOURCE PLANNING (ERP)  323
Appendix D  DATA GOVERNANCE AND MASTER DATA MANAGEMENT  326
Appendix E  OBJECT-ORIENTED DATABASES   330
Appendix F  DISTRIBUTED DATABASES, PARALLEL DATABASES, AND CLOUD COMPUTING   336
Appendix G  DATA MINING   343
Appendix H  XML   346
Appendix I  NOSQL DATABASES   353
Appendix J  BIG DATA   356

Glossary   361
Index   369