Preface xxvii
Acknowledgments xxx
Introduction xxxi
Part I Foundations 1
1 Data Models 3
Introduction 3
Relational Model 5
Table, Rows, and Columns 5
Relations and Tables 6
Properties of Relations 7
Keys 8
Relationships 9
Relational Algebra, Relational Calculus, and Tuple Calculus 11
Relational Algebra 11
Relational Calculus 14
Tuple Calculus 15
Relational Database Management Systems 16
Relational Database Management Systems Functionality 17
Relational Database Management Systems Architecture 18
Relational Database Management Systems Utilities 19
Relational Database Management Systems Advantages 19
Relational Database Management Systems Disadvantages 20
Relational Database Management Systems Guidelines 20
Relational Database Management Systems Extensions 21
Object Model 22
Object Oriented Concepts 22
Object Identity 23
Object Relational Extensions 24
Object Oriented Extensions 24
Object Oriented Database Management Systems Advantages 25
Object Oriented Database Management Systems Disadvantages 25
Object Oriented Database Management Systems Guidelines 26
Object Oriented Database Management Systems Extensions 26
Object Relational Database Management Systems Extensions 27
Object Relational Database Management Systems Advantages 27
Object Relational Database Management Systems Disadvantages 27
Object Relational Database Management Systems Guidelines 28
Object Relational Database Management Systems Extensions 28
Other Models 28
Hierarchical Model 28
Network Model 29
Semantic Model 29
Entity Relationship Model 29
Functional Model 29
Summary 29
Exercises 30
2 Data Independence and Distributed Processing 31
Introduction 31
Data Independence 32
Data Independence Examples 33
Data Independence Benefits 34
Distributed Processing Benefits 35
Distributed Processing Architectures 36
Client/Server Architecture 36
Two-Tier Client/Server Architecture 37
Three-Tier Client/Server Architecture 38
Distributed Database Management Systems Architecture 39
Distributed Database Management Systems Transparency 40
Distributed Database Management Systems Transparency Features 41
Distributed Database Management Systems Transparency Disadvantages 42
Distributed Database Management Systems Transparency Guidelines 42
Distributed Database Management Systems Transparency Extensions 43
Distributed Database Management Systems Functionality 43
Distributed Database Management Systems Functionality Features 44
Distributed Database Management Systems Functionality Disadvantages 45
Distributed Database Management Systems Functionality Guidelines 45
Distributed Database Management Systems Functionality Extensions 46
Summary 46
Exercises 47
3 Data Administration and Database Administration 49
Introduction 49
Data Administration 50
Data Administration Functions 51
Data Administration Benefits 52
Data Administration Disadvantages 53
Data Administration Guidelines 53
Data Administration Extensions 54
Database Administration 54
Database Administration Functions 55
Database Administration Benefits 56
Database Administration Disadvantages 57
Database Administration Guidelines 57
Database Administration Extensions 58
Summary 58
Exercises 59
4 Data Integrity 61
Introduction 61
Integrity Constraints 62
Integrity Constraints Benefits 63
Integrity Constraints Disadvantages 64
Integrity Constraints Guidelines 64
Integrity Constraints Extensions 65
Transaction Management 65
Transaction Management Benefits 66
Transaction Management Disadvantages 67
Transaction Management Guidelines 67
Transaction Management Extensions 68
Summary 68
Exercises 69
5 Data Security 71
Introduction 71
Computer Security 72
Computer Security Benefits 73
Computer Security Disadvantages 74
Computer Security Guidelines 74
Computer Security Extensions 75
Database Security 75
Database Security Functions 76
Database Security Benefits 77
Database Security Disadvantages 78
Database Security Guidelines 78
Database Security Extensions 79
Summary 79
Exercises 80
6 Concurrency Control 81
Introduction 81
Lost Update Problem 82
Uncommitted Dependency Problem 83
Inconsistent Analysis Problem 84
Serializability 85
Locking 86
Deadlock 87
Two-Phase Locking 88
Timestamp Ordering 89
Optimistic Techniques 90
Granularity of Locks 91
Multiversion Techniques 92
Summary 93
Exercises 94
7 Distributed Processing 95
Introduction 95
Distributed Processing Functions 96
Distributed Processing Benefits 97
Distributed Processing Disadvantages 98
Distributed Processing Guidelines 98
Distributed Processing Extensions 99
Summary 99
Exercises 100
8 Distributed Database Management Systems 101
Introduction 101
Distributed Database Management Systems Functions 102
Distributed Database Management Systems Benefits 103
Distributed Database Management Systems Disadvantages 104
Distributed Database Management Systems Guidelines 104
Distributed Database Management Systems Extensions 105
Summary 105
Exercises 106
9 Distributed Database Management Systems Transparency 107
Introduction 107
Distributed Database Management Systems Transparency Features 108
Distributed Database Management Systems Transparency Benefits 109
Distributed Database Management Systems Transparency Disadvantages 110
Distributed Database Management Systems Transparency Guidelines 110
Distributed Database Management Systems Transparency Extensions 111
Summary 111
Exercises 112
10 Distributed Database Management Systems Functionality 113
Introduction 113
Distributed Database Management Systems Functionality Features 114
Distributed Database Management Systems Functionality Benefits 115
Distributed Database Management Systems Functionality Disadvantages 116
Distributed Database Management Systems Functionality Guidelines 116
Distributed Database Management Systems Functionality Extensions 117
Summary 117
Exercises 118
Part II Relational Model 119
11 Introduction to Relational Model 121
Introduction 121
Relational Model Concepts 122
Relational Model Features 123
Relational Model Benefits 124
Relational Model Disadvantages 125
Relational Model Guidelines 125
Relational Model Extensions 126
Summary 126
Exercises 127
12 Relational Algebra 129
Introduction 129
Unary Relational Operations 130
SELECT (Restriction) Operation 130
PROJECT Operation 131
Relational Algebra Operations from Set Theory 132
UNION Operation 132
INTERSECTION Operation 133
DIFFERENCE Operation 134
PRODUCT Operation 135
Binary Relational Operations 136
JOIN Operation 136
EQUI-JOIN Operation 137
NATURAL Operation 138
DIVIDE Operation 139
Summary 140
Exercises 141
13 Relational Calculus 143
Introduction 143
Tuple Calculus 144
Tuple Calculus Quantifiers 145
Tuple Calculus Operations 146
Tuple Calculus Rules 147
Tuple Calculus Queries 148
Domain Calculus 149
Domain Calculus Quantifiers 150
Domain Calculus Operations 151
Domain Calculus Rules 152
Domain Calculus Queries 153
Summary 154
Exercises 155
14 Relational Database Design by Entity-Relationship Model 157
Introduction 157
Entity-Relationship Model 158
Entity-Relationship Model Features 159
Entity-Relationship Model Benefits 160
Entity-Relationship Model Disadvantages 161
Entity-Relationship Model Guidelines 161
Entity-Relationship Model Extensions 162
Summary 162
Exercises 163
15 Normalization 165
Introduction 165
Functional Dependencies 166
Identifying Attributes 167
Identifying Relationships 168
First Normal Form (1NF) 169
Second Normal Form (2NF) 170
Third Normal Form (3NF) 171
Boyce-Codd Normal Form (BCNF) 172
Fourth Normal Form (4NF) 173
Fifth Normal Form (5NF) 174
Summary 175
Exercises 176
16 Relational Database Design by Normalization 177
Introduction 177
Relational Database Design by Normalization Features 178
Relational Database Design by Normalization Benefits 179
Relational Database Design by Normalization Disadvantages 180
Relational Database Design by Normalization Guidelines 180
Relational Database Design by Normalization Extensions 181
Summary 181
Exercises 182
Part III Object Model 183
17 Introduction to Object Model 185
Introduction 185
Object Model Concepts 186
Object Model Features 187
Object Model Benefits 188
Object Model Disadvantages 189
Object Model Guidelines 189
Object Model Extensions 190
Summary 190
Exercises 191
18 Object Oriented Concepts 193
Introduction 193
Object Identity 194
Object Identity Features 195
Object Identity Benefits 196
Object Identity Disadvantages 197
Object Identity Guidelines 197
Object Identity Extensions 198
Encapsulation 198
Encapsulation Features 199
Encapsulation Benefits 200
Encapsulation Disadvantages 201
Encapsulation Guidelines 201
Encapsulation Extensions 202
Inheritance 202
Inheritance Features 203
Inheritance Benefits 204
Inheritance Disadvantages 205
Inheritance Guidelines 205
Inheritance Extensions 206
Polymorphism 206
Polymorphism Features 207
Polymorphism Benefits 208
Polymorphism Disadvantages 209
Polymorphism Guidelines 209
Polymorphism Extensions 210
Summary 210
Exercises 211
19 Object Oriented Database Design 213
Introduction 213
Object Oriented Database Design Features 214
Object Oriented Database Design Benefits 215
Object Oriented Database Design Disadvantages 216
Object Oriented Database Design Guidelines 216
Object Oriented Database Design Extensions 217
Summary 217
Exercises 218
Part IV Object Relational Model 219
20 Introduction to Object Relational Model 221
Introduction 221
Object Relational Model Concepts 222
Object Relational Model Features 223
Object Relational Model Benefits 224
Object Relational Model Disadvantages 225
Object Relational Model Guidelines 225
Object Relational Model Extensions 226
Summary 226
Exercises 227
21 Object Relational Database Design 229
Introduction 229
Object Relational Database Design Features 230
Object Relational Database Design Benefits 231
Object Relational Database Design Disadvantages 232
Object Relational Database Design Guidelines 232
Object Relational Database Design Extensions 233
Summary 233
Exercises 234
Part V Other Models 235
22 Hierarchical Model 237
Introduction 237
Hierarchical Model Features 238
Hierarchical Model Benefits 239
Hierarchical Model Disadvantages 240
Hierarchical Model Guidelines 240
Hierarchical Model Extensions 241
Summary 241
Exercises 242
23 Network Model 243
Introduction 243
Network Model Features 244
Network Model Benefits 245
Network Model Disadvantages 246
Network Model Guidelines 246
Network Model Extensions 247
Summary 247
Exercises 248
24 Semantic Model 249
Introduction 249
Semantic Model Features 250
Semantic Model Benefits 251
Semantic Model Disadvantages 252
Semantic Model Guidelines 252
Semantic Model Extensions 253
Summary 253
Exercises 254
25 Functional Model 255
Introduction 255
Functional Model Features 256
Functional Model Benefits 257
Functional Model Disadvantages 258
Functional Model Guidelines 258
Functional Model Extensions 259
Summary 259
Exercises 260
Part VI Appendixes 261
A Entity-Relationship Model Notation 263
Introduction 263
Entity Notation 264
Relationship Notation 265
Attribute Notation 266
Cardinality Notation 267
Summary 268
B Relational Database Management Systems Functionality Features 269
Introduction 269
Relational Database Management Systems Functionality Features 270
Summary 271
C Object Oriented Database Management Systems Functionality Features 273
Introduction 273
Object Oriented Database Management Systems Functionality Features 274
Summary 275
D Object Relational Database Management Systems Functionality Features 277
Introduction 277
Object Relational Database Management Systems Functionality Features 278
Summary 279
E Distributed Database Management Systems Functionality Features 281
Introduction 281
Distributed Database Management Systems Functionality Features 282
Summary 283
F Distributed Database Management Systems Transparency Features 285
Introduction 285
Distributed Database Management Systems Transparency Features 286
Summary 287
G Data Administration Functions 289
Introduction 289
Data Administration Functions 290
Summary 291
H Database Administration Functions 293
Introduction 293
Database Administration Functions 294
Summary 295
I Data Security Features 297
Introduction 297
Data Security Features 298
Summary 299
J Data Integrity Features 301
Introduction 301
Data Integrity Features 302
Summary 303
K Transaction Management Features 305
Introduction 305
Transaction Management Features 306
Summary 307
L Concurrency Control Features 309
Introduction 309
Concurrency Control Features 310
Summary 311
M Distributed Processing Functions 313
Introduction 313
Distributed Processing Functions 314
Summary 315
N Distributed Processing Architectures 317
Introduction 317
Distributed Processing Architectures 318
Summary 319
O Distributed Database Management Systems Functions 321
Introduction 321
Distributed Database Management Systems Functions 322
Summary 323
P Distributed Database Management Systems Functionality Features 325
Introduction 325
Distributed Database Management Systems Functionality Features 326
Summary 327
Q Relational Model Features 329
Introduction 329
Relational Model Features 330
Summary 331
R Relational Algebra Operations 333
Introduction 333
Relational Algebra Operations 334
Summary 335
S Relational Calculus Quantifiers 337
Introduction 337
Relational Calculus Quantifiers 338
Summary 339
T Relational Calculus Operations 341
Introduction 341
Relational Calculus Operations 342
Summary 343
U Relational Calculus Rules 345
Introduction 345
Relational Calculus Rules 346
Summary 347
V Relational Calculus Queries 349
Introduction 349
Relational Calculus Queries 350
Summary 351
W Normalization Functional Dependencies 353
Introduction 353
Normalization Functional Dependencies 354
Summary 355
X Normalization Identifying Attributes 357
Introduction 357
Normalization Identifying Attributes 358
Summary 359
Y Normalization Identifying Relationships 361
Introduction 361
Normalization Identifying Relationships 362
Summary 363
Z Normalization First Normal Form (1NF) 365
Introduction 365
Normalization First Normal Form (1NF) 366
Summary 367
AA Normalization Second Normal Form (2NF) 369
Introduction 369
Normalization Second Normal Form (2NF) 370
Summary 371
BB Normalization Third Normal Form (3NF) 373
Introduction 373
Normalization Third Normal Form (3NF) 374
Summary 375
CC Normalization Boyce-Codd Normal Form (BCNF) 377
Introduction 377
Normalization Boyce-Codd Normal Form (BCNF) 378
Summary 379
DD Normalization Fourth Normal Form (4NF) 381
Introduction 381
Normalization Fourth Normal Form (4NF) 382
Summary 383
EE Normalization Fifth Normal Form (5NF) 385
Introduction 385
Normalization Fifth Normal Form (5NF) 386
Summary 387
FF Object Oriented Database Design Features 389
Introduction 389
Object Oriented Database Design Features 390
Summary 391
GG Object Relational Database Design Features 393
Introduction 393
Object Relational Database Design Features 394
Summary 395
Glossary 397
Bibliography 399
Index 401