

3	Conceptual Data Modeling Using the (E)ER Model and UML Class Diagram	38			
3.1	Phases of Database Design	38			
3.2	The Entity Relationship Model	40			
3.2.1	Entity Types	40			
3.2.2	Attribute Types	40			
3.2.3.1	Domains	41			
3.2.3.2	Key Attribute Types	42			
3.2.3.3	Simple versus Composite Attribute Types	42			
3.2.3.4	Single-Valued versus Multi-Valued Attribute Types	43			
3.2.3.5	Derived Attribute Type	43			
3.2.4	Relationship Types	43			
3.2.4.1	Degree and Roles	44			
3.2.4.2	Cardinalities	45			
3.2.4.3	Relationship Attribute Types	46			
3.2.5	Weak Entity Types	46			
3.2.6	Ternary Relationship Types	48			
3.2.7	Examples of the ER Model	50			
3.2.8	Limitations of the ER Model	51			
3.3	The Enhanced Entity Relationship (EER) Model	52			
3.3.1	Specialization/Generalization	52			
3.3.2	Categorization	54			
3.3.3	Aggregation	55			
3.3.4	Examples of the EER Model	55			
3.3.5	Designing an EER Model	56			
3.4	The UML Class Diagram	57			
3.4.1	Recap of Object Orientation	57			
3.4.2	Classes	58			
3.4.3	Variables	58			
3.4.4	Access Modifiers	59			
3.4.5	Associations	59			
3.4.5.1	Association Class	60			
3.4.5.2	Unidirectional versus Bidirectional Association	60			
3.4.5.3	Qualified Association	61			
3.4.6	Specialization/Generalization	62			
3.4.7	Aggregation	62			
3.4.8	UML Example	63			
3.4.9	Advanced UML Modeling Concepts	64			
3.4.9.1	Changeability Property	64			
3.4.9.2	Object Constraint Language (OCL)	64			
3.4.9.3	Dependency Relationship	66			
3.4.10	UML versus EER	66			
	Summary		67		
	Key Terms List		71		
	Review Questions		71		
	Problems and Exercises		75		
4	Organizational Aspects of Data Management		79		
4.1	Data Management		79		
4.1.1	Catalogs and the Role of Metadata		80		
4.1.2	Metadata Modeling		80		
4.1.3	Data Quality		81		
4.1.3.1	Data Quality Dimensions		82		
4.1.3.2	Data Quality Problems		84		
4.1.4	Data Governance		85		
4.2	Roles in Data Management		86		
4.2.1	Information Architect		86		
4.2.2	Database Designer		87		
4.2.3	Data Owner		87		
4.2.4	Data Steward		87		
4.2.5	Database Administrator		87		
4.2.6	Data Scientist		88		
	Summary		88		
	Key Terms List		89		
	Review Questions		89		
	Problems and Exercises		90		
Part II Types of Database Systems			91		
5	Legacy Databases		93		
5.1	The Hierarchical Model		93		
5.2	The CODASYL Model		97		
	Summary		102		
	Key Terms List		102		
	Review Questions		102		
	Problems and Exercises		103		
6	Relational Databases: The Relational Model		104		
6.1	The Relational Model		105		
6.1.1	Basic Concepts		105		
6.1.2	Formal Definitions		106		
6.1.3	Types of Keys		108		
6.1.3.1	Superkeys and Keys		108		
6.1.3.2	Candidate Keys, Primary Keys, and Alternative Keys		108		
6.1.3.3	Foreign Keys		109		
6.1.4	Relational Constraints		111		
6.1.5	Example Relational Data Model		111		

6.2 Normalization	111	7.1.1 Key Characteristics of SQL	147
6.2.1 Insertion, Deletion, and Update Anomalies in an Unnormalized Relational Model	112	7.1.2 Three-Layer Database Architecture	149
6.2.2 Informal Normalization Guidelines	114	7.2 SQL Data Definition Language	149
6.2.3 Functional Dependencies and Prime Attribute Type	114	7.2.1 Key DDL Concepts	150
6.2.4 Normalization Forms	115	7.2.2 DDL Example	151
6.2.4.1 First Normal Form (1NF)	115	7.2.3 Referential Integrity Constraints	154
6.2.4.2 Second Normal Form (2NF)	117	7.2.4 DROP and ALTER Command	155
6.2.4.3 Third Normal Form (3NF)	118	7.3 SQL Data Manipulation Language	156
6.2.4.4 Boyce–Codd Normal Form (BCNF)	119	7.3.1 SQL SELECT Statement	156
6.2.4.5 Fourth Normal Form (4NF)	120	7.3.1.1 Simple Queries	157
6.3 Mapping a Conceptual ER Model to a Relational Model	121	7.3.1.2 Queries with Aggregate Functions	161
6.3.1 Mapping Entity Types	121	7.3.1.3 Queries with GROUP BY/HAVING	163
6.3.2 Mapping Relationship Types	122	7.3.1.4 Queries with ORDER BY	165
6.3.2.1 Mapping a Binary 1:1 Relationship type	122	7.3.1.5 Join Queries	166
6.3.2.2 Mapping a Binary 1:N Relationship Type	124	7.3.1.6 Nested Queries	172
6.3.2.3 Mapping a Binary M:N Relationship Type	126	7.3.1.7 Correlated Queries	175
6.3.2.4 Mapping Unary Relationship Types	127	7.3.1.8 Queries with ALL/ANY	178
6.3.2.5 Mapping <i>n</i> -ary Relationship Types	129	7.3.1.9 Queries with EXISTS	181
6.3.3 Mapping Multi-Valued Attribute Types	130	7.3.1.10 Queries with Subqueries in SELECT/FROM	182
6.3.4 Mapping Weak Entity Types	131	7.3.1.11 Queries with Set Operations	183
6.3.5 Putting it All Together	132	7.3.2 SQL INSERT Statement	185
6.4 Mapping a Conceptual EER Model to a Relational Model	133	7.3.3 SQL DELETE Statement	185
6.4.1 Mapping an EER Specialization	133	7.3.4 SQL UPDATE Statement	186
6.4.2 Mapping an EER Categorization	136	7.4 SQL Views	188
6.4.3 Mapping an EER Aggregation	137	7.5 SQL Indexes	190
Summary	138	7.6 SQL Privileges	191
Key Terms List	139	7.7 SQL for Metadata Management	192
Review Questions	139	Summary	194
Problems and Exercises	143	Key Terms List	195
7 Relational Databases: Structured Query Language (SQL)	146	Review Questions	196
7.1 Relational Database Management Systems and SQL	147	Problems and Exercises	205
		8 Object-Oriented Databases and Object Persistence	207
		8.1 Recap: Basic Concepts of OO	208
		8.2 Advanced Concepts of OO	209
		8.2.1 Method Overloading	209
		8.2.2 Inheritance	210
		8.2.3 Method Overriding	211
		8.2.4 Polymorphism and Dynamic Binding	212
		8.3 Basic Principles of Object Persistence	214
		8.3.1 Serialization	214

8.4	OODBMS	216	10.1.2	Document Type Definition and XML Schema Definition	260
8.4.1	Object Identifiers	216	10.1.3	Extensible Stylesheet Language	263
8.4.2	ODMG Standard	217	10.1.4	Namespaces	266
8.4.3	Object Model	217	10.1.5	XPath	267
8.4.4	Object Definition Language (ODL)	218	10.2	Processing XML Documents	267
8.4.5	Object Query Language (OQL)	221	10.3	Storage of XML Documents	269
8.4.5.1	Simple OQL Queries	221	10.3.1	The Document-Oriented Approach for Storing XML Documents	270
8.4.5.2	SELECT FROM WHERE OQL Queries	221	10.3.2	The Data-Oriented Approach for Storing XML Documents	270
8.4.5.3	Join OQL Queries	222	10.3.3	The Combined Approach for Storing XML Documents	270
8.4.5.4	Other OQL Queries	222	10.4	Differences Between XML Data and Relational Data	271
8.4.6	Language Bindings	223	10.5	Mappings Between XML Documents and (Object-) Relational Data	272
8.5	Evaluating OODBMSs	225	10.5.1	Table-Based Mapping	272
	Summary	227	10.5.2	Schema-Oblivious Mapping	273
	Key Terms List	227	10.5.3	Schema-Aware Mapping	275
	Review Questions	228	10.5.4	SQL/XML	276
	Problems and Exercises	229	10.6	Searching XML Data	279
9	Extended Relational Databases	231	10.6.1	Full-Text Search	280
9.1	Limitations of the Relational Model	231	10.6.2	Keyword-Based Search	280
9.2	Active RDBMS Extensions	232	10.6.3	Structured Search With XQuery	280
9.2.1	Triggers	233	10.6.4	Semantic Search With RDF and SPARQL	282
9.2.2	Stored Procedures	234	10.7	XML for Information Exchange	284
9.3	Object-Relational RDBMS Extensions	236	10.7.1	Message-Oriented Middleware	284
9.3.1	User-Defined Types	236	10.7.2	SOAP-Based Web Services	285
9.3.1.1	Distinct Data Types	237	10.7.3	REST-Based Web Services	288
9.3.1.2	Opaque Data Types	238	10.7.4	Web Services and Databases	289
9.3.1.3	Unnamed Row Types	238	10.8	Other Data Representation Formats	290
9.3.1.4	Named Row Types	239		Summary	293
9.3.1.5	Table Data Types	240		Key Terms List	296
9.3.2	User-Defined Functions	240		Review Questions	297
9.3.3	Inheritance	242		Problems and Exercises	298
9.3.3.1	Inheritance at Data Type Level	242	11	NoSQL Databases	300
9.3.3.2	Inheritance at Table Type Level	243	11.1	The NoSQL Movement	301
9.3.4	Behavior	244	11.1.1	The End of the “One Size Fits All” Era?	301
9.3.5	Polymorphism	244			
9.3.6	Collection Types	245			
9.3.7	Large Objects	247			
9.4	Recursive SQL Queries	247			
	Summary	250			
	Key Terms List	251			
	Review Questions	252			
	Problems and Exercises	253			
10	XML Databases	255			
10.1	Extensible Markup Language	256			
10.1.1	Basic Concepts	256			

11.1.2 The Emergence of the NoSQL Movement	302	12.3.4.1 Key-to-Address Transformation	365
11.2 Key-Value Stores	304	12.3.4.2 Factors that Determine the Efficiency of Random File Organization	368
11.2.1 From Keys to Hashes	304	12.3.5 Indexed Sequential File Organization	370
11.2.2 Horizontal Scaling	305	12.3.5.1 Basic Terminology of Indexes	370
11.2.3 An Example: Memcached	306	12.3.5.2 Primary Indexes	371
11.2.4 Request Coordination	308	12.3.5.3 Clustered Indexes	373
11.2.5 Consistent Hashing	309	12.3.5.4 Multilevel Indexes	374
11.2.6 Replication and Redundancy	311	12.3.6 List Data Organization (Linear and Nonlinear Lists)	375
11.2.7 Eventual Consistency	312	12.3.6.1 Linear Lists	375
11.2.8 Stabilization	314	12.3.6.2 Tree Data Structures	377
11.2.9 Integrity Constraints and Querying	314	12.3.7 Secondary Indexes and Inverted Files	379
11.3 Tuple and Document Stores	315	12.3.7.1 Characteristics of Secondary Indexes	380
11.3.1 Items with Keys	316	12.3.7.2 Inverted Files	381
11.3.2 Filters and Queries	316	12.3.7.3 Multicolumn Indexes	382
11.3.3 Complex Queries and Aggregation with MapReduce	320	12.3.7.4 Other Index Types	383
11.3.4 SQL After All...	330	12.3.8 B-Trees and B ⁺ -Trees	384
11.4 Column-Oriented Databases	331	12.3.8.1 Multilevel Indexes Revisited	384
11.5 Graph-Based Databases	333	12.3.8.2 Binary Search Trees	385
11.5.1 Cypher Overview	335	12.3.8.3 B-Trees	386
11.5.2 Exploring a Social Graph	336	12.3.8.4 B ⁺ -Trees	388
11.6 Other NoSQL Categories	341	Summary	390
Summary	342	Key Terms List	391
Key Terms	344	Review Questions	392
Review Questions	345	Problems and Exercises	393
Problems and Exercises	347		
Part III Physical Data Storage, Transaction Management, and Database Access	349		
12 Physical File Organization and Indexing	351	13 Physical Database Organization	395
12.1 Storage Hardware and Physical Database Design	351	13.1 Physical Database Organization and Database Access Methods	396
12.1.1 The Storage Hierarchy	352	13.1.1 From Database to Tablespace	396
12.1.2 Internals of Hard Disk Drives	353	13.1.2 Index Design	398
12.1.3 From Logical Concepts to Physical Constructs	356	13.1.3 Database Access Methods	400
12.2 Record Organization	359	13.1.3.1 Functioning of the Query Optimizer	400
12.3 File Organization	361	13.1.3.2 Index Search (with Atomic Search Key)	402
12.3.1 Introductory Concepts: Search Keys, Primary, and Secondary File Organization	362	13.1.3.3 Multiple Index and Multicolumn Index Search	403
12.3.2 Heap File Organization	363	13.1.3.4 Index-Only Access	407
12.3.3 Sequential File Organization	363	13.1.3.5 Full Table Scan	408
12.3.4 Random File Organization (Hashing)	365		

13.1.4	Join Implementations	408	14.3.3	Media Recovery	438
13.1.4.1	Nested-Loop Join	409	14.4	Concurrency Control	439
13.1.4.2	Sort-Merge Join	410	14.4.1	Typical Concurrency Problems	439
13.1.4.3	Hash Join	410	14.4.1.1	Lost Update Problem	440
13.2	Enterprise Storage Subsystems and Business Continuity	411	14.4.1.2	Uncommitted Dependency Problem (aka Dirty Read Problem)	440
13.2.1	Disk Arrays and RAID	411	14.4.1.3	Inconsistent Analysis Problem	441
13.2.2	Enterprise Storage Subsystems	413	14.4.1.4	Other Concurrency-Related Problems	442
13.2.2.1	Overview and Classification	414	14.4.2	Schedules and Serial Schedules	442
13.2.2.2	DAS (Directly Attached Storage)	416	14.4.3	Serializable Schedules	442
13.2.2.3	SAN (Storage Area Network)	416	14.4.4	Optimistic and Pessimistic Schedulers	443
13.2.2.4	NAS (Network Attached Storage)	417	14.4.5	Locking and Locking Protocols	444
13.2.2.5	NAS Gateway	418	14.4.5.1	Purposes of Locking	444
13.2.2.6	iSCSI/Storage Over IP	419	14.4.5.2	The Two-Phase Locking Protocol (2PL)	446
13.2.3	Business Continuity	421	14.4.5.3	Cascading Rollbacks	447
13.2.3.1	Contingency Planning, Recovery Point, and Recovery Time	421	14.4.5.4	Dealing with Deadlocks	448
13.2.3.2	Availability and Accessibility of Storage Devices	422	14.4.5.5	Isolation Levels	449
13.2.3.3	Availability of Database Functionality	422	14.4.5.6	Lock Granularity	450
13.2.3.4	Data Availability	423	14.5	The ACID Properties of Transactions	452
Summary		426	Summary		453
Key Terms List		426	Key Terms List		453
Review Questions		427	Review Questions		454
Problems and Exercises		429	Problems and Exercises		456
14	Basics of Transaction Management	430	15	Accessing Databases and Database APIs	458
14.1	Transactions, Recovery, and Concurrency Control	431	15.1	Database System Architectures	459
14.2	Transactions and Transaction Management	432	15.1.1	Centralized System Architectures	459
14.2.1	Delineating Transactions and the Transaction Lifecycle	432	15.1.2	Tiered System Architectures	460
14.2.2	DBMS Components Involved in Transaction Management	433	15.2	Classification of Database APIs	462
14.2.3	The Logfile	435	15.2.1	Proprietary versus Universal APIs	463
14.3	Recovery	436	15.2.2	Embedded versus Call-Level APIs	464
14.3.1	Types of Failures	436	15.2.3	Early Binding versus Late Binding	465
14.3.2	System Recovery	436			

15.3 Universal Database APIs	466	16.3.1 Vertical Fragmentation	520
15.3.1 ODBC	466	16.3.2 Horizontal Fragmentation (Sharding)	521
15.3.2 OLE DB and ADO	467	16.3.3 Mixed Fragmentation	521
15.3.3 ADO.NET	468	16.3.4 Replication	523
15.3.4 Java DataBase Connectivity (JDBC)	471	16.3.5 Distribution and Replication of Metadata	524
15.3.5 Intermezzo: SQL Injection and Access Security	477	16.4 Transparency	524
15.3.6 SQLJ	479	16.5 Distributed Query Processing	525
15.3.7 Intermezzo: Embedded APIs versus Embedded DBMSs	480	16.6 Distributed Transaction Management and Concurrency Control	528
15.3.8 Language-Integrated Querying	482	16.6.1 Primary Site and Primary Copy 2PL	529
15.4 Object Persistence and Object- Relational Mapping APIs	483	16.6.2 Distributed 2PL	529
15.4.1 Object Persistence with Enterprise JavaBeans	484	16.6.3 The Two-Phase Commit Protocol (2PC)	530
15.4.2 Object Persistence with the Java Persistence API	488	16.6.4 Optimistic Concurrency and Loosely Coupled Systems	532
15.4.3 Object Persistence with Java Data Objects	495	16.6.5 Compensation-Based Transaction Models	534
15.4.4 Object Persistence in Other Host Languages	498	16.7 Eventual Consistency and BASE Transactions	538
15.5 Database API Summary	502	16.7.1 Horizontal Fragmentation and Consistent Hashing	538
15.6 Database Access in the World Wide Web	504	16.7.2 The CAP Theorem	539
15.6.1 Introduction: the Original Web Server	504	16.7.3 BASE Transactions	540
15.6.2 The Common Gateway Interface: Toward Dynamic Web Pages	504	16.7.4 Multi-Version Concurrency Control and Vector Clocks	541
15.6.3 Client-Side Scripting: The Desire for a Richer Web	507	16.7.5 Quorum-Based Consistency	542
15.6.4 JavaScript as a Platform	508	Summary	544
15.6.5 DBMSs Adapt: REST, Other Web Services, and a Look Ahead	509	Key Terms	545
Summary	512	Review Questions	546
Key Terms List	513	Problems and Exercises	547
Review Questions	513	Part IV Data Warehousing, Data Governance, and (Big) Data Analytics	549
Problems and Exercises	515		
16 Data Distribution and Distributed Transaction Management	516	17 Data Warehousing and Business Intelligence	551
16.1 Distributed Systems and Distributed Databases	517	17.1 Operational versus Tactical/ Strategic Decision-Making	552
16.2 Architectural Implications of Distributed Databases	518	17.2 Data Warehouse Definition	553
16.3 Fragmentation, Allocation, and Replication	519	17.3 Data Warehouse Schemas	554
		17.3.1 Star Schema	555

17.3.2	Snowflake Schema	556	18.1.2.1	Data Consolidation: Extract, Transform, Load (ETL)	593
17.3.3	Fact Constellation	557	18.1.2.2	Data Federation: Enterprise Information Integration (EII)	595
17.3.4	Specific Schema Issues	557	18.1.2.3	Data Propagation: Enterprise Application Integration (EAI)	596
17.3.4.1	Surrogate keys	557	18.1.2.4	Data Propagation: Enterprise Data Replication (EDR)	597
17.3.4.2	Granularity of the Fact Table	558	18.1.2.5	Changed Data Capture (CDC), Near-Real- Time ETL, and Event Processing	598
17.3.4.3	Factless Fact Tables	559	18.1.2.6	Data Virtualization	598
17.3.4.4	Optimizing the Dimension Tables	559	18.1.2.7	Data as a Service and Data in the Cloud	599
17.3.4.5	Defining Junk Dimensions	560	18.1.3	Data Services and Data Flows in the Context of Data and Process Integration	601
17.3.4.6	Defining Outtrigger Tables	561	18.1.3.1	Business Process Integration	602
17.3.4.7	Slowly Changing Dimensions	561	18.1.3.2	Patterns for Managing Sequence Dependencies and Data Dependencies in Processes	604
17.3.4.8	Rapidly Changing Dimensions	563	18.1.3.3	A Unified View on Data and Process Integration	606
17.4	The Extraction, Transformation, and Loading (ETL) Process	565	18.2	Searching Unstructured Data and Enterprise Search	610
17.5	Data Marts	567	18.2.1	Principles of Full-Text Search	610
17.6	Virtual Data Warehouses and Virtual Data Marts	569	18.2.2	Indexing Full-Text Documents	611
17.7	Operational Data Store	571	18.2.3	Web Search Engines	613
17.8	Data Warehouses versus Data Lakes	571	18.2.4	Enterprise Search	616
17.9	Business Intelligence	572	18.3	Data Quality and Master Data Management	617
17.9.1	Query and Reporting	573	18.4	Data Governance	618
17.9.2	Pivot Tables	573	18.4.1	Total Data Quality Management (TDQM)	619
17.9.3	On-Line Analytical Processing (OLAP)	574	18.4.2	Capability Maturity Model Integration (CMMI)	619
17.9.3.1	MOLAP	574	18.4.3	Data Management Body of Knowledge (DMBOK)	620
17.9.3.2	ROLAP	575			
17.9.3.3	HOLAP	575			
17.9.3.4	OLAP Operators	575			
17.9.3.5	OLAP Queries in SQL	577			
	Summary	583			
	Key Terms List	584			
	Review Questions	585			
	Problems and Exercises	587			
18	Data Integration, Data Quality, and Data Governance	590			
18.1	Data and Process Integration	591			
18.1.1	Convergence of Analytical and Operational Data Needs	591			
18.1.2	Data Integration and Data Integration Patterns	593			

18.4.4	Control Objectives for Information and Related Technology (COBIT)	620	20.4.5	Outlier Detection and Handling	672
18.4.5	Information Technology Infrastructure Library	621	20.5	Types of Analytics	673
18.5	Outlook	621	20.5.1	Predictive Analytics	673
18.6	Conclusion	622	20.5.1.1	Linear Regression	673
	Key Terms List	622	20.5.1.2	Logistic Regression	675
	Review Questions	623	20.5.1.3	Decision Trees	677
	Problems and Exercises	625	20.5.1.4	Other Predictive Analytics Techniques	681
19	Big Data	626	20.5.2	Evaluating Predictive Models	682
19.1	The 5 Vs of Big Data	627	20.5.2.1	Splitting Up the Dataset	682
19.2	Hadoop	630	20.5.2.2	Performance Measures for Classification Models	684
19.2.1	History of Hadoop	630	20.5.2.3	Performance Measures for Regression Models	687
19.2.2	The Hadoop Stack	631	20.5.2.4	Other Performance Measures for Predictive Analytical Models	688
19.2.2.1	The Hadoop Distributed File System	631	20.5.3	Descriptive Analytics	689
19.2.2.2	MapReduce	635	20.5.3.1	Association Rules	689
19.2.2.3	Yet Another Resource Negotiator	641	20.5.3.2	Sequence Rules	691
19.3	SQL on Hadoop	643	20.5.3.3	Clustering	692
19.3.1	HBase: The First Database on Hadoop	644	20.5.4	Social Network Analytics	695
19.3.2	Pig	648	20.5.4.1	Social Network Definitions	696
19.3.3	Hive	649	20.5.4.2	Social Network Metrics	696
19.4	Apache Spark	652	20.5.4.3	Social Network Learning	699
19.4.1	Spark Core	653	20.6	Post-Processing of Analytical Models	700
19.4.2	Spark SQL	654	20.7	Critical Success Factors for Analytical Models	701
19.4.3	Mllib, Spark Streaming, and GraphX	656	20.8	Economic Perspective on Analytics	702
19.5	Conclusion	659	20.8.1	Total Cost of Ownership (TCO)	702
	Key Terms List	660	20.8.2	Return on Investment	702
	Review Questions	660	20.8.3	In- versus Outsourcing	704
	Problems and Exercises	662	20.8.4	On-Premises versus Cloud Solutions	705
20	Analytics	664	20.8.5	Open-Source versus Commercial Software	706
20.1	The Analytics Process Model	665			
20.2	Example Analytics Applications	667			
20.3	Data Scientist Job Profile	668			
20.4	Data Pre-Processing	669			
20.4.1	Denormalizing Data for Analysis	669			
20.4.2	Sampling	670			
20.4.3	Exploratory Analysis	671			
20.4.4	Missing Values	671			

20.9 Improving the ROI of Analytics	708	20.10.3.2 SQL Views	719
20.9.1 New Sources of Data	708	20.10.3.3 Label-Based Access Control	719
20.9.2 Data Quality	711	20.10.4 Privacy Regulation	721
20.9.3 Management Support	712	20.11 Conclusion	723
20.9.4 Organizational Aspects	712	Key Terms List	724
20.9.5 Cross-Fertilization	713	Review Questions	725
20.10 Privacy and Security	714	Problems and Exercises	729
20.10.1 Overall Considerations Regarding Privacy and Security	714	Appendix Using the Online Environment	731
20.10.2 The RACI Matrix	715	Glossary	741
20.10.3 Accessing Internal Data	716	Index	770
20.10.3.1 Anonymization	717		