

Contents

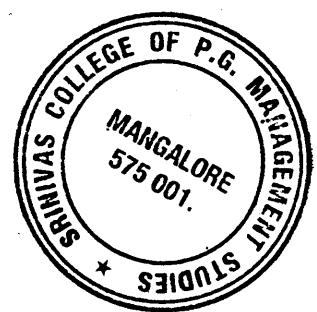
Preface xv

Chapter 1 **Basic Concepts 1**

- 1.1 Data Modeling for a Database 2**
 - 1.1.1 Entities and Their Attributes 3
 - 1.1.2 Relationships 7
- 1.2 Records and Files 7**
- 1.3 Abstraction and Data Integration 9**
- 1.4 The Three-Level Architecture Proposal for a DBMS 14**
 - 1.4.1 Mapping between Views 15
 - 1.4.2 Data Independence 17
- 1.5 Components of a DBMS 20**
 - 1.5.1 Classification of DBMS Users 20
 - 1.5.2 DBMS Facilities 21
 - 1.5.3 Structure of a DBMS 23
 - 1.5.4 Database Access 27
- 1.6 Advantages and Disadvantages of a DBMS 27**
 - 1.6.1 Advantages of a DBMS 27
 - 1.6.2 Disadvantages of a DBMS 29
- 1.7 Summary 30**
 - Key Terms* 31
 - Exercises* 32
 - Bibliographic Notes* 33
 - Bibliography* 33

Chapter 2 **Data Models 34**

- 2.1 Introduction 35**
- 2.2 Data Associations 35**
 - 2.2.1 Entities, Attributes, and Associations 36
 - 2.2.2 Relationships among Entities 41
 - 2.2.3 Representation of Associations and Relationships 44
- 2.3 Data Models Classification 45**
- 2.4 Entity-Relationship Model 46**
 - 2.4.1 Entities 47
 - 2.4.2 Relationships 49
 - 2.4.3 Representation of Entities 51
 - 2.4.4 Representation of Relationship Set 52
 - 2.4.5 Generalization and Aggregation 53
- 2.5 A Comparative Example 57**
- 2.6 Relational Data Model 59**
- 2.7 Network Data Model 63**
- 2.8 Hierarchical Model 67**
- 2.9 A Comparison 69**
- 2.10 Summary 72**
 - Key Terms* 72
 - Exercises* 72



6.6	Concluding Remarks	333
6.7	Summary	335
	<i>Key Terms</i>	335
	<i>Exercises</i>	336
	<i>Bibliographic Notes</i>	338
	<i>Bibliography</i>	338

Chapter 7

Synthesis Approach and Higher Order Normal Form 340

7.1	Problems in the Decomposition Approach	341
7.2	Normalization through Synthesis	342
7.2.1	Functional Dependencies and Semantics	342
7.2.2	Semantics of Nonfunctional Relationships	343
7.2.3	Synthesis Approach	343
7.2.4	Synthesis Algorithm	345
7.3	Multivalued Dependency	348
7.3.1	MVD and Normalization	352
7.3.2	Axioms for Functional and Multivalued Dependencies	353
7.3.3	Closure under MVDS	354
7.3.4	Fourth Normal Form	357
7.3.5	Lossless Join Decomposition into Fourth Normal Form	357
7.3.6	Enforceability of Dependencies in the Fourth Normal Form	360
7.4	Normalization Using Join Dependency: Fifth Normal Form	361
7.4.1	Join Dependencies	364
7.4.2	Project-Join Normal Form	366
7.5	Domain Key Normal Form	368
7.6	Summary	372
	<i>Key Terms</i>	373
	<i>Exercises</i>	373
	<i>Bibliographic Notes</i>	373
	<i>Bibliography</i>	374

Chapter 8

The Network Model 376

8.1	The Network Data Model	377
8.1.1	Expressing Relationship: The DBTG Set	378
8.1.2	Multiple Level Set Construct	380
8.1.3	Complex Multilevel Set Construct	382
8.2	DBTG Set Construct and Restrictions	384
8.2.1	Implementation of the DBTG Set Construct	385
8.3	Expressing an M:N Relationship in DBTG	386
8.4	Cycles in DBTG	391
8.4.1	Set Involving Only One Type of Record	391
8.4.2	Sets Involving Different Record Types in a Cycle	395
8.5	Data Description in the Network Model	395
8.5.1	Record	395
8.5.2	Set	397
8.5.3	Order of Members in a Set	398
8.5.4	Set Membership	399
8.5.5	Structural Constraint	402
8.5.6	Set Selection	402
8.5.7	Singular Sets	403
8.5.8	Area	403
8.6	Schema and Subschema	403
8.7	DBTG Data Manipulation Facility	405
8.7.1	Run Unit	405
8.7.2	Currency Indicators	406
8.7.3	Database Status Registers	406
8.7.4	Record Templates	407
8.7.5	DML Commands	407
8.8	Database Manipulation	407
8.8.1	Operations on Records	410
8.8.2	Operations on Sets	413
8.9	Concluding Remarks	421
8.10	Summary	421

<i>Key Terms</i>	422	10.3	General Strategies for Query Processing
<i>Exercises</i>	422	10.3.1	467
<i>Bibliographic Notes</i>	425	10.3.2	Query Representation 467
<i>Bibliography</i>	426		General Processing Strategies 469

Chapter 9

The Hierarchical Data Model 427

9.1	The Tree Concept	428
9.2	Hierarchical Data Model	430
9.2.1	Replication vs. Virtual Record	435
9.2.2	Expressing a Many-to-Many Relationship	436
9.2.3	Another Example of a Many-to-Many Relationship	438
9.3	Data Definition	441
9.4	Data Manipulation	443
9.4.1	User Work Area in the HDM	443
9.4.2	Basic Data Manipulation	444
9.4.3	Sequential Retrieval	444
9.4.4	Sequential Retrieval within a Hierarchy	446
9.5	Updates	447
9.5.1	Insert	448
9.5.2	Modification and Deletion	449
9.5.3	Updates of Virtual Records	450
9.6	Implementation of the Hierarchical Database	451
9.7	Additional Features of the Hierarchical DML	453
9.8	Concluding Remarks	455
9.9	Summary	456
	<i>Key Terms</i>	457
	<i>Exercises</i>	457
	<i>Bibliographic Notes</i>	459
	<i>Bibliography</i>	459

Chapter 10

Query Processing 460

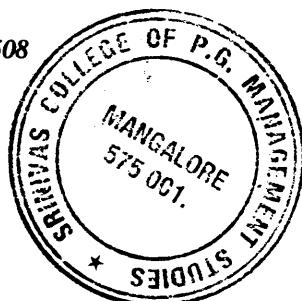
10.1	Introduction	461
10.2	An Example	463

10.3	General Strategies for Query Processing
10.3.1	Query Representation 467
10.3.2	General Processing Strategies 469
10.4	Transformation into an Equivalent Expression
10.5	Expected Size of Relations in the Response
10.5.1	Selections 476
10.5.2	Projection 477
10.5.3	Join 478
10.6	Statistics in Estimation
10.7	Query Improvement
10.8	Query Evaluation
10.8.1	One-Variable Expressions 486
10.8.2	Two-Variable Expressions 488
10.8.3	N-Variable Expressions 496
10.8.4	Access Plan 501
10.9	Evaluation of Calculus Expressions
10.10	View Processing
10.11	A Typical Query Processor
10.12	Summary
	<i>Key Terms</i>
	<i>Exercises</i>
	<i>Bibliographic Notes</i>
	<i>Bibliography</i>

Chapter 11

Recovery 510

11.1	Reliability	511
11.1.1	Types of Failures	513
11.1.2	Types of Errors in Database Systems and Possible Detection Schemes	515
11.1.3	Audit Trails	516
11.1.4	Recovery Schemes	516
11.2	Transactions	517
11.2.1	States of a Transaction	521
11.2.2	Properties of a Transaction	523



11.2.3	Failure Anticipation and Recovery 523	12.3	Concurrency Control 569
11.3	Recovery in a Centralized DBMS 524	12.4	Locking Scheme 570
11.3.1	Logs 524	12.4.1	Two-Phase Locking 574
11.3.2	Checkpoints 526	12.4.2	Granularity of Locking 576
11.3.3	Archival Database and Implementation of the Storage Hierarchy of a Database System 529	12.4.3	Hierarchy of Locks and Intention-Mode Locking 576
11.3.4	Do, Undo, and Redo 530	12.4.4	Tree-Locking Protocol 581
11.4	Reflecting Updates to the Database and Recovery 532	12.4.5	DAG Database Storage Structure 582
11.4.1	Update in Place 533	12.5	Timestamp-Based Order 583
11.4.2	Indirect Update and Careful Replacement 538	12.6	Optimistic Scheduling 588
11.5	Buffer Management, Virtual Memory, and Recovery 544	12.7	Multiversion Techniques 591
11.6	Other Logging Schemes 546	12.8	Deadlock and Its Resolution 594
11.7	Cost Comparison 547	12.8.1	Deadlock Detection and Recovery 594
11.8	Disaster Recovery 548	12.8.2	Deadlock Avoidance 599
11.9	Summary 549	12.9	Atomicity, Concurrency, and Recovery 603
	<i>Key Terms 550</i>	12.10	Summary 603
	<i>Exercises 551</i>		<i>Key Terms 605</i>
	<i>Bibliographic Notes 552</i>		<i>Exercises 605</i>
	<i>Bibliography 552</i>		<i>Bibliographic Notes 607</i>

Chapter 12

Concurrency Management 554

12.1	Introduction 555
12.1.1	Lost Update Problem 557
12.1.2	Inconsistent Read Problem 558
12.1.3	The Phantom Phenomenon 560
12.1.4	Semantics of Concurrent Transactions 561
12.2	Serializability 562
12.2.1	Precedence Graph 565
12.2.2	Serializability Algorithm: Read-before-Write Protocol 567
12.2.3	Serializability Algorithm: Read-Only and Write-Only Protocols 569

Chapter 13

Database Security, Integrity, and Control 610

13.1	Introduction 611
13.2	Security and Integrity Threats 612
13.3	Defense Mechanisms 614
13.3.1	Security Policies 615
13.3.2	Authorization 619
13.3.3	Identification and Authentication 625
13.3.4	Views/Subschemes in Security Enforcement 626
13.3.5	Distributed Systems 626
13.3.6	Cryptography and Encryption 627

13.4	Integrity 629	14.9	Summary 655
13.4.1	Domain or Data-Item Value Integrity Rules 630		<i>Key Terms 656</i>
13.4.2	Implicit and Data Dependency Constraints 632		<i>Exercises 656</i>
13.4.3	Violation of Integrity Constraints and Corrective Action 634		<i>Bibliographic Notes 658</i>
13.4.4	A General Model of Integrity 634		<i>Bibliography 658</i>
13.4.5	Expressing Integrity Constraints 635		
13.5	Statistical Databases 636		
13.6	Auditing and Control 639		
13.7	Summary 640		
	<i>Key Terms 641</i>		
	<i>Exercises 641</i>		
	<i>Bibliographic Notes 642</i>		
	<i>Bibliography 643</i>		
 Chapter 14			
Database Design 644			
14.1	The Organization and Its Information System 645		
14.2	Phase I: Definition of the Problem 645		
14.3	Phase II: Analysis of Existing System and Procedures 646		
14.4	Phase III: Preliminary Design 648		
14.5	Phase IV: Computing System Decision 649		
14.6	Phase V: Final Design 650		
14.6.1	Designing the Conceptual Database—Relational DBMS 650	15.3.1	Fragmentation 672
14.6.2	Designing the Conceptual Database—Network DBMS 652	15.3.2	Replication 676
14.6.3	Designing the Conceptual Database—Hierarchical DBMS 652	15.3.3	Transparency 676
14.6.4	Designing the Physical Database 652	15.3.4	System Catalogs 677
14.7	Phase VI: Implementation and Testing 654	15.4	Object Naming 678
14.8	Phase VII: Operation and Tuning 655	15.5	Distributed Query Processing 679
		15.5.1	Parallelism in Distributed Query Processing 681
		15.5.2	Semijoin 681
		15.5.3	Semijoin and Reduction of Relations 684
		15.5.4	Concluding Remarks 686
		15.6	Consistency 686
		15.7	Concurrency Control 688
		15.7.1	Distributed Locking 688
		15.7.2	Timestamp-Based Concurrency Control 692
		15.8	Distributed Commitment and Recovery 694
		15.8.1	Two-Phase Commit 695
		15.8.2	Recovery with Two-Phase Commit 698
		15.9	Deadlocks in Distributed Systems 700
		15.9.1	Deadlock Detection by Probe Computation 702

15.9.2	Deadlock Prevention 705	16.8	Object Databases 755
15.10	Security and Protection 705	16.8.1	Pros and Cons of the Object Approach in Databases 757
15.11	Homogeneous and Heterogeneous Systems 705	16.9	Summary 758
15.11.1	The Homogeneous DDBMS 707		<i>Key Terms 759</i>
15.11.2	The Heterogeneous DDBMS 710		<i>Exercises 759</i>
15.12	Summary 715		<i>Bibliographic Notes 761</i>
	<i>Key Terms 716</i>		<i>Bibliography 761</i>
	<i>Exercises 716</i>		
	<i>Bibliographic Notes 718</i>		
	<i>Bibliography 719</i>		

Chapter 16

Current Topics in Database Research 721

16.1	What Is a Knowledge Base System? 722
16.2	Knowledge Base and Database Systems: A Comparison 723
16.3	Knowledge and Its Representation 724
16.3.1	Semantic Networks 726
16.3.2	First-Order Logic (Predicate Logic) 729
16.3.3	Frames 732
16.3.4	Rule-Based Systems (Production Systems) 733
16.3.5	Procedural Representation 736
16.4	Deductive Databases 737
16.5	Expert Systems 742
16.6	Expert Database Systems: Integration of Expert Systems in Database Applications 746
16.7	Object Approach 747
16.7.1	Concept of the Object 749
16.7.2	Names and Identity 750
16.7.3	Database and Identity 752
16.7.4	Implementation of Object Identifiers 752
16.7.5	Object Class and Instantiation 753
16.7.6	Inheritance 753

Chapter 17

Database Machines 766

17.1	Introduction 767
17.2	Database Machine Taxonomy 767
17.2.1	Backend Software Approach 768
17.2.2	Processor Associated with Memory or Intelligent Memory Approach 770
17.2.3	Special Hardware Approach 772
17.3	DBC/1012 Overview and Features 774
17.3.1	Operation of the DBC/1012 780
17.3.2	System Facilities of the DBC/1012 781
17.4	Summary 781
	<i>Key Terms 782</i>
	<i>Bibliographic Notes 782</i>
	<i>Bibliography 782</i>

Appendix 3.1	Sequence 785
Appendix 3.2	Average Seek Distance Computation 789
Appendix 3.3	Rotational Delay (Latency) 791
Appendix 3.4	Probabilities of Access 793
Appendix 4.1	Formal Definitions of Some Relational Algebraic Operations 795
Appendix 4.2	Recursive Queries: Transitive Closure 799
Appendix 5.1	Syntax of SQL 801
Appendix 5.2	Syntax of QL 803
Index	805