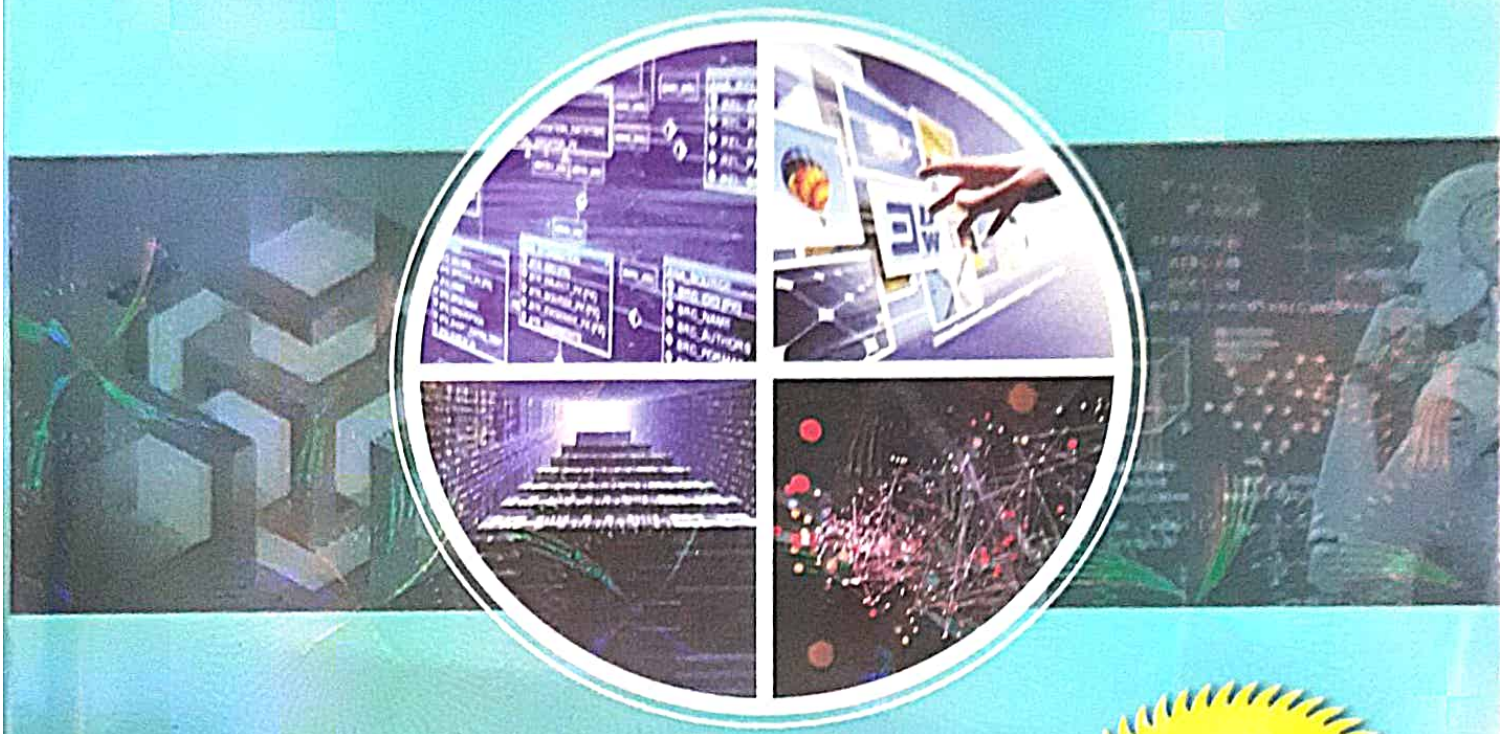
Quantum Series

ENGINEERING

QUANTUM *Series*

Semester - 5 CS & IT

Database Management System



- Topic-wise coverage of entire syllabus in Question-Answer form.
- Short Questions (2 Marks)

Session 2024-25 Odd Semester

Includes solution of following AKTU Question Papers

2020-21 • 2021-22 • 2022-23 • 2023-24

CONTENTS

BCS–501 : Database Management System

PART-1

Overview, Database System vs File System, Database System Concept and Architecture.

Que 1.1. What is database management system (DBMS) ? What are the tasks performed by users in DBMS ?

Answer

1. Database management system (DBMS) is a software which is use to manage the database. For example, MySQL, Oracle, are commercial database which is used in different applications.
2. DBMS provides an interface to perform various operations like database creation, storing data, updating data, creating a table in the database etc.
3. It provides protection and security to the database. In case of multiple users, it also maintains data consistency.

DBMS allows users the following tasks :

1. **Data definition :** It is used for creation, modification, and removal of database objects that defines the organization of data in the database.
2. **Data updation :** It is used for the insertion, modification, and deletion of the actual data in the database.
3. **Data retrieval :** It is used to retrieve the data from the database which can be used by applications for various purposes.
4. **User administration :** It is used for registering and monitoring users, maintaining data integrity, enforcing data security, dealing with concurrency control, monitoring performance and recovering information corrupted by unexpected failure.

Que 1.2. What are the advantages and disadvantages of DBMS ?

Answer

Advantages of DBMS :

1. **Database redundancy :** It controls data redundancy because it stores all the data in one single database file and that recorded data is placed in the database.
2. **Data sharing :** In DBMS, the authorized users of an organization can share the data among multiple users.
3. **Easy maintenance :** It can be easily maintainable due to the centralized nature of the database system.

4. **Reduce time :** It reduces development time and maintenance need.
5. **Backup :** It provides backup and recovery subsystems which create automatic backup of data from hardware and software failures and restores the data if required.
6. **Multiple user interface :** It provides different types of user interfaces like graphical user interface, application program interface.

Disadvantages of DBMS :

1. **Cost of hardware and software :** It requires high speed of data processor and large memory size to run DBMS software.
2. **Size :** It occupies a large space of disks and large memory to run efficiently.
3. **Complexity :** Database system creates additional complexity and requirements.
4. **Higher impact of failure :** Failure is highly impacted the database because in most of the organization, all the data stored in a single database and if the database is damaged due to electric failure or database corruption then the data may be lost forever.

Que 1.3. What do you understand by database users ? Describe the different types of database users.

Answer

Database users are the one who use and take the benefits of database. The different types of users depending on the need and way of accessing the database are :

1. **Application programmers :**
   a. They are the developers who interact with the database by means of DML queries.
   b. These DML queries are written in the application programs like C, C++, JAVA, Pascal etc.
   c. These queries are converted into object code to communicate with the database.
2. **Sophisticated users :**
   a. They are database developers, who write SQL queries to select/ insert/delete/update data.
   b. They directly interact with the database by means of query language like SQL.
   c. These users can be scientists, engineers, analysts who thoroughly study SQL and DBMS to apply the concepts in their requirement.
3. **Specialized users :**
   a. These are also sophisticated users, but they write special database application programs.

b. They are the developers who develop the complex programs according to the requirement.

4. **Standalone users :**
   a. These users will have standalone database for their personal use.
   b. These kinds of database will have predefined database packages which will have menus and graphical interfaces.

5. **Native users :**
   a. These are the users who use the existing application to interact with the database.
   b. For example, online library system, ticket booking systems, ATMs etc.

Que 1.4. Who are data administrators ? What are the functions of database administrator ?

OR

Discuss the role of database administrator.

Answer

Database administrators are the personnel's who has control over data and programs used for accessing the data.

Functions/role of database administrator (DBA) :

1. **Schema definition :**
   a. Original database schema is defined by DBA.
   b. This is accomplished by writing a set of definitions, which are translated by the DDL compiler to a set of labels that are permanently stored in the data dictionary.

2. **Storage structure and access method definition :**
   a. The creation of appropriate storage structure and access method.
   b. This is accomplished by writing a set of definitions, which are translated by the data storage and definition language compiler.

3. **Schema and physical organization and modification :**
   a. Modification of the database schema or the description of the physical storage organization.
   b. These changes are accomplished by writing a set of definition to do modification to the appropriate internal system tables.

4. **Granting of authorization for data access :** DBA grants different types of authorization for data access to the various users of the database.

5. **Integrity constraint specification :** DBA carry out data administration in data dictionary such as defining constraints.

Que 1.5. **What is data abstraction ? Explain different levels of abstraction.**

OR

What is data abstraction ? How the data abstraction is achieved in DBMS ? **AKTU 2020-21, Marks 10**

OR

Discuss three level of abstractions or schemas architecture of DBMS. **AKTU 2023-24, Marks 10**

Answer

Data abstraction is the process of finding irrelevant details from user *i.e.*, hiding the background details from the users.

Different levels of data abstraction :

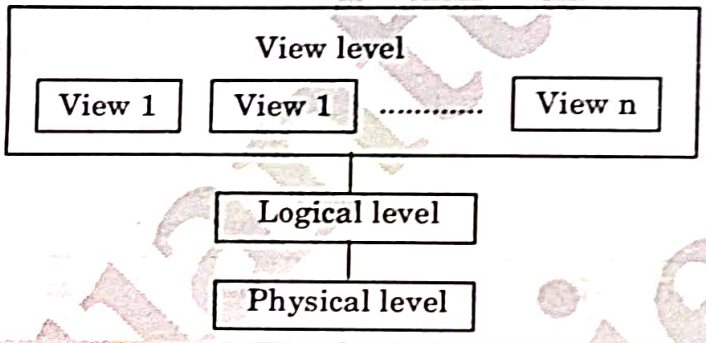


Fig. 1.5.1. The three levels of data abstraction.

1. **Physical level :**
   i. Physical level is the lowest level of abstraction and describes how the data are actually stored.
   ii. The physical level describes the complex low-level data structures in details.
2. **Logical level :**
   i. Logical level is the next-higher level of abstraction and it describes what data are stored in the database, and what relationship exists among those data.
   ii. The logical level thus describes the entire database in terms of a small number of relatively simple structures.
3. **View level :**
   i. View level is the highest level of abstraction; it describes only part of the entire database.
   ii. The view level of abstraction exists to simplify their interaction with the system.
   iii. The system may provide many views for the same database.

Que 1.6. **Explain the differences between physical level, conceptual level and view level of data abstraction.**

Answer

S. No.	Aspect	Physical level	Conceptual level	View level
1.	Focus	How data is stored on disk (e.g., indexing, files)	Logical structure of the database (entities, relationships).	Tailored representation of data for users.
2.	Abstraction	Lowest level; describes storage details.	Middle level; defines what data is stored and how.	Highest level; shows data specific to user needs.
3.	Data Access	Describes data storage mechanisms.	Defines entities, relationships, and constraints.	Allows limited access to certain data.
4.	Complexity	Highly complex.	Medium complexity.	Simplified, user-friendly.
5.	Security/ Privacy	Low-level control over data storage.	Provides a unified logical view of data.	Restricts access to sensitive information.

Que 1.7. **Explain the difference between database management system (DBMS) and file system.**

Answer

S. No.	Basis	DBMS	File System
1.	Meaning	In DBMS, the user is not required to write the procedures.	In this system, the user has to write the procedures for managing the database.
2.	Sharing of data	Due to the centralized approach, data sharing is easy.	Data is distributed in many files, and it may be of different formats, so it isn't easy to share data.

3.	Data Abstraction	DBMS gives an abstract view of data that hides the details.	The file system provides the detail of the data representation and storage of data.
4.	Security and Protection	DBMS provides a good protection mechanism.	It isn't easy to protect a file under the file system.
5.	Cost	The database system is expensive to design.	The file system approach is cheaper to design.

Que 1.8. Discuss the architecture of DBMS. What are the types of DBMS architecture ?

Answer

1. The DBMS design depends upon its architecture. The basic client/ server architecture is used to deal with a large number of PCs, web servers, database servers and other components that are connected with networks.
2. DBMS architecture depends upon how users are connected to the database to get their request done.

Types of DBMS architecture :

i. 1-Tier architecture :

1. In this architecture, the database is directly available to the user.
2. Any changes done are directly done on the database itself. It does not provide a handy tool for end users.
3. The 1-Tier architecture is used for development of the local application, where programmers can directly communicate with the database for the quick response.

ii. 2-Tier architecture :

1. The 2-Tier architecture is same as basic client-server.
2. In the two-tier architecture, applications on the client end can directly communicate with the database at the server side. For this interaction, API's such as : ODBC, JDBC are used.
2. The user interfaces and application programs are run on the client-side.
3. The server side is responsible to provide the functionalities like query processing and transaction management.
4. To communicate with the DBMS, client-side application establishes a connection with the server side.

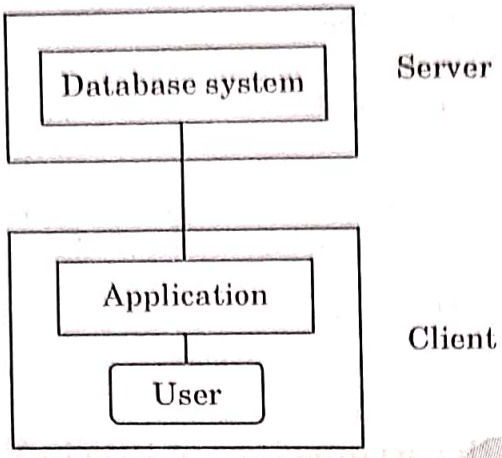


Fig. 1.8.1. 2-Tier architecture.

iii. 3-Tier architecture :

1. The 3-Tier architecture contains another layer between the client and server. In this architecture, client cannot directly communicate with the server.
2. The application on the client-end interacts with an application server which further communicates with the database system.
3. End user has no idea about the existence of the database beyond the application server. The database also has no idea about any other user beyond the application.
4. The 3-Tier architecture is used in case of large web application.

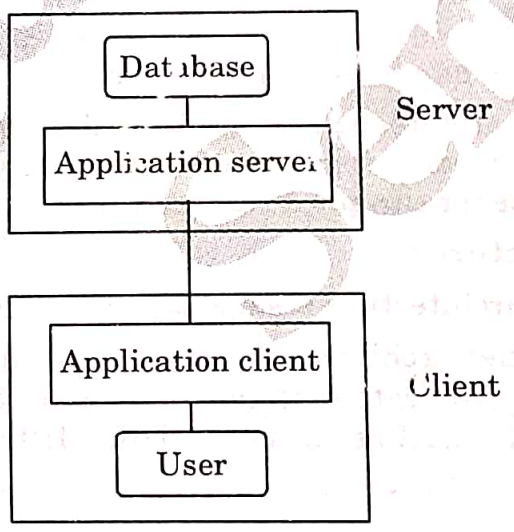


Fig. 1.8.2. 3-Tier architecture.

Que 1.9. Discuss the role of database administrator and explain the database architecture. **AKTU 2023-24, Marks 10**

Answer

Role of Database Administrator : Refer Q. 1.4, Page 1–4A, Unit-1.

Database Architecture : Refer Q. 1.8, Page 1–7A, Unit-1.

PART-2

Data Model Schema and Instances.

Que 1.10. What are data models ? Briefly explain different types of data models.

OR

What are the different types of Data Models in DBMS ? Explain them.

AKTU 2021-22, Marks 10

AKTU 2022-23, Marks 10

Answer

Data models :

1. Data models define how the logical structure of the database is modeled.
2. Data models are a collection of conceptual tools for describing data, data relationships, data semantics and consistency constraints.
3. Data models define how data is connected to each other and how they are processed and stored inside the system.

Types of data models :

1. **Entity relationship model :**
   a. The entity relationship (ER) model consists of a collection of basic objects, called entities and of relationships among these entities.
   b. Entities are represented by means of their properties, called attributes.

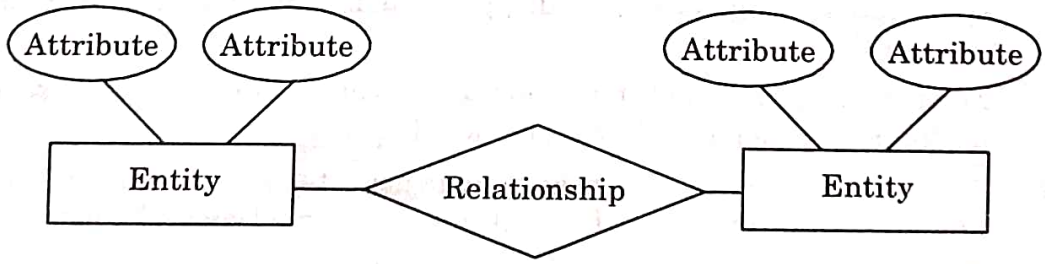


Fig. 1.10.1. The ER model.

2. **Relational model :**
   a. The relational model represents data and relationships among data by a collection of tables, each of which has a number of columns with unique names.
   b. Relational data model is used for data storage and processing.
   c. This model is simple and it has all the properties and capabilities required to process data with storage efficiency.
3. **Hierarchical model :**
   a. In hierarchical model data elements are linked as an inverted tree structure (root at the top with branches formed below).
   b. Below the single root data element are subordinate elements each of which in turn has its own subordinate elements and so on, the tree can grow to multiple levels.
   c. Data element has parent child relationship as in a tree.
4. **Network model :**
   a. This model is the extension of hierarchical data model.
   b. In this model there exist a parent child relationship but a child data element can have more than one parent element or no parent at all.
5. **Object-oriented model :**
   a. Object-oriented models were introduced to overcome the shortcomings of conventional models like relational, hierarchical and network model.
   b. An object-oriented database is collection of objects whose behaviour, state, and relationships are defined in accordance with object-oriented concepts (such as objects, class, etc.).

Que 1.11. Describe data schema and instances.

Answer

1. The description of a database is called the database schema, which specified during database design and is not expected to change frequently.
2. Most of the data models have certain convention for displaying schema as diagram which is called as schema diagram.
3. A schema diagram displays only some aspects of a schema, such as the names of record types and data items, and some types of constraints.

   For example : Schema diagram for studentinfo database

   Student (Name, Student_number, Class, Branch)

   Course (Course_name, Course_number, Department)

Instances :

1. The data in the database at a particular moment is called a database state or snapshot. It is also called the current set of occurrences or instances in the database.
2. In a database state, each schema construct has its own current set of instances.
3. Many database states can be constructed to correspond to a particular database schema. Every time we insert or delete a record or change the value of a data item in a record, we change one state of the database into another state.

PART-3

Data Independence and Database Language and Interfaces, Data Definition Language, DML.

Que 1.12. Describe data independence with its types.

Answer

Data independence : Data independence is defined as the capacity to change the schema at one level of a database system without having to change the schema at the next higher level.

Types of data independence :

1. **Physical data independence :**
   a. Physical data independence is the ability to modify internal schema without changing the conceptual schema.
   b. Modification at the physical level is occasionally necessary in order to improve performance.
   c. It refers to the immunity of the conceptual schema to change in the internal schema.
   d. Examples of physical data independence are reorganizations of files, adding a new access path or modifying indexes, etc.
2. **Logical data independence :**
   a. Logical data independence is the ability to modify the conceptual schema without having to change the external schemas or application programs.
   b. It refers to the immunity of the external model to changes in the conceptual model.
   c. Examples of logical data independence are addition/removal of entities.

Que 1.13. **Describe the classification of database language. Which type of language is SQL ?**

OR

Discuss the following terms (i) DDL Command (ii) DML command.

Answer

Classification of database languages :

1. **Data Definition Language (DDL) :**
   a. DDL is set of SQL commands used to create, modify and delete database structures but not data.
   b. They are used by the DBA to a limited extent, a database designer, or application developer.
   c. Create, drop, alter, truncate are commonly used DDL command.
2. **Data Manipulation Language (DML) :**
   a. A DML is a language that enables users to access or manipulates data as organized by the appropriate data model.
   b. There are two types of DMLs :
      i. **Procedural DMLs :** It requires a user to specify what data are needed and how to get those data.
      ii. **Declarative DMLs (Non-procedural DMLs) :** It requires a user to specify what data are needed without specifying how to get those data.
   c. Insert, update, delete, query are commonly used DML commands.
3. **Data Control Language (DCL) :**
   a. It is the component of SQL statement that control access to data and to the database.
   b. Commit, rollback command are used in DCL.
4. **Data Query Language (DQL) :**
   a. It is the component of SQL statement that allows getting data from the database and imposing ordering upon it.
   b. It includes select statement.
5. **View Definition Language (VDL) :**
   1. VDL is used to specify user views and their mapping to conceptual schema.
   2. It defines the subset of records available to classes of users.
   3. It creates virtual tables and the view appears to users like conceptual level.
   4. It specifies user interfaces.

SQL is a DML language.

Que 1.14. **State the procedural DML and non-procedural DML with their differences.**

AKTU 2021-22, Marks 10

AKTU 2023-24, Marks 10

Answer

Procedural and non-procedural DML : Refer Q. 1.13, Page 1–12A, Unit-1.

Difference :

S. No.	Procedural DML	Non-procedural DML
1.	It is command-driven language.	It is a function-driven language.
2.	It works through the state of machine.	It works through the mathematical functions.
3.	Its semantics are quite tough.	Its semantics are very simple.
4.	It returns only restricted data types and allowed values.	It can return any data type or value.
5.	Overall efficiency is very high.	Overall efficiency is low as compared to Procedural Language.

Que 1.15. **Explain all database languages in detail with example.**

Answer

Database languages : Refer Q. 1.13, Page 1–12A, Unit-1.

Examples :

DDL :

CREATE, ALTER, DROP, TRUNCATE, COMMENT, GRANT, REVOKE statement

DML :

INSERT, UPDATE, DELETE statement

DCL :

GRANT and REVOKE statement

DQL :

SELECT statement

VDL :

1. create view emp5 as
   select * from employee
   where dno = 5 ;
   Creates view for dept 5 employees.

2. create view empdept as
select fname, lname, dno, dname
from employee, department
where dno=dnumber ;
Creates view using two tables.

Que 1.16. Explain DBMS interfaces. What are the various DBMS interfaces ?

Answer

DBMS interfaces : A database management system (DBMS) interface is a user interface which allows for the ability to input queries to a database without using the query language itself.

Various DBMS interfaces are :

1. **Menu-based interfaces for web clients or browsing :**
   a. These interfaces present the user with lists of options (called menus) that lead the user through the formulation of a request.
   b. Pull-down menus are a very popular technique in Web-based user interfaces.
   c. They are also often used in browsing interfaces, which allow a user to look through the contents of a database in an exploratory and unstructured manner.
2. **Forms-based interfaces :**
   a. A forms-based interface displays a form to each user.
   b. Users can fill out all of the form entries to insert new data, or they can fill out only certain entries, in which the DBMS will retrieve matching data for the remaining entries.
3. **Graphical user interfaces (GUI) :**
   a. A GUI typically displays a schema to the user in diagrammatic form.
   b. The user then can specify a query by manipulating the diagram. In many cases, GUIs utilize both menus and forms.
4. **Natural language interfaces :**
   a. A natural language interface has its own schema, which is similar to the database conceptual schema, as well as a dictionary of important words.
   b. The natural language interface refers to the words in its schema, as well as to the set of standard words in its dictionary to interpret the request.
   c. If the interpretation is successful, the interface generates a high-level query corresponding to the natural language request and submits it to the DBMS for processing; otherwise, a dialogue is started with the user to clarify the request.

5. **Speech input and output :**
   a. The speech input is detected using a library of predefined words and used to set up the parameters that are supplied to the queries.
   b. For output, a similar conversion from text or numbers into speech takes place.
6. **Interfaces for the DBA :**
   a. Most database systems contain privileged commands that can be used only by the DBA's staff.
   b. These include commands for creating accounts, setting system parameters, granting account authorization, changing a schema, and reorganizing the storage structures of a database.

PART-4

Overall Database Structure.

Que 1.17. Briefly describe the overall structure of DBMS.

OR

Draw the overall structure of DBMS and explain its various components. **AKTU 2021-22, Marks 10**

Answer

A database system is partitioned into modules that deal with each of the responsibilities of the overall system. The functional components of a database system can be broadly divided into two components :

1. **Storage Manager (SM) :** A storage manager is a program module that provides the interface between the low level data stored in the database and the application programs and queries submitted to the system. The SM components include :
   a. **Authorization and integrity manager :** It tests for the satisfaction of integrity constraints and checks the authority of users to access data.
   b. **Transaction manager :** It ensures that the database remains in a consistent state despite of system failures and that concurrent transaction executions proceed without conflicting.
   c. **File manager :** It manages the allocation of space on disk storage and the data structures are used to represent information stored on disk.
   d. **Buffer manager :** It is responsible for fetching data from disk storage into main memory and deciding what data to cache in main memory. The buffer manager is a critical part of the database system, since it enables the database to handle data sizes that are much larger than the size of main memory.

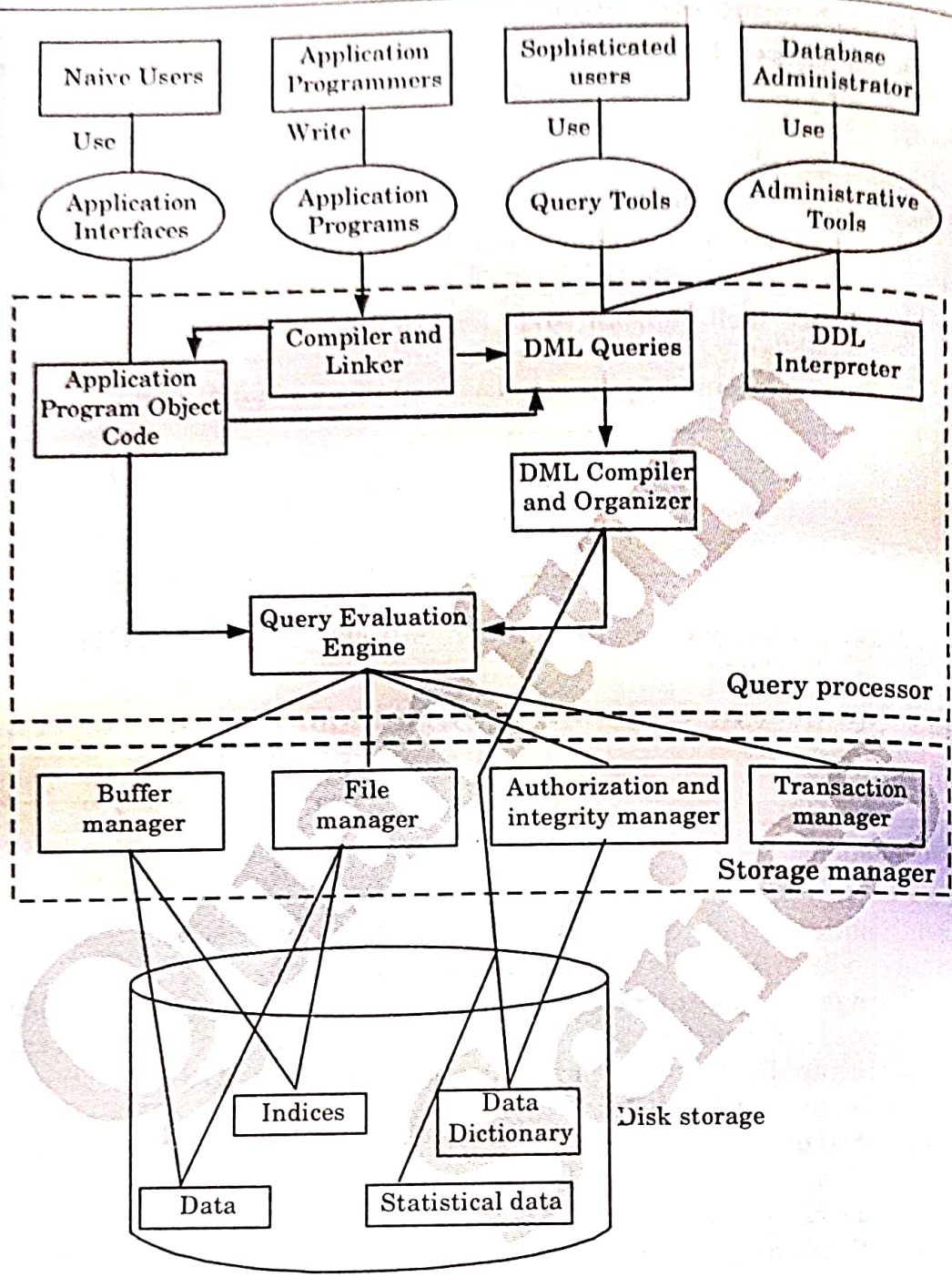


Fig. 1.17.1. Overall database structure.

2. **Query Processor (QP) :** The Query Processor (Query Optimizer) is responsible for taking every statement sent to SQL Server and figure out how to get the requested data or perform the requested operation.

   The QP components are :

   a. **DDL interpreter :** It interprets DDL statements and records the definition in data dictionary.

   b. **DML compiler :** It translates DML statements in a query language into an evaluation plan consisting of low-level instructions that the query evaluation engine understands.

c. **Query optimization :** It picks the lowest cost evaluation plan from among the alternatives.

d. **Query evaluation engine :** It executes low-level instructions generated by the DML compiler.

PART-5

Data Modeling using the Entity Relationship Model : ER Model Concepts, Notation for ER Diagram, Mapping Constraints.

Que 1.18. What is ER model ? What are the elements of ER model ?

OR

What are the notations of ER diagram ?

Answer

An entity relationship model (ER model) is a way of representing the entities and the relationships between the entities in order to create a database.

Elements/notation of ER model/diagram :

1. **Entity :**
   a. An entity is a real world object that can be easily identifiable.
   b. An entity can be abstract.
   c. An entity is an object that exists and is distinguishable from other objects.
2. **Entity set :**
   a. Entity set is a collection of similar type of entities.
   b. An entity set may contain entities with attribute sharing similar values.
3. **Attribute :**
   a. An attribute gives the characteristics of the entity.
   b. It is also called as data element, data field, a field, a data item, or an elementary item.
4. **Relationship :**
   a. A relationship is the association between entities or entity occurrence.
   b. Relationship is represented by diamond with straight lines connecting the entities.

Que 1.19. What do you understand by attributes and domain ? Explain various types of attributes used in conceptual data model.

Answer

Attributes :

1. Attributes are properties which are used to represent the entities.
2. All attributes have values. For example, a student entity may have name, class, and age as attributes.
3. There exists a domain or range of values that can be assigned to attributes.
4. For example, a student's name cannot be a numeric value. It has to be alphabetic. A student's age cannot be negative, etc.

Domain :

1. A domain is an attribute constraint which determines the type of data values that are permitted for that attribute.
2. Attribute domains can be very large, or very short.

Types of attributes used in conceptual data model :

1. **Simple attribute :** Simple attributes are atomic values, which cannot be divided further. For example, a student's phone number is an atomic value of 10 digits.
2. **Composite attribute :** Composite attributes are made of more than one simple attribute. For example, a student's complete name may have first_name and last_name.
3. **Derived attribute :** Derived attributes are the attributes that do not exist in the physical database, but their values are derived from other attributes present in the database. For example, average_salary in a department should not be saved directly in the database, instead it can be derived.
4. **Single-value attribute :** Single-value attributes contain single value. For example, Social_Security_Number.
5. **Multi-value attribute :** Multi-value attributes may contain more than one values. For example, a person can have more than one phone number, email_address, etc.

Que 1.20. **What is ER diagram ? Explain different components of an ER diagram with their notation. Also make an ER diagram for employee project management system.** **AKTU 2020-21, Marks 10**

OR

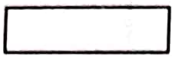
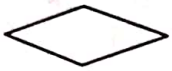
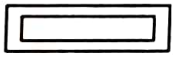
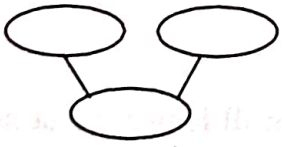
What is ER diagram ? Explain different components of an ER diagram with employee project management system.

AKTU 2023-24, Marks 10

Answer

ER diagram : An entity relationship diagram (ERD) is a graph based on the ER model. ER diagrams can be used to visually represent the structure of a database.

Components of ER diagram :

1.  → Entity
2.  → Relationship
3.  → Attribute
4.  → Weak entity
5.  → Weak entity relationship
6.  → Multivalued attribute
7.  → Derived attribute
8.  → Key attribute
9.  → Composite attribute

ER diagram for employee project management system :

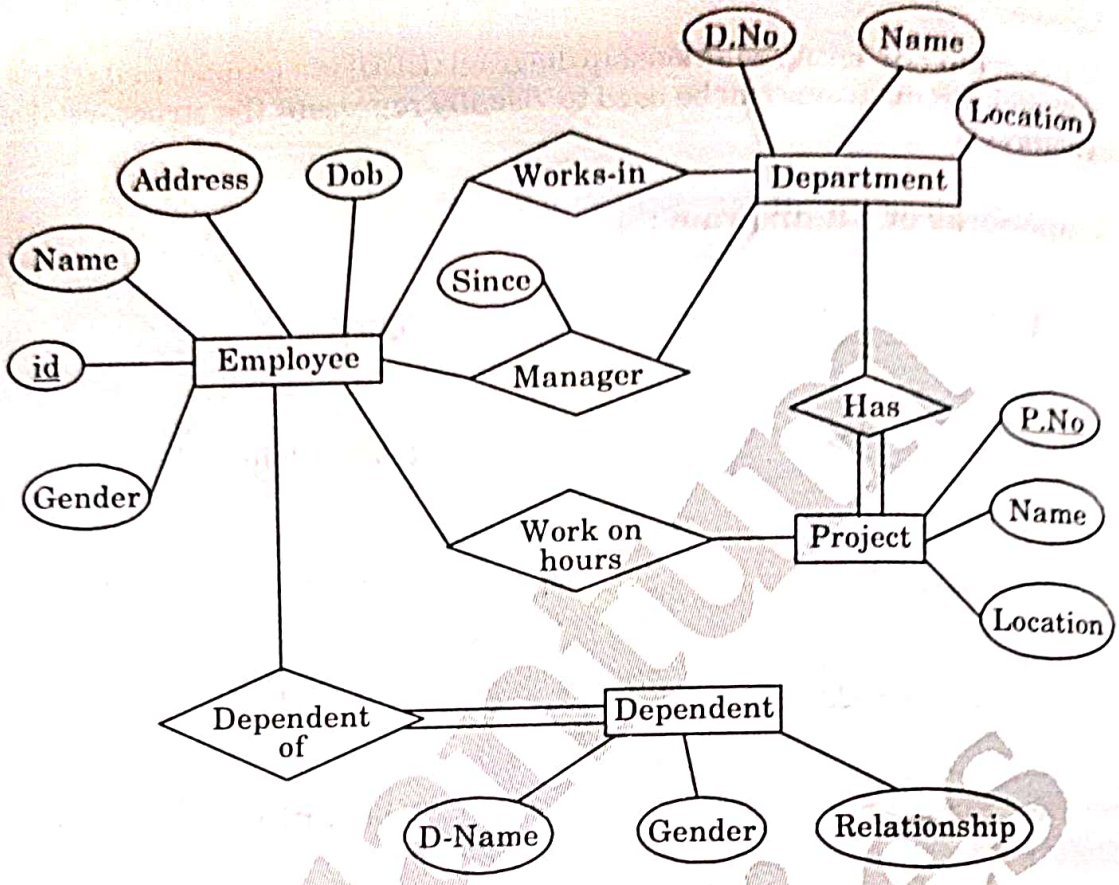


Fig. 1.20.3.

Que 1.21. What is purpose of the ER diagram ? Construct an ER diagram for a University system which should include information about students, departments, professors, courses, which students are enrolled in which course, which professors are teaching which courses, student grades, which course a department offers.

Answer

Purpose of the ER diagram :

1. ER diagram is used to represent the overall logical structure of the database.

2. ER diagrams emphasis on the schema of the database and not on the instances because the schema of the database is changed rarely.

3. It is useful to communicate the logical structure of database to end users.

4. It serves as a documentation tool.

5. It helps the database designer in understanding the information to be contained in the database.

ER diagram :

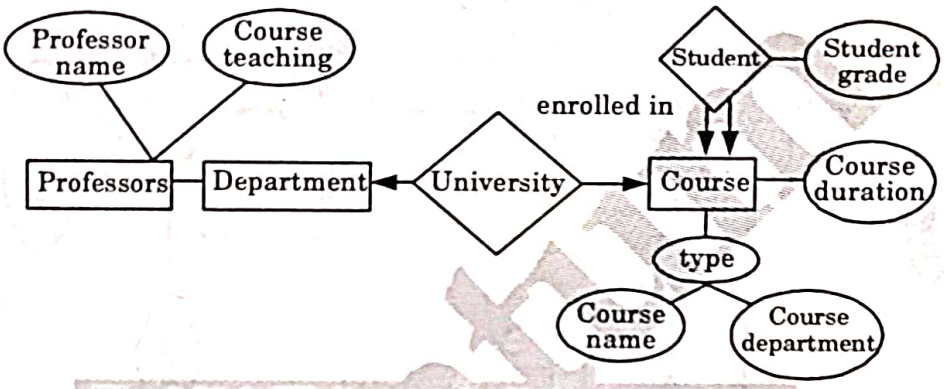


Fig. 1.21.1. ER diagram for University system.

Que 1.22. Draw an ER diagram for a small marketing company database, assuming your own data requirements.

Answer

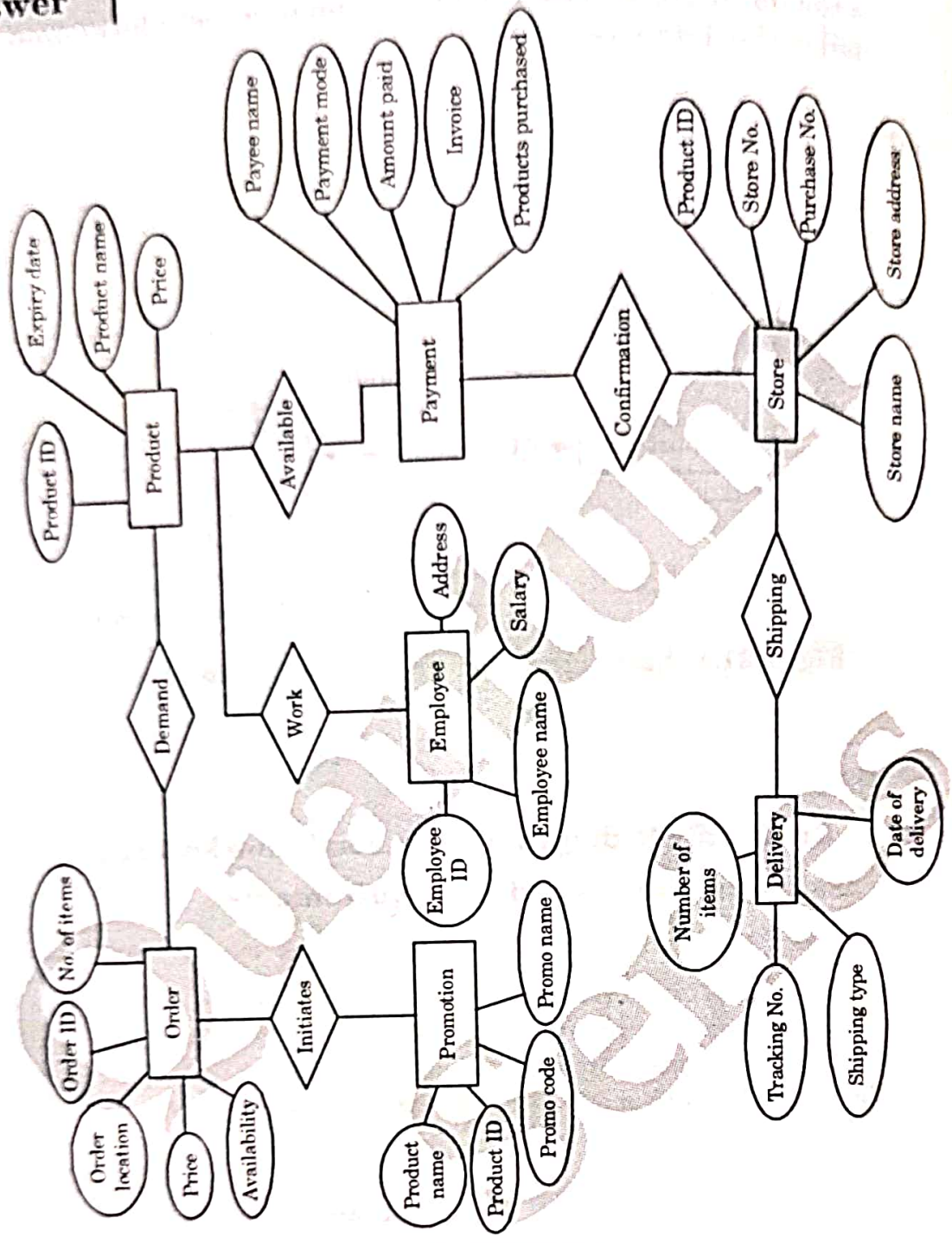


Fig.1.22.1.

Que 1.23. Describe mapping constraints with its types.

Answer

1. Mapping constraints act as a rule followed by contents of database.
2. Data in the database must follow the constraints.

Types of mapping constraints are :

1. Mapping cardinalities :

a. Mapping cardinalities (or cardinality ratios) specifies the number of entities of which another entity can be associated via a relationship set.

b. Mapping cardinalities are used in describing binary relationship sets, although they contribute to the description of relationship sets that involve more than two entity sets.

c. For binary relationship set R between entity sets A and B, the mapping cardinality must be one of the following :

i. **One to one :** An entity in A is associated with at most one entity in B and an entity in B is associated with at most one entity in A.

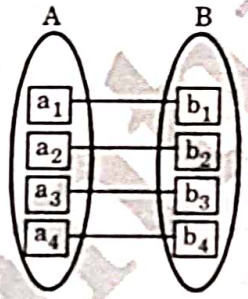


Fig. 1.23.1.

ii. **One to many :** An entity in A is associated with any number of entities in B. An entity in B, however, can be associated with at most one entity in A.

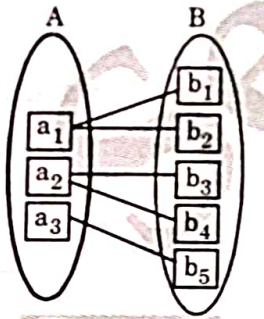


Fig. 1.23.2.

iii. **Many to one :** An entity in A is associated with at most one entity in B, and an entity in B, however, can be associated with any number of entities in A.

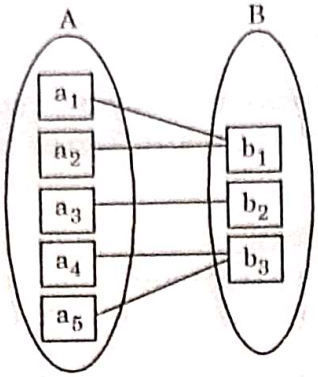


Fig. 1.23.3.

iv. **Many to many :** An entity in *A* is associated with any number of entities in *B*, and an entity in *B* is associated with any number of entities in *A*.

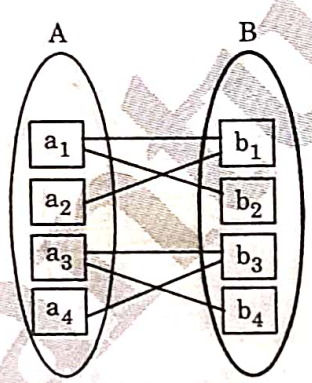


Fig. 1.23.4.

2. **Participation constraints :** It tells the participation of entity sets. There are two types of participations :
   i. Partial participation
   ii. Total participation

Que 1.24. Describe the three-schema architecture. Why do we need mappings between schema levels ? How do different schema definition languages support this architecture ?

AKTU 2022-23, Marks 10

Answer

Three-schema architecture : The three-schema architecture is a widely used framework for database design and management that consists of three levels of schema :

1. **External schema :** The external schema is the level of schema that is closest to the end user or application. It defines how the data is presented to users or applications and how it is accessed.
2. **Conceptual schema :** The conceptual schema is an abstract representation of the entire database, and defines the relationships

between different data elements. It provides a high-level view of the database and serves as an intermediate layer between the external schema and the internal schema.

3. **Internal schema :** The internal schema is the level of schema that is closest to the physical representation of the data on disk. It defines how the data is stored and accessed by the database management system.

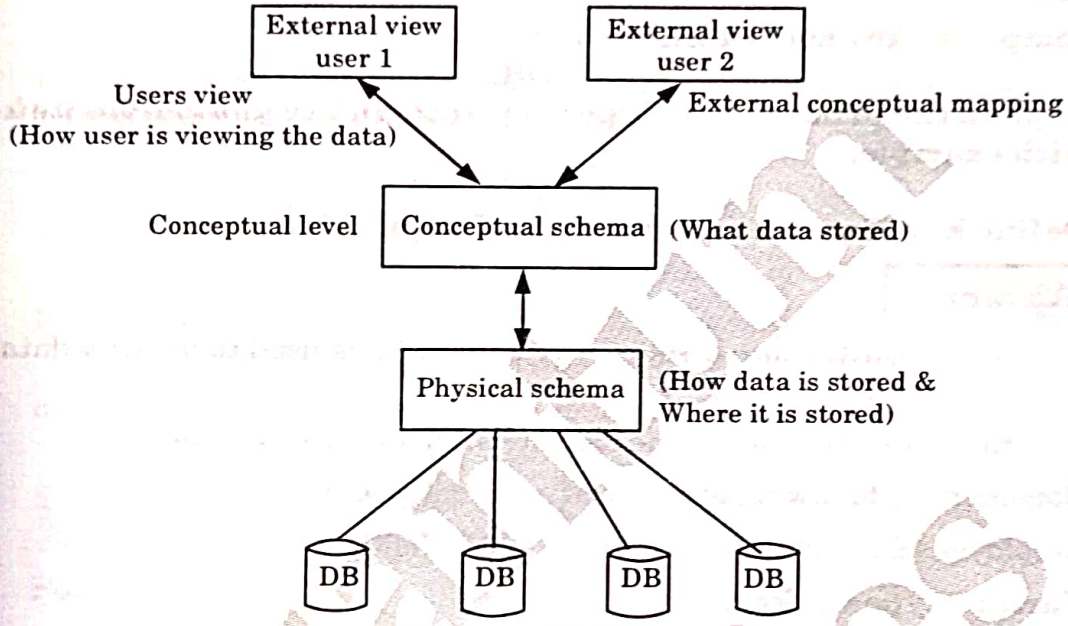


Fig. 1.24.1.

Need for mapping : The need for mappings between schema levels arises because the different levels of schema are designed for different purposes and are optimized for different tasks. The mappings between schema levels allow data to be translated between these different levels.

Schema definition languages : Different schema definition languages support the three-schema architecture in different ways.

For example :

1. **SQL :** It supports the three-schema architecture by providing commands for defining tables, views, and other database objects at the external schema level, and for defining database structures and constraints at the conceptual and internal schema levels.
2. **XML :** It supports the three-schema architecture by providing a flexible framework for defining data structures and hierarchies at the conceptual schema level, and for mapping these structures to external and internal schema levels.
3. **UML :** It supports the three-schema architecture by providing a set of diagrams and tools for defining the structure and behavior of a database at the conceptual schema level, and for mapping this structure to external and internal schema levels.

PART-6

Keys, Concept of Super Key, Candidate Key, Primary Key, Generalization, Aggregation.

Que 1.25. **Discuss the candidate key, primary key, super key, composite key and alternate key.**

OR

Explain the primary key, super key, foreign key and candidate key with example.

OR

Define key. Explain various types of keys.

Answer

1. Key is a attribute or set of attributes that is used to identify data in entity sets.
2. Key is defined for unique identification of rows in table.

Consider the following example of an Employee table :

Employee (EmployeeID, FullName, SSN, DeptID)

Various types of keys are :

1. **Primary key :**
   a. Primary key uniquely identifies each record in a table and must never, be the same for records. Here in Employee table we can choose either EmployeeID or SSN columns as a primary key.
   b. Primary key is a candidate key that is used for unique identification of entities within the table.
   c. Primary key cannot be null.
   d. Any table has a unique primary key.
2. **Super key :**
   a. A super key for an entity is a set of one or more attribute whose combined value uniquely identifies the entity in the entity set.
   b. For example : Here in employee table (EmployeeID, FullName) or (EmployeeID, FullName, DeptID) is a super key.
3. **Candidate key :**
   a. A candidate key is a column, or set of column, in the table that can uniquely identify any database record without referring to any other data.

b. Candidate key are individual columns in a table that qualifies for uniqueness of all the rows. Here in Employee table EmployeeID and SSN are candidate keys.

c. Minimal super keys are called candidate keys.

4. Composite key :

a. A composite key is a combination of two or more columns in a table that can be used to uniquely identify each row in the table.

b. It is used when we cannot identify a record using single attributes.

c. A primary key that is made by the combination of more than one attribute is known as a composite key.

5. Alternate key :

a. The alternate key of any table are those candidate keys which are not currently selected as the primary key.

b. Exactly one of those candidate keys is chosen as the primary key and the remainders, if any are then called alternate keys.

c. An alternate key is a function of all candidate keys minus the primary key.

d. Here in Employee table if EmployeeID is primary key then SSN would be the alternate key.

6. Foreign key :

a. Foreign key represents the relationship between tables and ensures the referential integrity rule.

b. A foreign key is derived from the primary key of the same or some other table.

c. Foreign key is the combination of one or more columns in a table (parent table) at references a primary key in another table (child table).

d. A foreign key value can be left null.

For example : Consider another table :

Project (ProjectName, TimeDuration, EmployeeID)

a. Here, the 'EmployeeID' in the 'Project' table points to the 'EmployeeID' in 'Employee' table

b. The 'EmployeeID' in the 'Employee' table is the primary key.

c. The 'EmployeeID' in the 'Project' table is a foreign key.

Que 1.26. Explain generalization, specialization and aggregation.

OR

Compare generalization, specialization and aggregation with suitable examples.

OR

Explain the following with example :

i. Generalization

ii. Specialization

iii. Aggregation **AKTU 2020-21, Marks 10**

Answer

Generalization :

a. Generalization is a process in which two lower level entities combine to form higher level entity.

b. It is bottom-up approach.

c. Generalization is used to emphasize the similarities among lower level entity sets and to hide the differences.

For example :

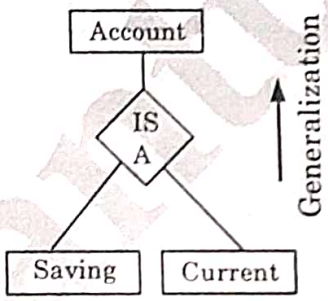


Fig. 1.26.1.

Specialization :

a. Specialization is a process of breaking higher level entity into lower level entity.

b. It is top-down approach.

c. It is opposite to generalization.

For example :

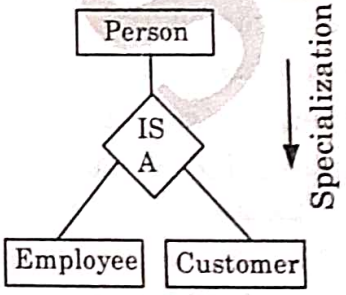


Fig. 1.26.2.

Aggregation :

a. Aggregation is an abstraction through which relationships are treated as higher level entities.

For example :

1. The relationship works_on (relating the entity sets employee, branch and job) act as a higher-level entity set.

2. We can then create a binary relationship 'Manages', between works on and manager to represent who manages what tasks.

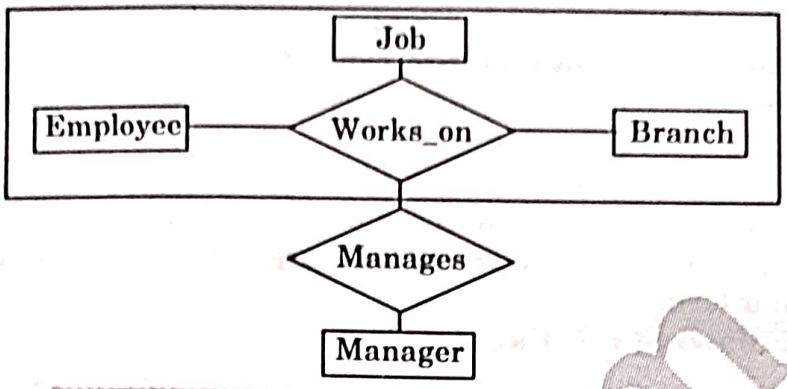


Fig. 1.26.3. ER diagram with aggregation.

Comparison :

S. No.	Generalization	Specialization	Aggregation
1.	In generalization, the common attributes of two or more lower-level entities combines to form a new higher-level entity.	In specialization, an entity of higher-level entity is broken down into two or more entities of lower level.	Aggregation is an abstraction through which relationships are treated as higher level entities.
2.	Generalization is a bottom-up approach.	Specialization is a top-down approach.	It allows us to indicate that a relationship set participates in another relationship set.
3.	It helps in reducing the schema size.	It increases the size of schema.	It also increases the size of schema.
4.	It is applied to group of entities.	It can be applied to a single entity.	It is applied to group of relationships.

PART-7

Reduction of an ER Diagram to Tables, Extended ER Model, Relationship of Higher Degree.

Que 1.27. **Explain the reduction of ER schema to tables.**

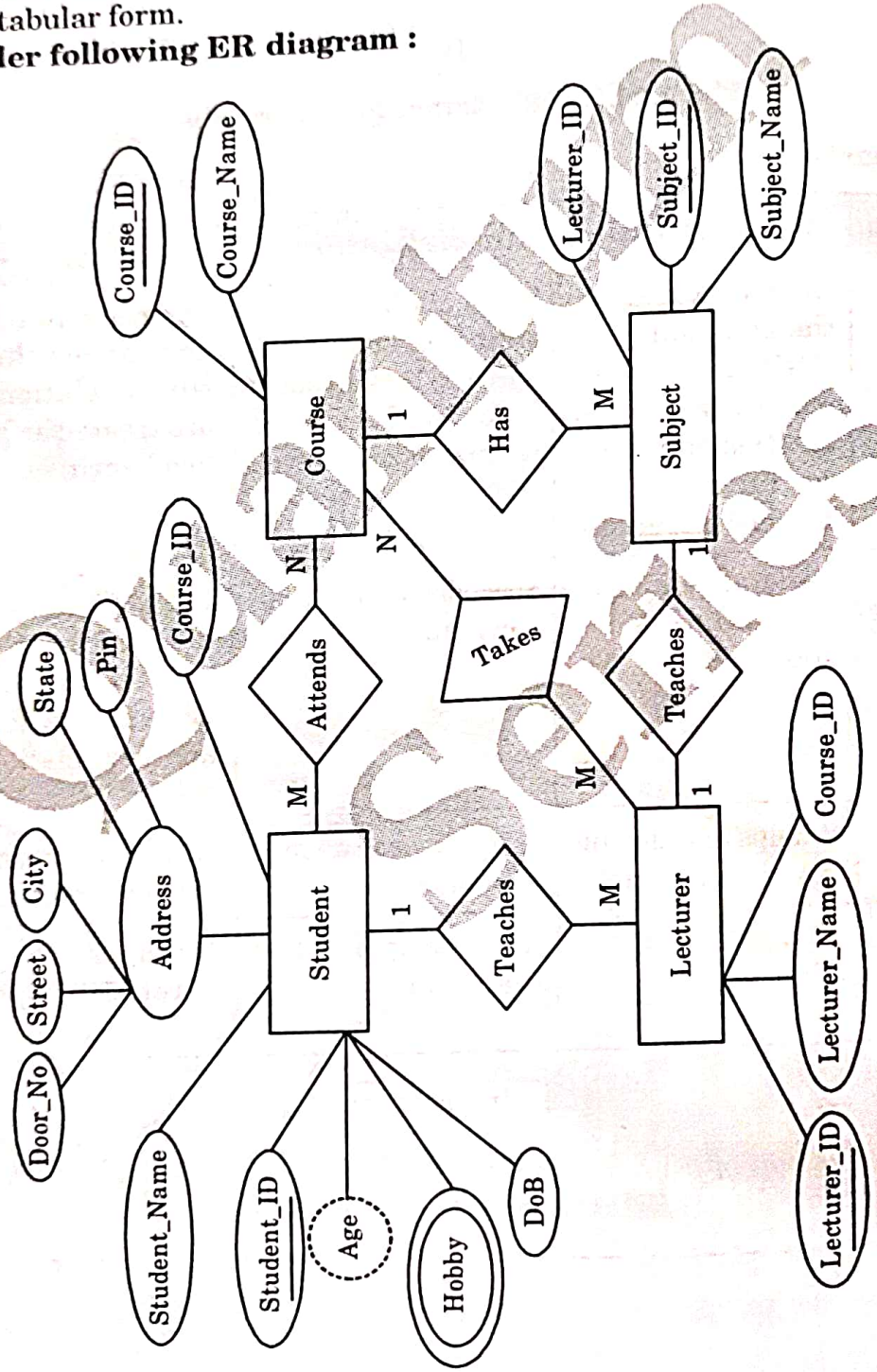
OR

How to reduce an ER model into table ?

Answer

1. In ER model, database are represented using the different notations or diagrams, and these notations can be reduced to a collection of tables.
2. In the database, every entity set or relationship set can be represented in tabular form.

Consider following ER diagram :



Basic rules for converting the ER diagrams into tables are :

1. Convert all the entities in the diagram to tables :

a. All the entities represented in the rectangular box in the ER diagram become independent tables in the database.

b. In the ER diagram, Student, Course, Lecturer and Subjects forms individual tables.

2. All single-valued attribute becomes a column for the table :

a. All the attributes, whose value at any instance of time is unique, are considered as columns of that table.

b. In the Student entity, Student_Name and Student_ID form the column of Student table. Similarly, Course_Name and Course_ID form the column of Course table and so on.

3. A key attribute of the entity is the primary key :

a. All the attributes represented in the oval shape and underlined in the ER diagram are considered as key attribute which act as a primary key of table.

b. In the given ER diagram, Student_ID , Course_ID, Subject_ID, and Lecture_ID are the key attribute of the Student, Course, Subjects and Lecturer entity.

4. The multivalued attribute is represented by a separate table :

a. In the student table, a hobby is a multivalued attribute.

b. So it is not possible to represent multiple values in a single column of Student table. Hence we create a table Stud_Hobby with column name Student_ID and Hobby. Using both the column, we create a composite key.

5. Composite attributes are merged into same table as different columns :

a. In the given ER diagram, student address is a composite attribute. It contains City, Pin, Door_No, Street, and State.

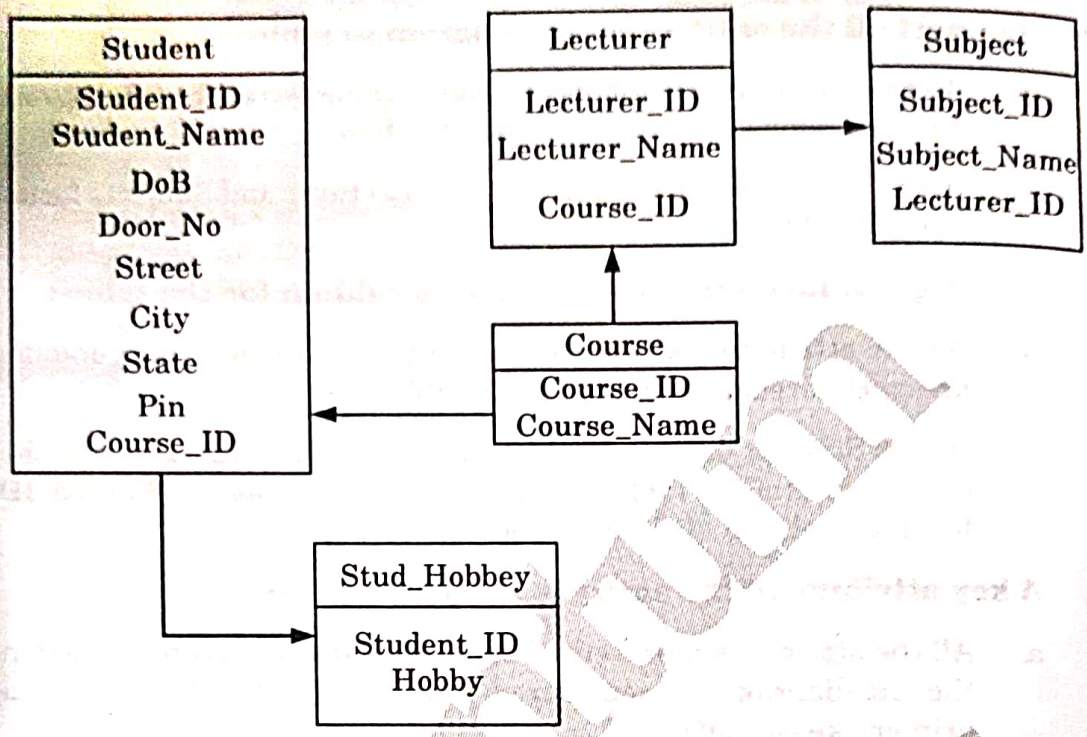
b. In the Student table, these attributes can merge as an individual column.

6. Derived attributes are not considered in the table :

a. In the Student table, Age is the derived attribute.

b. It can be calculated at any point of time by calculating the difference between current date and Date of Birth (DoB).

Table structure for given ER diagram is :



Que 1.28. Discuss extended ER (EER) model.

Answer

1. The ER model that is supported with the additional semantic concepts is called the extended entity relationship model or EER model.
2. The EER model includes all the concepts of the original ER model together with the following additional concepts :
   a. **Specialization :** Refer Q. 1.26, Page 1–27A, Unit-1.
   b. **Generalization :** Refer Q. 1.26, Page 1–27A, Unit-1.
   c. **Aggregation :** Refer Q. 1.26, Page 1–27A, Unit-1.
3. The super class/subclass entity types (or super type /subtype entities) is one of the most important modelling constructs that is included in the EER model.
4. This feature enables us to model a general entity and then subdivide it into several specialized entity types (subclasses or subtypes).
5. EER diagrams are used to capture business rules such as constraints in the super type/subtype relations. Thus, a super class is an entity type that includes distinct subclasses that require to be represented in a data model.
6. A subclass is an entity type that has a distinct role and is also a member of a super class.

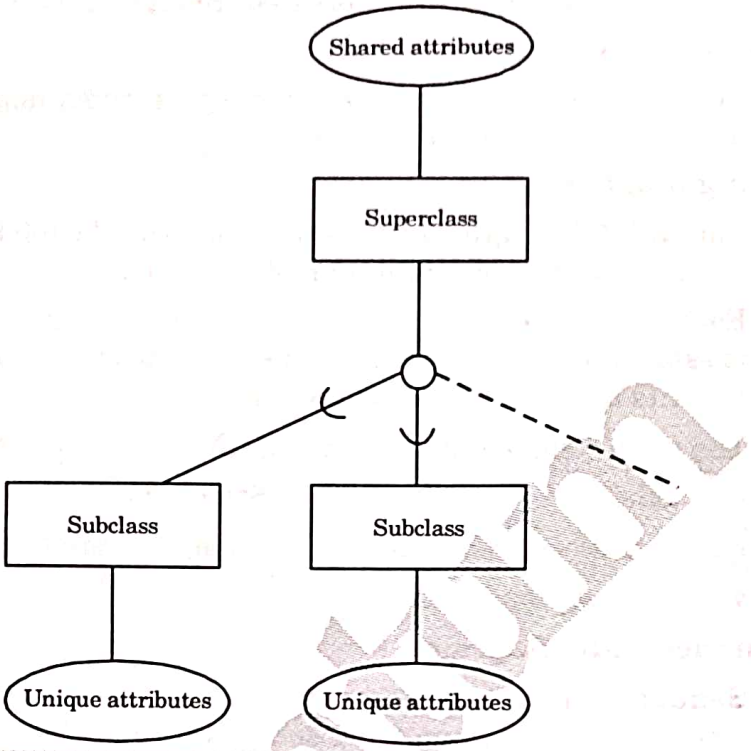


Fig. 1.28.1. Basic notation of the superclass/subclass relationship.

Que 1.29. What is Unified Modeling Language ? Explain different types of UML.

Answer

1. Unified Modeling Language (UML) is a standardized modeling language enabling developers to specify, visualize, construct and document artifacts of a software system.
2. UML makes these artifacts scalable, secure and robust in execution.
3. UML is an important aspect involved in object-oriented software development.
4. It uses graphic notation to create visual models of software systems.

Types of UML :

1. **Activity diagram :**
   a. It is generally used to describe the flow of different activities and actions.
   b. These can be both sequential and in parallel.
   c. They describe the objects used, consumed or produced by an activity and the relationship between the different activities.
2. **Use case diagram :**
   a. Case diagrams are used to analyze the system's high-level requirements.

b. These requirements are expressed through different use cases.

3. **Interaction overview diagram :**
   a. The interaction overview diagram is an activity diagram made of different interaction diagrams.

4. **Timing diagram :**
   a. Timing UML diagrams are used to represent the relations of objects when the center of attention rests on time.
   b. Each individual participant is represented through a lifeline, which is essentially a line forming steps since the individual participant transits from one stage to another.
   c. The main components of a timing UML diagram are :
      i. Lifeline
      ii. State timeline
      iii. Duration constraint
      iv. Time constraint
      v. Destruction occurrence

5. **Sequence UML diagram :**
   a. Sequence diagrams describe the sequence of messages and interactions that happen between actors and objects.
   b. Actors or objects can be active only when needed or when another object wants to communicate with them.
   c. All communication is represented in a chronological manner.

6. **Class diagram :**
   a. Class diagrams contain classes, alongside with their attributes (also referred to as data fields) and their behaviours (also referred to as member functions).
   b. More specifically, each class has three fields : the class name at the top, the class attributes right below the name, the class operations/ behaviours at the bottom.
   c. The relation between different classes (represented by a connecting line), makes up a class diagram.

Que 1.30. **A database is being constructed to keep track of the teams and games of a sport league. A team has a number of players, not all of whom participate in each game. It is desired to keep track of players participating in each game for each team, the positions they play in that game and the result of the game.**

i. **Design an *E-R* schema diagram for this application.**

ii. **Map the *E-R* diagram into relational model.**

AKTU 2022-23, Marks 10

Answer

1. The following design may be used for a baseball league. Here, we assumed that each game in the schedule is identified by a unique Game#, and a game is also identified uniquely by the combination of date, starting time, and field where it is played.

2. The performance attribute of PARTICIPATE is used to store information on the individual performance of each player in a game.

3. This attribute can be designed to keep the information needed for statistics, and may be quite complex.

4. One possible design for the performance attribute may be the following :

Performance({Hitting(AtBat#, Inning#, HitType, Runs, RunsBattedIn, StolenBases)}, {Pitching(Inning#, Hits, Runs, EarnedRuns, StrikeOuts, Walks, Outs, Balls, WildPitches)}, {Defense(Inning#, {FieldingRecord(Position, PutOuts, Assists, Errors)})})

5. Here, performance is a composite attribute made up of three multivalued components : Hitting, Pitching, and Defense.

   i. Hitting has a value for each AtBat of a player, and records the HitType (suitable coded; for example, 1 for single, 2 for double, 3 for triple, 4 for home run, 0 for walk, – 1 for strikeout, – 2 for fly out, ...) and other information concerning the AtBat.

   ii. Pitching has a value for each inning during which the player pitched.

   iii. Defense has a value for each inning a player played a fielding position.

6. We can have a less detailed or a more detailed design for the performance of a player in each game, depending on how much information we need to keep in the database.

7. Suitable variations of the ER diagram shown in Fig. 1.30.1 can be used for other sports.

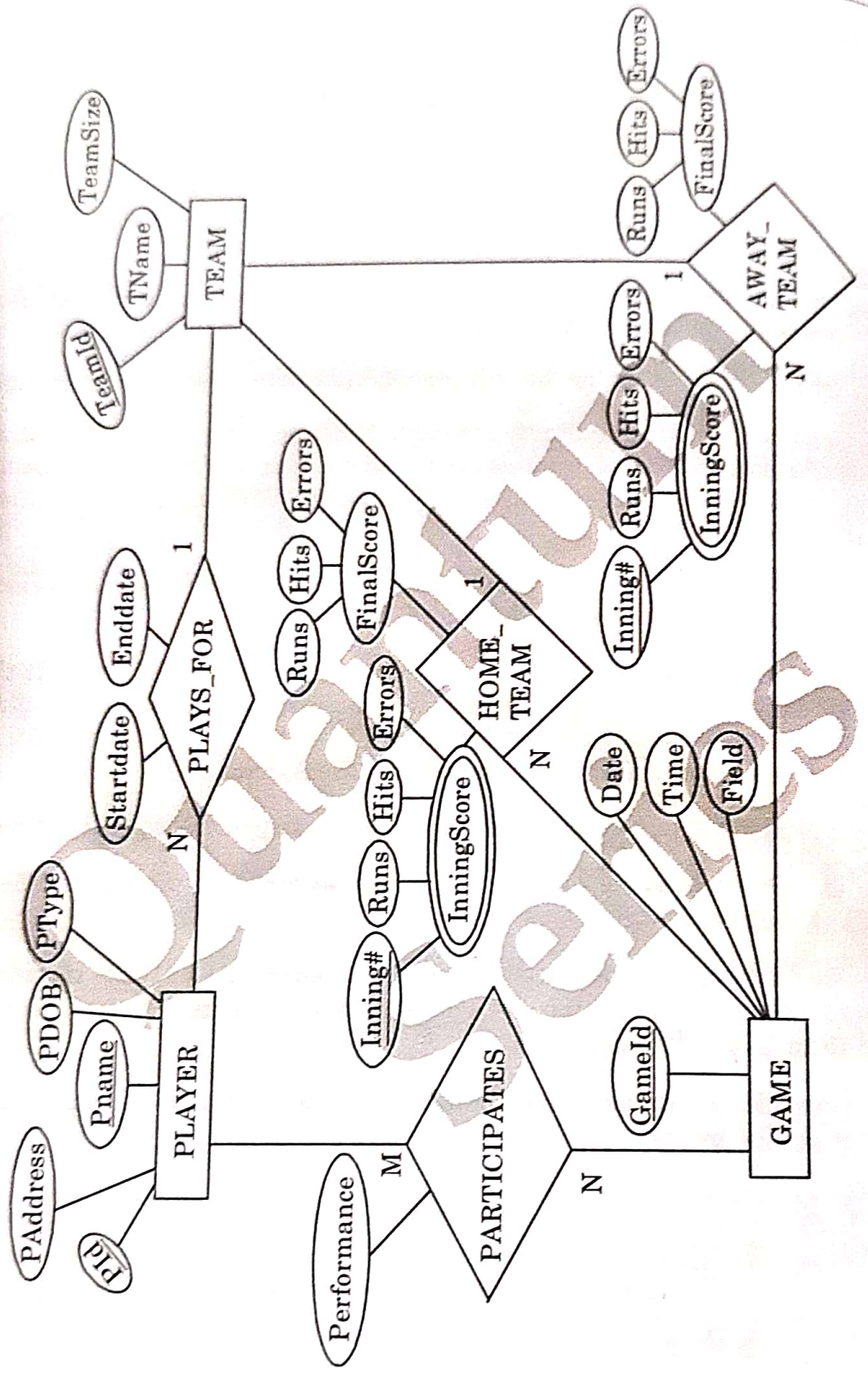


Fig. 1.30.1.

Relational model : Relational model for the sport league E.R diagram.

PLAYER (PId, PName, PAddress, PDOB, PType, TeamId)

PLAYS_FOR (PId, TeamId, StartDate, End Date)

GAME (GameID, Date, Time, Field, Home TeamID, AWAY TeamId)
Participates (PId, GameId, Performance)
HOMETEAM (GameId, TeamId, InningId, FinalScore)
AWAY_TEAM (GameId, TeamId, InningId, FinalScore)
InningScore (InningId, Runs, Hits, Errors)
TEAM (TeamId, Tname, TeamSize)

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. What is data abstraction ? Explain different levels of abstraction.
Ans. Refer Q. 1.5.

Q. 2. Explain the difference between database management system (DBMS) and file system.
Ans. Refer Q. 1.7.

Q. 3. Discuss the architecture of DBMS. What are the types of DBMS architecture ?
Ans. Refer Q. 1.8.

Q. 8. What are data models ? Briefly explain different types of data models.
Ans. Refer Q. 1.10.

Q. 7. Describe the classification of database language. Which type of language is SQL ?
Ans. Refer Q. 1.13.

Q. 4. Briefly describe the overall structure of DBMS.
Ans. Refer Q. 1.17.

Q. 5. Discuss the candidate key, primary key, super key, composite key and alternate key.
Ans. Refer Q. 1.25.

Q. 6. Explain generalization, specialization and aggregation.
Ans. Refer Q. 1.26.

☺☺☺

2 UNIT

Relational Data Model

CONTENTS

PART-1

Relational Data Model Concept, Integrity Constraints, Entity Integrity, Referential Integrity, Keys Constraints, Domain Constraints.

Que 2.1. What is relational model ? Explain with example.

Answer

1. A relational model is a collection of conceptual tools for describing data, data relationships, data semantics and consistency constraints.
2. It is the primary data model for commercial data processing applications.
3. The relational model uses collection of tables to represent both data and the relationships among those data.
4. Each table has multiple columns and each column has a unique name.

For example :

1. The tables represent a simple relational database.
2. The Table 2.1.1 shows details of bank customers, Table 2.1.2 shows accounts and Table 2.1.3 shows which accounts belong to which customer.

Table 2.1.1 : Customer table

cust_id	c_name	c_city
C_101	Ajay	Delhi
C_102	Amit	Mumbai
C_103	Alok	Kolkata
C_104	Akash	Chennai

Table 2.1.2 : Account table

acc_no.	balance
A-1	1000
A-2	2000
A-3	3000
A-4	4000

Table 2.1.3 : Depositor table

cust_id	acc_no.
C_101	A-1
C_102	A-2
C_103	A-3
C_104	A-4

3. The Table 2.1.1, *i.e.*, customer table, shows the customer identified by cust_id C_101 is named Ajay and lives in Delhi.
4. The Table 2.1.2, *i.e.*, accounts, shows that account A-1 has a balance of ₹ 1000.
5. The Table 2.1.3, *i.e.*, depositor table, shows that account number (acc_no) A-1 belongs to the cust whose cust_id is C_101 and account number (acc_no) A-2 belongs to the cust whose cust_id is C_102 and likewise.

Que 2.2. Explain constraints and its types.

Answer

1. A constraint is a rule that is used for optimization purposes.
2. Constraints enforce limits to the data or type of data that can be inserted/updated/deleted from a table.
3. The whole purpose of constraints is to maintain the data integrity during an update/delete/insert into a table.

Types of constraints :

1. **NOT NULL :**
   i. NOT NULL constraint makes sure that a column does not hold NULL value.
   ii. When we do not provide value for a particular column while inserting a record into a table, it takes NULL value by default.
   iii. By specifying NULL constraint, we make sure that a particular column cannot have NULL values.
2. **UNIQUE :**
   i. UNIQUE constraint enforces a column or set of columns to have unique values.
   ii. If a column has a unique constraint, it means that particular column cannot have duplicate values in a table.
3. **DEFAULT :**
   i. The DEFAULT constraint provides a default value to a column when there is no value provided while inserting a record into a table.
4. **CHECK :**
   i. This constraint is used for specifying range of values for a particular column of a table.
   ii. When this constraint is being set on a column, it ensures that the specified column must have the value falling in the specified range.
5. **Key constraints :**
   i. **Primary key :**
      a. Primary key uniquely identifies each record in a table.

b. It must have unique values and cannot contain null.

ii. **Foreign key :**

a. Foreign keys are the columns of a table that points to the primary key of another table.

b. They act as a cross-reference between tables.

6. **Domain constraints :**

i. Each table has certain set of columns and each column allows a same type of data, based on its data type.

ii. The column does not accept values of any other data type.

Que 2.3. **Explain integrity constraints.**

Answer

1. Integrity constraints provide a way of ensuring that changes made to the database by authorized users do not result in a loss of data consistency.
2. A form of integrity constraint with ER models is :
   a. **key declarations :** certain attributes form a candidate key for the entity set.
   b. **form of a relationship :** mapping cardinalities one-one, one-many and many-many.
3. An integrity constraint can be any arbitrary predicate applied to the database.
4. Integrity constraints are used to ensure accuracy and consistency of data in a relational database.

Que 2.4. **Explain the following constraints :**

i. Entity integrity constraint
ii. Referential integrity constraint
iii. Domain constraint

Answer

i. Entity integrity constraint :

a. This rule states that no attribute of primary key will contain a null value.

b. If a relation has a null value in the primary key attribute, then uniqueness property of the primary key cannot be maintained.

Example : In the Table 2.4.1 SID is primary key and primary key cannot be null.

Table 2.4.1

SID	Name	Class (semester)	Age
8001	Ankit	1st	19
8002	Srishti	2nd	18
8003	Somvir	4th	22
	Sourabh	6th	19

ii. Referential integrity constraint :

a. This rule states that if a foreign key in Table 2.4.2 refers to the primary key of Table 2.4.3, then every value of the foreign key in Table 2.4.2 must be null or be available in Table 2.4.3.

Table 2.4.2.

ENO	NAME	Age	DNO
1	Ankit	19	10
2	Srishti	18	11
3	Somvir	22	14
4	Sourabh	19	10

Foreign Key

Not Allowed, as DNO 14 is not defined as a primary key of Table 2.4.3, and in Table 2.4.2, DNO is a foreign key defined

Relationship

Table 2.4.3.

DNO	D.Location
10	Rohtak
11	Bhiwani
12	Hansi

Primary Key

iii. Domain constraints :

a. Domain constraints specify that what set of values an attribute can take, value of each attribute X must be an atomic value from the domain of X.

b. The data type associated with domains includes integer, character, string, date, time, currency etc. An attribute value must be available in the corresponding domain.

Example :

SID	Name	Class (semester)	Age
S001	Ankit	1st	19
S002	Srishti	1st	18
S003	Somvir	4th	22
S004	Sourabh	6th	A

A is not allowed here because Age is an integer attribute.

PART-2

Relational Algebra.

Que 2.5. **What is relational algebra ? Discuss its basic operations.**

OR

What is relational algebra ? Explain different operations of relational algebra with example. **AKTU 2020-21, Marks 10**

Answer

1. The relational algebra is a procedural query language.
2. It consists of a set of operations that take one or two relations as input and produces a new relation as a result.
3. The operations in the relational algebra are select, project, union, set difference, cartesian product and rename.

Basic relational algebra operations are as follows :

1. Select operation :

a. The select operation selects tuples that satisfies a given predicate.

b. Select operation is denoted by sigma (σ).

c. The predicate appears as a subscript to σ.

d. The argument relation is in parenthesis after the σ.

Example :

a. **Relation :** Employees :

ID	Name	Age	Department
1	Alice	30	HR
2	Bob	25	IT
3	Carol	28	HR

b. Query : σ_Age > 27 (Employees)

c. Result :

ID	Name	Age	Department
1	Alice	30	HR
3	Carol	28	HR

2. Project operation :

a. The project operation is a unary operation that returns its argument relation with certain attributes left out.

b. In project operation duplicate rows are eliminated.

c. Projection is denoted by pi (Π).

Example :

a. Query : Π_Name,
Department (Employees)

b. Result :

Name	Department
Alice	HR
Bob	IT
Carol	HR

3. Set difference operation :

a. The set difference operation denoted by (–) allows us to find tuples that are in one relation but are not in another.

b. The expression $r - s$ produces a relation containing those tuples in r but not in s.

Example :

a. Query : A-B

b. Result :

ID	Name
1	Alice

4. Cartesian product operation :

a. The cartesian product operation, denoted by a cross (×), allows us to combine information from any two relations. The cartesian product of relations r_1 and r_2 is written as $r_1 \times r_2$.

Example :

a. Relation A :

ID	Name
1	Alice
2	Bob

b. Relation B :

DeptID	Department
101	HR
102	IT

c. Query : A × B

d. Result :

ID	Name	DeptID	Department
1	Alice	101	HR
1	Alice	102	IT
2	Bob	101	HR
2	Bob	102	IT

5. Rename operation :

a. The rename operator is denoted by rho (ρ).

b. Given a relational algebra expression E,

$$\rho_x(E)$$

returns the result of expression E under the name x.

c. The rename operation can be used to rename a relation r to get the same relation under a new name.

d. The rename operation can be used to obtain a new relation with new names given to the original attributes of original relation as

$$\rho_{xA1, xA2, \ldots\ldots, xAn}(E)$$

Example :

a. Query : ρ(EmployeeID, Name) (Employees)

b. Result :

EmployeeID	Name	Age	Department
1	Alice	30	HR
2	Bob	25	IT
2	Carol	28	HR

Que 2.6. **What are the additional operations in relational algebra ?**

Answer

The additional operations of relational algebra are :

1. **Set intersection operation :**
   a. Set intersection is denoted by $\cap$, and returns a relation that contains tuples that are in both of its argument relations. The set intersection operation is written as :
   $$r \cap s = r - (r - s)$$
2. **Natural join operation :**
   a. The natural join is a binary operation that allows us to combine certain selections and a cartesian product into one operation. It is denoted by the join symbol $\bowtie$.
   b. The natural join operation forms a cartesian product of its two arguments, performs a selection forcing equality on those attributes that appear in both relation schemas and finally removes duplicate attributes.
3. **Division operation :**

1. In division operation, division operator is denoted by the symbol E ($\div$).
2. The relation $r \div s$ is a relation on schema $R - S$. A tuple t is in $r \div s$ if and only if both of two conditions hold :
   a. t is in $\Pi_{R-S}(r)$.
   b. For every tuple t_s in s, there is a tuple t_r in r satisfying both of the following :
      i. $t_r[S] = t_s[S]$
      ii. $t_r[R - S] = t$
3. The division operation can be written in terms of fundamental operation as follows :
   $$r \div s = \Pi_{R-S}(r) - \Pi_{R-S}((\Pi_{R-S}(r) \times s) - \Pi_{R-S,S}(r))$$
4. **Assignment operation :** The assignment operation, denoted by $\leftarrow$, works like assignment in a programming language.

Que 2.7. **Give the following queries in the relational algebra using the relational schema :**
student(id, name)
enrolled(id, code)
subject(code, lecturer)
i. What are the names of students enrolled in cs3020 ?
ii. Which subjects is Hector taking ?

iii. Who teaches cs1500 ?
iv. Who teaches cs1500 or cs3020 ?
v. Who teaches at least two different subjects ?
vi. What are the names of students in cs1500 or cs307 ?
vii. What are the names of students in both cs1500 and cs1200 ?

Answer

i. $\pi_{name}(\sigma_{code = cs3020}(student \bowtie enrolledin))$

ii. $\pi_{code}(\sigma_{name = Hector}(student \bowtie enrolledin))$

iii. $\pi_{lecturer}(\sigma_{code = cs1500}(subject))$

iv. $\pi_{lecturer}(\sigma_{code = cs1500 \vee \neg code = cs3020}(subject))$

v. For this query we have to relate subject to itself. To disambiguate the relation, we will call the subject relation R and S.

$\pi_{lecturer}(\sigma_{R.lecture = S.lecturer \wedge R.code < > S.code}(R \bowtie S))$

vi. $\pi_{name}(\sigma_{code = cs1500}(student \bowtie enrolledin)) \cup (\pi_{name}(\sigma_{code = cs307}(student \bowtie enrolledin)))$

vii. $\pi_{name}(\sigma_{code = cs1500}(student \bowtie enrolledin)) \cap \pi_{name}(\sigma_{code = cs1200}(student \bowtie enrolledin))$

Que 2.8. Which relational algebra operations require the participating tables to be union-compatible ? Give the reason in detail. **AKTU 2021-22, Marks 10**

Answer

1. The basic relational algebraic operations are the four set operations : UNION, INTERSECTION, SET DIFFERENCE and CARTESIAN PRODUCT.
2. Three of these operations : UNION, INTERSECTION and SET DIFFERENCE require that the tables (relations) involved be union compatible.
3. Two relations are said to be union compatible if the following conditions are satisfied :
   i. The two relations/tables must contain the same number of columns (have the same degree).
   ii. Each column of the first relation/table must be either the same data type as the corresponding column of the second relation/table or convertible to the same data type as corresponding column of the second.

Reg_No	Stu_Name
101	Amit
102	Aparajita
103	Ashish
104	Bhoomika
105	Debasis
106	Divij

Table (a) : CLASS (C)

Reg_No	Stu_Name
105	Debasis
106	Divij
107	Harsh
108	Rahul

Table (b) : LIBRARY (L)

Table : Relation C and L

4. Now consider the two relations CLASS and LIBRARY.
5. The class and library contains the entire list of Reg_No and Stu_Name.
6. For simplicity we will call the class relation as C and the library relation as L.
7. The two relations, as we can see, are union compatible.

PART-3

Relational Calculus, Tuple and Domain Calculus.

Que 2.9. What is relational calculus ? Describe its important characteristics. Explain tuple and domain calculus.

OR

What is tuple relational calculus and domain relational calculus ?

Answer

1. Relational calculus is a non-procedural query language.
2. Relational calculus is a query system where queries are expressed as formulas consisting of a number of variables and an expression involving these variables.
3. In a relational calculus, there is no description of how to evaluate a query.

Important characteristics of relational calculus :

1. The relational calculus is used to measure the selective power of relational languages.
2. Relational calculus is based on predicate calculus.
3. In relational calculus, user is not concerned with the procedure to obtain the results.

4. In relational calculus, output is available without knowing the method about its retrieval.

Tuple Relational Calculus (TRC) :

1. The TRC is a non-procedural query language.
2. It describes the desired information without giving a specific procedure for obtaining that information.
3. A query in TRC is expressed as :

$$\{t \mid P(t)\}$$

That is, it is the set of all tuples t such that predicate P is true for t. The notation $t[A]$ is used to denote the value of tuple t on attribute A and $t \in r$ is used to denote that tuple t is in relation r.

4. A tuple variable is said to be a free variable unless it is quantified by a $\exists$ or $\forall$.
5. Formulae are built using the atoms and the following rules :
   a. An atom is a formula.
   b. If P_1 is a formula, then so are $\neg P_1$ and (P_1).
   c. If P_2 and P_1 are formulae, then so are $P_1 \vee P_2$, $P_1 \wedge P_2$ and $P_1 \Rightarrow P_2$.
   d. If $P_1(s)$ is a formula containing a free tuple variable s, and r is a relation, then $\exists\, s \in r\,(P_1(s))$ and $\forall\ s \in r\,(P_1(s))$ are also formulae.

Domain Relational Calculus (DRC) :

1. DRC uses domain variables that take on values from an attributes domain, rather than values for an entire tuple.
2. An expression in the DRC is of the form :

$$\{<x_1, x_2, \ldots\ldots, x_n> \mid P(x_1, x_2, \ldots\ldots, x_n)\}$$

where $x_1, x_2, \ldots\ldots, x_n$ represent domain variable. P represents a formula compose of atoms.

3. An atom in DRC has one of the following forms :
   a. $<x_1, x_2, \ldots\ldots, x_n> \in r$, where r is a relation on n attributes and $x_1, x_2, \ldots\ldots, x_n$ are domain variables or domain constant.
   b. $x\ \theta\ y$, where x and y are domain variable and θ is a comparison operator ($<$, $\leq$, $=$, $\neq$, $>$, $\geq$). The attributes x and y must have the domain that can be compared.
   c. $x\ \theta\ c$, where x is a domain variable, θ is a comparison operator and c is a constant in the domain of the attribute for which x is a domain variable.
4. Following are the rules to build up the formula :
   a. An atom is a formula.
   b. If P_1 is a formula then so is $\neg P_1$.

c. If P_1 and P_2 are formula, then so are $P_1 \vee P_2$, $P_1 \wedge P_2$ and $P_1 \Rightarrow P_2$.

d. If $P_1(x)$ is a formula in x, where x is a domain variable, then $\exists x\,(P_1(x))$ and $x\ \forall\,(P_1(x))$ are also formulae.

PART-4

Introduction on SQL : Characteristics of SQL, Advantage of SQL.

Que 2.10. Write short note on SQL. Explain various characteristics of SQL.

Answer

1. SQL stands for Structured Query Language.
2. It is a non-procedural language that can be used for retrieval and management of data stored in relational database.
3. It can be used for defining the structure of data, modifying data in the database and specifying the security constraints.
4. The two major categories of SQL commands are :
   a. **Data Definition Language (DDL) :** DDL provides commands that can be used to create, modify and delete database objects.
   b. **Data Manipulation Language (DML) :** DML provides commands that can be used to access and manipulate the data, that is, to retrieve, insert, delete and update data in a database.

Characteristics of SQL :

1. SQL usage is extremely flexible.
2. It uses a free form syntax that gives the user the ability to structure SQL statements in a way best suited to them.
3. Each SQL request is parsed by the RDBMS before execution, to check for proper syntax and to optimize the request.
4. Unlike certain programming languages, there is no need to start SQL statements in a particular column or be finished in a single line. The same SQL request can be written in a variety of ways.

Que 2.11. What are the advantages and disadvantages of SQL ?

Answer

Advantages of SQL :

1. **Faster query processing :** Large amount of data is retrieved quickly and efficiently. Operations like insertion, deletion, manipulation of data is done in almost no time.

2. **No coding skills :** For data retrieval, large number of lines of code is not required. All basic keywords such as SELECT, INSERT INTO, UPDATE, etc are used and also the syntactical rules are not complex in SQL, which makes it a user-friendly language.
3. **Standardised language :** Due to documentation it provides a uniform platform worldwide to all its users.
4. **Portable :** It can be used in programs in PCs, server, laptops independent of any platform (Operating System, etc). Also, it can be embedded with other applications as per need/requirement/use.
5. **Interactive language :** Easy to learn and understand, answers to complex queries can be received in seconds.

Disadvantages of SQL :

1. **Complex interface :** SQL has a difficult interface that makes few users uncomfortable while dealing with the database.
2. **Cost :** Some versions are costly and hence, programmers cannot access it.
3. **Partial control :** Due to hidden business rules, complete control is not given to the database.

PART-5

SQL Data Type and Literals, Types of SQL Commands, SQL Operators and their Procedure.

Que 2.12. What are the different datatypes used in SQL ?

Answer

SQL supports following datatypes :

1. **char (*n*) :** A fixed length character string with user specified maximum length *n*.
2. **varchar (*n*) :** A variable length character string with user specified maximum length *n*.
3. **int :** An integer which is a finite subset of the integers that is machine dependent.
4. **small int :** A small integer is machine independent subset of integer domain type.
5. **numeric (*p*, *d*) :** A fixed point number with user defined precision. It consists of *p* digits and *d* of the *p* digits are to the right of the decimal point.
6. **real or double precision :** Floating point and double precision floating point numbers with machine dependent precision.

7. **float (*n*) :** A floating point number with precision of at least *n* digits.
8. **date :** A calendar date containing a year (four digit), month (two digit) and day (two digit) of the month.
9. **time :** The time of the day in hours, minutes and seconds.

Que 2.13. What are the types of literal used in SQL ?

Answer

The four kinds of literal values supported in SQL are :

1. **Character string :**
   a. Character strings are written as a sequence of characters enclosed in single quotes.
   b. The single quote character is represented within a character string by two single quotes. For example, 'Computer Engg', 'Structured Query Language'
2. **Bit string :**
   a. A bit string is written either as a sequence of 0s and 1s enclosed in single quotes and preceded by the letter '*B*' or as a sequence of hexadecimal digits enclosed in single quotes and preceded by the letter '*X*'.
   b. For example, B' 1011011', B'1', B'0', X'A 5' , X"T"
3. **Exact numeric :**
   a. These literals are written as a signed or unsigned decimal number possibly with a decimal point.
   b. For example, 9, 90, 90.00, 0.9, + 99.99, – 99.99.
4. **Approximate numeric :**
   a. Approximate numeric literals are written as exact numeric literals followed by the letter 'E', followed by a signed or unsigned integer.
   b. For example, 5E5, 55.5E5, + 55E–5, + 55E–5, 055E, – 5.55E–9.

Que 2.14. What are the different types of SQL commands ?

Answer

Different types of SQL commands are :

1. **Insert :**
   a. This command is used to insert tuples in a table.
   b. This command adds a single tuple at a time in a table.

   Syntax :

   Insert into table_name (attribute$_1$, ..., attribute$_n$) values (values_list);

2. **Update :**
   a. This command is used to make changes in the values of attributes of the table.
   b. It use set and where clause.

   Syntax :

   Update table_name set attribute_name = new_value where condition;

3. **Delete :**
   a. This command is used to remove tuples.
   b. Tuples can be deleted from only one table at a time.

   Syntax :

   Delete from table_name where condition;

4. **Select :** This command is used to retrieve a subset of tuples from one or more table.

   Syntax :

   Select $attribute_1$, ..., $attribute_n$ from table_name where condition;

5. **Alter table :**
   a. This command is used to make changes in the structure of a table.
   b. This command is used :
      i. to add an attribute
      ii. to drop an attribute
      iii. to rename an attribute
      iv. to add and drop a constraint

   Syntax :

   Alter table table_name add column_name datatype;
   Alter table table_name drop column column_name;
   Alter table table_name drop constraint constraint_name;

Que 2.15. Write a short note on SQL DDL commands.

Answer

a. SQL DDL is used to define relation of a system. The general syntax of SQL sentence is :

   VERB (parameter1, parameter2; ....., parameter*n*)

b. The relations are created using CREATE verb.

   1. **CREATE TABLE :** This command is used to create a new relation and the corresponding syntax is :

      CREATE TABLE relation_name

      (field1 datatype (size), field2 datatype (size),..., fieldn datatype (size));

2. **CREATE TABLE ... AS SELECT ... :** This type of create command is used to create the structure of a new table from the structure of existing table.

   The generalized syntax of this form is :

```
CREATE TABLE relation_name1
(field1, field2, ...., fieldn)
AS SELECT field1, field2, ..., fieldn
FROM relation_name2;
```

c. Structure of relations are changed using ALTER verb.

1. **ALTER TABLE ... ADD ... :** This is used to add some extra columns into an existing table. The generalized format is :

```
ALTER TABLE relation_name
ADD (new field1 datatype (size),
new field2 datatype (size), ......,
new fieldn datatype (size)) ;
```

2. **ALTER TABLE .... MODIFY ... :** This form is used to change the width as well as data type of existing relations. The generalized syntax is :

```
ALTER TABLE relation_name
MODIFY (field1 new data type (size),
        field2 new data type (size),
        ----------
        fieldn new data type (size)) ;
```

Que 2.16. Draw an ER diagram of Hospital or Bank with showing the specialization, Aggregation, Generalization. Also convert it in to relational schemas and SQL DDL.

Answer

Relational schemas :

branch (branch-name, branch-city, assets)

customer (customer-name, customer-street, customer-city, customer-id)

account (account-number, balance)

loan (loan-number, amount)

employee (employee-id, employee-name, telephone-number, start- date, employment length, dependent-name)

payment (payment-number, payment-amount, payment-date)

saving-account (interest-rate)

checking-account (overdraft-amount)

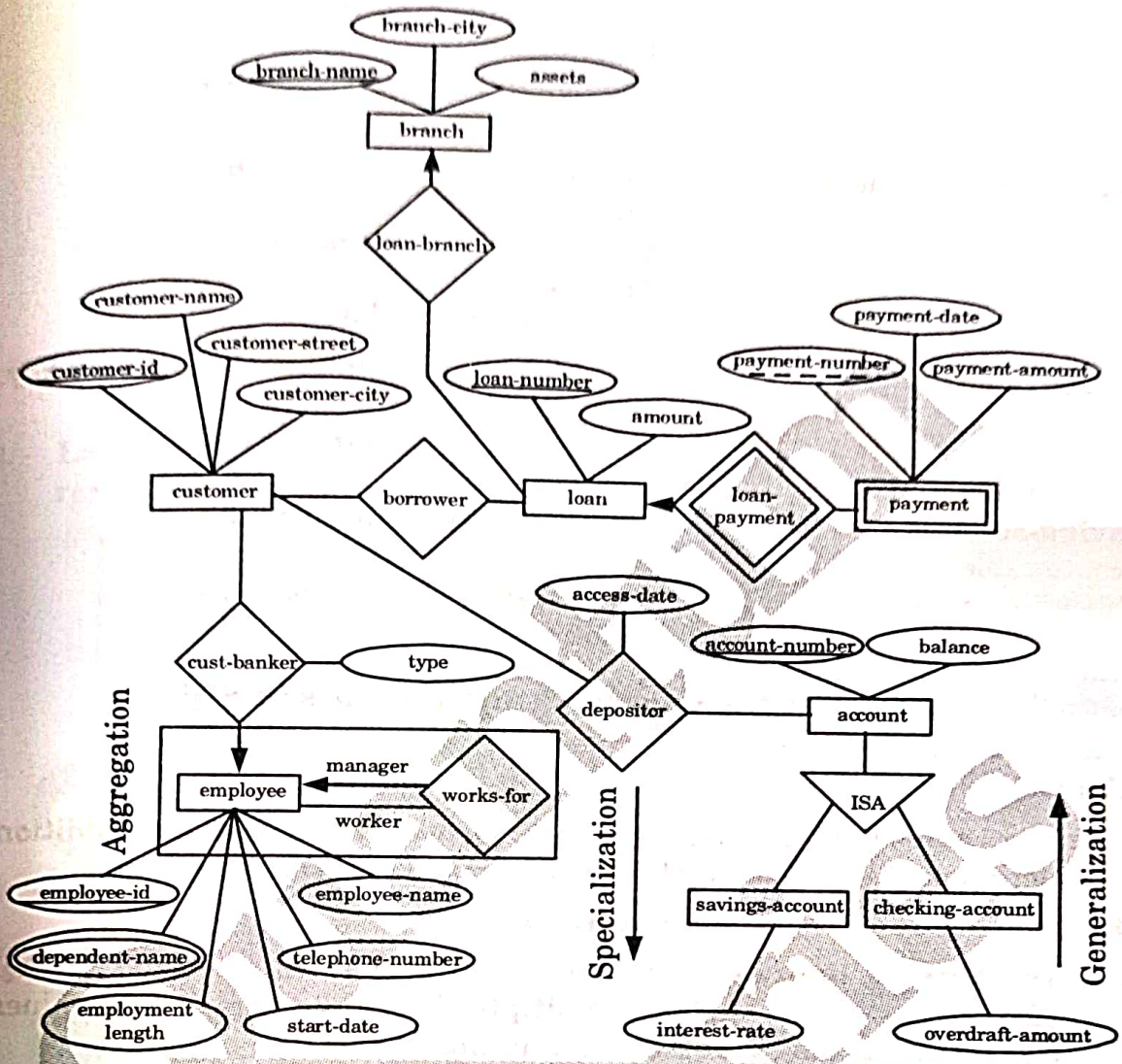


Fig. 2.17.1. ER diagram for a banking enterprise.

SQL DDL of ER diagram :

```
create table branch      (branch-city      varchar (40),
                          branch-name      varchar (40) primary key,
                          assets           number (20));

create table customer    (customer-id      number (5) primary key,
                          customer-name    varchar (40),
                          customer-street  varchar (20),
                          customer-city    varchar (30));

create table loan        (loan-number      number (6) primary key,
                          amount           number (10));

create table employee    (employee-id      number(5) primary key,
                          employee-name    varchar (40),
                          telephone-       number (10),
                          number
```

```
                        start-date          date,
                        employment          number (4),
                        length
                        dependent-          varchar (10));
                        name
create table payment    (payment-           number (6),
                        number
                        payment-            number (10),
                        amount
                        payment-date        date);
create table account    (account-           number (12) primary key,
                        number
                        balance             number (10));
create table
saving-account          (interest-rate      number (3);
create table
checking-account        (overdraft-         number (15));
                        amount
```

Que 2.17. Describe the operators and its types in SQL.

Answer

Operators and conditions are used to perform operations such as addition, subtraction or comparison on the data items in an SQL statement.

Different types of SQL operators are :

1. **Arithmetic operators :** Arithmetic operators are used in SQL expressions to add, subtract, multiply, divide and negate data values. The result of this expression is a number value.

Unary operators (B)	
+, –	Denotes a positive or negative expression
Binary operators (B)	
*	Multiplication
/	Division
+	Addition
–	Subtraction

Fig. 2.17.1. Arithmetic operators.

2. **Comparison operators :** These are used to compare one expression with another. The comparison operators are given below :

Operator	Definition
=	Equality
!=, <>	Inequality
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to

Fig. 2.17.2. Comparison operators.

3. **Logical operators :** A logical operator is used to produce a single result from combining the two separate conditions.

Operator	Definition
AND	Returns true if both component conditions are true; otherwise returns false.
OR	Returns true if either component condition is true otherwise returns false
NOT	Returns true if the condition is false; otherwise returns false.

Fig. 2.17.3. Logical operators.

4. **Set operators :** Set operators combine the results of two separate queries into a single result.

Operator	Definition
UNION	Returns all distinct rows from both queries
INTERSECT	Returns common rows selected by both queries
MINUS	Returns all distinct rows that are in the first query, but not in second one.

Fig. 2.17.4. Set operators.

5. **Operator precedence :**

a. Precedence defines the order that the DBMS uses when evaluating the different operators in the same expression.

b. The DBMS evaluates operators with the highest precedence first before evaluating the operators of lower precedence. Operators of equal precedence are evaluated from the left to right.

Operator	Definition
:	Prefix for host variable
,	Variable separator
( )	Surrounds subqueries
"	Surrounds a literal
" "	Surrounds a table or column alias or literal text
( )	Overrides the normal operator precedence
+, –	Unary operators
*, /	Multiplication and division
+, –	Addition and subtraction
||	Character concatenation
NOT	Reverses the result of an expression
AND	True if both conditions are true
OR	True if either conditions are true
UNION	Returns all data from both queries
INTERSECT	Returns only rows that match both queries
MINUS	Returns only row that do not match both queries

Fig. 2.17.5. Operators precedence.

Que 2.18. What are the relational algebra operations supported in SQL ? Write the SQL statement for each operation.

Answer

Basic relational algebra operations : Refer Q. 2.5, Page 2–6A, Unit-2.

SQL statement for relational algebra operations :

1. **Select operation :** Consider the loan relation,

   loan (loan_number, branch_name, amount)

   Find all the tuples in which the amount is more than ₹ 12000, then we write

$$\sigma_{amount > 12000}(loan)$$

2. **Project operation :** We write the query to list all the customer names and their cities as :

$$\Pi_{customer\_name,\ customer\_city}\ (customer)$$

3. **Set difference operation :** We can find all customers of the bank who have an account but not a loan by writing :

$$\Pi_{customer\_name}\ (depositor) - \Pi_{customer\_name}\ (borrower)$$

4. **Cartesian product :** We have the following two tables :

PERSONNEL

Id	Name
101	Jai
103	Suraj
104	XX
105	BB
106	CC

SOFTWARE PACKAGES

S
J_1
J_2

We want to manipulate the × operation between [personnel × software packages].

$P_i$id	P_iName	S
101	Jai	J_1
101	Jai	J_2
103	Suraj	J_1
103	Suraj	J_2
104	XX	J_1
104	XX	J_2
105	BB	J_1
105	BB	J_1
106	CC	J_1
106	CC	J_2

5. **Rename :**

Consider the Book relation with attributes Title, Author, Year and Price. The rename operator is used on Book relation as follows :

* $\rho_{Temp(Bname,\ Aname,\ Pyear,\ Bprice)}$ (Book)

Here both the relation name and the attribute names are renamed.

PART-6

Tables, Views and Indexes, Queries and Sub Queries.

Que 2.19. Give the brief explanation of view.

Answer

1. A view is a virtual relation, whose contents are derived from already existing relations and it does not exist in physical form.
2. The contents of view are determined by executing a query based on any relation and it does not form the part of database schema.
3. Each time a view is referred to, its contents are derived from the relations on which it is based.
4. A view can be used like any other relation that is, it can be queried, inserted into, deleted from and joined with other relations or views.
5. Views can be based on more than one relation and such views are known as complex views.
6. A view in SQL terminology is a single table that is derived from other tables. These other tables can be base tables or previously defined views.

Syntax for creating view :

```
CREATE VIEW view_name
AS SELECT * FROM table_name
WHERE Category IN ('attribute1', 'attribute2');
```

For example : Command to create a view consisting of attributes Book_title, Category, Price and P_ID of the BOOK relation, Pname and State of the PUBLISHER relation can be specified as

```
CREATE VIEW BOOK_3
AS SELECT BOOK_title, Category, Price, BOOK.P_ID, Pname, State
FROM BOOK, PUBLISHER
WHERE BOOK.P_ID = PUBLISHER.P_ID;
```

Que 2.20. Describe indexes in SQL.

Answer

1. Indexes are special lookup tables that the database search engine can use to speed up data retrieval.
2. An index helps to speed up SELECT queries and WHERE clauses, but it slows down data input, with the UPDATE and the INSERT statements.

3. Indexes can be created or dropped with no effect on the data.
4. Indexes are used to retrieve data from the database more quickly.
5. The users cannot see the indexes; they are just used to speed up searches/ queries.
6. **Syntax :**

   CREATE INDEX index

   ON TABLE column;

   where the index is the name given to that index and TABLE is the name of the table on which that index is created and column is the name of that column for which it is applied.
7. Unique indexes are used for the maintenance of the integrity of the data present in the table as well as for the fast performance; it does not allow multiple values to enter into the table.

   Syntax for creating unique index is :

   CREATE UNIQUE INDEX index_name

   ON TABLE column;
8. To remove an index from the data dictionary by using the DROP INDEX command.

   DROP INDEX index_name;

Que 2.21. Explain sub-query with example.

Answer

1. A sub-query is a SQL query nested inside a larger query.
2. Sub-queries must be enclosed within parenthesis.
3. The sub-query can be used with the SELECT, INSERT, UPDATE, or DELETE statement along with the operators like =, >, <, >=, <=, IN, ANY, ALL, BETWEEN.
4. A sub-query is usually added within the WHERE clause of another SQL SELECT statement.
5. A sub-query is also called an inner query while the statement containing a sub-query is also called an outer query.
6. The inner query executes first before its parent query so that the result of an inner query can be passed to the outer query.

Syntax of SQL sub-query : A sub-query with the IN operator,

```
SELECT column_names
FROM table_name1
WHERE column_name IN (SELECT column_name
FROM table_name2
WHERE condition);
```

Example :

We have the following two tables 'student' and 'marks' with common field 'StudentID'.

Student

StudentID	Name
V001	Abha
V002	Abhay
V003	Anand
V004	Amit

Marks

StudentID	Total_marks
V001	95
V002	80
V003	74
V004	81

Now considering table 'Student', we want to write a query to identify all students who get more marks than the student whose StudentID is 'V002', but we do not know the marks of 'V002'.

So, consider another table 'Marks' containing total marks of the student and apply query considering both tables.

SQL code with sub-query :

```
SELECT a.StudentID, a.Name, b.Total_marks
FROM student a, marks b
WHERE a.StudentID = b.StudentID AND b.Total_marks >
(SELECT Total_marks
FROM marks
WHERE StudentID = 'V002');
```

Query result :

StudentID	Name	Total_marks
V001	Abha	95
V004	Amit	81

PART-7

Aggregate Functions, Insert,Update and Delete Operations.

Que 2.22. **Write full relation operation in SQL. Explain any one of them.**

OR

Explain aggregate function in SQL.

OR

What is aggregate function in SQL ? Write SQL query for different aggregate function. **AKTU 2020-21, Marks 10**

OR

What is aggregate function in SQL ? Write SQL query for aggregate function. **AKTU 2023-24, Marks 10**

Answer

In SQL, there are many full relation operations like :

i. Eliminating duplicates
ii. Duplicating in union, intersection and difference
iii. Grouping
iv. Aggregate function

Aggregate function :

1. Aggregate functions are functions that take a collection of clues as input and return a single value.
2. SQL offers five built-in aggregate functions :

a. Average : avg

Syntax : avg ([Distinct |All] *n*)

Purpose : Returns average value of *n*, ignoring null values.

Example : Let us consider a SQL query :

select avg(unit price) as "Average Price" from book;

Output :

Average Price
359.8

b. Minimum : min

Syntax : min ([Distinct | All] expr)

Purpose : Returns minimum value of expression

Example :

SQL> select min(unit_price) as "Minimum Price"
from book ;

Output :

Minimum Price
250

c. Maximum : max

Syntax : max ([Distinct | All] expr)

Purpose : Returns maximum value of expression

Example :

SQL> select max(unit_price) as "Maximum Price"
from book;

Output :

Maximum Price
450

d. Sum : sum

Syntax : sum ([Distinct | All] *n*)

Purpose : Returns sum of values of *n*

Example :

SQL> select sum(unit price) as "Total"
from book;

Output :

Total
1799

e. Count : count

Syntax : count ([Distinct | All] expr)

Purpose : Returns the number of rows where expr is not null

Example :

SQL> select count(title) as "No. of Books"
from book;

Output :

No. of Books
5

Que 2.23. Explain how the GROUP BY clause in SQL works. What is the difference between WHERE and HAVING clause ?

Answer

GROUP BY :

1. GROUP BY was added to SQL because aggregate functions (like SUM) return the aggregate of all column values every time they are called, and without the GROUP BY function it is not possible to find the sum for each individual group of column values.
2. The syntax for the GROUP BY function is :

   SELECT columns, SUM(column) FROM table GROUP BY column

Example :

This "Sales" Table :

Company	Amount
TCS	5500
IBM	4500
TCS	7100

And this SQL :

SELECT Company, SUM(Amount) FROM Sales

GROUP BY Company

Return following result :

Company	Amount
TCS	12600
IBM	4500

Difference :

S. No.	WHERE	HAVING
1.	WHERE clause is used for filtering rows and it applies on each and every row.	HAVING clause is used to filter groups in SQL.
2.	WHERE clause is used before GROUP BY clause.	HAVING clause is used after GROUP BY clause.
3.	WHERE clause can be used with SELECT, INSERT, UPDATE and DELETE clause.	HAVING clause can only be used with SELECT query *i.e.*, if we want to perform INSERT, UPDATE and DELETE clause it will returns an error.
4.	We cannot use aggregate functions in the WHERE clause unless it is in a sub query contained in a HAVING clause.	We can use aggregate function in HAVING clause.

Que 2.24. Explain how a database is modified in SQL.

OR

Explain database modification.

Answer

Different operations that modify the contents of the database are :

1. **Delete :**
   a. The delete operation is used to delete all or specific rows from database.
   b. Delete command do not delete values of particular attributes.
   c. A delete command operates only on relation or table.

   Syntax :

   delete from table_name
   where condition;

2. **Insert :**
   a. Insert command is used to insert data into a relation/table.
   b. The attribute values for inserted tuples must be members of the attribute's domain specified in the same order as in the relation schema.

   Syntax : Insert into table_name values (attribute1, attribute2, attribute3, ... attributeN);

3. **Updates :** Update command is used to update a value in a tuple.

   Syntax : Update table_name set column_name = new_value condition;

PART-8

Joins, Unions, Intersections, Minus.

Que 2.25. Discuss join and types with suitable example.

OR

Define join. Explain different types of join.

OR

What are joins ? Discuss all types of joins with the help of suitable examples.

AKTU 2022-23, Marks 10

Answer

A join clause is used to combine rows from two or more tables, based on a related column between them.

Various types of join operations are :

1. **Inner join :**
   a. Inner join returns the matching rows from the tables that are being joined.

   For example : Consider following two relations :

Employee (Emp_Name, City)

Employee_Salary (Emp_Name, Department, Salary)

These two relations are shown in Table 2.25.1 and 2.25.2.

Table. 2.25.1. The Employee relation.

Employee	
Emp_Name	**City**
Hari	Pune
Om	Mumbai
Suraj	Nashik
Jai	Solapur

Table. 2.25.2. The Employee_Salary relation.

Employee_Salary		
Emp_Name	**Department**	**Salary**
Hari	Computer	10000
Om	IT	7000
Billu	Computer	8000
Jai	IT	5000

Select Employee.Emp_Name, Employee_Salary.Salary from Employee inner join Employee_Salary on Employee.Emp_Name = Employee_Salary.Emp_Name;

Result : The result of preceding query with selected fields of Table 2.25.1 and Table 2.25.2.

Emp_Name	Salary
Hari	10000
Om	7000
Jai	5000

2. Outer join :

a. An outer join is an extended form of the inner join.

b. It returns both matching and non-matching rows for the tables that are being joined.

c. Types of outer join are as follows :

i. **Left outer join :** The left outer join returns matching rows from the tables being joined and also non-matching rows from the left table in the result and places null values in the attributes that comes from the right table.

For example :

```
Select Employee.Emp_Name, Salary
from Employee left outer join Employee_Salary
on Employee.Emp_Name = Employee_Salary.Emp_Name;
```

Result : The result of preceding query with selected fields of Table 2.25.1 and Table 2.25.2.

Emp_Name	Salary
Hari	10000
Om	7000
Jai	5000
Suraj	null

ii. **Right outer join :** The right outer join operation returns matching rows from the tables being joined, and also non-matching rows from the right table in the result and places null values in the attributes that comes from the left table.

For example :

```
Select Employee.Emp_Name, City, Salary from Employee
right outer join
Employee_Salary on Employee.Emp_Name =
Employee_Salary. Emp_Name;
```

Result : The result of preceding query with selected fields of Table 2.25.1 and Table 2.25.2.

Emp_Name	City	Salary
Hari	Pune	10000
Om	Mumbai	7000
Jai	Solapur	5000
Billu	null	8000

Que 2.26. Write difference between cross join, natural join, left outer join and right outer join with suitable example.

AKTU 2023-24, Marks 10

Answer

Cross join :

1. Cross join produces a result set which is the product of number of rows in the first table multiplied by the number of rows in the second table if no where clause is used along with cross join. This kind of result is known as Cartesian product.
2. If where clause is used with cross join, it functions like an inner join.

For example :

Beers

Name	Manf
Beer 1	XYZ
Beer 2	ABC
Beer 3	ABC

Likes

Drinker	Beer
Kanika	Beer 1
Aditya	Beer 2
Mahesh	Beer 3

Select * From Beers
Cross Join Likes

Name	Manf	Drinker	Beer
Beer 1	XYZ	Kanika	Beer 1
Beer 1	XYZ	Aditya	Beer 1
Beer 1	XYZ	Mahesh	Beer 3
Beer 2	ABC	Kanika	Beer 1
Beer 2	ABC	Aditya	Beer 1
Beer 2	ABC	Mahesh	Beer 3
Beer 3	ABC	Kanika	Beer 1
Beer 3	ABC	Aditya	Beer 1
Beer 3	ABC	Mahesh	Beer 3

Natural join :

1. Natural join joins two tables based on same attribute name and data types.
2. The resulting table will contain all the attributes of both the table but keep only one copy of each common column.
3. In natural join, if there is no condition specifies then it returns the rows based on the common column.

For example : Consider the following two relations :

Student (Roll_No, Name)

Marks (Roll_No, Marks)

These two relations are shown in Table 2.26.1 and 2.26.2.

Table 2.26.1. The Student relation.

Student	
Roll_No	**Name**
1	A
2	B
3	C

Table 2.26.2. The Marks relation.

Marks	
Roll_No	**Marks**
2	70
3	50
4	85

Consider the query :
Select * from Student natural join Marks;
Result :

Roll_No	Name	Marks
2	B	70
3	C	50

Left outer join and right outer join : Refer Q. 2.25, Page 2–29A, Unit-2.

Que 2.27. **Describe the SQL set operations.**

Answer

The SQL set operations are :

1. **Union operation :** Union clause merges the output of two or more queries into a single set of rows and column.

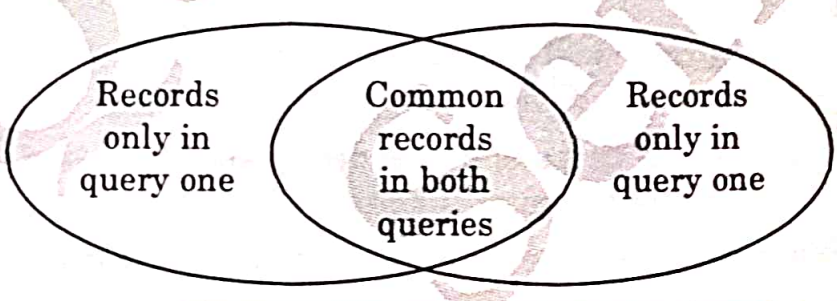


Fig. 2.27.1. Output of union clause.

Output = Record only in query one + records only in query two + A single set of records which is common in both queries.

2. **Intersect operation :** The intersect clause outputs only rows produced by both the queries intersected *i.e.*, the intersect operation returns common records from the output of both queries.

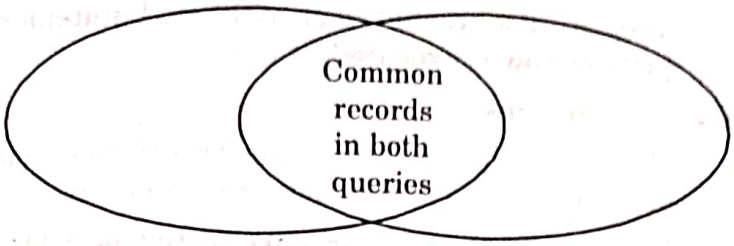


Fig. 2.27.2. Output of intersect clause.

Output = A single set of records which are common in both queries.

3. **The except operation :** The except also called as Minus outputs rows that are in first table but not in second table.

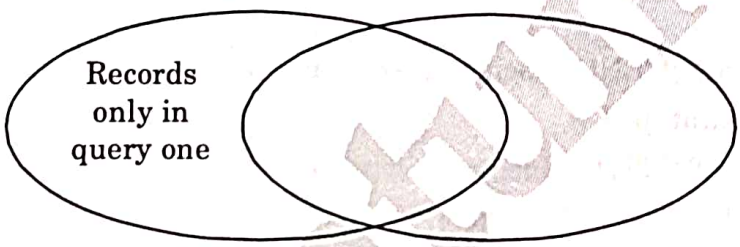


Fig. 2.27.3. Output of except (Minus) clause.

Output = Records only in query one.

PART-9

Cursors, Triggers, Procedures in SQL/PL SQL.

Que 2.28. Explain cursors, sequences and procedures used in SQL.

Answer

Cursors :

1. A cursor is a temporary work area created in the system memory when a SQL statement is executed.
2. A cursor contains information on a select statement and the rows of data accessed by it.
3. A cursor can hold more than one row, but can process only one row at a time.
4. The set of rows the cursor holds is called the active set.
5. There are two types of cursors :
   a. **Implicit cursors :**
      i. These are created by default when DML statements like, INSERT, UPDATE, and DELETE statements are executed.

ii. They are also created when a SELECT statement that returns just one row is executed.

b. Explicit cursors :

i. They must be created when we are executing a SELECT statement that returns more than one row.

ii. When we fetch a row the current row position moves to next row.

Sequences :

Sequences are frequently used in databases because many applications require each row in a table to contain a unique value and sequences provide an easy way to generate them.

Syntax :

```
CREATE SEQUENCE [schema.]sequence_name
    [ AS datatype ]
    [ START WITH value ]
    [ INCREMENT BY value ]
    [ MINVALUE value | NO MINVALUE ]
    [ MAXVALUE value | NO MAXVALUE ]
    [ CYCLE | NO CYCLE ]
    [ CACHE value | NO CACHE ];
```

Procedures :

1. A procedure is a sub-program that performs a specification.
2. A procedure has two parts :
   - **i. Specification :** The procedure specification begins with the keyword procedure and ends with the procedure name or parameter list.
   - **ii. Body :** The procedure body begins with the keyword is and ends with the keyword end.

Syntax : To create a procedure,

```
create or replace procedure <proc name> [parameter list] is
< local declaration >
begin
(executable statements)
[exception] (exception handlers)
end ;
```

Syntax : To execute a procedure,

```
exec < proce_name > (parameters);
```

Que 2.29. What is trigger ? Explain different trigger with example.

OR

Describe the following terms trigger.

OR

What do you mean by trigger ? Explain it by a suitable example.

AKTU 2021-22, Marks 10

OR

Explain different types of triggers in SQL / PL SQL.

AKTU 2022-23, Marks 10

Answer

Triggers :

1. Trigger is a special type of stored procedure that is automatically executed in response to certain database events such as an INSERT, UPDATE, or DELETE operation.
2. Triggers can be used to perform actions such as data validation, enforcing business rules, or logging.
3. They can be defined to execute before or after the triggering event and can be defined to execute for every row or once for each statement.
4. Triggers are a powerful feature of dbms that allow developers to define automatic actions based on database events.

   Example : Suppose we have a table named "employees" with columns "id", "name", "age", and "salary". We want to ensure that whenever a new employee is added to the table, the age of the employee must be greater than or equal to 18. We can create a BEFORE INSERT trigger to enforce this rule.

Following are different types of triggers :

1. **DML Triggers (Data Manipulation Language Triggers) :**
   a. These triggers fire in response to DML operations like INSERT, UPDATE, and DELETE.
   b. Types :
      i. **BEFORE Triggers :** Executed before the DML operation.
      ii. **AFTER Triggers :** Executed after the DML operation.
      iii. **INSTEAD OF Triggers :** Used primarily on views, these replace the DML operation.
   c. **Example :**

```
CREATE TRIGGER trg_before_insert
BEFORE INSERT ON Employees
FOR EACH ROW
BEGIN
```

```
    SET NEW.created_at = NOW();
END;
```

2. DDL Triggers (Data Definition Language Triggers) :

a. These triggers fire in response to DDL events like CREATE, ALTER, and DROP statements.

b. **Usage :** Often used for auditing and enforcing security.

c. **Example :**

```
CREATE TRIGGER trg_audit_table_change
AFTER CREATE ON SCHEMA
FOR EACH STATEMENT
BEGIN
    INSERT INTO Audit_Log (event_type, event_time)
    VALUES ('Table Created', NOW());
END;
```

3. LOGON and LOGOFF Triggers :

a. These are special types of triggers that fire when a user logs in or out of the database.

b. **Usage :** Commonly used for auditing and managing user sessions.

c. **Example :**

```
CREATE TRIGGER trg_logon
AFTER LOGON ON SCHEMA
BEGIN
    INSERT INTO User_Session_Log (username, logon_time)
    VALUES (USER, NOW());
END;
```

4. Row-Level and Statement-Level Triggers :

a. **Row-Level Triggers :** These execute once for each row affected by the triggering event.

b. **Statement-Level Triggers :** These execute once for the entire statement, regardless of how many rows are affected.

c. **Example :**

```
-- Row-Level Trigger
CREATE TRIGGER trg_row_level
AFTER UPDATE ON Employees
FOR EACH ROW
BEGIN
```

```
    INSERT INTO Change_Log (employee_id, change_time)
    VALUES (NEW.id, NOW());
END;
-- Statement-Level Trigger
CREATE TRIGGER trg_statement_level
AFTER UPDATE ON Employees
BEGIN
    INSERT INTO Change_Log (event, change_time)
    VALUES ('Employees updated', NOW());
END;
```

Que 2.30. **Consider the following relation. The primary key is Rollno, ISBN, Student(Roll No, Name, Branch), Book(ISBN, Title, Author, Publisher) Issue(Roll No, ISBN, date_of_issue). Write the query in relational algebra and SQL of the following :**

i. **List the Roll Number and Name of All CSE Branch Students.**

ii. **Find the name of students who have issued a book of publication 'BPB'.**

iii. **List the title and author of all books which are issued by a student name started with 'a'.**

iv. **List the title of all books issued on or before 20/09/2012.**

v. **List the name of student who will read the book of author named 'Sanjeev'.**

Answer

i. **In relational algebra :**

$\pi_{\text{Roll No, Name}} (\sigma_{\text{Branch = "CSE"}} (\text{Student}))$

In SQL :

```
Select Roll No, Name from Students
where Branch = "CSE";
```

ii. **In relational algebra :**

$\pi_{\text{Name}} \sigma_{\text{Publisher = "BPB" and Student\_Roll No = P.Roll No}} (\text{Student} \bowtie (\pi_{\text{Roll No, Publisher}} (\sigma_{\text{Issue.ISBN = Book.ISBN}} \rho_P (\text{Book} \bowtie \text{Issue}))))$

In SQL :

```
Select Student.name from Student inner join
(Select Book.Publisher, Issue.Roll No from Issue inner join Book on
Issue.ISBN = Book.ISBN as P)
ON Student.Roll No = P. Roll No
where P.Publisher = "BPB";
```

iii. In relational algebra :

$\pi_{S.Title, S.Author}\ \sigma_{S.Name\ like('a\%')}\ (\pi_{T.Name, Book.Author, Book.Title}\ \sigma_{Book.ISBN = T.ISBN}\ \rho_S\ (Book \bowtie (\pi_{Name, ISBN}\ \sigma_{Student.Roll\ No = Issue.Roll\ No}\ \rho_T\ (Student \bowtie Issue))));$

In SQL :

```
Select S.title, S.Author from
(Select T.Name, Book.Author, Book.Title from Book inner join (Select
Student.Name, Issue.ISBN from Student inner join Issue
ON Student.Roll No = Issue.Roll No as T)
ON Book.ISBN = T.ISBN as S)
where S.Name like 'a%';
```

iv. In relational algebra :

$\pi_{Title}\ (\sigma_{date >= 20/09/2012}\ (Book \bowtie Issue))$

In SQL :

```
Select Book.Title from Book inner join Issue ON Book.ISBN = Issue.ISBN
as R
where R.date >= 20/09/2012;
```

iv. In relational algebra :

$\pi_{Name}\ (\sigma_{Author = \text{“Sanjeev”}\ and\ Student.Roll\ No = Q.Roll\ No}\ (Student \bowtie \pi_{Roll\ No, Author}\ \sigma_{Issue.ISBN = Book.ISBN}\ \rho_Q\ (Book \bowtie Issue)))$

In SQL :

```
Select Student.Name from Student inner join
(Select Issue.Roll No, Book.Author from Issue inner join Book ON
Issue.ISBN = Book.ISBN as Q)
ON Student.Roll No = Q.Roll No
where Q.Author = "Sanjeev";
```

Que 2.31. Consider the following schema for institute library :

Student (RollNo, Name, Father_Name, Branch)
Book (ISBN, Title, Author, Publisher)
Issue (RollNo, ISBN, Date-of-Issue)
Write the following queries in SQL and relational algebra :

I. **List roll number and name of all students of the branch 'CSE'.**
II. **Find the name of student who has issued a book published by 'ABC' publisher.**
III. **List title of all books and their authors issued to a student 'RAM'.**
IV. **List title of all books issued on or before December 1, 2020.**
V. **List all books published by publisher 'ABC'.**

AKTU 2021-22, Marks 10

AKTU 2022-23, Marks 10

Answer

1. **SQL** → SELECT Roll No, Name from Student where Branch = "CSE"

   Algebra → $\pi_{\text{Roll No, Name}}(\sigma_{\text{Branch = "CSE"}}(\text{Student}))$

2. **SQL** → SELECT Student.name FROM Student INNER JOIN (SELECT Book.Publisher , Issue.Roll No FROM Issue INNER JOIN BOOK on Issue.ISBN = Book.ISBN as P)ON Student.Roll no = P.Roll no WHERE P.Publisher =" ABC"

   Algebra → $\pi_{\text{Name}}(\sigma_{\text{Publisher = 'ABC'}}(\text{Student} \bowtie \text{Book} \bowtie \text{Issue}))$

3. **SQL** → SELECT Book.Title, Book.Author FROM Book INNER JOIN Issue ON Book.ISBN = Issue.ISBN INNER JOIN Student Issue.Roll no = Student.Roll no WHERE Student.Name = "Ram"

   Algebra → $\pi_{(\text{Title, Author})}(\sigma_{\text{name= 'Ram'}}(\text{Book} \bowtie \text{Issue} \bowtie \text{Student}))$

4. **SQL** → SELECT book.Title FROM Book INNER JOIN Issue ON Book.ISBN = Issue.ISBN WHERE (Issue.date_of_issue < 'dec-1-2020' OR Issue.date_of_issue = 'dec-1-2020')

   Algebra → $\pi_{\text{Title}}(\sigma_{\text{date\_of\_issue} \le \text{(dec-1-2020)}}(\text{Book} \bowtie \text{Issue}))$

5. **SQL** → Select Title from Book where Publisher ="ABC";

   Algebra → π Title$(\sigma_{\text{Publisher= "ABC"}}(\text{Book}))$

Que 2.32. **Suppose there are two relations $R(A, B, C)$, $S(D, E, F)$. Write TRC and SQL for the following RAs :**

i. $\Pi_{A,B}(R)$

ii. $\sigma_{B=45}(R)$

iii. $\Pi_{A,F}(\sigma_{C=D}(R \times S))$

Answer

i. $\Pi_{A,B}(R)$:

TRC : $\{s.A, s.B \mid R(s)\}$

SQL : Select A, B from R ;

ii. $\sigma_{B=45}(R)$:

TRC : $\{s \mid R(s) \wedge s.B = 45\}$

SQL : Select * from R where $B = 45$;

iii. $\Pi_{A,F}(\sigma_{C=D}(R \times S))$:

TRC : $\{t \mid \exists p \in r\ \exists q \in s\ (t[A] = p[A] \wedge t[F] = q[F] \wedge p[C] = q[D])\}$

SQL : Select A, F from R inner join S ON $R.C = S.D$;

Que 2.33. **Consider the following relational DATABASE. Give an expression in SQL for each following queries. Underline records are primary key**

Employee(person_name, street, city)
Works(person_name, Company_name, salary)
Company(Company_name, city)
Manages(person_name, manager_name)

i. **Finds the names of all employees who work for the ABC bank.**
ii. **Finds the name of all employees who live in the same city and on the same street as do their managers.**
iii. **Find the name street address and cities of residence of all employees who work for ABC bank and earn more than 7,000 per annum.**
iv. **Find the name of all employees who earn more than every employee of XYZ.**
v. **Give all employees of corporation ABC a 7% salary raise.**
vi. **Delete all tuples in the works relation for employees of ABC.**
vii. **Find the name of all employees in this DATABASE who live in the same city as the company for which they work.**

Answer

i.
```
Select person_name from Works
Where company_name='ABC Bank'
```

ii.
```
Select E1.person_name
From Employee as E1, Employee as E2, Manages as M
Where E1.person_name=M.person_name
and E2.person_name=M.manager_name
and E1.street=E2.street and E1.city=E2.city
```

iii.
```
Select * from employee
where person_name in
(select person_name from Works
where company_name= 'ABC Bank' and salary>7000
select E.person_name, street,
city from Employee as E, Works as W
where E.person_name = W.person_name
and W.company_name='ABC Bank' and W.salary>7000
```

iv.
```
Select person_name from Works
      where salary > all
(select salary from Works
where company_name='XYZ')
select person_name from Works
where salary>(select max(salary) from Works
```

where company_name='XYZ')

v. Update Works
set salary=salary*1.07
where company_name='ABC Bank'

vi. Delete from Works
where company_name='ABC Bank'

vii. Select E.person_name
from Employee as E, Works as W, Company as C
where E.person_name=W.person_name and E.city=C.city
and W.company_name=C.company_name

Que 2.34. Explain embedded SQL and dynamic SQL in detail.

Answer

Embedded SQL :

1. The SQL standard defines embeddings of SQL in a variety of programming languages such as Pascal, PL/I, Fortran, C and COBOL.
2. A language in which SQL queries are embedded is referred to as a host language and the SQL structures permitted in the host language constitute embedded SQL.
3. Programs written in the host language can use the embedded SQL syntax to access and update data stored in a database.
4. In embedded SQL, all query processing is performed by the database system.
5. The result of the query is then made available to the program one tuple at a time.
6. Embedded SQL statements must be completely present at compile time and compiled by the embedded SQL preprocessor.
7. To identify embedded SQL requests to the preprocessor, we use the EXEC, SQL statement as :

   EXEC SQL <embedded SQL statement> END.EXEC
8. Variable of the host language can be used within embedded SQL statements, but they must be preceded by a colon (:) to distinguish them from SQL variables.

Dynamic SQL :

1. The dynamic SQL component of SQL allows programs to construct and submit SQL queries at run time.
2. Using dynamic SQL, programs can create SQL queries as strings at run time and can either have them executed immediately or have them prepared for subsequent use.

3. Preparing a dynamic SQL statement compiles it, and subsequent uses of the prepared statement use the compiled version.
4. SQL defines standards for embedding dynamic SQL calls in a host language, such as C, as in the following example,

```
char * sqlprog = "update account set balance = balance * 1.05
where account_number = ?";
EXEC SQL prepare dynprog from : sqlprog;
char account[10] = "A-101";
EXEC SQL execute dynprog using : account;
```

Que 2.35. Describe procedures in PL/SQL with its advantages and disadvantages.

Answer

1. PL/SQL is a block-structured language that enables developers to combine the power of SQL with procedural statements.
2. A stored procedure in PL/SQL is nothing but a series of declarative SQL statements which can be stored in the database catalogue.
3. A procedure can be thought of as a function or a method.
4. They can be invoked through triggers, other procedures, or applications on Java, PHP etc.
5. All the statements of a block are passed to Oracle engine all at once which increases processing speed and decreases the traffic.

Advantages of procedures in PL/SQL :

1. They result in performance improvement of the application. If a procedure is being called frequently in an application in a single connection, then the compiled version of the procedure is delivered.
2. They reduce the traffic between the database and the application, since the lengthy statements are already fed into the database and need not be sent again and again via the application.
3. They add to code reusability, similar to how functions and methods work in other languages such as C/C++ and Java.

Disadvantages of procedures in PL/SQL :

1. Stored procedures can cause a lot of memory usage. The database administrator should decide an upper bound as to how many stored procedures are feasible for a particular application.
2. MySQL does not provide the functionality of debugging the stored procedures.

Que 2.36. Explain procedure in SQL/PL SQL.

AKTU 2020-21, Marks 10

Answer

Procedures in SQL : Refer Q. 2.28, Page 2–34A, Unit-2.
Procedures in PL SQL : Refer Q. 2.35, Page 2–43A, Unit-2.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. Explain the following constraints :
i. **Entity integrity constraint**
ii. **Referential integrity constraint**
iii. **Domain constraint**

Ans. Refer Q. 2.4.

Q. 2. What is relational algebra ? Discuss its basic operations.

Ans. Refer Q. 2.5.

Q. 3. Write short note on SQL. Explain various characteristics of SQL.

Ans. Refer Q. 2.10.

Q. 4. Describe the operators and its types in SQL.

Ans. Refer Q. 2.17.

Q. 5. Write full relation operation in SQL. Explain any one of them.

OR

Explain aggregate function in SQL.

Ans. Refer Q. 2.22.

Q. 6. Discuss join and types with suitable example.

Ans. Refer Q. 2.25.

Q. 7. Write difference between cross join, natural join, left outer join and right outer join with suitable example.

Ans. Refer Q. 2.26.

Q. 8. What is trigger ? Explain different trigger with example.

Ans. Refer Q. 2.29.

3

UNIT

Database Design and Normalization

CONTENTS

PART-1

Functional Dependencies.

Que 3.1. What is functional dependency ? Explain its role in database design. Describe the inference rules for functional dependencies.

Answer

Functional dependency :

1. A functional dependency is a constraint between two sets of attributes from the database.
2. A functional dependency is denoted by $X \rightarrow Y$, between two sets of attributes X and Y that are subsets of R specifies a constraint on the possible tuples that can form a relation r.
3. The constraint for any two tuples t_1 and t_2, in r which have
   $$t_1 [X] = t_2 [X];$$
   Also, must have
   $$t_1 [Y] = t_2 [Y];$$
4. This means that the values of the Y component of a tuple in r depends on, or are determined by the value of the X components, or alternatively, the values of the X component of a tuple uniquely (or functionally) determine the value of the Y component.

Role of functional dependency :

1. Functional dependency allows the database designer to express facts about the enterprise that the designer is modeling with the enterprise databases.
2. It allows the designers to express constraints, which cannot be expressed with super keys.

Inference rules for functional dependencies :

1. **Reflexivity rule :** If α is a set of attributes and $\beta \subseteq \alpha$ then $\alpha \rightarrow \beta$ holds.
2. **Augmentation rule :** If $\alpha \rightarrow \beta$ holds and γ is a set of attributes then $\gamma\alpha \rightarrow \gamma\beta$ holds.
3. **Transitivity rule :** If $\alpha \rightarrow \beta$ holds and $\beta \rightarrow \gamma$ holds, then $\alpha \rightarrow \gamma$ holds.
4. **Complementation rule :** If $\alpha \rightarrow\rightarrow \beta$ hold, then $\alpha \rightarrow\rightarrow (R - (\alpha \cup \beta))$ holds.
5. **Multivalued augmentation rule :** $\alpha \rightarrow\rightarrow \beta$ hold and $\gamma \subseteq R$ and $\delta \subseteq \gamma$, then $\gamma\alpha \rightarrow\rightarrow \delta\beta$ holds.
6. **Multivalued transitivity rule :** If $\alpha \rightarrow\rightarrow \beta$ holds, then $\beta \rightarrow\rightarrow \gamma$ holds, then $\alpha \rightarrow\rightarrow \gamma - \beta$ holds.

7. **Replication rule :** If $\alpha \rightarrow\rightarrow \beta$ holds and $\gamma \subseteq \beta$ and there is a δ such that $\delta \subseteq R$ and $\delta \cap \beta = \phi$ and $\delta \rightarrow \gamma$, then $\alpha \rightarrow \gamma$ holds.
8. **Union rule :** if $\alpha \rightarrow \beta$ holds and $\alpha \rightarrow \gamma$ holds, then $\alpha \rightarrow \beta\gamma$ holds.
9. **Decomposition rule :** If $\alpha \rightarrow \beta$ holds, then $\alpha \rightarrow \beta$ holds, and $\alpha \rightarrow \gamma$ holds.
10. **Pseudotransitivity rule :** If $\alpha \rightarrow \beta$ holds and $\gamma\beta \rightarrow \delta$ holds, then $\gamma\alpha \rightarrow \delta$ holds.

Que 3.2. **What is functional dependency ? Explain trivial and non-trivial functional dependency. Define canonical cover. Compute canonical cover for the following :**
$R = (A, B, C)$ $F = \{A \rightarrow BC, B \rightarrow C, A \rightarrow B, AB \rightarrow C\}$

Answer

Functional dependency : Refer Q. 3.1, Page 3–2A, Unit-3.

Trivial functional dependency : The dependency of an attribute on a set of attributes is known as trivial functional dependency if the set of attributes includes that attribute.

$A \rightarrow B$ is trivial functional dependency if B is a subset of A.

Non-trivial functional dependency : If a functional dependency $X \rightarrow Y$ holds true where Y is not a subset of X then this dependency is called non-trivial functional dependency.

For example :

Let a relation R (A, B, C)

The following functional dependencies are non-trivial :

$A \rightarrow B$ (B is not a subset of A)

$A \rightarrow C$ (C is not a subset of A)

The following dependencies are trivial :

$\{A, B\} \rightarrow B$ [B is a subset of $\{A, B\}$]

Canonical cover : A canonical cover of a set of functional dependencies F is a simplified set of functional dependencies that has the same closure as the original set F.

Numerical :

There are two functional dependencies with the same set of attributes

$A \rightarrow BC$

$A \rightarrow B$

These two can be combined to get

$A \rightarrow BC$

Now, the revised set F becomes :

$F = \{$

$A \rightarrow BC$
$B \rightarrow C$
$AB \rightarrow C$
}

There is an extraneous attribute in $AB \rightarrow C$ because even after removing $AB \rightarrow C$ from the set F, we get the same closures. This is because $B \rightarrow C$ is already a part of F.

Now, the revised set F becomes :

F= {
$A \rightarrow BC$
$B \rightarrow C$
}

C is an extraneous attribute in $A \rightarrow BC$, also $A \rightarrow B$ is logically implied by $A \rightarrow B$ and $B \rightarrow C$ (by transitivity)

F= {
$A \rightarrow B$
$B \rightarrow C$
}

After this step, F does not change anymore.

Hence, the required canonical cover is,

$F = \{A \rightarrow B, B \rightarrow C\}$

Que 3.3. **What is functional dependency ? Explain the procedure of calculating the canonical cover of a given functional dependency set with suitable example.**

AKTU 2020-21, Marks 10

AKTU 2023-24, Marks 10

Answer

Functional dependency : Refer Q. 3.1, Page 3–2A, Unit-3.

The procedure of calculating the canonical cover a given functional dependency set :

1. **Reduction :** The first step is to reduce the original set of functional dependencies to an equivalent set that has the same closure as the original set, but with fewer dependencies. This is done by removing redundant dependencies and combining dependencies that have common attributes on the left-hand side.
2. **Elimination :** The second step is to eliminate any extraneous attributes from the left-hand side of the dependencies. An attribute is considered extraneous if it can be removed from the left-hand side without changing the closure of the dependencies.

3. **Minimization :** The final step is to minimize the number of dependencies by removing any dependencies that are implied by other dependencies in the set.

Example : Consider the following set F of functional dependencies : $F = \{A \rightarrow BC, B \rightarrow C, A \rightarrow B, AB \rightarrow C\}$. Below mentioned are the steps to find the canonical cover of the functional dependency given above.

Step 1 : Reduction : There are two functional dependencies with the same attributes on the left : $A \rightarrow BC, A \rightarrow B$ are already in their simplest form.

Step 2 : Elimination : In $A \rightarrow BC$, C is extraneous because $A \rightarrow C$ can be derived from $A \rightarrow B$ and $B \rightarrow C$. Thus, we reduce it to $A \rightarrow B$.

Step 3 : Minimization : There are no redundant dependencies remaining.

Hence the required canonical cover is, $F_c = \{A \rightarrow B, B \rightarrow C\}$.

Que 3.4. Explain full functional dependency and partial functional dependency.

Answer

Full functional dependency :

1. Given a relation scheme R and functional dependency $X \rightarrow Y$, Y is fully functionally dependent on X, if there is no Z, where Z is a proper subset of Y such that $Z \rightarrow Y$.
2. The dependency $X \rightarrow Y$ is left reduced, there being no extraneous attributes in the L.H.S of the dependency.

For example : In the relational schema R ($ABCDEH$) with the FDs. $F = \{A \rightarrow BC, CD \rightarrow E, E \rightarrow C, CD \rightarrow AH, ABH \rightarrow BD, DH \rightarrow BC\}$. The dependency $A \rightarrow BC$ is left reduced and BD is fully functionally dependent on A.

However the functional dependencies $ABH \rightarrow BC$ is not left reduced because the attribute B being extraneous in this dependency.

Partial functional dependency :

1. Given a relation schema R with the functional dependencies F defined on the attributes of R and K as a candidate keys if X is a proper subset of K and if $X \rightarrow A$ then A is said to be partially dependent on K.

For example :

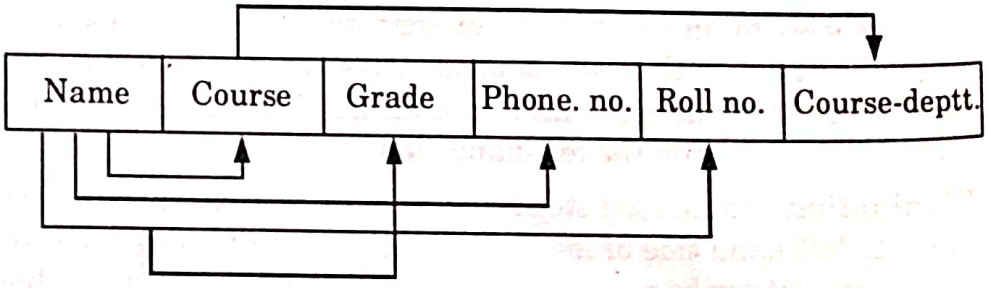


Fig. 3.4.1.

i. In Fig. 3.3.1, {Name + Course} is a candidate key, So Name and Course are prime attributes, Grade is fully functionally dependent on the candidate keys and Phone no., Course-deptt. and roll no. are partially functional dependent on the candidate key.

ii. Given $R(A, B, C, D)$ and $F = \{AB \rightarrow C, B \rightarrow D\}$. Then key of this relation is AB and D is partially dependent on the key.

Que 3.5. Describe Armstrong's axioms in detail. What is the role of these rules in database development process ?

AKTU 2021-22, Marks 10

Answer

1. The term Armstrong axioms refer to the sound and complete set of inference rules or axioms that are used to test the logical implication of functional dependencies.
2. If F is a set of functional dependencies then the closure of F, denoted as F^+, is the set of all functional dependencies logically implied by F.
3. Armstrong's axioms are a set of rules, that when applied repeatedly, generates a closure of functional dependencies.
4. Armstrong's axioms has mainly two different sets of rules :

A. Primary Rule :

Rule 1 : Reflexivity : If A is a set of attributes and B is a subset of A, then A holds B. { A → B }

Rule 2 : Augmentation : If A hold B and C is a set of attributes, then AC holds BC {AC → BC}. It means that attribute in dependencies does not change the basic dependencies.

Rule 3 : Transitivity : If A holds B and B holds C, then A holds C, *i.e.*, if {A → B} and {B → C}, then {A → C}. A holds B {A → B} means that A functionally determines B.

B. Secondary Rule :

Rule 1 : Union : If A holds B and A holds C, then A holds BC *i.e.*, if {A → B} and {A → C}, then {A → BC}.

Rule 2 : Decomposition : If A holds BC and A holds B, then A holds C *i.e.*, if {A → BC} and {A → B}, then {A → C}.

Rule 3 : Pseudo Transitivity : If A holds B and BC holds D, then AC holds D *i.e.*, if {A → B} and {BC → D}, then {AC → D}.

Role of Armstrong's axioms : Armstrong's axiom is used to analyze, refine and maintain relational databases.

Que 3.6. Define partial functional dependency. Consider the following two steps of functional dependencies $F = \{A \rightarrow C, AC \rightarrow D, E \rightarrow AD, E \rightarrow H\}$ and $G = \{A \rightarrow CD, E \rightarrow AH\}$. Check whether or not they are equivalent.

Answer

Partial functional dependency : Refer Q. 3.4, Page 3–5A, Unit-3.

Numerical :

From F,

$E \rightarrow AD$

$E \rightarrow A$ (By Decomposition Rule)

$E \rightarrow D$

Also given that

$E \rightarrow H$

So, $E \rightarrow AH$ (By Union Rule)

which is a FD of set G.

Again $A \rightarrow C$ and $AC \rightarrow D$

Imply $A \rightarrow D$ (By Pseudotransitivity Rule)

$A \rightarrow CD$ (by Union Rule)

which is FD of set G.

Hence, F and G are equivalent.

Que 3.7. Write the algorithm to find minimal cover F for set of functional dependencies E.

Answer

Algorithm :

1. Set $F := E$.
2. Replace each functional dependency $X \rightarrow \{A_1, A_2, ..., A_n\}$ in F by the n functional dependencies $X \rightarrow A_1, X \rightarrow A_2, ..., X \rightarrow A_n$.
3. For each functional dependency $X \rightarrow A$ in F
   for each attribute B that is an element of X
   if $\{ \{F - \{X \rightarrow A\}\} \cup \{ (X - \{B\}) \rightarrow A\} \}$ is equivalent to F,
   then replace $X \rightarrow A$ with $(X - \{B\}) \rightarrow A$ in F.
4. For each remaining functional dependency $X \rightarrow A$ in F
   if $\{F - \{X \rightarrow A\}\}$ is equivalent to F,
   then remove $X \rightarrow A$ from F.

Que 3.8. Define minimal cover. Suppose a relation $R(A, B, C)$ has FD set $F = \{A \rightarrow B, B \rightarrow C, A \rightarrow C, AB \rightarrow B, AB \rightarrow C, AC \rightarrow B\}$. Convert this FD set into minimal cover.

Answer

Minimal cover : A minimal cover of a set of FDs F is a minimal set of functional dependencies F_{min} that is equivalent to F.

Numerical :

Given : $R(A, B, C)$

Non-redundant cover for F :

Step 1 : Only one attribute on right hand side

$$F = A \rightarrow B$$
$$B \rightarrow C$$
$$A \rightarrow C$$
$$AB \rightarrow B$$
$$AB \rightarrow C$$
$$AC \rightarrow B$$

Step 2 : No extraneous attribute on left hand side. Since $AB \rightarrow B, AB \rightarrow C, AC \rightarrow B$ are extraneous attribute. Hence, remove all these we get

$$A \rightarrow B$$
$$B \rightarrow C$$
$$A \rightarrow C$$

Step 3 : By rule of transitivity, we can remove. Hence, we get the minimal cover

$$A \rightarrow C$$
$$A \rightarrow B$$
$$B \rightarrow C$$

Que 3.9. **A set of FDs for the relation R(A, B, C, D, E, F) is AB → C, C → A, BC → D, ACD → B, BE → C, EC → FA, CF → BD, D → E. Find a minimum cover for this set of FDs.** **AKTU 2022-23, Marks 10**

Answer

Step 1 : Decompose FDs

AB → C, C → A, BC → D, ACD → B, BE → C, EC → F, EC → A, CF → D, D → E

Step 2 : Remove extraneous attributes from the LHS

Checking FD : AB → C :

i. Check if A → C holds : It does not

ii. Check if B → C holds : It does not

So, AB → C remains as is

Checking FD : C → A :

This FD is already minimal.

Checking FD : BC → D :

i. Check if B → D holds : It does not

ii. Check if C → D holds : It does not

So, BC → D remains as is

Checking FD : ACD → B :

i. Check if A → B holds : It does not

ii. Check if C → B holds : It does not

iii. Check if D → B holds : It does not

iv. Check if AC → B holds : It does not

v. Check if AD → B holds : It does not

vi. Check if CD → B holds : It does not

So, ACD → B remains as is :

Checking FD : BE → C :

i. Check if B → C holds : It does not

ii. Check if E → C holds : It does not

So, BE → C remains as is :

Checking FD : EC → F :

i. Check if E → F holds : It does not

ii. Check if C → F holds : It does not

So, EC → F remains as is :

Checking FD : EC → A :

i. Check if E → A holds : It does not

ii. Check if C → A holds : It does not

Thus, EC → A can be simplified to C → A. But this FD is already present.

Checking FD : CF → B :

i. Check if C → B holds : It does not

ii. Check if F → B holds : It does not

So, CF → B remains as is :

Checking FD : CF → D :

i. Check if C → D holds : It does not

ii. Check if F → D holds : It does not

So, CF → D remains as is :

Checking FD : D → E :

This FD is already minimal.

Step 3 : Remove Redundant FDS.

$$AB \rightarrow C$$
$$C \rightarrow A$$
$$BC \rightarrow D$$
$$ACD \rightarrow B$$
$$BE \rightarrow C$$
$$EC \rightarrow F$$
$$EC \rightarrow A$$
$$CF \rightarrow B$$
$$CF \rightarrow D$$
$$D \rightarrow E$$

After checking for derivability among the FDs, we get :

The minimal cover for the given set of FDs is

$$AB \rightarrow C$$
$$C \rightarrow A$$
$$BC \rightarrow D$$
$$ACD \rightarrow B$$
$$BE \rightarrow C$$
$$EC \rightarrow F$$
$$CF \rightarrow B$$
$$D \rightarrow E$$

PART-2

Normal Forms, First, Second, Third Normal Form, BCNF.

Que 3.10. Define normal forms. List the definitions of first, second and third normal forms. Explain BCNF with a suitable example.

OR

Explain 1NF, 2NF, 3NF and BCNF with suitable example.

Answer

1. Normal forms are simply stages of database design, with each stage applying more strict rules to the types of information which can be stored in a table.
2. Normal form is a method to normalize the relations in database.
3. Normal forms are based on the functional dependencies among the attributes of a relation.

Different normal forms are :

1. First Normal Form (1NF) :

a. A relations *R* is in 1NF if all domains are simple *i.e.*, all elements are atomic.

For example : The relation LIVED-IN given in Table 3.10.1 is not in 1NF because the domain values of the attribute ADDRESS are not atomic.

Table 3.10.1. LIVED-IN

Name	Address		
Ashok	CITY	Year-moved-in	Year-left
	Kolkata Delhi	2007 2011	2015 2015
Ajay	CITY	Year-moved-in	Year-left
	Mumbai Chennai	2000 2005	2004 2009

Relation not in 1NF and can be normalized by replacing the non-simple domain with simple domains. The normalized form of LIVED-IN is given in Table 3.10.2.

Table 3.10.2. LIVED-IN

Name	City	Year-moved-in	Year-left
Ashok	Kolkata	2007	2010
Ashok	Delhi	2011	2015
Ajay	Mumbai	2000	2004
Ajay	Chennai	2005	2009

2. Second Normal Form (2NF) :

a. A relation *R* is in 2NF if and only if it is in 1NF and every non-key attribute is fully dependent on the primary key.

b. A relation *R* is in 2NF if every non-prime attribute of *R* is fully functionally dependent on each relation key.

For example : The relation flight (flight#, Type_of_aircraft, date, source, destination) with functional dependencies given is not in 2NF.

flight# → Type_of_aircraft

flight# date → source destination

Here flight# date is key but Type_of_aircraft depends only on flight#.

To convert relation flight (flight#, Type_of_aircraft, data, source, destination) into 2NF break the relation into two relation :

flight1 (flight#, Type_of_aircraft)

flight2 (flight#, date, source, destination)

3. Third Normal Form (3NF) :

a. A relation R is in 3NF if and only if, for all time, each tuple of R consists of a primary key value that identifies some entity in the database.

b. A relation schema R is in 3NF with respect to a set F of functional dependencies, if for all functional dependencies in F^+ of the form $\alpha \rightarrow \beta$, where $\alpha \subseteq R$ and $\beta \subseteq R$, at least one of the following holds :

i. $\alpha \rightarrow \beta$ is a trivial functional dependency.

ii. α is a super key for R.

iii. Each attribute A in $\beta - \alpha$ is contained in candidate key for R.

For example : Let us consider a relation $R(B, E, F, G, H)$ with primary key $BFGH$ and functional dependency are $B \rightarrow F$, $F \rightarrow GH$.

The relation R has transitive property as $B \rightarrow F$, $F \rightarrow GH$ then $B \rightarrow GH$. So R is not in 3NF. To convert relation R in 3NF break the relation R into two relation as $R_1(B, E, F)$, $R_2(F, G, H)$.

4. Boyce-Codd Normal Form (BCNF) :

a. A relation R is in BCNF if and only if every determinant is a candidate key.

b. A relation schema R is in BCNF with respect to a set F of functional dependencies if for all functional dependencies in F^+ of the form $\alpha \rightarrow \beta$, where $\alpha \subseteq R$ and $\beta \subseteq R$, at least one of the following holds :

i. $\alpha \rightarrow \beta$ is a trivial functional dependency (*i.e.*, $\beta \subseteq \alpha$)

ii. α is a super key for schema R.

c. A database design is in BCNF if each member of the set of relation schemas that constitute the design is in BCNF.

For example : Let consider a relation $R(A, B, C, D, E)$ with AC as primary key and functional dependencies in the relation R is given as $A \rightarrow B$, $C \rightarrow DE$.

To convert relation R into BCNF break the relation in three relation $R_1(A, B)$, $R_2(C, D, E)$, $R_3(A, C)$.

Que 3.11. Consider the universal relational schema R ($A, B, C, D, E, F, G, H, I, J$) and a set of following functional dependencies. $F = \{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$ determine the keys for R ? Decompose R into 2nd normal form.

OR

Consider the universal relation $R = \{A, B, C, D, E, F, G, H, I, J\}$ and the set of functional dependencies $F = \{ \{A, B\} \rightarrow \{C\}, \{A\} \rightarrow \{D, E\}, \{B\} \rightarrow \{F\}, \{F\} \rightarrow \{G, H\}, \{D\} \rightarrow \{I, J\} \}$. What is the key for R ? Decompose R into 2NF and then 3NF relations. **AKTU 2022-23, Marks 10**

Answer

Let $R = \{A, B, C, D, E, F, G, H, I, J\}$ and the set of functional dependencies $F = \{ \{A, B\} \rightarrow \{C\}, \{A\} \rightarrow \{D, E\}, \{B\} \rightarrow \{F\}, \{F\} \rightarrow \{G, H\}, \{D\} \rightarrow \{I, J\} \}$.

A minimal set of attributes whose closure includes all the attributes in R is a key. Since, the closure of $\{A,B\}$, $\{A,B\}$ += R,

So, one key of R is $\{A, B\}$

Decompose R into 2NF and then 3NF : For this normalize R intuitively into 2NF and 3NF :

1. Identify partial dependencies and that may violate 2NF. These are attributes that are functionally dependent on either parts of the key, $\{A\}$ or $\{B\}$, alone
2. Now we can calculate the closure (A)+and (B)+to determine partially dependent attributes :

   (A)+= $\{A, D, E, I, J\}$

   Hence $(A) \rightarrow \{D, E, I, J\}$ $(A) \rightarrow \{A\}$ is a trivial dependency

   (B)+= $\{B, F, G, H\}$

   Hence $(B) \rightarrow \{F, G, H\}$ $(B) \rightarrow \{B\}$ is a trivial dependency
3. For normalizing into 2NF, we may remove the attributes that are functionally dependent on part of the key (A or B) and R and place them in separate relations $R1$ and $R2$, along with the part of the key they depend on (A or B), which are copied into each of these relations but also remains in the original relation, which we call $R3$ below :

   $R1 = \{A, D, E, I, J\}$, $R2 = \{B, F, G, H\}$, $R3 = \{A, B, C\}$
4. The new keys for $R1$, $R2$, and $R3$.
5. Next, we look for transitive dependencies in $R1$, $R2$ and $R3$.

   The relation $R1$ has the transitive dependency $\{A\} \rightarrow \{D\} \rightarrow \{I, J\}$, so we remove the transitively dependent attributes $\{I, J\}$ from $R1$ into relation $R11$ and copy the attribute D they are dependent on into $R11$.
6. The remaining attributes are kept in relation $R12$. Hence, $R1$ is decomposed into $R11$ and $R12$ as follows :

   $R11 = \{D, I, J\}$, $R12 = \{A, D, E\}$
7. The relation $R2$ is similarly decomposed into $R21$ and $R22$ based on the transitive dependent $\{B\} \rightarrow \{F\} \rightarrow \{G, H\}$

   $R2 = \{F, G, H\}$, $R2 = \{B, F\}$
8. The final set of relations in 3NF are $\{R11, R12, R22, R3\}$

Que 3.12. Write the difference between BCNF and 3NF.

Answer

S. No.	BCNF	3NF
1.	In BCNF, for any FDs for a relation R, $A \rightarrow B$, A should be a super key of relation.	In 3NF, there should be no transitive dependency that is no non prime attribute should be transitively dependent on the candidate key.
2.	It is comparatively stronger than 3NF.	It is less strong than BCNF.
3.	In BCNF, the functional dependencies are already in 1NF, 2NF and 3NF.	In 3NF, the functional dependencies are already in 1NF and 2NF.
4.	Redundancy is low.	Redundancy is high.
5.	In BCNF, there may or may not be preservation of all.	In 3NF, there is preservation of all functional dependencies.
6.	It is difficult to achieve.	It is comparatively easier to achieve.
7.	Lossless decomposition is hard to achieve in BCNF.	Lossless decomposition can be achieved by 3NF.

Que 3.13. Prove that BCNF is stricter than 3NF.

OR

Prove that BCNF is stronger than 3NF.

Answer

1. A relation, R, is in 3NF iff for every dependency $X \rightarrow A$ satisfied by R at least one of the following conditions :
   a. $X \rightarrow A$ is trivial (*i.e.*, A is subset of X)
   b. X is a superkey for R, or
   c. A is a key attribute for R.

   BCNF does not permit the third of these options.
2. BCNF identifies some of the anomalies that are not addressed by 3NF.
3. A relation in BCNF is also in 3NF but vice-versa is not true.

Hence, BCNF is more strict / stronger than 3NF.

Que 3.14.

i. Consider the relation R(a, b, c, d) with set F = {a → c, b → d} decompose this relation in 2 NF.

ii. Explain the lossless decomposition with example.

AKTU 2020-21, Marks 10

Answer

i. Given R(a, b, c, d) and F = {a → c, b → d}

Step 1 : Find candidate key :

$$(ab)^+ = \{a, b, c, d\}$$

Step 2 : Prime attributes are {a, b}

Step 3 : Finding partial dependency {a → c}

Step 4 : Find $(a)^+$

i.e., $(a)^+ = \{a, c\}$

Step 5 : R1{A, C} and R2{b, d}

Step 6 : Now finding normal form

F1 : {a → c} F2 : {b → d}

Hence, F1 and F2 are in 2NF.

ii. **Lossless decomposition :** A decomposition $\{R_1, R_2, \ldots R_n\}$ of a relation R is called a lossless decomposition for R if the natural join of $R_1, R_2, \ldots, R_n$ produces exactly the relation R.

Following are the condition to show that decompositions are lossless using FD set :

1. Union of attributes of R_1 and R_2 must be equal to attribute of R. Each attribute of R must be either in R_1 or in R_2.

$$\text{Att}(R_1) \cup \text{Att}(R_2) = \text{Att}(R)$$

2. Intersection of attributes of R_1 and R_2 must not be NULL.

$$\text{Att}(R_1) \cap \text{Att}(R_2) \neq \phi$$

3. Common attribute must be a key for at least one relation (R_1 or R_2)

$\text{Att}(R_1) \cap \text{Att}(R_2) \rightarrow \text{Att}(R_1)$ or $\text{Att}(R_1) \cap \text{Att}(R_2) \rightarrow \text{Att}(R_2)$

For example :

Consider a relation R (A, B, C, D) with FD set $A \rightarrow BC$ and $A \rightarrow D$ is decomposed into $R_1(A, B, C)$ and $R_2(A, D)$ which is a lossless join decomposition as :

1. First condition holds true as :

$\text{Att}(R_1) \cup \text{Att}(R_2) = (A, B, C) \cup (A, D) = (A, B, C, D) = \text{Att}(R)$.

2. Second condition holds true as :

$$\text{Att}(R_1) \cap \text{Att}(R_2) = (A, B, C) \cap (A, D) \neq \phi$$

3. Third condition holds true as :

$\text{Att}(R_1) \cap \text{Att}(R_2) = A$ is a key of $R_1(A, B, C)$ because $A \rightarrow BC$.

Que 3.15. **Write the difference between 3NF and BCNF. Find the normal form of relation $R(A, B, C, D, E)$ having FD set $F = \{A \rightarrow B, BC \rightarrow E, ED \rightarrow A\}$.**

Answer

Difference : Refer Q. 3.12, Page 3–14A, Unit-3.

Numerical :

Given : $R(A, B, C, D, E)$ and

$$F = A \rightarrow B$$
$$BC \rightarrow E$$
$$ED \rightarrow A$$

$$(ACD)^+ = ACDB \quad \because \; A \rightarrow B$$
$$= ABCDE \quad \because \; BC \rightarrow E$$
$$= ABCDE \quad \because \; ED \rightarrow A$$

So, ACD is a key of R.

Relation R is in 1NF as all domains are simple *i.e.*, all elements are atomic.

Que 3.16.

i. **What is highest normal form of the relation R(W, X, Y, Z) with the set F = {WY → XZ, X → Y}.**

ii. **Consider a relation R(A, B, C, D, E) with set F = {A → CD, C → B, B → AE}. What are the prime attributes of this relation and decompose the given relation in 3 NF.**

AKTU 2020-21, Marks 10

Answer

i. **Step 1 :** Find the candidate key :

$$F = WY \rightarrow XZ$$
$$X \rightarrow Y$$
$$WY \rightarrow X$$
$$WY \rightarrow Z$$
$$X \rightarrow Y$$

$$WXY^+ = \{W, X, Y, Z\}$$

So, WXY is a candidate key.

Step 2 : Prime attributes are {W, X, Y} non-prime attributes is {Z}.

Step 3 : The relation R is in 1st normal form as a relational DBMS does not allow multi-valued or composite attributes.

Step 4 : The relation is not in 2nd normal form because WY → Z is partial dependency and 2nd normal form does not allow partial dependency.

So, the highest normal form will be the 1st normal form.

ii.Step 1 : Find the candidate key :

$A \rightarrow CD$, $C \rightarrow B$, $B \rightarrow AE$

$(A)^+ = \{A, C, D, B, E\}$, $B^+ = \{B, C, A, E, D\}$

So, (A, B) are the candidate key.

Step 2 : Prime attribute is (A, B) and non-prime attributes are {C, D, E}.

Step 3 : A relation is in third normal form as {A, B} are super key and {C, D, E} are non-prime attributes, we can drive {C, D, E} from {A, B}.

Que 3.17. What do you understand by transitive dependencies ? Explain with an example any two problems that can arise in the database if transitive dependencies are present in the database.

AKTU 2021-22, Marks 10

Answer

A. Transitive dependencies :

1. A transitive dependency in a database is an indirect relationship between values in the same table that causes a functional dependency.
2. To achieve the normalization standard of Third Normal Form (3NF), we eliminate any transitive dependency.
3. A transitive dependency exists when you have the following functional dependency pattern :

   $A \rightarrow B$ and $B \rightarrow C$; therefore $A \rightarrow C$
4. Consider the following example :

Course	Field	Instructor	Instructor Phone
English	Languages	Abha Dixit	0123456789
French	Languages	Abha Dixit	0123456789
Drawing	Art	N D Bhatt	9876543210
PHP	Programming	Arun Tripathi	222XXX8887
C++	Programming	Arun Tripathi	222XXX8887

5. If you have a **Course** you can easily get its **Instructor** so **Course → Instructor.**

6. If you have an **Instructor** you can't get his **Course** as he might be teaching different courses.
7. If you have an **Instructor** you can easily get his **Phone** so
   Instructor → Phone.
8. That means if you have a **Course** then you can get the **Instructor Phone** which means **Course → Instructor Phone** (*i.e.*, Transitive dependency).

B. Transitive dependencies have following problem :

1. If you delete both the **French** and **English** courses then you will delete their instructor **Abha Dixit** as well and his phone number will be lost forever.
2. There is no way to add a new **Instructor** to your database unless you add a **Course** for him first or you can duplicate the data in an **Instructors table** which is even worse.
3. If Instructor **Abha Dixit** changes her phone number then you will have to update all Courses that she teaches with the new info which can be very prone to mistakes.
4. You can't delete an instructor from your database unless you delete all the courses he teaches or set all his fields to null.

PART-3

Inclusion Dependence, Lossless Join Decomposition.

Que 3.18. Explain inclusion dependencies.

Answer

1. An inclusion dependency $R.X < S.Y$ between two set of attributes X of relation schema R, and Y of relation schema S specifies the constraint that, at any specific time when r is a relation state of R and s a relation state of S, we must have

$$\pi_X(r(R)) \subseteq \pi_Y(s(S))$$

2. The set of attributes on which the inclusion dependency is specified X of R and Y of S must have the same number of attributes. Also domains for each pair of corresponding attributes should be compatible.
3. Inclusion dependencies are defined in order to formalize two types of interrelational constraints :
   a. The foreign key (or referential integrity) constraint cannot be specified as a functional or multivalued dependency because it relates attributes across relations.
   b. The constraint between two relations that represent a class/subclass relationship also has no formal definition in terms of the functional, multivalued, and join dependencies.

4. For example, if $X = \{A_1, A_2, \ldots, A_n\}$ and $Y = \{B_1, B_2, \ldots, B_n\}$, one possible correspondence is to have $\text{dom}(A_i)$ compatible with $\text{dom}(B_i)$ for $1 \leq i \leq n$. In this case, we say that A_i corresponds to B_i.

Que 3.19. Describe lossless decomposition.

OR

Define functional dependency. What do you mean by lossless decomposition ? Explain with suitable example how functional dependencies can be used to show that decompositions are lossless.

Answer

Functional dependency : Refer Q. 3.1, Page 3–2A, Unit-3.

Lossless decomposition : A decomposition $\{R_1, R_2, \ldots R_n\}$ of a relation R is called a lossless decomposition for R if the natural join of R_1, R_2, ..., R_n produces exactly the relation R.

Following are the condition to show that decompositions are lossless using FD set :

1. Union of attributes of R_1 and R_2 must be equal to attribute of R. Each attribute of R must be either in R_1 or in R_2.
$$\text{Att}(R_1) \cup \text{Att}(R_2) = \text{Att}(R)$$
2. Intersection of attributes of R_1 and R_2 must not be NULL.
$$\text{Att}(R_1) \cap \text{Att}(R_2) \neq \phi$$
3. Common attribute must be a key for at least one relation (R_1 or R_2)
$$\text{Att}(R_1) \cap \text{Att}(R_2) \rightarrow \text{Att}(R_1) \text{ or } \text{Att}(R_1) \cap \text{Att}(R_2) \rightarrow \text{Att}(R_2)$$

For example :

Consider a relation R (A, B, C, D) with FD set $A \rightarrow BC$ and $A \rightarrow D$ is decomposed into $R_1(A, B, C)$ and $R_2(A, D)$ which is a lossless join decomposition as :

1. First condition holds true as :
$$\text{Att}(R_1) \cup \text{Att}(R_2) = (A, B, C) \cup (A, D) = (A, B, C, D) = \text{Att}(R).$$
2. Second condition holds true as :
$$\text{Att}(R_1) \cap \text{Att}(R_2) = (A, B, C) \cap (A, D) \neq \phi$$
3. Third condition holds true as :
$\text{Att}(R_1) \cap \text{Att}(R_2) = A$ is a key of $R_1(A, B, C)$ because $A \rightarrow BC$.

Que 3.20. Consider the relation $r(X, Y, Z, W, Q)$ the set $F = \{X \rightarrow Z, Y \rightarrow Z, Z \rightarrow W, WQ \rightarrow Z, ZQ \rightarrow X\}$ and the decomposition of r into relations $R_1(X, W)$, $R_2(X, Y)$, $R_3(Y, Q)$, $R_4(Z, W, Q)$ and $R_5(X, Q)$. Check whether the decompositions are lossy or lossless.

Answer

To check the decomposition is lossless following condition should hold.

1. $R_1 \cup R_2 \cup R_3 \cup R_4 \cup R_5 = (X, W) \cup (X, Y) \cup (Y, Q) \cup (Z, W, Q) \cup (X, Q) = (X, Y, Z, W, Q) = R$

2. $(R_1 \cap R_2) \cap (R_3 \cap R_4) \cap R_5 = ((X, W) \cap (X, Y)) \cap ((Y, Q) \cap (Z, W, Q)) \cap (X, Q) = X \cap Q \cap \{X, Q\} = X \cap Q = \phi$

Since, condition 2 violates the condition of lossless join decomposition. Hence decomposition is lossy.

Que 3.21. Given the following set of FDs on schema R (V, W, X, Y, Z) $\{Z \rightarrow V, W \rightarrow Y, XY \rightarrow Z, V \rightarrow WX\}$ State whether the following decomposition are loss-less-join decompositions or not.

i. $R1 = (V, W, X)$, $R2 = (V, Y, Z)$

ii. $R1 = (V, W, X)$, $R2 = (X, Y, Z)$

AKTU 2022-23, Marks 10

Answer

To check whether a decomposition is lossless-join or not, we need to find the common attributes between the decomposed relations, and then check if their natural join yields the original relation. If it does, the decomposition is lossless-join, otherwise, it is not.

Given Functional Dependencies (FDs) :

$$Z \rightarrow V$$
$$W \rightarrow Y$$
$$XY \rightarrow Z$$
$$V \rightarrow WX$$

i. Decomposition :

$$R1 = (V, W, X)$$
$$R2 = (V, Y, Z)$$

a. Common attribute : V

b. Closure of V :

$$V^+ = \{V, W, X, Y, Z\}$$

V is a superkey for R

So, it is lossless join decomposition

ii. Decomposition $R1 = (V, W, X)$

$$R2 = (X, Y, Z)$$

a. Common Attribute : X

b. Closure of X :

$$X^+ = \{X\}$$

X alone is not a superkey.

c. Intersection check : $R1 \cap R2 = \{X\}$

X does not determine all attribute in $R1$ or $R2$. So, it is not a lossless-join decomposition.

PART-4

Normalization using FD, MVD and JDs, Alternative Approaches to Database Design.

Que 3.22. What is normalization ? Explain.

OR

Write a short note on normalization with advantages.

Answer

1. Normalization is the process of reducing data redundancy in a relational database.
2. Normalization is a refinement process that the database designer undertakes. After identifying the data objects of the proposed database, their relationships define the tables required and columns within each table.
3. The fundamental principle of normalization is, "The same data should not be stored in multiple places." No information is lost in the process; however, the number of tables generally increases as the rules are applied.

Advantages :

1. It helps to remove the redundancy from the relation.
2. It helps in easy manipulation of data.
3. It helps to provide more information to the user.
4. It eliminates modification anomalies.

Que 3.23. What is MVD and join dependency ? Describe.

OR

Write a short note on MVD or JD.

OR

Describe the multivalued dependency.

Answer

Multivalued Dependency (MVD) :

1. MVD occurs when two or more independent multivalued facts about the same attribute occur within the same relation.

2. MVD is denoted by $X \rightarrow\rightarrow Y$ specified on relation schema R, where X and Y are both subsets of R.

3. Both X and Y specifies the following constraint on any relation state r of R : If two tuples t_1 and t_2 exist in r such that $t_1(X) = t_2(X)$, then two tuples t_3 and t_4 should also exist in r with the following properties, where we use Z to denote $(R - (X \cup Y))$

$$t_3(X) = t_4(X) = t_1(X) = t_2(X)$$
$$t_3(Y) = t_1(Y) \text{ and } t_3(Z) = t_2(Z)$$
$$t_4(Y) = t_2(Y) \text{ and } t_4(Z) = t_1(Z)$$

4. An MVD $X \rightarrow Y$ in R is called a trivial MVD if
   a. X is a subset of Y or
   b. $X \cup Y = R$

   An MVD that satisfies neither (a) nor (b) is called a non-trivial MVD.

For example :

Relation with MVD

Faculty	Subject	Committee
John	DBMS	Placement
John	Networking	Placement
John	MIS	Placement
John	DBMS	Scholarship
John	Networking	Scholarship
John	MIS	Scholarship

Join Dependency (JD) :

1. A Join Dependency (JD), denoted by $(R_1, R_2, ..., R_n)$ specified on relation scheme R, specifies a constraints on the states r of R.

2. The constraint states that every legal state r of R should have a lossless join decomposition into $R_1, R_2, ..., R_n$. That is, for every such r, we have

$$(\Pi_{R1}(r), \Pi_{R2}(r), ..., \Pi_{Rn}(r)) = r$$

3. A join dependency JD $(R_1, R_2, ..., R_n)$, specified on relation schema R, is a trivial JD if one of the relation schemas R_i in JD $(R_1, R_2, ..., R_n)$ is equal to R.

4. Such a dependency is called trivial because it has the lossless join property for any relation state r of R and hence does not specify any constraint on R.

Que 3.24. Describe the following terms :

i. **Multivalued dependency.**

ii. **Trigger.**

AKTU 2023-24, Marks 10

Answer

i. **Multivalued Dependency (MVD) :** Refer Q. 3.23, Page 3–21A, Unit-3.

ii. **Trigger :** Refer Q. 2.29, Page 2–35A, Unit-2.

Que 3.25. Explain the fourth and fifth normal with suitable example.

OR

Describe the term MVD in the context of DBMS by giving an example. Discuss 4NF and 5NF also.

AKTU 2023-24, Marks 10

AKTU 2021-22, Marks 10

Answer

Fourth Normal Form (4NF) :

1. A table is in 4NF, if it is in BCNF and it contains multivalued dependencies.
2. A relation schema R is in 4NF, with respect to a set of dependencies F (that includes FD and multivalued dependencies) if, for every non-trivial multivalued dependency $X \rightarrow\rightarrow Y$ in F^+, X is superkey for R.
   For example : A Faculty has multiple courses to teach and he is leading several committees. This relation is in BCNF, since all the three attributes concatenated together constitutes its key. The rule for decomposition is to decompose the offending table into two, with the multi-determinant attribute or attributes as part of the key of both. In this case to put the relation in 4NF, two separate relations are formed as follows :

FACULTY_COURSE (FACULTY, COURSE)
FACULTY_COMMITTEE (FACULTY, COMMITTEE)

Faculty	Course
John	Subject
John	Networking
John	MIS

Faculty	Committee
John	Placement
John	Scholarship

Fifth Normal Form (5NF) :

1. A relation is in 5NF, if it is 4NF and cannot be further decomposed.
2. In 5NF, we use the concept of join dependency which is a generalized form of multivalued dependency.

3. A relation schema R is in 5NF or Project Join Normal Form (PJNF) with respect to a set F of functional, multivalued and join dependencies if, for every non-trivial join dependency JD (R_1, R_2, ... R_n) in F^* (that is implied by F), every R_i is a superkey of R.

For example :

Company	Product	Supplier
Godrej	Soap	Mr. X
Godrej	Shampoo	Mr. X
Godrej	Shampoo	Mr. Y
Godrej	Shampoo	Mr. Z
H.Lever	Soap	Mr. X
H.Lever	Soap	Mr. Y
H.Lever	Shampoo	Mr. Y

The table is in 4NF as there is no multivalued dependency.

If we decompose the table then we will lose information, which can be as follows :

Suppose the table is decomposed into two parts as :

Company_Product

Company	Product
Godrej	Soap
Godrej	Shampoo
H.Lever	Soap
H.Lever	Shampoo

Company_Supplier

Company	Supplier
Godrej	Mr. X
Godrej	Mr. X
Godrej	Mr. Z
H.Lever	Mr. X
H.Lever	Mr. Y

The redundancy has been eliminated but we have lost the information. Now suppose that the original table to be decomposed in three parts, Company_Product, Company_Supplier and Product_Supplier, which is as follows :

Product_Supplier

PRODUCT	SUPPLIER
Soap	Mr. X
Soap	Mr. Y
Shampoo	Mr. X
Shampoo	Mr. Y
Shampoo	Mr. Z

So, it is clear that if a table is in 4NF and cannot be further decomposed, it is said to be in 5NF.

Multivalued Dependency (MVD) : Refer Q. 3.23, Page 3–21A, Unit-3.

Que 3.26. What is meant by the attribute preservation condition on decomposition ? Given relation $R(A, B, C, D, E)$ with the functional dependencies $F = \{AB \rightarrow CD, A \rightarrow E, C \rightarrow D\}$, the decomposition of R into $R_1(A, B, C)$, $R_2(B, C, D)$, $R_3(C, D, E)$ check whether the relation is lossy or lossless.

Answer

Attribute preservation condition on decomposition :

1. The relational database design algorithms start from a single universal relation schema $R = \{A_1, A_2, ..., A_n\}$ that includes all the attributes of the database.
2. We implicitly make the universal relation assumption, which states that every attribute name is unique.
3. Using the functional dependencies, the algorithms decompose the universal relation schema R into a set of relation schemas $D = \{R_1, R_2, ..., R_m\}$ that will become the relational database schema; D is called a decomposition of R.
4. Each attribute in R must appear in at least one relation schema R_i in the decomposition so that no attributes are lost; formally, we have

$$\bigcup_{i=1}^{m} R_i = R$$

This is called the attribute preservation condition of decomposition.

Numerical :

$R_1 = (A, B, C)$
$R_2 = (B, C, D)$
$R_3 = (C, D, E)$
$R_1 \cap R_2 \cap R_3 = C$

	A	B	C	D	E
R_1	a_1	a_2	a_3	a_4	a_5
R_2	a_1	b_{22}	b_{23}	b_{24}	a_5
R_3	b_{31}	b_{32}	a_3	a_4	b_{35}

After applying first two functional dependencies first row contain all "a" symbols. Hence it is lossless join.

Que 3.27. What are the alternate approaches to database design ?

OR

Describe dangling tuples.

Answer

An alternate approach to database design is dangling tuples :

1. Tuples that "disappear" in computing a join are known as dangling tuples.
   a. Let $r_1(R_1), r_2(R_2), ..., r_n(R_n)$ be a set of relations.
   b. A tuple t of relation R_i is a dangling tuple if t is not in the relation :
   $$\Pi_{Ri} (r_1 \bowtie r_2 \bowtie ... \bowtie r_n)$$
2. The relation $r_1 \bowtie r_2 \bowtie ... \bowtie r_n$ is called a universal relation since it involves all the attributes in the "universe" defined by $R_1 \cup R_2 \cup ... \cup R_n$.
3. If dangling tuples are allowed in the database, instead of decomposing a universal relation, we may prefer to synthesize a collection of normal form schemas from a given set of attributes.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. What is functional dependency ? Explain the procedure of calculating the canonical cover of a given functional dependency set with suitable example.

Ans. Refer Q. 3.3.

Q. 2. A set of FDs for the relation R{A, B, C, D, E, F} is AB → C, C → A, BC → D, ACD → B, BE → C, EC → FA, CF → BD, D → E. Find a minimum cover for this set of FDs.

Ans. Refer Q. 3.9.

Q. 3. Define normal forms. List the definitions of first, second and third normal forms. Explain BCNF with a suitable example.

Ans. Refer Q. 3.10.

Q. 4. Consider the universal relational schema R ($A, B, C, D, E, F, G, H, I, J$) and a set of following functional dependencies. $F = \{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$ determine the keys for R ? Decompose R into 2^{nd} normal form.

Ans. Refer Q. 3.12.

Q. 5. Prove that BCNF is stricter than 3NF.

Ans. Refer Q. 3.13.

Q. 6. What is MVD and join dependency ? Describe.

Ans. Refer Q. 3.23.

Q. 7. Describe the following terms :

i. Multivalued dependency.

ii. Trigger.

Ans. Refer Q. 3.24.

Q. 8. Describe the term MVD in the context of DBMS by giving an example. Discuss 4NF and 5NF also.

Ans. Refer Q. 3.25.

☺☺☺

4

UNIT

Transaction Processing Concept

CONTENTS

PART-1

Transaction System, Testing of Serializability, Serializability of Schedules.

Que 4.1. Write a short note on transaction.

Answer

1. A transaction is a logical unit of database processing that includes one or more database access operations; these include insertion, deletion, modification or retrieval operations.
2. The database operations that form a transaction can be embedded within an application program.
3. By specifying explicit begin transaction and end transaction we can specify the transaction boundaries.
4. If the database operations in a transaction do not update the database but only retrieve data, the transaction is called a read-only transaction.

Que 4.2. Explain ACID properties of transaction.

OR

What do you mean by transaction ? Explain transaction property with detail and suitable example.

OR

What do you understand by ACID properties of transaction ? Explain in details.

OR

Define transaction and explain its properties with suitable example.

Answer

Transaction : Refer Q. 4.1, Page 4–2A, Unit-4.

To ensure integrity of data, the database system maintains some properties of transaction. These properties are known as ACID properties.

Let us consider an example for the set of operations :

1. Deduct the amount Rs.500 from *A*'s account.
2. Add amount Rs. 500 to *B*'s account.

ACID properties are as follows :

1. **Atomicity :** It implies that either all of the operations of the transaction should execute or none of them should occur.

   Example : All operations in this set must be done.

If the system fails to add the amount in B's account after deducting from A's account, revert the operation on A's account.

2. **Consistency :** The state of database before the execution of transaction and after the execution of transaction should be same.

Example : Let us consider the initial value of accounts A and B are Rs.1000 and Rs.1500. Now, account A transfer Rs. 500 to account B.

Before transaction : $A + B = 1000 + 1500 = 2500$

After transaction : $A + B = 500 + 2000 = 2500$

Since, total amount before transaction and after transaction are same. So, this transaction preserves consistency.

3. **Isolation :** A transaction must not affect other transactions that are running parallel to it.

Example : Let us consider another account C. If there is any ongoing transaction between C and A, it should not make any effect on the transaction between A and B. Both the transactions should be isolated.

4. **Durability :** Once a transaction is completed successfully. The changes made by transaction persist in database.

Example : A system gets crashed after completion of all the operations. If the system restarts it should preserve the stable state. An amount in A and B account should be the same before and after the system gets a restart.

Que 4.3. List the ACID properties. Explain the usefulness of each property.

Answer

ACID properties of transaction : Refer Q. 4.2, Page 4–2A, Unit-4.

Usefulness of ACID properties :

Atomicity : Atomicity is useful to ensure that if for any reason an error occurs and the transaction is unable to complete all of its steps, then the system is returned to the state it was in before the transaction was started.

Consistency : The consistency property is useful to ensure that a complete execution of transaction from beginning to end is done without interference of other transactions.

Isolation : Isolation property is useful to ensure that a transaction should appear isolated from other transactions, even though many transactions are executing concurrently.

Durability : Durability is useful to ensure that the changes applied to the database by a committed transaction must persist in the database.

Que 4.4. **Explain transaction state in brief.**

OR

What is transaction ? Draw a state diagram of a transaction showing its states. Explain ACID properties of a transaction with suitable examples.

OR

Draw a transaction state diagram and describe the states that a transaction goes through during execution.

Answer

Transaction : Refer Q. 4.1, Page 4–2A, Unit-4.

State diagram of transaction :

1. **Active :** The transaction is said to be in the active state till the final statement is executed.

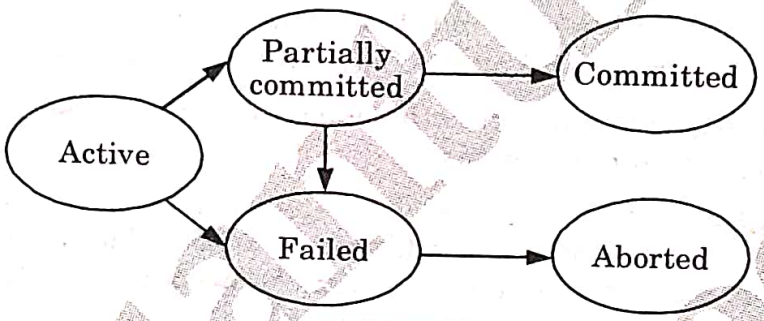


Fig. 4.4.1.

2. **Partially committed :** A transaction is said to be entered in the partial state when final statement gets executed. But it is still possible that it may have to be aborted, since its actual operation is still resided in main memory in which the power failure brings failure of its execution.
3. **Failed :** A transaction enters a failed state after the system determines that the transaction can no longer proceeds with its normal execution.
4. **Aborted :** A transaction enters this state after the transaction has been rolledback and the database has been restored to its state, prior to the start of the transaction.
5. **Committed :** A transaction enter this state after successful completion.

ACID properties with example : Refer Q. 4.2, Page 4–2A, Unit-4.

Que 4.5. **What is serializability ? Why serializability is required ? Write short note on serializability of schedule.**

Answer

Serializability : Serializability is a property of a transaction schedule which is used to keep the data in the data item in consistent state. It is the classical concurrency scheme.

Serializability is required :

1. To control concurrent execution of transaction.
2. To ensure that the database state remains consistent.

Serializability of schedule :

1. In DBMS, the basic assumption is that each transaction preserves database consistency.
2. Thus, the serial execution of a set of transaction preserves database consistency.
3. A concurrent schedule is serializable if it is equivalent to a serial schedule.

PART-2

Conflict and View Serializable Schedule, Recoverability, Recovery from Transaction Failures.

Que 4.6. Discuss conflict serializability with example.

Answer

1. Consider a schedule S, in which there are two consecutive instructions I_i and I_j of transactions T_i and T_j respectively $(i \neq j)$.
2. If I_i and I_j refer to different data items, then swap I_i and I_j without affecting the results of any instruction in the schedule.
3. However, if I_i and I_j refer to the same data item Q, then the order of the two steps matter.
4. Following are four possible cases :

I_i	I_j	Swapping possible
Read (Q)	Read (Q)	Yes
Read (Q)	Write (Q)	No
Write (Q)	Read (Q)	No
Write (Q)	Write (Q)	No

5. I_i and I_j conflict if there are operations by different transactions on the same data item, and at least one of these instructions is a write operation.

For example :

Schedule S

T_1	T_2
read (A)	
write (A)	
	read (A)
	write (A)
read (B)	
write (B)	
	read (B)
	write (B)

i. The write (A) instruction of T_1 conflicts with read (A) instruction of T_2. However, the write (A) instruction of T_2 does not conflict with the read (B) instruction of T_1 as they access different data items.

Schedule S'

T_1	T_2
read (A)	
write (B)	
	read (A)
read (B)	
	write (A)
write (B)	
	read (B)
	write (B)

ii. Since the write (A) instruction of T_2 in Schedule S' does not conflict with the read (B) instruction of T_1, we can swap these instructions to generate an equivalent schedule.

iii. Both schedules will produce the same final system state.

6. If a schedule S can be transformed into a schedule S' by a series of swaps of non-conflicting instructions, we say that S and S' are conflict equivalent.

7. The concept of conflict equivalence leads to the concept of conflict serializability and the schedule S is conflict serializable.

Que 4.7. What is conflict serializable schedule ? Check the given schedule S1 is conflict serializable or not ?
S1 : R1(X), R2(X), R2(Y), W2(Y), R1(Y), W1(X)

AKTU 2020-21, Marks 10

Answer

A. **Conflict serializable schedule :** Refer Q. 4.6, Page 4–5A, Unit-4.

B. **Numerical :**

S1 : R1(X), R2(X), R2(Y), W2(Y), R1(Y), W1(X)

T_1	T_2
$r_1(x)$	
	$r_2(x)$
	$r_2(y)$
	$w_2(y)$
$r_1(y)$	
$w_1(x)$	

Precedence graph : $T_1 \leftarrow T_2$

Since, the graph does not contain cycle. Hence, it is conflict serializable.

Que 4.8. Describe serializable schedule. Discuss conflict serializability with suitable example. **AKTU 2021-22, Marks 10**

OR

What is conflict serializable schedule ? Explain the difference between conflict and view serializable schedule using suitable example ? **AKTU 2023-24, Marks 10**

Answer

Conflict serializable schedule : Refer Q. 4.6, Page 4–5A, Unit-4.

Serializable schedule : Refer Q. 4.5, Page 4–4A, Unit-4.

S. No.	Conflict serializability	View serializability
1.	Easy to achieve.	Difficult to achieve.
2.	Cheaper to test.	Expensive to test.
3.	Every conflict serializable is view serializable.	Every view serializable is not conflict serializable.
4.	Used in most concurrency control scheme.	Not used in concurrency control scheme.
5.	Example schedule : T1: R(A) W(A) T2: R(A) W(A)	Example schedule : T1: W(A) T2: R(A) W(A) T3: R(A)

Que 4.9. Explain view serializability with example.

Answer

1. The schedule S and S' are said to be view equivalent if following three conditions met :
   a. For each data item Q, if transaction T_i reads the initial value of Q in schedule S, then transaction T_i in schedule S', must also read the initial value of Q.
   b. For each data item Q if transaction T_i executes read (Q) in schedule S and if that value produced by a write (Q) operation executed by transaction T_j, then the read (Q) operation of transaction T_i in schedule S', must also read the value of Q that was produced by the same write (Q) operation of transaction T_j.
   c. For each data item Q, the transaction (if any) that performs the final write (Q) operation in schedule S must perform the final write (Q) operation in schedule S'.
2. Conditions (a) and (b) ensure that each transaction reads the same values in both schedules and therefore, performs the same computation. Condition (c), coupled with condition (a) and condition (b) ensure that both schedules result in the same final system state.
3. The concept of view equivalence leads to the concept of view serializability.
4. We say that schedule S is view serializable, if it is view equivalent to serial schedule.
5. Every conflict serializable schedule is also view serializable but there are view serializable schedules that are not conflict serializable.

Example :

Schedule S1

T_1	T_2
read (A)	
write (A)	
read (B)	
write (B)	
	read (A)
	write (A)
	read (B)
	write (B)

Schedule S2

T_1	T_2
read (A)	
write (A)	
	read (A)
	write (A)
read (B)	
write (B)	
	read (B)
	write (B)

Schedule $S1$ and $S2$ are view equivalent as :
1. T_1 reads initial value of data item A in $S1$ and $S2$.
2. T_2 reads value of data item A written by T_1 in $S1$ and $S2$.
3. T_2 writes final value of data item A in $S1$ and $S2$.

Que 4.10. **What is schedule ? Define the concept of recoverable, cascadeless and strict schedules.**

Answer

Schedule : A schedule is a set of transaction with the order of execution of instruction in the transaction.

Recoverable schedule :

A recoverable schedule is one in which for each pair of transaction T_i and T_j if T_j reads a data item previously written by T_i, the commit operation of T_i appears before the commit operation of T_j.

For example : In schedule S, let T_2 commits immediately after executing read (A) *i.e.*, T_2 commits before T_1 does. Now let T_1 fails before it commits, we must abort T_2 to ensure transaction atomicity. But as T_2 has already committed, it cannot be aborted. In this situation, it is impossible to recover correctly from the failure of T_1.

Schedule S

T_1	T_2
read (A)	
write (A)	
	read (A)
read (B)	

Cascadeless schedule :

1. A cascadeless schedule is one, where for each pair of transaction T_i and T_j such that T_j reads a data item previously written by T_i, the commit operation to T_j appears before the read operation of T_i.
2. Even if a schedule is recoverable, to recover correctly from the failure of a transaction T_i, we may have to rollback several transactions. Such situations occur if transactions have read data written by T_i.

Strict schedule :

1. A schedule is called strict if every value written by a transaction T is not read or changed by other transaction until T either aborts or commits.
2. A strict schedule avoids cascading and recoverability.

Que 4.11. **What is a schedule ? Define the concepts of recoverable, cascadeless and strict schedules, and compare them in terms of their recoverability.** **AKTU 2022-23, Marks 10**

Answer

Schedule, recoverable, cascadeless and strict schedules :
Refer Q. 4.10, Page 4–9A, Unit-4.

Comparison in terms of recoverability :

S. No.	Schedule type	Recoverability
1.	Recoverable schedule.	Ensures recoverability.
2.	Cascadeless schedule.	Does not ensure recoverability.
3.	Strict schedule.	Ensures recoverability.

Que 4.12. What is precedence graph ? How can it be used to test the conflict serializability of a schedule ?

Answer

Precedence graph :

1. A precedence graph is a directed graph $G = (N, E)$ that consists of set of nodes $N = \{T_1, T_2, ..., T_n\}$ and set of directed edges $E = [e_1, e_2...., e_m]$.
2. There is one node in the graph for each transaction T_i in the schedule.
3. Each edge e_i in the graph is of the form $(T_j \rightarrow T_k)$, $1 \leq j \leq n$, $1 \leq k \leq n$, where T_j is the starting node of e_i and T_k is the ending node of e_i.
4. Such an edge is created if one of the operations in T_j appears in the schedule before some conflicting operation in T_k.

Algorithm for testing conflict serializability of schedule S :

a. For each transaction T_i participating in schedule S, create a node labeled T_i in the precedence graph.

b. For each case in S where T_j executes a read_item(X) after T_i executes a write_item(X), create an edge $(T_i \rightarrow T_j)$ in the precedence graph.

c. For each case in S where T_j executes a write_item(X) after T_i executes read_item(X), create an edge $(T_i \rightarrow T_j)$ in the precedence graph.

d. For each case in S where T_j executes a write_item(X) after T_i executes a write_item(X), create an edge $(T_i \rightarrow T_j)$ in the precedence graph.

e. The schedule S is serializable if and only if the precedence graph has no cycles.

5. The precedence graph is constructed as described in given algorithm.

6. If there is a cycle in the precedence graph, schedule S is not (conflict) serializable; if there is no cycle, S is serializable.

7. In the precedence graph, and edge from T_i to T_j means that transaction T_i must come before transaction T_j in any serial schedule that is equivalent to S, because two conflicting operations appear in the schedule in that order.

8. If there is no cycle in the precedence graph, we can create an equivalent serial schedule S' that is equivalent to S, by ordering the transactions that participate in S as follows : Whenever an edge exists in the precedence graph from T_i to T_j, T_i must appear before T_j in the equivalent serial schedule S'.

Example :

T_1	T_2	T_3
		read (Y) ;
		read (Z) ;
read (X) ;		
write (X) ;		
		write (Y) ;
		write (Z) ;
	read (Z) ;	
read (Y) ;		
write (Y) ;		
	read (Y) ;	
	write (Y) ;	
	read (X) ;	
	write (X) ;	

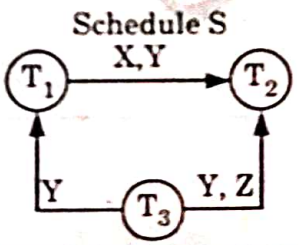


Fig. 4.12.1. Equivalent serial schedules $T_3 \rightarrow T_1 \rightarrow T_2$.

Que 4.13. Test the serializability of the following schedule :

i. $r_1(x); r_3(x); w_1(x); r_2(x); w_3(x)$

ii. $r_3(x); r_2(x); w_3(x); r_1(x); w_1(x)$

Answer

i. The serialization graph is :

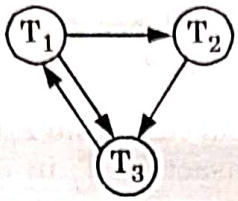


Fig. 4.13.1.

There are two cycles. It is not serializable.

ii. The serialization graph is :

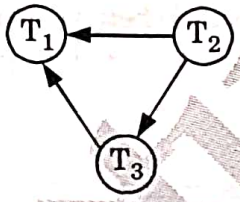


Fig. 4.13.2.

There is no cycle, so it is serialized.

The equivalent serial schedule is :

$$r_3(x), r_2(x), w_3(x), r_1(x), w_1(x)$$

Que 4.14. Discuss cascadeless schedule and cascading rollback. Why is cascadeless of schedule desirable ?

Answer

Cascadeless schedule : Refer Q. 4.10, Page 4–9A, Unit-4.

Cascading rollback : Cascading rollback is a phenomenon in which a single failure leads to a series of transaction rollback.

For example :

Schedule S

T_1	T_2	T_3
read (A)		
read (B)		
write (A)		
	read (A)	
	write (A)	
		read (A)

In the example, transaction T_1 writes a value of A that is read by transaction T_2. Transaction T_2 writes a value of A that is read by transaction T_3. Suppose that at this point T_1 fails. T_1 must be rolled back. Since T_2 is dependent on T_1, T_2 must be rolled back, since T_3 is dependent on T_2, T_3 must be rolled back.

Need for cascadeless schedules :

Cascadeless schedules are desirable because the failure of a transaction does not lead to the aborting of any other transaction. This comes at the cost of less concurrency.

Que 4.15. What are schedules ? What are differences between conflict serializability and view serializability ? Explain with suitable example what are cascadeless and recoverable schedules ?

Answer

Schedule : Refer Q. 4.10, Page 4–9A, Unit-4.

Difference between conflict and view serializability : Refer Q. 4.8, Page 4–7A, Unit-4.

Recoverable and cascadeless schedule : Refer Q. 4.10, Page 4–9A, Unit-4.

Example of recoverable schedule :

Transaction	Operation
T1	W(A)
T2	R(A) (Reads A written by T1)
T1	Commit
T2	Commit

This is a recoverable schedule because T2 commits after T1 has committed.

Example of cascadeless schedule :

Transaction	Operation
T1	W(A)
T1	Commit
T2	R(A)
T2	Commit

This is a cascadeless schedule because T2 reads A only after T1 has committed.

Que 4.16. What is schedule ? What are its types ? Explain view serializable and cascadeless schedule with suitable example of each.

Answer

Schedule : Refer Q. 4.10, Page 4–9A, Unit-4.

Types of schedule are :

1. Recoverable schedule

2. Cascadeless schedule
3. Strict schedule

View serializable : Refer Q. 4.9, Page 4–8A, Unit-4.

Example of cascadeless schedule : Refer Q. 4.15, Page 4–13A, Unit-4.

Que 4.17. Consider schedules S1, S2, and S3 below. Determine whether each schedule is strict, cascadeless, recoverable, or non recoverable. (Determine the strictest recoverability condition that each schedule satisfies).

S1: r1 (X); r2 (Z); r1 (Z); r3 (X); r3 (Y); w1 (X); c1; w3 (Y); c3; r2 (Y); w2 (Z); w2 (Y); c2;

S2: r1 (X); r2 (Z); r1 (Z); r3 (X); r3 (Y); w1 (X); w 3 (Y); r2 (Y); w2 (Z); w2 (Y); c1; c2; c3;

S3: r1 (X); r2 (Z); r3 (X); r1 (Z); r2 (Y); r3 (Y); w1 (X); c1; w2 (Z); w3 (Y); w2 (Y); c3; c2;

AKTU 2022-23, Marks 10

Answer

a. Recoverable schedule : The transaction which does uncommitted read operation should not commit before the commit/rollback of the transaction which updated that data item.

Non-recoverable schedule : Opposite of recoverable schedule

Cascadeless schedule : No uncommitted read is allowed.

Strict recoverable schedule : Read/Write(WR,WW) operations are not allowed by any other transactions until the transaction commit/ rollback which updated a data item.

T1	T2	T3
r1(X)		
	r2(Z)	
r1(Z)		
		r3(X)
		r3(Y)
w1(X)		
c1		
		w3(Y)
		c3
	r2 (Y)	
	w2 (Z)	
	w2 (Y)	
	c2	

S1

T1	T2	T3
r1(X)		
	r2(Z)	
r1(Z)		
		r3(X)
		r3(Y)
w1(X)		
		w3(Y)
	r2 (Y)	
	w2 (Z)	
	w2 (Y)	
c1		
	c2	
		c3

S2

T1	T2	T3
r1(X)		
	r2(Z)	
		r3(X)
r1(Z)		
	r2 (Y)	
		r3(Y)
w1(X)		
c1		
	w2 (Z)	
		w3(Y)
w2 (Y)		
		c3
	c2	

S3

S1: recoverable, cascadeless, strict recoverable.

S2: There is a dirty read between W3(Y) and R2(Y) hence not cascadeless, Not recoverable because T2 is committing before T3.

S3: No dirty read hence recoverable and cascadeless schedule but not strict recoverable because WW exists between W3(Y) and W2(Y).

Que 4.18. **Consider the three transactions *T1*, *T2*, and *T3* and the schedules *S1* and *S2* given below. State whether each schedule is serializable or not. If a schedule is serializable, write down the equivalent serial schedule (s).**

T1: r1 (X); r1 (Z); w1 (X);

T2: r2 (Z); r2 (Y); w2 (Z); w2 (Y);

T3: r3 (X); r3 (Y); w3 (Y);

S1: r1 (X); r2 (Z); r1 (Z); r3 (X); r3 (Y); w1 (X); w3 (Y); r2 (Y); w2 (Z); w2 (Y);

S2: r1 (X); r2 (Z); r3 (X); r1 (Z); r2 (Y); r3 (Y); w1 (X); w2 (Z); w3 (Y); w2 (Y);

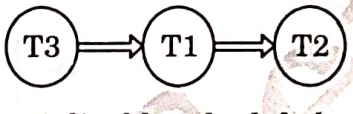
AKTU 2022-23, Marks 10

Answer

Schedule S1 : It is a serializable schedule because

1. T1 only reads X (r1(X)), which is not modified either by T2 or T3,
2. T3 reads X (r3(X)) before T1 modifies it (w1(X)),T2 reads Y (r2(Y)) and writes it (w2(Y)) only after T3 has written to it (w3(Y)).

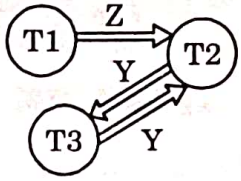
Thus, the serializability graph is



Schedule S2 : It is not a serializable schedule because

1. T2 reads Y (r2(Y)), which is then read and modified by T3 (w3(Y))
2. T3 reads Y (r3(Y)), which then modified before T2 modifies Y (w2(Y)).

In the above order T3 interferes in the execution of T2, which makes the schedule nonserializable.



Que 4.19. **Which of the following schedules are conflicts serializable ? For each serializable schedule find the equivalent schedule.**

S1 : r1(x); r3(x); w3(x); w1(x); r2(x)
S2 : r3(x); r2(x); w3(x); r1(x); w1(x)
S3 : r1(x); r2(x); r3(y); w1(x); r2(z); r2(y); w2(y)

Answer

For S1 :

T_1	T_2	T_3
$r1(x)$		
		$r3(x)$
		$w3(x)$
$w1(x)$		
	$r2(x)$	

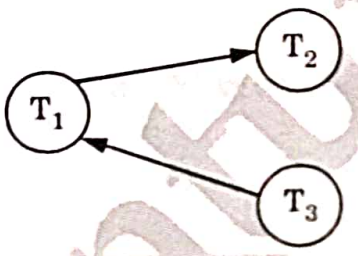


Fig. 4.19.1.

Since, the graph does not contain cycle. Hence, it is conflict serializable.

For S2 :

T_1	T_2	T_3
		$r3(x)$
	$r2(x)$	
		$w3(x)$
$r1(x)$		
$w1(x)$		

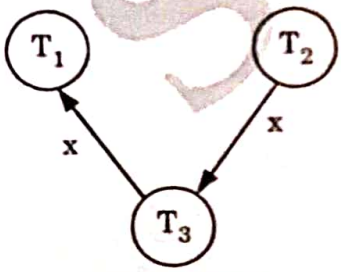


Fig. 4.19.2.

Since, the graph does not contain cycle. Hence, it is conflict serializable.

For S3 :

T_1	T_2	T_3
		$r3(x)$
	$r3(x)$	
$r1(x)$		
		$w3(x)$
$w1(x)$		

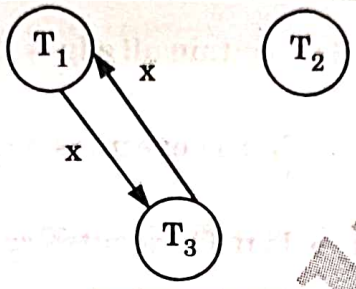


Fig. 4.19.3.

Since, the graph contains cycle. Hence, it is not conflict serializable.

Que 4.20. **Given a schedule S for transactions T1 and T2 with set of read and write operations,**
S: R1(X) R2(X) R2(Y) W2(Y) R1(Y) W1(X).
Identify, whether given schedule is equivalent to serial schedule or not ?

AKTU 2021-22, Marks 10

Answer

Schedule S

T1	T2
R1(X)	
	R2(X)
	R2(Y)
	W2(Y)
R1(Y)	
W1(X)	

Thus, the given schedule

S = R1(X) R2(X) R2(Y) W2 (Y) R1(Y) W1 (X) is not equivalent to a serial schedule because it is not conflict-serializable.

Que 4.21. **Explain the method of testing the serializability.**
Consider the schedule S1 and S2 given below :
S1 : R1(A), R2(B), W1(A), W2(B)
S2 : R2(B), R1(A), W2(B), W1(A)
Check whether the given schedules are conflict equivalent or not ?

AKTU 2020-21, Marks 10

Answer

Method of testing the serializability :

1. For S, we construct a graph known as precedence graph.
2. This graph has a pair G = (V, E), where V consists a set of vertices, and E consists a set of edges.
3. The set of vertices is used to contain all the transactions participating in the schedule.
4. The set of edges is used to contain all edges Ti ->Tj for which one of the three conditions holds :
   a. Create a node Ti → Tj if Ti executes write (Q) before Tj executes read (Q).
   b. Create a node Ti → Tj if Ti executes read (Q) before Tj executes write (Q).
   c. Create a node Ti → Tj if Ti executes write (Q) before Tj executes write (Q).

Numerical : Consider the schedule S1 :

Step 1 : List all the conflicting operation and determine the dependency between the transaction :

R1(A), W1(A) (T1 → T1)

R2(B), W2(B) (T2 → T2)

Step 2 : Draw precedence graph

Clearly, there exist a cycle in graph. Hence schedule S1 is not conflict serializable.

Consider the schedule S2 :

Step 1 : List all the conflicting operation :

R2(T2), W2(B) (T2 → T2)

R1(A), W1(A) (T1 → T1)

Step 2 : Draw precedence graph

Clearly, there exist a cycle in graph. So, S2 is not conflict serializable.

PART-3

Log Based Recovery, Checkpoints.

Que 4.22. **Explain log based recovery.**

OR

What is log ? How is it maintained ? Discuss the features of deferred database modification and immediate database modification in brief.

AKTU 2023-24, Marks 10

Answer

1. The log / system log is a sequence of log records, recording all the update activities in the database.
2. Various types of log records are denoted as :
   a. **<T_i start> :** Transaction T_i has started.
   b. **<T_i, X_j, V_1, V_2> :** Transaction T_i has performed a write on data item X_j. X_j had value V_1 before the write, and will have value V_2 after the write.
   c. **<T_i commit> :** Transaction T_i has committed.
   d. **<T_i abort> :** Transaction T_i has aborted.
3. Whenever a transaction performs a write, it is essential that the log record for that write be created before the database is modified.

Log is maintained : Log of each transaction is maintained in some stable storage so that if any failure occurs, then it can be recovered from there. If any operation is performed on the database, then it will be recorded in the log.

Log based recovery : Log based recovery is a method to ensure atomicity using log when failure occurs. In log based recovery, following two techniques are used to ensure atomicity and to maintain log :

1. **Deferred database modification :**
   i. The deferred database modification technique ensures transaction atomicity by recording all database modifications in the log, but deferring the execution of all write operations of a transaction until the transaction partially commits.
   ii When a transaction partially commits, the information on the log associated with the transaction is used in executing the deferred writes.

Features of deferred database modification :

1. All logs written onto the database is updated when a transaction commits.
2. It does not require old value of data item on the log.
3. It do not need extra I/O operation before commit time.
4. It can manage with large memory space.
5. Locks are held till the commit point.

2. **Immediate database modification :**
   i. The immediate database modification technique allows database modifications to be output to the database while the transaction is still in the active state.
   ii. Data modification written by active transactions.

Features of immediate database modification :

1. All logs written onto the database is updated immediately after every operation.
2. It requires both old and new value of data item on the log.
3. It needs extra I/O operation to flush out block-buffer.
4. It can manage with less memory space.
5. Locks are released after modification.

Que 4.23. List ACID properties of transaction. Explain the usefulness of each. What is the importance of log ?

AKTU 2021-22, Marks 10

Answer

ACID properties : Refer Q. 4.2, Page 4–2A, Unit-4.

Usefulness of ACID properties : Refer Q. 4.3, Page 4–3A, Unit-4.

Importance of log :

1. **Recovery :** Restores the database to a consistent state after crashes by replaying or undoing transactions.
2. **Transaction Management :** Ensures all-or-nothing execution of transactions, supporting atomicity.
3. **Data Integrity :** Maintains ACID properties, ensuring reliable and consistent data.
4. **Audit Trails :** Provides a history of all transactions for auditing and tracking.
5. **Concurrency Control :** Manages simultaneous access to prevent conflicts between transactions.

Que 4.24. Describe shadow paging recovery technique.

Answer

1. Shadow paging is a technique in which multiple copies (known as shadow copies) of the data item to be modified are maintained on the disk.
2. Shadow paging considers the database to be made up of fixed-size logical units of storage called pages.
3. These pages are mapped into physical blocks of storage with the help of page table (or directory).
4. The physical blocks are of the same size as that of the logical blocks.
5. A page table with n entries is constructed in which the i^{th} entry in the page table points to the i^{th} database page on the disk as shown in Fig. 4.24.1.

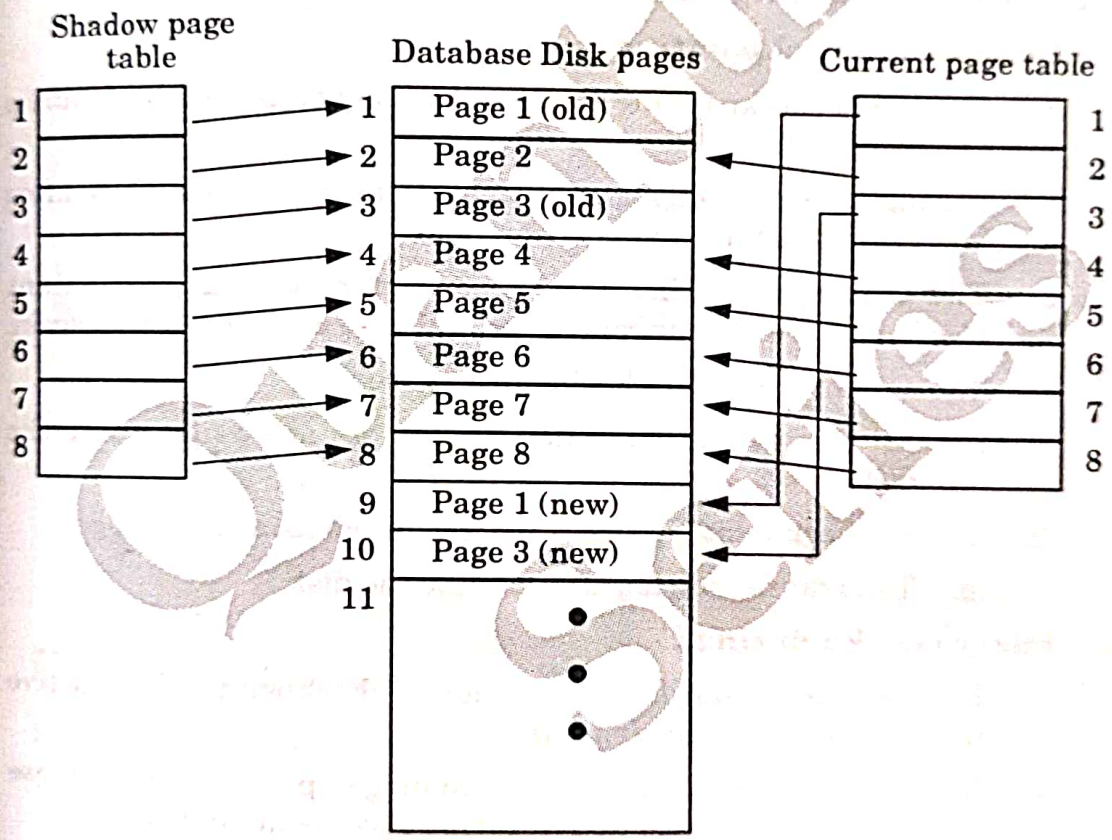


Fig. 4.24.1. Shadow paging.

6. The main idea behind this technique is to maintain two page tables.
   a. In current page the entries points to the most recent database pages on the disk. When a transaction starts, the current page table is copied into a shadow page table (or shadow directory).
   b. The shadow page table is then saved on the disk and the current page table is used by the transaction. The shadow page table is never modified during the execution of the transaction.

When shadow paging does not require log : It does not require the use of log in an environment where only one transaction is active at a time.

Que 4.25. What do you mean by checkpointing ? Explain important types of checkpointing methods.

Answer

Checkpointing :

1. It is a process of saving a snapshot of the application's state, so that it can restart from that point in case of failure.
2. Checkpoint is a point of time at which a record is written onto the database from the buffers.
3. Checkpointing shortens the recovery process.

Types of checkpointing techniques :

1. **Consistent checkpointing :**
   a. Consistent checkpointing creates a consistent image of the database at checkpoint.
   b. During recovery, only those transactions which take place after last checkpoint are undone or redone.
   c. The transactions that take place before the last consistent checkpoint are already committed and need not be processed again.
   d. The actions taken for checkpointing are :
      i. All changes in main-memory buffers are written onto the disk.
      ii. A "checkpoint" record is written in the transaction log.
      iii. The transaction log is written to the disk.
2. **Fuzzy checkpointing :**
   a. In fuzzy checkpointing, at the time of checkpoint, all the active transactions are written in the log.
   b. In case of failure, the recovery manager processes only those transactions that were active during checkpoint and later.
   c. The transactions that have been committed before checkpoint are written to the disk and hence need not be redone.

Que 4.26. What is log file ? Write the steps for log based recovery of a system with suitable example.

Answer

Log file : A log file is a file that records all the update activities occur in the database.

Steps for log based recovery :

1. The log file is kept on a stable storage media.
2. When a transaction enters the system and starts execution, it writes a log about it

$$<T_n, \text{start}>$$

3. When the transaction modifies an item X, it write log as follows

$$<T_n, X, V_1, V_2>$$

It reads as T_n has changed the value of X, from V_1 to V_2.

4. When the transaction finishes, it logs

$$<T_n, \text{commit}>$$

For example :

$<T_0, \text{start}>$

$<T_0, A, 0, 10>$

$<T_0, \text{commit}>$

$<T_1, \text{start}>$

$<T_1, B, 0, 10>$

$<T_2, \text{start}>$

$<T_2, C, 0, 10>$

$<T_2, C, 10, 20>$

<checkpoint (T_1, T_2)>

$<T_3, \text{start}>$

$<T_3, A, 10, 20>$

$<T_3, D, 0, 10>$

$<T_3, \text{commit}>$

Que 4.27. Describe the important types of recovery techniques. Explain their advantages and disadvantages.

Answer

There are many different database recovery techniques to recover a database :

1. **Deferred update recovery :** Refer Q. 4.22, Page 4–19A, Unit-4.

Advantages :

a. Recovery is easy.

b. Cascading rollback does not occur because no other transaction sees the work of another until it is committed.

Disadvantages :

a. Concurrency is limited.

2. **Immediate update recovery :** Refer Q. 4.22, Page 4–19A, Unit-4.

Advantages :

a. It allows higher concurrency because transactions write continuously to the database rather than waiting until the commit point.

Disadvantages :

a. It leads to cascading rollbacks.

b. It is time consuming and may be problematic.

Que 4.28. Discuss the immediate update recovery technique in both single-user and multiuser environment. What are the advantages and disadvantages of immediate update ?

AKTU 2022-23, Marks 10

Answer

Immediate update recovery technique works differently in single-user and multiuser environments, as discussed below :

Single-user environment :

1. In a single-user environment, immediate update recovery is relatively simple, as there is only one user.
2. Changes made by the user are immediately written to the database.
3. There are no concerns about other users accessing the database or conflicting with the changes.
4. In the event of a system failure, recovery involves restoring the database to its last consistent state.

Multiuser environment :

1. In a multiuser environment, immediate update recovery can be more complex, as multiple users are accessing the database.
2. In this environment, it is important to ensure that changes made by one user do not conflict with changes made by another user.
3. To achieve this, a variety of techniques may be used, such as locking, timestamp ordering, or optimistic concurrency control.

Advantages and disadvantages of immediate update : Refer Q. 4.27, Page 4–23A, Unit-4.

PART-4

Deadlock Handling.

Que 4.29. **What is a deadlock ? Describe methods to handle a deadlock.**

OR

What is deadlock ? How it can be detected and avoided ?

Answer

Deadlock :

1. A deadlock is a situation in which two or more transactions are waiting for locks held by the other transaction to release the lock.
2. Every transaction is waiting for another transaction to finish its operations.

Methods to handle a deadlock :

1. **Deadlock prevention protocol :** This protocol ensures that the system will not go into deadlock state. There are different methods that can be used for deadlock prevention :
   a. **Pre-declaration method :** This method requires that each transaction locks all its data item before it starts execution.
   b. **Partial ordering method :** In this method, system imposes a partial ordering of all data items and requires that a transaction can lock a data item only in the order specified by partial order.
   c. **Timestamp method :** In this method, the data item are locked using timestamp of transaction.
2. **Deadlock detection :**
   a. When a transaction waits indefinitely to obtain a lock, system should detect whether the transaction is involved in a deadlock or not.
   b. Wait-for-graph is one of the methods for detecting the deadlock situation.
   c. In this method a graph is drawn based on the transaction and their lock on the resource.
   d. If the graph created has a closed loop or a cycle, then there is a deadlock.

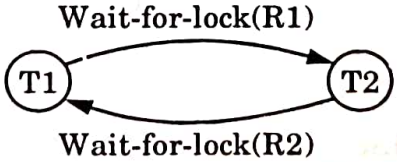


Fig. 4.29.1. Wait-for-graph.

3. **Recovery from deadlock :**
   a. **Selection of a victim :** In this we determine which transaction (or transactions) to roll back to break the deadlock. We should rollback those transactions that will incur the minimum cost.

b. **Rollback :** The simplest solution is a "total rollback". Abort the transaction and then restart it.

c. **Starvation :** In a system where selection of transactions, for rollback, is based on the cost factor, it may happen that the some transactions are always picked up.

4. **Deadlock avoidance :** Deadlock can be avoided by following methods :

a. **Serial access :** If only one transaction can access the database at a time, then we can avoid deadlock.

b. **Autocommit transaction :** It includes that each transaction can only lock one resource immediately as it uses it, then finishes its transaction and releases its lock before requesting any other resource.

c. **Ordered updates :** If transactions always request resources in the same order (for example, numerically ascending by the index value of the row being locked) then system do not enters in deadlock state.

d. By rolling back conflicting transactions.

e. By allocating the locks where needed.

Que 4.30. Discuss the procedure of deadlock detection and recovery in transaction ? **AKTU 2021-22, 2023-24; Marks 10**

Answer

Deadlock detection :

1. **Wait-for Graph (WFG) :**
   a. Create a graph where each node is a transaction.
   b. An edge from transaction Ti to Tj indicates Ti is waiting for a resource held by Tj.
   c. Periodically check for cycles in the graph; a cycle indicates a deadlock.
2. **Cycle detection :** Use algorithms like Depth-First Search (DFS) to detect cycles in the WFG.

Deadlock recovery :

1. **Transaction rollback :**
   a. **Victim selection :** Choose a transaction to abort based on criteria like transaction age or resources held.
   b. **Rollback :** Abort the selected transaction, releasing its resources.
2. **Partial rollback :** Roll back only the operations involved in the deadlock, minimizing lost work.

3. **Graph adjustment :** Update the WFG after a rollback and check for remaining cycles.
4. **Transaction restart :** Restart the rolled-back transaction, ensuring to avoid the previous deadlock sequence.

Que 4.31. Discuss about the deadlock prevention schemes.

OR

Discuss about deadlock prevention schemes.

Answer

Deadlock prevention schemes :

1. **Wait-die scheme :**
   i. In this scheme, if a transaction request to lock a resource (data item), which is already held with conflicting lock by some other transaction, one of the two possibilities may occur :
      a. If $TS(T_i) < TS(T_j)$, *i.e.*, T_i, which is requesting a conflicting lock, is older than T_j, T_i is allowed to wait until the data item is available.
      b. If $TS(T_i) > TS(T_j)$, *i.e.*, T_i is younger than T_j, so T_i dies. T_i is restarted later with random delay but with same timestamp.
   ii. This scheme allows the older transaction to wait but kills the younger one.
2. **Wound-wait scheme :**
   i. In this scheme, if a transaction request to lock a resource (data item), which is already held with conflicting lock by some other transaction, one of the two possibilities may occur :
      a. If $TS(T_i) < TS(T_j)$, *i.e.*, T_i, which is requesting a conflicting lock, is older than T_j, T_i forces T_j to be rolled back, that is T_i wounds T_j. T_j is restarted later with random delay but with same timestamp.
      b. If $TS(T_i) > TS(T_j)$, *i.e.*, T_i is younger than T_j, T_i is forced to wait until the resource (*i.e.*, data item) is available.
   ii. This scheme, allows the younger transaction to wait but when an older transaction request an item held by younger one, the older transaction forces the younger one to abort and release the item. In both cases, transaction, which enters late in the system, is aborted.

Que 4.32. What is deadlock ? What are necessary conditions for it ? How it can be detected and recovered ?

Answer

Deadlock : Refer Q. 4.29, Page 4–25A, Unit-4.

Necessary condition for deadlock : A deadlock situation can arise if the following four conditions hold simultaneously in a system :

1. **Mutual exclusion :** At least one resource must be held in a non-sharable mode; that is, only one process at a time can use the resource. If another process requests that resource, the requesting process must be delayed until the resource has been released.
2. **Hold and wait :** A process must be holding at least one resource and waiting to acquire additional resources that are currently being held by other processes.
3. **No pre-emption :** Resources cannot be pre-empted; *i.e.*, a resource can be released only by the process holding it, after that process has completed its task.
4. **Circular wait :** A set $\{P_0, P_1, ..., P_n\}$ of waiting processes must exist such that P_0 is waiting for a resource held by P_1, P_1 is waiting for a resource held by P_2, ..., P_{n-1} is waiting for a resource held by P_n, and P_n is waiting for a resource held by P_0.

Deadlock detection and recovery : Refer Q. 4.29, Page 4–25A, Unit-4.

Que 4.33. Explain deadlock handling with suitable example.

AKTU 2020-21, Marks 10

Answer

Deadlock : Deadlock handling involves strategies to detect and resolve deadlocks, which occur when two or more transactions are blocked indefinitely, waiting for resources held by each other.

Deadlock detection and recovery : Refer Q. 4.29, Page 4–25A, Unit-4.

Example : Imagine two transactions, T1 and T2, accessing resources R1 and R2 in the following sequence :

T1 locks R1, then waits for R2

T2 locks R2, then waits for R1

Neither transaction can proceed because each is waiting for a resource held by the other, causing a deadlock.

PART-5

Distributed Database : Distributed Data Storage.

Que 4.34. **What is distributed databases ? What are the advantages and disadvantages of distributed databases ?**

OR

Explain the advantages of distributed DBMS.

Answer

Distributed database :

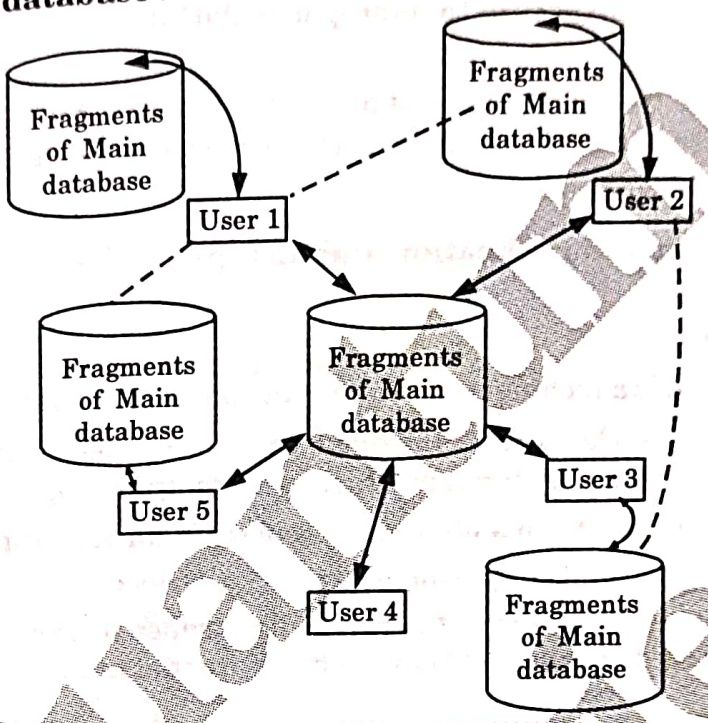


Fig. 4.34.1. Distributed database.

1. A distributed database system consists of collection of sites, connected together through a communication network.
2. Each site is a database system site in its own right and the sites have agreed to work together, so that a user at any site can access anywhere in the network as if the data were all stored at the user's local site.
3. Each side has its own local database.
4. A distributed database is fragmented into smaller data sets.
5. DDBMS can handle both local and global transactions.

Advantages of DDBMS :

1. DDBMS allows each site to store and maintain its own database, causing immediate and efficient access to data.
2. It allows access to the data stored at remote sites. At the same time users can retain the control to its own site to access the local data.
3. If one site is not working due to any reason (for example, communication link goes down) the system will not be down because other sites of the network can possibly continue functioning.
4. New sites can be added to the system anytime with no or little efforts.

5. If a user needs to access the data from multiple sites then the desired query can be subdivided into sub-queries in parallel.

Disadvantages of DDBMS :

1. Complex software is required for a distributed database environment.
2. The various sites must exchange message and perform additional calculations to ensure proper coordination among the sites.
3. A by-product of the increased complexity and need for coordination is the additional exposure to improper updating and other problems of data integrity.
4. If the data are not distributed properly according to their usage, or if queries are not formulated correctly, response to requests for data can be extremely slow.

Que 4.35. Explain replication and its types in distributed system.

Answer

1. Replication is a technique of replicating data over a system.
2. Replication is a key to the effectiveness of distributed systems in that, it provides enhanced performance, high availability and high fault tolerance.
3. The replication is the maintenance of copies of data at multiple computers.
4. Replication is a technique for enhancing a service.
5. When data are replicated, the replication transparency is required *i.e.*, clients should not normally have to be aware that multiple copies of data exist.

Types of replication :

i. Active replication :

1. In active replication each client request is processed by all the servers.
2. This requires that the process hosted by the servers is deterministic, *i.e.*, given the same initial state and a request sequence, all processes will produce the same response sequence and end up in the same final state.

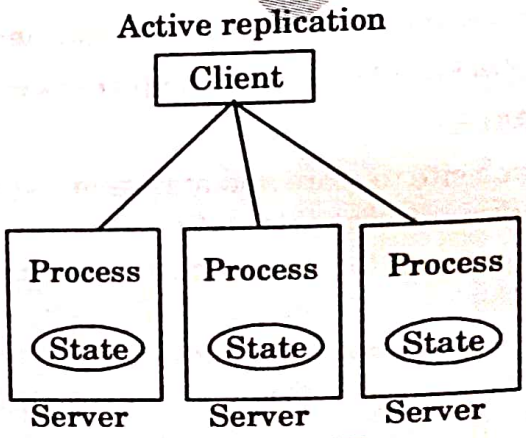


Fig. 4.35.1.

3. In order to make all the servers receive the same sequence of operations, an atomic broadcast protocol must be used.
4. An atomic broadcast protocol guarantees that either all the servers receive a message or none, plus that they all receive messages in the same order.

ii. Passive replication :

1. In passive replication there is only one server (called primary) that processes client requests.
2. After processing a request, the primary server updates the state on the other (backup) servers and sends back the response to the client.
3. If the primary server fails, one of the backup servers takes its place.
4. Passive replication may be used even for non-deterministic processes.

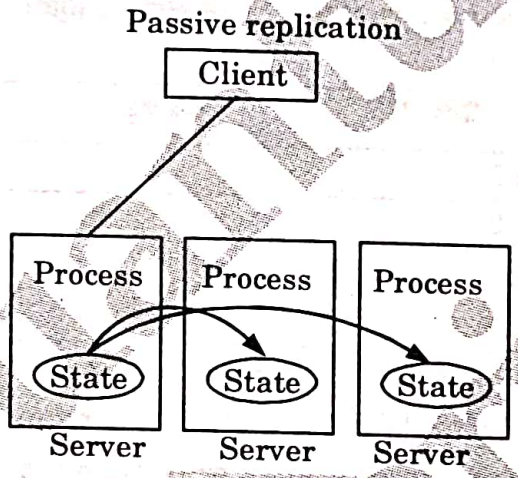


Fig. 4.35.2.

Que 4.36. Explain data fragmentation with types.

Answer

Fragmentation :

1. It is the decomposition of a relation into fragments.
2. It permits to divide a single query into a set of multiple sub-queries that can execute parallel on fragments.
3. Fragmentation is done according to the data selection patterns of applications running on the database.

Fragmentation techniques/types are as follows :

1. **Vertical fragmentation :**
   a. It divides a relation into fragments which contain a subset of attributes of a relation along with the primary key attribute of the relation.

Name	Reg. No.	Course	Dept
Fragmentation1	Fragmentation2	Fragmentation3	

Fig. 4.36.1. Vertical fragmentation.

b. The purpose of vertical fragmentation is to partition a relation into a set of smaller relations to enable user applications to run on only one fragment.

2. **Horizontal fragmentation :**

a. It divides a relation into fragments along its tuples. Each fragment is a subset of tuples of a relation.

b. It identifies some specific rows based on some criteria and marks it as a fragment.

Name	Reg. No.	Course	Depth
Fragmentation1			
Fragmentation2			
Fragmentation3			
Fragmentation4			

Fig. 4.36.2. Horizontal fragmentation.

c. Various horizontal fragmentation techniques are :

i. **Primary horizontal fragmentation :** This type of fragmentation is done where the tables in a database are neither joined nor have dependencies. So, no relationship exists among the tables.

ii. **Derived horizontal fragmentation :** Derived horizontal fragmentation is used for parent relation. It is used where tables are interlinked with the help of foreign keys. It ensures that the fragments which are joined together are put on the same site.

3. **Hybrid/mixed fragmentation :**

a. The mixed/hybrid fragmentation is combination of horizontal and vertical fragmentations.

b. This type is most complex one, because both types are used in horizontal and vertical fragmentation of the DB application.

c. The original relation is obtained back by join or union operations.

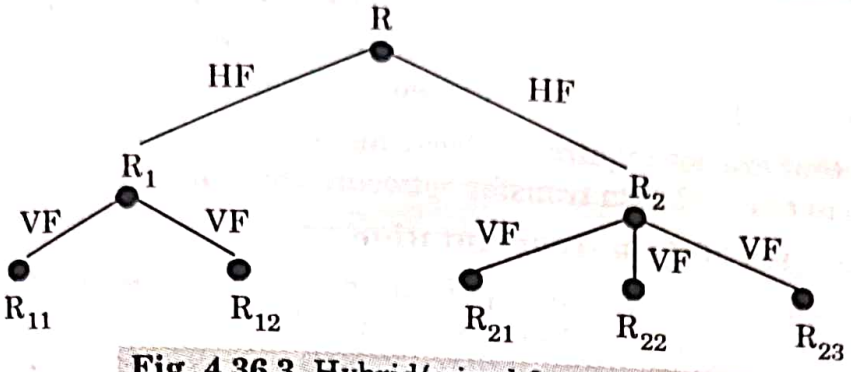


Fig. 4.36.3. Hybrid/mixed fragmentation.

Que 4.37. **What are distributed database ? List advantages and disadvantages of data replication and data fragmentation. Explain with a suitable example, what are the differences in replication and fragmentation transparency ?**

OR

Explain the types of distributed data storage.

OR

What are distributed database? List advantage and disadvantage of data replication and data fragmentation.

Answer

Distributed database : Refer Q. 4.34, Page 4–29A, Unit-4.

Advantages of data replication :

i. **Availability :** If one of the sites containing relation *r* fails, then the relation *r* can be found in another site. Thus, the system can continue to process queries involving '*r*', despite the failure of one site.

ii. **Increased parallelism :** Number of transactions can read relation *r* in parallel. The more replicas of '*r*' there are, the greater parallelism is achieved.

Disadvantages of data replication :

i. **Increased overhead on update :** The system must ensure that all replicas of a relation *r* are consistent; otherwise, erroneous computation may result. Thus, whenever *r* is updated, the update must be propagated to all sites containing replicas. The result is increased overhead.

Advantages of data fragmentation :

i. Parallelized execution of queries by different sites is possible.

ii. Data management is easy as fragments are smaller compare to the complete database.

iii. Increased availability of data to the users/queries that are local to the site in which the data stored.

iv. As the data is available close to the place where it is most frequently used, the efficiency of the system in terms of query processing, transaction processing is increased.

v. Data that are not required by local applications are not stored locally. It leads to reduced data transfer between sites, and increased security.

Disadvantages of data fragmentation :

i. The performance of global application that requires data from several fragments located at different sites may be slower.

ii. Integrity control may be more difficult if data and functional dependencies are fragmented and located at different sites.

Differences in replication and fragmentation transparency :

S. No.	Replication transparency	Fragmentation transparency
1.	It involves placing copies of each table or each of their fragments on more than one site in the system.	It involves decomposition of a table in many tables in the system.
2.	The user does not know about how many replicas of the relation are present in the system.	The user does not know about how relation is divided/ fragmented in the system.
3.	For example, if relation *r* is replicated, a copy of relation *r* is stored in two or more sites. In extreme case, a copy is stored in every site in the system which is called as full replication.	For example, if relation '*r*' is fragmented, '*r*' is divided into a number of fragments. These fragments contain sufficient information to allow reconstruction of the original relation '*r*'.

There are two types of distributed data storage :

1. **Data fragmentation :** Refer Q. 4.36, Page 4–31A, Unit-4.
2. **Data replication :** Refer Q. 4.35, Page 4–30A, Unit-4.

Que 4.38. Discuss the types of distributed database.

Answer

Distributed databases are classified as :

1. **Homogeneous distributed database :**
   a. In this, all sites have identical database management system software.
   b. All sites are aware of one another, and agree to co-operate in processing user's requests.

2. **Heterogeneous distributed database :**
   a. In this, different sites may use different schemas, and different database management system software.
   b. The sites may not be aware of one another, and they may provide only limited facilities for co-operation in transaction processing.

PART-6

Concurrent Control, Directory System.

Que 4.39. What is concurrency control ? Why it is needed in database system.

OR

Explain concurrency control. Why it is needed in database system ?

Answer

1. Concurrency Control (CC) is a process to ensure that data is updated correctly and appropriately when multiple transactions are concurrently executed in DBMS.
2. It is a mechanism for correctness when two or more database transactions that access the same data or dataset are executed concurrently with time overlap.
3. In general, concurrency control is an essential part of transaction management.

Concurrency control is needed :

1. To ensure consistency in the database.
2. To prevent following problem :
   a. **Lost update :**
      i. A second transaction writes a second value of a data item on top of a first value written by a first concurrent transaction, and the first value is lost to other transactions running concurrently which need, by their precedence, to read the first value.
      ii. The transactions that have read the wrong value end with incorrect results.
   b. **Dirty read :**
      i. Transactions read a value written by a transaction that has been later aborted.
      ii. This value disappears from the database upon abort, and should not have been read by any transaction ("dirty read").
      iii. The reading transactions end with incorrect results.

Que 4.40. **Explain concurrency control mechanism performed in distributed databases ?**

Answer

Following are concurrency control mechanism in distributed database :

a. **Two-phase commit protocol :** Two-phase commit protocol is designed to allow any participant to abort its part of transaction. Due to the requirement for atomicity, if one part of a transaction is aborted then the whole transaction must also be aborted.

Following are the two phase used in this protocol :

Phase 1 (voting phase) :

1. The co-ordinator sends a canCommit? request to each of the participants in the transaction.
2. When a participant receives canCommit? request it replies with its vote (Yes or No) to the co-ordinator. Before voting Yes, it prepares to commit by saving objects in permanent storage. If the vote is No, the participant aborts immediately.

Phase 2 (completion according to outcome of vote) :

1. The co-ordinator collects the votes (including its own).
   a. If there are no failures and all the votes are Yes the co-ordinator decides to commit the transaction and sends a doCommit request to each of the participants.
   b. Otherwise the co-ordinator decides to abort the transaction and sends doAbort requests to all participants that voted Yes.
2. Participants that voted Yes are waiting for a doCommit or doAbort request from the co-ordinator. When a participant receives one of these messages it acts accordingly and in the case of commit, makes a haveCommitted calls as confirmation to the co-ordinator.

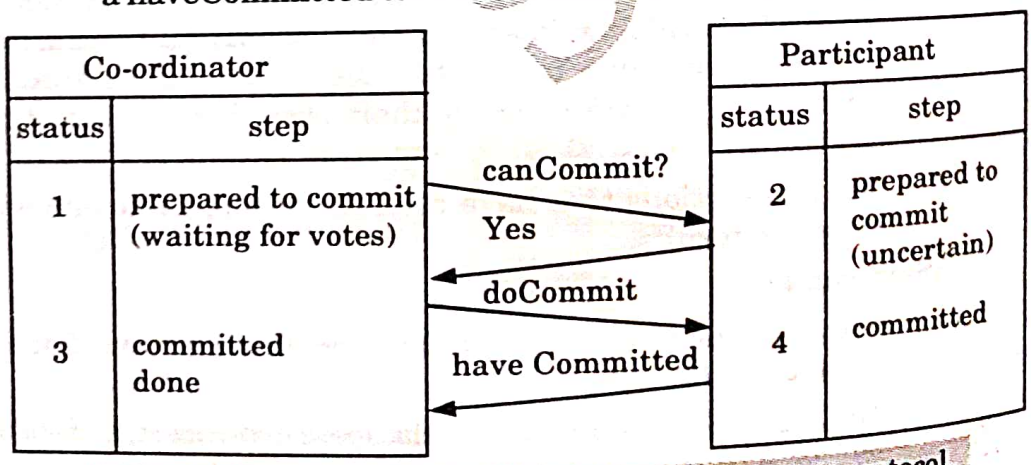


Fig. 4.40.1. Communication in two-phase commit protocol.

b. Moss concurrency control protocol :

1. Moss concurrency control protocol for nested transactions is based on the concept of upward inheritance of locks.
2. A transaction can acquire a lock on object O in some mode M.
3. Doing that, it holds the lock in mode M until its termination.
4. Besides holding a lock, a transaction can retain a lock in mode M.
5. When a subtransaction commits, its parent transaction inherits its locks and then retains them. If a transaction holds a lock, it has the right to access the locked object (in the corresponding mode).
6. However, the same is not true for retained locks.
7. A retained lock is only a place holder and indicates that transactions outside the hierarchy of the retainer cannot acquire the lock, but that descendants potentially can.
8. As soon as a transaction becomes a retainer of a lock, it remains a retainer for the lock until it terminates.

Que 4.41. Explain directory system in detail.

Answer

1. A directory is a listing of information about some class of objects such as persons.
2. Directories can be used to find information about a specific object, or in the reverse direction to find objects that meet a certain requirement.
3. In the networked world, the directories are present over a computer network, rather than in a physical (paper) form.
4. A directory system is implemented as one of more servers, which service multiple clients.
5. Clients use the application programmer interface defined by the directory system to communicate with the directory servers.

Directory access protocols :

1. Directory access protocol is a protocol that allows to access directory information through program.
2. Directory access protocols also define a data model and access control.
3. For instance, web browsers can store personal bookmarks and other browser settings in a directory system. A user can thus access the same settings from multiple locations, such as at home and at work, without having to share a file system.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. List the ACID properties. Explain the usefulness of each property.

Ans. Refer Q. 4.3.

Q. 2. Explain transaction state in brief.

Ans. Refer Q. 4.4.

Q. 3. Discuss conflict serializability with example.

Ans. Refer Q. 4.6.

Q. 4. Describe serializable schedule. Discuss conflict serializability with suitable example.

Ans. Refer Q. 4.8.

Q. 5. Explain view serializability with example.

Ans. Refer Q. 4.9.

Q. 6. What is schedule ? Define the concept of recoverable, cascadeless and strict schedules.

Ans. Refer Q. 4.10.

Q. 7. Test the serializability of the following schedule :

i. $r_1(x); r_3(x); w_1(x); r_2(x); w_3(x)$

ii. $r_3(x); r_2(x); w_3(x); r_1(x): w_1(x)$

Ans. Refer Q. 4.13.

Q. 8. Consider schedules *S*1, *S*2, and *S*3 below. Determine whether each schedule is strict, cascadeless, recoverable, or non recoverable. (Determine the strictest recoverability condition that each schedule satisfies).

S1: r1 (X); r2 (Z); r1 (Z); r3 (X); r3 (Y); w1 (X); c1; w3 (Y); c3; r2 (Y); w2 (Z); w2 (Y); c2;

S2: r1 (X); r2 (Z); r1 (Z); r3 (X); r3 (Y); w1 (X); w3 (Y); r2 (Y); w2 (Z); w2 (Y); c1; c2; c3;

S3: r1 (X); r2 (Z); r3 (X); r1 (Z); r2 (Y); r3 (Y); w1 (X); c1; w2 (Z); w3 (Y); w2 (Y); c3; c2;

Ans. Refer Q. 4.17.

Q. 9. Which of the following schedules are conflicts serializable ? For each serializable schedule find the equivalent schedule.
$S1 : r1(x); r3(x); w3(x); w1(x); r2(x)$
$S2 : r3(x); r2(x); w3(x); r1(x); w1(x)$
$S3 : r1(x); r2(x); r3(y); w1(x); r2(z); r2(y); w2(y)$

Ans. Refer Q. 4.19.

Q. 10. Explain log based recovery.

Ans. Refer Q. 4.22.

Q. 11. What do you mean by checkpointing ? Explain important types of checkpointing methods.

Ans. Refer Q. 4.25.

Q. 12. Discuss the procedure of deadlock detection and recovery in transaction ?

Ans. Refer Q. 4.30.

Q. 13. Explain deadlock handling with suitable example.

Ans. Refer Q. 4.33.

Q. 14. What are distributed database ? List advantages and disadvantages of data replication and data fragmentation. Explain with a suitable example, what are the differences in replication and fragmentation transparency ?

Ans. Refer Q. 4.37.

Q. 15. Explain concurrency control mechanism performed in distributed databases ?

Ans. Refer Q. 4.40.

5 UNIT

Concurrency Control Techniques

CONTENTS

PART-1

Concurrency Control, Locking Techniques for Concurrency Control.

Que 5.1. **Describe concurrency control.**

Answer

Refer Q. 4.39, Page 4–35A, Unit-4.

Que 5.2. **What is lock ? Explain different types of locks.**

OR

Describe lock based locking techniques.

Answer

Lock : A lock is a variable associated with each data item that indicates whether read or write operation is applied.

Different types of locks are :

1. **Binary lock :**
   - i. A binary lock can be two states or values : locked and unlocked (or 1 and 0).
   - ii. A distinct lock is associated with each database item X.
   - iii. If the value of the lock on X is 1, item X cannot be accessed by a database operation that requests the item.
   - iv. If the value of the lock on X is 0, the item can be accessed when requested.
   - v. We refer to the current value (or state) of the lock associated with item X as lock(X).
   - vi. Two operations, lock_item and unlock_item, are used with binary locking.

   If the simple binary locking scheme is used, every transaction must obey the following rules :

   - i. A transaction T must issue the operation lock_item(X) before any read_item(X) or write_item(X) operations are performed in T.

ii. A transaction T must issue the operation unlock_item(X) after all read_item(X) and write_item(X) operations are completed in T.

iii. A transaction T will not issue a lock_item(X) operation if it already holds the lock on item X.

iv. A transaction T will not issue an unlock_item(X) operation unless it already holds the lock on item X.

2. Shared/Exclusive locks :

i. In this scheme there are three locking operations : read_lock(X), write_lock(X), and unlock(X).

ii. A lock associated with an item X, lock(X), has three possible states : read-locked, write-locked and unlocked.

iii. A read-locked item is also called share-locked because other transactions are allowed to read the item, whereas a write-locked item is called exclusive-locked because a single transaction exclusively holds the lock on the item.

If the shared/exclusive locking scheme is used, every transaction must obey the following rules :

i. A transaction T must issues the operation read_lock(X) or write_lock(X) before any read_item(X) operation is performed in T.

ii. A transaction T must issue the operation write_lock(X) before any write_item(X) operation is performed in T.

iii. A transaction T must issue the operation unlock(X) after all read_item(X) and write_item(X) operations are completed in T.

iv. A transaction T will not issue a read_lock(X) operation if it already holds a read (shared) lock or a write (exclusive) lock on item X.

v. A transaction T will not issue a write_lock(X) operation if it already holds a read (shared) lock or write (exclusive) lock on item X.

vi. A transaction T will not issue an unlock(X) operation unless it already holds a read (shared) lock or a write (exclusive) lock on item X.

Que 5.3. What do you understand by lock compatibility ? Explain with example.

Answer

1. Lock compatibility determines whether locks can be acquired on a data item by multiple transactions at the same time.

2. Suppose a transaction T_i requests a lock of mode m_1 on a data item Q on which another transaction T_j currently holds a lock of mode m_2.
3. If mode m_2 is compatible with mode m_1, the request is immediately granted, otherwise rejected.
4. The lock compatibility can be represented by a matrix called the compatibility matrix.
5. The term "YES" indicates that the request can be granted and "NO" indicates that the request cannot be granted.

Requested mode	Shared	Exclusive
Shared	YES	NO
Exclusive	NO	NO

Fig. 5.3.1. Compatibility matrix.

Que 5.4. How is locking implemented ? How are requests to lock and unlock a data item handled ?

Answer

Implementation of locking :

1. The locking or unlocking of data items is implemented by a subsystem of the database system known as the lock manager.
2. It receives the lock requests from transactions and replies them with a lock grant message or rollback message (in case of deadlock).
3. In response to an unlock request, the lock manager only replies with an acknowledgement. In addition, it may result in lock grant messages to other waiting transactions.

The lock manager handles the requests by the transaction to lock and unlock a data item in the following way :

1. **Lock request :**
   a. When a first request to lock a data item arrives, the lock manager creates a new linked list to record the lock request for the data item.
   b. It immediately grants the lock request of the transaction.
   c. If the linked list for the data item already exists, it includes the request at the end of the linked list.

d. The lock request will be granted only if the lock request is compatible with all the existing locks and no other transaction is waiting for acquiring lock on this data item otherwise, the transaction has to wait.

2. **Unlock request :**

a. When an unlock request for the data items arrives, the lock manager deletes the record corresponding to that transaction from the linked list for the data item.

b. It then checks whether other waiting requests on that data item can be granted.

c. If the request can be granted, it is granted by the lock manager, and the next record, if any, is processed.

d. If a transaction aborts, the lock manager deletes all waiting lock requests by the transaction.

e. In addition, the lock manager releases all locks acquired by the transaction and updates the records in the lock table.

Que 5.5. Write short notes on lock based protocols.

Answer

1. Lock based protocol indicates when a transaction may lock and unlock the data items, during the concurrent execution. It restricts the number of possible schedules.
2. It ensures that the data items must be accessed in mutual exclusive manner and for this we use different lock modes.
3. There are two modes in which a data item may be locked :

i. **Shared mode lock :** If a transaction T_i has obtained a shared mode lock on item Q then T_i can read but cannot write Q. It is denoted by S.

ii. **Exclusive lock :** If a transaction T_i has obtained an exclusive mode lock on item Q then T_i can read and also write Q. It is denoted by X.

Que 5.6. Explain two-phase locking technique for concurrency control.

OR

What is two-phase locking (2PL) ? Describe with the help of example.

OR

Explain two phase locking protocol with suitable example.

Answer

1. Two-phase locking is a procedure in which a transaction is said to follow the two-phase locking protocol if all locking operations precede the first unlock operation in the transaction.

2. In 2PL, each transaction lock and unlock the data item in two phases :

   a. **Growing phase :** In the growing phase, the transaction acquires locks on the desired data items.

   b. **Shrinking phase :** In the shrinking phase, the transaction releases the locks acquired by the data items.

3. According to 2PL, the transaction cannot acquire a new lock, after it has unlocked any of its existing locked items.

4. Given below, the two transactions T_1 and T_2 that do not follow the two-phase locking protocol.

T_1	T_2
Read-lock (Y);	Read-lock (X);
Read-item (Y);	Read-item (X);
Unlock (Y);	Unlock (X);
Write-lock (X);	Write-lock (Y);
Read-item (X);	Read-item (Y);
$X := X + 1$;	$Y := Y + 1$;
Write-item (X);	Write-item (Y);
Unlock (X);	Unlock (Y);

5. This is because the write-lock (X) operation follows the unlock (Y) operation in T_1, and similarly the write-lock (Y) operation follows the unlock (X) operation in T_2.

6. If we enforce two-phase locking, the transaction can be rewritten as :

T_1	T_2
Read-lock (Y);	Read-lock (X);
Read-item (Y);	Read-item (X);
Write-lock (X);	Write-lock (Y);
Unlock (Y);	Unlock (X);
Write-lock (X);	Write-lock (Y);
Read-item (X);	Read-item (Y);
$X := X + 1$;	$Y := Y + 1$;
Write-item (X);	Write-item (Y);
Unlock (X);	Unlock (Y);

7. It can be proved that, if every transaction in a schedule follows the two-phase locking protocol, the schedule is guaranteed to be serializable, obviating the need to test for serializability of schedules any more.

Que 5.7. Discuss strict 2PL.

Answer

1. Cascading rollbacks can be avoided by a modification of two-phase locking called the strict two-phase locking protocol.
2. This protocol requires not only that locking be two phase, but also that all exclusive-mode locks taken by a transaction be held until that transaction commits.
3. This requirement ensures that any data written by an uncommitted transaction are locked in exclusive mode until the transaction commits, preventing any other transaction from reading the data.
4. Strict two-phase is the most widely used locking protocol in concurrency control. This protocol has two rules :
   a. If a transaction T wants to read (modify) an object, it first requests a shared (exclusive) lock on the object.
   b. All locks held by a transaction are released when the transaction is completed.
5. If strict two-phase locking is used for concurrency control, locks held by a transaction T may be released only after the transaction has been rolledback.
6. Once transaction T (that is being rolledback) has updated a data item, no other transaction could have updated the same data item, because of the concurrency control requirements.
7. Therefore, restoring the old value of the data item will not erase the effects of any other transaction.

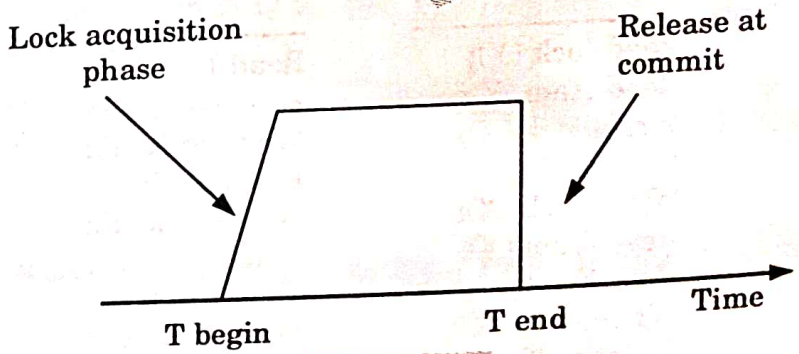


Fig. 5.7.1.

Que 5.8. **Write the salient features of graph based locking protocol with suitable example.** **AKTU 2023-24, Marks 10**

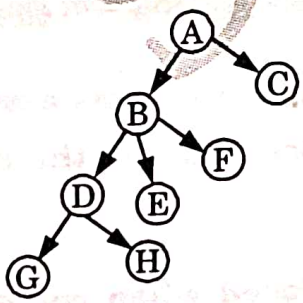
Answer

Salient features of graph based locking protocol are :

1. The graph based locking protocol ensures conflict serializability.
2. Free from deadlock.
3. Unlocking may occur earlier in the graph based locking protocol than in the two phase locking protocol.
4. Shorter waiting time, and increase in concurrency.
5. No rollbacks are required.
6. Data items may be unlocked at any time.
7. Only exclusive locks are considered.
8. The first lock by T_1 may be on any data item. Subsequently, a data Q can be locked by T_1 only if the parent of Q is currently locked by T_1.
9. A data item that has been locked and unlocked by T_1 cannot subsequently be relocked by T_1.

For example :

We have three transactions in this schedule, *i.e.*, we will only see how locking and unlocking of data item.



T_1	T_2	T_3
Lock-X(A)		
	Lock-X(D)	
	Lock-X(H)	
	Unlock-X(D)	
Lock-X(E)		
Lock-X(D)		
Unlock-X(B)		
Unlock-X(E)		
		Lock-X(B)
		Lock-X(E)
	Unlock-X(H)	

The schedule is conflict serializable.

Serializablity for locks can be written as $T_2 \rightarrow T_1 \rightarrow T_3$.

Que 5.9. Describe two-phase locking technique for concurrency control. Explain. How does it guarantee serializability ?

Answer

Two-phase locking technique : Refer Q. 5.6, Page 5–5A, Unit-5.

Two-phase locking guarantees the serializability :

1. Two-phase locking protocol restricts the unwanted read/write by applying exclusive lock.
2. Moreover, when there is an exclusive lock on an item it will only be released in shrinking phase.
3. Due to this restriction, there is no chance of getting any inconsistent state. Because any inconsistency may only be created by write operation. In this way the two-phase locking protocol ensures serializability.

Que 5.10. Describe major problems associated with concurrent processing with examples. What is the role of locks in avoiding these problems ?

OR

Describe the problem faced when concurrent transactions are executing in uncontrolled manner. Give an example and explain.

Answer

Concurrent transaction : Concurrent transaction means multiple transactions are active at the same time.

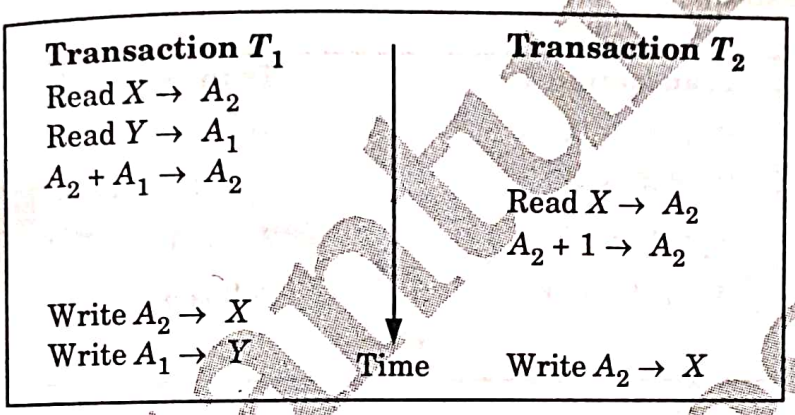
Following problems can arise if many transactions try to access a common database simultaneously :

1. **The lost update problem :**

   a. A second transaction writes a second value of a data item on top of a first value written by a first concurrent transaction, and the first value is lost to other transactions running concurrently which need, by their precedence, to read the first value.

   b. The transactions that have read the wrong value end with incorrect results.

   Example :



   In the example, the update performed by the transaction T_2 is lost (overwritten) by transaction T_1.

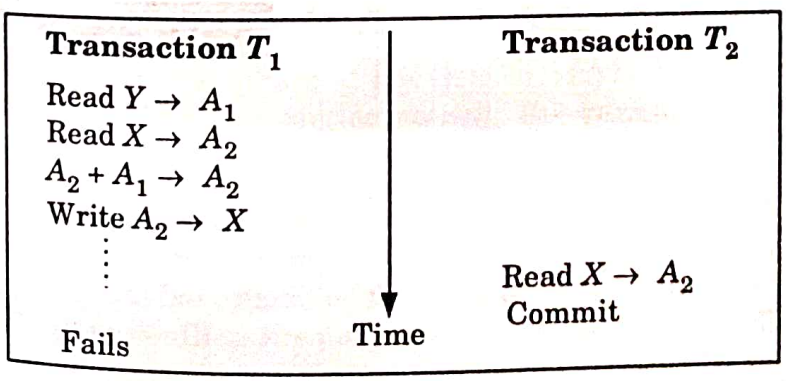
2. **The dirty read problem :**

   a. Transactions read a value written by a transaction that has been later aborted.

   b. This value disappears from the database upon abort, and should not have been read by any transaction ("dirty read").

   c. The reading transactions end with incorrect results.

   Example :



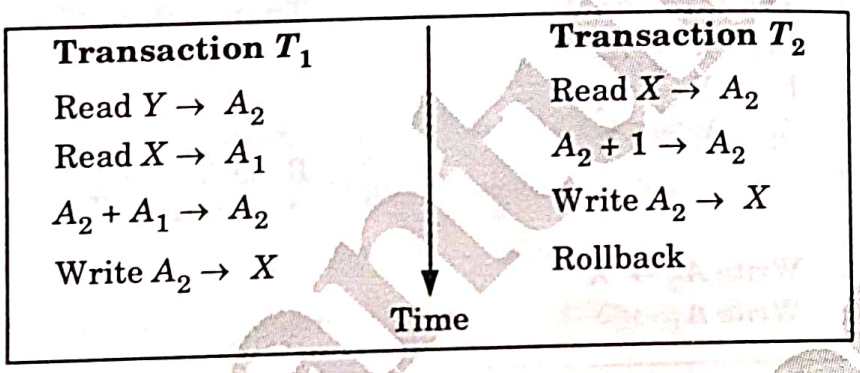
In the example, transaction T_1 fails and changes the value of X back to its old value, but T_2 is committed and reads the temporary incorrect value of X.

3. **The incorrect summary problem :**

   a. While one transaction takes a summary over the values of all the instances of a repeated data item, a second transaction updates some instances of that data item.

   b. The resulting summary does not reflect a correct result for any (usually needed for correctness) precedence order between the two transactions (if one is executed before the other).

Example :



An example of unrepeatable read in which if T_1 were to read the value of X after T_2 had updated X, the result of T_1 would be different.

Role of locks :

1. It locks the data item in the transaction in correct order.
2. If any data item is locked than it must be unlock at the end of operation.

Que 5.11. How do optimistic concurrency control techniques differ from other concurrency control techniques ? Why they are also called validation or certification techniques ? Discuss the typical phases of an optimistic concurrency control method.

AKTU 2022-23, Marks 10

Answer

Feature	Optimistic concurrency control	Other concurrency control techniques
Conflict Detection	Detects conflicts at transaction commit time.	Detects conflicts during transaction execution.
Locking Mechanism	Typically avoids locking, allowing concurrent transactions freely.	Relies heavily on locking mechanisms to manage concurrency.
Transaction Rollback	Rolls back transactions only when conflicts occur at commit time.	May roll back transactions during execution to resolve conflicts.
Isolation Level	Provides lower isolation initially but resolves conflicts later.	Offers varying isolation levels (e.g., Read Committed, Serializable).
Performance Impact	Generally performs better under low contention and high throughput.	Can suffer from lock contention and overhead, impacting performance.
Concurrency Control Complexity	Less complex to implement due to minimal locking and simpler conflict resolution.	More complex due to locking protocols and conflict detection methods.
Usage Scenarios	Suitable for environments with low contention and frequent read operations	Used in environments where data consistency and strict isolation are crucial.

Validation or certification techniques : Optimistic concurrency control techniques are also called validation or certification techniques because they involve validating or certifying transactions after they have completed. This involves checking whether the transactions have created conflicts with other transactions that have completed concurrently.

Typical phases of an optimistic concurrency control method :

1. **Read Phase :** In this phase, a transaction reads data items without acquiring locks. The transaction records the version number of each data item that it reads.
2. **Validation Phase :** After the transaction has completed its operations, it attempts to commit. In this phase, the system checks whether any other transactions have modified the same data items that the transaction has read. If any conflicts are detected, the transaction is rolled back.

3. **Write Phase :** If the transaction is validated, it proceeds to write its changes to the database.

PART-2

Time Stamping Protocols for Concurrency Control, Validation Based Protocol.

Que 5.12. Explain timestamp based protocol and timestamp ordering protocol.

OR

Discuss the timestamp based protocol to maintain serializability in concurrent execution. Also explain its advantages and disadvantages.

OR

Explain time stamp based concurrency control technique.

AKTU 2020-21, Marks 10

Answer

Timestamp based protocols :

Timestamp based protocol ensures serializability. It selects an ordering among transactions in advance using timestamps.

Timestamps :

1. With each transaction in the system, a unique fixed timestamp is associated. It is denoted by $TS(T_i)$.
2. This timestamp is assigned by the database system before the transaction T_i starts execution.
3. If a transaction T_i has been assigned timestamp $TS(T_i)$, and a new transaction T_j enters the system, then $TS(T_i) < TS(T_j)$.
4. The timestamps of the transactions determine the serializability order. Thus, if $TS(T_j) > TS(T_i)$, then the system must ensure that in produced schedule, transaction T_i appears before transaction T_j.
5. To implement this scheme, two timestamps are associated with each data item Q.
   a. **W-timestamp (Q) :** It denotes the largest timestamp of any transaction that executed write(Q) successfully.
   b. **R-timestamp (Q) :** It denotes the largest timestamp of any transaction that executed read(Q) successfully.

These timestamps are updated whenever a new read(Q) or write(Q) instruction is executed.

The timestamp ordering protocol :

The timestamp ordering protocol ensures that any conflicting read and write operations are executed in timestamp order. This protocol operates as follows :

1. Suppose that transaction T_i issues read(Q).
   a. If $TS(T_i)$ < W-timestamp(Q), then T_i needs a value of Q that was already overwritten. Hence, read operation is rejected, and T_i is rolledback.
   b. If $TS(T_i) \geq$ W-timestamp(Q), then the read operation is executed, and R-timestamp(Q) is set to the maximum of R-timestamp(Q) and $TS(T_i)$.
2. Suppose that transaction T_i issues write(Q).
   a. If $TS(T_i)$ < R-timestamp(Q), then the value of Q that T_i is producing was needed previously, and the system assumed that the value would never be produced. Hence, the system rejects write operation and rolls T_i back.
   b. If $TS(T_i)$ < W-timestamp(Q), then T_i is attempting to write an obsolete value of Q. Hence, the system rejects this write operation and rolls back T_i.
   c. Otherwise, the system executes the write operation and sets W-timestamp(Q) to $TS(T_i)$. If a transaction T_i is rolled by the concurrency control scheme, the system assigns it a new timestamp and restarts it.

Advantages of timestamp ordering protocol :

1. The timestamp ordering protocol ensures conflict serializability. This is because conflicting operation are processed in timestamp order.
2. The protocol ensures freedom from deadlock, since no transaction ever waits.

Disadvantages of timestamp ordering protocol :

1. There is a possibility of starvation of long transaction if a sequence of conflicting short transaction causes repeated restarting of the long transaction.
2. The protocol can generate schedules that are not recoverable.

Que 5.13. **Discuss 2 phase commit (2PC) protocol and time stamp based protocol with suitable example. How the validation based protocols differ from 2PC ?**

AKTU 2021-22, Marks 10

AKTU 2023-24, Marks 10

Answer

Two phase commit protocol :

1. Two-phase commit (2PC) is a standardized protocol that ensures atomicity, consistency, isolation and durability (ACID) of a transaction; it is an atomic commitment protocol for distributed systems.
2. In a distributed system, transactions involve altering data on multiple databases or resource managers, causing the processing to be more complicated since the database has to coordinate the committing or rolling back of changes in a transaction as a self-contained unit; either the entire transaction commits or the entire transaction rolls back.

Timestamp based protocols : Refer Q. 5.12, Page 5–13A, Unit-5.

Difference :

S. No.	2PC	Validation Based Protocol
1.	The 2PC protocol is a blocking Two-Phase commit protocol.	The validation based protocol (3PC) is a non-blocking Three-Phase commit protocol.
2.	For 2PC, the coordinator may abort the transaction globally or resend the global decision.	For 3PC, the coordinator can abort the transaction globally, send global-commit message to the participants or simply send the global decision to all sites that have not acknowledged.

Que 5.14. **Write short note on the following :**

i. Thomas' write rule

ii. Strict timestamp ordering protocol

Answer

i. **Thomas' write rule :** Thomas' write rule is a modified version of timestamp ordering protocol. Suppose that transaction T_i issues write(Q) :

1. If $TS(T_i) <$ R-timestamp(Q), then the value of Q that T_i is producing was previously needed, and it had been assumed that the value would never be produced. Hence, the system rejects the write operation and rolls T_i back.
2. If $TS(T_i) <$ W-timestamp(Q), then T_i is attempting to write an obsolete value of Q. Hence, this write operation can be ignored.
3. Otherwise, the system executes the write operation and sets W-timestamps (Q) to $TS(T_i)$.

ii. **Strict timestamp ordering protocol :**

1. Strict timestamp ordering ensures that the schedules are both strict and serializable.
2. In this variation, a transaction T issues a read_item (X) or write_item (X) such that $TS(T) >$ W-timestamp (X) has its read or write operation delayed until the transaction T_1 that wrote the value of X (hence $TS(T_1)$ = W-timestamp (X)) has committed or aborted.
3. To implement this algorithm, it is necessary to simulate the locking of an item X that has been written by transaction T until T_1 is either committed or aborted.
4. This algorithm does not cause deadlock, since T waits for T_1 only if $TS(T) > TS(T_1)$.

Que 5.15. Discuss the timestamp ordering protocol for concurrency control. How does strict timestamp ordering differ from basic timestamp ordering ? **AKTU 2022-23, Marks 10**

Answer

The timestamp ordering protocol : Refer Q. 5.12, Page 5–13A, Unit-5.

Difference :

Feature	Strict Timestamp Ordering	Basic Timestamp Ordering
Concurrency Control	Ensures transactions execute in timestamp order strictly.	Allows transactions to execute out of timestamp order occasionally.
Timestamp Assignment	Timestamps are assigned to transactions based on a strict order.	Timestamps are assigned to transactions as they arrive.
Transaction Rollback	May cause frequent transaction rollbacks if timestamp order is violated.	Generally avoids frequent rollbacks by allowing some flexibility.
Complexity	More complex to implement due to strict adherence to timestamp order.	Simpler to implement as it allows flexibility in transaction order.
Performance Impact	May impact performance due to potential rollbacks and strict ordering checks.	Generally performs better under varying workload conditions.

Que 5.16. Explain validation protocol in concurrency control.

OR

Explain the validation based protocol for concurrency control.

AKTU 2020-21, Marks 10

Answer

Validation protocol in concurrency control consists of following three phase :

1. **Read phase :**
   a. During this phase, the system executes transaction T_i.
   b. It reads the values of the various data items and stores them in variables local to T_i.
   c. It performs all write operations on temporary local variables, without updates of the actual database.
2. **Validation phase :** Transaction T_i performs a validation test to determine whether it can copy to the database, the temporary local variables that hold the results of write operations without causing a violation of serializability.

3. **Write phase :** If transaction T_i succeeds in validation phase, then the system applies the actual updates to the database, otherwise, the system rolls back T_i.

All three phases of concurrently executing transactions can be interleaved.

To perform the validation test, we should know when the various phases of transactions T_i took place. We shall, therefore, associate three different timestamps with transaction T_i :

1. Start (T_i), the time when T_i started its execution.
2. Validation (T_i), the time when T_i finished its read phase and started its validation phase.
3. Finish (T_i), the time when T_i finished its write phase.

Que 5.17. Explain the phantom phenomenon. Discuss a timestamp based protocol that avoids the phantom phenomenon.

Answer

Phantom phenomenon :

1. A deadlock that is detected but is not really a deadlock is called a phantom deadlock.
2. In distributed deadlock detection, information about wait-for relationship between transactions is transmitted from one server to another.
3. If there is a deadlock, the necessary information will eventually be collected in one place and a cycle will be detected.
4. As this procedure will take some time, there is a chance that one of the transactions that hold a lock will meanwhile have released it; in this case the deadlock will no longer exist.

For example :

1. Consider the case of global deadlock detector that receives local wait-for graph from servers X and Y as shown in Fig. 5.17.1 and 5.17.2.

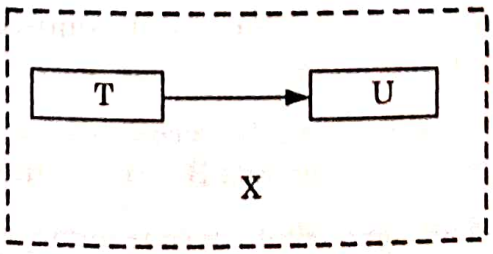


Fig. 5.17.1. Local wait-for graph.

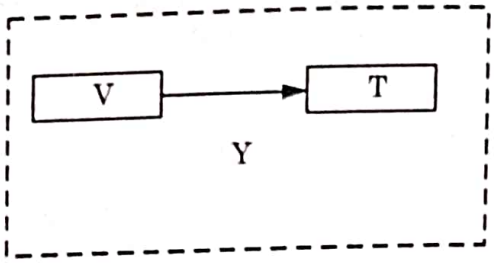


Fig. 5.17.2. Local wait-for graph.

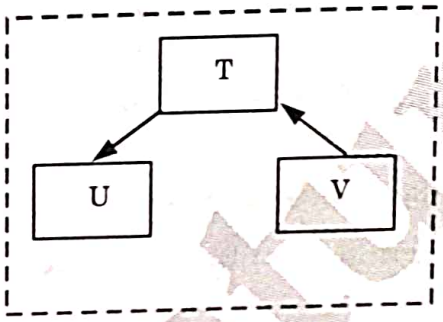


Fig. 5.17.3. Global wait-for graph.

2. Suppose that transaction U releases an object at server X and requests the one held by V at server Y.
3. Suppose also that the global detector receives server Y's local graph before server X's.
4. In this case, it would detect a cycle $T \rightarrow U \rightarrow V \rightarrow T$, although the edge $T \rightarrow U$ no longer exists.
5. A phantom deadlock could be detected if a waiting transaction in a deadlock cycle aborts during the deadlock detection procedure.

   For example, if there is a cycle $T \rightarrow U \rightarrow V \rightarrow T$ and U aborts after the information concerning U has been collected, then the cycle has been broken already and there is no deadlock.

Timestamp based protocol that avoids phantom phenomenon :

1. The B + tree index based approach can be adapted to timestamping by treating index buckets as data items with timestamps associated with them, and requiring that all read accesses use an index.
2. Suppose a transaction T_i wants to access all tuples with a particular range of search-key values, using a B + tree index on that search-key.
3. T_i will need to read all the buckets in that index which have key values in that range.

4. T_i will need to write one of the buckets in that index when any deletion or insertion operation on the tuple is done.
5. Thus the logical conflict is converted to a conflict on an index bucket, and the phantom phenomenon is avoided.

PART-3

Multiple Granularity, Multiversion Schemes.

Que 5.18. What do you mean by multiple granularities ? How it is implemented in transaction system ?

Answer

Multiple granularity :

1. Multiple granularity can be defined as hierarchically breaking up the database into blocks which can be locked.
2. It maintains the track of what to lock and how to lock.
3. It makes easy to decide either to lock a data item or to unlock a data item.

Implementation :

1. Multiple granularity is implemented in transaction system by defining multiple levels of granularity by allowing data items to be of various sizes and defining a hierarchy of data granularity where the small granularities are nested within larger ones.
2. In the tree, a non leaf node represents the data associated with its descendents.
3. Each node is an independent data item.
4. The highest level represents the entire database.
5. Each node in the tree can be locked individually using shared or exclusive mode locks.

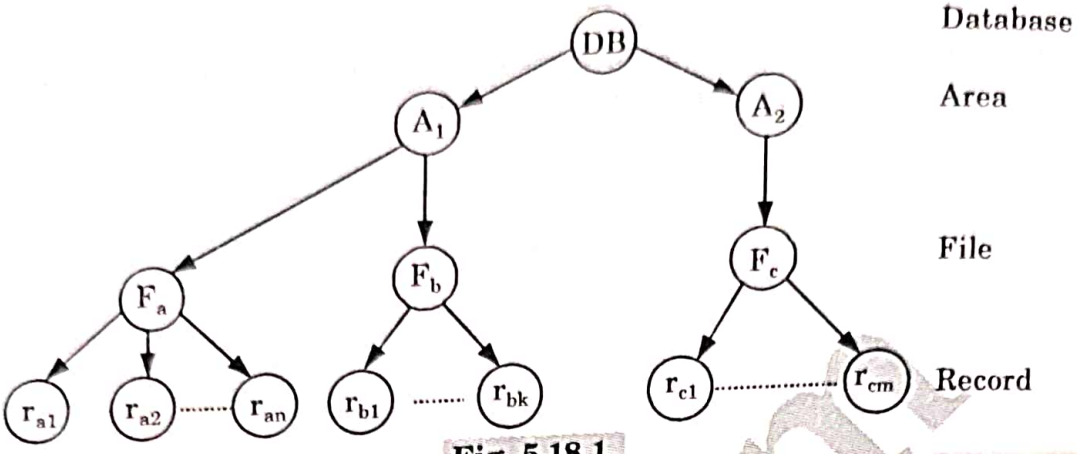


Fig. 5.18.1.

6. If a node is locked in an intention mode, explicit locking is being done at lower level of the tree (that is, at a finer granularity).
7. Intention locks are put on all the ancestors of a node before that node is locked explicitly.
8. While traversing the tree, the transaction locks the various nodes in an intention mode. This hierarchy can be represented graphically as a tree.
9. When a transaction locks a node, it also has implicitly locked all the descendents of that node in the same mode.

Que 5.19. What is multiple granularity protocol of concurrency control ?

Answer

1. Multiple granularity protocol is a protocol in which we lock the data items in top-down order and unlock them in bottom-up order.
2. In multiple granularity locking protocol, each transaction T_i can lock a node Q in any locking mode by following certain rules, which ensures serializability. These rules are as follows :
   i. T_i must follow the compatibility matrix as shown in Fig. 5.19.1 to lock a node Q. This matrix contain following additional locks :
      a. **Intension-Shared (IS) :** Explicit locking at a lower level of tree but only with shared locks.
      b. **Intension-Exclusive (IX) :** Explicit locking at a lower level with exclusive or shared locks.
      c. **Shared and Intension-Exclusive (SIX) :** The sub-tree rooted by that node is locked explicitly in shared mode and

explicit locking is being done at a lower level with exclusive mode locks.

ii. It first locks the root of the tree and then locks the other nodes.

iii. It can lock a node Q in S or IS mode only if it currently has the parent of Q locked in either IX or IS mode.

iv. It can lock node Q in X, SIX or IX mode only if it currently has the parent of Q locked in either IX or SIX mode.

v. It can lock a node if it has not previously unlocked any node.

vi. It can unlock a node Q only if it currently has none of the children of Q locked.

Requested mode	X	SIX	IX	S	IS
X	NO	NO	NO	NO	NO
SIX	NO	NO	NO	NO	YES
IX	NO	NO	YES	NO	YES
S	NO	NO	NO	YES	YES
IS	NO	YES	YES	YES	YES

Fig. 5.19.1. Compatibility matrix for different mode in multiple granularity protocol.

Que 5.20. What is granularity locking ? How does granularity of data item affect the performance of concurrency control ? What factors affect the selection of granularity size of data item ?

Answer

Granularity locking :

1. Granularity locking is a concept of locking the data item on the basis of size of data item.
2. It is based on the hierarchy of data where small granularities are nested within larger one. The lock may be granted at any level from bottom to top.

Effect of granularity of data item over the performance of concurrency control :

1. The larger the data item size is, the lower the degree of concurrency permitted. For example, if the data item size is disk block, a transaction T that needs to lock a record B must lock the whole disk block X that

contains B. If the other transactions want to lock record C which resides in same lock then it is forced to wait.

2. If the data item size is small then the number of items in the database increases. Because every item is associated with a lock, the system will have a larger number of active locks to be handled by the lock manager.

3. More lock and unlock operations will be performed which cause higher overhead.

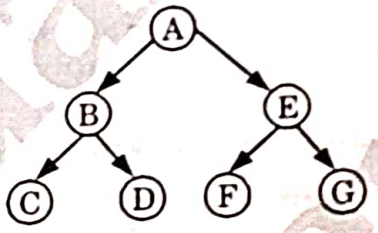
Factors affecting the selection of granularity size of data items :

1. It depends on the types of transaction involved.

2. If a typical transaction accesses a small number of records, it is advantageous to have the data item granularity be one record.

3. If a transaction typically accesses many records in the same file, it may be better to have block or file granularity so that the transaction will consider all those records as one (or a few) data items.

Que 5.21. **What do you mean by multi granularity ? How the concurrency is maintained in this case. Write the concurrent transaction for the following graph.**



T_1 wants to access item C in read mode
T_2 wants to access item D in exclusive mode
T_3 wants to read all the children of item B
T_4 wants to access all items in read mode

Answer

Multi granularity : Refer Q. 5.18, Page 5–20A, Unit-5.

Concurrency in multi granularity protocol : Refer Q. 5.19, Page 5–21A, Unit-5.

Numerical :

1. Transaction T_1 reads the item C in B. Then, T_2 needs to lock the item the item A and B in IS mode (and in that order), and finally to lock the item C in S mode.

2. Transaction T_2 modifies the item D in B. Then, T_2 needs to lock the item A AND B (and in that order) in IX mode, and at last to lock the item D in X mode.
3. Transaction T_3 reads all the records in B. Then, T_3 needs to lock the A and B (and in that order) in IS mode, and at last to lock the item B in S mode.
4. Transaction T_4 read the all item. It can be done after locking the item A in S mode.

Que 5.22. **What is multiversion concurrency control ? Explain multiversion timestamping protocol.**

OR

What do you mean by time stamping protocol for concurrency controlling? Discuss multi version scheme of concurrency control.

AKTU 2021-22, Marks 10

Answer

Time stamping protocol : Refer Q. 5.12, Page 5–13A, Unit-5.

Multiversion concurrency control :

1. Multiversion concurrency control is a schemes in which each write(Q) operation creates a new version of Q.
2. When a transaction issues a read(Q) operation, the concurrency-control manager selects one of the version of Q to be read.
3. The concurrency control scheme must ensure that the version to be read is selected in manner that ensures serializability.

Multiversion timestamping protocol :

1. The most common transaction-ordering technique used by multiversion schemes is timestamping.
2. With each transaction T_i in the system, we associate a unique static timestamp, denoted by $TS(T_i)$.
3. This timestamp is assigned before the transaction starts execution.
4. Concurrency can be increased if we allow multiple versions to be stored, so that the transaction can access the version that is consistent for them.
5. With this protocol, each data item Q is associated with a sequence of versions $< Q_1, Q_2, \ldots, Q_m >$.
6. Each version Q_k contains three data fields :

a. Content is the value of version Q_k.

b. W-timestamp(Q_k) is the timestamp of the transaction that created version Q_k.

c. R-timestamp(Q_k) is the largest timestamp of any transaction that successfully read version Q_k.

7. The scheme operates as follows :

Suppose that transaction T_i issues a read(Q) operation. Let Q_k denote the version of Q whose write timestamp is the largest write timestamp less than or equal to $TS(T_i)$.

a. If transaction T_i issues a read(Q), then the value returned is the content of version Q_k.

b. When transaction T_i issues write(Q) :

i. If $TS(T_j)$ < R-timestamp(Q_k), then the system rolls back transaction T_i.

ii. If $TS(T_i)$ = W-timestamp(Q_k), the system overwrites the contents of Q_k; otherwise it creates a new version of Q.

iii. This rule forces a transaction to abort if it is "too late" in doing a write.

Que 5.23. Discuss multiversion two-phase locking.

Answer

1. The multiversion two-phase locking attempts to combine the advantages of multiversion concurrency control with the advantages of two-phase locking.

2. In addition to read and write lock modes, multiversion two-phase locking provides another lock mode, *i.e.*, certify.

3. In order to determine whether these lock modes are compatible with each other or not, consider Fig. 5.23.1

Requested mode	Shared	Exclusive	Certify
Shared	YES	YES	NO
Exclusive	YES	NO	NO
Certify	NO	NO	NO

Fig. 5.23.1. Compatibility matrix for multiversion two-phase locking.

4. The term "YES" indicates that if a transaction T_i hold a lock on data item Q than lock can be granted by other requested transaction T_j on same data item Q.

5. The term "NO" indicates that requested mode is not compatible with the mode of lock held. So, the requested transaction must wait until the lock is released.

6. In multiversion two-phase locking, other transactions are allowed to read a data item while a transaction still holds an exclusive lock on the data item.

7. This is done by maintaining two versions for each data item *i.e.*, certified version and uncertified version.

8. In this situation, T_j is allowed to read the certified version of Q while T_i is writing the value of uncertified version of Q.

   However, if transaction T_i is ready to commit, it must acquire a certify lock on Q.

Que 5.24. **What are multiversion schemes of concurrency control ? Describe with the help of an example. Discuss the various time stamping protocols for concurrency control also.**

AKTU 2023-24, Marks 10

Answer

Multiversion schemes of concurrency control : Refer Q. 5.22, Page 5–24A, Unit-5.

Example :

Consider two transactions, T1 and T2, operating on a data item X :

1. T1 (Read-Only Transaction) starts and reads version X1 of X, which has a value of 10.
2. T2 (Update Transaction) starts, modifies X to 20, and creates a new version X2.
3. T1 still sees the old version X1 (value = 10) while T2 commits with the new version X2 (value = 20).

Thus, T1 reads consistent data without being affected by T2's updates.

Various time stamping protocols for concurrency control are :

1. **Timestamp ordering protocol :** Refer Q. 5.12, Page 5–12A, Unit-5.

2. **Thomas' write rule :** Refer Q. 5.14, Page 5–15A, Unit-5.

3. **Multiversion timestamping protocol :** Refer Q. 5.22, Page 5–24A, Unit-5.

PART-4

Recovery with Concurrent Transaction, Case Study of Oracle.

Que 5.25. **Explain the recovery with concurrent transactions.**

OR

Explain recovery from concurrent transaction.

AKTU 2020-21, Marks 10

Answer

Recovery from concurrent transaction can be done in the following four ways :

1. **Interaction with concurrency control :**
   a. In this scheme, the recovery scheme depends greatly on the concurrency control scheme that is used.
   b. So to rollback a failed transaction, we must undo the updates performed by the transaction.

2. **Transaction rollback :**
   a. In this scheme we rollback a failed transaction by using the log.
   b. The system scans the log backward, for every log record found in the log the system restores the data item.

3. **Checkpoints :**
   a. In this scheme we used checkpoints to reduce the number of log records that the system must scan when it recovers from a crash.
   b. In a concurrent transaction processing system, we require that the checkpoint log record be of the form <checkpoint *L*>, where '*L*' is a list of transactions active at the time of the checkpoint.

4. **Restart recovery :**
   a. When the system recovers from a crash, it constructs two lists.
   b. The undo-list consists of transactions to be undone, and the redo-list consists of transaction to be redone.

c. The system constructs the two lists as follows : Initially, they are both empty. The system scans the log backward, examining each record, until it finds the first <checkpoint> record.

Que 5.26. Describe Oracle. How data is stored in Oracle RDBMS ?

Answer

1. The Oracle database (commonly referred to as Oracle RDBMS or simply Oracle) consists of a relational database management system (RDBMS).
2. Oracle is a multi-user database management system. It is a software package specializing in managing a single, shared set of information among many concurrent users.
3. Oracle is one of many database servers that can be plugged into a client/server equation.
4. Oracle works to efficiently manage its resource, a database of information, among the multiple clients requesting and sending data in the network.

Storage :

1. The Oracle RDBMS stores data logically in the form of table spaces and physically in the form of data files.
2. Table spaces can contain various types of memory segments, such as data segments, index segments, etc.

Que 5.27. Write the name of disk files used is Oracle. Explain database schema.

Answer

Disk files consists two files which are as follows :

1. **Data files :**
   a. At the physical level, data files comprise one or more data blocks, where the block size can vary between data files.
   b. Data files can occupy pre-allocated space in the file system of a computer server, utilize raw disk directly, or exist within ASM logical volumes.
2. **Control files :** One (or multiple multiplexed) control files (also known as "control files") store overall system information and statuses.

Database schema :

1. Oracle database conventions refer to defined groups of object ownership as schemas.
2. Most Oracle database installation has a default schema called SCOTT.
3. After the installation process has set up the sample tables, the user can log into the database with the username scott and the password tiger.
5. The SCOTT schema has seen less use as it uses few of the features of the more recent releases of Oracle.
6. Most recent examples supplied by Oracle Corporation reference the default HR or OE schemas.

Que 5.28. Define in terms of Oracle :

i. Tablespace
ii. Package
iii. Schema

Answer

i. Tablespace :

1. A tablespace is a logical portion of an Oracle database used to allocate storage for table and index data.
2. Each tablespace corresponds to one or more physical database files.
3. Every Oracle database has a tablespace called SYSTEM and may have additional tablespaces.
4. A tablespace is used to group related logical structures together.

ii. Package :

1. Packages are a method of encapsulating and storing related procedures, functions, and other package constructs together as a unit in the database.
2. It also offers increased functionality and database performance.
3. Calling a public procedure or function that is part of a package is no different than calling a standalone procedure or function, except that we must include the program's package name as a prefix to the program name.

iii. Schema :

1. A schema is a collection of table definitions or related objects owned by one person or user.
2. SCOTT is schema in the Oracle database.

3. Schema objects are the logical structures that directly refer to the database's data.
4. Schema objects include such structures as tables, views, sequences, stored procedures, synonyms, indexes, clusters and database links.

Que 5.29. Explain SQL Plus, SQL * Net and SQL & LOADER.

Answer

SQL Plus :

1. SQL Plus is the front end tools for Oracle.
2. The SQL Plus window looks much like a DOS window with a white background similar Notepad.
3. This tool allows us to type in our statements, etc., and see the results.

SQL * Net :

1. This is Oracle's own middleware product which runs on both the client and server to hide the complexity of the network.
2. SQL * Net's multiprotocol interchange allows client/server connections to span multiple communication protocols without the need for bridges and routers, etc., SQL * Net will work with any configuration design.

SQL * LOADER :

1. A utility used to load data from external files into Oracle tables.
2. It can load data from as ASCII fixed-format or delimited file into an Oracle table.

Que 5.30. What do you mean by locking techniques of concurrency control ? Discuss the various locking techniques and recovery with concurrent transaction also in detail.

Answer

Locking techniques :

1. The locking technique is used to control concurrency execution of transactions which is based on the concept of locking data items.
2. The purpose of locking technique is to obtain maximum concurrency and minimum delay in processing transactions.
3. A lock is a variable associate with a data item in the database and describes the status of that data item with respect to possible operations

that can be applied to the item; there is one lock for each data item in the database.

Following are the locking techniques with concurrent transaction :

1. **Lock based locking technique :** Refer Q. 5.2, Page 5–2A, Unit-5.
2. **Two-phase locking technique :** Refer Q. 5.6, Page 5–5A, Unit-5.

Following are the recovery techniques with concurrent transaction :

1. **Log based recovery :** Refer Q. 4.22, Page 4–19A, Unit-4.
2. **Checkpoint :** Refer Q. 4.25, Page 4–21A, Unit-4.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. What is lock ? Explain different types of locks.

Ans. Refer Q. 5.2.

Q. 2. Explain two-phase locking technique for concurrency control.

Ans. Refer Q. 5.6.

Q. 3. Write the salient features of graph based locking protocol with suitable example.

Ans. Refer Q. 5.8.

Q. 4. Describe major problems associated with concurrent processing with examples. What is the role of locks in avoiding these problems ?

Ans. Refer Q. 5.10.

Q. 5. How do optimistic concurrency control techniques differ from other concurrency control techniques ? Why they are also called validation or certification techniques ? Discuss the typical phases of an optimistic concurrency control method.

Ans. Refer Q. 5.11.

Q. 6. Explain timestamp based protocol and timestamp ordering protocol.

Ans. Refer Q. 5.12.

Q. 7. Discuss 2 phase commit (2PC) protocol and time stamp based protocol with suitable example. How the validation based protocols differ from 2PC ?

Ans. Refer Q. 5.13.

Q. 8. Explain validation protocol in concurrency control.

Ans. Refer Q. 5.16.

Q. 9. What do you mean by multiple granularities ? How it is implemented in transaction system ?

Ans. Refer Q. 5.18.

Q. 10. What is multiversion concurrency control ? Explain multiversion timestamping protocol.

Ans. Refer Q. 5.22.

Q. 11. What are multiversion schemes of concurrency control ? Describe with the help of an example. Discuss the various time stamping protocols for concurrency control also.

Ans. Refer Q. 5.25.

Q. 12. What do you mean by locking techniques of concurrency control ? Discuss the various locking techniques and recovery with concurrent transaction also in detail.

Ans. Refer Q. 5.30.

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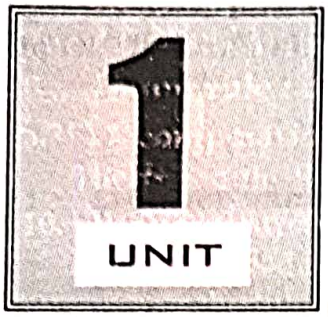


Introduction (2 Marks Questions)

1.1. What are the functions of DBMS ?

Ans. **The functions of DBMS are :**

i. The ability to update and retrieve data
ii. Support concurrent updates
iii. Recovery of data
iv. Security
v. Data integrity

1.2. List the four functions of DBA. **AKTU 2021-22, Marks 02**

Ans.

1. Schema definition.
2. Storage structure and access method definition.
3. Schema and physical organization and modification.
4. Granting of authorization for data access.

1.3. What are the advantages of file processing system which were removed by the DBMS ?

Ans.

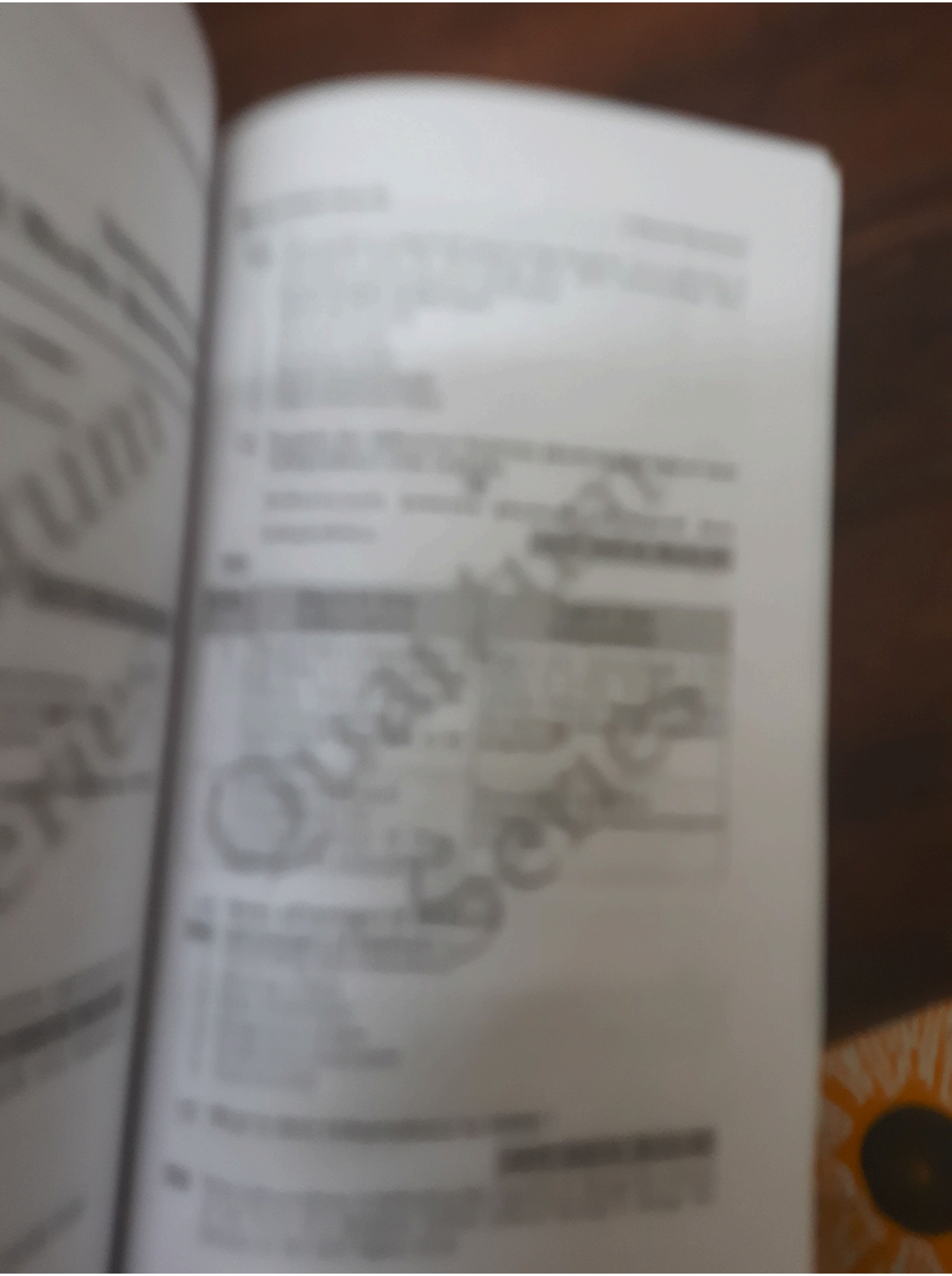
i. No problem of centralization
ii. Less expensive
iii. Less need of hardware
iv. Less complex in backup and recovery

1.4. List any four disadvantages of file system approach over database approach. **AKTU 2022-23, Marks 02**

Ans. **Disadvantages of file system approach over database approach :**

i. Data redundancy
ii. Limited data sharing
iii. Limited data access control
iv. Limited scalability

1.5. What is data model ? List the types of data model used.



Ans. Data model is a logical structure of the database. It is a collection of conceptual tools for describing data, data relationships, data semantics and consistency constraints.

Types of data model used :

1. Hierarchical model
2. Network model
3. Relational model
4. Object-oriented model
5. Object-relational model

1.6. Explain the difference between physical and logical data independence with example.

OR

Differentiate between physical and logical data independence.

AKTU 2022-23, Marks 02

Ans.

S. No.	Physical data independence	Logical data independence
1.	Physical data independence is the ability to modify physical schema without causing the conceptual schema or application programs to be rewritten.	Logical data independence is the ability to modify the conceptual schema without having to change the external schemas or application programs.
2.	Examples of physical independence are reorganisations of files, adding a new access path etc.	Examples of logical data independence are addition/removal of entities.

1.7. Write advantages of database.

Ans. Advantages of database :

1. Controlling data redundancy
2. Sharing of data
3. Data consistency
4. Integration of data
5. Integration constraints
6. Data security

1.8. What is data independency in DBMS ?

AKTU 2020-21, Marks 02

Ans. Data independence is defined as the capacity to change the schema at one level of a database system without having to change the schema at the next higher level.

1.9. Explain logical data independence.

Ans. The separation of the external views from the conceptual views which enables the user to change the conceptual view without effecting the external views or application program is called logical data independence.

1.10. What is the significance of physical data independence ?

AKTU 2021-22, Marks 02

Ans.

1. Physical data independence helps us to separate conceptual levels from the internal/physical levels.
2. It allows us to provide a logical description of the database without the need to specify physical structures.

1.11. Define the term data redundancy and data consistency.

Ans. **Data redundancy :** The occurrence of values for data elements more than once within a file or database is called data redundancy.
Data consistency : Data consistency states that only valid data will be written to the database.

1.12. What do you mean by DML and DDL ?

OR

Define DML.

Ans. **Data Manipulation Language (DML) :** A DML is a language that enables users to access and manipulate data as organized by the appropriate data model. Insert, update, delete, query are commonly used DML commands.
Data Definition Language (DDL) : DDL is set of SQL commands used to create, modify and delete database structures but not data.They are normally used by the DBA. Create, drop, alter, truncate are commonly used DDL command.

1.13. Write the difference between DDL and DML.

AKTU 2020-21, Marks 02

Ans.

S. No.	Data Definition Language (DDL)	Data Manipulation Language (DML)
a.	DDL is set of SQL commands used to create, modify and delete database structures but not data.	A DML is a language that enables users to access or manipulates data as organized by the appropriate data model.
b.	Create, drop, alter, truncate are commonly used DDL command.	Insert, update, delete, query are commonly used DML commands.

1.14. Write the difference between super key and candidate key.

Ans.

S. No.	Super key	Candidate key
1.	Super key is a set of one or more attributes taken collectively that allows us to identify uniquely an entity in the entity set.	A candidate key is a column, or set of column, in the table that can uniquely identify any database record without referring to any other data.
2.	Super key is a broadest unique identifier.	Candidate key is a subset of super key.

1.15. What is the concept of keys in database ?

AKTU 2023-24, Marks 02

Ans.

1. Key is a attribute or set of attributes that is used to identify data in entity sets.
2. Key is defined for unique identification of rows in table.

1.16. Describe the purpose of foreign key.

Ans. A foreign key is used to link tables together and create a relationship. It is a field in one table that is linked to the primary key in another table.

1.17. Explain specialization.

Ans. Specialization is the abstracting process of introducing new characteristics to an existing class of objects to create one or more new classes of objects. This involves taking a higher-level, and using additional characteristics, generating lower-level entities.

1.18. What do you mean by aggregation ?

Ans. Aggregation is an abstraction through which relationships are treated as higher level entities.

1.19. Define super key, candidate key, primary key and foreign key.

Ans. **Super key :** It is a set of one or more attributes that, taken collectively, allows us to identify uniquely an entity in the entity set.

Candidate key : A candidate key is a column, or set of column, in the table that can uniquely identify any database record without referring to any other data.

Primary key : Primary key is a candidate key that is used for unique identification of entities within the table.

Foreign key : A foreign key is derived from the primary key of the same or some other table. Foreign key is the combination of one or more columns in a table (parent table) at references a primary key in another table (child table).

1.20. What is strong and weak entity set ?

AKTU 2023-24, Marks 02

Ans. **Strong entity :** Strong entity is not dependent of any other entity in schema. Strong entity always has primary key. Strong entity is represented by single rectangle. Two strong entity's relationship is represented by single diamond.

Weak entity : Weak entity is dependent on strong entity to ensure the existence of weak entity. Weak entity does not have any primary key, it has partial discriminator key. Weak entity is represented by double rectangle.

1.21. Explain the difference between a weak and a strong entity set with example.

Ans.

S. No.	Weak entity set	Strong entity set
1.	An entity set which does not possess sufficient attributes to from a primary key is called a weak entity set.	An entity set which does have a primary key is called a strong entity set.
2.	It is represented by a rectangle.	It is represented by a double rectangle.
3.	It contains a primary key represented by an underline.	It contains a primary key represented by a dashed underline.

1.22. Discuss three level of abstractions or schemas architecture of DBMS.

Ans. **Different levels of data abstraction :**

1. Physical level
2. Logical level
3. View level

2 UNIT Relational Data Model (2 Marks Questions)

2.1. Define the term degree and cardinality.

Ans. **Degree :** The number of attributes in a relation is known as degree.
Cardinality : The number of tuples in a relation is known as cardinality.

2.2. What are different integrity constraints ?

AKTU 2020-21, Marks 02

AKTU 2022-23, Marks 02

Ans. **Different integrity constraints :**
1. Domain constraint
2. Entity integrity constraint
3. Referential integrity constraint
4. Key constraint

2.3. What do you mean by referential integrity ?

OR

Explain referential integrity. **AKTU 2023-24, Marks 02**

Ans. In the relational model, for some cases, we often wish to ensure that a value that appears in one relation for a given set of attributes also appears for a certain set of attributes in another relation. This condition is called as referential integrity.

2.4. Explain entity integrity constraints.

AKTU 2023-24, Marks 02

Ans. The entity integrity constraint states that primary keys cannot be null. There must be a proper value in the primary key field. This is because the primary key value is used to identify individual rows in a table. If there were null values for primary keys, it would mean that we could not identify those rows.

2.5. Define foreign key constraint.

Ans. A foreign key constraint allows certain attributes in one relation to refer to attributes in another relation. The relation on which foreign key constraint is defined contains the partial information.

2.6. When do you get constraints violation ? Also, define null value constraint.

Ans. Constraints get violated during update operations on the relation.
Null value constraint : While creating tables, if a row lacks a data value for a particular column, that value is said to be null.

2.7. What is the role of join operations in relational algebra ?

Ans. The join operation, denoted by $\bowtie$, is used to join two relations to form a new relation on the basis of a common attribute present in the two operand relations.

2.8. Explain different features of SQL.

AKTU 2020-21, Marks 02

Ans. **Different features of SQL are :**
1. SQL provides commands for defining, deleting and modifying relational schema.
2. It provides commands for manipulating data in a table.
3. It helps in implementing relational databases.

2.9. What are characteristics of SQL ?

Ans. **Characteristics of SQL :**
1. SQL usage is extremely flexible.
2. It uses a free form syntax

2.10. Give merits and demerits of SQL database.

Ans. **Merits of SQL database :**
i. High speed
ii. Security
iii. Compatibility
iv. No coding required

Demerits of SQL database :
i. Some versions of SQL are costly.
ii. Difficulty in interfacing
iii. Partial control is given to database.

2.11. What do you mean by query and subquery ?

Ans. **Query :** Query is a request to database for obtaining some data.
Subquery : A subquery is a SQL query nested inside a larger query. Subqueries must be enclosed within parenthesis.

2.12. Write the purpose of trigger.

Ans. **Purpose of trigger :**
1. Automatically generate derived column values.
2. Prevent invalid transactions.
3. Enforce complex security authorizations.
4. Enforce referential integrity across nodes in a distributed database.
5. Enforce complex business rules.

2.13. What do you mean by PL / SQL ?

Ans. PL/SQL stands for Procedural Language/SQL. PL/SQL extends SQL by adding constructs found in procedural languages, resulting is a structural language that is more powerful than SQL.

2.14. What is union compatibility ?

Ans. Two relation instances are said to be union compatible if the following conditions hold :

i. They have the same number of the fields.

ii. Corresponding fields, taken in order from left to right, have the same domains.

2.15. What is relational algebra ?

Ans. The relational algebra is a procedural query language. It consists of a set of operations that take one or two relations as input and produces a new relation as a result.

2.16. When a relation set is called a recursive relationship set ?

AKTU 2021-22, Marks 02

Ans. When there is a relationship between two entities of the same type, it is known as a recursive relationship. This means that the relationship is between different instances of the same entity type.

2.17. Define constraint and its types in DBMS.

Ans. A constraint is a rule that is used for optimization purposes.

Types of constraints :
1. NOT NULL
2. UNIQUE
3. DEFAULT
4. CHECK
5. Key constraints

i. Primary key

ii. Foreign key

6. Domain constraints

2.18. What do you mean by currency with respect to database ?

AKTU 2021-22, Marks 02

Ans. The DBMS uses currency to keep track of the database location (db-key) of the most recently accessed record occurrences for the run unit, record type, set, and area. By keeping track of the most recently accessed records, currency enables you to navigate the database with a minimum of effort.

2.19. What is Relational Calculus ? **AKTU 2021-22, Marks 02**

Ans.

1. Relational calculus is a non-procedural query language.
2. Relational calculus is a query system where queries are expressed as formulas consisting of a number of variables and an expression involving these variables.

2.20. What is Equi-Join in database ?

AKTU 2021-22, Marks 02

Ans. An equi-join is a type of join that combines tables based on matching values in specified columns. The column names do not need to be the same. The resultant table contains repeated columns. It is possible to perform an equi-join on more than two tables.

2.21. What is a CLAUSE in terms of SQL ?

AKTU 2021-22, Marks 02

Ans. A CLAUSE in SQL is a part of a query that lets us filter or customizes how we want our data to be queried to us.

2.22. What is the difference between DROP and DELETE command ? **AKTU 2022-23, Marks 02**

Ans.

Command	Functionality	Scope	Syntax
DROP	Removes entire tables or databases from a DBMS	Database, Table	'DROP TABLE - name;' 'DROP DATABASE database-name;'
DELETE	Removes specific rows of data from a table in a DBMS	Table	'DELETE FROM table -name WHERE condition.'

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3 UNIT

Database Design and Normalization (2 Marks Questions)

3.1. Distinguish between functional dependency and multivalued dependency.

Ans. **Functional dependency :**
A functional dependency, denoted by $X \rightarrow Y$, between two sets of attributes X and Y that are subsets of R specifies a constraint on the possible tuples that can form a relation, state r or R.
Multivalued dependency (MVD) :
MVD occurs when two or more independent multivalued facts about the same attribute occur within the same relation. MVD is denoted by $X \rightarrow\rightarrow Y$ specified on relation schema R, where X and Y are both subsets of R.

3.2. Define the following :
a. Full functional dependency
b. Partial dependency

Ans.
a. A dependency $X \rightarrow Y$ in a relational schema R is said to be a fully functionally dependency if there is no A, where A is the proper subset of X such that $A \rightarrow Y$. It implies removal of any attribute from X means that the dependency does not hold any more.
b. A dependency $X \rightarrow Y$ in a relational schema R is said to be a partial dependency if there is any attribute A where A is the proper subset of X such that $A \rightarrow Y$. The attribute Y is said to be partially dependent on the attribute X.

3.3. What is transitive dependency ? Name the normal form which is based on the concept of transitive dependency.

Ans. An attribute Y of a relational schema R is said to be transitively dependent on attribute X ($X \rightarrow Y$), if there is a set of attributes A that is neither a candidate key nor a subset of any key of R and both $X \rightarrow A$ and $A \rightarrow Y$ hold.
The normal form that is based on transitive dependency is 3NF.

3.4. What is normalization ?

Ans. Normalization is the process of organizing a database to reduce redundancy and improve data integrity.

3.5. What are advantages of normalization ?

AKTU 2020-21, Marks 02

Ans. **Advantages :**

1. It helps to remove the redundancy from the relation.
2. It helps in easy manipulation of data.

3.6. Define 2NF.

Ans. A relation R is in second normal form (2NF) if and only if it is in 1NF and every non-key attribute is fully dependent on the primary key. A relation R is in 2NF if every non-prime attribute of R is fully functionally dependent on each relation key.

3.7. Why is BCNF considered simpler as well as stronger than 3NF ?

Ans. BCNF is the simpler form of 3NF as it makes explicit reference to neither the first and second normal forms nor to the concept of transitive dependence.

In addition, it is stronger than 3NF as every relation that is in BCNF is also in 3NF but the vice versa is not necessarily true.

3.8. Describe the dependency preservation property.

Ans. It is a property that is desired while decomposition, that is, no FD of the original relation is lost. The dependency preservation property ensures that each FD represented by the original relation is enforced by examining and single relation resulted from decomposition or can be inferred from FDs in some decomposed relation.

3.9. What are the various anomalies associated with RDBMS ?

OR

What are the different types of anomalies associated with database ?

Ans. In RDBMS, certain update anomalies can arise, which are as follows :

i. **Insertion anomaly :** It leads to a situation in which certain information cannot be inserted in a relation unless some other information is stored.

ii. **Deletion anomaly :** It leads to a situation in which deletion of data representing certain information results in losing data representing some other information that is associated with it.

iii. **Modification anomaly :** It leads to a situation in which repeated data changed at one place results in inconsistency unless the same data are also changed at other places.

3.10. Explain normalization. What is normal form ?

Ans. **Normalization :** Refer Q. 3.4, Page SQ–10A, Unit-3, Two Marks Questions.

Normal form : Normal forms are based on the functional dependencies among the attributes of a relation. These forms are simply stages of database design, with each stage applying more strict rules to the types of information which can be stored in a table.

3.11. Why do we normalize database ?

AKTU 2023-24, Marks 02

Ans. **We normalize database :**
1. To avoid redundancy
2. To avoid update/delete anomalies

3.12. Are normal forms alone sufficient as a condition for a good schema design ? Explain.

Ans. No, normal forms alone are not sufficient as a condition for a good schema design. There are two additional properties, namely lossless join property and dependency preservation property that must hold on decomposition to qualify it as a good design.

3.13. Write different inference rule for functional dependency ?

AKTU 2020-21, 2023-24; Marks 10

Ans. **Inference rules for functional dependencies :**
1. Reflexivity rule
2. Augmentation rule
3. Transitivity rule
4. Complementation rule
5. Multivalued augmentation rule
6. Multivalued transitivity rule
7. Replication rule
8. Union rule
9. Decomposition rule
10. Pseudotransitivity rule

3.14. Define the closure of an attribute set.

AKTU 2021-22, Marks 02

Ans. The closure of a set of attributes X is the set of those attributes that can be functionally determined from X. The closure of X is denoted as X +. When given a closure problem, we have a set of functional dependencies over which to compute the closure and the set X for which to find the closure.

3.15. List all prime and non-prime attributes in relation $R(A, B, C, D, E)$ with FD set $F = \{AB \rightarrow C, B \rightarrow E, C \rightarrow D\}$.

AKTU 2022-23, Marks 02

Ans. **Prime attributes :** A, B
Non-prime attributes : C, D, E

3.16. Explain MVD with the help of suitable example.

AKTU 2022-23, Marks 02

Ans.

1. MVD occurs when two or more independent multivalued facts about the same attribute occur within the same relation.
2. MVD is denoted by $X \rightarrow\rightarrow Y$ specified on relation schema R, where X and Y are both subsets of R.

For example :

Relation with MVD

Faculty	Subject	Committee
John	DBMS	Placement
John	Networking	Placement
John	MIS	Placement
John	DBMS	Scholarship
John	Networking	Scholarship
John	MIS	Scholarship

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4 UNIT

Transaction Processing Concept (2 Marks Questions)

4.1. Define transaction.

Ans. A collection of operations that form a single logical unit of work is called a transaction. The operations that make up a transaction typically consist of requests to access existing data, modify existing data, add new data or any combination of these requests.

4.2. Define the term ACID properties.

Ans. ACID (Atomicity, Consistency, Isolation, Durability) is a set of properties of database transactions intended to guarantee validity even in the event of errors, power failures, etc.

4.3. State the properties of transaction.

OR

What are ACID properties of transaction ?

AKTU 2020-21, Marks 02

Ans. **ACID properties of transaction :**

i. Atomicity
ii. Consistency
iii. Isolation
iv. Durability

4.4. Explain I in ACID property.

Ans. I in ACID property stands for isolation *i.e.*, each transaction is unaware of other transaction executing concurrently in the system.

4.5. What is serializability ? How it is tested ?

OR

What do you mean by testing of serializability ?

AKTU 2023-24, Marks 02

Ans. Serializability is the classical concurrency scheme which ensures that a schedule for executing concurrent transaction serially in same order. Serializability is tested by constructing precedence graph.

4.6. Define schedule.

Ans. A schedule is a list of operations (actions) ordered by time, performed by a set of transactions that are executed together in the system.

4.7. What do you mean by serial schedule ?

Ans. Serial schedule is a schedule in which transactions in the schedule are defined to execute one after the other.

4.8. Define replication in distributed database.

AKTU 2023-24, Marks 02

Ans. Replication is a technique used in distributed databases to store multiple copies of a data table at different sites.

4.9. Define data atomicity.

Ans. Data atomicity is one of the transaction properties which specify that either all operations of the transaction are reflected properly in the database or not.

4.10. Define precedence graph.

Ans. A precedence graph is a directed graph $G = (N, E)$ where $N = \{T_1, T_2, \ldots, T_n\}$ is a set of nodes and $E = \{e_1, e_2 \ldots e_n\}$ is a set of directed edges.

4.11. Give types of failures.

Ans. **Types of failures :**

i. Transaction failure
ii. System crash
iii. Disk failure

4.12. What are various reasons for transaction failure ?

AKTU 2020-21, Marks 02

Ans. **Various reasons for transaction failure are :**

1. System crash,
2. Disk failure,
3. Catastrophe situation,
4. System error, and
5. Concurrency control enforcement.

4.13. Give the idea behind shadow paging technique.

Ans. The key idea behind shadow paging technique is to maintain following two page tables during the life of transaction :

i. Current page table
ii. Shadow page table

4.14. Give merits and demerits of shadow paging.

Ans. **Merits of shadow paging :**

i. The overhead of log record output is eliminated.

ii. Recovery from crashes is significantly faster.

Demerits :

i. Commit overhead

ii. Data fragmentation

iii. Garbage collection

4.15. What is multimedia database ?

Ans. Multimedia database provides features that allow users to store and query different types of multimedia information, which includes images (pictures or drawings), video clips (movies, news reels, home video), audio clips (songs, phone messages, speeches) and documents (books, articles).

4.16. What do you mean by conflict serializable schedule ?

Ans. A schedule is called conflict serializable if it can be transformed into a serial schedule by swapping non-conflicting operation.

4.17. When is a transaction rolled back ?

AKTU 2021-22, Marks 02

Ans. A transaction is rolled back when :

1. A system failure occurs, disrupting the normal execution of the transaction.
2. The transaction violates integrity constraints or encounters a runtime error, necessitating its termination to maintain database consistency.

4.18. Discuss consistency and isolation property of a transaction.

AKTU 2022-23, Marks 02

Ans. **Consistency :** The state of database before the execution of transaction and after the execution of transaction should be same.
Isolation : A transaction must not affect other transactions that are running parallel to it.

4.19. Draw a state diagram and discuss the typical states that a transaction goes through during execution.

AKTU 2022-23, Marks 02

Ans. **State diagram of transaction :**

1. **Active :** The transaction is said to be in the active state till the final statement is executed.

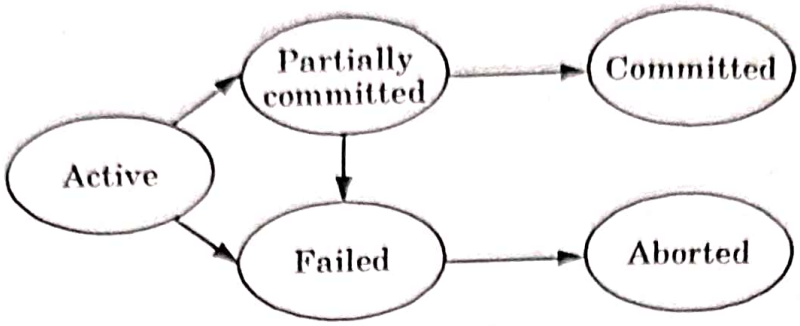

Fig. 4.19.1.

2. **Partially committed :** A transaction is said to be entered in the partial state when final statement gets executed. But it is still possible that it may have to be aborted, since its actual operation is still resided in main memory in which the power failure brings failure of its execution.
3. **Failed :** A transaction enters a failed state after the system determines that the transaction can no longer proceeds with its normal execution.
4. **Aborted :** A transaction enters this state after the transaction has been rolledback and the database has been restored to its state, prior to the start of the transaction.
5. **Committed :** A transaction enter this state after successful completion.

4.20. Describe how view serializability is related to conflict serializability.

AKTU 2022-23, Marks 02

Ans. The relationship between view serializability and conflict serializability is that if a schedule of transactions is conflict serializable, then it is also view serializable. This means that if the order of transactions in a schedule can be rearranged in a way that preserves the order of read and write operations and maintains the same results, then the schedule is both conflict serializable and view serializable.

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5 UNIT

Concurrency Control Techniques (2 Marks Questions)

5.1. Define concurrency control. **AKTU 2023-24, Marks 02**

Ans. Concurrency Control (CC) is a process to ensure that data is updated correctly and appropriately when multiple transactions are concurrently executed in DBMS.

5.2. Write down the main categories of concurrency control.

Ans. **Categories of concurrency control are :**

i. Optimistic
ii. Pessimistic
iii. Semi-optimistic

5.3. What do you mean by optimistic concurrency control ?

Ans. Optimistic concurrency control states means transactions fails when they commit with conflicts. It is useful where we do not expect conflicts but if it occurs than the committing transaction is rollbacked and can be restarted.

5.4. Define locks.

OR

What is lock in transaction management ?

AKTU 2020-21, Marks 02

Ans. A lock is a variable associated with each data item that indicates whether read or write operation is applied.

5.5. Define the modes of lock.

Ans. **Data items can be locked in two modes :**

1. **Exclusive (X) mode :** If a transaction T_i has obtained an exclusive mode lock on item Q, then T_i can read as well as write Q data item.
2. **Shared (S) mode :** If a transaction T_i has obtained a shared mode lock on item Q, then T_i can only read the data item Q but T_i cannot write the data item Q.

5.6. List the various levels of locking ?

AKTU 2021-22, Marks 02

Ans. **The various levels of locking are :**

1. Database level
2. Table level
3. Page level
4. Row level

5.7. Give merits and demerits of two-phase locking.

Ans. **Merits of two phase locking :**

i. It maintains database consistency.

ii. It increases concurrency over static locking as locks are held for shorter period.

Demerits of two-phase locking :

i. Deadlock

ii. Cascade aborts / rollback

5.8. Define lock compatibility.

Ans. Lock compatibility determines whether locks can be acquired on a data item by multiple transactions at the same time.

5.9. Define upgrade and downgrade in locking protocol.

Ans. **Upgrade :** Upgrade is the lock conversion from shared to exclusive mode. It takes place only in growing phase.

Downgrade : Downgrade is the lock conversion from exclusive to shared mode. It can take place only in shrinking phase.

5.10. Define the term intention lock.

Ans. Intention lock is a type of lock mode used in multiple granularity locking in which a transaction intends to explicitly lock a lower level of the tree. To provide a higher degree of concurrency, intention mode is associated with shared mode and exclusive mode.

5.11. What are the pitfalls of lock based protocol ?

Ans. **Pitfalls of lock based protocols are :**

i. Deadlock can occur.

ii. Starvation is also possible if concurrency control manager is badly designed.

5.12. Define exclusive lock. **AKTU 2023-24, Marks 02**

Ans. Exclusive lock is a lock which provides only one user to read a data item at a particular time.

5.13. Define timestamp.

Ans. A timestamp is a unique identifier created by the DBMS to identify a transaction. This timestamp is used in timestamp based concurrency control techniques.

5.14. Define multiversion scheme.

Ans. Multiversion concurrency control is a scheme in which each write(Q) operation creates a new version of Q. When a transaction issues a read(Q) operation, the concurrency control manager selects one of the version of Q to be read that ensures serializability.

5.15. Define Thomas' write rule.

Ans. Thomas' write rule is the modification to the basic timestamp ordering, in which the rules for write operations are slightly different from those of basic timestamp ordering. It does not enforce conflict serializability.

5.16. What are concurrent transactions ?

AKTU 2020-21, Marks 02

Ans. Concurrent transaction means multiple transactions are active at the same time.

5.17. Discuss conservative 2PL and strict 2PL.

AKTU 2022-23, Marks 02

Ans. **Conservative 2PL :** This protocol requires the transaction to lock all the items it access before the transaction begins execution by predeclaring its read-set and write-set.

Strict 2PL : This protocol requires not only that locking be two phase, but also that all exclusive-mode locks taken by a transaction be held until that transaction commits.

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B. Tech.
(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2020-21
DATA BASE MANAGEMENT SYSTEM

Time : 3 Hours **Max. Marks : 100**

Note : Attempt **all** Sections. If require any missing data; then choose suitably.

SECTION-A

1. Attempt **all** questions in brief : **(2 × 10 = 20)**

a. What is data independency in DBMS ?

Ans. Refer Q. 1.8, Page SQ–2A, Unit-1, Two Marks Questions.

b. Write the difference between DDL and DML.

Ans. Refer Q. 1.13, Page SQ–3A, Unit-1, Two Marks Questions.

c. What are different integrity constraints ?

Ans. Refer Q. 2.2, Page SQ–6A, Unit-2, Two Marks Questions.

d. Explain different features of SQL.

Ans. Refer Q. 2.8, Page SQ–7A, Unit-2, Two Marks Questions.

e. What are advantages of normalization ?

Ans. Refer Q. 3.5, Page SQ–11A, Unit-3, Two Marks Questions.

f. Write different inference rule for functional dependency ?

Ans. Refer Q. 3.13, Page SQ–12A, Unit-3, Two Marks Questions.

g. What are ACID properties of transaction ?

Ans. Refer Q. 4.3, Page SQ–14A, Unit-4, Two Marks Questions.

h. What are various reasons for transaction failure ?

Ans. Refer Q. 4.12, Page SQ–15A, Unit-4, Two Marks Questions.

i. What are concurrent transactions ?

Ans. Refer Q. 5.16, Page SQ–20A, Unit-5, Two Marks Questions.

j. What is lock in transaction management ?

Ans. Refer Q. 5.4, Page SQ–18A, Unit-5, Two Marks Questions.

SECTION-B

2. Attempt any three of the following : (3 × 10 = 30)

a. **What is ER diagram ? Explain different components of an ER diagram with their notation. Also make an ER diagram for employee project management system.**

Ans: Refer Q. 1.20, Page 1–18A, Unit-1.

b. **What is relational algebra ? Explain different operations of relational algebra with example.**

Ans: Refer Q. 2.5, Page 2–6A, Unit-2.

c.

i. **What is highest normal form of the relation R(W, X, Y, Z) with the set F = {WY → XZ, X → Y}.**

ii. **Consider a relation R(A, B, C, D, E) with set F = {A → CD, C → B, B → AE}. What are the prime attributes of this relation and decompose the given relation in 3 NF.**

Ans: Refer Q. 3.16, Page 3–16A, Unit-3.

d. **Explain the method of testing the serializability. Consider the schedule S1 and S2 given below :**
S1 : R1(A), R2(B), W1(A), W2(B)
S2 : R2(B), R1(A), W2(B), W1(A)
Check whether the given schedules are conflict equivalent or not ?

Ans: Refer Q. 4.21, Page 4–17A, Unit-4.

e. **Explain the validation based protocol for concurrency control.**

Ans: Refer Q. 5.16, Page 5–17A, Unit-5.

SECTION-C

3. Attempt any one part of the following : (10 × 1 = 10)

a. **What is data abstraction ? How the data abstraction is achieved in DBMS ?**

Ans: Refer Q. 1.5, Page 1–5A, Unit-1.

b. **Explain the following with example :**
i. **Generalization**
ii. **Specialization**
iii. **Aggregation**

Ans: Refer Q. 1.26, Page 1–27A, Unit-1.

4. Attempt any one part of the following : (10 × 1 = 10)

a. What is aggregate function in SQL ? Write SQL query for different aggregate function.

Ans. Refer Q. 2.22, Page 2–25A, Unit-2.

b. Explain procedure in SQL/PL SQL.

Ans. Refer Q. 2.36, Page 2–43A, Unit-2.

5. Attempt any one of the following : **(10 × 1 = 10)**

a. What is functional dependency ? Explain the procedure of calculating the canonical cover of a given functional dependency set with suitable example.

Ans. Refer Q. 3.3, Page 3–4A, Unit-3.

b.

i. Consider the relation R(a, b, c, d) with set F = {a → c, b → d} decompose this relation in 2 NF.

ii. Explain the lossless decomposition with example.

Ans. Refer Q. 3.14, Page 3–15A, Unit-3.

6. Attempt any one of the following : **(10 × 1 = 10)**

a. What is conflict serializable schedule ? Check the given schedule S1 is conflict serializable or not ?
S1 : R1(X), R2(X), R2(Y), W2(Y), R1(Y), W1(X)

Ans. Refer Q. 4.7, Page 4–6A, Unit-4.

b. Explain deadlock handling with suitable example.

Ans. Refer Q. 4.33, Page 4–28A, Unit-4.

7. Attempt any one part of the following : **(10 × 1 = 10)**

a. Explain time stamp based concurrency control technique.

Ans. Refer Q. 5.12, Page 5–13A, Unit-5.

b. Explain recovery from concurrent transaction.

Ans. Refer Q. 5.25, Page 5–27A, Unit-5.

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B. Tech.
(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2021-22
DATA BASE MANAGEMENT SYSTEM

Time : 3 Hours **Max. Marks : 100**

Note : Attempt **all** Sections. If require any missing data; then choose suitably.

SECTION-A

1. Attempt **all** questions in brief : **(2 × 10 = 20)**

a. What is the significance of physical data independence ?

Ans. Refer Q. 1.10, Page SQ–3A, Unit-1, Two Marks Questions.

b. List the four functions of DBA.

Ans. Refer Q. 1.2, Page SQ–1A, Unit-1, Two Marks Questions.

c. When a relation set is called a recursive relationship set ?

Ans. Refer Q. 2.16, Page SQ–8A, Unit-2, Two Marks Questions.

d. What do you mean by currency with respect to database ?

Ans. Refer Q. 2.18, Page SQ–8A, Unit-2, Two Marks Questions.

e. What is Relational Calculus ?

Ans. Refer Q. 2.19, Page SQ–9A, Unit-2, Two Marks Questions.

f. What is Equi-Join in database ?

Ans. Refer Q. 2.20, Page SQ–9A, Unit-2, Two Marks Questions.

g. What is a CLAUSE in terms of SQL ?

Ans. Refer Q. 2.21, Page SQ–9A, Unit-2, Two Marks Questions.

h. Define the closure of an attribute set.

Ans. Refer Q. 3.14, Page SQ–12A, Unit-3, Two Marks Questions.

i. When is a transaction rolled back ?

Ans. Refer Q. 4.17, Page SQ–16A, Unit-4, Two Marks Questions.

j. List the various levels of locking ?

Ans. Refer Q. 5.6, Page SQ–18A, Unit-5, Two Marks Questions.

SECTION-B

2. Attempt any three of the following : (3 × 10 = 30)

a. **Draw the overall structure of DBMS and explain its various components.**

Ans. Refer Q. 1.17, Page 1–15A, Unit-1.

b. **Which relational algebra operations require the participating tables to be union-compatible ? Give the reason in detail.**

Ans. Refer Q. 2.8, Page 2–10A, Unit-2.

c. **What do you understand by transitive dependencies ? Explain with an example any two problems that can arise in the database if transitive dependencies are present in the database.**

Ans. Refer Q. 3.17, Page 3–17A, Unit-3.

d. **List ACID properties of transaction. Explain the usefulness of each. What is the importance of log ?**

Ans. Refer Q. 4.23, Page 4–20A, Unit-4.

e. **What do you mean by time stamping protocol for concurrency controlling ? Discuss multi version scheme of concurrency control.**

Ans. Refer Q. 5.22, Page 5–24A, Unit-5.

SECTION-C

3. Attempt any one part of the following : (10 × 1 = 10)

a. **What are the different types of Data Models in DBMS ? Explain them.**

Ans. Refer Q. 1.10, Page 1–9A, Unit-1.

b. **State the procedural DML and non-procedural DML with their differences.**

Ans. Refer Q. 1.14, Page 1–13A, Unit-1.

4. Attempt any one part of the following : (10 × 1 = 10)

a. **Consider the following schema for institute library :**
Student (RollNo, Name, Father_ Name, Branch)
Book (ISBN, Title, Author, Publisher)
Issue (RollNo, ISBN, Date-of-Issue)
Write the following queries in SQL and relational algebra:

I. **List roll number and name of all students of the branch 'CSE'.**

II. **Find the name of student who has issued a book published by 'ABC' publisher.**

III. **List title of all books and their authors issued to a student 'RAM'.**

IV. **List title of all books issued on or before December 1, 2020.**

V. **List all books published by publisher 'ABC'.**

Ans. Refer Q. 2.31, Page 2–39A, Unit-2.

b. **What do you mean by trigger ? Explain it by a suitable example.**

Ans. Refer Q. 2.29, Page 2–35A, Unit-2.

5. Attempt any **one** of the following : **(10 × 1 = 10)**

a. **Describe Armstrong's axioms in detail. What is the role of these rules in database development process ?**

Ans. Refer Q. 3.5, Page 3–6A, Unit-3.

b. **Describe the term MVD in the context of DBMS by giving an example. Discuss 4NF and 5NF also.**

Ans. Refer Q. 3.25, Page 3–23A, Unit-3.

6. Attempt any **one** of the following : **(10 × 1 = 10)**

a. **Describe serializable schedule. Discuss conflict serializability with suitable example.**

Ans. Refer Q. 4.8, Page 4–7A, Unit-4.

b. **Discuss the procedure of deadlock detection and recovery in transaction ?**

Ans. Refer Q. 4.30, Page 4–26A, Unit-4.

7. Attempt any **one** part of the following : **(10 × 1 = 10)**

a. **Given a schedule S for transactions T1 and T2 with set of read and write operations,**

S: R1(X) R2(X) R2(Y) W2(Y) R1(Y) W1(X).

Identify, whether given schedule is equivalent to serial schedule or not ?

Ans. Refer Q. 4.20, Page 4–17A, Unit-4.

b. **Discuss 2 phase commit (2PC) protocol and time stamp based protocol with suitable example. How the validation based protocols differ from 2PC ?**

Ans. Refer Q. 5.13, Page 5–15A, Unit-5.

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B. Tech.
(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2022-23
DATABASE MANAGEMENT SYSTEM

Time : 3 Hours Max. Marks : 100

Note : 1. Attempt all sections. If require any missing data; then choose suitably.

Section-A

1. Attempt all questions in brief. (2 × 10 = 20)

a. List any four disadvantages of file system approach over database approach.

Ans. Refer Q. 1.4, Page SQ–1A, Unit-1, Two Marks Questions.

b. Differentiate between physical and logical data independence.

Ans. Refer Q. 1.6, Page SQ–2A, Unit-1, Two Marks Questions.

c. What is the difference between DROP and DELETE command ?

Ans. Refer Q. 2.22, Page SQ–9A, Unit-2, Two Marks Questions.

d. What are different integrity constraints ?

Ans. Refer Q. 2.2, Page SQ–6A, Unit-2, Two Marks Questions.

e. List all prime and non-prime attributes in relation $R(A, B, C, D, E)$ with FD set $F = \{AB \rightarrow C, B \rightarrow E, C \rightarrow D\}$.

Ans. Refer Q. 3.15, Page SQ–12A, Unit-3, Two Marks Questions.

f. Explain MVD with the help of suitable example.

Ans. Refer Q. 3.16, Page SQ–13A, Unit-3, Two Marks Questions.

g. Discuss consistency and isolation property of a transaction.

Ans. Refer Q. 4.18, Page SQ–16A, Unit-4, Two Marks Questions.

h. Draw a state diagram and discuss the typical states that a transaction goes through during execution.

Ans. Refer Q. 4.19, Page SQ–16A, Unit-4, Two Marks Questions.

i. Discuss conservative 2PL and strict 2PL.

Ans. Refer Q. 5.17, Page SQ–20A, Unit-5, Two Marks Questions.

j. Describe how view serializability is related to conflict serializability.

Ans. Refer Q. 4.20, Page SQ–17A, Unit-4, Two Marks Questions.

Section-B

2. Attempt any **three** of the following : **(10 × 3 = 30)**

a. A database is being constructed to keep track of the teams and games of a sport league. A team has a number of players, not all of whom participate in each game. It is desired to keep track of players participating in each game for each team, the positions they play in that game and the result of the game.

i. Design an *E-R* schema diagram for this application.

ii. Map the *E-R* diagram into relational model.

Ans. Refer Q. 1.30, Page 1–34A, Unit-1.

b. What are joins ? Discuss all types of joins with the help of suitable examples.

Ans. Refer Q. 2.25, Page 2–29A, Unit-2.

c. A set of FDs for the relation *R*{A, B, C, D, E, F} is AB → C, C → A, BC → D, ACD → B, BE → C, EC → FA, CF → BD, D → E. Find a minimum cover for this set of FDs.

Ans. Refer Q. 3.9, Page 3–8A, Unit-3.

d. What is a schedule ? Define the concepts of recoverable, cascadeless and strict schedules, and compare them in terms of their recoverability.

Ans. Refer Q. 4.11, Page 4–9A, Unit-4.

e. Discuss the immediate update recovery technique in both single-user and multiuser environment. What are the advantages and disadvantages of immediate update ?

Ans. Refer Q. 4.28, Page 4–24A, Unit-4.

Section-C

3. Attempt any **one** part of the following : **(10 × 1 = 10)**

a. Describe the three-schema architecture. Why do we need mappings between schema levels ? How do different schema definition languages support this architecture ?

Ans. Refer Q. 1.24, Page 1–24A, Unit-1.

b. What are the different types of data models in DBMS ? Explain them.

Ans. Refer Q. 1.10, Page 1–9A, Unit-1.

4. Attempt any one part of the following : (10 × 1 = 10)

a. **Consider the following schema for institute library :**
Student (Roll No, Name, Father_ Name, Branch)
Book (ISBN, Title, Author, Publisher)
Issue (Roll No, ISBN, Date-of-Issue)
Write the following queries in SQL and relational algebra :

i. **List roll number and name of all students of the branch 'CSE'.**

ii. **Find the name of student who has issued a book published by 'ABC' publisher.**

iii. **List title of all books and their authors issued to a student 'RAM'.**

iv. **List title of all books issued on or before December 1, 2020.**

v. **List all books published by publisher 'ABC'**

Ans. Refer Q. 2.31, Page 2–39A, Unit-2.

b. **Explain different types of triggers in SQL / PL SQL.**

Ans. Refer Q. 2.29, Page 2–35A, Unit-2.

5. Attempt any one part of the following : (10 × 1 = 10)

a. **Given the following set of FDs on schema R (V, W, X, Y, Z) $\{Z \rightarrow V, W \rightarrow Y, XY \rightarrow Z, V \rightarrow WX\}$ State whether the following decomposition are loss-less-join decompositions or not.**

i. $R1 = (V, W, X)$, $R2 = (V, Y, Z)$

ii. $R1 = (V, W, X)$, $R2 = (X, Y, Z)$

Ans. Refer Q. 3.21, Page 3–20A, Unit-3.

b. **Consider the universal relation $R = \{A, B, C, D, E, F, G, H, I, J\}$ and the set of functional dependencies $F = \{ \{A, B\} \rightarrow \{C\}, \{A\} \rightarrow \{D, E\}, \{B\} \rightarrow \{F\}, \{F\} \rightarrow \{G, H\}, \{D\} \rightarrow \{I, J\} \}$. What is the key for R ? Decompose R into 2NF and then 3NF relations.**

Ans. Refer Q. 3.11, Page 3–12A, Unit-3.

6. Attempt any one part of the following : (10 × 1 = 10)

a. **Consider schedules S1, S2, and S3 below. Determine whether each schedule is strict, cascadeless, recoverable, or non recoverable. (Determine the strictest recoverability condition that each schedule satisfies).**
S1: r1 (X); r2 (Z); r1 (Z); r3 (X); r3 (Y); w1 (X); c1; w3 (Y); c3; r2 (Y); w2 (Z); w2 (Y); c2;
S2: r1 (X); r2 (Z); r1 (Z); r3 (X); r3 (Y); w1 (X); w3 (Y); r2 (Y); w2 (Z); w2 (Y); c1; c2; c3;
S3: r1 (X); r2 (Z); r3 (X); r1 (Z); r2 (Y); r3 (Y); w1 (X); c1; w2 (Z); w3 (Y); w2 (Y); c3; c2;

Ans. Refer Q. 4.17, Page 4–14A, Unit-4.

b. Consider the three transactions T1, T2, and T3 and the schedules S1 and S2 given below. State whether each schedule is serializable or not. If a schedule is serializable, write down the equivalent serial schedule (s).

T1: r1 (X); r1 (Z); w1 (X);

T2: r2 (Z); r2 (Y); w2 (Z); w2 (Y);

T3: r3 (X); r3 (Y); w3 (Y);

S1: r1 (X); r2 (Z); r1 (Z); r3 (X); r3 (Y); w1 (X); w3 (Y); r2 (Y); w2 (Z); w2 (Y);

S2: r1 (X); r2 (Z); r3 (X); r1 (Z); r2 (Y); r3 (Y); w1 (X); w2 (Z); w3 (Y); w2 (Y);

Ans. Refer Q. 4.18, Page 4–15A, Unit-4.

7. Attempt any **one** part of the following : **(10 × 1 = 10)**

a. Discuss the timestamp ordering protocol for concurrency control. How does strict timestamp ordering differ from basic timestamp ordering ?

Ans. Refer Q. 5.15, Page 5–16A, Unit-5.

b. How do optimistic concurrency control techniques differ from other concurrency control techniques ? Why they are also called validation or certification techniques ? Discuss the typical phases of an optimistic concurrency control method.

Ans. Refer Q. 5.11, Page 5–11A, Unit-5.

B. Tech.
(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2023-24
DATA BASE MANAGEMENT SYSTEM

Time : 3 Hours **Max. Marks : 100**

Note : 1. Attempt all sections. If require any missing data; then choose suitably.

SECTION-A

1. Attempt all questions in brief. **(2 × 10 = 20)**

a. What is the concept of keys in database ?

Ans. Refer Q. 1.15, Page SQ–4A, Unit-1, Two Marks Questions.

b. What is strong and weak entity set ?

Ans. Refer Q. 1.20, Page SQ–5A, Unit-1, Two Marks Questions.

c. Explain referential integrity.

Ans. Refer Q. 2.3, Page SQ–6A, Unit-2, Two Marks Questions.

d. Explain entity integrity constraints.

Ans. Refer Q. 2.4, Page SQ–6A, Unit-2, Two Marks Questions.

e. Write different inference rule for functional dependency ?

Ans. Refer Q. 3.13, Page SQ–12A, Unit-3, Two Marks Questions.

f. Why do we normalize database ?

Ans. Refer Q. 3.11, Page SQ–12A, Unit-3, Two Marks Questions.

g. What do you mean by testing of serializability ?

Ans. Refer Q. 4.5, Page SQ–14A, Unit-4, Two Marks Questions.

h. Define replication in distributed database.

Ans. Refer Q. 4.8, Page SQ–15A, Unit-4, Two Marks Questions.

i. Define concurrency control.

Ans. Refer Q. 5.1, Page SQ–18A, Unit-5, Two Marks Questions.

j. Define exclusive lock.

Ans. Refer Q. 5.12, Page SQ–19A, Unit-5, Two Marks Questions.

SECTION-B

2. Attempt any **three** of the following : **(10 × 3 = 30)**

a. **Discuss three level of abstractions or schemas architecture of DBMS.**

Ans. Refer Q. 1.5, Page 1–5A, Unit-1.

b. **What is aggregate function in SQL ? Write SQL query for aggregate function.**

Ans. Refer Q. 2.22, Page 2–25A, Unit-2.

c. **Describe the following terms :**

i. **Multivalued dependency.**

ii. **Trigger.**

Ans. Refer Q. 3.24, Page 3–23A, Unit-3.

d. **Discuss the procedure of deadlock detection and recovery in transaction ?**

Ans. Refer Q. 4.30, Page 4–26A, Unit-4.

e. **Write the salient features of graph based locking protocol with suitable example.**

Ans. Refer Q. 5.8, Page 5–8A, Unit-5.

SECTION-C

3. Attempt any **one** part of the following : **(10 × 1 = 10)**

a. **State the procedural DML and nonprocedural DML with their differences.**

Ans. Refer Q. 1.14, Page 1–13A, Unit-1.

b. **Discuss the role of database administrator and explain the database architecture.**

Ans. Refer Q. 1.9, Page 1–8A, Unit-1.

4. Attempt any **one** part of the following : **(10 × 1 = 10)**

a. **What is ER diagram ? Explain different components of an ER diagram with employee project management system.**

Ans. Refer Q. 1.20, Page 1–18A, Unit-1.

b. **Write difference between cross join, natural join, left outer join and right outer join with suitable example.**

Ans. Refer Q. 2.26, Page 2–31A, Unit-2.

5. Attempt any **one** part of the following : **(10 × 1 = 10)**

a. What is functional dependency ? Explain the procedure of calculating the canonical cover of a given functional dependency set with suitable example.

Ans. Refer Q. 3.3, Page 3–4A, Unit-3.

b. Describe the term MVD in the context of DBMS by giving an example. Discuss 4NF and 5NF also.

Ans. Refer Q. 3.25, Page 3–23A, Unit-3.

6. Attempt any **one** part of the following : **(10 × 1 = 10)**

a. What is conflict serializable schedule ? Explain the difference between conflict and view serializable schedule using suitable example ?

Ans. Refer Q. 4.8, Page 4–7A, Unit-4.

b. What is log ? How is it maintained ? Discuss the features of deferred database modification and immediate database modification in brief.

Ans. Refer Q. 4.22, Page 4–19A, Unit-4.

7. Attempt any **one** part of the following : **(10 × 1 = 10)**

a. Discuss 2 phase commit (2PC) protocol and time stamp-based protocol with suitable example. How the validation-based protocols differ from 2PC ?

Ans. Refer Q. 5.13, Page 5–15A, Unit-5.

b. What are multi version schemes of concurrency control ? Describe with the help of an example. Discuss the various time stamping protocols for concurrency control also.

Ans. Refer Q. 5.24, Page 5–26A, Unit-5.

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