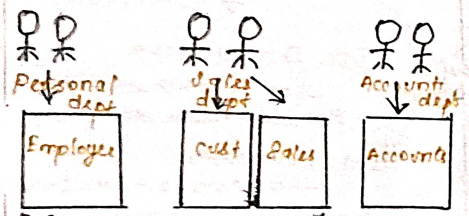
DBMS – INTRODUCTION

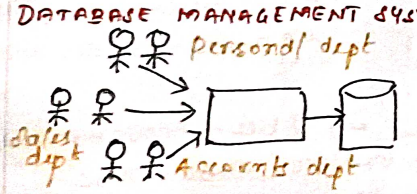
FILE MANAGEMENT SYSTEMS



DISADVANTAGES

→ Data redundancy and inconsistency (→ duplicate copies)
→ Difficulty in accessing data
→ Data Isolation
→ Integrity problems
→ Atomicity of updates
→ Concurrent access of data
→ security problems

DATABASE MANAGEMENT SYSTEMS



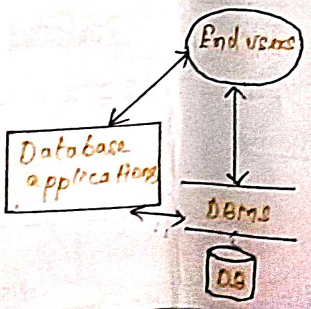
Data → raw fact
Information → processed data
Database → Collection of interrelated data

DBMS - Software to define, create and manipulate db
(e.g) mysql
Oracle
Sql Server
IBM DB2

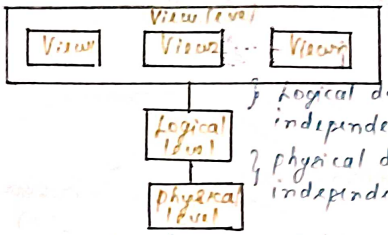
ADVANTAGES
→ Easy retrieval
→ Minimum redundancy
→ Data integrity
→ Data security
→ Reduced development time
→ Concurrent access
→ Data consistency

DISADVANTAGES
→ Larger in size
→ except mysql, costly

COMPONENTS OF DBMS



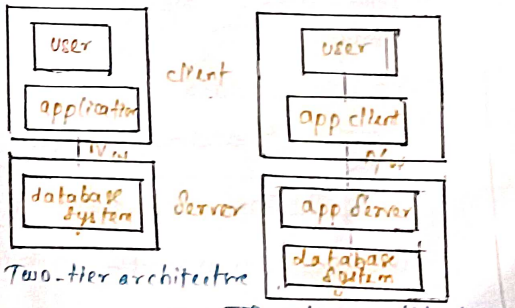
DATA ABSTRACTION (VIEWS OF DATA)



physical level – how the data stored complex low-level data structures
Logical level - what data stored, relationship
view level – part of the database

SCHEMA – Overall design
INSTANCE – Instance data

DATABASE APPLICATIONS



Two-tier architecture
Three tier architecture

HISTORY OF DATABASE SYSTEMS

1960 – Charles
1970 – IBM's IMS
1976 – ER MODEL
1980 – RELATIONAL MODEL
1985 – OBJECT DBMS
1991 – MS-ACCESS
1995 – INTERNET DB
1997 – XML

CONCEPT MAP 2 - DATABASE SYSTEM STRUCTURE AND SOFTWARE ARCHITECTURE OF A TYPICAL (2) DBMS

DATABASE SYSTEM STRUCTURE

- modules
- functional components
  - Storage manager (SM)
  - Query Processor (QP)
- SM - large - Storage space
- Sample
  - i) gigabytes
  - ii) tetrabytes
  - iii) megabytes
- Stored - disks
- Data - disk Storage - main memory
- QP - Access data
- Updates - Queries - operations

STORAGE MANAGER

- interfaces - low level - application - program
- file manager - DML -
  - STORING
  - RETRIEVING
  - UPDATING

SM COMPONENTS

- Authorization & Integrity manager
- Transaction Manager
- File manager
- Buffer Manager

PHYSICAL SYSTEM IMPLEMENTATION

- → Data file - Stores
- → Data dictionary - meta data - Structure - Schema - database
- → Indicies - fast access - values

(Architecture - components of data is nothing data about the data - meta data)

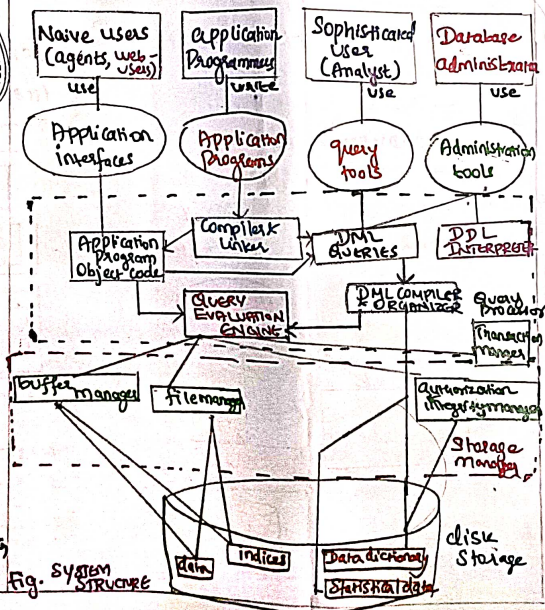


Fig. SYSTEM STRUCTURE

QUERY PROCESSOR

→ COMPONENTS

DDL INTERPRETER
- interprets - ddl statements - records - data dictionary

DML COMPILER
- translates - DML statements - query language - evaluation plan - 2 level instructions ↔ low-level query evaluation

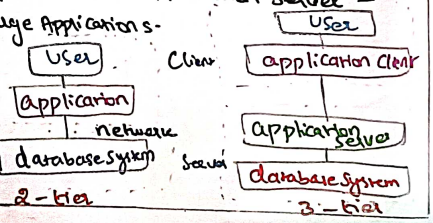
QUERY OPTIMIZATION
- low cost - evaluation plan

QUERY EVALUATION ENGINE
- executes - low level - instructions - DML Compiler.

APPLICATION ARCHITECTURE
- Networks - Client - Server
- 2 parts ⇒ two-tier architecture
  ⇒ three-tier architecture

⇒ 2 tier - Application Program interface - ODBC - JDBC

⇒ 3 tier - Application Server - large Applications -



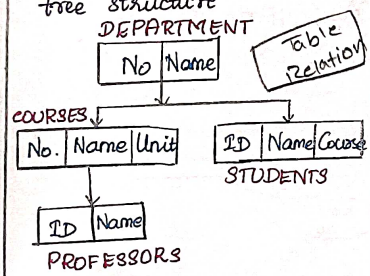
DATA MODELS

* collection of concepts that can be used to describe structure of a database.

TYPES:

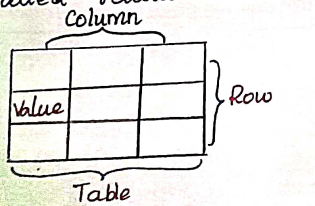
① HIERARCHICAL MODEL

* data - hierarchical tree structure



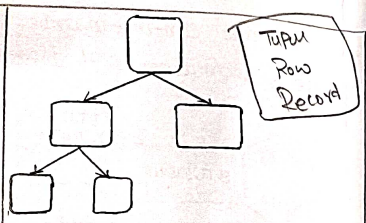
② RELATIONAL MODEL

* data - organized in 2-dimensional tables - called relations.



③ NETWORK MODEL

* allows a record to have more than one parent



④ OBJECT MODEL

* stores the data - form of objects, classes, inheritance.
* used in File Management System.

⑤ ER Model - EER

NTT, column Name, Attribute

* objects
* relationships.

DATA MODEL - SCHEMA & INSTANCE.

INSTANCE: data stored in db at particular time.

SCHEMA: Overall design of a database.

* logical view.
* contains - table, foreign key, primary key, views, columns, data types.

STUDENT:

Name	Student-Number	class	Major

COURSE

Name	Number	Credit-hours	Dept.

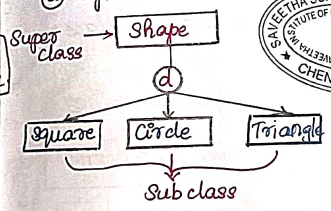
ENHANCED ENTITY RELATIONSHIP MODEL (EER)

* incorporates extensions to ER model.
* represents following concepts

① Subclass & Superclass

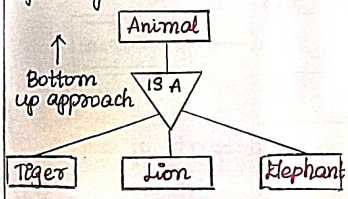
- concept of inheritance.

ⓓ symbol.



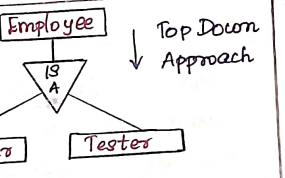
② Generalization

- bottom approach
- process of generalizing entities - contains properties of all generalized entities.



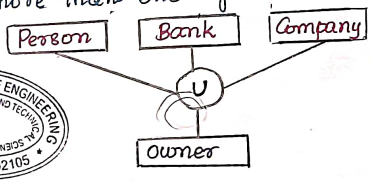
Specialization

- top down approach



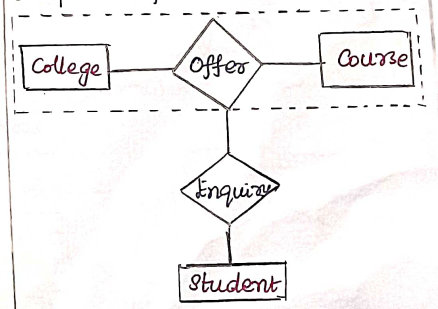
③ Category or Union

* represents single super class/ sub class relationship with more than one super class.



④ Aggregation

* represent a relationship between a whole object & its component parts.



- Relation between College & Course - Entity in relation with Student

ER Model

* Entity-Relationship model
* used to define data elements & relationship for a specified system.
* Develops conceptual design for the database.

eg: school database

Entity: student

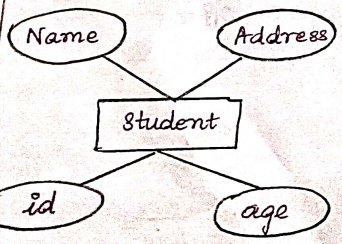
attributes

address, name, id, age.

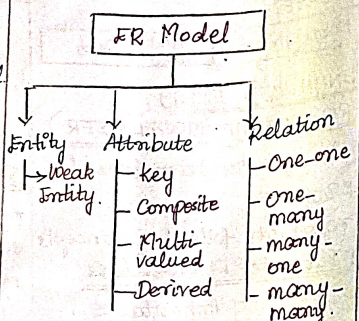
Entity: address

attributes

city, street name, pincode



Components of ER diagram

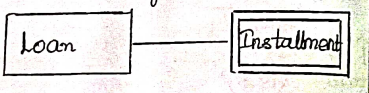


1. ENTITY:

* Object, class, person / place.
* rectangle shape.
* employee, department: eg

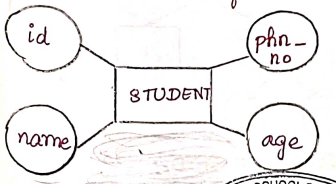
a) WEAK ENTITY

* Entity that depends on another entity.
* doesn't contain any key attribute of its own.



2. ATTRIBUTE

* describes property of an entity.
* eclipse shape.
* eg: id, age, contact number, name → attributes of student

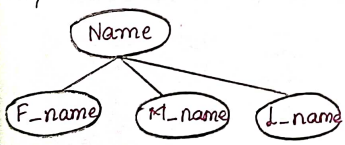


a) KEY ATTRIBUTE

* represents main characteristics of an entity.
* primary key.
* ellipse with text underlined
* eg: id.

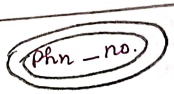
b) COMPOSITE ATTRIBUTE:

* composed of many other attributes.
* ellipse.



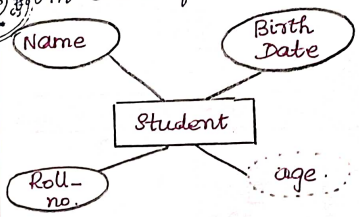
c) MULTIVALUED ATTRIBUTE:

* attribute has more than one value.
* double oval.
* eg: student - more phone number.



d) DERIVED ATTRIBUTE:

* Attribute derived from other attribute.
* dashed ellipse.
* eg: Person's age is derived from Date of birth.



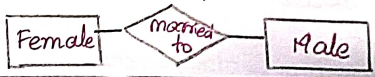
3. RELATIONSHIP

* describes relation between entities

TYPES

* ONE - TO - ONE

→ One instance of an entity is associated with the relationship.



UNIT – 2 RELATIONAL MODEL

1. INTRODUCTION

* Relational model can represent as a table with columns and rows.
* Each row – tuple.
* Each table – name / attribute.

TERMINOLOGIES.

* DOMAIN: set of atomic values that an attribute can take.
* ATTRIBUTE: contains name of column in a particular table.
* RELATIONAL INSTANCE: * represented by a finite set of tuples.
* Relational schema: Name of relation + name of all columns / attributes.
* Relational key: identify the row in the relation uniquely.

Eg: STUDENT Relation

NAME	ROLL_NO	PH_NO	ADDRESS	AGE
Ram	1423	1321689	Noida	24
Mohan	1679	6471321	Delhi	36
Reeta	5234	1783261	Chennai	48

Attributes: NAME, ROLL_NO, PH_NO, ADDRESS, AGE

Instance of schema STUDENT ⇓ 5 tuples.

RELATIONAL ALGEBRA

* procedural query language.
* operators are used to perform queries.

OPERATORS:

① Selection (σ)

* used to select the required tuple / row from the table.

$\sigma_{condition}$ (Relation / Table Name)

② Project Operator (π)

* used to retrieve data from a column of a table.

$\pi_{col.name1 \ldots col.nameN}$ (table_name)

③ Union Operation (∪)

* used to select all rows (tuples) from two tables (relations)

table_1 ∪ table_2

④ Intersection Operator (∩)

* used to select common rows (tuples) from two tables (relations)

table_1 ∩ table_2

⑤ Set Difference Operator (−)

* Suppose 2 tuples R & S.
* ∩ contains all tuples that are in R but not in S.

R − S
table_1 − table_2.

⑥ Cartesian product (X)

* used to combine each row in one table with each row in other table
* cross product

R1 × R2

⑦ Rename (ρ)

* used to rename a relation or an attribute of a relation.

ρ(new_relation, old_relation)

JOIN OPERATION (⋈)

cartesian product followed by a selection criterion.

JOIN OPERATION

- Natural Join
- Outer Join
  - Left outer
  - Right outer
  - Full outer
- Equi Join

Natural join: performed if there is a common attribute between the relations.

Left Outer Join (⟕)

* allows keeping all tuple in left relation.

Right Outer Join (A ⟖ B)

* operations allows keeping all tuple in right relation.

Full outer join (⟗)

all tuples from both relations are included in the result, irrespective of the matching condition.

Equi Join (=)

* inner join
* based on matched data as per equality condition

RELATIONAL CALCULUS

* non-procedural query language.

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Types

1. Tuple Relational Calculus.

* used for selecting those tuples that satisfy the given condition.

Syntax: {T | Condition}
Eg: T.name | Student(T) AND T.age > 17

* fetch names of students.

2. Domain Relational Calculus

* records are filtered based on the domains of attributes & not based on tuple values.

Syntax: {c1, c2, ... cn | F(c1, ..., cn)}
c1, c2 : domain of attributes F : formula.
eg: {<name, age> | ∈ Student ∧ age > 17}

SQL

* Structured Query Language
* storing & managing data in RDBMS.

DATA TYPES

* CHAR(n); VARCHAR(n); FLOAT

TYPES :

① DATA DEFINITION LANGUAGE (DDL) :

(i) CREATE
create new table in database
create table table_name (col_name datatypes[,...]);

(ii) DROP : delete record
DROP TABLE table_name

(iii) ALTER : alter db structure
ALTER TABLE table_name ADD col_name COL_definition;

(iv) TRUNCATE : delete all rows
TRUNCATE TABLE table_name.

② DATA MANIPULATION LANGUAGE

* used to modify database

(i) INSERT:
INSERT INTO TABLE_NAME VALUES (val1, val2, ... val.N);

(ii) UPDATE:
UPDATE table_name SET [col_name 1 = val.1, ... col_name = val N] [WHERE CONDITION]

(iii) DELETE:
DELETE FROM table_name [WHERE condition];

③ DATA CONTROL LANGUAGE (DCL)

(i) GRANT : give user access privileges to a database

(ii) REVOKE : used to take back permissions from the user.

④ TRANSACTION CONTROL LANGUAGE (TCL)

(i) COMMIT : used to save all transactions to database

(ii) ROLLBACK : undo transactions that have not already been saved

(iii) SAVEPOINT : roll back transaction back to a certain point

⑤ DATA QUERY LANGUAGE (DQL)

fetch data from database

(i) SELECT
select attribute based on condition by WHERE clause.

SQL OPERATORS

- ARITHMETIC → +, -, *, /, %
- COMPARISON → =, !=, <>, >, <, >=, <=, !<, !>
- LOGICAL → ALL, AND, NOT, OR, ANY, BETWEEN

SQL UPDATE : modify data is already in the database.

UPDATE table_name
SET col 1 = value 1, col 2 = value 2
WHERE condition;

VIEWS IN SQL

* Virtual table.
* contains rows & columns
(i) CREATE VIEW
(ii) DELETE VIEW ⇒ DROP VIEW

SUB-QUERY

* inner query / nested query is a query within another SQL query & embedded within WHERE
* used with SELECT, INSERT, UPDATE, DELETE & operators (=, >, <)

CONSTRAINTS

* used to specify rules for data in a table.

(1) NOT NULL : value cannot be em
(2) UNIQUE : duplicate values not allowed.
(3) PRIMARY KEY : Not null + Uniqu
(4) FOREIGN KEY : referential inte
(5) CHECK : condition checked.
(6) DEFAULT : default value inse
(7) CREATE INDEX : create index

INTEGRITY AND SECURITY

* correctness, consistency.

(i) Entity integrity, (ii) Referen integrity, (iii) Domain integri

* protection from malicious attempts to steal / modify dat

NORMAL FORMS IN DBMS

Normalization

* process of minimizing redundancy from a relation or set of relations. A process that makes sure something more normal or regular
* Redundancy cause
  - ↳ insertion
  - → deletion
  - → update anomalies
* Normal forms
  - eliminate / reduce redundancy in database tables.

1. FIRST NORMAL FORM

* A relation is in first normal form if every attribute in that relation is singled valued attribute.
* If a relation contains multi-valued attribute, it violates first normal form.

Teacher table

TeacherID	Subject	TeacherAge

Table 1: Relation STUDENT
Multi-valued attributed STUD_PHONE

STUD_NO	STUD_NAME	STUD_PHONE	STUD_COUNTRY
823	RAM	9716210 23	INDIA
		9843050634	INDIA
824	SURESH	9888456211	INDIA

⇓ Conversion to first NORMAL FORM

STUD_NO	STUD_NAME	STUD_PHONE	STUD_COUNTRY
823	RAM	9716210 23	INDIA
823	RAM	9843050634	INDIA
824	SURESH	9888456211	INDIA.

2. SECOND NORMAL FORM

* A relation must be in 1NF.
* Relation must not contain any partial dependency.
* no partial dependency

eg: Table: 2 (Prime attribute - key attribute; non-prime attribute - non-key attribute)

STUD_NO	COURSE_NO	COURSE_FEE
1	C1	1000
2	C2	1500
1	C4	2000
1	C3	1000
4	C1	1000
2	C5	2000

cid	country	dept	dept type	fee

cid is candidate key; dept, dept type are non-key attributes; some key attribute become a primary key to become candidate key

Many course with same course fees.
Split Table as,
Table 1: STUD_NO, COURSE_NO
Table 2: COURSE_NO, COURSE_NO

TABLE 1		TABLE 2	
STUD NO	COURSE_NO	COURSE_NO	COURSE FEE
1	C1	C1	1000
2	C2	C2	1500
1	C4	C3	1000
4	C3	C4	2000
4	C1	C5	2000

3. THIRD NORMAL FORM

A relation is in 3NF, if there is no transitive dependency for non-prime attributes. (Indirect dependency)

* A relation must be in 2NF
* functional dependency. $X \to Y$
  - X is a super key.
  - Y is a prime attribute.

Eg: Table 3.

STUD_NO	STUD_NAME	STUD_STATE	STUD_COUNTRY	STUD_AGE
1	RAM	HARYANA	INDIA	20
2	RAM	PUNJAB	INDIA	19
3	SURESH	PUNJAB	INDIA	21

Transitive Dependency - If $A \to B$ & $B \to C$ are two FDs, $A \to C$ is TD.

Eg: 1 Relation STUDENT
FD set : {STUD_NO → STUD_NAME, STUD_NO → STUD_STATE, STUD_STATE → STUD_COUNTRY, STUD_NO → STUD_AGE}
candidate key : {STUD_NO}
⇓ decomposed as

STUDENT (STUD_NO, STUD_NAME, STUD_PHONE, STUD_STATE, STUD_AGE)
STATE COUNTRY (STATE, COUNTRY)

4. BOYCE - CODD NORMAL FORM

* A relation in R is in BCNF
  - → if R is in 3NF.
  - → for every FD, LHS is a super key. (↳ Functional dependency)
  - → iff in every non-trivial functional dependency $X \to Y$, X is a super key.

Eg: Find highest normal form of a relation R(A, B, C, D, E) with FD set as {BC→D, AC→BE, B→E}.

* AC : candidate key.
* prime attributes {A, C}
  non-prime : {B, D, E}
* 1NF : No multi-valued attribute
* 2NF : BC→D, AC→BE, B→E
* Highest normal form → SECOND NORMAL FORM

N. Deepa, AR & VR

TOPIC: FUNCTIONAL DEPENDENCES, JOIN DEPENDENCIES - DEFINITION OF 5NF

FUNCTIONAL DEPENDENCIES

DEFINITION:

→ Constraint between 2 Set of attributes from database.

Relational database schema
- n attributes
- $A_1, A_2 \cdots A_n$

Universal Schema
$R = \{A_1, A_2, A_3 \cdots A_n\}$

denoted by
$X \rightarrow Y$, between 2 sets of attributes.

$X \& Y$ – Subset of R

on tuples from State rel^n r

Constraint:

Tuples t_1 & t_2 in r.

$t_1[X] = t_2[X]$ also

$t_1[Y] = t_2[Y]$

⇒ Functional dependency (FD or f.d.)

↳ Properties → Semantics
→ Relation States r(R)

Relation extension that satisfy fd constraints are called legal relation States (or) legal extension of R.

Attributes

{State, Driver_license-number} → SSn

SSn – hold fraudulent in US

Used whenever Particular attribute required.

Some attribute Changes

Ex: FD Zip Code → Area_Code

Used to exist as a relationship between Postal Code & telephone number in US.

→ Telephone Code may Change.

Eg: SSn → Ename

Pnumber → {Pname, Plocation}

{SSn, Pnumber} → Hours

Above are functional dependencies

TEACH

Teacher	Course	Text
Smith	Data Structure	Bartram
Smith	Data management	Martin
Hall	Compilers	Hoffman
Brown	Data Structures	Horowitz

Relation State of Teach

With a possible functional dependency:

TEXT → COURSE

TEACHER → COURSE is ruled out.

A Single Counter Example for functional dependency is shown in table.

JOIN DEPENDENCIES

The binary decompositions which follows BCNF will follow 4CNF as well.

↳ 2 Relation schema after R which voilates BCNF and no nontrivial R there comes a join dependency.

↳ This also follows the multiway decomposition into fifth Normal form (5NF).

A Join dependency (JD)

JD (R 1, R2, ··· Rn)

Specified on

Relation schema R.

Specifies on

States r of R.

Should have nonadditive join decomposition into

$R_1, R_2, \cdots R_n$

Hence r have

$* (\pi_{R_1}(r), \pi_{R_2}(r), \cdots \pi_{R_n}(r)) = r$

Multivalued dependency (MVD)

JD where n = 2

JD(R_1, R_2)

(implies)

MVD($R_1 \cap R_2$) →→ ($R_1 - R_2$)

(or)

Symmetry, ($R_1 \cap R_2$) →→ ($R_2 - R_1$))

5NF – A Definition.

Also called Project-join normal form (PJNF)

Set F of functional, multivalued and join dependency if for every nontrivial join dependency

JD($R_1, R_2 \cdots R_n$) in F^+

R_i is a super key of R.

Supply all-key relation where

Supply is an example of supermarket that can hold Parts to use relations.

TOPIC TITLE: Record Storage and Primary File Organization, Secondary Storage devices.

Record storage
* Data collection
* Computerized database
* Stored physically.

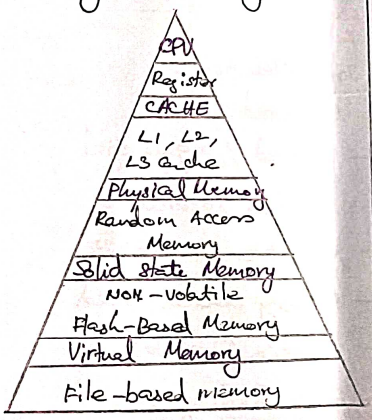
Two Categories

(i) Primary storage
- Directly operated
- Main Memory
- Fast access
- Limited storage.

(ii) Secondary storage
- Magnetic disks,
- optical disks
- Tapes
- Large capacity
- Low cost
- Slow access
- No direct access

(iii) Tertiary storage
- Removable media
- CD-ROM's, DVD's
- Larger capacity
- Cost Less
- Slower access

Memory Hierarchy



Storage organization

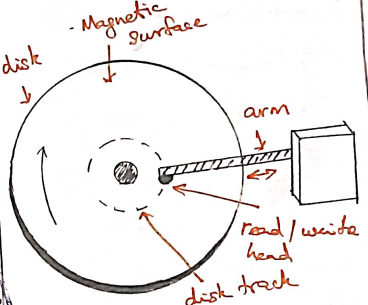
(a) Persistent Data
- Store large data
- Persist long time

(b) Transient Data
- Persist short time
- For execute programs.

Secondary storage

(i) Hard Disk Drive (HDD)
- Magnetic disks
- Store large data
- Format 0's & 1's
- bytes/characters.
- Single-sided - one side data
- Double-sided - both side data
- Assembled - Disk pack.
- Circle as tracks
- same tracks - cylinder
- Blocks / sectors - tracks divided

(ii) Access efficiency
- Data buffering
- Organize data
- IO scheduling



- Log disks
- Ahead read
- Use SSD/Flash

(iii) Solid State Devices
- Flash Memory based
- intermediate
- Non volatile

(iv) Magnetic Tapes
- Sequential access
- mounted
- scanned
- Backup/archive

TOPIC TITLE : Operations on Files, Heap file, Sorted Files

Operations on Files

1. Retrieval operation
   - Data no change
2. Update operation
   - Data change
   - insert, delete

Accessing Commands

- Open
- Reset
- Find
- Read
- FindNext
- Delete
- Modify
- Insert
- close

Program variables

- scan
- FindAll

record-at-a-time

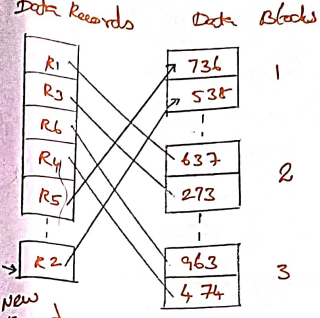
- FindOrdered
- Reorganize

set-at-a-time

File Organization	File Access
- Physical placements - Files into records - Pages on secondary	- data retrieved - steps to read - Sequential access - Back to end - Direct access

Heap file - method of storing the data, where it can be store mostly in Last or End

(i) Unordered
- unordered / Heap / pile
- insert at end
- order of insertion
- Efficient insertion
- Linear searching - Search
- reading as sorted
- Deletion Techniques
  - Rewrite
  - use deletion



Sort files

(ii) Ordered
- Ordered / Sequential
- Sorted records
- insertion expensive
- Binary search used
- Efficient sorted
- Easy finding next

Access Time

Type	Access	Avg Access
Heap	Sequential	b/2
ordered	sequential	b/2
ordered	Binary	$\log_2 b$

(iii) Quick sort
- Identify pivot
- less pivot - move left
- greater pivot - move right
- n log (n)
- less stable

(iv) Merge sort
- Larger tables
- better than quick
- upto 4 records

Binary Search Algo.

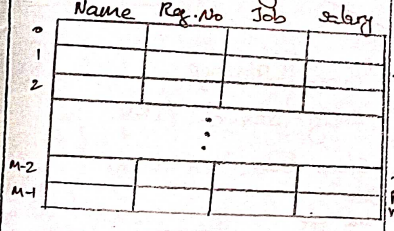
```
l ← 1; u ← b;
while (u ≥ l) do
  begin i ← (l+u) div 2;
  read block
if k < (ordering)
  then u ← i - 1
else if k > ordering
  then l ← i + 1
else if k = value
  then goto found
end;
goto not found;
```

TOPIC : Hashing Techniques

Hashing

- Fast access
- search conditions
- Single equality condition
- hash field value h
- yields address

(i) Internal hashing



- Hash table used
- Array of records
- Index : 0, 1, 2, ... M-1.
- transforms hash field
- integer b/w 0 to M-1.

$h(K) = K \bmod M$

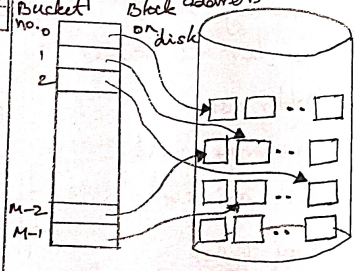
↳ hash key field

Problem

- hash field >> address
- doesn't guarantee
- collision occurs
  - open addressing
  - Chaining
  - Multiple hashing

(ii) External hashing

- made of buckets
- each has multiple records
- either single / cluster
- maps bucket numbers



- collision less
- Static hashing
  - fixed buckets

Hashing with Dynamic file

(a) Extendible hashing

- performance doesn't degrade
- used in dynamic files
- file grows (dynamic)
- stored access structure
- Binary representation
- Directory
  - 2^d bucket address
  - d - depth
  - d = 1

(b) Linear hashing

- expands
- shrinks
- no directory
- File M : 0, 1, 2, ... M-1.

$h_i(K) = K \bmod M$

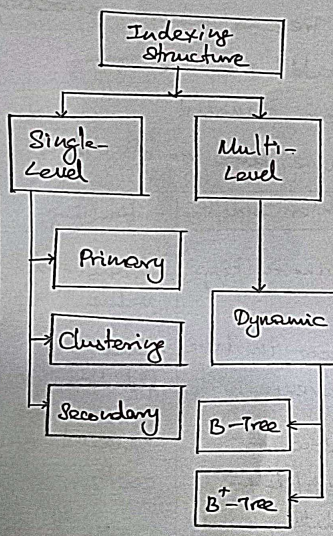
- collision leads overflow
- Split bucket.
  start - 0 ; end - M.

(c) Dynamic hashing

- Tree - structure directory
- add / remove
- on demand
- use large no. of values

Order Indexing	Hashing
- Primary key	- hash fun. value
- poor in data increases	- best in addition
- slow for insert/delete/update	- maintenance costlier
- used for limited range	- retrieve search key
- many unused blocks	- memory managed
- unused can't reused	- overflow handled.
- maintenance required	

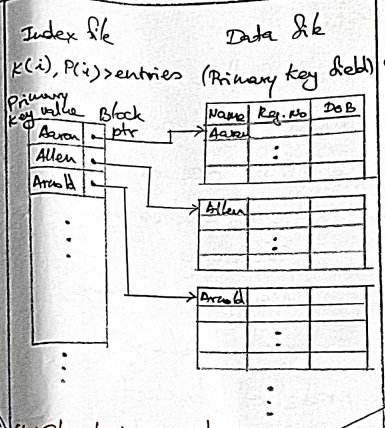
Topic : Index Structure for files, Different types of Indexes



- Speed up retrieval
- use search conditions
- secondary access path
- any field - Index
- multiple indexes used
- Index ordered files
- Tree data structure used.

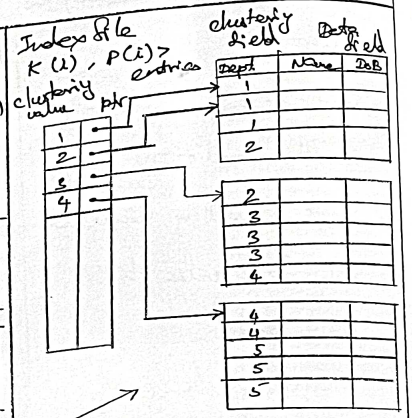
(i) Single-Level Ordered Indexes
- textbook index
- use fields (attributes)
- stores with pointers
- blocks contains records
- pointer maps blocks
- ordered values

(a) Primary Index
- ordered records
- Two fields
  - Primary key K(i)
  - Pointer P(i)
- Single index entry
- dense / sparse
- pointer maps each block.

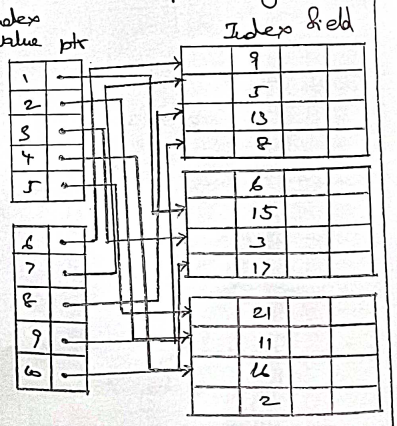


(b) Clustering Index
- Clustering field
  - physically ordered
  - non-key field
  - no distinct values
- Two fields used
  - clustering field
  - disk pointer

(c) Secondary Index
- secondary access
- primary access exists
- 2 fields to order



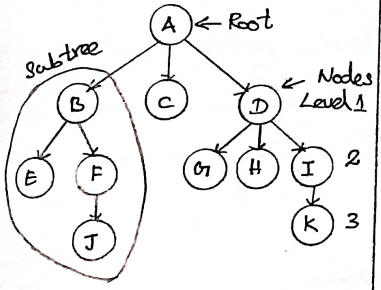
- more storage
- Long search time
- Slow than primary



TOPIC : B-Tree, B+-Tree, Index, Sequences

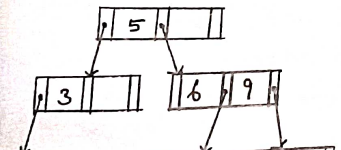
Dynamic Multi-Level Indexes

- Tree data structure
  - formed of nodes
  - has parent & child
  - Leaf has no child
    ⇓
    Internal Node
  - has descendent nodes



Search Trees

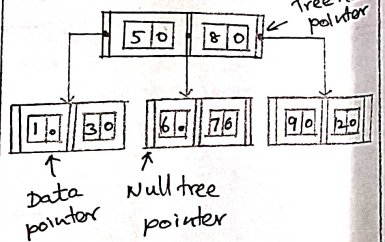
- guide record search
- for inserting & deletion



Search order p=3

B-Trees

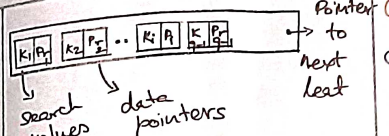
- provides multi-level access
- balanced tree
- less wastage space
- each node half-full.
- p-1 search values.



B+-Trees

- data pointer at leaf nodes
- have entry
- point to record → key field
- point to data → Non-key field

- Internal nodes
  - guide search
- search values } q-1
- data pointers }



Database objects

Object	Description
Table	Rows & Columns.
View	Logical representation
Sequence	generate primary key
Index	Improve performance
Synonym	object

Sequence

- Automatic sequence unique no.
- Sharable objects
- Create primary key
- replace application code
- Speed up efficiency.

Create Sequence

```
CREATE SEQUENCE dept_deptno
    INCREMENT by 1
    START with 91
    MAXVALUE 100
    NOCACHE
    NOCYCLE;
```

Index

- is a schema object
- Speed up retrieval
- reduce disk I/O
- independent from table
- Maintained by oracle.

Create Index

```
CREATE INDEX emp_ename_idx
    emp(ename);
```

- automatically defined by primary key
- unique index create.

QUERY PROCESSING

→ Steps in query processing
→ measures of Query cost
→ Selection operation
→ Sorting
→ Join operation
→ Other operations
→ Evaluation of expressions

Steps in query processing

query → Parser & translator → Relational algebra expression → optimizer → Execution plan → Query evaluation engine → o/p

Statistics about data → optimizer

engine ↔ data

measures of query cost

Factors: disk access, CPU, network communication

cpu cost → response time
disk cost → number of seeks
number of blocks reads
number of blocks written
average-seek-cost,
average-block-read-cost
average-block-write-cost

Cost for block transfer
$= b * t_T + S * t_S$

selection operation

→ index scan
→ linear search
→ clustering index, equality on key
→ clustering index, equality on non-key
→ Secondary index
→ clustering index
→ Conjunctive selection
→ disjunctive selection
→ negation

Sorting

→ external sort-merge

Join operation

→ Nested-loop join
→ Block nested loop join
→ indexed nested_loop join
→ Merge-join
→ Hash-join

Other operations

→ Duplication elimination
→ Projection
→ Aggregation
→ Set operations
→ Outer join

Evaluation of expressions

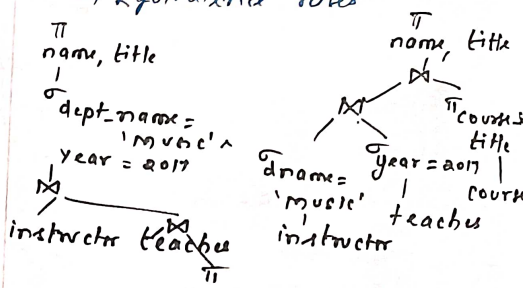
→ materialization
→ Pipelining

QUERY OPTIMIZATION

→ Transformation of relational expression
→ cost-based optimization

Transformation of relational expression

→ Equivalence rules

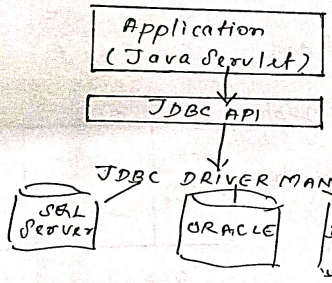


cost-based optimization

→ Need statistics of relations
→ Need statistics of expression results

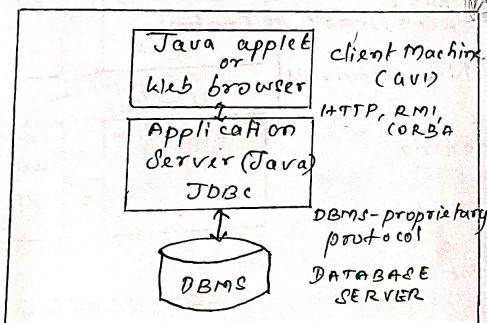
IMPLEMENTATION OF DATABASE CONNECTIVITY

INTRODUCTION TO JDBC (JAVA DATABASE CONNECTIVITY)



JDBC DRIVERS

JDBC ARCHITECTURE



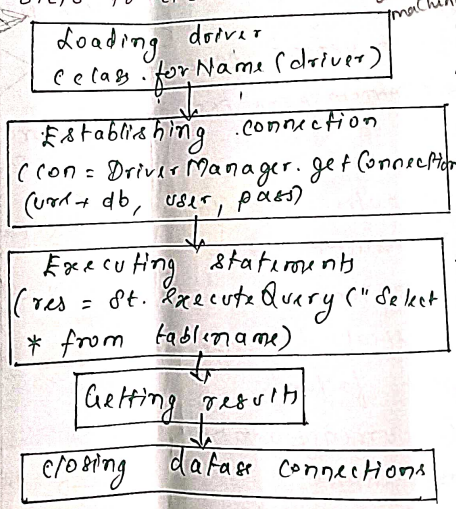
ACTIVITIES
- → Connect database
- → Send queries
- → Retrieve results

JAVA API
- → java.sql
- → javax.sql

TYPES OF JDBC DRIVER
- → Type 1 - JDBC ODBC bridge
- → Type 2 - Native API connection driver
- → Type 3 - Network connection driver
- → Type 4 - Database protocol

driver CD → system software → A machine interact with another machine

STEPS TO CREATE JDBC APP



TYPES OF STATEMENT OBJECT

→ Statement : access database

```
Statement stmt = null;
try {  →object
stmt = conn.createStatement();
}
catch() e { }
```

→ Prepared statement : use SQL statements many times

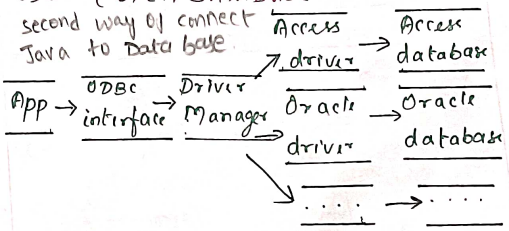
```
String SQL = "Queries"
Prepared statement pstmt = null
pstmt = conn.prepareStatement(SQL)
```

→ Callable statement : access database stored procedures

```
CallableStatement cstmt = null
string SQL = "{queries}"
cstmt = conn.prepareCall(SQL)
```

ODBC (OPEN DATABASE CONNECTIVITY)

second way of connect Java to Data base



- → App - GUI
- → ODBC - database connectivity
- → Driver Manager - Part of ODBC

TRANSACTION DEFINITION

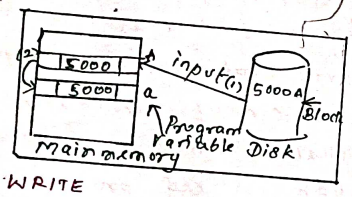
Saving A/c Rs 5000 to 1000

checking A/c Rs 1000 to 2000

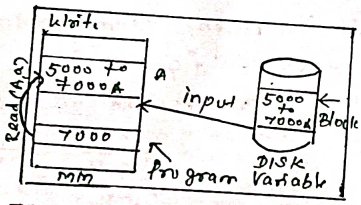
Transaction

1. Subtract Rs 1000 from Saving (machine crashes)
2. Add Rs 1000 to checking (money disappears)

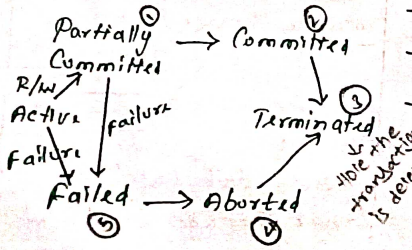
READ



WRITE



TRANSACTION STATES



TRANSACTION PROPERTIES

ACID PROPERTIES

- ATOMICITY (All or Nothing)
- CONSISTENCY Guaranteed.
- ISOLATION: Committed state independent
- DURABILITY
- Never Lost

NEED FOR CONCURRENCY CONTROL

- → DIRTY READ PROBLEM
- → UNREPEATABLE READ PROBLEM
- → LOST UPDATE PROBLEM
- → PHANTOM READ PROBLEM

CAUSES OF TRANSACTION FAILURE

- → Computer Crash/failure
- → Transaction failure
- → Exceptions
- → physical damange
- → Disk failure
- → Concurrency control enforcement

SCHEDULE TYPES

- Schedule the transaction to do the work.

Schedule
- Serial
- Non Serial

Non-Serial
- Serializable
- Non Serializable

Serializable
- Conflict
- View

Non Serializable
- Recoverable
- Non recoverable

Recoverable
- Cascading
- Cascadeless
- Strict

TYPES OF LOCKS

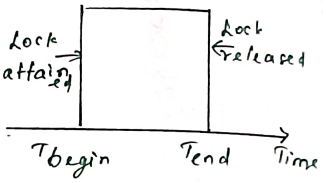
- → Binary lock
  - → locked (1)
  - → Unlocked (0)
- → Shared / Exclusive lock

LOCK COMPATIBILITY GRAPH

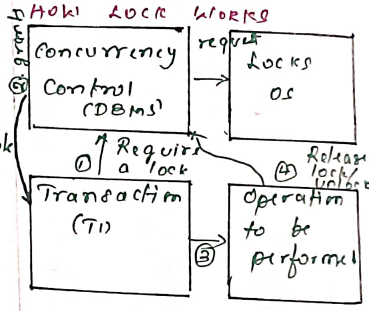
- securing the resources.

	S	X
S	T	F
X	F	F

LOCK BASED PROTOCOLS



HOW LOCK WORKS



PITFALLS

- → deadlock
- → Starvation

EXAMPLE

```
Lock_S(A)
READ(A)
UNLOCK(A)
Lock_S(B)
READ(B)
UNLOCK(B)
DISPLAY(A+B);
```

Two phase locking (2PL)

- ensure conflict serializable

Phase 1: GROWING

- obtain locks.

Phase 2: SHRINKING

- release locks.

2PL LOCKING CONVERSIONS

Phase 1

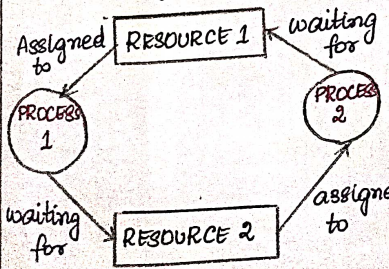
- acquire lock-S
- acquire lock-X
- convert lock-S to lock-X

Phase 2

- release lock-S
- release lock-X
- convert lock-X to lock-S

DEADLOCK: → never ending process

* T_1 waiting for T_{i-1}



- wait for lock.

DEADLOCK DETECTION

* Build wait-for graph
* cycle found - rollback

DEADLOCK RECOVERY threshold value

* Roll back → break deadlock

HOW ROLLBACK?

TOTAL ROLLBACK

* abort & restart fully

PARTIAL ROLLBACK

* starvation
* cost factors.

DEADLOCK HANDLING

- Predeclaration
- Partial Ordering
- Time out based schema - threshold.
- Timestamp

DEADLOCK PREVENTION by ordering the resources (ie)

- resource ordering

(i) **WAIT-DIE SCHEME**

- non preemptive
- old transaction wait for young transaction.

(ii) **WOUND-WAIT SCHEME**

- pre emptive
- old transaction wounds
  * force rollback

TIMESTAMP-BASED CONCURRENCY CONTROL one after another

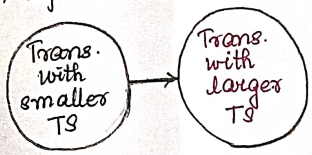
$TS(T_i) < TS(T_j)$ — new transaction

timestamp (given) — old transaction (serial)

* determine serializability

T_i issues write(Q)

- if $TS(T_i) < R\text{-timestamp}(Q)$ // Reject write (Read), rollback T_i
- if $TS(T_i) < W\text{-timestamp}(Q)$ // Reject write, rollback T_i



RECOVERY TECHNIQUES

* Restore DB
* Information in system log.

RECOVERY STRATEGIES

(i) Restore Backup
- extensive damage

(ii) Identify inconsistency changes
- non catastrophic failure.

(iii) Deferred update
- no physical update until commit

(iv) Immediate update
- update before commit

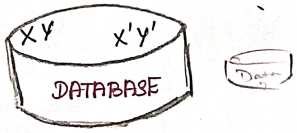
(v) Undo & Redo
- multiple times execution

(vi) Caching (buffering)
- memory buffers
- cache directory used.

(vii) other strategies
- checkpoints
- cascading rollback
- UNDO/REDO type log entries

SHADOW PAGING

* shadow copy of data
* 2 different places in disk



X', Y' - current copies

X, Y - shadow copies.

- 2 directories.
- No log for single user
- disks: n-fixed size
- new copy of modified page created

* **Failure recovery**
  - NO-UNDO/NO-REDO
  - discard current direc