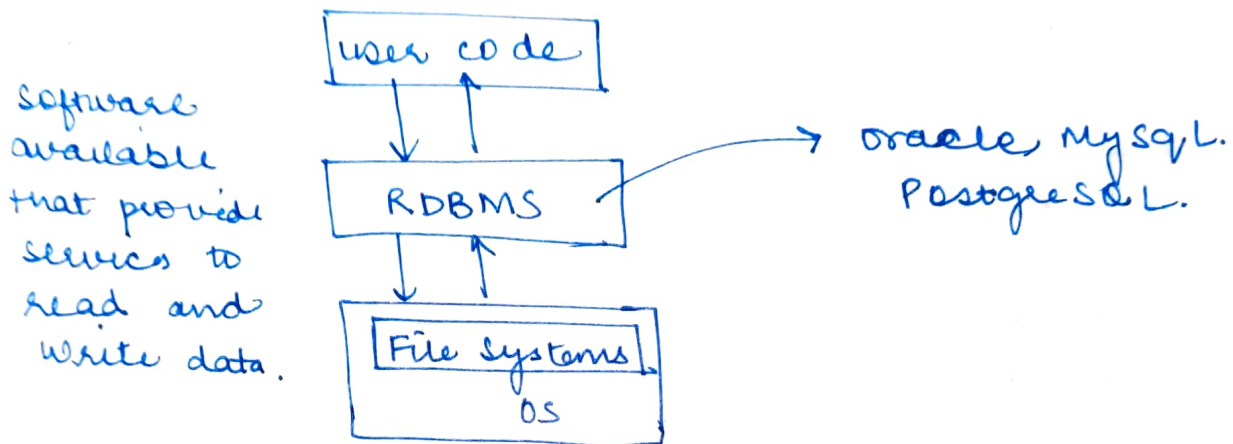


Database management systems

↳ software for providing a quick way to access and modify data

RDBMS

↳ Data is stored with the help of relations & tables.



Schema of table → basically the header of each column.

- logical definition of a table
 - defines name of table, name & type of each column
- (Blueprint)

Student

- st id
- name
- address
- class

RDBMS provides SQL (Structured query language)

↓
fourth gen. programming language.

↓
allows user code to access the data in convenient way.

Relational Database Management system

↓
also have administrative panels to define user role

→ codes to handle concurrency

RDBMS vs File system

Focus only on business logic.

- possibility of Redundancy.
- concurrency issue
- Data inconsistent
- security issues

Disadvantages of RDBMS

- Has to be in proper structural form | data has to follow the schema.
- Scalability issues
- can be handled by NoSQL
 - MongoDB
 - DynamoDB
 - Cassandra.

Entity Relationship Model

→ design DB before implementation

ER model

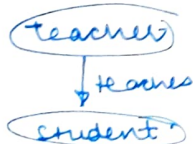
- Entity set
- Relationship set
- Attributes

main items in DB

↓
a particular row in table

↓
entity set
|||
table

Relationship between entities



columns of each row
name, id,
address etc.

How to Represent these

ES → or → weak ES.

RS → or → weak

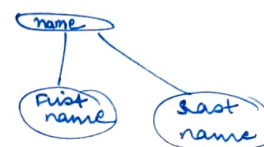
Attributes



→ composite

→ multiple features

Eg:- name → First name
Last name



Address
↓
~~School name~~
house no.
street no.
district
state.

→ Multiple values

→ Multivalued

Eg:- Phone number



→ Derived attribute

can be derived with the help of existing attributes



Eg:- age with the help of ~~DOB~~ DOB

→ Key attribute

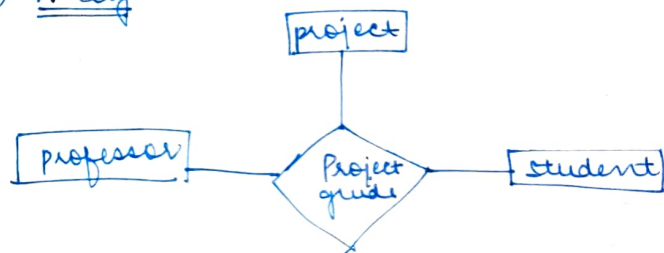
that define a particular entity set



Relationships

Degree of Relationship

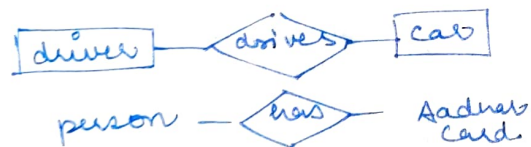
- 1) unary \rightarrow % entity set related to itself
 - \downarrow student is friend of student
 - \downarrow employee is managed by employee.
 - person is married to person.
- 2) Binary \rightarrow
 - \rightarrow student attends course
 - \rightarrow supplier supplies items
 - \rightarrow prof. teaches subject
- 3) n-ary



Cardinality

\rightarrow how many entities of 1 side can participate in a relationship

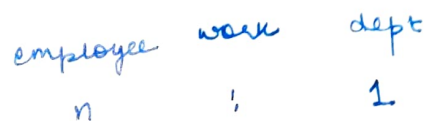
1 one to one



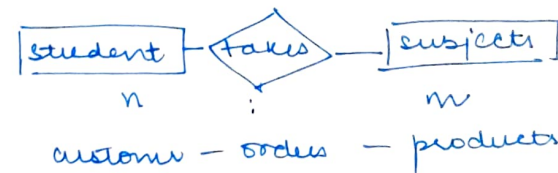
1 one to many



1 many to one



many to many



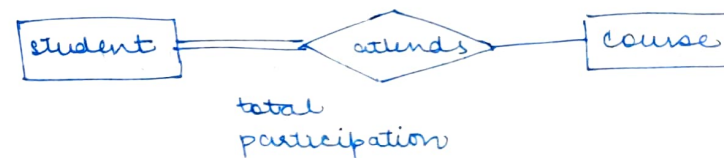
ER diagram

participation

entity set \rightarrow set of entities

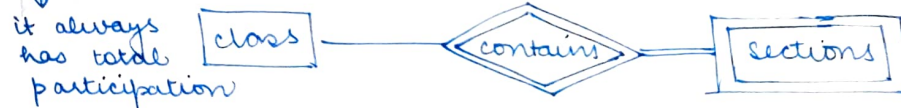
participation of entities

total \rightarrow every entity of one side participate in the relationship



weak entity set

\rightarrow do not have their own primary key.



key \rightarrow attribute or set of attributes that define an entity uniquely.

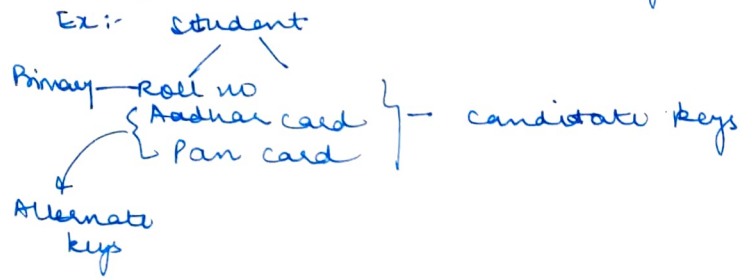
candidate key

\rightarrow minimum set of attributes of identify uniquely.

primary key is one of candidate key.

super key \supseteq candidate key

Candidate keys — Primary keys
+ Alternate keys



→ candidate key has to be minimal.

Super key → any combination of keys so that a row can be uniquely identified

Armstrong axioms

- Reflexing (A derives A)
- Transitivity ($A \rightarrow C, C \rightarrow D \Rightarrow A \rightarrow D$)
- Augmentation ($X \rightarrow Y$
 $XZ \rightarrow YZ$)

1) $R_1(A, B, C, D)$
 $A \rightarrow B, A \rightarrow C$
 $C \rightarrow D$

candidate key
→ A derives everything

2) $R_2(A, B, C, D)$
 $AB \rightarrow CD$
→ candidate key AB

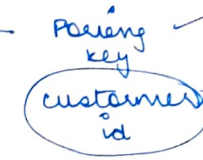
3) $R_3(A, B, C, D)$
 $B \rightarrow AC, C \rightarrow D$
→ CK → B

Foreign key

→ Data has to be divided into different tables to reduce redundancy.

Order table

customer table



Referential Integrity

- Foreign key must not point to NULL set.
- caused by removing data from 1 table

Normalization

- To reduce data redundancy (having same data at multiple data)
- data integrity
- NO erroneous data

Objectives of good database design

- NO updation, deletion, insertion anomaly.
- Easy Extendible
- Good performance for all query sets.
- more informative

(a) update anomaly

→ some database is update while other didn't because of server crash / other failure leading to inconsistent data.

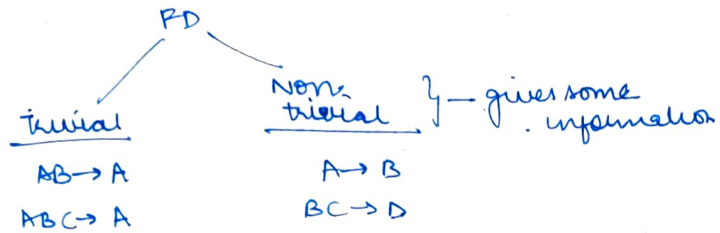
(b) insertion anomaly

no able to insert data because of some required fields → can be resolved by splitting tables.

(c) deletion anomaly → other data is also deleted with the row del. which needs to be prevented

Functional dependency

$A \rightarrow B$ B is functionally dependent on A
 \rightarrow if we lookup A, we can definitely learn B.



First Normal Form

every attribute contains only single values.

cust ID	Name	Phone no
101	ABC	991, 923
102	XYZ	456, 178, 984

many values

create different columns for mobile no.

cust ID	name	Ph-1	Ph-2	Ph-3
101	ABC	991	923	-
102	567	456	178	984
...	...	236	-	-

creating different entity for same customer

cust ID	Name	Ph
101	ABC	999
101	ABC	923
101	ABC	956
102		

lot of null values

or can create a separate table

cust ID	name
101	ABC
102	XYZ

\rightarrow cust ID | Ph. no.

Second normal form

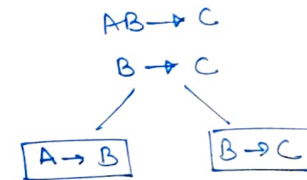
user-id	course-id	course-fee
1	CS101	5000
2	CS102	2000
1	CS102	2000
3	CS101	5000
4	CS102	2000
2	CS103	7000

non-prime attribute should depend with partial candidate key.

course-id \rightarrow course-ID \rightarrow (Non-prime att)

candidate key \rightarrow (user-id, course-id)

part of candidate key.



Third normal form

non-prime \rightarrow non-prime (Not allowed)

$R(A, B, C, D)$

$A \rightarrow (B, C, D)$

$C \rightarrow D$ violates

BCNF

prime / non prime \rightarrow prime attribute

Indexing in Database

→ to reduce lookup time

Clustered index

data is stored in increasing order on the basis of primary key.

- Extra cost in deleting & insertion

prime index → primary key is used as index.

Non clustered indexing

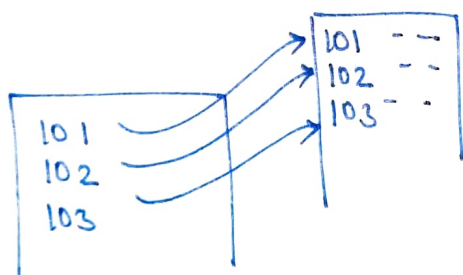
secondary indexing

data is not ordered on the basis of key in HDD

clustered Index

search key	Pointer
------------	---------

stores references to disk block containing given key.



Ordered Index file
Haship file org

Dense

every key has a entry in index table

sparse

some keys are skip

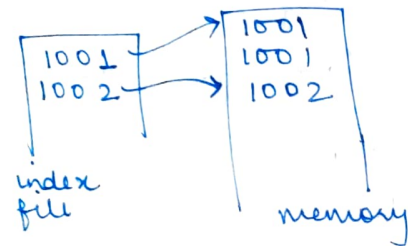
101 }
101 }
121 }

→ search a key 106

↓
go to 101 and move linearly

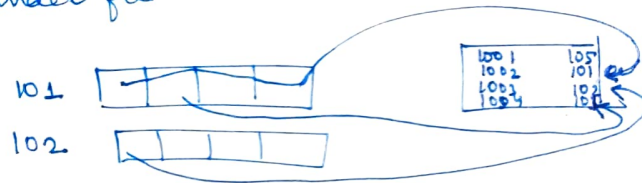
Dense → Every entry has to be present exactly once, not every row

order-ID	order date	cost	cust-id
101	-	-	1001
102	-	-	1002
103	-	-	1001



Non-clustered Index

index file

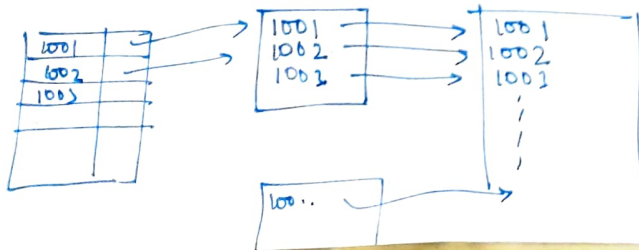


All the attribute are stored in increasing order in index file ~~but~~
Sparse is not possible.

there are many fields ~~on the basis of~~ corresponding to single index

Multilevel indexing

→ we have big index file, then we create one more index file for the index file



we use B-trees for insuring scalability.
→ Balanced Binary search trees which grow & shrink accordingly

B and B+ trees

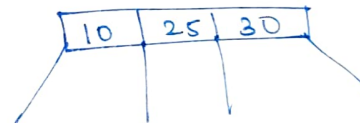
- n-ary search trees
- If branching factor is b , then every node has $\lfloor b/2 \rfloor$ to b children.
- In B+ tree leaves contain all the data present in internal nodes so that sequential access to data is possible.

$b = 4$
min = 2 children
max. = 4 " "

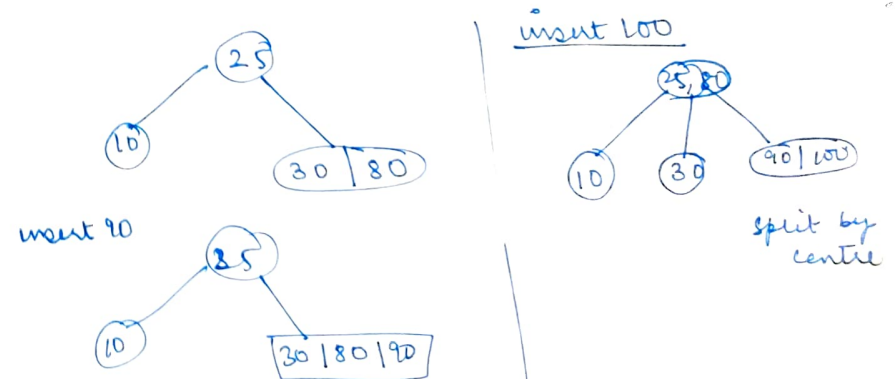
key → children

height never goes beyond $\log n$ if there are n cells

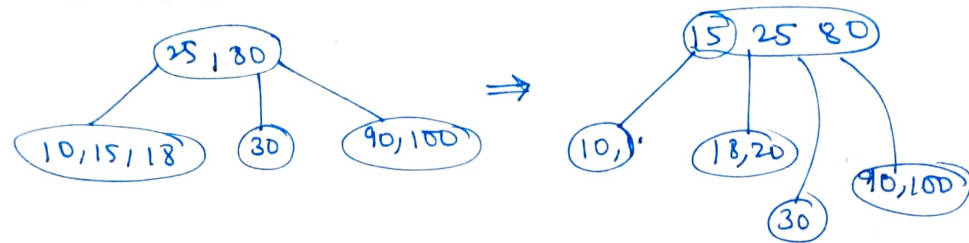
B tree has data in internal nodes also
B+ trees has data on leaves only



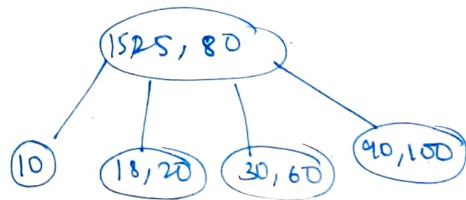
if we want to insert 80 → not possible as it will have 5 children



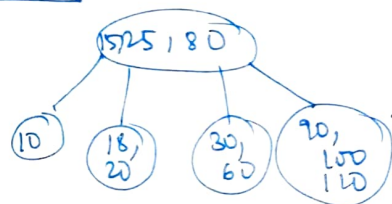
insert 15, 18



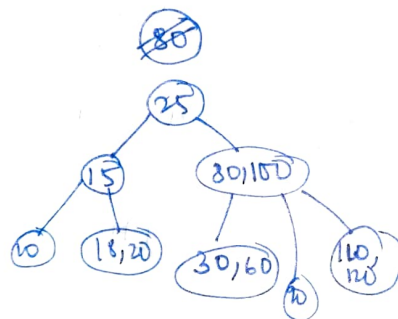
insert 60



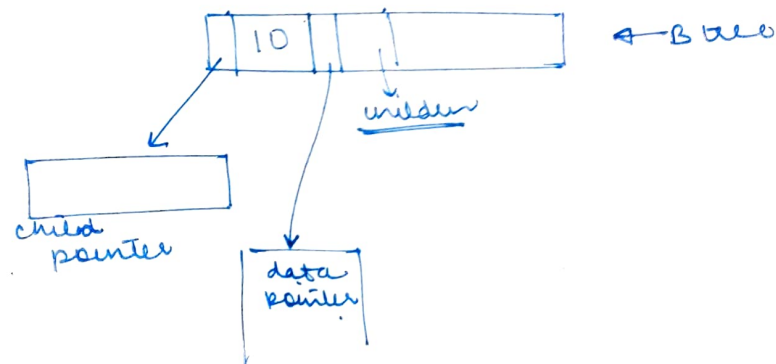
insert 110



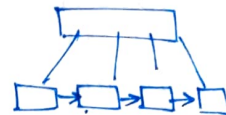
insert 120



in deletion
→ shrink



B+ trees → only leaf nodes contain data pointers and leaf nodes are connected



internal nodes have pointers to index blocks, leaf nodes have pointers to data blocks.

→ every node has only one pointer & sequential access

Transaction & concurrency control

↓
set of instructions that has to be executed together

Atomicity → either whole transaction is completed or every instruction executed must be reverted

Consistency → Database should be in consistent after a transaction happens.

Isolation → no transaction must not be interfered by other transaction

Durability → changes should be permanent

Conflict serializability

1) Serializability

you have an interleaved scheduled then check if it is view equivalent of $T_1 T_2$ or $T_2 T_1$

Suppose if we have 6 transactions then we have to check if our trans. is view equivalent to any of 6! permutations

lets do $T_1 T_2$

data item X
→ initial read is done by T_1

data item Y
→ initial read is done by T_2
↓
because in $T_1 T_2$ Y must be read by T_1 first X

check for $T_2 T_1$

data item X
→ T_2 is not reading X and prev

data item Y
→ T_2 reads first

Serializability

check if transactions schedule is serializable. A serializable schedule is one that always leaves the DB in consistent state.

It is required only when interleaving is done.

we need to check these 3 rules for every item

Initial Read
Update Read
Final Write

T_1	T_2
Read(X)	
$X = X - 10$	
Write(X)	
	Read(Y)
	$Y = Y - 10$
	Write(Y)
Read(Y)	
$Y = Y + 10$	
Write(Y)	
	Read(Z)
	$Z = Z + 10$
	Write(Z)

② update Read

sequence of read write should be same in both schedule.

③ Final Write → final write made on an item should be same.

Conflict Serializable

Conflict operations

Two operations from two different transaction on same data with one of them being "Write"

check if given schedule is conflict equivalent to any of the schedules $T_1 T_2$ or $T_2 T_1$

T_1	T_2	T_1	T_2
Read(A)		Read(A)	
Write(A)		Write(A)	
	↑ Read(A) ↓ Write(A)	Read(B)	
		Write(B)	
Read(B)			Read(A)
Write(B)			Write(A)
	Read(B) Write(B)		Read(B)
			Write(B)

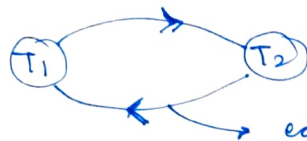
we can swap ↑ operations and get a serial schedule
→ Hence conflict serializable.

T_1	T_2
Read(A)	
	Read(A)
Write(A)	
	Write(A)
Read(B)	
Write(B)	
	Read(B)
	Write(B)

we can't swap these operations as these are conflict Reading & writing A

Simple graph based method. (Precedence graph)

no of transaction \rightarrow no of nodes



cycles
shows that
not conflict
serializable

edge when
there is a
read ~~after~~ followed
by write

T ₁	T ₂
Read (X)	
	Read Read (Y)
	Write (X)
Read Write (Y)	

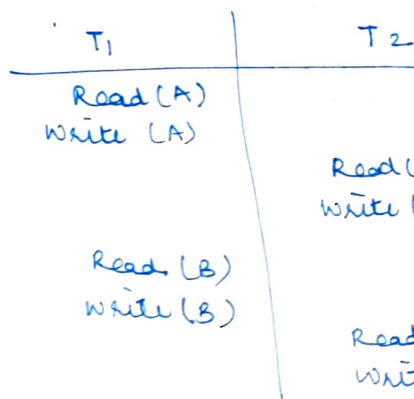
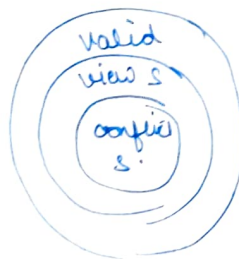


Diagram illustrating a cycle in a dependency graph:

```
graph LR; T1((T1)) --> T2((T2)); T2 --> T1;
```

not conflict
serializable

conflict serializability is more strict



Recoverable, Cascadefless and Stick

problem → suppose a transaction is rolled back in middle ~~the~~, the changes done by ~~it~~ is its execution is used by another transaction that has committed already.

T₁
Read (A)
Write (A).

 T_2

Read A)
write (A) .
↓
comini

T₁ is rolled back and but T₂ has already committed which leads to inconsistent DB

Intercommable

Rules to ensure recoverable schedule

* one problem is dirty read → reading the value changed by the transaction that has not committed yet.

↓

If there is a

If there is a
dirty read then
the transaction doing
dirty read must commit
after the transaction
from which it's read

cascadeless

↳ one rollback is causing other rolls back
to ensure cascadability

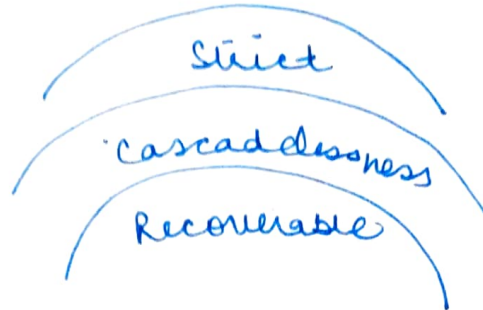
- for us make some rules
- for dirty ready, will wait until the traveller has committed already

Strict schedule

→ B handles blind writes

→ write without read

even write
operations
should wait
for commit



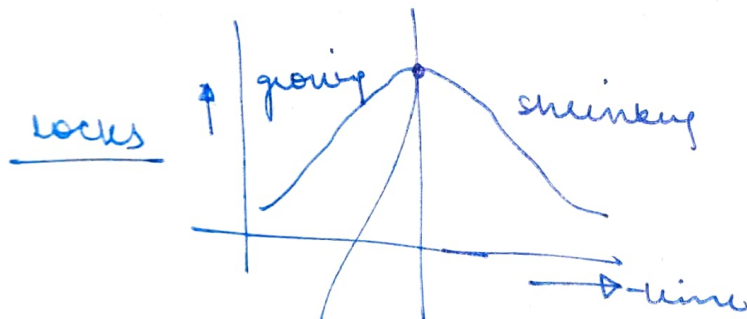
Two phase locking protocols

two types of locks

- shared
- Exclusive

two phases

→ growing
→ shrinking



all locks are
acquired
here only

all locks are
released here
only.

lock point → where all locks are
acquired and no more
locks are left.

	S	E
S	✓	X
E	X	X

→ deadlock
→ cascade