* Serializability

Is a schedule serializable (i.e. be made serial)?

schedule ↓ collection of transactions

Serial Schedules

S

T_1	T_2
R(A)	
W(A)	
	R(A)
	W(A)

$$T_1 \longrightarrow T_2$$

S

T_1	T_2
	R(A)
	W(A)
R(A)	
W(A)	

$$T_1 \longleftarrow T_2$$

S_1

T_1	T_2
R(A)	
	R(A)
	W(A)
W(A)	

$$\begin{tikzcd} T_1 \arrow[r, shift left] & T_2 \arrow[l, bend right] \end{tikzcd}$$

Is it serializable?
i.e. Equivalent to a serial schedule

$\Rightarrow$ $T_1 \longrightarrow T_2$
OR
$T_2 \longrightarrow T_1$

Serializability
- Conflict
- View

Conflict-equivalent schedule

Eg:

S

T_1	T_2
R(A)	
W(A)	
	R(A)
	W(A)
R(B)	

S'

T_1	T_2
R(A)	
W(A)	
R(B)	
	R(A)
	W(A)

Is $S \equiv S'$?

check adjacent non-conflict pairs and swap them.

S

T_1	T_2
R(A)	
W(A)	
	R(A)
	W(A)
R(B)	

$\Rightarrow$

S

T_1	T_2
R(A)	
W(A)	
	R(A)
R(B)	
	W(A)

$\Downarrow$

S

T_1	T_2
R(A)	
W(A)	
R(B)	
	R(A)
	W(A)

is equivalent S'

$\therefore S \equiv S'$

T_1	T_2
R(A)	
W(A)	
	R(A)
W(A)	
R(B)	

No change in position (Conflict pair)

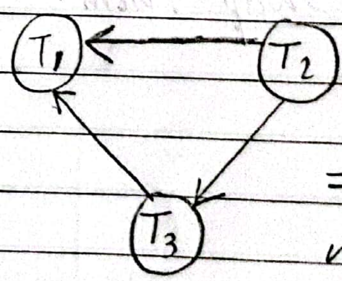
$S \xrightarrow{CE} S' \Rightarrow$ Serializable

PRECEDENCE GRAPH

T_1	T_2	T_3
~~R(x)~~		
		~~R(y)~~
		~~R(x)~~
	~~R(y)~~	
	~~R(Z)~~	
		~~W(y)~~
	~~W(Z)~~	
R(Z)		
→ W(X)		
W(Z)		

- check conflict pairs in other transactions and draw edges.

Precedence Graph

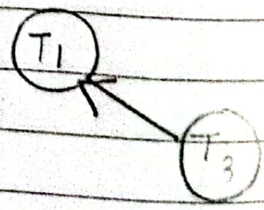


⇒ No loop/ no cycle exist
⇒ Conflict - serializ...

Loop/ Cycle exists or not?

Choose vertex whose Indegree = 0

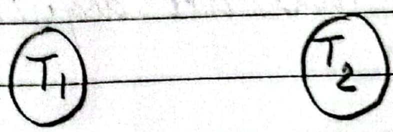
T2 — T3 — T1



Q2 i)

T1	T2
~~r(X)~~	
~~W(X)~~	
	~~r(Y)~~
	~~W(Y)~~

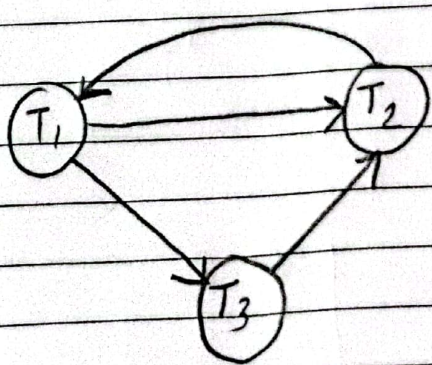
Serializable



Equivalent $T_1 - T_2$
or, $T_2 - T_1$

Q ii)

T_1	T_2	T_3
~~r(y)~~		
	~~r(y)~~	
		~~r(y)~~
	~~W(y)~~	
~~W(y)~~		
		W(y)



$T_2 \longrightarrow T_2$ possible
$\therefore$ Not serializable

June 5, 2024

Normalization in DBMS

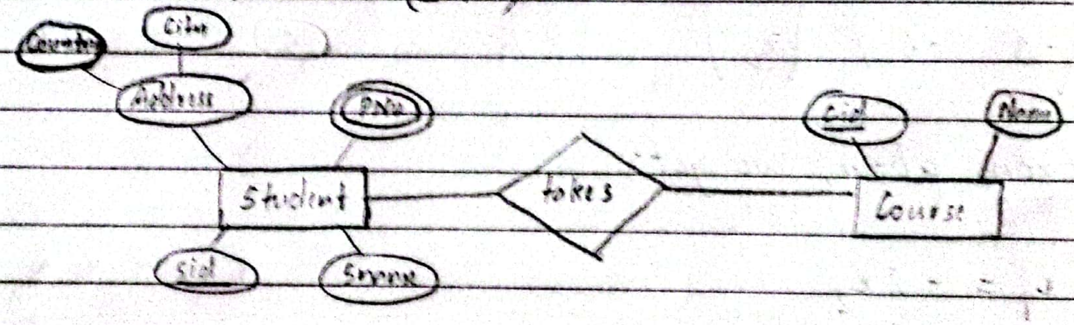
Sid	Sname	Credits	Dep_Name	Building	Room_no
1	John	5	CSE	B1	101
2	Jim	8	CSE	B1	101
3	Tom	8	Phy	B1	101

Redundancy

Problems caused by redundancy

- Insertion anomaly — eg: Insert Dept_name only
- Deletion anomaly — eg: CSE dept updated to C...
- Updation anomaly — eg: Department

1st Normal Form (1NF)



Student

Sid	Sname	SAddress	Phone
1	Niraz	Kathmandu, Nepal	P1, P2
2			
3			

← Not in 1NF

$\boxed{\text{Rule}}$

* Each columns should contain atomic values
  ↓
  indivisible

OR

Each cell contains exactly one value

* Column should contain values from same domain.

* Each column should have unique name
* No ordering to rows and columns
* No duplicate rows

To convert into 1NF

⇒ Composite attribute must be broken down into separate attributes / columns.

⇒ for multi-valued attributes, we make one tuple for each value in the multi-valued set.

Sid	Sname	City	Country	Phone
1	Niraz	Kathmandu	Nepal	P1
1	Niraz	Kathmandu	Nepal	P2

When ER diagram is converted into relation, it is by default in 1NF.

2nd Normal form (2NF)

Rules

* The relation should be in 1NF.
* There should be no partial dependency in the relation.

eg: R (A, B, C, D, E, F)

FD = { $A \to B$, $B \to C$, $C \to D$, $D \to E$ }

Partial Dependency ⇒ Proper subset of CK ⟶ Non-prime attribute

Prime attributes are part of candidate keys. (Minimal superkey).

Remaining attributes are non-prime attribute.

Q1. ** $R(A, B, C, D, E, F)$

$FD = \{A \rightarrow B,\ B \rightarrow C,\ C \rightarrow D,\ D \rightarrow E\}$

Find out candidate keys:

$A\cancel{B}\cancel{C}\cancel{D}\cancel{E}F^+ = \{ABCDEF\}$

$AF^+ = \{ABCDEF\}$

$A^+ = \{ABCDE\}$ ✗

$F^+ = \{F\}$ ✗

Candidate Key $= \{A, F\}$ (Also, prime attributes)

Non-prime attributes = B, C, D, E

** $A \rightarrow B \Rightarrow$ Partial dependency exists

Not in 2NF

Q2. $R(A, B, C, D)$

$FD = \{AB \rightarrow CD,\ C \rightarrow A,\ D \rightarrow B\}$

$AB\cancel{C}\cancel{D}^+ = \{ABCD\}$

SK → $AB^+ = \{ABCD\}$ (CK) Prime attributes: A, B, C, D

⇓

2NF

$A^+ = \{A\}$ ✗

$B^+ = \{B\}$ ✗

$\therefore CK = \{AB\}$

CB (CK) AD (CK)

B^+ ✗ A^+ ✗

$C^+ = \{CA\}$ $D^+ = \{DB\}$ ✗

Q3. $R(A, B, C, D)$

$FD = \{A \to B,\ B \to C,\ C \to D\}$

SK $A\cancel{B}\cancel{C}\cancel{D}^+ = \{ABCD\}$ Prime attribute: A

CK: $\{A\}$

$\therefore$ It is in 2NF.

Q4 $R(A, B, C, D)$

$F: \{A \to B,\ B \to C\}$

$A\cancel{B}\cancel{C}D^+ = \{ABCD\}$

SK: AD Prime attribute: A, D

$A^+ = \{ABC\}$ ✗

$D^+ = \{D\}$ ✗

CK: $\{AD\}$

PD: $A \to B$

$A^+ = ABC$

$R_1 = \{A, B, C\}$ $R_2 = \{A, D\}$ Superkey for R_1 as $A^+ = \{ABC\}$

$R_1 = \{A, B, C\}$

$F_1: \{A \to BC,\ B \to C$

$A^+ = ABC$ AB^+

$B^+ = BC$ $BC^+ = BC$

$C^+ = C$

CK: A, ($\therefore$ No partial dependency) (In 2NF)

$R_2 = \{A, D\} \Rightarrow$ BCNF

$F_2: \{\ \}$

$A^+ = \cancel{ABC}$

$D^+ = D$

$F_1 \cup F_2 \equiv F \Rightarrow$ Dependency preserving

Q5. $R(A, B, C, D)$

$F: \{A \rightarrow B, C \rightarrow D\}$

$A\cancel{B}C\cancel{D}^+ = ABCD$

SK: $AC^+ = ABCD$

$A^+ = AB$ ✗

$C^+ = CD$ ✗

$\therefore CK = AC$ Prime attributes : A, C

PD: $A \rightarrow B$

$C \rightarrow D$

$A \rightarrow B$

$A^+ = AB$

$R_1 = \{A, B\}$

$C \rightarrow D$

$C^+ = CD$

$R_2 = \{C, D\}$

~~R_3~~: $R_3 = \{A, C\}$

$A^+ = AB$ $C^+ = CD$

↓ ↓

a superkey of R_1 Superkey of R_2

Date
Page

BCNF

R_1 $\{A, B\}$

R_2 $\{C, D\}$

R_3 $\{A, C\}$

F_1: $A \rightarrow B$
$A^+ = AB$
$B^+ = B$

F_2: $C \rightarrow D$
$C^+ = CD$
$D^+ = D$

F_3: $\{ \}$
$A^+ = A$
$C^+ = C$

$$F_1 \cup F_2 \cup F_3 \equiv \{A \rightarrow B, C \rightarrow D\}$$

$$\equiv F$$

3rd Normal Form (3NF)

Sid	Sname	DOB	State	Country	PINCode	Tot-Credits
1	A	-	HR	IN	122001	-
2	B	-	HR	IN	122001	-
3	C	-	HR	IN	122001	-
4	D	-	PJ	IN	123456	-

If CK has one attribute, the table is in 2NF.

PINCode $\longrightarrow$ State, Country

$\Downarrow$

State	Country	PINCode

Problem occured by Non-prime attribue $\longrightarrow$ Non-prime attribute

Rules * Should be in 2NF * No transitive dependency for NPA.

eg.

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

$\Downarrow$

$\underset{\substack{\uparrow \\ NPA}}{A} \longrightarrow \underset{\substack{\uparrow \\ NPA}}{C}$

$PA \rightarrow NPA$ (PD)

$CK \longrightarrow NPA$ (Not a transitive dependency)

$NPA \longrightarrow PA$ (" " " ")

A table is in 3NF iff for each of its non-trivial FD at least one of the following conditions hold:

i) LHS is SK

ii) RHS is prime attribute

Q1:

R (A, B, C, D)

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

$(A\cancel{B}\cancel{C}\cancel{D})^+$ = ABCD

SK: A^+ = ABCD

CK: A

PA: A

A^+ = ABCD

The relation is not in 3NF.

$B \rightarrow C$, $C \rightarrow D$ Transitive dependency

Q2 $R(A, B, C, D, E, F)$

$F = \{ AB \longrightarrow CDEF, \ BD \longrightarrow F \}$

$ABCDEF^+ = ABCDEF$

SK: $AB^+ = ABCDEF$

$A^+ = A$ ✗

$B^+ = B$ ✗

CK: AB

$\downarrow$

AB

PA: A, B

NPA: $CDEF$

It is not in 3NF as

$BD \longrightarrow F$

* Decomposition into 3NF

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

$F: \{ A \longrightarrow B, \ B \longrightarrow C, \ C \longrightarrow D \}$

$ABCD^+ = \{ABCD\}$

SK: $A^+ = \{ABCD\}$

CK: A

PA: A

NPA: B, C, D

Not in 3NF: Transitive dependency exists

$B \longrightarrow C \qquad C \longrightarrow D$

$B^+ = BCD$

$R_1 = \{B, C, D\}$

$F_1 = \{ B \rightarrow CD, \ C \xrightarrow{TD} D \}$

$B^+ = BCD$. $BC^+ \rightarrow B$

$C^+ = CD$ $\quad BD^+ \rightarrow$

$D^+ = D$ $\quad CD^+ \rightarrow CD$

$C^+ = CD$

$R_2 = \{C, D\}$

$F_2 = \{ C \longrightarrow D. \}$

$C^+ = CD$

$D^+ = D$

BCNF

Remaining

$R_3 = \{A, B\}$

$F_3 = \{ A \longrightarrow B \}$

$A^+ = AB$

$B^+ = B$

BCNF

F_1

$BCD^+ : \{BCD\}$

$B^+ : \{BCD\}$

SK/CK : B PA: B

For R_1

Again TD exists

$C \longrightarrow D$

$C^+ = CD$

$R_{11} = \{C, D\}$ $F_{11} : \{C \rightarrow D\}$

$R_{12} = \{C, B\}$ $F_{12} : \{B \longrightarrow C\}$

$R_{12}(B, C)$, $R_2(C, D)$, $R_3(A, B)$

$F_{11} \cup F_{12} \cup F_2 \cup F_3 \equiv A \rightarrow B,\ B \rightarrow C,\ C \rightarrow D$

BCNF (Boyce-Codd Normal Form)

3NF is not able to handle overlapping candidate keys.

AB

BC

DC

Q1. R (A, B, C)

FD : $\{A \longrightarrow B,\ B \longrightarrow C,\ C \longrightarrow A\}$

* A relation is in BCNF iff
- it is in 3NF
- for each non-trivial FD $X \longrightarrow Y$, X must be superkey.

CamScanner

Q1. $R(A, B, C)$

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

SK $A\cancel{B}\cancel{C}^+ = \{ABC\}$

CK $\Rightarrow A^+ = \{ABC\}$

PA: A, B, C

~~NPA~~ ~~B/C~~

$\downarrow$

CK $\Rightarrow$ C

$\downarrow$

CK $\Rightarrow$ B

$\therefore$ It is in BCNF

Q2. $R(A, B, C, D, E)$

$FD: \{A \rightarrow BCDE,\ BC \rightarrow ACE,\ D \rightarrow E\}$

$A\cancel{B}\cancel{C}\cancel{D}\cancel{E}^+ = \{ABCDE\}$

SK: $A^+ = \{ABCDE\}$

CK: A

$\downarrow$

CK: BC

PA: A, B, C

NPA: D, E

CK = A, BC

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

$C^+ = \{C\}$

AC X

BA X

BCNF	✓	✓	X
3NF	✓	✓	X
$\Rightarrow$ 2NF	✓	✓	✓

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

$f = \{AB \longrightarrow CDE,\ D \longrightarrow A\}$

$AB\cancel{C}\cancel{D}\cancel{E}^+ = \{ABCDE\}$

SK AB^+

$A^+ = \{A\}$

$B^+ = \{B\}$

CK = AB

$\Downarrow$

DB

$D^+ = \{DA\}$ $\quad$ $B^+ = \{B\}$

PA: A, B, D

NPA: C, E

CK: AB, DB

BCNF	✓	✗
3NF	✓	✓