COMPUTER SCIENCE

Database Management System

Transaction & Concurrency Control

Lecture_02

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TOPICS TO BE COVERED

01 Normal Form Decomposition

02 Transcation Concept

Normal Forms

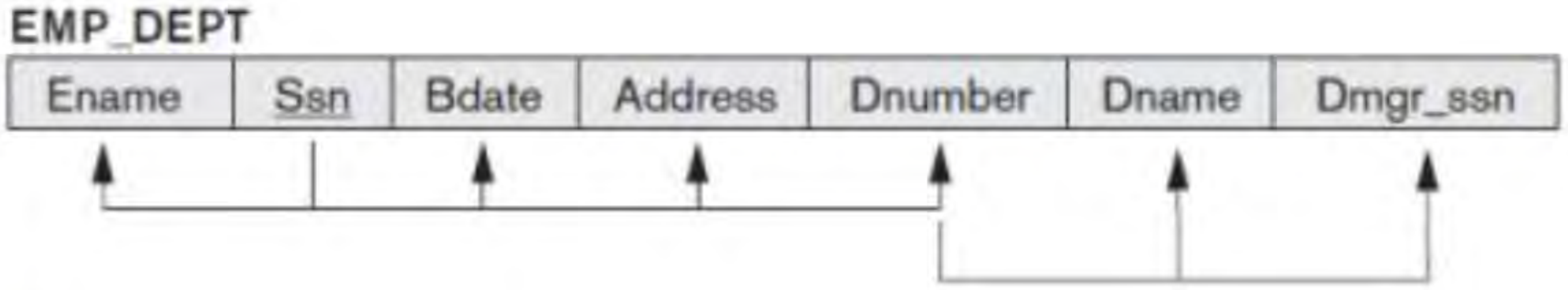
15.3.5 Second Normal Form

Second normal form (2NF) is based on the concept of *full functional dependency*. A functional dependency $X \rightarrow Y$ is a **full functional dependency** if removal of any attribute A from X means that the dependency does not hold any more; that is, for any attribute $A \in X$, $(X - \{A\})$ does *not* functionally determine Y. A functional dependency $X \rightarrow Y$ is a **partial dependency** if some attribute $A \in X$ can be removed from X and the dependency still holds; that is, for some $A \in X$, $(X - \{A\}) \rightarrow Y$. In Figure 15.3(b), {Ssn, Pnumber} → Hours is a full dependency (neither Ssn → Hours nor Pnumber → Hours holds). However, the dependency {Ssn, Pnumber} → Ename is partial because Ssn → Ename holds.

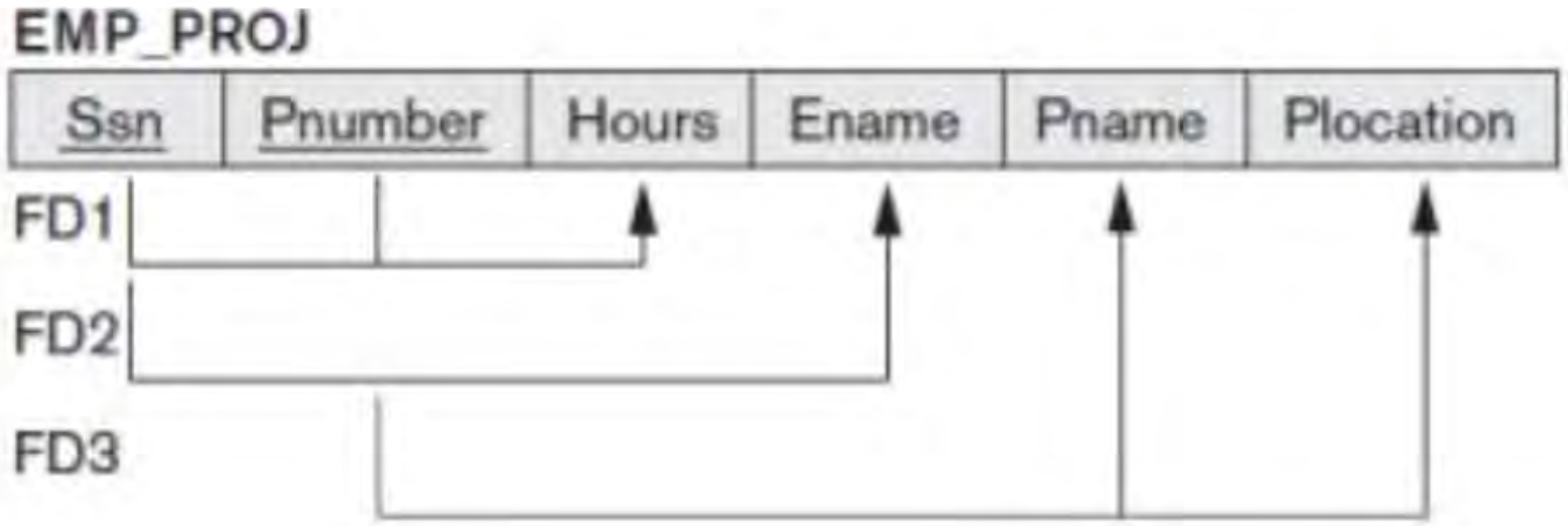
Definition. A relation schema R is in 2NF if every nonprime attribute A in R is *fully functionally dependent* on the primary key of R.

Figure 15.3

(a)



(b)



Normal Forms

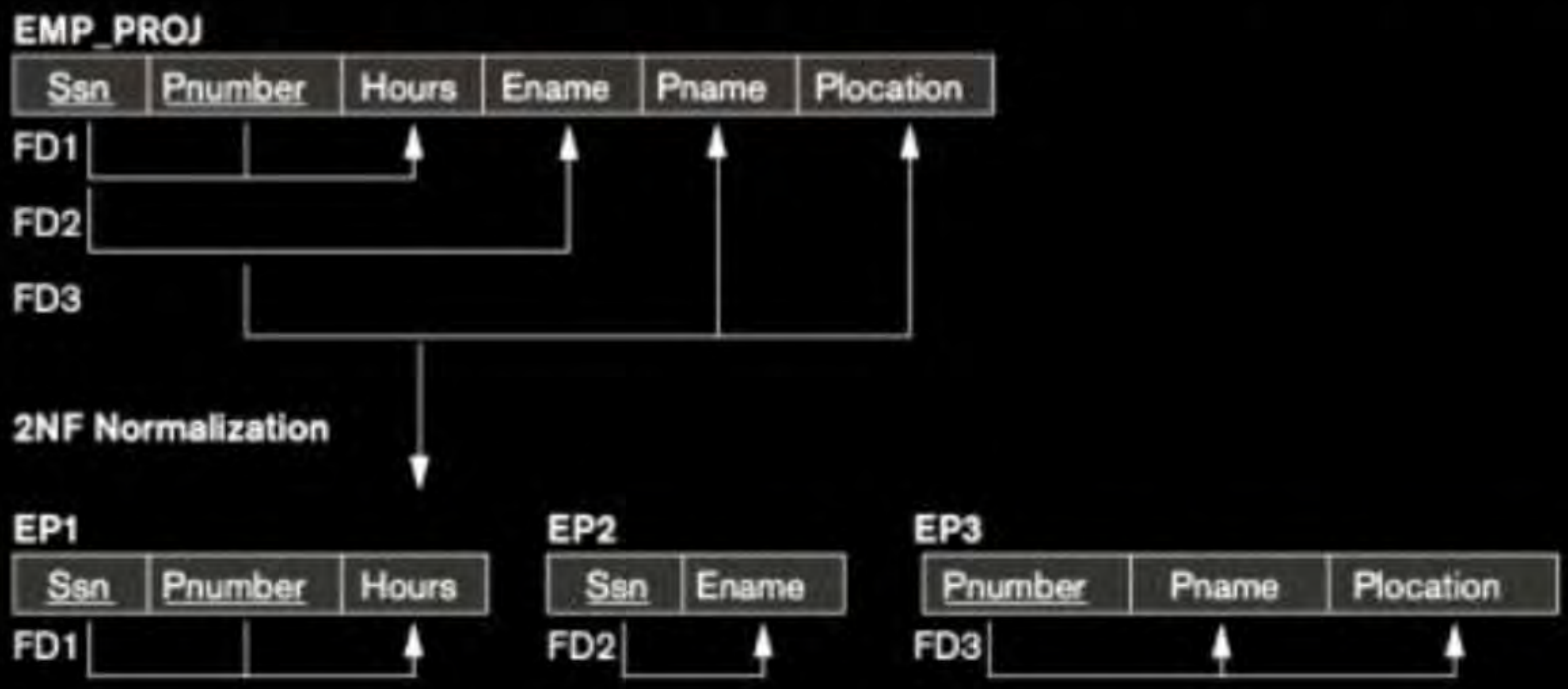
8.17 A functional dependency $\alpha \rightarrow \beta$ is called a partial dependency if there is a proper subset γ of α such that $\gamma \rightarrow \beta$. We say that β is *partially dependent* on α. A relation schema R is in second normal form (2NF) if each attribute A in R meets one of the following criteria:

- It appears in a candidate key.
- It is not partially dependent on a candidate key.

Normal Forms

Second Normal Form

Definition: A relation schema R is in 2NF if every nonprime attribute A in R is fully functionally dependent on the primary key of R.



$R(ABCDEF)\ \{ABC \rightarrow DE, DE \rightarrow ABC, AB \rightarrow D, DE \rightarrow F, E \rightarrow C\}$

(i) $ABC \rightarrow D$

(ii) $AE \rightarrow C$

(iii) $AF \rightarrow D$

(iv) $AB \rightarrow D$

(v) $AC \rightarrow D$

(vi) $BC \rightarrow D$

(vii) $DE \rightarrow C$

(vi) $AB \rightarrow F$

Q. Let R(A, B, C, D, E, P, G) be a relational schema in which the following functional dependencies are known to hold:

$AB \rightarrow CD$, $DE \rightarrow P$, $C \rightarrow E$, $P \rightarrow C$ and $B \rightarrow G$.

The relational schema R is

(A) In BCNF

(B) In 3NF, but not in BCNF

(C) In 2NF, but not in 3NF

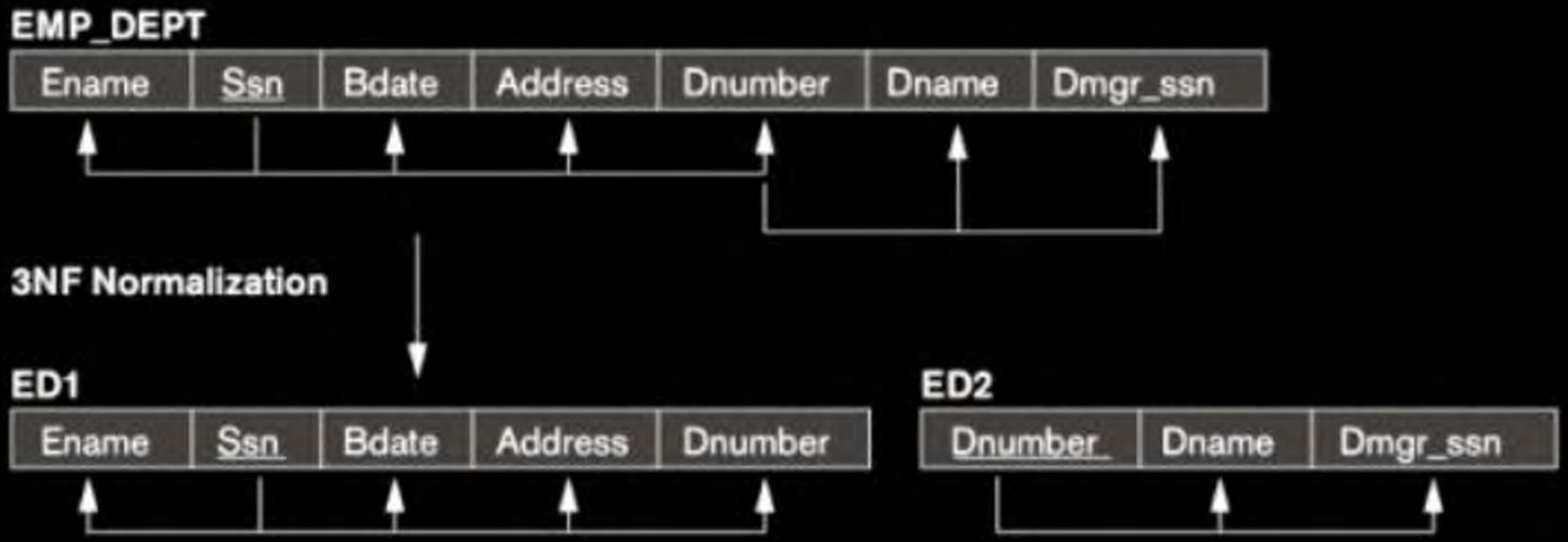
(D) Not in 2NF

Normal Forms

Third Normal Form

Definition: According to Codd's original definition, a relation schema R is in 3NF if it satisfies 2NF and no nonprime attribute of R is transitively dependent on the primary key.

Definition: A relation schema R is in third normal form (3NF) if, whenever a nontrivial functional dependency $X \rightarrow A$ holds in R either (a) X is a superkey of R, or (b) A is a prime attribute of R.


EMP_DEPT
Ename
Ssn
Bdate
Address
Dnumber
Dname
Dmgr_ssn
3NF Normalization
ED1
Ename
Ssn
Bdate
Address
Dnumber
ED2
Dnumber
Dname
Dmgr_ssn

Boyce – Codd Normal Form

Definition: A relation schema R is in BCNF if whenever a nontrivial functional dependency $X \rightarrow A$ holds in R, then X is a superkey of R.

Q. In a relational data model, which one of the following statements is TRUE?

(A) A relation with only two attributes is always in BCNF.

(B) If all attributes of a relation are prime attributes, then the relation is in BCNF.

(C) Every relation has at least one non-prime attribute.

(D) BCNF decompositions preserve functional dependencies.

Q. Let R(A, B, C, D, E, P, G) be a relational schema in which the following functional dependencies are known to hold:

$AB \rightarrow CD$, $DE \rightarrow P$, $C \rightarrow E$, $P \rightarrow C$ and $B \rightarrow G$.

The relational schema R is

(A) In BCNF

(B) In 3NF, but not in BCNF

(C) In 2NF, but not in 3NF

(D) Not in 2NF

Q

Consider the following statements: [MSQ]

S_1: If every attribute is prime attribute in R, then Relation R will always be in BCNF.

S_2: Any Relation with two Attribute is in 3 NF and 2 NF.

S_3: If every key of relation R is a simple candidate key (No composite key) then the relation R not always in NF.

S_4: In BCNF there is always a lossless join and Dependency Preserving Decomposition.

Which of the above statement are incorrect

(A) S_1

(B) S_2

(C) S_3

(D) S_4

Q

The relation scheme student Performance (name, courseNO, rollNo, grade) has the following functional dependencies:

[2004: 2 Marks]

name, courseNo $\rightarrow$ grade

RollNo, courseNo $\rightarrow$ grade

name $\rightarrow$ rollNo

rollNO $\rightarrow$ name

The highest normal form of this relation scheme is

(A) 2 NF

(B) 3 NF

(C) BCNF

(D) 4 NF

MCQ

In a relational data model, which one of the following statements is TRUE?

GATE-2022-CS: 1M]

A. A relation with only two attributes is always in BCNF.

B. If all attributes of a relation are prime attributes, then the relation is in BCNF.

C. Every relation has at least one non-prime attribute.

D. BCNF decompositions preserve functional dependencies.

NAT

Consider a relation R(A, B, C, D, E) with the following three functional dependencies.

$AB \rightarrow C$; $BC \rightarrow D$; $C \rightarrow E$;

The number of super keys in the relation R is ______.

[GATE-2022-CS: 1M]

MCQ

Consider a relational table R that is in 3 NF, but not in BCNF. Which one of the following statements is TRUE?

[GATE-2020-CS: 2M]

(A) R has a non-trivial functional dependency $X \rightarrow A$, where X is not a superkey and A is a prime attribute.

(B) R has a non-trivial functional dependency $X \rightarrow A$, where X is not a superkey and A is a non-prime attribute and X is not a proper subset of any key.

(C) R has a non-trivial functional dependency $X \rightarrow A$, where X is not a superkey and A is a non-prime attribute and X is a proper subset of some key.

(D) A cell in R holds a set instead of an atomic value.

MCQ

Let the set of functional dependencies $F = \{QR \rightarrow S, R \rightarrow P, S \rightarrow Q\}$ hold on a relation schema $X = (PQRS)$. X is not in BCNF. Suppose X is decomposed into two schemas Y and Z, where $Y = (P\,R)$ and $Z = (Q\,R\,S)$.

Consider the two statements given below.

I. Both Y and Z are in BCNF

II. Decomposition of X into Y and Z is dependency preserving and lossless

Which of the above statements is/are correct?

[GATE-2019-CS: 2M]

(A) Both I and II

(B) I only

(C) II only

(D) Neither I nor II

Q.

Consider the following four relational schemas. For each schema, all non-trivial functional dependencies are listed. The underlined attributes are the respective primary keys.

Schema I: Registration (<u>rollno</u>, courses)

Field 'courses' is a set-valued attribute containing the set of courses a student has registered for.

Non-trivial functional dependency:

rollno $\rightarrow$ courses

Schema II: Registration (<u>rollno, courseid</u>, email)

Non-trivial functional dependencies:

rollno, courseid $\rightarrow$ email

email $\rightarrow$ rollno

Schema III: Registration (<u>rollno, courseid</u>, marks, grade)

Non-trivial functional dependencies:

rollno, courseid $\rightarrow$ marks, grade

marks $\rightarrow$ grade

Schema IV: Registration (<u>rollno, courseid</u>, marks, credit)

Non-trivial functional dependencies:

rollno, courseid $\rightarrow$ credit

courseid $\rightarrow$ credit

Which one of the relational schemas above is in 3NF but not in BCNF? [MCQ: 2018: 2M]

(A) Schema I

(B) Schema II

(C) Schema III

(D) Schema IV

Q.

A database of research articles in a journal uses the following schema.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, YEAR, PRICE)

The primary key is (VOLUME, NUMBER, STARTPAGE, ENDPAGE) and the following functional dependencies exist in the schema.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) $\rightarrow$ TITLE

(VOLUME, NUMBER) $\rightarrow$ YEAR

(VOLUME, NUMBER, STARTPAGE, ENDPAGE) $\rightarrow$ PRICE.

The database is redesigned to use the following schemas.

(VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, PRICE)

(VOLUME, NUMBER, YEAR)

Which of the weakest normal form that the new database satisfies, but the old one does not? [MCQ: 2016: 1M]

A. 1NF

C. 2NF

B. 3NF

D. BCNF

NAT

Given an instance of the STUDENTS relation as shown below:

Student ID	Student Name	Student Email	Student Age	CPI
2345	Shankar	shankar@math	X	9.4
1287	Swati	swati@ee	19	9.5
7853	Shankar	shankar@cse	19	9.4
9876	Swati	swati@mech	18	9.3
8765	Ganesh	ganesh@civil	19	8.7

For (Student Name, Student Age) to be a key for this instance, the value X should NOT be equal to ____________.

[GATE-2014-CS: 1M]

NAT

The maximum number of superkeys for the relation schema R (E, F, G, H) with E as the key is ___________.

[GATE-2014-CS: 1M]

MCQ

Given the following two statements:

S1: Every table with two single-valued attributes is in 1 NF, 2 NF, 3 NF and BCNF.

S2: $AB \rightarrow C$, $D \rightarrow E$, $E \rightarrow C$ is a minimal cover for the set of functional dependencies $AB \rightarrow C$, $D \rightarrow E$, $AB \rightarrow E$, $E \rightarrow C$.

Which one of the following is CORRECT?

[GATE-2014-CS: 2M]

A. S1 is TRUE and S2 is FALSE.

B. Both S1 and S2 are TRUE.

C. S1 is FALSE and S2 is TRUE

D. Both S1 and S2 are FALSE.

MCQ

Relation R has eight attributes ABCDEFGH.
Fields of R contain only atomic values.
$F = \{CH \rightarrow G, A \rightarrow BC, B \rightarrow CFH, E \rightarrow A, F \rightarrow EG\}$ is a set of functional dependencies (FDs) so that F^+ is exactly the set of FDs that hold for R.
How many candidate keys does the relation R have?

[GATE-2013-CS: 2M]

(A) 3

(B) 4

(C) 5

(D) 6

MCQ

Relation R has eight attributes ABCDEFGH.
Fields of R contain only atomic values.
$F = \{CH \rightarrow G, A \rightarrow BC, B \rightarrow CFH, E \rightarrow A, F \rightarrow EG\}$ is a set of functional dependencies (FDs) so that F^+ is exactly the set of FDs that hold for R.
The relation R is

[GATE-2013-CS: 2M]

(A) in 1 NF, but not in 2 NF.

(B) in 2 NF, but not in 3 NF.

(C) in 3NF, but not in BCNF.

(D) in BCNF.

MCQ

Which of the following is TRUE?

[GATE-2012-CS: 1M]

(A) Every relation in 3 NF is also in BCNF

(B) A relation R is in 3 NF if every non-prime attribute of R is fully functionally dependent on every key of R

(C) Every relation in BCNF is also in 3 NF

(D) No relation can be in both BCNF and 3 NF

MCQ

Consider the following relational schemes for a library database:

Book (Title, Author, Catalog_no, Publisher, Year, price)

Collection (Title, Author, Catalog_no)

With the following functional dependencies:

I. TitleAuthor ⟶ Catalog_no

II. Catalog_no ⟶ Title Author Publisher Year

III. Publisher Title Year → Price

Assume { Author, Title} is the key for both schemes.

Which of the following statements is true?

[GATE-2008-CS: 2M]

A. Both Book and Collection are in BCNF

B. Both Book and Collection are in 3 NF only

C. Book is in 2 NF and Collection is in 3NF

D. Both Book and Collection are in 2 NF only

MCQ

Let R(A, B, C, D, E, P, G) be a relational schema in which the following functional dependencies are known to hold:

$AB \to CD$, $DE \to P$, $C \to E$, $P \to C$ and $B \to G$.

The relational schema R is

[GATE-2008-CS: 2M]

A. in BCNF

B. in 3NF, but not in BCNF

C. in 2 NF, but not in 3 NF

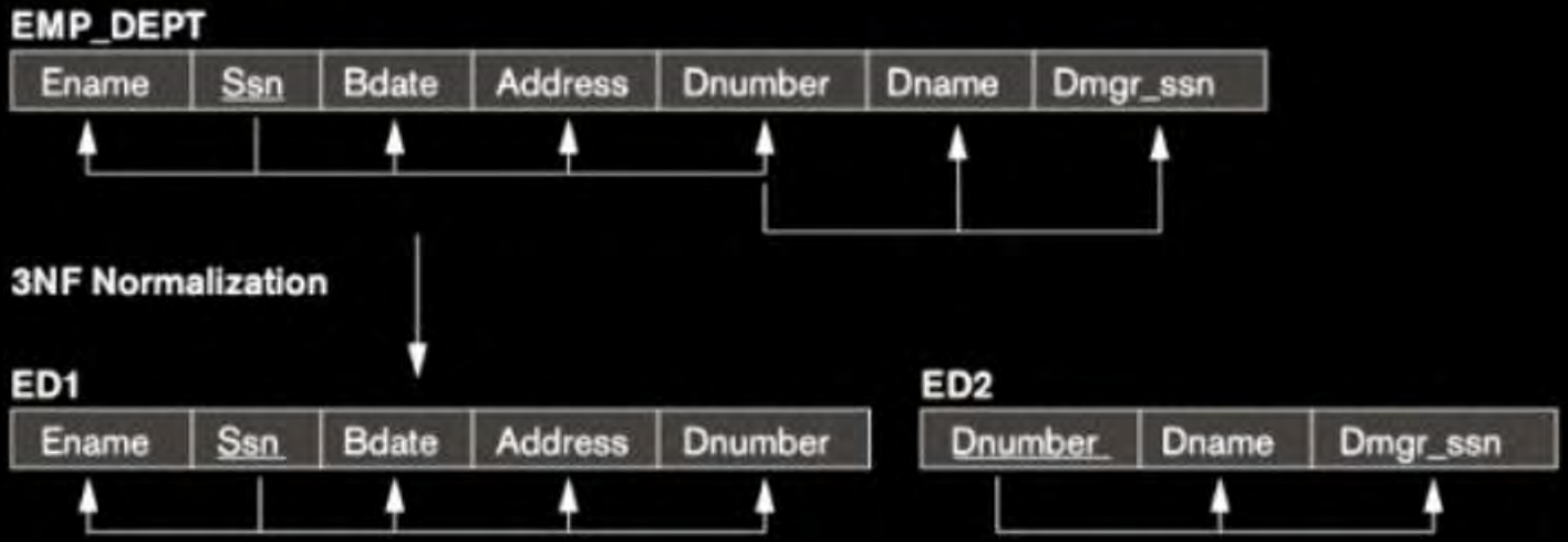
D. not in 2 NF

Normal Forms

Third Normal Form

Definition: According to Codd's original definition, a relation schema R is in 3NF if it satisfies 2NF and no nonprime attribute of R is transitively dependent on the primary key.

Definition: A relation schema R is in third normal form (3NF) if, whenever a nontrivial functional dependency $X \rightarrow A$ holds in R either (a) X is a superkey of R, or (b) A is a prime attribute of R.


EMP_DEPT
Ename
Ssn
Bdate
Address
Dnumber
Dname
Dmgr_ssn
3NF Normalization
ED1
Ename
Ssn
Bdate
Address
Dnumber
ED2
Dnumber
Dname
Dmgr_ssn

3NF Decomposition

Q.2 R(ABCDEF) [AB → C, C → D, D → E, E → F]

Candidate key = [AB]

Non key Attribute = [C, D, E, F]

CHECK 3NF ?

$$\left.\begin{array}{l} C \to D \\ D \to E \\ E \to F \end{array}\right\} \text{Violate 3NF}$$

$C \to D$

$D \to E$

$E \to F$

3NF Decomposition.

R_1	R_2	R_3	R_4
ABC	CD	DE	EF

3NF + D.P

+ Lossless

3NF Decomposition

already Done in 2NF

Q.3 R (ABCDEFGHIJ) {AB→C, BD→EF, AD→GH, A→I, H→J}

Candidate key = ABD.

2NF Decomposition

ABD	ABC	BDEF	ADGHJ	AI

3NF Decomposition.

R_1	R_2	R_3	R_4	R_5	R_6
ABD	ABC	BDEF	ADGH	HJ	AI

3NF + lossless + D.P

3NF Decomposition

Q.4 R (ABCD) {AB→CD, D→A}

Candidate key = [AB, DB]

CHECK 3NF ?

AB → CD: AB is a Super key.

D → A; D is Not Super key
But A is key/Prime Attribute
So R is in 3NF.

Already R is in 3NF.

So '0' additional Table (Relation) Required for 3NF Decomposition.

3NF Decomposition

Q.5 R (ABCDEFGH) {A→BC, B→DEF, DE→AGH}

Candidate key = [A, DE, B]

$$\left.\begin{array}{l} A \rightarrow BC \\ B \rightarrow DEF \\ DE \rightarrow AGH \end{array}\right\} X : \text{superkey}$$

R is in 3NF &
BCNF.

Q.6 R(ABCDE) {AB → C, C → D, B → E}

Decompose into 2NF, 3NF, ~~BCNF~~

Candidate key = [AB].

Non key Attribute = [C, D, E]

Check 2NF ?

B → E

Violation of 2NF

2NF Decomposition

R(ABCD~~E~~)

$(B)^+ = (BE)$

R1: ABCD   R2: BE

R is in 2NF But Not in 3NF

Bcz of C → D

3NF Decomposition

R1: ABC   R2: CD   R3: BE

3NF +
Lossless +
D.P.

& also is in BCNF

Bcz in R1, R2 & R3 X: super key
X → Y

BCNF

$X \to Y$ Every Non Trivial FD is in BCNF

iff

X : Super key.

Boyce – Codd Normal Form

Definition: A relation schema R is in BCNF if whenever a nontrivial functional dependency $X \rightarrow A$ holds in R, then X is a superkey of R.

$X \rightarrow A$

X : super key

BCNF Decomposition

Q.1 R(ABCDE) $\{A \to B, B \to C, C \to D, D \to E\}$

Candidate key = [A]

Non key Attribute = [B, C, D, E]

CHECK 2NF ?

YES R is in 2NF.

CHECK 3NF ?

$\left.\begin{array}{l} B \to C \\ C \to D \\ D \to E \end{array}\right\}$ Not in 3NF

3NF Decomposition

R_1	R_2	R_3	R_4
$\underline{A}\,B$	$\underline{B}\,C$	$\underline{C}\,D$	$\underline{D}\,E$

3NF + D.P + Lossless & BCNF

BCNF Decomposition.

Step1 : first find Minimal Cover & Candidate key.

BCNF Decomposition

Q.1 R(ABCDE) $\{A \to B, B \to C, C \to D, D \to E\}$

Candidate key = [A]

Check BCNF ?

$B \to C$
$C \to D$
$D \to E$

BCNF Violate

Not in BCNF

BCNF Decomposition.

R(AB~~C~~D~~E~~)

① $B \to C$

× $C \to D$

② $D \to E$

$R_2(BC)$

$R_3(DE)$

R_1	R_2	R_3
ABD	BC	DE

BCNF Decomposition

Q.1 R(ABCDE) $\{A \to B, B \to C, C \to D, D \to E\}$

Candidate key = [A]

Check BCNF ?

$B \to C$
$C \to D$
$D \to E$

BCNF Violate.

Not in BCNF

BCNF Decomposition.

R(AB$\cancel{C}\cancel{D}$E)

② $B \to C$
① $C \to D$
× $D \to E$

R_2(C D)
R_3(B C)

R_1	R_2	R_3
ABE	CD	BC

BCNF Decomposition

Q.1 R(ABCDE) $\{A \to B, B \to C, C \to D, D \to E\}$

Candidate key = [A]

Check BCNF ?

$B \to C$
$C \to D$
$D \to E$

BCNF Violate.

Not in BCNF

BCNF Decomposition.

R(AB$\cancel{C}\cancel{D}\cancel{E}$)

(3) $B \to C$
(2) $C \to D$
(1) $D \to E$

$R_2(DE)$
$R_3(CD)$
$R_4(BC)$

$\boxed{AB}$ $\quad R_2\ \boxed{DE}$ $\quad R_3\ \boxed{CD}$ $\quad R_4\ \boxed{BC}$

BCNF Decomposition

Q.2 R(ABCD) $\{AB \to CD, D \to A\}$

Candidate key = (AB, DB)

CHECK BCNF ?

AB → CD ✓ BCNF (AB is Super key)

D → A [D is Not Super key)

So Not in BCNF.

BCNF Decomposition

R(~~A~~BCD)

D → A

R_2 (D A)

R_1

B C D

R_2

D A

DB is CK

BCNF + Lossless

+ Dep. Not Preserved.

$R_1 \cap R_2 = D$

$(D)^+ = (DA)$

Lossless

BCNF Decomposition

Q.3 R(ABCDE) $\{A \rightarrow B, BC \rightarrow D, D \rightarrow E\}$

Candidate key = [AC]

Check BCNF

$A \rightarrow B$

$BC \rightarrow D$

$D \rightarrow E$

Violate BCNF.

I BCNF Decomposition

R(ABCDE)

1 $A \rightarrow B$

$BC \rightarrow D$

2 $D \rightarrow E$

$R_2(AB)$

$R_3(DE)$

R_1	R_2	R_3
ACD	AB	DE

II BCNF Decomposition

R(ABCDE)

2 $A \rightarrow B$

1 $BC \rightarrow D$

$D \rightarrow E$

$R_2(BCD)$

$R_3(AB)$

R_1	R_2	R_3
ACE	BCD	AB

III BCNF Decomposition.

R(ABCDE)

$A \rightarrow B$

2 $BC \rightarrow D$

1 $D \rightarrow E$

$R_2(DE)$

$R_3(BCD)$

$R_4(AB)$

R_1	R_2	R_3	R_4
AC	DE	BCD	AB

BCNF

+D.P

+LJ

+Key

If $BC \rightarrow D$

$$\left.\begin{array}{l} B \rightarrow D \\ C \rightarrow D \end{array}\right] \times$$

$B \rightarrow CD$

$B \rightarrow C$ ✓

$B \rightarrow D$ ✓

BCNF Decomposition

H.W

Q.4 $R(ABCDEFG)$ $\{A \rightarrow BF, F \rightarrow DEG, A \rightarrow D\}$

Q.5 R(ABCDEFGHIJ) $\{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$

Candidate key = [AB]

Non key Attribute = [C, D, E, F, G, H, I, J]

CHECK 2NF ?

$A \rightarrow DE$, $B \rightarrow F$ } Violate 2NF.

$(A)^+ = [ADEIJ]$

$(B)^+ = [BFGH]$

2NF Decomposition

R(ABC~~DEFGHIJ~~)

R_2 [ADEIJ]

R_3 (BFGH)

2NF But Not in 3NF ($D \rightarrow IJ$, $F \rightarrow GH$)

ABC

ADEIJ

BFGH

3NF Decomposition

ABC

ADE

DIJ

BF

FGH

3NF + lossless + D.P

&

BCNF + lossless + D.P

Q.5 R(ABCDEFGHIJ) $\{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$

Candidate

ABC ADE BF FGH DIJ

BCNF

\+ Lossless

\+ Dep. Preserving.

Q.5 R(ABCDEFGHIJ) $\{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$

Candidate

BCNF:

R_1	R_2	R_3	R_4	R_5
<u>A B</u> C	<u>A</u> D E	<u>B</u> F	<u>F</u> G H	<u>D</u> I J

1 lakh

1	b_1	x
2	b_1	x
3	b_1	x
4	b_1	x
5	b_1	x
6	c_1	y
7	c_1	y
8	c_1	y
9	c_1	y
10	c_1	y
11	c_1	y

$$\boxed{\begin{array}{cc} b_1 & x \\ c_1 & y \end{array}}$$

Univerisity DB. → 1 lakh student
8 semester

Roll	Name	Father N	MN	10th	12th	DOB	Add.	Phone	Gm ~~email~~ ID

7 time Unnessary Repeat

for 1 Student 40 Attribute 7 time Repeat

Arity (#field) = 50 (eg Name FN. MN. - - - - -)

40 X 7 = 280 Attribute

40 same

10 Attribute Unique

8 Semester

1 lakh Student = 1 lakh X 280
= 280L
= 2.8 Crore
Attribute extra

Q

Relation R is decomposed using a set of functional dependencies, F, and relation S is decomposed using another set of functional dependencies, G. One decomposition is definitely BCNF, the other is definitely 3NF, but it is not know which is which. To make a guaranteed identification, which one of the following tests should be used on the decompositions? (Assume that the closures of F and G are available).

[2002: 2 Marks]

3NF

R

S

BCNF Test

R

S

Any one Pass

(A) Dependency-preservation

(B) Lossless-join

(C) BCNF definition

(D) 3 NF definition

Q Which of the following relational schema with given FD's follows is/are in BCNF?

(A) R(ABCDE) and FD's are $\{A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow E, C \rightarrow A\}$

(B) R(ABCDE) and FD's are $\{A \rightarrow B, C \rightarrow D, D \rightarrow E\}$

(C) R(ABCD) and FD's are $\{A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow A\}$

(D) R(ABCD) and FD's are $\{A \rightarrow B, B \rightarrow C, C \rightarrow A\}$

Q

Consider the following Relation:

R(ABCDEFG) with FD set of Relation R $\{A \rightarrow B, C \rightarrow D, E \rightarrow FG\}$. What is the minimum number of relations required to decompose into BCNF which satisfy lossless join and Dependency preserving decomposition ________

10th : 3NF

12th : BCNF

R

10th

S

10th 12th

$A \xrightarrow{1000} B$

Transaction

Read(A)

$A = A - 1000$

Write(A)

Read(B)

$B = B + 1000$

Write(B)

Transaction Concept

- A transaction is a unit of program execution that accesses and possibly updates various data items.
- E.g. Transaction to transfer Rs 500 from account A to account B:

1. read (A)
2. A : = A – 500
3. write(A)
4. read(B)
5. B: = B + 500
6. write(B)

A C I D

Atomicity

Consistency.

Isolation

Durablity.

ACID Properties

- A transaction is a unit of program execution that accesses and possibly updates various data items. To preserve the integrity of data the database system must ensure:

1 A. Atomicity

2 C. Consistency

3 I. Isolation

4 D. Durability

1. **Atomicity**: Either execute all operation of the transaction successfully or None of them.

(FULL OR None]

ACID Properties

- (1) Atomicity: Either all operations of the transaction are properly reflected in the database or none are.
- Consistency: Execution of a transaction in isolation preserves the consistency of the database.
- Isolation: Although multiple transactions may execute concurrently, each transaction must be unaware of other concurrently executing transactions. Intermediate transaction results must be hidden from other concurrently executed transactions.

- That is, for every pair of transactions T_i and T_j, it appears to T_i that either T_j, finished exection before T_i started, or T_j started execution after T_i finished.

- Durability: After a transaction completes successfully, the changes it has made to the database persist, even if there are system failures.

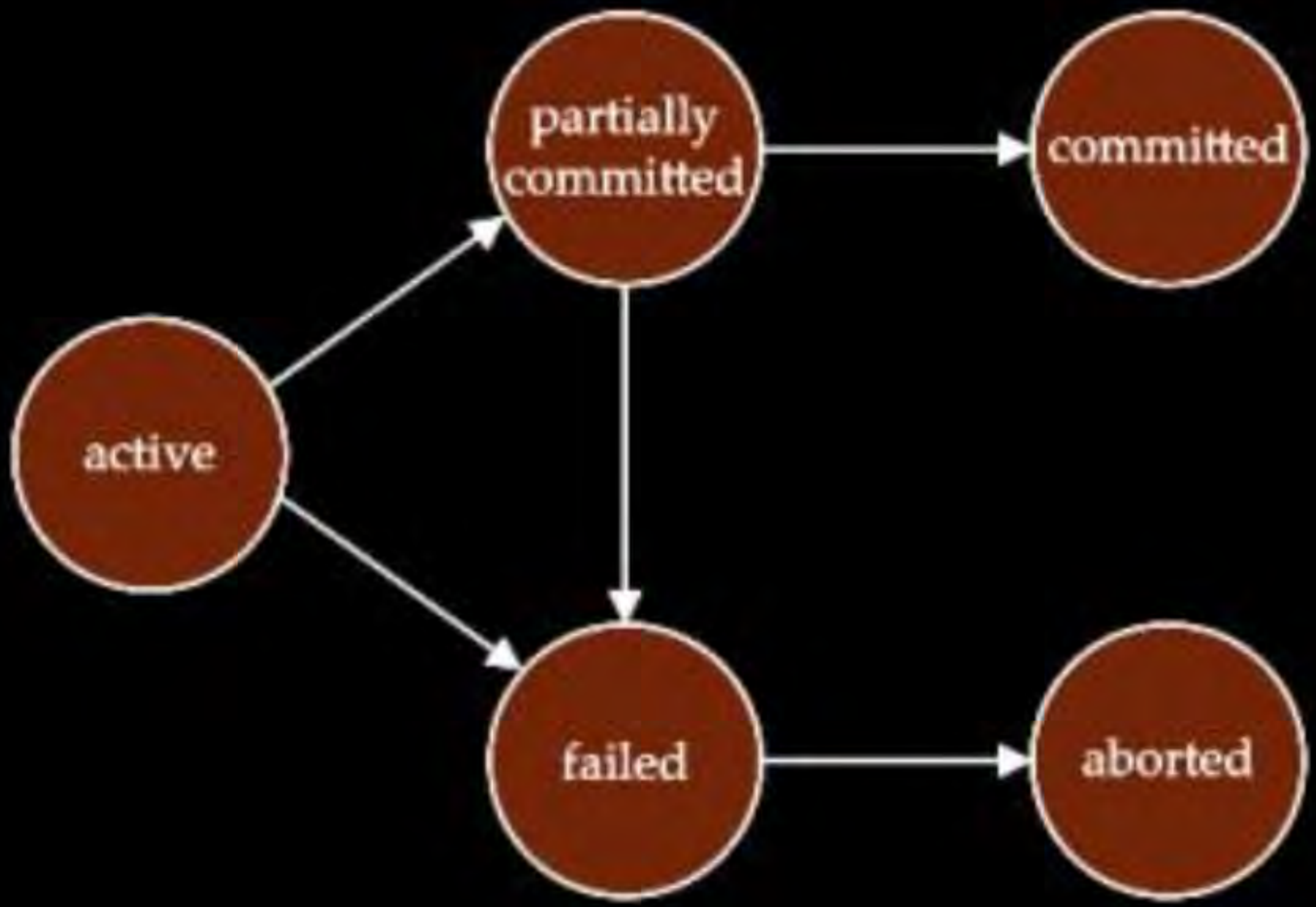
Transaction State

- Active : the initial state; the transaction stays in this state while it is executing.
- Partially committed : after the final statement has been executed.
- Failed: after the discovery that normal execution can no longer proceed.
- Aborted: after the transaction has been rolled back and the database restored to its state prior to the start of the transaction. Two options after it has been aborted:

- Restart the transaction
  - Can be done only if no internal logical error
- Kill the transaction

- **Committed:** After successful completion.

Transaction State (Cont.)



Schedules

- Schedule: a sequences of instructions that specify the chronological order in which instructions of concurrent transactions are executed.
  - A schedule for a set of transactions must consist of all instructions of those transactions
  - Must preserve the order in which the instructions appear in each individual transaction.
- A transaction that successfully completes its execution will have a commit instructions as the last statement
  - By default transaction assumed to execute commit instruction as its last step

- A transaction that fails to successfully complete its execution will have an abort instruction as the last statement.

Let T_1 transfer 100 Rs from A to B, and T_2 transfer 10% of the balance from A to B.

A = 2000
+B = 3000
5000

Schedule 1

T_1	T_2
read (A)	
A: = A – 100	
write (A)	
read (B)	
B: = B + 100	
write (B)	
commit	
	read (A)
	temp := A * 0.1
	A := A – temp
	write (A)
	read (B)
	B := B + temp
	write (B)
	Commit

$S_1 < T_1\ T_2 >$

Serial schedule in which T_1 is followed by T_2:

A = 2000
B = 3000
5000

Schedule 2

T_1	T_2
	read (A)
	temp := A * 0.1
	A := A – temp
	write (A)
	read (B)
	B := B + temp
	write (B)
	Commit
read (A)	
A: = A – 100	
write (A)	
read (B)	
B: = B + 100	
write (B)	
commit	

$S_2 < T_2\ T_1 >$

serial schedule where T_2 is followed by T_1

A: 2000
+B: 3000
5000

Schedule 3

T_1	T_2
read (A)	
A: = A – 100	
write (A)	
	read (A)
	temp := A * 0.1
	A := A – temp
	write (A)
read (B)	
B: = B + 100	
write (B)	
commit	
	read (B)
	B := B + temp
	write (B)
	Commit

C_1

A: 2000
+B: 3000
5000.

Schedule 4

T_1	T_2
read (A)	
A: = A – 100	
	read (A)
	temp := A * 0.1
	A := A – temp
	write (A)
write (A)	
read (B)	
B: = B + 100	
write (B)	
commit	
	read (B)
	B := B + temp
	write (B)
	Commit

C_2

Serial Schedule

- After Commit of one transaction, begins (Start) another transaction.
- Number of possible serial Schedules with 'n' transactions is "n!"
- The execution sequence of Serial Schedule always generates consistent result.

Example

S : $R_1(A)$ $W_1(A)$ Commit (T_1) $R_2(A)W_2(A)$ commit (T_2).

Advantage

- Serial Schedule always produce correct result (integrity guaranteed)

as no resource sharing.

Disadvantage

- Less degree of concurrency.
- Through put of system is low.
- It allows transactions to execute one after another.

THANK YOU!