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DATE
PAGE NO.

Q. 1.

Given

For r(A, B, C, D, E)

1) AB → C, D → E, B → E
2) A → CD, B → DE
3) AB → C, C → D

Find a candidate key for the given schema:

For AB → C, D → E, B → E :-

→ The RHS doesn't have A, B, D, so they must be in candidate key.
ABD^+ = ABDCE [closure of ABD]
· It contains all the attributes and is minimal. So, (ABD) is a ~~superkey~~ candidate key.

For A → CD, B → DE

→ RHS doesn't have AB, so they must definitely be there in candidate key.

Closure of AB = AB^+ = ABCDE which contains all attributes and is minimal and hence is a ~~superkey~~ candidate key. ∴ AB is candidate key.

For AB → C, C → D
→ RHS doesn't have A, B, E, so they must be there in candidate key.
ABE^+ = ABECD, all attributes and minimal.
∴ ABE is a candidate key.

DATE
PAGE No.

Q.1. continued.

Find the attribute closure ~~attrib~~ of AB.

For $AB \to C$, $D \to E$, $B \to E$

$AB^+ = ABCE$

For $A \to CD$, $B \to DE$

$AB^+ = ABCDE$

For $AB \to C$, $C \to D$

$AB^+ = ABCD$

Q.2. Decompose into BCNF (Boyce Codd Normal Form)

1) $AB \to C$, $D \to E$, $B \to E$

→ Candidate key = {ABD}
→ Prime Attributes = {A, B, D}
→ Non-prime Attributes = {C, E}

For BCNF, LHS must be candidate key or super key.

$AB \to C$ doesn't satisfy the condition.
Neither do $D \to E$ and $B \to E$

DATE
PAGE No.

→ $AB \to C$ violation can be removed by decomposing ABCDE into ABDE and ABC.

→ $D \to E$ can be removed by decomposing ABDE to ABD and DE. Doing this removes the $B \to E$ dependency and we achieve BCNF.

ABD, DE, ABC

↓

Candidate key = {ABD}

2) For $A \to CD$, $B \to DE$

→ Candidate key = {AB}

→ Prime attributes = {A, B}

→ Non-prime attributes = {C, D, E}

$A \to CD$ and $B \to DE$ both are not in BCNF.

For $A \to CD$, we decompose ABCDE into ACD and ABE. Still $B \to E$ won't satisfy so we decompose ABE into BE and AB and we have BCNF.

ACD, AB, BE

3) $AB \to C$, $C \to D$

→ Candidate key = {ABE}

Both violations

From $C \to D$, we decompose ABCDE to ABCE and CD. With $AB \to C$, we decompose ABCE into ABC and ABE.

Q.3. Ans

1) A → CD, B → DE, C → D

For canonical cover

Expanding

A → C, A → D, B → D, B → E, C → D

→ A → D is not needed

so, [A → C, B → D, B → E, C → D]

or [A → C, B → DE, C → D]

For 3NF form

A → C, B → DE, C → D (canonical cover)

A, B must be in candidate key as they are not in RHS.

$(AB)^+$ = ABCDE, so AB is candidate key.

→ Prime attr = {A, B}

→ For 3NF, LHS must be candidate key or super key or RHS must be prime attribute.

ABCDE

All the dependencies are violating 3NF.

To get rid of B → DE violation,

simplest way is to decompose ABCDE into

BDE and ACD and AB. still

C → D will violate, so decompose

ACD to AC and CD.

Finally

AC, CD, BDE, AB

For A → B, B → C, A → C, D → E, B → E, AD → E

→ A → C is not needed.

[A → B, B → C, D → E, B → E, AD → E]

∵ D → E is already there AD → E is not needed.

So, Finally

[A → B, B → C, D → E, B → E]

or [A → B, B → CE, D → E]

For candidate key, A and D must be in ~~RHS~~ candidate key atleast.

AD^+ = ABCDE, so AD is candidate key.

→ Prime attrs {A, D}.

~~To~~ → 3NF form is violated

→ Decompose ~~ABCDE~~ ABCDE to AB, BCE, DE, AD and we get 3NF form

AB solves A → B violation

DE solves D → E violation

BCE solve B → CE violation

and AD to maintain candidate key.

DATE
PAGE No.

Q. 4. Ans

student (ID, name, courseID, year, semester, grade)
instructor(ID, name, deptname, deptbudget)

For student

[ID → name]
[ID, courseID, year, semester → grade] (This is taken like this because we don't want to lose other data. We could very well just use ID, courseID but doing that we will not be able to figure out thing like when did this student take this course)

For instructor

[I.D → name]
[deptname → deptbudget]

For student

Candidate key = (ID, courseID, year, semester)
because they are not in RHS and their closure includes all attributes.

For Instructor

Candidate key = (ID, deptname)
because they are not in RHS and their closure includes all attributes.

BCNF Form

~~ID → name~~ Decompose (ID, CourseID, name, year, semester, grade)

to (ID, name) and (I.D, courseID, year, semester, grade)

& we have BCNF form for student

For instructor

Con

Decompose (ID, name, deptname, deptbudget) into (ID, name, deptname) and (deptname, deptbudget) and we have BCNF form.