CLASS 10/05/2021

Q) Consider a universal relation R={A,B,C,D,E,F,G,H,I,J} and the set of FD

F={ AB→C, A→DE, B→F,F→GH,D→IJ}. What is the key of R? Decompose R into 2NF and 3NF relations.

→

(AB)+={AB}

={ABC} AB→C

={ABCDE} A→DE

={ABCDEF} B→F

={ABCDEFGH} F→GH

={ABCDEFGHIJ} D→IJ

=R

So AB is the candidate key.

As the relation R contains candidate key so R is in 1NF.

2NF?

AB is candidate key and also A→DE exist. As A is a subset of candidate key AB so A→DE is a partial dependency.

AB is candidate key and also B→F exist. As B is a subset of candidate key AB so B→F is partial dependency.

Hence R is not in 2NF.

To remove the partial dependency A→DE, Find

(A)+={ A}

={ADEIJ} Rule A→DE, D→IJ

To remove the partial dependency B→F, Find

(B)+={B}

={BFGH} Rule B→F, F→GH

We remove PD A→DE by creating a relation for (A)+

R1=(A)+={ADEIJ} with FD set F1={A→DE,D→IJ}

with candidate key A.

We remove PD B→F by creating a relation for (B)+

R2=(B)+={BFGH} with FD set F2={B→F, F→GH}

And a third relation

R3={R-(R1UR2)}UAB={ABC} with FD set F3={AB→C}

Hence R1,R2,R3 is in 2NF.

3NF?

- For relation R1

R1={ADEIJ} with FD set F1={A→DE,D→IJ}

We have A→D a FD as A is primary key and D is a non prime attribute.

And also we have D→IJ. Hence IJ is transitively dependent on primary key A. Hence R1 is not in 3NF.

- For relation R2

R2=(B)+={BFGH} with FD set F2={B→F, F→GH}

And also we have B→F. Hence GH is transitively dependent on primary key B. Hence R2 is not in 3NF.

- For relation R3

R3={ABC} with FD set F3={AB$\rightarrow$C}. There is no transitive dependency hence it is in 3NF.

To convert relation R1 in 3NF we are removing D$\rightarrow$IJ which is causing transitivity,

R11=(D)+={DIJ} with FD set F11={D$\rightarrow$IJ}

R12=(R1-R11)UD={AED} with FD set F12={A$\rightarrow$DE}

To convert relation R2 in 3NF we are removing F$\rightarrow$GH from R2.

R21=(F)+={FGH} with FD set F21={F$\rightarrow$GH}

R22=(R2-R21)UF={BF} with FD set F22={B$\rightarrow$F}

Hence the 3NF decomposition of R is

- R11=(D)+={DIJ} with FD set F11={D$\rightarrow$IJ}
- R12=(R1-R11)UD={AED} with FD set F12={A$\rightarrow$DE}
- R21=(F)+={FGH} with FD set F21={F$\rightarrow$GH}
- R22=(R2-R21)UF={BF} with FD set F22={B$\rightarrow$F}
- R3={ABC} with FD set F3={AB$\rightarrow$C}.

General 2NF

A relation is in 2NF if every non-key attribute is fully functionally dependent on all candidate keys.

General 3NF

A relation is in 3NF if every functional dependency of the form X→A where X is a set of attributes and A is a single attribute then

- either X is a super key
- or A is a prime attribute

- Example1: R11=(D)+={DIJ} with FD set F11={D→IJ}

Is it in 3NF?

Primary key D.

D→IJ can be written as

D→I

Left hand is superkey

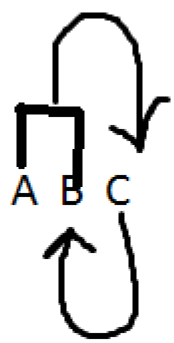
D→J

Left hand is superkey

Hence R11 is in 3NF.

- Example2: R=(ABC) with FD set F={AB→C,C→B}

Is it in 3NF?



Here primary key AB.

For AB→C,

left hand side is super key.

C→B

right hand side B is prime attribute .

Hence R is in 3NF.

Boyce Codd Normal Form(BCNF)

A relation is in BCNF if every functional dependency of the form X→A where X is a set of attributes and A is a single attribute then

- X must be a super key

- Example1: R11=(D)+={DIJ} with FD set F11={D→IJ}

Is it in BCNF?

Primary key D.

D→IJ can be written as

D→I

D→J

For both the FD LHS is superkey. Hence R11 is in BCNF.

- Example2: R=(ABC) with FD set F={AB→C,C→B}

Is it in BCNF?

Primary key AB.

For FD AB→C , LHS AB is superkey

For FD C→B. LHS C is not superkey.

Hence it is violating BCNF. Hence R is not in BCNF.

BCNF decomposition

- Let us consider there is a relation R
- A FD X→Y is violating BCNF property

  Decompose R into

  R1=(XUY)

  R2=(R-Y)

For last example:

C→B is violating BCNF.

Hence R1=(CB)   with FD set ={C→B}

and R2=(AC) with AC is primary key.

So we have lost the FD AB→C.

So this decomposition is not dependency preserving.

- **Lossless Join Decomposition or Non additive decomposition**

Definition: A decomposition D={R1,R2,R3,…,Rn} of a relation schema R is lossless w.r.t a set of functional dependencies F on R if every relation r of schema R, the following holds,

$\Pi_{R1}(r)* \Pi_{R2}(r)* \Pi_{R3}(r)*\ldots.. \Pi_{Rn}(r)=r$

* represents natural join.

Testing Lossless decomposition into more than 2 relations

Example:

R={ssn,ename,pnumber,pname,plocation,hours}

There is a decomposition D={R1,R2,R3}

R1=EMP={ssn,ename}

R2=PROJ={pnumber,pname,plocation}

R3=Works_ON={ssn,pnumber,hours}

FD set F={ssn→ename,

pnumber→pname,plocation

ssn pnumber→hous}

Is D lossless?

	ssn	ename	pnumber	pname	ploaction	hours
R1	a1	a2	b13	b14	b15	b16
R2	b21	b22	a3	a4	a5	b26
R3	a1	b32	a3	b34	b35	a6

Apply ssn→ename

	ssn	ename	pnumber	pname	ploaction	hours
R1	a1	a2	b13	b14	b15	b16
R2	b21	b22	a3	a4	a5	b26
R3	a1	a2	a3	b34	b35	a6

pnumber→pname plocation

	ssn	ename	pnumber	pname	ploaction	hours
R1	a1	a2	b13	b14	b15	b16
R2	b21	b22	a3	a4	a5	b26
R3	a1	a2	a3	a4	a5	a6

As the last row contains all a symbols hence the decomposition is lossless.

Testing Lossless decomposition into 2 relation

- A decomposition D={R1,R2} of R is lossless w.r.t a set of FD F on R iff
  - either (R1ΠR2)→(R1-R2) is in F+
  - or (R1ΠR2)→(R2-R1) is in F+

Example:

R=(ABC) FD set F={AB→C,C→B}

Decomposition D={R1,R2} and R1=(CB),R2=(AC). Test whether it is lossless?

R1ΠR2=(CB) Π(AC)=C

R1-R2=B

R2-R1=A

Here R1ΠR2→(R1-R2) i.e. C→B is in F

Hence this decomposition is lossless.