

EXERCÍCIOS

1. Considere a relação $R(A, C, D, E, H)$. Calcule o conjunto de cobertura mínima de cada um dos conjuntos de dependências funcionais abaixo:

1.1. $F = \{A \rightarrow C, CA \rightarrow D, E \rightarrow AD, E \rightarrow H\}$

Find Minimal Cover

$A \rightarrow C$
 $A \rightarrow D$
 $E \rightarrow A$
 $E \rightarrow H$

1.2. $G = \{A \rightarrow CD, E \rightarrow AH\}$

Find Minimal Cover

$A \rightarrow C$
 $A \rightarrow D$
 $E \rightarrow A$
 $E \rightarrow H$

- 1.3. Os conjuntos de dependências funcionais F e G são equivalentes?

- Sim. São equivalentes pois os conjuntos de cobertura mínima de ambos são iguais.

2. Considere o esquema de relação

$EMP_DEPT(ename, ssn, bdate, address, dnumber, dname, dmgrssn)$

e o seguinte conjunto G de dependências funcionais em EMP_DEPT :

$$G = \{\{ssn\} \rightarrow \{ename, bdate, address, dnumber\}, \\ \{dnumber\} \rightarrow \{dname, dmgrssn\}\}$$

Calcule o conjunto de cobertura mínima de G .

Find Minimal Cover

$ssn \rightarrow ename$
 $ssn \rightarrow bdate$
 $ssn \rightarrow address$
 $ssn \rightarrow dnumber$
 $dnumber \rightarrow dname$
 $dnumber \rightarrow dmgrssn$

3. Considere a relação $R(A, B, C, D, E, F, G, H, I, J)$ e o conjunto de dependências funcionais $F = \{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$.

3.1. Qual são as chaves candidatas de R ?

- São candidatas A e B . Conforme imagem.

Candidate Keys Found

- A B

3.2. Ela está na 3NF?

- Não atende os critérios para 2NF, 3NF e nem BCNF. Conforme imagem.



2NF

The table is not in 2NF.



3NF

The table is not in 3NF.



BCNF

The table is not in BCNF.

3.3. Em caso negativo, decomponha R em relações 3NF.

- Seguindo o primeiro método:

Step 1: Find the minimal cover of FDs, which contains

$A, B \rightarrow C$
 $A \rightarrow D$
 $A \rightarrow E$
 $B \rightarrow F$
 $F \rightarrow G$
 $F \rightarrow H$
 $D \rightarrow I$
 $D \rightarrow J$

Step 2. Find all candidate keys. The set of candidates keys is $\{(A, B), \}$.
The set of key attributes is: $\{A, B\}$.

Step 3: Merge FDs with same LHS and whose RHS are non-key attributes, we get the set F_1 which contains:

$A, B \rightarrow C$
 $A \rightarrow E, D$
 $B \rightarrow F$
 $F \rightarrow H, G$
 $D \rightarrow J, I$

Step 4: Check each FD in the set F1 for violation of 3NF, and split table accordingly.

Checking FD $A, B \rightarrow C$

FD does not violate 3NF

Checking FD $A \rightarrow E, D$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).

The following 3NF table is obtained:

A, E, D
with FDs
 $A \rightarrow D, E$

Checking FD $B \rightarrow F$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).

The following 3NF table is obtained:

B, F
with FDs
 $B \rightarrow F$

Checking FD $F \rightarrow H, G$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).

The following 3NF table is obtained:

F, H, G
with FDs
 $F \rightarrow H, G$

Checking FD $D \rightarrow J, I$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).

The following 3NF table is obtained:

D, J, I
with FDs
 $D \rightarrow J, I$

Step 5: Finally, add the following table into normalized 3NF table set (obtained by removing RHS attributes of FDs using which we produced a table):

A, B, C
with FDs
 $A, B \rightarrow C$

4. Considere a relação $R(A, B, C, D, E, F, G, H, I, J)$ e o conjunto de dependências funcionais $F = \{AB \rightarrow C, BD \rightarrow EF, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$.

4.1. Qual são as chaves candidatas de R ?

- São chaves candidatas A, B e D.

Candidate Keys Found

- A B D

4.2. Ela está na 3NF?

- Não atende os critérios para 2NF, 3NF e nem BCNF. Conforme imagem.



2NF

The table is not in 2NF.



3NF

The table is not in 3NF.



BCNF

The table is not in BCNF.

4.3. Em caso negativo, decompõe R em relações na 3NF.

- Seguindo o primeiro método:

Step 1: Find the minimal cover of FDs, which contains

$A, B \rightarrow C$
 $B, D \rightarrow E$
 $B \rightarrow F$
 $F \rightarrow G$
 $F \rightarrow H$
 $D \rightarrow I$
 $D \rightarrow J$

Step 2. Find all candidate keys. The set of candidate keys is $\{ (A, B, D), \}$.
The set of key attributes is: $\{ A, B, D \}$.

Step 3: Merge FDs with same LHS and whose RHS are non-key attributes, we get the set F1 which contains:

$A, B \rightarrow C$
 $B, D \rightarrow E$
 $B \rightarrow F$
 $F \rightarrow H, G$
 $D \rightarrow J, I$

Step 4: Check each FD in the set F1 for violation of 3NF, and split table accordingly.

Checking FD $A, B \rightarrow C$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

A, B, C
with FDs
 $A, B \rightarrow C$

Checking FD $B, D \rightarrow E$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

B,D,E
with FDs
 $B,D \rightarrow E$

Checking FD $B \rightarrow F$
The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

B,F
with FDs
 $B \rightarrow F$

Checking FD $F \rightarrow H,G$
The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

F,H,G
with FDs
 $F \rightarrow H,G$

Checking FD $D \rightarrow J,I$
The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

D,J,I
with FDs
 $D \rightarrow J,I$

Step 5: Finally, add the following table into normalized 3NF table set (obtained by removing RHS attributes of FDs using which we produced a table):

A,B,D
with FDs

5. Considere uma relação $R(A, B, C, D, E)$ e o conjunto de dependências funcionais $F = \{AB \rightarrow C, CD \rightarrow E, DE \rightarrow B\}$

AB é uma chave candidata dessa relação? Se não, ABD é?

- Não. Tanto AB quanto ABD não são chaves candidatas da relação.

Candidate Keys Found

- A D B
- A D C
- A D E

6. Considere a relação R, que possui atributos que guardam horários de cursos e seções em uma universidade:

R(courseno, secno, offeringdept, credithours, courselevel,
instructorssn, semester, year, dayshours, roomno, noofstudents)

Suponha que as seguintes dependências funcionais em R:

$\{\text{courseno}\} \rightarrow \{\text{offeringdept}, \text{credithours}, \text{courselevel}\},$
 $\{\text{courseno}, \text{secno}, \text{semester}, \text{year}\} \rightarrow$
 $\{\text{dayshours}, \text{roomno}, \text{noofstudents}, \text{instructorssn}\}$
 $\{\text{roomno}, \text{dayshours}, \text{semester}, \text{year}\} \rightarrow$
 $\{\text{instructorssn}, \text{courseno}, \text{secno}\}$

Encontre as chaves candidatas para R e decomponha a relação em relações na 3NF.

- As chaves candidatas para a relação são as seguintes:

Candidate Keys Found

- semester year courseno secno
- semester year dayshours roomno

- Decompondo a relação para a 3NF, seguindo o primeiro método:

Step 1: Find the minimal cover of FDs, which contains
 courseno \rightarrow offeringdept
 courseno \rightarrow credithours
 courseno \rightarrow courselevel
 courseno,secno,semester,year \rightarrow dayshours
 courseno,secno,semester,year \rightarrow roomno
 courseno,secno,semester,year \rightarrow noofstudents
 roomno,dayshours,semester,year \rightarrow instructorssn
 roomno,dayshours,semester,year \rightarrow courseno
 roomno,dayshours,semester,year \rightarrow secno

Step 2. Find all candidate keys. The set of candidates keys is { (semester,year,courseno,secno), (semester,year,dayshours,roomno), }.
 The set of key attributes is: { semester,year,courseno,secno,dayshours,roomno }.

Step 3: Merge FDs with same LHS and whose RHS are non-key attributes, we get the set F1 which contains:
 courseno \rightarrow courselevel,credithours,offeringdept
 courseno,secno,semester,year \rightarrow noofstudents
 roomno,dayshours,semester,year \rightarrow instructorssn

Step 4: Check each FD in the set F1 for violation of 3NF, and split table accordingly.

Checking FD courseno \rightarrow courselevel,credithours,offeringdept
 The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
 The following 3NF table is obtained:

courseno,courselevel,credithours,offeringdept
 with FDs
 courseno \rightarrow courselevel,credithours,offeringdept

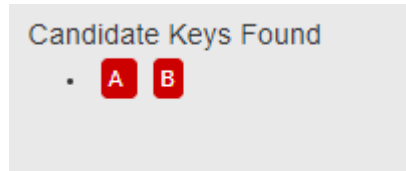
Checking FD courseno,secno,semester,year \rightarrow noofstudents
 FD does not violate 3NF
 Checking FD roomno,dayshours,semester,year \rightarrow instructorssn
 FD does not violate 3NF

Step 5: Finally, add the following table into normalized 3NF table set (obtained by removing RHS attributes of FDs using which we produced a table):

courseno,secno,instructorssn,semester,year,dayshours,roomno,noofstudents
 with FDs
 courseno,secno,semester,year \rightarrow roomno,dayshours
 dayshours,roomno,semester,year \rightarrow secno,courseno,instructorssn,noofstudents

7. Considere a relação universal $R(A, B, C, D, E, F, G, H, I, J)$ e o conjunto de dependências funcionais $F = \{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$. Determine as chaves candidatas para R , encontre uma cobertura mínima para F e decomponha R em relações na 3NF.

- As chaves candidatas para a relação são A e B . Conforme imagem:



- A cobertura mínima para F é:

Find Minimal Cover



- Decompondo a relação para a 3NF, seguindo o primeiro método:

Step 1: Find the minimal cover of FDs, which contains

A,B → C
A → D
A → E
B → F
F → G
F → H
D → I
D → J

Step 2. Find all candidate keys. The set of candidates keys is $\{(A,B), \}$.
The set of key attributes is: $\{A,B\}$.

Step 3: Merge FDs with same LHS and whose RHS are non-key attributes, we get the set F_1 which contains:

A,B → C
A → E,D
B → F
F → H,G
D → J,I

Step 4: Check each FD in the set F_1 for violation of 3NF, and split table accordingly.

Checking FD A,B → C

FD does not violate 3NF

Checking FD A → E,D

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).

The following 3NF table is obtained:

A,E,D
with FDs
A → D,E

Checking FD $B \rightarrow F$
 The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
 The following 3NF table is obtained:

B,F
 with FDs
 $B \rightarrow F$

Checking FD $F \rightarrow H,G$
 The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
 The following 3NF table is obtained:

F,H,G
 with FDs
 $F \rightarrow H,G$

Checking FD $D \rightarrow J,I$
 The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
 The following 3NF table is obtained:

D,J,I
 with FDs
 $D \rightarrow J,I$

Step 5: Finally, add the following table into normalized 3NF table set (obtained by removing RHS attributes of FDs using which we produced a table):

A,B,C
 with FDs
 $A,B \rightarrow C$

8. Considere a relação universal $R(A, B, C, D, E, F, G, H, I, J)$ e o conjunto de dependências funcionais $F = \{AB \rightarrow C, BD \rightarrow EF, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$. Determine as chaves candidatas para R , encontre uma cobertura mínima para F e decomponha R em relações na 3NF.

- As chaves candidatas para a relação são A, B e D. Conforme imagem:

Candidate Keys Found

- A B D

- A cobertura mínima para F é:

Find Minimal Cover

A B \rightarrow C

B D \rightarrow E

B \rightarrow F

F \rightarrow G

F \rightarrow H

D \rightarrow I

D \rightarrow J

- Decompondo a relação para a 3NF, seguindo o primeiro método:

Step 1: Find the minimal cover of FDs, which contains

$A, B \rightarrow C$
 $B, D \rightarrow E$
 $B \rightarrow F$
 $F \rightarrow G$
 $F \rightarrow H$
 $D \rightarrow I$
 $D \rightarrow J$

Step 2. Find all candidate keys. The set of candidates keys is $\{ (A,B,D), \}$.
The set of key attributes is: $\{ A,B,D \}$.

Step 3: Merge FDs with same LHS and whose RHS are non-key attributes, we get the set F1 which contains:

$A, B \rightarrow C$
 $B, D \rightarrow E$
 $B \rightarrow F$
 $F \rightarrow H, G$
 $D \rightarrow J, I$

Step 4: Check each FD in the set F1 for violation of 3NF, and split table accordingly.

Checking FD $A, B \rightarrow C$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

A, B, C
with FDs
 $A, B \rightarrow C$

Checking FD $B, D \rightarrow E$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

B, D, E
with FDs
 $B, D \rightarrow E$

Checking FD $B \rightarrow F$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

B, F
with FDs
 $B \rightarrow F$

Checking FD $F \rightarrow H, G$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

F, H, G
with FDs
 $F \rightarrow H, G$

Checking FD $D \rightarrow J, I$

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).
The following 3NF table is obtained:

D, J, I
with FDs
 $D \rightarrow J, I$

Step 5: Finally, add the following table into normalized 3NF table set (obtained by removing RHS attributes of FDs using which we produced a table):

A, B, D
with FDs

9. Considere a relação universal $R(A, B, C, D, E, F, G, H, I, J)$ e o conjunto de dependências funcionais $F = \{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$. Decomponha R em relações na BCNF.

- É possível verificar que a relação R não atende nenhuma NF:

Check Normal Form



2NF

The table is not in 2NF.



3NF

The table is not in 3NF.



BCNF

The table is not in BCNF.

- Decompondo a relação para a BCNF, temos o seguinte:

Step 1. Find merged minimal cover of FDs, which contains:

$A, B \rightarrow C$

$A \rightarrow D, E$

$B \rightarrow F$

$F \rightarrow G, H$

$D \rightarrow I, J$

Initially $rel[1]$ contains the original table, with the FDs above

Round1: Checking whether table $rel[1]$ is in BCNF

The FD $A \rightarrow D, E$ violates BCNF as the LHS is not superkey. Table is split into the two below:

$rel[2] = (A, D, E, I, J)$

With FDs:

$rel[3] = (A, B, C, F, G, H)$

With FDs:

Round2: Checking whether table $rel[2]$ is in BCNF

The FD $D \rightarrow I, J$ violates BCNF as the LHS is not superkey. Table is split into the two below:

$rel[4] = (D, I, J)$

With FDs:

$rel[5] = (A, D, E)$

With FDs:

Round3: Checking whether table $rel[3]$ is in BCNF

The FD $B \rightarrow F$ violates BCNF as the LHS is not superkey. Table is split into the two below:

$rel[6] = (B, F, G, H)$

With FDs:

rel[7]= (A,B,C)
With FDs:

Round4: Checking whether table rel[4] is in BCNF

*** Table rel[4] is in BCNF already, send it to output ***

Round5: Checking whether table rel[5] is in BCNF

*** Table rel[5] is in BCNF already, send it to output ***

Round6: Checking whether table rel[6] is in BCNF

The FD $[F \rightarrow G, H]$ violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[8]= (F,G,H)
With FDs:

rel[9]= (B,F)
With FDs:

Round7: Checking whether table rel[7] is in BCNF

*** Table rel[7] is in BCNF already, send it to output ***

Round8: Checking whether table rel[8] is in BCNF

*** Table rel[8] is in BCNF already, send it to output ***

Round9: Checking whether table rel[9] is in BCNF

*** Table rel[9] is in BCNF already, send it to output ***

Normalize to BCNF

Attributes

D I J

Functional Dependencies

$D \rightarrow I \ J$

Attributes

A D E

Functional Dependencies

$A \rightarrow D \ E$

Attributes

A B C

Functional Dependencies

A B \rightarrow C

Attributes

F G H

Functional Dependencies

F \rightarrow G H

Attributes

B F

Functional Dependencies

B \rightarrow F

10. Considere a relação universal $R(A, B, C, D, E, F, G, H, I, J)$ e o conjunto de dependências funcionais $F = \{AB \rightarrow C, BD \rightarrow EF, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$. Decomponha R em relações na BCNF.

- É possível verificar que a relação R não atende nenhuma NF:

Check Normal Form**2NF**

The table is not in 2NF.

**3NF**

The table is not in 3NF.

**BCNF**

The table is not in BCNF.

- Decompondo a relação para a BCNF, temos o seguinte:

Step 1. Find merged minimal cover of FDs, which contains:

$A, B \rightarrow C$
 $B, D \rightarrow E$
 $B \rightarrow F$
 $F \rightarrow G, H$
 $D \rightarrow I, J$

Initially rel[1] contains the original table, with the FDs above

Round1: Checking whether table rel[1] is in BCNF

The FD $[A, B \rightarrow C]$ violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[2] = (A, B, C, F, G, H)
With FDs:

rel[3] = (A, B, D, E, I, J)
With FDs:

Round2: Checking whether table rel[2] is in BCNF

The FD $[B \rightarrow F]$ violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[4] = (B, F, G, H)
With FDs:

rel[5] = (A, B, C)
With FDs:

Round3: Checking whether table rel[3] is in BCNF

The FD $[B, D \rightarrow E]$ violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[6] = (B, D, E, I, J)
With FDs:

rel[7] = (A, B, D)
With FDs:

Round4: Checking whether table rel[4] is in BCNF

The FD $[F \rightarrow G, H]$ violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[8] = (F, G, H)
With FDs:

rel[9] = (B, F)
With FDs:

Round5: Checking whether table rel[5] is in BCNF

*** Table rel[5] is in BCNF already, send it to output ***

Round6: Checking whether table rel[6] is in BCNF

The FD $[D \rightarrow I, J]$ violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[10] = (D, I, J)
With FDs:

rel[11] = (B, D, E)
With FDs:

Round7: Checking whether table rel[7] is in BCNF

*** Table rel[7] is in BCNF already, send it to output ***

Round8: Checking whether table rel[8] is in BCNF

*** Table rel[8] is in BCNF already, send it to output ***

Round9: Checking whether table rel[9] is in BCNF

*** Table rel[9] is in BCNF already, send it to output ***

Round10: Checking whether table rel[10] is in BCNF

*** Table rel[10] is in BCNF already, send it to output ***

Round11: Checking whether table rel[11] is in BCNF

*** Table rel[11] is in BCNF already, send it to output ***

Normalize to BCNF

Attributes

A B C

Functional Dependencies

A B \rightarrow C

Attributes

A B D

Functional Dependencies

Attributes

F G H

Functional Dependencies

F \rightarrow G H

Attributes

B F

Functional Dependencies

B \rightarrow F

Attributes

D I J

Functional Dependencies

D \rightarrow I J

Attributes

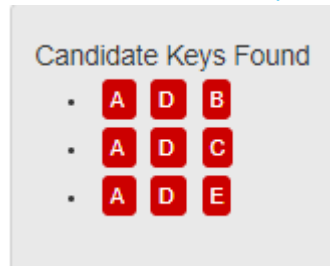
B D E

Functional Dependencies

B D \rightarrow E

11. Considere uma relação $R(A, B, C, D, E)$ com as seguintes dependências funcionais:
 $F = \{AB \rightarrow C, CD \rightarrow E, DE \rightarrow B\}$. Determine as chaves candidatas para R e decomponha R em relações na 3NF e em relações na BCNF.

- As chaves candidatas para a relação são mostradas na imagem:



- É possível verificar que a relação R atende a 2NF e a 3NF:

Check Normal Form



2NF

The table is in 2NF



3NF

The table is in 3NF



BCNF

The table is not in BCNF.

- Tendo em vista que a Relação já se encontra na 3NF, segue a decomposição para a BCNF:

Step 1. Find merged minimal cover of FDs, which contains:
 $A, B \rightarrow C$
 $C, D \rightarrow E$
 $D, E \rightarrow B$

Initially rel[1] contains the original table, with the FDs above

Round1: Checking whether table rel[1] is in BCNF

The FD $[A, B \rightarrow C]$ violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[2]= (A,B,C)
 With FDs:

rel[3]= (A,B,D,E)
 With FDs:

Round2: Checking whether table rel[2] is in BCNF

*** Table rel[2] is in BCNF already, send it to output ***

Round3: Checking whether table rel[3] is in BCNF

The FD $[D, E \rightarrow B]$ violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[4]= (D,E,B)
 With FDs:

rel[5]= (A,D,E)
 With FDs:

Round4: Checking whether table rel[4] is in BCNF

*** Table rel[4] is in BCNF already, send it to output ***

Round5: Checking whether table rel[5] is in BCNF

*** Table rel[5] is in BCNF already, send it to output ***

Attributes

A B C

Functional Dependencies

A B → C

Attributes

D E B

Functional Dependencies

D E → B

Attributes

A D E

Functional Dependencies

12. Considere a relação

$R = \{\text{courseno}, \text{secno}, \text{offeringdept}, \text{credithours}, \text{courselevel},$
 $\text{instructorssn}, \text{semester}, \text{year}, \text{dayshours}, \text{roomno},$
 $\text{noofstudents}\}$

a as seguintes dependências funcionais:

$\{\text{courseno}\} \rightarrow \{\text{offeringdept}, \text{credithours}, \text{courselevel}\}$,
 $\{\text{courseno}, \text{secno}, \text{semester}, \text{year}\} \rightarrow$
 $\{\text{dayshours}, \text{roomno}, \text{noofstudents}, \text{instructorssn}\}$,
 $\{\text{roomno}, \text{dayshours}, \text{semester}, \text{year}\} \rightarrow$
 $\{\text{instructorssn}, \text{courseno}, \text{secno}\}$

Determine as chaves candidatas para R e decomponha R em relações na 3NF e em relações na BCNF.

- As chaves candidatas para a relação são mostradas na imagem:

Candidate Keys Found

- semester year courseno secno
- semester year dayshours roomno

- É possível verificar que a relação R não atende a nenhuma NF:

Check Normal Form

**2NF**

The table is not in 2NF.

**3NF**

The table is not in 3NF.

**BCNF**

The table is not in BCNF.

- Decompondo a Relação para a 3NF, temos:

Step 1: Find the minimal cover of FDs, which contains

courseno \rightarrow offeringdept
 courseno \rightarrow credithours
 courseno \rightarrow courselevel
 courseno,secno,semester,year \rightarrow dayshours
 courseno,secno,semester,year \rightarrow roomno
 courseno,secno,semester,year \rightarrow noofstudents
 roomno,dayshours,semester,year \rightarrow instructorssn
 roomno,dayshours,semester,year \rightarrow courseno
 roomno,dayshours,semester,year \rightarrow secno

Step 2. Find all candidate keys. The set of candidates keys is { (semester,year,courseno,secno), (semester,year,dayshours,roomno), }.

The set of key attributes is: { semester,year,courseno,secno,dayshours,roomno }.

Step 3: Merge FDs with same LHS and whose RHS are non-key attributes, we get the set F1 which contains:

courseno \rightarrow courselevel,credithours,offeringdept
 courseno,secno,semester,year \rightarrow noofstudents
 roomno,dayshours,semester,year \rightarrow instructorssn

Step 4: Check each FD in the set F1 for violation of 3NF, and split table accordingly.

Checking FD courseno \rightarrow courselevel,credithours,offeringdept

The FD violates 3NF as its LHS is not a superkey (and RHS is a set of non-key attributes).

The following 3NF table is obtained:

courseno,courselevel,credithours,offeringdept
 with FDs
 courseno \rightarrow courselevel,credithours,offeringdept

Checking FD courseno,secno,semester,year \rightarrow noofstudents

FD does not violate 3NF

Checking FD roomno,dayshours,semester,year \rightarrow instructorssn

FD does not violate 3NF

Step 5: Finally, add the following table into normalized 3NF table set (obtained by removing RHS attributes of FDs using which we produced a table):

courseno,secno,instructorssn,semester,year,dayshours,roomno,noofstudents
 with FDs
 courseno,secno,semester,year \rightarrow roomno,dayshours
 dayshours,roomno,semester,year \rightarrow secno,courseno,instructorssn,noofstudents

Attributes

courseno courselevel credithours offeringdept

Functional Dependencies

courseno \rightarrow courselevel credithours offeringdept

Attributes

courseno secno instructorssn semester year dayshours roomno noofstudents

Functional Dependencies

courseno secno semester year \rightarrow roomno dayshours

dayshours roomno semester year \rightarrow secno courseno instructorssn noofstudents

- Decompondo a Relação para a BCNF, temos:

Step 1. Find merged minimal cover of FDs, which contains:
courseno \rightarrow offeringdept,credithours,courselevel
courseno,secno,semester,year \rightarrow dayshours,roomno,noofstudents
roomno,dayshours,semester,year \rightarrow instructorssn,courseno,secno

Initially rel[1] contains the original table, with the FDs above

Round1: Checking whether table rel[1] is in BCNF

The FD [courseno \rightarrow offeringdept,credithours,courselevel] violates BCNF as the LHS is not superkey. Table is split into the two below:

rel[2]= (courseno,offeringdept,credithours,courselevel)
With FDs:

rel[3]= (courseno,secno,instructorssn,semester,year,dayshours,roomno,noofstudents)
With FDs:

Round2: Checking whether table rel[2] is in BCNF

*** Table rel[2] is in BCNF already, send it to output ***

Round3: Checking whether table rel[3] is in BCNF

*** Table rel[3] is in BCNF already, send it to output ***

Attributes

courseno offeringdept credithours courselevel

Functional Dependencies

courseno \rightarrow offeringdept credithours courselevel

Attributes

courseno secno instructorssn semester year dayshours roomno noofstudents

Functional Dependencies

courseno secno semester year \rightarrow roomno dayshours

dayshours roomno semester year \rightarrow secno courseno instructorssn noofstudents

13. Considere o seguinte esquema de relação

LOTS(propertyid, countyname, lotno, area, price, taxrate)

e conjunto associado de dependências funcionais abaixo:

```
{propertyid} → {countyname, lotno, area, price, taxrate},
{countyname, lotno} → {propertyid, area, price, taxrate},
{countyname} → {taxrate},
{area} → {price}
```

Determine se a decomposição de LOTS apresentada abaixo é uma decomposição de junção sem perdas.

DICA: Para isso, você precisará usar a função `1jd` da ferramenta SWI-Prolog.

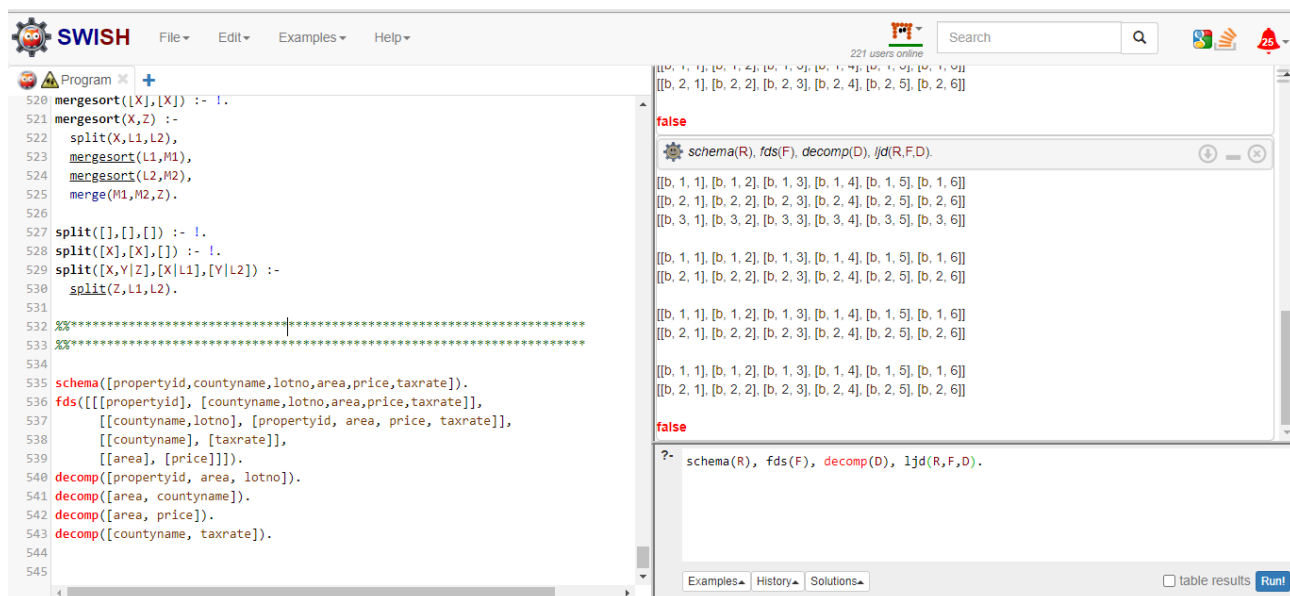
LOTS1AX (propertyid, area, lotno)

LOTS1AY (area, countyname)

LOTS1B (area, price)

LOTS2 (countyname, taxrate)

- Conforme visto na imagem abaixo, as decomposições não apresentam junção sem perdas:



14. Considere a relação universal $R(A, B, C, D, E, F, G, H, I, J)$ e o conjunto de dependências funcionais $F = \{AB \rightarrow C, A \rightarrow DE, B \rightarrow F, F \rightarrow GH, D \rightarrow IJ\}$. Determine se cada uma das seguintes decomposições tem:

(a) propriedade de preservação de dependência

```

518
519 mergesort([],[]) :- !.
520 mergesort([X],X) :- !.
521 mergesort(X,Z) :-
522   split(X,L1,L2),
523   mergesort(L1,M1),
524   mergesort(L2,M2),
525   merge(M1,M2,Z).
526
527 split([],[],[]) :- !.
528 split([X],X,[]) :- !.
529 split([X,V|Z],[X|L1],[V|L2]) :-
530   split(Z,L1,L2).
531
532 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
533 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
534
535 schema([a,b,c,d,e,f,g,h,i,j]).
536 fds([[[a,b],[c]], [[a],[d,e]],
537      [[b],[f]], [[f],[g,h]], [[d],[i,j]]]).
538 fpd([[[a,b],[c]], [[a],[d,e]],
539      [[b],[f]], [[f],[g,h]], [[d],[i,j]]]).
540 decomp([[[a,b,c],[a,d,e],[b,f],[f,g,h],[d,i,j]]]).
541 decomp([[[a,b,c,d,e],[b,f,g,h],[d,i,j]]]).
542 decomp([[[a,b,c,d],[d,e],[b,f],[f,g,h],[d,i,j]]]).
543

```

Considering [a,b]→[c]
Xplus=[c, a, e, b, f, g, h, d, i, j]
Considering [a]→[d, e]
Xplus=[a, e, d, i, j]
Considering [b]→[f]
Xplus=[b, f, g, h]
Considering [f]→[g, h]
Xplus=[f, g, h]
Considering [d]→[i, j]
Xplus=[d, i, j]
D = [[a, b, c], [a, d, e], [b, f], [f, g, h], [d, i, j]].
F = [[a, b], [c]], [[a], [d, e]], [[b], [f]], [[f], [g, h]], [[d], [i, j]].
R = [a, b, c, d, e, f, g, h, i, j]

Next 10 100 1,000 Stop

?- schema(R), fds(F), decomp(D), fpd(R,F,D).

Examples History Solutions ☐ table results Run!

(b) propriedade de junção sem perdas em relação a F.

```

518
519 mergesort([],[]) :- !.
520 mergesort([X],X) :- !.
521 mergesort(X,Z) :-
522   split(X,L1,L2),
523   mergesort(L1,M1),
524   mergesort(L2,M2),
525   merge(M1,M2,Z).
526
527 split([],[],[]) :- !.
528 split([X],X,[]) :- !.
529 split([X,V|Z],[X|L1],[V|L2]) :-
530   split(Z,L1,L2).
531
532 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
533 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
534
535 schema([a,b,c,d,e,f,g,h,i,j]).
536 fds([[[a,b],[c]], [[a],[d,e]],
537      [[b],[f]], [[f],[g,h]], [[d],[i,j]]]).
538 fpd([[[a,b],[c]], [[a],[d,e]],
539      [[b],[f]], [[f],[g,h]], [[d],[i,j]]]).
540 decomp([[[a,b,c],[a,d,e],[b,f],[f,g,h],[d,i,j]]]).
541 decomp([[[a,b,c,d,e],[b,f,g,h],[d,i,j]]]).
542 decomp([[[a,b,c,d],[d,e],[b,f],[f,g,h],[d,i,j]]]).
543

```

[[a, 1], [a, 2], [a, 3], [a, 4], [a, 5], [a, 6], [a, 7], [a, 8], [a, 9], [a, 10]]
[[a, 1], [b, 2, 2], [b, 2, 3], [a, 4], [a, 5], [b, 2, 6], [b, 2, 7], [b, 2, 8], [a, 9], [a, 10]]
[[b, 3, 1], [a, 2], [b, 3, 3], [b, 3, 4], [b, 3, 5], [a, 6], [a, 7], [a, 8], [b, 3, 9], [b, 3, 10]]
[[b, 4, 1], [b, 4, 2], [b, 4, 3], [b, 4, 4], [b, 4, 5], [a, 6], [a, 7], [a, 8], [b, 4, 9], [b, 4, 10]]
[[b, 5, 1], [b, 5, 2], [b, 5, 3], [a, 4], [b, 5, 5], [b, 5, 6], [b, 5, 7], [b, 5, 8], [a, 9], [a, 10]]

D = [[a, b, c], [a, d, e], [b, f], [f, g, h], [d, i, j]].
F = [[a, b], [c]], [[a], [d, e]], [[b], [f]], [[f], [g, h]], [[d], [i, j]].
R = [a, b, c, d, e, f, g, h, i, j]

Next 10 100 1,000 Stop

?- schema(R), fds(F), decomp(D), ljd(R,F,D).

Examples History Solutions ☐ table results Run!

DICA: Para isso, você precisará usar as funções ljd e fpd da ferramenta SWI-Prolog.

14.1. $D = \{R1, R2, R3, R4, R5\};$
 $R1 = \{a, b, c\},$
 $R2 = \{a, d, e\},$
 $R3 = \{b, f\},$
 $R4 = \{f, g, h\},$
 $R5 = \{d, i, j\}.$

14.2. $D = \{R1, R2, R3\};$
 $R1 = \{a, b, c, d, e\},$
 $R2 = \{b, f, g, h\},$
 $R3 = \{d, i, j\}.$

14.3. $D = \{R1, R2, R3, R4, R5\};$
 $R1 = \{a, b, c, d\},$
 $R2 = \{d, e\},$
 $R3 = \{b, f\},$
 $R4 = \{f, g, h\},$
 $R5 = \{d, i, j\}.$

15. Considere a relação `REFRIG(modelno, year, price, manufacturer, color)` que é abreviada como `REFRIG(m, y, p, mf, c)` e o conjunto de dependências funcionais $F = \{\{m\} \rightarrow \{mf\}, \{m, y\} \rightarrow \{p\}, \{mf\} \rightarrow \{c\}\}$

15.1. Avalie cada uma das seguintes opções como chaves candidatas:

- $\{m\}$
- $\{m, y\}$
- $\{m, c\}$
- Somente m e y são candidatas a chave:

Candidate Keys Found

- **m** **y**

Show Steps



Step 1: Find the minimal cover of FDs, which contains

$m \rightarrow mf$
 $m, y \rightarrow p$
 $mf \rightarrow c$

Step 2. Find the set of attributes not on the RHS of any FD, which is $\text{NotOnRHS} = \{m, y\}$. Every CK must contain these attributes.

Step 3: NotOnRHS is a superkey, so it is the only candidate key

15.2. Teste se `REFRIG` está na 3NF?

15.3. Teste se `REFRIG` está na BCNF?

- `REFRIG` não atende as regras de nenhuma NF:

Check Normal Form



2NF

The table is not in 2NF.



3NF

The table is not in 3NF.



BCNF

The table is not in BCNF.

Show Steps



2NF

find all candidate keys. The candidates keys are $\{m, y\}$. The set of key attributes are: $\{m, y\}$
for each non-trivial FD, check whether the LHS is a proper subset of some candidate key or the RHS are not all key attributes
checking FD: $m \rightarrow mf$
The FD violates definition of 2NF -- LHS is a proper subset of some CK

3NF

find all candidate keys. The candidates keys are $\{m, y\}$. The set of key attributes are: $\{m, y\}$
for each FD, check whether the LHS is superkey or the RHS are all key attributes
checking functional dependency $m \rightarrow mf$
The above FD violates definition of 3NF: it is non-trivial, LHS is not superkey, RHS contains a non-key attribute.

BCNF

A table is in BCNF if and only if for every non-trivial FD, the LHS is a superkey.
The FD $m \rightarrow mf$ is non-trivial and its LHS is not a superkey. It violates BCNF.

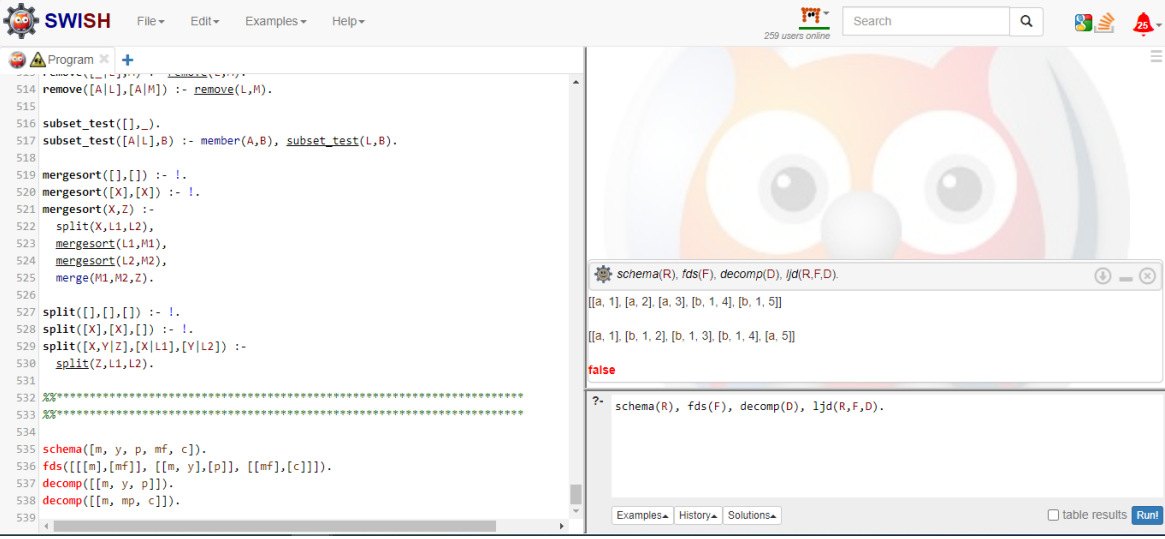
15.4. Teste se a decomposição abaixo tem a propriedade de junção sem perdas.

$D = \{R1, R2\};$

$R1 = \{m, y, p\},$

$R2 = \{m, mp, c\}.$

- Para o teste de propriedade de junção sem perda tivemos um retorno FALSE:



The screenshot shows the SWISH Prolog IDE interface. The main editor on the left contains a Prolog program with the following code:

```
514 remove([A|L],[A|M]) :- remove(L,M).
515
516 subset_test([],_).
517 subset_test([A|L],B) :- member(A,B), subset_test(L,B).
518
519 mergesort([],[]) :- !.
520 mergesort([X],[_]) :- !.
521 mergesort(X,Z) :-
522   split(X,L1,L2),
523   mergesort(L1,M1),
524   mergesort(L2,M2),
525   merge(M1,M2,Z).
526
527 split([],[],[]) :- !.
528 split([X],[_],[]) :- !.
529 split([X,Y|Z],[_],[_]) :-
530   split(Z,L1,L2).
531
532 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
533 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
534
535 schema([m, y, p, mp, c]).
536 fds([[[m],[mf]], [[m, y],[p]], [[mf],[c]]]).
537 decomp([[[m, y, p]]]).
538 decomp([[[m, mp, c]]]).
539
```

The right-hand side of the IDE shows the execution results. The top window displays the query `schema(R), fds(F), decomp(D), jld(R,F,D).` and its results:

```
[[a, 1], [a, 2], [a, 3], [b, 1, 4], [b, 1, 5]]
[[a, 1], [b, 1, 2], [b, 1, 3], [b, 1, 4], [a, 5]]
false
```

The bottom window shows the query `?- schema(R), fds(F), decomp(D), ljd(R,F,D).` and its results:

```
Examples History Solutions
```

At the bottom right, there is a checkbox for "table results" and a "Run!" button.