BCNF: is there any completely non-trivial FD wh
LHS attributes are not superkey?

3NF: BCNF || is there any completely non-trivial
where RHS attribute is not a prime attribute?

Is __ in BCNF

1. Check if LHS not superkey
2. Use armstrong axiom

Is __ in 3NF

1. `E -> B` is non-trivial.
2. `E` is not a superkey of `R`.
3. `B` is not a prime attribute.

LHS not superkey and RHS not prime attribute

Is all fragment in BCNF

1. Calculate projection of decomposed fragments
2. Check if it belongs to any of the FD in the not decomposed schema

• Trainings > Tutorial > Tutorial 08

$R_2(ABE)$ F[R1] ~~AB → C~~ $AB^+ = ABC$

Problem 1 : Normal Forms #1

A^+

B^+

Consider `R(A,B,C,D,E)` with `F = {AB -> C, AC -> D, E -> ABCD}`. Consider the decor
of `R` into the fragments `{R1(A,B,C), R2(A,B,E), R3(A,C,D)}`.

$E^+ = EABCD$

a) Is `R` in BCNF? *Explain.*

$\cap ABE$

b) Given the decomposition `{R1(A,B,C), R2(A,B,E), R3(A,C,D)}` is all fragment ir
Explain.

F[R1] = {AB -> C}. F[R2] =
{E -> AB}
F[R3] = {AC -> D}.

$E^+ = ABE$

c) Is `R` in 3NF? *Explain.*

$E \to AB$

d) Given the decomposition `{R1(A,B,C), R2(A,B,E), R3(A,C,D)}` is all fragment in
plain.

How to get prime attribute

Compute the closure

Common mistake E → ABCD and E+ = ABCDE

Prime attribute is the union of all possible keys

Consider `R(A,B,C,D,E)` with `F = {A -> E, AB -> D, CD -> AE, E -> B, E`
the decomposition of `R` into the fragments `{R1(B,D,E), R2(A,C,E)}`.

a) Is `R` in BCNF? *Explain.*

b) Given the decomposition `{R1(B,D,E), R2(A,C,E)}` is all fragment in BCNF

b) For the projection, we consider either (1) the completely non-trivial fds in the
the minimal cover of projection.

- `F[R1] = {E -> BD}`. Since `E` is a superkey of `R1`, then `R1` is in BCNF.
- `F[R2] = {A -> E, CE -> A}`. Consider `A -> E` in `F[R2]`.
  1. `A -> E` is non-trivial.
  2. `A` is not a superkey of `R2`.

Consider `R(A,B,C,D,E)` with `F = {AB -> CDE, AC -> BDE, B -> D, C -> B, C -> D,`

a) Find a lossless-join valid decomposition of `R` into BCNF.

1. Since `B -> DE` violates BCNF of `R` (*proof omitted*)
   ⇒ Decompose `R` into `R1(B,D,E)` and `R2(A,B,C)`.
2. Since `C -> B` violates BCNF of `R2` (*proof omitted*)
   ⇒ Decompose `R2` into `R3(B,C)` and `R4(A,C)`.

Therefore, one possible decomposition is `{R1(B,D,E), R3(B,C), R4(A,C)`

Is lossless join

1. Identify intersected attributes (can be a combination for eg. AB)
2. Get closure of intersected based on F
3. Check if any relation when intersected with the closure gives back the original relation

Problem 3 : Decomposition #1

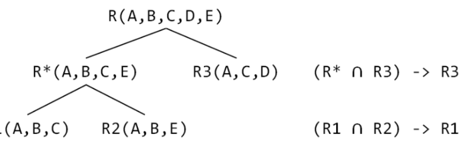
Consider `R(A,B,C,D,E)` with `F = {AB -> C, AC -> D, E -> ABCD}`. Consider the decomposition of `R` into the fragments `{R1(A,B,C), R2(A,B,E), R3(A,C,D)}`.

a) Is the decomposition a lossless-join decomposition? *Explain.*

b) Is the decomposition a dependency-preserving decomposition? *Explain.*

Solution Using AC —> D

a) Yes. The visual proof is as follows:



The more formal proof is as follows:

1. Consider `R*(A,B,C,E)`
2. The decomposition of `R` into `{R*, R3}` is a lossless-join decomposition because:
   ⇒ `(R3 ∩ R*) = AC`
   ⇒ `AC+ = {ACD}`
   ⇒ `AC -> ACD`
   ⇒ `R3 = ACD`
   ⇒ `(R3 ∩ R*) -> R3`
   ⇒ By *Theorem 1*, the decomposition of `R` into `{R*, R3}` is a lossless-join decomposition
3. The decomposition of `R*` into `{R1, R2}` is a lossless-join decomposition because:
   ⇒ `(R1 ∩ R2) = AB`
   ⇒ `AB+ = {ABC}`
   ⇒ `AB -> ABC`
   ⇒ `R1 = ABC`
   ⇒ `(R1 ∩ R2) -> R1`
   ⇒ By *Theorem 1*, the decomposition of `R*` into `{R1, R2}` is a lossless-join decomposition
4. By *Theorem 2*, the decomposition of `R` into `{R1, R2, R3}` is a lossless-join decomposition

R1 intersects with
closure gets back R1

Is dp

1. `F[R1] = {AB -> C}`
2. `F[R2] = {E -> AB}`
3. `F[R3] = {AC -> D}`
4. Let `G = F[R1] ∪ F[R2] ∪ F[R3] = {AB -> C, E -> AB, AC -> D}`
5. `G ⊨ F` because:
   ⇒ `G ⊨ AB -> C` (*trivial*)
   ⇒ `G ⊨ E -> AB` (*trivial*)
   ⇒ `G ⊨ AC -> D` (*trivial*)
   ⇒ `G ⊨ E -> CD` (*because E+ = ABCDE and hence E -> CD*)

Minimum cover

For each attribute on LHS, check if they are redundant and remove them

Consider R(A,B,C,D,E) with

F $= \{AB \to CDE, AC \to BDE, B \to D, C \to B, C \to D, B \to E\}$

G = {B -> D, AB -> C, C -> B, B -> E}

Combine same LHS

Find a lossless-join dependency-preserving valid decomposition of R into 3NF

Use synthesis method

1. Find min cover
2. Combine same LHS
3. Combine into attributes of FD into schemas
4. Add key to schema
5. Remove redundant schemas (subset of other schemas)

- With `B -> DE`, `R1(B,D,E)`
- With `AB -> C`, `R2(A,B,C)`
- With `C -> B`, `R3(B,C)`
- With key = `{A,B}`, `R4(A,B)`

Without the *redundant schema*, the decomposition is `{R1(B,D,E), R2(A,B,C)}`.

Another solution is the same as the previous one since if the schema is in BCNF, it is also in 3NF. Since the BCNF decomposition is dependency-preserving, the 3NF decomposition is also dependency-preserving.