

CSCI235 Database Systems

Normalization in Practice

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Example 1

A relational schema $R = (A, B, C)$

Functional dependencies: $AB \rightarrow C$

Keys ?

If $AB \rightarrow C$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, B)

No other minimal keys

Normal form ?

Left hand side of $AB \rightarrow C$ is a minimal key $K = (A, B)$

BCNF

Example 2

A relational schema $R = (A, B, C)$

Functional dependencies: $AB \rightarrow C, C \rightarrow B$

Keys ?

If $AB \rightarrow C$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, B)

If $C \rightarrow B$ then through **augmentation rule** $AC \rightarrow AB$

If $AC \rightarrow AB$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, C)

Normal form ?

Not BCNF because left hand side of $C \rightarrow B$ is not a minimal key

3NF because right hand side of $C \rightarrow B$ is a prime attribute

Decomposition into **BCNF** ?

$R_1 = (B, C), R_2 = (A, C)$ or

$R_1 = (B, C), R_2 = (A, B)$

Example 3

A relational schema $R = (A, B, C)$

Functional dependencies: $AB \rightarrow C, C \rightarrow B, C \rightarrow A$

Keys ?

If $AB \rightarrow C$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, B)

If $C \rightarrow B$ and $C \rightarrow A$ then through **union rule** $C \rightarrow AB$

If $C \rightarrow AB$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (C)

Normal form ?

BCNF because left hand side of each functional dependency is a minimal key

Example 4

A relational schema $R = (A, B, C)$

Functional dependencies: $A \rightarrow B$

Keys ?

If $A \rightarrow B$ is valid in R then through **augmentation rule** $AC \rightarrow BC$

If $AC \rightarrow BC$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, C)

Normal form ?

not 2NF because a nonprime attribute B functionally depends ($A \rightarrow B$) on a subset of primary key (A, C)

Decomposition into **BCNF** ?

$R_1 = (A, B), R_2 = (A, C)$ or

$R_1 = (A, B), R_2 = (B, C)$

Example 5

A relational schema $R = (A, B, C)$

Functional dependencies: $A \rightarrow B, B \rightarrow A$

Keys ?

If $A \rightarrow B$ then through **augmentation rule** $AC \rightarrow BC$

If $AC \rightarrow BC$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, C)

If $B \rightarrow A$ then through **augmentation rule** $BC \rightarrow AC$

If $BC \rightarrow AC$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (B, C)

Example 5

Normal form ?

Not BCNF because left hand side of $A \rightarrow B$ is not a minimal key

3NF because right hand side of $A \rightarrow B$ is a prime attribute and right hand side of $B \rightarrow A$ is a prime attribute

Decomposition into BCNF ?

$R1 = (A, B)$, $R2 = (A, C)$ or

$R1 = (A, B)$, $R2 = (B, C)$

Example 6

A relational schema $R = (A, B, C)$

Functional dependencies: $A \rightarrow B, B \rightarrow C$

Keys ?

If $A \rightarrow B$ and $B \rightarrow C$ then through **transitivity rule** $A \rightarrow C$

If $A \rightarrow B$ and $A \rightarrow C$ then through **union rule** $A \rightarrow BC$

If $A \rightarrow BC$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A)

Normal form ?

Not 3NF because a non prime attribute C is transitively dependent on primary key A

2NF because no nonprime attribute depends on a part of primary key

Example 6

Decomposition into **BCNF** ?

$R1 = (A, B)$, $R2 = (B, C)$ or

$R1 = (A, B)$, $R2 = (A, C)$

Example 7

A relational schema $R = (A, B, C, D)$

Functional dependencies: $A \rightarrow B, A \rightarrow C, B \rightarrow D$

Keys ?

If $A \rightarrow B$ and $A \rightarrow C$ then through **union rule** $A \rightarrow BC$

If $A \rightarrow B$ and $B \rightarrow D$ then through **transitivity rule** $A \rightarrow D$

If $A \rightarrow BC$ and $A \rightarrow D$ then through **union rule** $A \rightarrow BCD$

If $A \rightarrow BCD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A)

Normal form ?

Not 3NF because a non prime attribute D is transitively dependent on primary key A

2NF because no nonprime attribute depends on a part of primary key

Example 7

Decomposition into **BCNF** ?

$R1 = (A, B, C)$, $R2 = (B, D)$ or

$R1 = (A, B, C)$, $R2 = (A, D)$

Example 8

A relational schema $R = (A, B, C, D)$

Functional dependencies: $A \rightarrow B, B \rightarrow D, C \rightarrow B$

Keys ?

If $A \rightarrow B$ and $B \rightarrow D$ then through **transitivity rule** $A \rightarrow D$

If $A \rightarrow D$ and $A \rightarrow B$ then through **union rule** $A \rightarrow BD$

If $A \rightarrow BD$ then through **augmentation rule** $AC \rightarrow BCD$

If $AC \rightarrow BCD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, C)

If $C \rightarrow B$ and $B \rightarrow D$ then through **transitivity rule** $C \rightarrow D$

If $C \rightarrow D$ and $C \rightarrow B$ then through **union rule** $C \rightarrow BD$

If $C \rightarrow BD$ then through **augmentation rule** $AC \rightarrow ABD$

If $AC \rightarrow BCD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, C)

Example 8

Normal form ?

Not 2NF because a nonprime attribute B depends on a part of a primary key

(A, C)

Decomposition into BCNF ?

$R1 = (A, B)$, $R2 = (B, C)$, $R3 = (B, D)$

Example 9

A relational schema $R = (A, B, C, D)$

Functional dependencies: $A \rightarrow B, A \rightarrow C, B \rightarrow A, B \rightarrow C$

Keys ?

If $A \rightarrow B$ and $A \rightarrow C$ then through **union rule** $A \rightarrow BC$

If $A \rightarrow BC$ then through **augmentation rule** $AD \rightarrow BCD$

If $AD \rightarrow BCD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, D)

If $B \rightarrow A$ and $B \rightarrow C$ then through **union rule** $B \rightarrow AC$

If $B \rightarrow AC$ then through **augmentation rule** $BD \rightarrow ACD$

If $BD \rightarrow ACD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (B, D)

Example 9

Normal form ?

Not 2NF because a nonprime attribute C depends on a part of a primary key (B, D)

Decomposition into BCNF ?

$R1 = (A, B)$, $R2 = (B, C)$, $R3 = (A, D)$

Example 10

A relational schema $R = (A, B, C, D)$

Functional dependencies: $AB \rightarrow C, C \rightarrow D, D \rightarrow A, D \rightarrow B$

Keys ?

If $AB \rightarrow C$ and $C \rightarrow D$ then through **transitivity rule** $AB \rightarrow D$

If $AB \rightarrow D$ and $AB \rightarrow C$ then through **union rule** $AB \rightarrow CD$

If $AB \rightarrow CD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A, B)

If $D \rightarrow A$ and $D \rightarrow B$ then through **union rule** $D \rightarrow AB$

If $D \rightarrow AB$ and $AB \rightarrow C$ then through **transitivity rule** $D \rightarrow C$

If $D \rightarrow C$ and $D \rightarrow AB$ then $D \rightarrow ABC$

If $D \rightarrow ABC$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (D)

Example 10

If $C \rightarrow D$ and $D \rightarrow AB$ then through **transitivity rule** $C \rightarrow AB$

If $C \rightarrow D$ and $C \rightarrow AB$ then through **union rule** $C \rightarrow ABD$

If $C \rightarrow ABD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (C)

Normal form ?

BCNF because left hand side of each functional dependency is a superkey

Example 11

A relational schema $R = (A, B, C, D)$

Functional dependencies: $A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow A$

Keys ?

If $A \rightarrow B$ and $B \rightarrow C$ then through **transitivity rule** $A \rightarrow C$

If $A \rightarrow C$ and $C \rightarrow D$ then through **transitivity rule** $A \rightarrow D$

If $A \rightarrow B$ and $A \rightarrow C$ and $A \rightarrow D$ then through **union rule** $A \rightarrow BCD$

If $A \rightarrow BCD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (A)

If $B \rightarrow C$ and $C \rightarrow D$ then through **transitivity rule** $B \rightarrow D$

If $B \rightarrow D$ and $D \rightarrow A$ then through **transitivity rule** $B \rightarrow A$

If $B \rightarrow C$ and $B \rightarrow D$ and $B \rightarrow A$ then through **union rule** $B \rightarrow ACD$

If $B \rightarrow ACD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (B)

Example 11

If $C \rightarrow D$ and $D \rightarrow A$ then through **transitivity rule** $C \rightarrow A$

If $C \rightarrow A$ and $A \rightarrow B$ then through **transitivity rule** $C \rightarrow B$

If $C \rightarrow A$ and $C \rightarrow B$ and $C \rightarrow D$ then through **union rule** $C \rightarrow ABD$

If $C \rightarrow ABD$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (C)

If $D \rightarrow A$ and $A \rightarrow B$ then through **transitivity rule** $D \rightarrow B$

If $D \rightarrow B$ and $B \rightarrow C$ then through **transitivity rule** $D \rightarrow C$

If $D \rightarrow A$ and $D \rightarrow B$ and $D \rightarrow C$ then through **union rule** $D \rightarrow ABC$

If $D \rightarrow ABC$ is valid in R and it covers entire relational schema then its left hand side is a minimal key (D)

Normal form ?

BCNF because left hand side of each functional dependency is a superkey

References

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