Normalization in practice

Example 1

R =(A, B, C) F ={ AB → C}

Keys ?

AB → C ⇒ K_1 = (A, B)

BCNF

Redundancies: none

A	B	C
a_1	b_1	c_1
a_3	b_2	c_2
a_1	b_2	c_3
a_2	b_1	c_3
a_2	b_2	c_3

bldg#, room#, capacity

room#,bldg# → capacity

Example 2

R =(A, B, C) F ={ AB → C, C → B }

Keys ?

AB → C ⇒ K_1 = (A, B)

If C → B then (augmentation) AC → AB ⇒ K_2 =(A, C)

3NF and not BCNF (C → B)

Redundancies:

A	B	C
a_1	b_1	c_1
a_2	b_1	c_1
a_3	b_1	c_2
a_1	b_2	c_3
a_1	b_2	c_3
a_2	b_3	c_4

room#, bldg#, bldg-name

room#,bldg# → bldg-name
bldg-name → bldg#

Decomposition: R_1 = (C, B), R_2= (A, B)

Example 3

R =(A, B, C) F ={ AB → C, C → B, C → A }

Keys ?

AB → C ⇒ K_1 = (A, B)

If C → B and C → A then (union) C → AB ⇒ K_2 =(C)

BCNF

Redundancies: none

A	B	C
a_1	b_1	c_1
a_3	b_2	c_2
a_1	b_2	c_3

author, title, ISBN

author, title → ISBN
ISBN → title
ISBN → author (?)

Example 4

R =(A, B, C) F ={ A → B}

Keys ?

If A → B then (augmentation) AC → AB ⇒ K_1 =(A, C)

not 2NF (A → B)

Redundancies:

A	B	C
a_1	b_1	c_1
a_1	b_1	c_2
a_1	b_1	c_3
a_3	b_2	c_1
a_3	b_2	c_2

student#, sname, subject#

student# → sname

Decomposition: R_1 = (A, B), R_2= (A, C)

Example 5

R =(A, B, C) F ={ A → B, B → A}

Keys ?

If A → B then (augmentation) AC → CB ⇒ K_1 =(A, C)

If B → A then (augmentation) BC → AC ⇒ K_2 =(B,C)

3NF and not BCNF (A → B)

Redundancies:

Decomposition 1:
R_1 = (A, B),
R_2 = (A, C)

Decomposition 2:
R_1 = (A, B),
R_2 = (B, C)

A	B	C
a_1	b_1	c_1
a_1	b_1	c_2
a_1	b_1	c_3
a_2	b_2	c_2
a_2	b_2	c_3
a_3	b_3	c_3

student#, drv-lic#, subject#

student# → drv-lic#
drv-lic# → student#

Example 6

$R = (A, B, C)$ $F = \{ A \rightarrow B, B \rightarrow C\}$

Keys ?

If $A \rightarrow B$ and $B \rightarrow C$ then (transitivity) $A \rightarrow C \Rightarrow K_1 = (A)$

2NF and not 3NF ($A \rightarrow B, B \rightarrow C$)

Redundancies:

A	B	C
a_1	b_1	c_1
a_2	b_1	c_1
a_3	b_1	c_1
a_4	b_2	c_1
a_5	b_2	c_1

e#, department, address

e# $\rightarrow$ department

department $\rightarrow$ address

Decomposition 1:
$R_1 = (A, B)$,
$R_2 = (B, C)$

Decomposition 2:
$R_1 = (A, B)$,
$R_2 = (A, C)$

Example 7

$R = (A, B, C, D)$ $F = \{ A \rightarrow B, A \rightarrow C, B \rightarrow D\}$

Keys ?

If $A \rightarrow B$ and $A \rightarrow C$ then (union) $A \rightarrow BC$

If $A \rightarrow B$ and $B \rightarrow D$ then (transitivity) $A \rightarrow D$

If $A \rightarrow BC$ and $A \rightarrow D$ then (union) $A \rightarrow BCD \Rightarrow K_1 = (A)$

2NF and not 3NF ($A \rightarrow B, B \rightarrow D$)

Example 8

$R = (A, B, C, D)$ $F = \{ A \rightarrow B, B \rightarrow D, C \rightarrow B\}$

Keys ?

If $A \rightarrow B$ and $B \rightarrow D$ then (transitivity) $A \rightarrow D$

If $A \rightarrow D$ and $A \rightarrow B$ then (union) $A \rightarrow BD$

If $A \rightarrow BD$ then (augmentation) $AC \rightarrow BCD \Rightarrow K_1 = (AC)$

If $C \rightarrow B$ and $B \rightarrow D$ then (transitivity) $C \rightarrow D$

If $C \rightarrow D$ and $C \rightarrow B$ then (union) $C \rightarrow BD$

If $C \rightarrow BD$ then (augmentation) $AC \rightarrow ABD \Rightarrow K_1 = (AC)$!

not 2NF ($A \rightarrow B$)

Example 9

$R = (A, B, C, D)$ $F = \{ A \rightarrow B, A \rightarrow C, B \rightarrow A, B \rightarrow C\}$

Keys ?

If $A \rightarrow B$ and $A \rightarrow C$ then (union) $A \rightarrow BC$

If $A \rightarrow BC$ then (augmentation) $AD \rightarrow BCD \Rightarrow K_1 = (AD)$

If $B \rightarrow A$ and $B \rightarrow C$ then (union) $B \rightarrow AC$

If $B \rightarrow AC$ then (augmentation) $BD \rightarrow ACD \Rightarrow K_2 = (BD)$

not 2NF ($B \rightarrow C$)

Example 10

$R = (A, B, C, D)$ $F = \{ AB \rightarrow C, C \rightarrow D, D \rightarrow A, D \rightarrow B\}$

Keys ?

If $AB \rightarrow C$ and $C \rightarrow D$ then (transitivity) $AB \rightarrow D$

If $AB \rightarrow D$ and $AB \rightarrow C$ then (union) $AB \rightarrow CD \Rightarrow K_1 = (AB)$

If $D \rightarrow A$ and $D \rightarrow B$ then (union) $D \rightarrow AB$

If $D \rightarrow AB$ and $AB \rightarrow C$ then (transitivity) $D \rightarrow C$

If $D \rightarrow AB$ and $D \rightarrow C$ then (union) $D \rightarrow ABC \Rightarrow K_2 = (D)$

If $C \rightarrow D$ and $D \rightarrow AB$ then (transitivity) $C \rightarrow AB$

If $C \rightarrow D$ and $C \rightarrow AB$ then (union) $C \rightarrow ABD \Rightarrow K_3 = (C)$

BCNF

Example 11

$R = (A, B, C, D)$ $F = \{ A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow A\}$

Keys ?

If $A \rightarrow B$ and $B \rightarrow C$ then (transitivity) $A \rightarrow C$

If $A \rightarrow C$ and $C \rightarrow D$ then (transitivity) $A \rightarrow D$

If $A \rightarrow B$ and $A \rightarrow C$ and $A \rightarrow D$ then (union) $A \rightarrow BCD \Rightarrow$ $K_1 = (A)$

If $B \rightarrow C$ and $C \rightarrow D$ then (transitivity) $B \rightarrow D$

If $B \rightarrow D$ and $D \rightarrow A$ then (transitivity) $B \rightarrow A$

If $B \rightarrow C$ and $B \rightarrow D$ and $B \rightarrow A$ then (union) $B \rightarrow ACD \Rightarrow$ $K_2 = (B)$

and so on $\Rightarrow K_3 = (C), K_4 = (D)$

BCNF

References

Elmasri R., Navathe S. B., *Fundamentals of Database Systems*, chapters 10.3, 10.4, 10.5