

a)

$R(A, B, C, D)$  with FD's

$AB \rightarrow C$ ,  $B \rightarrow D$ ,  $CD \rightarrow A$ ,  $AD \rightarrow B$

### • BCNF violations

•  $AB^+ = A B D C$

- with  $AB$  you have  $A$  and  $B$
- since we have  $B$ , then we have  $D$
- since we have  $AB$ , then we have  $C$

$\{A, B\}^+ = \{A, B, C, D\}$

↳ represents  $R$

↳  $AB$  is super key

↳ No violation of BCNF

•  $B^+ = B D$

- with  $B$  we have  $B$
- with  $B$  we have  $D$

$\{B\}^+ = \{B, D\}$

↳ doesn't represent  $R$

↳ violation of BCNF

•  $CD^+ = C, D, A, B$

• with  $CD$  we have  $C$  and  $D$  and  $A$

• with  $AD$  we have  $B$

$\{CD\}^+ = \{A, B, C, D\}$

↳ represents  $R$

↳ superkey of  $R$

↳ no violation of BCNF

•  $AD^+ = A, D, B, C$

• with  $AD$  we have  $A, D$ , and  $B$

• with  $AB$  we have  $C$

$\{AD\}^+ = \{A, B, C, D\}$

↳ represents  $R$

↳ superkey of  $R$

↳ no violation of BCNF

• Total BCNF violations = 1

$$\hookrightarrow B \rightarrow D$$

$$\{B\}^+ = \{B, D\}$$

• Decomposition

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

$$R_1 = \{A, B, C\}, \quad R_2 = \{B, D\}$$

$\hookrightarrow$  These relations are in BCNF.

$\hookrightarrow$  No decompositions needed,

5)

$R(A, B, C, D)$  with FD's:

$A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow A$

•  $A^+ = A B C D$

↳ with  $A$  you have  $A$  and  $B$

↳ with  $B$  you have  $C$

↳ with  $C$  you have  $D$

$\{A^+\} = \{A, B, C, D\}$

↳ represents  $R$

↳  $A$  is superkey

↳ no violation of BCNF

•  $B^+ = B C D A$

↳ with  $B$  you have  $B$  and  $C$

↳ with  $C$  you have  $D$

↳ with D you have A

$$\{B^+\} = \{A, B, C, D\}$$

↳ represents R

↳ B is superkey

↳ no violation of BCNF

•  $C^+ = C D A B$

↳ with C you have C and D

↳ with D you have A

↳ with A you have B

$$\{C^+\} = \{A, B, C, D\}$$

↳ represents R

↳ C is a superkey

↳ no violation of BCNF

•  $D^+ = D A B C$

↳ with D you have D and A

↳ with A you have B

↳ with B you have C

$\{D^+\} = \{A, B, C, D\}$

↳ represents R

↳ is a superkey

↳ no violation of BCNF.