BCNF: FD: $\bar{A} \longrightarrow \bar{B}$ in R
then $\bar{A}$ must be key/superkey of R.

BCNF Decomposition Algorithm

Input: R and the set of FDs on R

Output: a set of relations in BCNF $R = R_1 \bowtie R_2 \cdots \bowtie R_n$

Example:

R (SSN, fname, office #, dno, school, student #, building, dname, size)

FD1: SSN $\longrightarrow$ fname, office#, dno

FD2: school, dno $\longrightarrow$ student #, building, dname, size

FD3: student# $\longrightarrow$ size

FD4: office # $\longrightarrow$ building

Step 1: Find key of R using closure of attributes

R (SSN, fname, office #, dno, school, student #, building, dname, size)

$(SSN)^+ = \{$ SSN, fname, office#, dno, building $\}$

$(school, dno)^+ = \{$ school, dno, student #, buildng, dname, size $\}$

(SSN, school) = { . . . . . }

Key : (SSN, school)

Step 2 : Repeat :

Pick any FD $\bar{A} \to \bar{B}$ that violates BCNF. Divide R into R_1 & R_2

R1 : ($\underline{\bar{A}}$, $\bar{B}$)

R2 : (R − $\bar{B}$)

FD4 : office # ⟶ building

R1 (<u>office #</u>, building) ✓ R1 in BCNF

R2 (office #, <u>SSN</u>, fname, <u>school</u>, dno, size
dname, student #) ✗

* Step 2

student # ⟶ size

R3 : (<u>student</u> #, size) ✓

R4 : (student #, <u>SSN</u>, office #, fname, <u>school</u>,
dno, dname) ✗

*Step 2

R5 : (<u>SSN</u>, fname, dno, office #) ✓

R6 : (<u>SSN</u>, <u>school</u>, student #, dname) ✓

$R = R1 \bowtie R3 \bowtie R5 \bowtie R6$

R1, R3, R5, R6 in BCNF

Another BCNF Decomposition :

R (SSN, fname, office #, dno, school, student #, building, dname, size)

FD1 : SSN $\longrightarrow$ fname, office#, dno ✓

FD2 : school, dno $\longrightarrow$ student #, building, dname, size

FD3 : student # $\longrightarrow$ size

FD4 : office # $\longrightarrow$ building

R1 : (SSN, fname, office #, dno) ✓

R2 : (SSN, school, student #, building, dname, size) ✗

R3 : (student #, size) ✓

R4 : (SSN, school, student #, building, dname) ✓

$R = R1 \bowtie R3 \bowtie R4$ R1, R3, R4 are in BCNF.

Example 2 : R(a, b, c, d)

ac $\longrightarrow$ d, d $\longrightarrow$ b, d $\longrightarrow$ a, d $\longrightarrow$ c

(d $\longrightarrow$ abc)

Keys : (ac) (d)

R(a, b, c, d) is in BCNF.

Example 3 R(a, b, c, d)

$bc \rightarrow a \quad bd \rightarrow c \quad cd \rightarrow b \quad ad \rightarrow c$

Keys (cd) (bd) (ad)

R1 : ($\underline{b}$, $\underline{c}$, a) Key (bc)

R2: (b, c, d) Key (cd) (bd)

$R = R1 \bowtie R2$ R1, R2 in BCNF.

Example 4: R(a, b, c, d)

$c \rightarrow b \quad bc \rightarrow a \quad a \rightarrow c \quad bd \rightarrow a$

$(bd)^+ = \{ b, d, a, c\}$ Key (bd)

$(cd)^+ = \{ c, d, b, a\}$ Key (cd)

$(ad)^+ = \{ a, d, c, b\}$ Key (ad)

$a \rightarrow c ; \; c \rightarrow b \Rightarrow a \rightarrow b$

$c \rightarrow b ; \; bc \rightarrow a \Rightarrow c \rightarrow a$

I $c \rightarrow b$

R1 ($\underline{c}$, b) ✓

R2 (a, c, d) ✗ Key (cd) (ad)

R3 (a, c) ✓ key (a) (c)

R4 (a, d) ✓ OR $R4'$ (c, d) ✓

$R = R1 \bowtie R3 \bowtie R4$

$R = R1 \bowtie R3 \bowtie R4'$

II $a \longrightarrow b$

R1 $(\underline{a}, b)$ key (a)

R2 (a, c, d) key (cd) (ad)

R3 (a, c) key (a) (c)

R4 (a, d) OR $R4'$ (c, d)

$R = R1 \bowtie R3 \bowtie R4$

$R = R1 \bowtie R3 \bowtie R4'$

<u>Example 5</u> $R(a, b, c, d, E)$

$bEd \longrightarrow c$ $b \longrightarrow c$ $ac \longrightarrow E$ $dE \longrightarrow a$

Key (bEd) (bda)

$(bda)^+ = \{b, d, a, c, E\}$

I R1: (a, c, E) R2 (b, c) R3 (a, b, d)

II R1 (a, d, E) R2 (b, c) R3 (b, d, E)