3NF Decomposition Alg:

Input: R with all attributes; all FDs

① Compute keys of R using closure property of FDs

$R' = R$

② Repeat until all relations in 3NF

ⓐ Pick any R' with FD: $\bar{A} \longrightarrow \bar{B}$ that violates 3NF.

ⓑ Divide R' into

$R_1' : (\bar{A}, \bar{B})$ (Note: $\bar{A} \in R_1' \cap R_2'$)

$R_2' : (R' - \bar{B})$

Example: R(SSN, name, dno, mgr, dname)

FD1

FD2

R : (<u>SSN</u>, name, dno, mgr, dname)

R_1' : (<u>dno</u>, mgr, dname) R_1' is in 3NF

R_2' : (<u>SSN</u>, name, dno) R_2' is in 3NF

$R = R_1' \bowtie R_2'$

Example: R (dno, dname, school, building)

FD1 : dno $\longrightarrow$ dname, school, building

FD2: dname → dno, school, building

FD3: building → school

Keys (dno) (dname)

R is not in 3NF: FD3 building → school

$\downarrow$ not key — $\downarrow$ non prime

R1 : (<u>building</u>, school)

R2 : (dno, dname, building) key (dno) (dname)

R1 & R2 in 3NF

$R = R1 \bowtie R2$

<u>Example</u>: R (dno, school, dname, building)

FD1: dno, school → dname, building

FD2: school → building

Is R in 3NF?

Key (dno, school)

FD2: school → building

$\downarrow$ not key — $\downarrow$ not prime

R not in 3NF.

R1 : (<u>school</u>, building) R1 in 3NF

R2: (<u>dno</u>, <u>school</u>, dname) R2 in 3NF

$R = R1 \bowtie R2$

Example: R(dno, dname, school, building)

FD1: dno, school $\longrightarrow$ dname, building

FD2: building $\longrightarrow$ school

Is R in 3NF?

Key: (dno, school) (dno, building)

$a \longrightarrow b$; $b \longrightarrow c$ $\Rightarrow$ $a \longrightarrow c$

building $\longrightarrow$ school dno, school $\longrightarrow$ ~

dno, building $\longrightarrow$ ~

FD2: $\underbrace{\text{building}}_{\text{not key}} \longrightarrow \underbrace{\text{school}}_{\text{prime attribute}}$

$\therefore$ R is in 3NF.

R:

dno	dname	school	building
1	CS	CEPS	Kingsbury
2	Earth	CEPS	Morse
3	math	CEPS	Kingsbury
1	Nutrition	COLSA	Thompson
2	Earth	COLSA	Thompson

* There is Redundancy; insert, delete, update anomalies.

BCNF: R is in 3NF, but not in BCNF.

R1 : (building, school)
R2 : (dno, building, dname)

BCNF: FD: $\overline{A} \longrightarrow \overline{B}$ in R

then $\overline{A}$ must be key/superkey of R.

R1 :

building	school
Kingsbury	CERS
Morse	CERS
Thompson	COLSA

R2 :

dno	building	dname
1	Kings	CS
2	Morse	Earth
3	Kings	Math
1	Thompson	Nutr
2	Thompson	Earth

R1 : (building, school)
R2 : (dno, building, dname)

R1, R2 are in BCNF

$R = R1 \bowtie R2$

FD2 : building $\longrightarrow$ school

FD1 : dno, school $\longrightarrow$ dname, building

FD1 is lost in R1 & R2

* Database designers may leave tables in 3NF since you may lose some FDs when you reduce to BCNF.

What if R(dno, dname, school, building) is divided into

R_1' : ($\underline{\text{building}}$, school)

R_2' : ($\underline{\text{dno}}$, $\underline{\text{school}}$, dname)

$$R'' = R_1' \bowtie R_2' \neq R$$

dno	dname	school	building
1	CS	CEPS	Kingsbury
~~1~~	~~CS~~	~~CEPS~~	~~Morse~~
2	Earth	CEPS	Kings
2	Earth	CEPS	Morse