

1)  $F = \{ a \rightarrow b, b \rightarrow c, c \rightarrow \{d, e\} \}$   $b^+$  ?

$a \rightarrow b$   
 $b \rightarrow c$   
 $c \rightarrow de$

$\frac{b^+}{bcde}$

$b$  is given by reflexivity (identity) law  
 $c$  is determined by  $b$   
 $d$  and  $e$  are determined by  $c$

2)  $R(a, b, c, d, e, f)$   $F = \{ ab \rightarrow cdef, c \rightarrow abdef \}$

$F = \{$   
 $ab \rightarrow c,$   
 $ab \rightarrow d,$   
 $ab \rightarrow e,$   
 $ab \rightarrow f,$   
 $c \rightarrow a,$   
 $c \rightarrow b,$   
 $c \rightarrow d,$   
 $c \rightarrow e,$   
 $c \rightarrow f,$   
 $\}$

$F_c = \{$

$ab \rightarrow c,$   
 $c \rightarrow a,$   
 $c \rightarrow b,$   
 $c \rightarrow d,$   
 $c \rightarrow e,$   
 $c \rightarrow f,$   
 $\}$

1)

L	M	R
	a	d
	b	e
	c	f

2)

$\frac{ab^+}{abcdef}$      $\frac{c^+}{abcdef}$

Candidate keys:  
 $ab$   
 $c$

3) prime

$a$   
 $b$   
 $c$

nonprime

$d$   
 $e$   
 $f$

4) BCNF, LHS is a super key for all FDs.

3)  $R(a, b, c, d, e, f)$   $F = \{ ab \rightarrow cdef, c \rightarrow abdef, e \rightarrow a \}$ .

$$F = \left\{ \begin{array}{l} ab \rightarrow c, \\ ab \rightarrow d, \\ ab \rightarrow e, \\ ab \rightarrow f, \end{array} \quad \begin{array}{l} c \rightarrow a, \\ c \rightarrow b, \\ c \rightarrow d, \\ c \rightarrow e, \\ c \rightarrow f, \end{array} \quad e \rightarrow a \right\} \quad \bigg| \quad F_c = \left\{ \begin{array}{l} ab \rightarrow c \\ c \rightarrow b \\ c \rightarrow d \\ c \rightarrow e \\ c \rightarrow f \\ e \rightarrow a \end{array} \right\}$$

1)

L	M	R
	a	d
	b	f
	c	
	e	

2)

$$\frac{ab^+}{abcdef} \quad \frac{c^+}{abcdef} \quad \frac{be^+}{abcdef}$$

Candidate Keys:  $ab, c, be$

3)

Prime	Nonprime
a	d
b	f
c	
e	

4) Not in BCNF, since FD:  $e \rightarrow a$  violates BCNF

3<sup>rd</sup> NF, since every FD either has LHS being a super key or RHS being a prime attribute

4)  $R(a, b, c, d, e, f, g)$   $F = \{ ab \rightarrow cdeg, c \rightarrow abdef, d \rightarrow b \}$

$$F = \left\{ \begin{array}{l} ab \rightarrow c, \\ \cancel{ab \rightarrow d}, \\ \cancel{ab \rightarrow e}, \\ ab \rightarrow g, \end{array} \quad \begin{array}{l} c \rightarrow a, \\ \cancel{c \rightarrow b}, \\ c \rightarrow d, \\ c \rightarrow e, \\ c \rightarrow f, \end{array} \quad d \rightarrow b \right\}$$

$$F_c = \{ ab \rightarrow c, \\ ab \rightarrow g, \\ c \rightarrow a, \\ c \rightarrow d, \\ c \rightarrow e, \\ c \rightarrow f, \\ d \rightarrow b \}$$

1)

L	M	R
	a	e
	b	f
	c	g
	d	

2)  $\frac{ab^+}{abcdefg} \quad \frac{c^+}{abcdefg} \quad \frac{ad^+}{abcdef}$

3)

<u>Prime</u>	<u>Nonprime</u>
a	e
b	f
c	g
d	

4) Not in BCNF, since FD:  $d \rightarrow b$  violates BCNF

3<sup>rd</sup> NF, since every FD either has LHS being a superkey or RHS being a prime attribute