4NF continued:

Example: $R(\underline{a}, \underline{b}, \underline{c}, \underline{d}, \underline{E})$

$a \twoheadrightarrow b, \quad b \twoheadrightarrow d$ Key (a, b, c, d, E)

R1: $(\underline{a}, \underline{b})$ $a \twoheadrightarrow b$ trivial MVD   4NF

R2: $(\underline{a}, \underline{c}, d, \underline{E})$ $a \twoheadrightarrow d$ ✗

R3: $(\underline{a}, \underline{d})$ ✓

R4: $(\underline{a}, \underline{c}, \underline{E})$ ✓

$R = R1 \bowtie R3 \bowtie R4$ R1, R3, R4 : 4NF

Example: $R(\underline{a}, \underline{b}, c, \underline{d}, \underline{E})$

$ab \longrightarrow c$ $\Big\}$ by Rule 8:

$abc \twoheadrightarrow d$ $ab \twoheadrightarrow d$

key $(a\,b\,d\,E)$

R1: $(\underline{a}, \underline{b}, c)$ ✓   4NF

R2 $(\underline{a}, \underline{b}, \underline{d}, \underline{E})$ ✗

R3 $(\underline{a}, \underline{b}, \underline{d})$ ✓ $R = R1 \bowtie R3 \bowtie R4$

R4 $(\underline{a}, \underline{b}, \underline{E})$ ✓

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

$$b \longrightarrow d \qquad ab \longrightarrow\!\!\!\!\!> c$$

Key (a, b, c)

R1 $(\underline{b}, d)$ ✓

R2 $(\underline{a}, \underline{b}, \underline{c})$ ✓ $R = R1 \bowtie R2$

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

$$a \longrightarrow b \qquad\qquad \Rightarrow a \longrightarrow\!\!\!\!> b$$
$$c \longrightarrow d \qquad\qquad\quad b \longrightarrow\!\!\!\!> c$$
$$b \longrightarrow\!\!\!\!> c \qquad\qquad \Rightarrow a \longrightarrow\!\!\!\!> c$$

<u>Disadvantage of BCNF & 4NF</u> :   lose FD

Example: $R(\underline{a}, \underline{b}, c)$

FD: $ab \longrightarrow c$ Key (ab)

$c \longrightarrow b$ ← prime attribute

$R(a, b, c)$ in 3NF,   but not in BCNF

<u>BCNF</u> :   R1 $(\underline{c}, b)$

R2 $(\underline{a}, \underline{c})$ but you lost $ab \longrightarrow c$

Data Modeling

New edition: Chapter 3
Old edition: Chapter 7

- early design phase: how does a designer determine FDs & the attributes in a table.

① Analyze and evaluate systems: speak to end users.

② Conceptual design: UML diagrams
                        ER data models
                        ↓
                      Entity Relationships
                        ↓
                      graphical: easy for end users
                      to understand, yet formal
                      enough for designers

ER Models

① Classes: entities - tables (objects with attributes)

② Associations: relationships between entities
                (interconnected tables)

* **Entities & attributes**

EMPLOYEE entity

e1 ─┬─ Name: 'John'
    │
    ├─ Address: " Kengsbury Hall "
    │
    ┊
    │
    ├─ Age:
    │
    └─ phone#