COMP 3311
DATABASE MANAGEMENT SYSTEMS

LECTURE 5 EXERCISES
RELATIONAL MODEL AND RELATIONAL DATA BASE DESIGN

EXERCISE 1

Given relation schema R(X, Y, U, V, W) and F = {X→Y, UV→W, V→X}

a) **Determine the closure of each attribute.**

X^+ = {X, Y} (Look for X on LHS of FDs)

Y^+ = {Y}

U^+ = {U}

V^+ = {V, X, Y}

W^+ = {W}

b) **What are the candidate keys of R?**

The candidate key is UV since UV^+ = {X, Y, U, V, W}.

EXERCISE 2

We want to create the database for a bank that contains accounts (A), branches (B) and customers (C).

a) **What are the functional dependencies implied by the following constraints?**

- An account cannot be shared by multiple customers.

  Account → Customer $A \rightarrow C$

- Two different branches do not have the same account.

  Account → Branch $A \rightarrow B$

- Each customer can have at most one account in a branch (but different accounts in different branches).

  Branch, Customer → Account $BC \rightarrow A$

b) **What are the candidate keys?**

(Branch, Customer) and Account   BC and A

EXERCISE 3

Given: R(A, B, C, D, E)

F = {A→BC}

Decomposition: R_1(A, B, C) and R_2(A, D, E)

a) **Is the decomposition lossless? Why?** (*iff* $R_1 \cap R_2 \rightarrow R_1$ or $R_1 \cap R_2 \rightarrow R_2$)

Yes The common attribute A is a key for R_1.

b) **Is the decomposition dependency preserving? Why?** (*iff* $(\cup F_i)^+ = F^+$)

Yes A→BC is preserved in R_1.

c) **Is the decomposition** R_1(A, B, C) and R_2(C, D, E) **lossless? Why?**

No C is not a key for any table.

EXERCISE 4

Identify the candidate key(s) and the current highest normal form for each of the following relation schemas given their corresponding FDs.

a) R(A, B, C, D, E) $F = \{A \rightarrow B, C \rightarrow D\}$

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

Candidate keys: ACE

Normal form: **1NF** (both FDs violate 2NF)

$\Longrightarrow$ Both A→B and C→D violate 2NF since A and C are proper subsets of the candidate key ACE.

$\Longrightarrow$ Both A→B and C→D violate 2NF since B and D are non-prime attributes of R.

2NF

R is in 2NF *if and only if*
For each FD: X→A in F^+:
A $\in$ X (*trivial FD*) ***or***
X is not a proper subset of a candidate key for R ***or***
A is a prime attribute for R.

3NF

R is in 3NF *if and only if*
For each FD: X→A in F^+:
A $\in$ X (*trivial FD*) ***or***
X is a superkey for R ***or***
A is a prime attribute for R.

EXERCISE 4 (cont'd)

b) R(A, B, C) $\quad F = \{AB \rightarrow C, C \rightarrow B\}$

$AB^+ = \{A, B, C\}$ $\quad C^+ = \{C, B\}$

Candidate keys: AB, AC

Normal form: 3NF

$\Longrightarrow$ For $AB \rightarrow C$, AB is a superkey of R.

$\Longrightarrow$ For $C \rightarrow B$, B is a prime attribute of R.

2NF

R is in 2NF *if and only if*

For each FD: $X \rightarrow A$ in F^+:

- $A \in X$ (*trivial FD*) ***or***
- X is not a proper subset of a candidate key for R ***or***
- A is a prime attribute for R.

3NF

R is in 3NF *if and only if*

For each FD: $X \rightarrow A$ in F^+:

- $A \in X$ (*trivial FD*) ***or***
- X is a superkey for R ***or***
- A is a prime attribute for R.

EXERCISE 4 (cont'd)

c) R(A, B, C, F) $\quad F = \{AB \rightarrow C, C \rightarrow F\}$

$AB^+ = \{A, B, C, F\}$ $\quad C^+ = \{C, F\}$

Candidate keys: AB

Normal form: 2NF (C→F violates 3NF)

⟹ For C→F, C is not a proper subset of a candidate key.

⟹ C→F violates 3NF since C is not a superkey of R.

⟹ C→F violates 3NF since F is a non-prime attribute.

2NF

R is in 2NF *if and only if*

For each FD: X→A in F^+:

- A ∈ X (*trivial FD*) ***or***
- X is not a proper subset of a candidate key for R ***or***
- A is a prime attribute for R.

3NF

R is in 3NF *if and only if*

For each FD: X→A in F^+:

- A ∈ X (*trivial FD*) ***or***
- X is a superkey for R ***or***
- A is a prime attribute for R.

EXERCISE 5

Given relation schema R(A, B, C, G, H, I) and

$F = \{A \rightarrow B, \quad A \rightarrow C, \quad CG \rightarrow H, \quad CG \rightarrow I, \quad B \rightarrow H\}$

a) **Determine the closure of each attribute.**

$A^+ = \{A, B, C, H\}$ $\quad B^+ = \{B, H\}$ $\quad C^+ = \{C\}$

$G^+ = \{G\}$ $\quad H^+ = \{H\}$ $\quad I^+ = \{I\}$

b) **What are the candidate keys of R?**

The candidate key is AG.

Compute AG^+

$AG^{(0)} = \{A, G\}$

$AG^{(1)} = \{A, G, B\}$ $\quad (A \rightarrow B \text{ and } A \subseteq \{A, G\})$

$AG^{(2)} = \{A, G, B, C\}$ $\quad (A \rightarrow C \text{ and } A \subseteq \{A, G\})$

$AG^{(3)} = \{A, G, B, C, H\}$ $\quad (CG \rightarrow H \text{ and } CG \subseteq \{A, G, B, C\})$

$AG^{(4)} = \{A, G, B, C, H, I\}$ $\quad (CG \rightarrow I \text{ and } CG \subseteq \{A, G, B, C, H\})$

EXERCISE 6

Given: Sale(customer, store, product, price) and the constraints:

A customer buys from only one store.

There is a unique price for each product in a store.

a) **What are the FDs implied by the above description?**

customer→store

store, product→price

b) **What are the candidate keys?**

customer, product

Since customer, product→store, product (**IR2**)

and customer, product→price (**IR3**)

EXERCISE 6 (cont'd)

3NF
R is in 3NF *if and only if*
For each FD: X→A in F^+:
A ∈ X (*trivial FD*) ***or***
X is a superkey for R ***or***
A is a prime attribute for R.

Given: Sale(customer, store, product, price)
A customer buys from only one store.
There is a unique price for each product in a store.

c) **Explain why Sale is not in 3NF.** candidate key: customer, product

F = {customer→store; store, product→price}

Both FDs violate 3NF.

The LHS of the FDs are not superkeys nor are the RHS prime attributes of Sale.

d) **Decompose Sale into 3NF relation schemas.**

R_1(<u>customer</u>, store) R_2(<u>store, product</u>, price)

e) **Is the decomposition dependency preserving? Why?**

Yes Each dependency is preserved in a relation, **BUT** … (see next page).

EXERCISE 6 (cont'd)

The decomposition R_1(customer, store), R_2(store, product, price) is lossy because the common attribute store is not a key of any table.

Sale

customer	product	store	price
c1	p1	s1	pr1
c1	p2	s1	pr2
c2	p1	s1	pr1

decompose

R_1

customer	store
c1	s1
c2	s1

R_2

store	product	price
s1	p1	pr1
s1	p2	pr2

– The two decomposed relations do not generate the original one if joined (on the common store attribute). The join result contains 4 records instead of 3 as in the original relation.

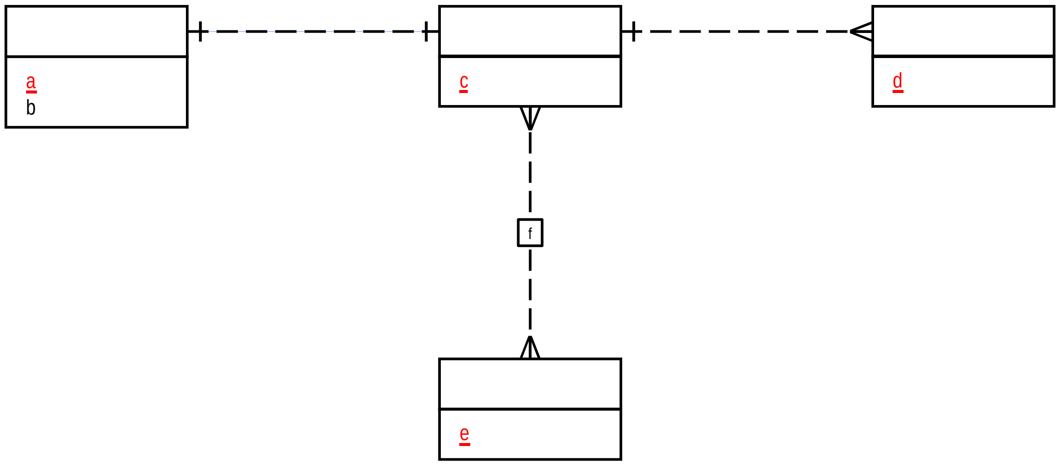
What is the problem? None of the fragments contains the candidate key (customer, product).

Solution? Include an additional table R_3(customer, product) containing the candidate key in the decomposition.

R_3

customer	product
c1	p1
c1	p2
c2	p1

EXERCISE 7



What are the FDs implied by the E-R diagram?

a→b

a→c

c→a

c→b (from c→a and a→b) **IR3**

d→c

d→a (from d→c and c→a) **IR3**

d→b (from d→c and c→b) **IR3**

ce→f