LAB 5 FUNCTIONAL DEPENDENCIES

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UPDATE ANOMALIES

- **Insertion anomalies**: the inability to add data to the database due to absence of other data.
- **Deletion anomalies**: the unintended loss of data due to deletion of other data.
- **Modification anomalies**: a data inconsistency that results from data redundancy and a partial update

FUNCTIONAL DEPENDENCIES AND IMPLICATION

- FDs tell us "relationship between and among attributes"!
- Components: Determinant & Dependant
- Implied FDs

X -> W

- Let Σ be a set of FDs. Check whether or not $\Sigma \models X \rightarrow W$ holds? We need to
  1. Compute **the set of all attributes** that are dependent on X, which is called the **closure** of X under Σ and is denoted by X^+.
  2. $\Sigma \models X \rightarrow W$ holds iff $W \subseteq X^+$.

EXERCICE

Consider a relation schema R = {A, B, C, D, E, F} with the following set Σ of functional dependencies:

AB → C, CF → B, BC → AD and D → E.

Does AB → D hold on any relation of R that satisfies Σ?

EXERCICE

Consider a relation schema R = {A, B, C, D, E, F} with the following set Σ of functional dependencies:

AB → C, CF → B, BC → AD and D → E.

Does AB → D hold on any relation of R that satisfies Σ?

compute the closure of AB, i.e.,

(AB) +
= AB by AB → AB
= ABC by AB → C
= ABC**D** by BC → AD **Yes!**

(B)+
= B by B->B
C is not included in (B)+
B->C does not hold

IDENTIFYING FD

- Analyse data requirements
- Analyse sample data

IDENTIFYING FD (ADR)

Workshop P152:

Consider the following:
HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}

Which functional dependency does the following requirement imply?
R1 A booking can be made for one day only.

IDENTIFYING FD (ADR)

Which functional dependency does the following requirement imply?

R1 A booking (for one room in one hotel by one guest)can be made for one day only (==in one date).

{guestNo, hotelNo, roomNo} → {date}

guestNo	hotelNo	roomNo	Date
001	H1	R101	28/08/2020
001	H1	R101	29/08/2020

Does not hold! Same combination on the LHS does not imply RHS...

PRACTICE

Consider the following:
HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}

Which functional dependency does the following requirement imply?
RX Only one guest can book a room in one hotel per day.

PRACTICE

Which functional dependency does the following requirement imply?
RX Only one guest can book a room in one hotel per day.
Same as R5: A room in any hotel can only be booked by one guest on the same date, i.e., no double-booking.

{roomNo, hotelNo, date} -> {guestNo}

101, A, 21/9, 668
101, A, 21/9, 669

IDENTIFYING FD

- Analyse data requirements
- Analyse sample data

IDENTIFYING FD (ASD)

Identifying all FDs (depending on the table only)

SALES

Customer_ID	Product	Price
1001	Laundry detergent	12
1007	Toothpaste	3
1010	Chlorine bleach	4
1024	Toothpaste	3

IDENTIFYING FD (ASD)

~~Customer_ID -> Product? Yes~~
~~Customer_ID -> Price? Yes~~
Product -> Price? **Yes**

What if the Customer_ID in row 1 is changed to 1007?

1007

SALES

Customer_ID	Product	Price
1001	Laundry detergent	12
1007	Toothpaste	3
1010	Chlorine bleach	4
1024	Toothpaste	3

IDENTIFYING FD (ASD)

What if the Customer_ID in row 1 is changed to 1007?

Customer_ID -> Product? **No (R1 & R2)**
Customer_ID -> Price? **No (R1 & R2)**
Product -> Customer_ID? **No (R2 & R4)**
Product -> Price? **Yes**
Price -> Customer_ID? **No (R2 & R4)**
Price -> Product? **Yes**
Customer_ID, Product -> Price?
No need to check, Product -> Price
Customer_ID, Price -> Produce? **No need**
Product, Price -> Customer_ID? **No (R2 & R4)**

SALES

Customer_ID	Product	Price
1001	Laundry detergent	12
1007	Toothpaste	3
1010	Chlorine bleach	4
1024	Toothpaste	3

LAB EXERCISE

Lab 3.4 Identifying all FDs

(4) *Consider the relation shown in Figure 3.*

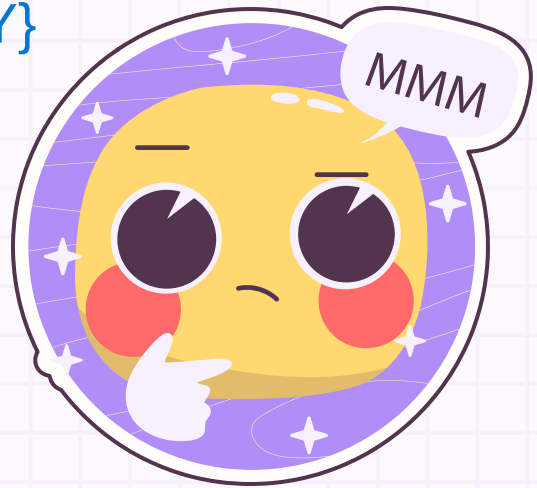
X	Y	Z
a_1	b	c_1
a_1	b	c_2
a_2	b	c_1
a_2	b	c_3

Figure 3: A relation for Exercise (2)

LAB EXERCISE

Lab 3.4 Identifying all FDs

{Z->Y, X->Y}



(4) *Consider the relation shown in Figure 3.*

X	Y	Z
a_1	b	c_1
a_1	b	c_2
a_2	b	c_1
a_2	b	c_3

Figure 3: A relation for Exercise (2)

c1

superkey

candidate key/minimal superkey/key

primary key

minimal != minimum

{ABC}

FINDING KEYS

superkeys, candidate keys, primary keys...

Consider the following:
HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}

R1 A booking can be made for one day only.
{guestNo, hotelNo, roomNo} → {date}

RX Only one guest can book a room in one hotel per day.
{roomNo, hotelNo, date} -> {guestNo}

What are the keys?

FINDING KEYS

FDs:
{guestNo, hotelNo, roomNo} → {date}
{roomNo, hotelNo, date} -> {guestNo}

What are the keys?
Check (X) + for every subset of {guestNo, hotelNo, date, roomNo}.

compute the closure for all of its subset
X+ = R -> X is a superkey
check for the proper subset Y in X
Y+ = R ?
if none of the subsets has Y+ = R, then X is a key.

FINDING KEYS

{A,B,C,D}
{A} {B} {C} {D} no!
{AB}(key!) {AC} {BC}(key!) {BD}(key!) {CD}
{ACD}

FDs:
{guestNo, hotelNo, roomNo} → {date}
{roomNo, hotelNo, date} -> {guestNo}

What are the keys?
Check (X) + for every subset of {guestNo, hotelNo, date, roomNo}.

{hotelNO} + = {hotelNO}
{hotelNO, roomNo} + = {hotelNO, roomNo}
{hotelNO, roomNo, guestNo} + = {guestNo, hotelNo, roomNo, date}
{roomNo, hotelNo, date} is also valid

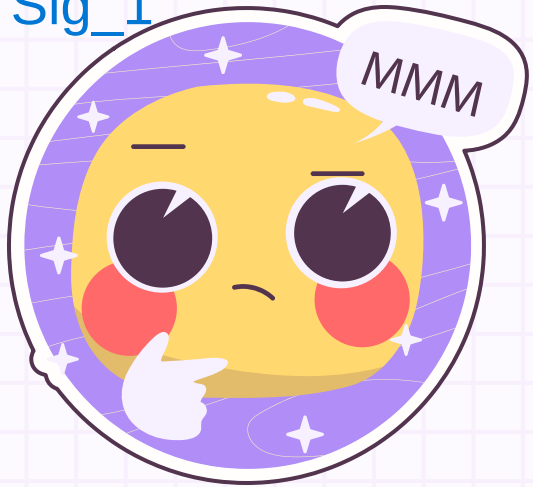
prime attributes: all attributes occurring in a key
{AB}{BC}{BD}

EQUIVALENCE OF FDS

Sig_1 -> Sig_2
Sig_2 -> Sig_1

Σ1 and Σ2 are equivalent if Σ1*= Σ2*.

Lab Q6: Consider a relation R = {A, B, C, D}.



Exercise:

Σ1 = {A → C, AC → B} and Σ2 = {A → B, A → C}

Sig_1 -> Sig_2
1. A->B holds in sig_1
2. A->C holds in sig_1

Sig_2 -> Sig1
1. A->C holds in sig_2
2. AC->B holds in sig_2
(AC)+ = ABC (by A->B)

EQUIVALENCE OF FDS

Σ1 and Σ2 are equivalent if Σ1*= Σ2*.

Lab Q6: Consider a relation R = {A, B, C, D}.

Exercise:

Σ1 = {A → C, AC → B} and Σ2 = {A → B, A → C}

Σ1* = {A → C, AC → B, A → B},

Σ2* = {A → B, A → C, AC → B}. Yes!

Sig_1 -> Sig_2
1. B->A does hold in sig_1.
(B)+ = B, A is not included!

MINIMAL COVER

Steps:

1. start from Σ
2. check whether all the FDs in Σ have only one attribute on the right hand side
3. check whether all the FDs in Σ have have minimized FDs on the left hand side
4. look for a redundant FD

MINIMAL COVER

Example: Σ = {B → A, D → A, AB → D}

1. start from Σ
   Σm = {B → A, D → A, AB → D}
2. check whether all the FDs in Σ have only one attribute on the right hand side
   Σm = {B → A, D → A, AB → D}
3. **Check whether all the FDs in Σ have have minimized FDs on the left hand side**
   For AB → D, can we convert it into A → D?
   NO!
   can we convert it into B → D?
   YES! B → AB → ABD
   Σm = {B → A, D → A, B → D}
4. **look for a redundant FD**

A->XY
A->X, A->Y

MINIMAL COVER

Example: Σ = {B → A, D → A, AB → D}

1. start from Σ
2. check whether all the FDs in Σ have only one attribute on the right hand side
3. **Check whether all the FDs in Σ have have minimized FDs on the left hand side**
   Σm = {B → A, D → A, B → D}
4. **look for a redundant FD**
   B → A redundant?
   YES! B → BD → BDA
   Σm = {D → A, B → D}

PRACTICE

$R = \{A, B, C, D\}$
$\Sigma = \{A \rightarrow B, AB \rightarrow CD, A \rightarrow D\}$

PRACTICE

$R = \{A, B, C, D\}$
$\Sigma = \{A \rightarrow B, AB \rightarrow CD, A \rightarrow D\}$

1. start from Σ
   $\Sigma m = \{A \rightarrow B, AB \rightarrow CD, A \rightarrow D\}$
2. check whether all the FDs in Σ have only one attribute on the right hand side
   $\Sigma m = \{A \rightarrow B, AB \rightarrow C, AB \rightarrow D, A \rightarrow D\}$
3. Check whether all the FDs in Σ have have minimized FDs on the left hand side
   For $AB \rightarrow C$, can we convert it into $A \rightarrow C$?
   YES! $A \rightarrow AB \rightarrow ABC$.
   Same for $AB \rightarrow D$.
   $\Sigma m = \{A \rightarrow B, A \rightarrow C, A \rightarrow D, A \rightarrow D\}$
4. look for a redundant FD
   $\Sigma m = \{A \rightarrow B, A \rightarrow C, A \rightarrow D\}$

{A->B, A->C}

MOVE ONTO LAB EXERCISE

Ask in the channel if you have any questions!

Note: for ER diagram in A2, if you are using other software, you must follow the terms in TerraER.