Relational Database Design Theory (I) [additional exercises]

CS348 Spring 2024

Exercises for Attribute closure

- The closure of attributes Z in a relation R (denoted Z^+) with respect to a set of FDs, $\mathcal{F}$, is the set of all attributes $\{A_1, A_2, \ldots\}$ functionally determined by Z (that is, $Z \rightarrow A_1 A_2 \ldots$)

- Algorithm for computing the closure Compute$Z^+(Z, \mathcal{F})$:
  - Start with closure $= Z$
  - If $X \rightarrow Y$ is in $\mathcal{F}$ and X is already in the closure, then also add Y to the closure
  - Repeat until no new attributes can be added

Example for computing attribute closure

Consider the schema of a table EmpProj and the FDs:

EmpProj

<u>SIN</u>	<u>PNum</u>	Hours	EName	PName	PLoc	Allowance

$\mathcal{F}$ includes:

SIN, PNum → Hours
SIN → EName
PNum → PName,PLoc
PLoc, Hours → Allowance

Example for computing attribute closure

Compute$Z^+(\{PNum, Hours\}, \mathcal{F})$:

$\mathcal{F}$ includes:
SIN, PNum → Hours
SIN → EName
PNum → PName,PLoc
PLoc, Hours → Allowance

FD	Z^+
initial	$PNum, Hours$
PNum → PName,PLoc	$PNum, Hours$**, PName, PLoc**
PLoc, Hours → Allowance	$PNum, Hours$, PName, PLoc, ***Allowance***

$$PNum, Hours \rightarrow PName, PLoc, Allowance$$

Using attribute closure

Given a relation R and set of FD's $\mathcal{F}$

- Does another FD $X \rightarrow Y$ follow from $\mathcal{F}$?
  - Compute X^+ with respect to $\mathcal{F}$
  - If $Y \subseteq X^+$, then $X \rightarrow Y$ follows from $\mathcal{F}$

- Is K a key of R?
  - Compute K^+ with respect to $\mathcal{F}$
  - If K^+ contains all the attributes of R, K is a super key
  - Still need to verify that K is *minimal* (how?)
    - Hint: check the attribute closure of its proper subset.
    - i.e., Check that for no set X formed by removing attributes from K is $K^+$the set of all attributes

Exercise I

$\text{Compute}Z^+(\{SIN, PNum\}, \mathcal{F})$:

$\mathcal{F}$ includes:

SIN, PNum → Hours
SIN → EName
PNum → PName,PLoc
PLoc, Hours → Allowance

$\text{Compute}Z^+(\{SIN, PNum, Hours\}, \mathcal{F})$?

Exercise I

$\mathcal{F}$ includes:

SIN, PNum → Hours
SIN → EName
PNum → PName,PLoc
PLoc, Hours → Allowance

Compute$Z^+(\{SIN, PNum\}, \mathcal{F})$:

FD	Z^+
initial	$SIN, PNum$
SIN → EName	$SIN, PNum,$ **EName**
PNum → PName, PLoc	$SIN, PNum, EName,$ **PName, PLoc**
SIN, PNum → Hours	$SIN, PNum, EName,$ PName, Ploc, **Hours**
Ploc, Hours → Allowance	$SIN, PNum, EName,$ PName, Ploc, Hours, ***Allowance***

$\{SIN, PNum\} \rightarrow \{SIN, PNum, Hours, EName,$ **PName, Ploc, Allowance**$\}$

$\{SIN, PNum\}$ **is key**

Compute$Z^+(\{SIN, PNum, Hours\}, \mathcal{F})$?

$\{SIN, PNum, Hours, EName,$ **PName, Ploc, Allowance**$\}$

→ A super key (why?)

Exercise II

- R(A,B,C)
- F includes
  - FD1: A → B
  - FD2: B → C
  - FD3: A → C
- $ComputeZ^+$({A}, F) = ?
  - {A,B,C}
- $ComputeZ^+$({B}, F) = ?
  - {B,C}
- $ComputeZ^+$({A,B,C}, F) = ?
  - {A,B,C}

- Super keys for R?
  - A, AB, AC, ABC
- Candidate keys for R?
  - A

Exercise III

- R(A,B,C)
- F includes
  - FD1: A → B
- $\mathrm{C}omputeZ^{+}$({A}, F) = ?
  - {A,B}
- Super keys for R?
  - AC, ABC
- Candidate keys for R?
  - AC