Normalization: Functional Dependencies

IT5008 Tutorial 07

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Background

Your company, Apasaja Private Limited, is commissioned by Toko Kopi Luwak to design relational schema for the management of their coffee beans, drinks, and cafes.

A coffee bean is fully identified by its unique brand name or a combination of its cultivar and region (since the same cultivar can be grown in different region). For instance, we may have a coffee bean named "The Waterfall" which comes from a Tabi cultivar grown in Colombia.

A drink can be made utilizing a particular coffee bean. The name of the drink is only unique for a particular coffee bean. This means, we can have an "Espresso" made with "The Waterfall" or "La Bella" (which is a Pacamara cultivar grown in Guatemala). The price of the drink is also recorded.

A branch identified by its branch name may then sell the drink. A drink may be sold by zero or more branches. A branch may sell zero or more drinks. Additionally, the address of the branch is also recorded. Lastly, for each drink sold by a branch, we record the quantity sold to see which branch is the most profitable.

Background (cont'd)

We are only given an abstract schema for this application as follows.

$$R = \{A, B, C, D, E, F, G, H\}$$

$$\Sigma = \{\{A\} \to \{C, E\}, \{A, B\} \to \{D\}, \{F\} \to \{H\}, \{C, E\} \to \{A\}, \{B, C, E\} \to \{D\}, \{A, B, F\} \to \{D, G\}, \{B, C, E, F\} \to \{G\}\}$$

FUNCTIONAL DEPENDENCIES

Question 1(a)

From the functional dependencies in Σ and the text description of the application, can you figure out the mapping of the attributes and the letters?

- While not necessary, it may be easier to draw an ER-D based on the text description of the application and figure out the mapping form there.
- Refer to PDF handout for a model ER-D for the given scenario.

FUNCTIONAL DEPENDENCIES

Question 1(b)

Compute the attribute closures of the subset of attributes of R with Σ in order to find the candidate keys of R with Σ.

$R = \{A, B, C, D, E, F, G, H\}$

$\Sigma = \{\{A\} \to \{C, E\}, \{A, B\} \to \{D\}, \{F\} \to \{H\}, \{C, E\} \to \{A\}, \{B, C, E\} \to \{D\}, \{A, B, F\} \to \{D, G\}, \{B, C, E, F\} \to \{G\}\}$

- Note that attributes B and F do not appear on the right-hand side (RHS) of any functional dependencies. Hence, these attributes must appear in all keys.
- For easier visualization, try drawing a hypergraph based on the relations in Σ.

$$\Sigma = \{\{A\} \to \{C, E\}, \{A, B\} \to \{D\}, \{F\} \to \{H\}, \{C, E\} \to \{A\}, \{B, C, E\} \to \{D\}, \{A, B, F\} \to \{D, G\}, \{B, C, E, F\} \to \{G\}\}$$

FUNCTIONAL DEPENDENCIES

Question 1(b)

Compute the attribute closures of the subset of attributes of R with Σ in order to find the candidate keys of R with Σ.

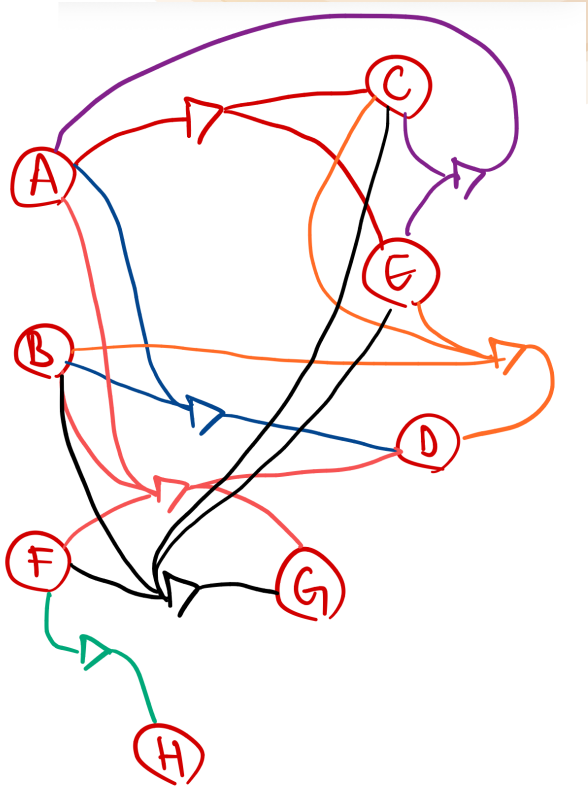
Found candidate keys: $\{\boldsymbol{A}, \boldsymbol{B}, \boldsymbol{F}\}$

Sets of 2 attributes:

- $\{B, F\}^+ = \{B, F, H\}$

Sets of 3 attributes, superset of $\{B, F\}$:

- $\{A, B, F\}^+ = \{A, B, C, D, E, F, G, H\} = R$ (candidate key)
- $\{B, C, F\}^+ = \{B, C, F, H\}$
- $\{B, D, F\}^+ = \{B, D, F, H\}$
- $\{B, E, F\}^+ = \{B, E, F, H\}$
- $\{B, F, G\}^+ = \{B, F, G, H\}$
- $\{B, F, H\}^+ = \{B, F, H\}$



$\Sigma = \{\{A\} \to \{C, E\}, \{A, B\} \to \{D\}, \{F\} \to \{H\}, \{C, E\} \to \{A\}, \{B, C, E\} \to \{D\}, \{A, B, F\} \to \{D, G\}, \{B, C, E, F\} \to \{G\}\}$

FUNCTIONAL DEPENDENCIES

Question 1(b)

Compute the attribute closures of the subset of attributes of R with Σ in order to find the candidate keys of R with Σ.

Found candidate keys: $\{A, B, F\}, \{\boldsymbol{B}, \boldsymbol{C}, \boldsymbol{E}, \boldsymbol{F}\}$

Sets of 4 attributes, superset of $\{B, F\}$, not superset of $\{A, B, F\}$:

- $\{B, C, D, F\}^+ = \{B, C, D, F, H\}$
- $\{B, C, E, F\}^+ = \{A, B, C, D, E, F, G, H\} = R$ (candidate key)
- $\{B, C, F, G\}^+ = \{B, C, F, G, H\}$
- $\{B, C, F, H\}^+ = \{B, C, F, H\}$
- $\{B, D, E, F\}^+ = \{B, D, E, F, H\}$
- $\{B, D, F, G\}^+ = \{B, D, F, G, H\}$
- $\{B, D, F, H\}^+ = \{B, D, F, H\}$
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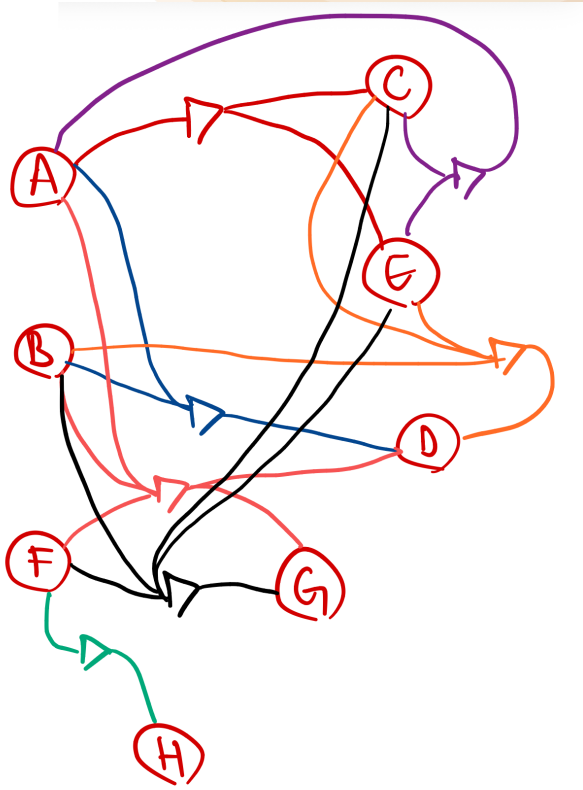


Attribute closures of ≥5 attributes do not make a candidate key.

FUNCTIONAL DEPENDENCIES

Question 1(b)

Compute the attribute closures of the subset of attributes of R with Σ in order to find the candidate keys of R with Σ.

$R = \{A, B, C, D, E, F, G, H\}$

$\Sigma = \{\{A\} \to \{C, E\}, \{A, B\} \to \{D\}, \{F\} \to \{H\}, \{C, E\} \to \{A\}, \{B, C, E\} \to \{D\}, \{A, B, F\} \to \{D, G\}, \{B, C, E, F\} \to \{G\}\}$

- Note that B and F do not appear on the right-hand side (RHS) of any functional dependencies. Hence, they must appear in all keys.
- For easier visualization, try drawing a hypergraph based on the relations in Σ.

Candidate keys: $\{A, B, F\}, \{B, C, E, F\}$

FUNCTIONAL DEPENDENCIES

Question 1(c)

Find the prime attributes of R with Σ.

Candidate keys: $\{A, B, F\}, \{B, C, E, F\}$

Prime attributes $= \{A, B, F\} \cup \{B, C, E, F\}$

$= \{\boldsymbol{A}, \boldsymbol{B}, \boldsymbol{C}, \boldsymbol{E}, \boldsymbol{F}\}$

$\Sigma = \{\{A\} \to \{C, E\}, \{A, B\} \to \{D\}, \{F\} \to \{H\}, \{C, E\} \to \{A\}, \{B, C, E\} \to \{D\}, \{A, B, F\} \to \{D, G\}, \{B, C, E, F\} \to \{G\}\}$

MINIMAL COVER

Question 2

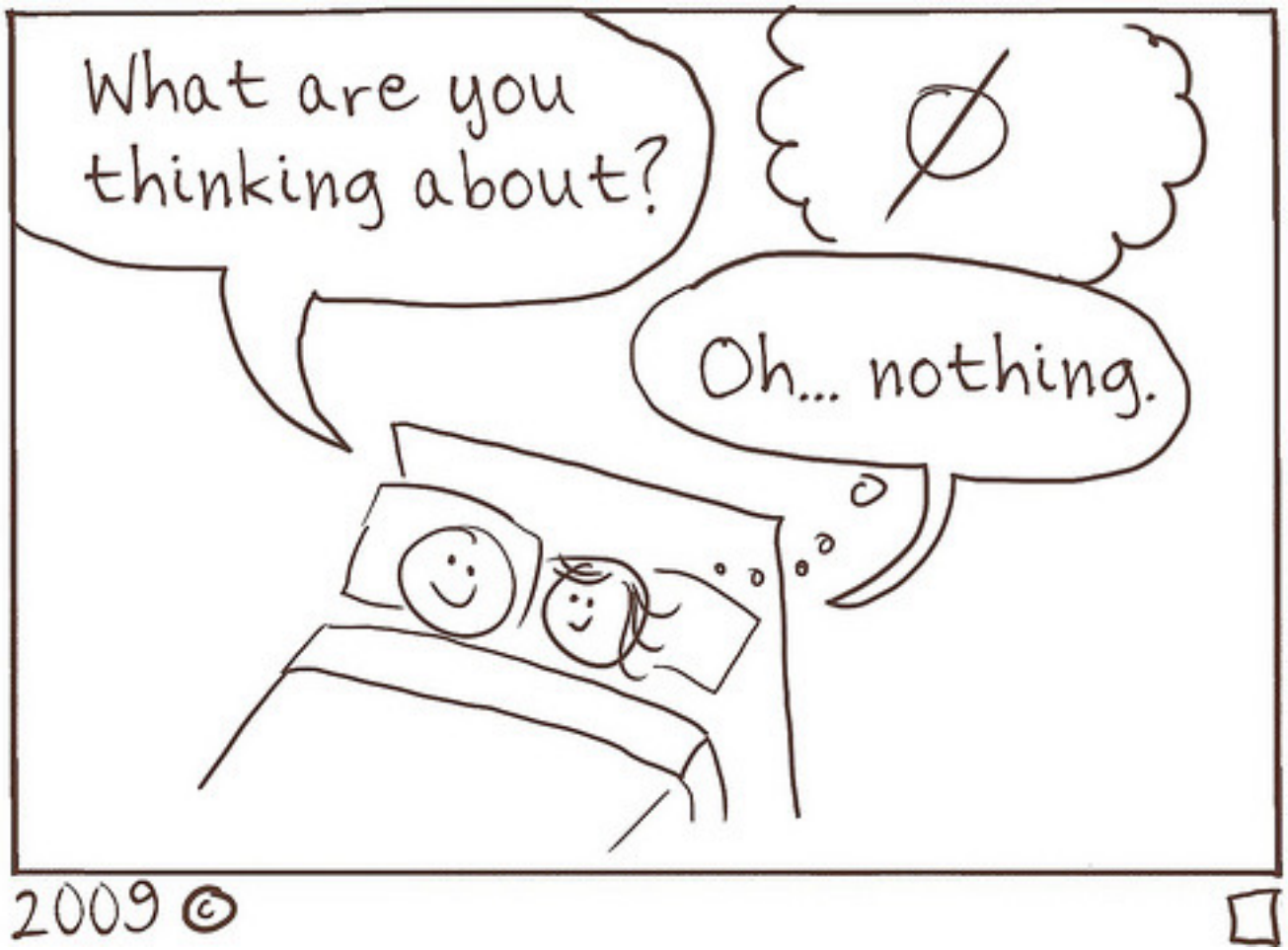
Compute:

(a) a minimal cover of R with Σ

(b) a canonical cover of R with Σ

After simplifying RHS:

$\{A\} \to \{C\}$ (split)
$\{A\} \to \{E\}$ (split)
$\{A, B\} \to \{D\}$
$\{F\} \to \{H\}$
$\{C, E\} \to \{A\}$
$\{B, C, E\} \to \{D\}$
$\{A, B, F\} \to \{D\}$ (split)
$\{A, B, F\} \to \{G\}$ (split)
$\{B, C, E, F\} \to \{G\}$



Source: https://brownsharpie.courtneygibbons.org/tag/set-theory/