COMPSCI 351 The University of Auckland + Southwest University

Fundamentals of Database Systems - Test 2

2024

Time allowed: FORTY FIVE (45) minutes

NOTE:
- The test is closed book.
- No calculators are permitted.
- Attempt ALL questions in this test.
- A maximum of 30 marks is available in this test.

Student Name: _____

Student ID: _____

1. **(Relational Calculus)**

Consider the relational database schema {CLIENT, LAWYER, CASE} with the relation schemata:

- CLIENT={*name, dob, address*} with key {name, dob}

- LAWYER={*name, practice, specialisation*} with key {*name, practice*}

- CASE={*c_name, c_dob, l_name, l_practice, started, jurisdiction, outcome*} with key {c_name, c_dob, l_name, l_practice, started, jurisdiction} and with foreign keys

[c_name, c_dob] $\subseteq$ CLIENT[name, dob]

[l_name, l_practice] $\subseteq$ LAWYER[name, practice]

(a) Write the following query in safe relational calculus:
Who are the clients (name and date of birth) that have some case with a lawyer from the practice "SP Law" where the outcome is not "settled"?

[3 marks]

(b) Write down in English what the following relational calculus query returns:
$\exists x_{name}, x_{dob}$
$(\texttt{CLIENT}(x_{name}, x_{dob}, x_{address}) \wedge$
$(\forall x'_{name}, x_{practice}, x_{started}, x_{outcome}$
$\texttt{CASE}(x_{name}, x_{dob}, x'_{name}, x_{practice}, x_{started},$ 'New Zealand' $, x_{outcome}) \Rightarrow$
$\texttt{LAWYER}(x'_{name}, x_{practice},$ 'New Zealand tax')))

[3 marks]

SOLUTION:

(a) $\exists x_{address}, x'_{name}, x_{specialisation}, x_{started}, x_{jurisdiction}, x_{outcome}$
$(\texttt{CLIENT}(x_{name}, x_{dob}, x_{address}) \wedge \texttt{LAWYER}(x'_{name},$ 'SP Law' $, x_{specialisation}) \wedge$
$\texttt{CASE}(x_{name}, x_{dob}, x'_{name},$ 'SP Law' $, x_{started}, x_{jurisdiction}, x_{outcome}) \wedge$
$\neg\ \texttt{CASE}(x_{name}, x_{dob}, x'_{name},$ 'SP Law' $, x_{started}, x_{jurisdiction},$ 'settled'))

(b) What are the addresses of clients that have every case with jurisdiction 'New Zealand' handled by a lawyer with specialisation in 'New Zealand tax'?

2. **(Entity-Relationship Modelling)**

Consider the relational database schema {CLIENT, LAWYER, CASE} with the relation schemata:

- CLIENT={*name, dob, address*} with key {name, dob}
- LAWYER={*name, practice, specialisation*} with key {*name, practice*}
- CASE={*c_name, c_dob, l_name, l_practice, started, jurisdiction, outcome*} with key {c_name, c_dob, l_name, l_practice, started, jurisdiction} and with foreign keys

  [c_name, c_dob] $\subseteq$ CLIENT[name, dob]

  [l_name, l_practice] $\subseteq$ LAWYER[name, practice]

(a) Specify the ER schema that corresponds to the database schema above.

[4 marks]

(b) Specify the ER diagram that corresponds to the database schema above.

[4 marks]

(c) Define an instance over the ER schema that contains at least two objects for each object type.

i) Use foreign key semantics to specify your instances.

ii) In addition, use identifier semantics to write down the same instances.

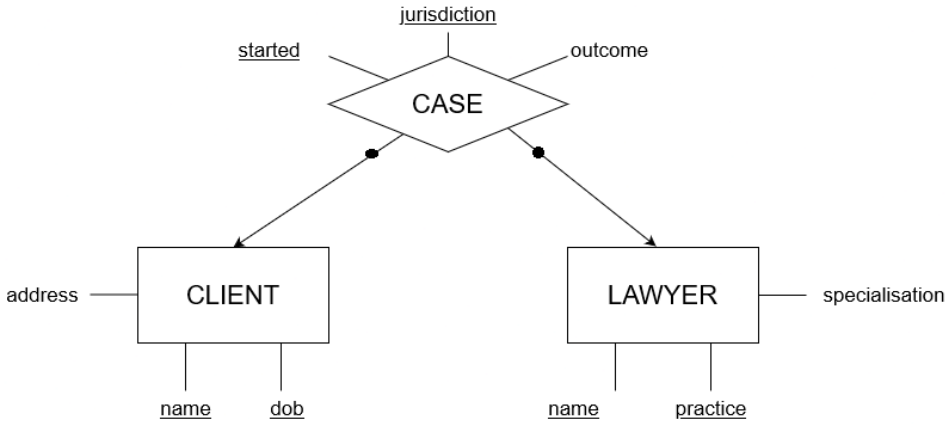
[3 marks]

SOLUTION:

(a) - CLIENT=({*name, dob, address*},{name, dob})

- LAWYER=({*name, practice, specialisation*},{*name, practice*})
- CASE=({CLIENT, LAWYER}, {*started, jurisdiction, outcome*},{CLIENT, LAWYER, started, jurisdiction})

(b) See the Entity Relationship Diagram below:



(c) i)

CLIENT		
name	dob	address
John Doe	1980-01-01	1 Main Street
Jane Doe	1982-01-01	1 Main Street

LAWYER		
name	practice	specialisation
Stan Peterson	SP Law	Financial
Sue Adams	Global Talent	Immigration

(In the below instance the value for the name attribute is abbreviated from 'Stan Peterson' to 'S P' due to formatting reasons)

CASE						
CLIENT		LAWYER		started	jurisdiction	outcome
John Doe	1980-01-01	S P	SP Law	2024-03-01	New Zealand	ongoing
Jane Doe	1982-01-01	S P	SP Law	2024-04-01	New Zealand	settled

ii)

CLIENT			
ID	name	dob	address
c1	John Doe	1980-01-01	1 Main Street
c2	Jane Doe	1982-01-01	1 Main Street

LAWYER			
ID	name	practice	specialisation
l1	Stan Peterson	SP Law	Financial
l2	Sue Adams	Global Talent	Immigration

CASE					
ID	CLIENT	LAWYER	started	jurisdiction	outcome
ca1	c1	l1	2024-03-01	New Zealand	ongoing
ca2	c2	l1	2024-04-01	New Zealand	settled

3. **(Database Normalization)**

Consider the relation schema `EVENT` = {*company*, *location*, *date*} which stores information on events. In addition, we have the set of functional dependencies that hold on `EVENT` which is $\Sigma = \{company \rightarrow location, location \rightarrow date\}$.

(a) Give an example of a relation over the schema `EVENT` that has redundant value occurrences and explain why the values are redundant.

[2 marks]

(b) Is the schema `EVENT` in 3NF (with respect to Σ)? Please explain why or why not. If not, determine a faithful, lossless 3NF decomposition of `EVENT`.

[5 marks]

(c) Is the schema `EVENT` in BCNF (with respect to Σ)? Please explain why or why not. If not, determine a lossless BCNF decomposition of `EVENT` and explain whether or not this is also faithful.

[3 marks]

(d) Give an example of database over the decomposition from c) and explain why no redundancy is possible now. Preferably use your example from a).

[3 marks]

SOLUTION:

(a) The following relation is an example of a relation with redundancy.

EVENT		
company	location	date
Countdown	Domain	01/01/2024
Neox	Domain	01/01/2024

The value occurrences 01/01/2024 of date are redundant as the value of location implies the value of date. (Note that any value replacement of date would violate the FD *location* $\rightarrow$ *date*)

(b) We can easily verify (for example using the closure algorithm) that we only have the (minimal) key is {*company*} which means *company* is the only prime attribute. The schema `EVENT` is not in 3NF as we have for example the FD location $\rightarrow$ date where neither location is a super key nor date is prime attribute.
Using the synthesis algorithm (where Σ is already canonical cover) we get

- $R_1 = \{company, location\}$ with FD set $\Sigma_1 = \{company \rightarrow location\}$ and *company* constitutes key of R_1.
- $R_2 = \{location, date\}$ with FD set $\Sigma_2 = \{location \rightarrow date\}$ and *location* constitutes key of R_2.

(c) The schema is not in BCNF as it was not in 3NF.
The lossless 3NF decomposition from a) is already in BCNF as we have the schemata:

- $R_1 = \{company, location\}$ with FD set $\Sigma_1 = \{company \rightarrow location\}$ and *company* constitutes key of R_1.
- $R_2 = \{location, date\}$ with FD set $\Sigma_2 = \{location \rightarrow date\}$ and *location* constitutes key of R_2.

As the decomposition into 3NF was already faithful this means this decomposition is also faithful. More specifically, Σ was already canonical cover and we are able to verify both FDs in Σ without having to join schemata.

(d) The following is the database that corresponds to the example relation in a).

R_1	
company	location
Countdown	Domain
Neox	Domain

R_2	
location	date
Domain	01/01/2024

Here, no redundant value occurrences are possible as both left hand sides of FDs (company and location) are now keys in the corresponding schema and value replacements of either location in R_1 nor date in R_2 can cause a violation of either FDs as they are now removed/transformed.

Possible Marks: 30