In the Lecture Series Introduction to Database Systems

Tuple Relational Calculus

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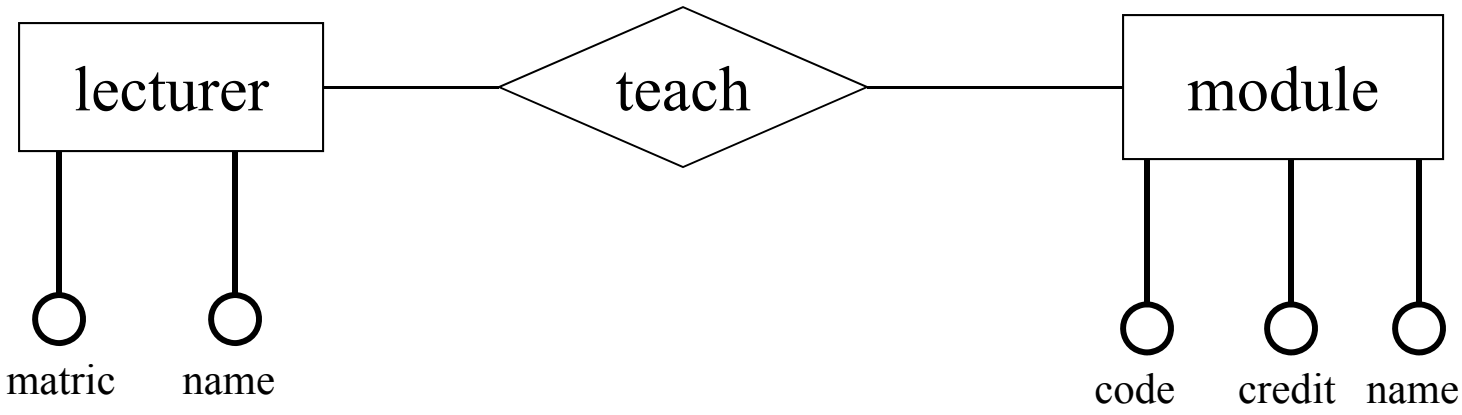
Example

- lecturer(<u>matric</u>, name)
- module(<u>code</u>, name, credit),
- teach(<u>matric</u>, <u>code</u>)



Example

- $\{T \mid T \in \text{lecturer}\}$
- $\{T \mid \exists\, T1\ (T1 \in \text{lecturer} \wedge T = T1)\}$
- $\{T \mid \exists\, T1\ (T1 \in \text{lecturer} \wedge T.\text{matric} = T1.\text{matric} \wedge T.\text{name} = T1.\text{name})\}$

by CONVENTION!

Syntax of Tuple Relational Calculus

- {T | formula}

- Variables are tuples
- T $\in$ rel: T is a tuple in relation *rel*
- T.a: The value of attribute *a* in T.
- T1 = T2: T1 and T2 must have the same attributes with same values.
- Parenthesis can be omitted if non ambiguous (not advised)
  - {T | $\exists$ T1 (T1 $\in$ lecturer $\wedge$ T.name = T1.name)}
  - {T | $\exists$ T1 T1 $\in$ lecturer $\wedge$ T.name = T1.name}

Example

- $\{T \mid \exists\ T1\ T1 \in \text{lecturer}$
  $\wedge\ T1.name = \text{“Smith”}$
  $\wedge\ T.matric = T1.matric\}$

Example

- $\{T \mid \exists T1 \exists T2 \exists T3$
  $T1 \in lecturer$
  $\wedge\ T2 \in module$
  $\wedge\ T3 \in teach$
  $\wedge\ T1.matric = T3.matric$
  $\wedge\ T2.code = T3.code$
  $\wedge\ T2.credit < 2$
  $\wedge\ T.lec\_name = T1.name$
  $\wedge\ T.mod\_name = T2.name\}$

Example

```
SELECT
   T1.name as lec_name,
   T2.name as mod_name
FROM  lecturer T1, module T2, teach t3
WHERE T1.matric = T3.matric
        AND T2.code = T3.code
        AND T2.credit < 2
```

Example

Find the names of the lecturers teaching all modules:

$$\{T \mid \exists\, T1\ \forall\, T2\ \exists\, T3$$
$$T1 \in \text{lecturer}$$
$$\wedge\ (T2 \in \text{module} \Rightarrow ($$
$$T3 \in \text{teach}$$
$$\wedge\ T1.\text{matric} = T3.\text{matric}$$
$$\wedge\ T2.\text{code} = T3.\text{code}))$$
$$\wedge\ T.\text{name} = T1.\text{name}\}$$

Example

Find the names of the lecturers T1 such that, for any module T2, the lecturer teaches the module (as recorded in T3).

$$\{T \mid \exists\, T1\ \forall\, T2\ \exists\, T3$$
$$T1 \in \text{lecturer}$$
$$\wedge\ (T2 \in \text{module} \Rightarrow ($$
$$T3 \in \text{teach}$$
$$\wedge\ T1.\text{matric} = T3.\text{matric}$$
$$\wedge\ T2.\text{code} = T3.\text{code}))$$
$$\wedge\ T.\text{name} = T1.\text{name}\}$$

Example

- $\{T \mid \exists T1($
  $T1 \in lecturer$
  $\wedge \quad \forall T2$
  $(T2 \in module \Rightarrow$
  $(\exists T3 \ (T3 \in teach$
  $\wedge T1.matric = T3.matric$
  $\wedge T2.code = T3.code)))$
  $\wedge T.name = T1.name)\}$

Example

$$\exists\ T1\ \forall\ T2\ \exists\ T3$$

We are looking for tuples T such that the formula below is true for **SOME** tuple T1, **ALL** tuples T2, and **SOME** tuple T3 and :

$$T1 \in \text{lecturer}$$
$$\wedge\ (T2 \in \text{module} \Rightarrow (T3 \in \text{teach} \wedge T1.\text{matric} = T3.\text{matric} \wedge T2.\text{code} = T3.\text{code}))$$
$$\wedge\ T.\text{name} = T1.\text{name}$$

Example

If $T1 \in$ lecturer and $T2 \notin$ module,

the formula is true!!!!

$$
\begin{aligned}
& T1 \in \text{lecturer} \\
\wedge\ & (T2 \in \text{module} \Rightarrow (\\
& \quad T3 \in \text{teach} \wedge T1.\text{matric} = T3.\text{matric} \\
& \quad \wedge\ T2.\text{code} = T3.\text{code})) \\
\wedge\ & T.\text{name} = T1.\text{name}
\end{aligned}
$$

Example

If T1 $\in$ lecturer and T2 $\in$ module, then the formula is true if there is a T3 $\in$ teach which shares the same matric number with T1 and module code with T2 .

Namely, if the lecturer teaches the module.

$$
\begin{aligned}
&T1 \in \text{lecturer} \\
&\wedge (T2 \in \text{module} \Rightarrow (\\
&\qquad T3 \in \text{teach} \wedge T1.\text{matric} = T3.\text{matric} \\
&\qquad \wedge T2.\text{code} = T3.\text{code})) \\
&\wedge T.\text{name} = T1.\text{name}
\end{aligned}
$$

Example

The formula is false only if

T1 $\notin$ lecturer or if T2 is a module, but there is no T3 which shares the same matric number with T1 and module code with T2

$$
\begin{aligned}
& T1 \in lecturer \\
\wedge\ & (T2 \in module \Rightarrow (\\
& \quad T3 \in teach \wedge T1.matric = T3.matric \\
& \quad \wedge\ T2.code = T3.code)) \\
\wedge\ & T.name = T1.name
\end{aligned}
$$

Example to SQL

$$\{T \mid \exists T1\ \forall T2\ \exists T3$$
$$(T1 \in \text{lecturer}$$
$$\wedge\ (T2 \in \text{module} \Rightarrow ($$
$$T3 \in \text{teach}$$
$$\wedge\ T1.\text{matric} = T3.\text{matric}$$
$$\wedge\ T2.\text{code} = T3.\text{code}))$$
$$\wedge\ T.\text{name} = T1.\text{name})\}$$

Example to SQL

$$
\begin{aligned}
&\{T \mid \exists\, T1\ \forall\, T2 \\
&\quad (T1 \in \text{lecturer} \\
&\quad \wedge\, (T2 \in \text{module} \Rightarrow (\exists\, T3 \\
&\quad\quad (T3 \in \text{teach} \\
&\quad\quad \wedge\, T1.\text{matric} = T3.\text{matric} \\
&\quad\quad \wedge\, T2.\text{code} = T3.\text{code}))) \\
&\quad \wedge\, T.\text{name} = T1.\text{name})\}
\end{aligned}
$$

Example to SQL

$$\{T \mid \exists\, T1\ \forall\, T2$$
$$(T1 \in \text{lecturer}$$
$$\wedge\ (\neg(T2 \in \text{module}) \vee (\exists\, T3$$
$$(T3 \in \text{teach}$$
$$\wedge\ T1.\text{matric} = T3.\text{matric}$$
$$\wedge\ T2.\text{code} = T3.\text{code})))$$
$$\wedge\ T.\text{name} = T1.\text{name})\}$$

$A \Rightarrow B$ is the same as $\neg\, A \vee B$

Example to SQL

$$\{T \mid \exists T1\ \forall T2$$
$$(T1 \in \text{lecturer}$$
$$\wedge \neg\neg(\neg(T2 \in \text{module}) \vee (\exists T3$$
$$(T3 \in \text{teach}$$
$$\wedge T1.\text{matric} = T3.\text{matric}$$
$$\wedge T2.\text{code} = T3.\text{code})))$$
$$\wedge T.\text{name} = T1.\text{name})\}$$

Double Negation:

A is the same as $\neg\neg A$

Example to SQL

$$\{T \mid \exists T1\ \forall T2$$
$$(T1 \in \text{lecturer}$$
$$\wedge \neg (T2 \in \text{module} \wedge \neg (\exists T3$$
$$(T3 \in \text{teach}$$
$$\wedge T1.\text{matric} = T3.\text{matric}$$
$$\wedge T2.\text{code} = T3.\text{code})))$$
$$\wedge T.\text{name} = T1.\text{name})\}$$

De Morgan:

$\neg \neg (\neg A \vee B)$ is the same as $\neg (A \wedge \neg B)$

Example to SQL

$$
\begin{aligned}
&\{T \mid \exists\, T1 \\
&\quad (T1 \in \text{lecturer} \\
&\quad \wedge \neg\, (\exists\, T3\ (\ T2 \in \text{module} \wedge \neg\, (\exists\, T3 \\
&\quad\quad (T3 \in \text{teach} \\
&\quad\quad \wedge\ T1.\text{matric} = T3.\text{matric} \\
&\quad\quad \wedge\ T2.\text{code} = T3.\text{code})))) \\
&\quad \wedge\ T.\text{name} = T1.\text{name})\}
\end{aligned}
$$

De Morgan (for quantifiers):

$\forall\ X\ (\neg\ A)$ is the same as $\neg\ (\exists\ X\ (A))$

Example to SQL

$$
\begin{aligned}
&\{T \mid \exists\, T1 \\
&\quad (T1 \in \text{lecturer} \\
&\quad \wedge \neg\, (\exists\, T2\, (T2 \in \text{module} \wedge \neg\, (\exists\, T3 \\
&\qquad (T3 \in \text{teach} \\
&\qquad \wedge\, T1.\text{matric} = T3.\text{matric} \\
&\qquad \wedge\, T2.\text{code} = T3.\text{code}))) \\
&\quad \wedge\, T.\text{name} = T1.\text{name})\}
\end{aligned}
$$

Example to SQL

```
SELECT T1.name
FROM lecturer T1
WHERE NOT EXISTS (
   SELECT *
   FROM module T2
   WHERE NOT EXISTS (
        SELECT * FROM teach T3
        WHERE T1.matric = T3.matric
        AND T2.code = T3.code))
```

Safety of Queries in T-uple Relational Calculus

{T | T $\notin$ lecturer}

(“mycat”, 22, “red”) is not a lecturer, any t-uple in the world maybe an answer if it is not already in the lecturer relation.

Safety of Queries in T-uple Relational Calculus

A query is **safe** if the set of t-uples in the answer is a subset of the set of t-uples that can be constructed from the constants explicitly referenced directly (they appear in the query) or indirectly (they appear in a relation mentioned in the query) in the query.

We consider only safe queries

Credits

The content of this lecture is based on chapter 3 of the book "Introduction to database Systems"
By
S. Bressan and B. Catania, McGraw Hill publisher

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