COMP 330/543: Relational Calculus

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Relational Calculus

Nothing more than a FOL predicate...

Embedded within a set constructor

Example: Bar-going People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who goes to a bar?

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$\{f.\textbf{DRINKER} \mid \textbf{FREQUENTS}(f)\}$

Example: Bar-going People

FREQUENTS (DRINKER, BAR)

Query: Who goes to a bar?

$\{f.\textbf{DRINKER} \mid \textbf{FREQUENTS}(f)\}$

FREQUENTS

DRINKER	BAR
Luis	Bar1
Luis	Bar2
Sinan	Bar2
Chris	Bar3

Output: {Luis, Sinan, Chris}

Example: Bad-Beer People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who goes to a bar serving Pabst Blue Ribbon (PBR)?

Example: Bad-Beer People

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SERVES (BAR, BEER)

Query: Who goes to a bar serving Pabst Blue Ribbon (PBR)?

$$\{f.\textbf{DRINKER} \mid \textbf{FREQUENTS}(f) \wedge \exists(s)(\textbf{SERVES}(s)$$
$$\wedge s.\textbf{BEER} = \text{“}\textbf{PBR}\text{”} \wedge s.\textbf{BAR} = f.\textbf{BAR})\}$$

Relational Calculus: Syntax

Recall the syntax $\{t|P(t)\}$

- 1. Start with $\{\}$
- 2. and the "such that" bar, $|$
- 3. Then add what you are looking for to the left of the $|$. This is a description of the tuples you want back
- 4. Then work on the right-hand side
- 5. Provide a predicate that evaluates to True over all the variables that appear on the left
- 6. If the predicate evaluates to True, that tuple will be included in the result set

Example: Not Bad-Beer People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who has not gone to a bar serving Pabst Blue Ribbon (PBR)?

Example: Not Bad-Beer People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who has not gone to a bar serving Pabst Blue Ribbon (PBR)?

$$\{f.\textbf{DRINKER} \mid \textbf{FREQUENTS}(f) \wedge \exists(s)(\textbf{SERVES}(s)$$
$$\wedge \textbf{not}\ (s.\textbf{BEER} = \text{“PBR”}) \wedge s.\textbf{BAR} = f.\textbf{BAR})\}$$

Example: Not Bad-Beer People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who has not gone to a bar serving Pabst Blue Ribbon (PBR)?

$$\{f.\textbf{DRINKER} \mid \textbf{FREQUENTS}(f) \wedge \exists(s)(\textbf{SERVES}(s) \wedge \textbf{not}\ (s.\textbf{BEER} = \text{“}\textbf{PBR}\text{”}) \wedge s.\textbf{BAR} = f.\textbf{BAR})\}$$

Wrong! This gives us “Who has gone to a bar that serves beers other than PBR”.

Example: Not Bad-Beer People

$$\{f.\text{DRINKER} \mid \text{FREQUENTS}(f) \wedge \exists(s)(\text{SERVES}(s)$$

$$\wedge \text{ not } (s.\text{BEER} = \text{“PBR”}) \wedge s.\text{BAR} = f.\text{BAR})\}$$

FREQUENTS

DRINKER	BAR
Luis	Bar1
Luis	Bar2
Sinan	Bar2
Chris	Bar3

SERVES

BAR	BEER
Bar1	Modelo
Bar2	PBR
Bar2	Corona
Bar3	PBR

Output: {Luis, Sinan}

Example: Not Bad-Beer People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who has not gone to a bar serving Pabst Blue Ribbon (PBR)?

$$\{f.\textbf{DRINKER} \mid \textbf{FREQUENTS}(f) \wedge \textbf{ not } \exists(s)(\textbf{SERVES}(s)$$
$$\wedge s.\textbf{BEER} = \text{“}\textbf{PBR}\text{”} \wedge s.\textbf{BAR} = f.\textbf{BAR})\}$$

Example: Not Bad-Beer People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who has not gone to a bar serving Pabst Blue Ribbon (PBR)?

$$\{f.\textbf{DRINKER} \mid \textbf{FREQUENTS}(f) \wedge \textbf{ not } \exists(s)(\textbf{SERVES}(s) \wedge s.\textbf{BEER} = \text{“}\textbf{PBR}\text{”} \wedge s.\textbf{BAR} = f.\textbf{BAR})\}$$

Wrong! This gives us “Who has gone to a bar that does not serve PBR”

Example: Not Bad-Beer People

$$\{f.\text{DRINKER} \mid \text{FREQUENTS}(f) \wedge \text{not } \exists(s)(\text{SERVES}(s)$$

$$\wedge s.\text{BEER} = \text{“PBR”} \wedge s.\text{BAR} = f.\text{BAR})\}$$

FREQUENTS

DRINKER	BAR
Luis	Bar1
Luis	Bar2
Sinan	Bar2
Chris	Bar3

SERVES

BAR	BEER
Bar1	Modelo
Bar2	PBR
Bar2	Corona
Bar3	PBR

Output: {Luis}

Example: Not Bad-Beer People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who has not gone to a bar serving Pabst Blue Ribbon (PBR)?

We need to introduce a second variable f_2

$$\{f.\textbf{DRINKER} \mid \textbf{FREQ}(f) \wedge \text{ not } \exists(f_2, s)(\textbf{FREQ}(f_2) \wedge \textbf{SERVES}(s)$$
$$\wedge s.\textbf{BEER} = \text{“PBR”} \wedge f_2.\textbf{BAR} = s.\textbf{BAR}$$
$$\wedge f.\textbf{DRINKER} = f_2.\textbf{DRINKER})\}$$

- Why do we need both f and f_2 here?

Example: Not Bad-Beer People

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who has not gone to a bar serving Pabst Blue Ribbon (PBR)?

The same result can be achieved using Universal quantification

$$\{f.\mathbf{DRINKER} \mid \mathbf{FREQUENTS}(f) \wedge \forall(f_2)(\mathbf{FREQUENTS}(f_2)$$
$$\wedge f.\mathbf{DRINKER} = f_2.\mathbf{DRINKER} \rightarrow \ \mathbf{not}\ \exists(s)(\mathbf{SERVES}(s)$$
$$\wedge s.\mathbf{BEER} = \text{“PBR”} \wedge s.\mathbf{BAR} = f_2.\mathbf{BAR}))\}$$

- Note: we invariably have a “$\rightarrow$” within a $\forall$ quantifier. Why?

Example: Not Bad-Beer People

$$\{f.\text{DRINKER} \mid \text{FREQUENTS}(f) \wedge \forall(f_2)(\text{FREQUENTS}(f_2)$$

$$\wedge f.\text{DRINKER} = f_2.\text{DRINKER} \rightarrow \text{ not } \exists(s)(\text{SERVES}(s)$$

$$\wedge s.\text{BEER} = \text{“PBR”} \wedge s.\text{BAR} = f_2.\text{BAR}))\}$$

FREQUENTS

DRINKER	BAR
Luis	Bar1
Luis	Bar2
Sinan	Bar2
Chris	Bar3

SERVES

BAR	BEER
Bar1	Modelo
Bar2	PBR
Bar2	Corona
Bar3	PBR

Output: {}

Example: Not Bad-Beer People

$$\{f.\text{DRINKER} \mid \text{FREQUENTS}(f) \wedge \forall(f_2)(\text{FREQUENTS}(f_2)$$

$$\wedge f.\text{DRINKER} = f_2.\text{DRINKER} \rightarrow \text{ not } \exists(s)(\text{SERVES}(s)$$

$$\wedge s.\text{BEER} = \text{“PBR”} \wedge s.\text{BAR} = f_2.\text{BAR}))\}$$

FREQUENTS

DRINKER	BAR
Luis	Bar1
Luis	Bar3
Sinan	Bar2
Chris	Bar3

SERVES

BAR	BEER
Bar1	Modelo
Bar2	PBR
Bar2	Corona
Bar3	Blue Moon

Output: {Luis, Chris}

Example: People Who Like to Drink

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who goes to a bar that serves a beer they like?

Example: People Who Like to Drink

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Who goes to a bar that serves a beer they like?

$$\{f.\mathbf{DRINKER} \mid \mathbf{FREQUENTS}(f) \wedge \exists(s,l)(\mathbf{SERVES}(s) \wedge \mathbf{LIKES}(l)$$
$$\wedge s.\mathbf{BEER} = l.\mathbf{BEER} \wedge s.\mathbf{BAR} = f.\mathbf{BAR}$$
$$\wedge l.\mathbf{DRINKER} = f.\mathbf{DRINKER})\}$$

- Why are we not referring to any relation more than once?

Example: Super Cool Bars

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Which bars serve all of the beers that Luis likes?

Example: Super Cool Bars

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Which bars serve all of the beers that Luis likes?

$\{s.\text{BAR} \mid \text{SERVES}(s) \wedge \forall(l)(\text{if } l \text{ is from LIKES and corresponds to "Luis", then the bar serves it})\}$

Example: Super Cool Bars

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Which bars serve all of the beers that Luis likes?

$$\{s.\text{BAR} \mid \text{SERVES}(s) \wedge \forall(l)(\text{LIKES}(l) \wedge l.\text{DRINKER} = \text{“Luis”}$$
$$\rightarrow \exists(s_2)(\text{SERVES}(s_2) \wedge s_2.\text{BAR} = s.\text{BAR} \wedge s_2.\text{BEER} = l.\text{BEER}))\}$$

Example: People Who Avoid Bad Bars

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Which people only go to bars that serve a beer they like?

Example: People Who Avoid Bad Bars

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Which people only go to bars that serve a beer they like?

$\{f.$**DRINKER** $\mid$ **FREQUENTS**$(f) \wedge \forall(f_2)($**if** f_2 **tells us a bar that** $f.$**DRINKER goes to then that bar needs to serve a beer that** $f.$**DRINKER likes**$)\}$

Example: People Who Avoid Bad Bars

LIKES (DRINKER, BEER)

FREQUENTS (DRINKER, BAR)

SERVES (BAR, BEER)

Query: Which people only go to bars that serve a beer they like?

$$\{f.\textbf{DRINKER} \mid \textbf{FREQUENTS}(f) \wedge \forall(f_2)(\textbf{FREQUENTS}(f_2)$$
$$\wedge f.\textbf{DRINKER} = f_2.\textbf{DRINKER} \rightarrow \exists(s, l)(\textbf{SERVES}(s) \wedge \textbf{LIKES}(l)$$
$$\wedge s.\textbf{BAR} = f_2.\textbf{BAR} \wedge l.\textbf{BEER} = s.\textbf{BEER}$$
$$\wedge l.\textbf{DRINKER} = f_2.\textbf{DRINKER}))\}$$

Questions?

Questions?

FREQUENTS

DRINKER	BAR
Luis	Bar1
Luis	Bar3
Sinan	Bar2
Chris	Bar3