

Relational Calculus

CSE 132a Winter 2016

Existential and Universal Quantifiers

$\exists b \in \text{Books}[\dots]$

There exists a book b where this condition holds.

$\exists b \in \text{Books}[\forall c \in \text{Customers}[\exists p \in \text{Purchases}[\dots]]]$

There exists a book, where for each customer, there exists a purchase where this condition holds.

Analagous to "FROM Books b WHERE ..." in SQL.

Tuples

Tuples are like rows in a database

$\exists b \in \text{Books}[b(\text{title})...]$

$\exists b \in \text{Books}[\forall c \in \text{Customers}[\exists p \in \text{Purchases}[$
 $c(\text{customerid})...p(\text{customerid})...p(\text{bookid})...b(\text{bookid})]]]$

Similar to $b.\text{title}$ and $p.\text{price}$

Additional Operators

Operators: $\wedge, \vee, =, \neq, \rightarrow, <, >, \leq, \geq$

$\exists b \in \text{Books}[b(\text{title}) = \text{'Twilight'}]$

$\exists b \in \text{Books}[\forall c \in \text{Customers}[\exists p \in \text{Purchases}[$
 $c(\text{customerid}) = p(\text{customerid}) \wedge p(\text{bookid}) = b(\text{bookid})]]]$

SELECT Analogy

$\{r : \text{bookid} \mid \exists b \in \text{Books}[b(\text{title}) = \text{'Twilight'} \\ \wedge r(\text{bookid}) = b(\text{bookid})]\}$

$\{r : \text{title} \mid \exists b \in \text{Books}[\forall c \in \text{Customers}[\exists p \in \text{Purchases}[\\ c(\text{customerid}) = p(\text{customerid}) \wedge p(\text{bookid}) = b(\text{bookid}) \\]]\wedge b(\text{title}) = r(\text{title})]\}$

Example 1

SQL to Relational Calculus

```
SELECT title  
FROM Books  
WHERE author = 'EDMUND MORGAN'  
AND year  $\geq$  1990;
```

Example 1

SQL to Relational Calculus

```
SELECT title  
FROM Books  
WHERE author = 'EDMUND MORGAN'  
AND year >= 1990;
```

$\{r : \text{title} \mid \dots\}$

Example 1

SQL to Relational Calculus

```
SELECT title
FROM Books
WHERE author = 'EDMUND MORGAN'
AND year >= 1990;
```

$$\{r : \text{title} \mid \exists b \in \text{Books}[\dots]\}$$

Example 1

SQL to Relational Calculus

```
SELECT title
FROM Books
WHERE author = 'EDMUND MORGAN'
AND year >= 1990;
```

```
{ $r$  : title |  $\exists b \in$   
Books[ $b(\text{author}) = \text{'EDMUND MORGAN'} \wedge b(\text{year}) \geq 1990$ ]}  
DONE?
```

Example 1

SQL to Relational Calculus

```
SELECT title
FROM Books
WHERE author = 'EDMUND MORGAN'
AND year >= 1990;
```

$$\{r : \text{title} \mid \exists b \in \text{Books}[b(\text{author}) = \text{'EDMUND MORGAN'} \wedge b(\text{year}) \geq 1990 \\ \wedge r(\text{title}) = b(\text{title})]\}$$

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$\{r : \text{title} \mid \dots\}$

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$$\{r : \text{title} \mid \exists b \in \text{Books}[\dots]\}$$

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$$\{r : \text{title} \mid \exists b \in \text{Books}[\forall o \in \text{Books}[\dots]]\}$$

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$\{r : \text{title} \mid \exists b \in \text{Books}[\forall o \in \text{Books}[b(\text{year}) \geq o(\text{year})]]\}$
DONE?

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$$\{r : \text{title} \mid \exists b \in \text{Books}[\forall o \in \text{Books}[b(\text{year}) \geq o(\text{year})] \\ \wedge b(\text{title}) = r(\text{title})]\}$$

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$$\{r : \text{title} \mid \exists b \in \text{Books}[\neg \exists o \in \text{Books}[b(\text{year}) < o(\text{year})] \\ \wedge b(\text{title}) = r(\text{title})]\}$$

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$$\{r : \text{title} \mid \exists b \in \text{Books}[\neg \exists o \in \text{Books}[b(\text{year}) < o(\text{year})] \\ \wedge b(\text{title}) = r(\text{title})]\}$$

```
SELECT b.title
FROM Books b
WHERE ...
```

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$$\{r : \text{title} \mid \exists b \in \text{Books}[\neg \exists o \in \text{Books}[b(\text{year}) < o(\text{year})] \\ \wedge b(\text{title}) = r(\text{title})]\}$$

```
SELECT b.title
FROM Books b
WHERE NOT EXISTS( SELECT ... FROM Books o
WHERE b.year < o.year);
```

Example 2

Relational Calculus to SQL

What are the titles of the newest books?

$$\{r : \text{title} \mid \exists b \in \text{Books} [\neg \exists o \in \text{Books} [b(\text{year}) < o(\text{year})] \\ \wedge b(\text{title}) = r(\text{title})]\}$$

```
SELECT b.title  
FROM Books b  
WHERE NOT EXISTS( SELECT *  
FROM Books o  
WHERE b.year < o.year);
```