Database Management Systems

Database management systems (DBMS) are important, heavily used, and interesting!

A table is a collection of records, which are rows that have a value for each column.

The Structured Query Language (SQL) is perhaps the most widely used programming language.

SQL is a declarative programming language.

Databases

SQL

Announcements
Declarative Programming

In declarative languages such as SQL & Prolog:
• A "program" is a description of the desired result
• The interpreter figures out how to generate the result

In imperative languages such as Python & Scheme:
• A "program" is a description of computational processes
• The interpreter carries out execution/evaluation rules

<table>
<thead>
<tr>
<th>Cities:</th>
<th>(latitude, longitude, name)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>122, Berkeley</td>
</tr>
<tr>
<td>42</td>
<td>71, Cambridge</td>
</tr>
<tr>
<td>45</td>
<td>93, Minneapolis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cities:</th>
<th>region, name</th>
</tr>
</thead>
<tbody>
<tr>
<td>west coast, Berkeley</td>
<td></td>
</tr>
<tr>
<td>other, Minneapolis</td>
<td></td>
</tr>
<tr>
<td>other, Cambridge</td>
<td></td>
</tr>
</tbody>
</table>

create table cities as
select 38 as latitude, 122 as longitude, "Berkeley" as name union
select 42, 71, "Cambridge" union
select 45, 93, "Minneapolis";

select "west coast" as region, name from cities where longitude >= 115 union
select "other", name from cities where longitude < 115;

Structured Query Language (SQL)

SQL Overview

The SQL language is an ANSI and ISO standard, but DBMS's implement custom variants
• A select statement creates a new table, either from scratch or by projecting a table
• A create table statement gives a global name to a table
• Lots of other statements exist: analyze, delete, explain, insert, replace, update, etc.
• Most of the important action is in the select statement

Getting Started with SQL

Install sqlite (version 3.8.3 or later): http://sqlite.org/download.html
Use sqlite online: code.cs61a.org/sql

Today's theme:
Selecting Value Literals

A `select` statement always includes a comma-separated list of column descriptions.
A column description is an expression, optionally followed by `as` and a column name.

`select` [expression] as [name], [expression] as [name];

Selecting literals creates a one-row table.
The union of two select statements is a table containing the rows of both of their results.

```
select "delano" as parent, "herbert" as child; union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
select "fillmore", "grover" union
select "eisenhower", "fillmore";
```

Parents:

<table>
<thead>
<tr>
<th>parent</th>
<th>child</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
</tr>
<tr>
<td>abraham</td>
<td>clinton</td>
</tr>
<tr>
<td>delano</td>
<td>Herbert</td>
</tr>
<tr>
<td>fillmore</td>
<td>abraham</td>
</tr>
<tr>
<td>fillmore</td>
<td>delano</td>
</tr>
<tr>
<td>fillmore</td>
<td>grover</td>
</tr>
<tr>
<td>eisenhower</td>
<td>fillmore</td>
</tr>
</tbody>
</table>

Naming Tables

SQL is often used as an interactive language.
The result of a `select` statement is displayed to the user, but not stored.

A `create table` statement gives the result a name.

```
create table [name] as [select statement];
```

```
create table parents as
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
select "fillmore", "grover" union
select "eisenhower", "fillmore";
```

Select Statements Project Existing Tables

A `select` statement can specify an input table using a `from` clause.
A subset of the rows of the input table can be selected using a `where` clause.
An ordering over the remaining rows can be declared using an `order by` clause.

Column descriptions determine how each input row is projected to a result row.

```
select [expression] as [name], [expression] as [name], ...;
select [columns] from [table] where [condition] order by [order];
select child from parents where parent = "abraham";
select parent from parents where parent > child;
```

Parents:

<table>
<thead>
<tr>
<th>parent</th>
<th>child</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
</tr>
<tr>
<td>abraham</td>
<td>clinton</td>
</tr>
<tr>
<td>delano</td>
<td>Herbert</td>
</tr>
<tr>
<td>fillmore</td>
<td>abraham</td>
</tr>
<tr>
<td>fillmore</td>
<td>delano</td>
</tr>
<tr>
<td>fillmore</td>
<td>grover</td>
</tr>
<tr>
<td>eisenhower</td>
<td>fillmore</td>
</tr>
</tbody>
</table>

Selecting Value Literals

A `select` statement always includes a comma-separated list of column descriptions.
A column description is an expression, optionally followed by `as` and a column name.

`select` [expression] as [name], [expression] as [name];

Selecting literals creates a one-row table.
The union of two select statements is a table containing the rows of both of their results.

```
select "delano" as parent, "herbert" as child; union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
select "fillmore", "grover" union
select "eisenhower", "fillmore";
```

Parents:

<table>
<thead>
<tr>
<th>parent</th>
<th>child</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
</tr>
<tr>
<td>abraham</td>
<td>clinton</td>
</tr>
<tr>
<td>delano</td>
<td>Herbert</td>
</tr>
<tr>
<td>fillmore</td>
<td>abraham</td>
</tr>
<tr>
<td>fillmore</td>
<td>delano</td>
</tr>
<tr>
<td>fillmore</td>
<td>grover</td>
</tr>
<tr>
<td>eisenhower</td>
<td>fillmore</td>
</tr>
</tbody>
</table>

Naming Tables

SQL is often used as an interactive language.
The result of a `select` statement is displayed to the user, but not stored.

A `create table` statement gives the result a name.

```
create table [name] as [select statement];
```

```
create table parents as
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
select "fillmore", "grover" union
select "eisenhower", "fillmore";
```

Select Statements Project Existing Tables

A `select` statement can specify an input table using a `from` clause.
A subset of the rows of the input table can be selected using a `where` clause.
An ordering over the remaining rows can be declared using an `order by` clause.

Column descriptions determine how each input row is projected to a result row.

```
select [expression] as [name], [expression] as [name], ...;
select [columns] from [table] where [condition] order by [order];
select child from parents where parent = "abraham";
select parent from parents where parent > child;
```

Parents:

<table>
<thead>
<tr>
<th>parent</th>
<th>child</th>
</tr>
</thead>
<tbody>
<tr>
<td>abraham</td>
<td>barack</td>
</tr>
<tr>
<td>abraham</td>
<td>clinton</td>
</tr>
<tr>
<td>delano</td>
<td>Herbert</td>
</tr>
<tr>
<td>fillmore</td>
<td>abraham</td>
</tr>
<tr>
<td>fillmore</td>
<td>delano</td>
</tr>
<tr>
<td>fillmore</td>
<td>grover</td>
</tr>
<tr>
<td>eisenhower</td>
<td>fillmore</td>
</tr>
</tbody>
</table>
Arithmetic in Select Expressions

In a select expression, column names evaluate to row values. Arithmetic expressions can combine row values and constants.

```sql
create table lift as
    select 101 as chair, 2 as single, 2 as couple union
    select 102 , 0 , 3 union
    select 103 , 4 , 1;

select chair, single + 2 * couple as total from lift;
```

<table>
<thead>
<tr>
<th>chair</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>6</td>
</tr>
<tr>
<td>102</td>
<td>6</td>
</tr>
<tr>
<td>103</td>
<td>6</td>
</tr>
</tbody>
</table>

Discussion Question

Given the table `ints` that describes how to sum powers of 2 to form various integers:

```sql
create table ints as
    select "zero" as word, 0 as one, 0 as two, 0 as four, 0 as eight union
    select "one" , 0 , 0 , 0 , 0 union
    select "two" , 0 , 2 , 0 , 0 union
    select "three" , 0 , 2 , 0 , 0 union
    select "four" , 0 , 0 , 4 , 0 union
    select "five" , 1 , 0 , 4 , 0 union
    select "six" , 0 , 2 , 4 , 0 union
    select "seven" , 1 , 2 , 4 , 0 union
    select "eight" , 0 , 0 , 0 , 8 union
    select "nine" , 1 , 0 , 0 , 8 union
```

(A) Write a select statement for a two-column table of the `word` and `value` for each integer.

(B) Write a select statement for the `word` names of the powers of two.

<table>
<thead>
<tr>
<th>word</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>0</td>
</tr>
<tr>
<td>one</td>
<td>1</td>
</tr>
<tr>
<td>two</td>
<td>2</td>
</tr>
<tr>
<td>three</td>
<td>3</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

(word)