Announcements
Declarative Languages
Database Management Systems
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SQL is a declarative programming language.
Declarative Programming
Declarative Programming

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• The interpreter figures out how to generate the result
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create table cities as
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```
create table cities as
    select 38 as latitude, 122 as longitude, "Berkeley" as name union
```

<table>
<thead>
<tr>
<th>Cities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
</tr>
<tr>
<td>-------</td>
</tr>
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<td>38</td>
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```
create table cities as
    select 38 as latitude, 122 as longitude, "Berkeley" as name union
select 42, 71, "Cambridge" union
```

<table>
<thead>
<tr>
<th>Cities:</th>
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```sql
create table cities as
    select 38 as latitude, 122 as longitude, "Berkeley" as name union
    select 42, 71, "Cambridge" union
    select 45, 93, "Minneapolis";
```

<p>| | | |</p>
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```
cREATE TABLE cities AS
   SELECT 38 AS latitude, 122 AS longitude, "Berkeley" AS name UNION
   SELECT 42, 71, "Cambridge" UNION
   SELECT 45, 93, "Minneapolis"
;
```

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select "west coast" as region, name from cities where longitude >= 115 union
select "other", name from cities where longitude < 115;
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```sql
create table cities as
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<td>------------</td>
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</tr>
<tr>
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Structured Query Language (SQL)
SQL Overview
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The SQL language is an ANSI and ISO standard, but DBMS's implement custom variants.
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*Today's theme:*
SQL Overview

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• 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

Today's theme:
Getting Started with SQL

Install sqlite (version 3.8.3 or later): http://sqlite.org/download.html

Use sqlite online: http://kripken.github.io/sql.js/GUI/
Selecting Value Literals
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```sql
select [expression] as [name]
```
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```
select [expression] as [name], [expression] as [name]
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```
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```
select [expression] as [name], [expression] as [name];
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Selecting literals creates a one-row table.
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The union of two `select` statements is a table containing the rows of both of their results.
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```
select [expression] as [name], [expression] as [name];
```

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The union of two select statements is a table containing the rows of both of their results:

```
select "delano" as parent, "herbert" as child;
```
Selecting Value Literals

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```
select [expression] as [name], [expression] as [name];
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```
select "delano" as parent, "herbert" as child union
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```sql
select [expression] as [name], [expression] as [name];
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The union of two select statements is a table containing the rows of both of their results.

```sql
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
```
Selecting Value Literals

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

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```
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" union
```
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```
select "delano" as parent, "herbert" as child union
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select "abraham", "clinton" union
select "fillmore", "abraham" union
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A `select` statement always includes a comma-separated list of column descriptions.

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```
select "delano" as parent, "herbert" as child union
select "abraham", "barack" union
select "abraham", "clinton" union
select "fillmore", "abraham" union
select "fillmore", "delano" union
```
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select [expression] as [name], [expression] as [name];
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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
```
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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 "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";
Naming Tables

SQL is often used as an interactive language

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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";
```
**Naming Tables**

SQL is often used as an interactive language

The result of a `select` statement is displayed to the user, but not stored

```sql
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";
```
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.

```sql
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";
```
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

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

```sql
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";
```
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];
```

```sql
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";
```
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:

\[
\text{create table } [\text{name}] \text{ as } [\text{select statement}];
\]

```sql
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";
```

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

<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>
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Projecting Tables
Select Statements Project Existing Tables
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A `select` statement can specify an input table using a `from` clause.
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```
select [expression] as [name], [expression] as [name], ...;
```
Select Statements Project Existing Tables

A `select` statement can specify an input table using a `from` clause

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

```
select [columns] ;
```
Select Statements Project Existing Tables

A `select` statement can specify an input table using a `from` clause

```
select [expression] as [name], [expression] as [name], ...;
select [columns] from [table];
```
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.

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

```
select [columns] from [table]
```
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.

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

select [columns] from [table] where [condition] ;
```
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.

```
select [expression] as [name], [expression] as [name], ...;
select [columns] from [table] where [condition];
```
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.

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```
select [expression] as [name], [expression] as [name], ...;
select [columns] from [table] where [condition] order by [order];
```
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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.

```sql
select [expression] as [name], [expression] as [name], ... ;
select [columns] from [table] where [condition] order by [order];
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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";
```

Diagram:
- Eisenhower
  - Fillmore
    - Abraham
      - Barack
    - Delano
    - Grover
    - Clinton
    - Herbert
Select Statements Project Existing Tables

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```

```
select [columns] from [table] where [condition] order by [order];
```

```
select child from parents where parent = "abraham";
```

```
select parent from parents where parent > child;
```

<table>
<thead>
<tr>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>barack</td>
</tr>
<tr>
<td>clinton</td>
</tr>
</tbody>
</table>

Diagram:

- Abraham
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select child from parents where parent = "abraham";
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```

<table>
<thead>
<tr>
<th>Child</th>
<th>Parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>barack</td>
<td>fillmore</td>
</tr>
<tr>
<td>clinton</td>
<td>fillmore</td>
</tr>
</tbody>
</table>

(Demo)
Arithmetic
Arithmetic in Select Expressions
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In a select expression, column names evaluate to row values.

Arithmetic expressions can combine row values and constants.
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```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;
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select 102 , 0 , 3 union
select 103 , 4 , 1;

select chair, single + 2 * couple as total from lift;
```
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In a select expression, column names evaluate to row values

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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" , 1 , 0 , 0 , 0 union
    select "two" , 0 , 2 , 0 , 0 union
    select "three" , 1 , 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;
```
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    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;
```

(A) Write a select statement for a two-column table of the **word** and **value** for each integer
Discussion Question

Given the table \texttt{ints} that describes how to sum powers of 2 to form various integers

\begin{verbatim}
create table ints as
    select "zero" as word, 0 as one, 0 as two, 0 as four, 0 as eight union
    select "one" , 1 , 0 , 0 , 0 union
    select "two" , 0 , 2 , 0 , 0 union
    select "three" , 1 , 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;
\end{verbatim}

(A) Write a select statement for a two-column table of the \texttt{word} and \texttt{value} for each integer

<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>
</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", 1, 0, 0, 0 union
    select "two", 0, 2, 0, 0 union
    select "three", 0, 0, 0, 0 union
    select "four", 1, 2, 0, 0 union
    select "five", 0, 0, 0, 0 union
    select "six", 1, 2, 0, 0 union
    select "seven", 0, 0, 0, 0 union
    select "eight", 0, 0, 0, 8 union
    select "nine", 1, 0, 0, 8;
```

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

<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>

(B) Write a select statement for the word names of the powers of two
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"     , 1     , 0     , 0     , 0     union
    select "two"     , 0     , 2     , 0     , 0     union
    select "three"   , 1     , 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    ;
```

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

<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>
</tbody>
</table>

...     ...

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

<table>
<thead>
<tr>
<th>word</th>
</tr>
</thead>
<tbody>
<tr>
<td>one</td>
</tr>
<tr>
<td>two</td>
</tr>
<tr>
<td>four</td>
</tr>
<tr>
<td>eight</td>
</tr>
</tbody>
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Discussion Question

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

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

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

<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>
</tbody>
</table>
| ...  | ...   | (Demo)

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

<table>
<thead>
<tr>
<th>word</th>
</tr>
</thead>
<tbody>
<tr>
<td>one</td>
</tr>
<tr>
<td>two</td>
</tr>
<tr>
<td>four</td>
</tr>
<tr>
<td>eight</td>
</tr>
</tbody>
</table>
Prolog: Another Declarative Language
(a side excursion)
Prolog

Prolog is a logic programming language developed about 1972 by Alain Colmerauer et al. Originally developed for computational linguistics and AI.

Programs consist of rules, which define relations, rather than functions.

\[
\text{succ(1, 2).} \\
\text{plus(X, 1, Z) :- succ(X, Z).}
\]

A simple fact: successor of 1 is 2

For any X and Z, X+1=Z if Z is successor of X.

Demo