

Lecture 31: Declarative Programming: SQL

- So far, our programs are explicit directions for solving a problem; the problem itself is *implicit* in the program.
- *Declarative* programming turns this around:
 - A “program” is a description of the desired characteristics of a solution.
 - It is up to the system to figure out how to achieve these characteristics.
- Example (somewhat impure) of a declaration language: SQL (Structured Query Language).
- SQL is a widely used notation for interrogating and modifying *database management systems* (DBMSs).

Relational Databases

- A DBMS is a collection of data. The kind of DBMS accessed by SQL is *relationsl*.
- In mathematics, a *relation* is a set of tuples that represent values that *stand in some relationship* to one another.
- In a relational DBMS, relations take the form of *tables* with labeled columns. Each entry (tuple) is called a *row*.

Table Name: **students**

SID	Last	First	SemEnt	YearEnt	Major	⇐ Column Titles
101	Knowles	Jason	F	2003	EECS	
102	Chan	Valerie	S	2003	Math	
103	Xavier	Jonathan	S	2004	LSUnd	⇐ Row
104	Armstrong	Thomas	F	2003	EECS	
105	Brown	Shana	S	2004	EECS	
106	Chan	Yangfan	F	2003	LSUnd	

↑
Column

Defining a Table in SQL

grades		
SID	CCN	Grade
101	21228	B
102	21231	A
101	21105	B+
106	21001	B
103	21005	B+
102	21229	A

One way to create this table in SQL:

```
create table grades as
  select "101" as SID, 21228 as CCN, "B" as Grade union
  select "102", 21231, "A" union
  select "101", 21105, "B+" union
  select "106", 21001, "B" union
  select "103", 21005, "B+" union
  select "102", 21229, "A";
```

Warning: *This lecture shows atypical use of SQL.*

Some Details on Definition

```
create table grades as
  select "101" as SID, 21228 as CCN, "B" as Grade union
  select "102", 21231, "A" union
  select "101", 21105, "B+" union
  select "106", 21001, "B" union
  select "103", 21005, "B+" union
  select "102", 21229, "A";
```

- This `create` statement is essentially an assignment to a new table variable, `grades`.
- Each `select` is a *table-valued expression* that defines a set of rows (all singleton sets in this case).
- `union` is then the set union operator on tables.
- The unioned tables must be compatible (same columns).
- First `select` establishes column names.

Selection

- Power of SQL comes from **select** statements with conditions.
- Given table **grades** on left, the queries

```
select Grade, CCN from grades where SID = '101';  
create table roster21228 as  
select SID from grades where CCN = 21228;
```

create two new tables shown on the right (the first anonymous):

grades					roster21228
SID	CCN	Grade	Grade	CCN	SID
101	21228	B	B	21228	101
102	21231	A	B+	21105	105
101	21105	B+	A-	21232	104
102	21229	A	B	21001	
102	21105	A-			
101	21232	A-			
104	21228	A-			
102	21001	B+			
104	21105	A-			
105	21228	A			
104	21005	A-			
101	21001	B			

Selection II

```
select Grade, CCN from grades where SID = '101';  
create table roster21228 as  
select distinct SID from grades where CCN = 21228;
```

- In these statements, the values added to the resulting tables are not constants (as before), but rather *column specifiers*: expressions that extract values from rows of the table `grades`.
- By default (no `as` clauses), columns in result take their names from the selected columns.
- SQL is declarative in the sense that we *declare the characteristics* of the table we want, without saying how to conduct the necessary search.
- In the cases above, the search looks pretty simple, but the system hides the complexity that results when
 - *multiple* tables are involved, or
 - certain columns are *indexed* to speed up searches involving those columns.

Multiple Tables

- Searches can involve multiple tables:

students

SID	Last	First	SemEnt	YearEnt	Major
101	Knowles	Jason	F	2003	EECS
102	Chan	Valerie	S	2003	Math
103	Xavier	Jonathan	S	2004	LSUnd
104	Armstrong	Thomas	F	2003	EECS
105	Brown	Shana	S	2004	EECS
106	Chan	Yangfan	F	2003	LSUnd

```
create table report as select Last, First, CCN, Grade
from grades, students where students.SID = grades.SID;
```

report

Last	First	CCN	Grade
Knowles	Jason	21228	B
Chan	Valerie	21231	A
Knowles	Jason	21105	B+
Chan	Valerie	21229	A
...

Another Example

- Suppose we supply a translation table from grades to points (on the left).
- Now can ask

```
select Last, First, CCN, Grade from students, grades, grade_values where
students.SID = grades.SID and Letter = Grade and GP >= 3.7;
```

points		Last	First	CCN	Grade
A+	4	Chan	Valerie	21231	A
A	4	Chan	Valerie	21229	A
A-	3.7	Chan	Valerie	21105	A-
B+	3.3	Knowles	Jason	21232	A-
B	3	Armstrong	Thomas	21228	A-
B-	2.7
...	...				