

More SQL

Relations as Bags
Grouping and Aggregation
Database Modification

Union, Intersection, and Difference



◆ Union, intersection, and difference of relations are expressed by the following forms, each involving subqueries:

- ▶ (subquery) UNION (subquery)
- ▶ (subquery) INTERSECT (subquery)
- ▶ (subquery) EXCEPT (subquery)

Example


- ◆ From relations Likes(drinker, beer), Sells(bar, beer, price) and Frequents(drinker, bar), find the drinkers and beers such that:
 1. The drinker likes the beer, and
 2. The drinker frequents at least one bar that sells the beer.

Solution

```
(SELECT * FROM Likes)  
INTERSECT
```

The drinker frequents
a bar that sells the
beer.

```
(SELECT drinker, beer  
FROM Sells, Frequents  
WHERE Frequents.bar = Sells.bar  
);
```



Bag Semantics

- ◆ Although the SELECT-FROM-WHERE statement uses bag semantics, the default for union, intersection, and difference is set semantics.
 - ▶ That is, duplicates are eliminated as the operation is applied.

Motivation: Efficiency

- ◆ When doing projection in relational algebra, it is easier to avoid eliminating duplicates.
 - ▶ Just work tuple-at-a-time.
- ◆ When doing intersection or difference, it is most efficient to sort the relations first.
 - ▶ At that point you may as well eliminate the duplicates anyway.

Controlling Duplicate Elimination



- ◆ Force the result to be a set by `SELECT DISTINCT . . .`
- ◆ Force the result to be a bag (i.e., don't eliminate duplicates) by `ALL`, as in `. . . UNION ALL . . .`

Example: DISTINCT

- ◆ From Sells(bar, beer, price), find all the different prices charged for beers:
`SELECT DISTINCT price`
`FROM Sells;`
- ◆ Notice that without DISTINCT, each price would be listed as many times as there were bar/beer pairs at that price.

Example: ALL

- ◆ Using relations Frequents(drinker, bar) and Likes(drinker, beer):

```
(SELECT drinker FROM Frequents)  
EXCEPT ALL
```

```
(SELECT drinker FROM Likes);
```

- ◆ Lists drinkers who frequent more bars than they like beers, and does so as many times as the difference of those counts.

Join Expressions

- ◆ SQL provides a number of expression forms that act like varieties of join in relational algebra.
 - ◆ But using bag semantics, not set semantics.
- ◆ These expressions can be stand-alone queries or used in place of relations in a FROM clause.

Products and Natural Joins

- ◆ Natural join is obtained by:

`R NATURAL JOIN S;`

- ◆ Product is obtained by:

`R CROSS JOIN S;`

- ◆ Example:

`Likes NATURAL JOIN Serves;`

- ◆ Relations can be parenthesized subexpressions, as well.

Theta Join



- ◆ $R \text{ JOIN } S \text{ ON } \langle \text{condition} \rangle$ is a theta-join, using $\langle \text{condition} \rangle$ for selection.
- ◆ Example: using Drinkers(name, addr) and Frequents(drinker, bar):

`Drinkers JOIN Frequents ON
name = drinker;`

gives us all (d, a, d, b) quadruples such that drinker d lives at address a and frequents bar b .

Outerjoins

- ◆ R OUTER JOIN S is the core of an outerjoin expression. It is modified by:
 1. Optional NATURAL in front of OUTER.
 2. Optional ON <condition> after JOIN.
 3. Optional LEFT, RIGHT, or FULL before OUTER.
 - ◆ LEFT = pad dangling tuples of R only.
 - ◆ RIGHT = pad dangling tuples of S only.
 - ◆ FULL = pad both; this choice is the default.

Aggregations

- ◆ SUM, AVG, COUNT, MIN, and MAX can be applied to a column in a SELECT clause to produce that aggregation on the column.
- ◆ Also, COUNT(*) counts the number of tuples.

Example: Aggregation

- ◆ From Sells(bar, beer, price), find the average price of Bud:

```
SELECT AVG(price)
FROM Sells
WHERE beer = 'Bud';
```

Eliminating Duplicates in an Aggregation 🍷

- ◆ DISTINCT inside an aggregation causes duplicates to be eliminated before the aggregation.
- ◆ Example: find the number of different prices charged for Bud:

```
SELECT COUNT(DISTINCT price)
FROM Sells
WHERE beer = 'Bud';
```


NULL's Ignored in Aggregation



- ◆ NULL never contributes to a sum, average, or count, and can never be the minimum or maximum of a column.
- ◆ But if there are no non-NULL values in a column, then the result of the aggregation is NULL.

Example: Effect of NULL's

```
SELECT count(*)  
FROM Sells  
WHERE beer = 'Bud';
```

The number of bars
that sell Bud.



```
SELECT count(price)  
FROM Sells  
WHERE beer = 'Bud';
```

The number of bars
that sell Bud at a
known price.



Grouping

- ◆ We may follow a SELECT-FROM-WHERE expression by GROUP BY and a list of attributes.
- ◆ The relation that results from the SELECT-FROM-WHERE is grouped according to the values of all those attributes, and any aggregation is applied only within each group.

Example: Grouping

- ◆ From Sells(bar, beer, price), find the average price for each beer:

```
SELECT beer, AVG(price)
FROM Sells
GROUP BY beer;
```

Example: Grouping

- ◆ From Sells(bar, beer, price) and Frequents(drinker, bar), find for each drinker the average price of Bud at the bars they frequent:

```
SELECT drinker, AVG(price)
```

```
FROM Frequents, Sells
```

```
WHERE beer = 'Bud' AND
```

```
    Frequents.bar = Sells.bar
```

```
GROUP BY drinker;
```

Compute drinker-bar-price of Bud tuples first, then group by drinker.



Restriction on SELECT Lists With Aggregation

- ◆ If any aggregation is used, then each element of the SELECT list must be either:
 1. Aggregated, or
 2. An attribute on the GROUP BY list.

Illegal Query Example

- ◆ You might think you could find the bar that sells Bud the cheapest by:

SELECT bar, MIN(price)

FROM Sells

WHERE beer = 'Bud';

- ◆ But this query is illegal in SQL.
 - ◆ Why? Note bar is neither aggregated nor on the GROUP BY list.

HAVING Clauses



- ◆ HAVING <condition> may follow a GROUP BY clause.
- ◆ If so, the condition applies to each group, and groups not satisfying the condition are eliminated.

Requirements on HAVING Conditions

- ◆ These conditions may refer to any relation or tuple-variable in the FROM clause.
- ◆ They may refer to attributes of those relations, as long as the attribute makes sense within a group; i.e., it is either:
 1. A grouping attribute, or
 2. Aggregated.

Example: HAVING

- ◆ From Sells(bar, beer, price) and Beers(name, manf), find the average price of those beers that are either served in at least three bars or are manufactured by Pete's.

Solution



```
SELECT beer, AVG(price)
FROM Sells
GROUP BY beer
```

Beer groups with at least 3 non-NULL bars and also beer groups where the manufacturer is Pete's.



```
HAVING COUNT(bar) >= 3 OR
beer IN (SELECT name
FROM Beers
WHERE manf = 'Pete's');
```

Beers manufactured by Pete's.



Database Modifications

- ◆ A modification command does not return a result as a query does, but it changes the database in some way.
- ◆ There are three kinds of modifications:
 1. *Insert* a tuple or tuples.
 2. *Delete* a tuple or tuples.
 3. *Update* the value(s) of an existing tuple or tuples.

Insertion



- ◆ To insert a single tuple:

```
INSERT INTO <relation>  
VALUES ( <list of values> );
```

- ◆ Example: add to Likes(drinker, beer) the fact that Sally likes Bud.

```
INSERT INTO Likes  
VALUES( 'Sally', 'Bud' );
```

Specifying Attributes in INSERT



- ◆ We may add to the relation name a list of attributes.
- ◆ There are two reasons to do so:
 1. We forget the standard order of attributes for the relation.
 2. We don't have values for all attributes, and we want the system to fill in missing components with NULL or a default value.

Example: Specifying Attributes



- ◆ Another way to add the fact that Sally likes Bud to Likes(drinker, beer):

```
INSERT INTO Likes(beer, drinker)  
VALUES( 'Bud', 'Sally');
```

Inserting Many Tuples

- ◆ We may insert the entire result of a query into a relation, using the form:

```
INSERT INTO <relation>  
( <subquery> );
```


Example: Insert a Subquery



- ◆ Using `Frequents(drinker, bar)`, enter into the new relation `PotBuddies(name)` all of Sally's "potential buddies," i.e., those drinkers who frequent at least one bar that Sally also frequents.

The other
drinker

Solution

Pairs of Drinker
tuples where the
first is for Sally,
the second is for
someone else,
and the bars are
the same.

INSERT INTO PotBuddies

(SELECT d2.drinker

FROM Frequents d1, Frequents d2
WHERE d1.drinker = 'Sally' AND
d2.drinker <> 'Sally' AND
d1.bar = d2.bar

);

Deletion

- ◆ To delete tuples satisfying a condition from some relation:

```
DELETE FROM <relation>  
WHERE <condition>;
```

Example: Deletion

- ◆ Delete from Likes(drinker, beer)
the fact that Sally likes Bud:

```
DELETE FROM Likes  
WHERE drinker = 'Sally' AND  
      beer = 'Bud';
```

Example: Delete all Tuples

- ◆ Make the relation Likes empty:

```
DELETE FROM Likes;
```

- ◆ Note no WHERE clause needed.

Example: Delete Many Tuples

- ◆ Delete from Beers(name, manf) all beers for which there is another beer by the same manufacturer.

```
DELETE FROM Beers b  
WHERE EXISTS (
```

```
SELECT name FROM Beers  
WHERE manf = b.manf AND  
name <> b.name);
```

Beers with the same manufacturer and a different name from the name of the beer represented by tuple b.

Semantics of Deletion -- 1

- ◆ Suppose Anheuser-Busch makes only Bud and Bud Lite.
- ◆ Suppose we come to the tuple b for Bud first.
- ◆ The subquery is nonempty, because of the Bud Lite tuple, so we delete Bud.
- ◆ Now, When b is the tuple for Bud Lite, do we delete that tuple too?

Semantics of Deletion -- 2

- ◆ The answer is that we *do* delete Bud Lite as well.
- ◆ The reason is that deletion proceeds in two stages:
 1. Mark all tuples for which the WHERE condition is satisfied in the original relation.
 2. Delete the marked tuples.

Updates



- ◆ To change certain attributes in certain tuples of a relation:

UPDATE <relation>

SET <list of attribute
assignments>

WHERE <condition on tuples>;

Example: Update

- ◆ Change drinker Fred's phone number to 555-1212:

```
UPDATE Drinkers
```

```
SET phone = '555-1212'
```

```
WHERE name = 'Fred';
```

Example: Update Several Tuples



- ◆ Make \$4 the maximum price for beer:

```
UPDATE Sells
```

```
SET price = 4.00
```

```
WHERE price > 4.00;
```