

More SQL

Relations as Bags
Grouping and Aggregation
Database Modification

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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)

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Example

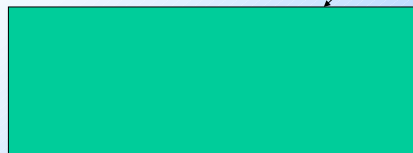
- ◆ From relations Likes(drinker, beer), Sells(bar, beer, price) and Frequent(drinker, bar), find the drinkers and beers such that:
 1. The drinker likes the beer, and
 2. The drinker frequents at least one bar that sells the beer.

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Solution

(SELECT * FROM Likes)
INTERSECT

The drinker frequents
a bar that sells the
beer.



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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.

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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.

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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 . . .`

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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.

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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.

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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.

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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.

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Theta Join

- ◆ `R JOIN S ON <condition>` is a theta-join, using `<condition>` 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 .

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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.

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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.

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Example: Aggregation

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

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

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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';
```

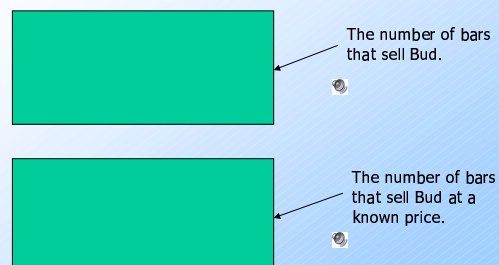
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NULL's Ignored in Aggregation

- ◆ 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.

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Example: Effect of NULL's



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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.

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Example: Grouping

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

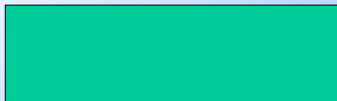
```
SELECT beer, AVG(price)
FROM Sells
GROUP BY beer;
```

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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)
```



```
GROUP BY drinker;
```

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

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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.

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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.

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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.

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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.

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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.

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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.

Beers manufactured by Pete's.

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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.

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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' );
```

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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.

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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');
```

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Inserting Many Tuples

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

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

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Example: Insert a Subquery

- ◆ Using Frequent(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.

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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
(
  [yellow box]
  [green box]
);
```

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Deletion

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

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

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Example: Deletion

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

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

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Example: Delete all Tuples

- ◆ Make the relation Likes empty:

```
DELETE FROM Likes;
```

- ◆ Note no WHERE clause needed.

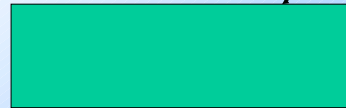
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Example: Delete Many Tuples

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

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

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



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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?

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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.

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Updates

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

```
UPDATE <relation>  
SET <list of attribute assignments>  
WHERE <condition on tuples>;
```

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Example: Update

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

```
UPDATE Drinkers  
SET phone = '555-1212'  
WHERE name = 'Fred';
```

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Example: Update Several Tuples

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

```
UPDATE Sells  
SET price = 4.00  
WHERE price > 4.00;
```

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