SQL Queries

- Principal form:

  `SELECT` desired attributes
  `FROM` tuple variables —
  range over relations
  `WHERE` condition about t.v.'s;

Running example relation schema:

`Beers(`<u>`name`</u>`, manf)`
`Bars(`<u>`name`</u>`, addr, license)`
`Drinkers(`<u>`name`</u>`, addr, phone)`
`Likes(`<u>`drinker`</u>`, `<u>`beer`</u>`)`
`Sells(`<u>`bar`</u>`, `<u>`beer`</u>`, price)`
`Frequents(`<u>`drinker`</u>`, `<u>`bar`</u>`)`

Example

What beers are made by Anheuser-Busch?

```
Beers(name, manf)

SELECT name
FROM Beers
WHERE manf = 'Anheuser-Busch';
```

- Note single quotes for strings.

name
Bud
Bud Lite
Michelob

Formal Semantics of Single-Relation SQL Query

1. Start with the relation in the `FROM` clause.
2. Apply (bag) σ, using condition in `WHERE` clause.
3. Apply (extended, bag) π using terms in `SELECT` clause.

Equivalent Operational Semantics

Imagine a *tuple variable* ranging over all tuples of the relation. For each tuple:

- Check if it satisfies the `WHERE` clause.
- Print the values of terms in `SELECT`, if so.

Star as List of All Attributes

```
Beers(name, manf)

SELECT *
FROM Beers
WHERE manf = 'Anheuser-Busch';
```

name	manf
Bud	Anheuser-Busch
Bud Lite	Anheuser-Busch
Michelob	Anheuser-Busch

Renaming columns

```
Beers(name, manf)

SELECT name AS beer
FROM Beers
WHERE manf = 'Anheuser-Busch';
```

beer
Bud
Bud Lite
Michelob

Expressions as Values in Columns

```
Sells(bar, beer, price)
```

```
SELECT bar, beer,
    price*120 AS priceInYen
FROM Sells;
```

bar	beer	priceInYen
Joe's	Bud	300
Sue's	Miller	360
...	...	...

- Note no `WHERE` clause OK.

- Trick: If you want an answer with a particular string in each row, use that constant as an expression.

  Likes(drinker, beer)

```
SELECT drinker,
    'likes Bud' AS whoLikesBud
FROM Likes
WHERE beer = 'Bud';
```

drinker	whoLikesBud
Sally	likes Bud
Fred	likes Bud
...	...

Example

Find the price Joe's Bar charges for Bud.

```
Sells(bar, beer, price)

SELECT price
FROM Sells
WHERE bar = 'Joe''s Bar' AND
    beer = 'Bud';
```

- Note: two single-quotes in a character string represent one single quote.
- Conditions in `WHERE` clause can use logical operators `AND`, `OR`, `NOT` and parentheses in the usual way.
- Remember: SQL is *case insensitive*. Keywords like `SELECT` or `AND` can be written upper/lower case as you like.
  - ✥ Only inside quoted strings does case matter.

Patterns

- `%` stands for any string.
- `_` stands for any one character.
- "Attribute `LIKE` pattern" is a condition that is true if the string value of the attribute matches the pattern.
  - ❖ Also `NOT LIKE` for negation.

Example

Find drinkers whose phone has exchange 555.

```
Drinkers(name, addr, phone)

SELECT name
FROM Drinkers
WHERE phone LIKE '%555-____';
```

- Note patterns must be quoted, like strings.

Nulls

In place of a value in a tuple's component.

- Interpretation is not exactly "missing value."
- There could be many reasons why no value is present, e.g., "value inappropriate."

Comparing Nulls to Values

- 3rd truth value `UNKNOWN`.
- A query only produces tuples if the `WHERE`-condition evaluates to `TRUE` (`UNKNOWN` is not sufficent).

Example

bar	beer	price
Joe's bar	Bud	NULL

```
SELECT bar
FROM Sells
WHERE price < 2.00 OR price >= 2.00;
    ------------    -------------
     UNKNOWN         UNKNOWN
     ------------------------
              UNKNOWN
```

- Joe's Bar is not produced, even though the `WHERE` condition is a tautology.

3-Valued Logic

Think of true = 1; false = 0, and unknown = 1/2. Then:

- AND = min.
- OR = max.
- NOT(x) = $1 - x$.

Some Key Laws Fail to Hold

Example: Law of the excluded middle, i.e.,

p `OR NOT` p `= TRUE`

- For 3-valued logic: if p = unknown, then left side = max(1/2,(1-1/2)) = 1/2 $\neq$ 1.
- Like bag algebra, there is no way known to make 3-valued logic conform to all the laws we expect for sets/2-valued logic, respectively.

Multirelation Queries

- List of relations in `FROM` clause.
- Relation-dot-attribute disambiguates attributes from several relations.

Example

Find the beers that the frequenters of Joe's Bar like.

```
Likes(drinker, beer)
Frequents(drinker, bar)

SELECT beer
FROM Frequents, Likes
WHERE bar = 'Joe''s Bar' AND
    Frequents.drinker = Likes.drinker;
```

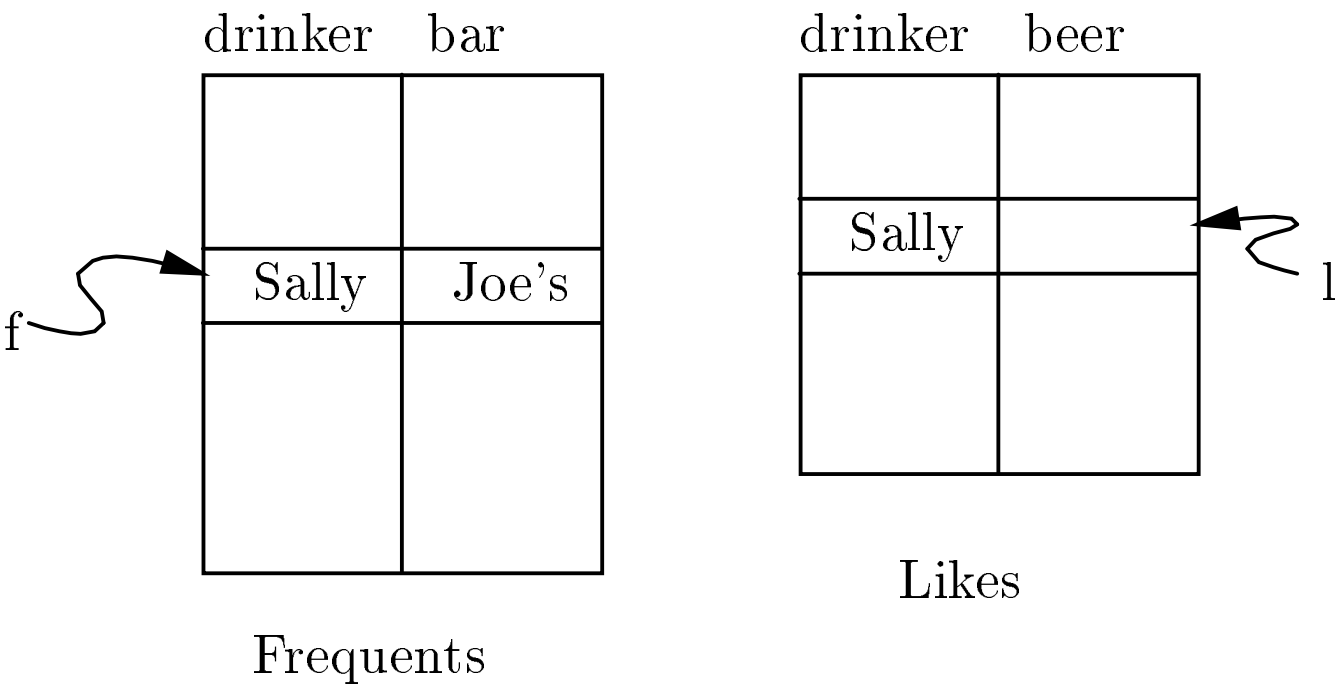
Formal Semantics of Multirelation Queries

Same as for single relation, but start with the product of all the relations mentioned in the `FROM` clause.

Operational Semantics

Consider a tuple variable for each relation in the `FROM`.

- Imagine these tuple variables each pointing to a tuple of their relation, in all combinations (e.g., nested loops).
- If the current assignment of tuple-variables to tuples makes the `WHERE` true, then output the terms of the `SELECT`.


drinker
bar
Sally
Joe's
f
Frequents
drinker
beer
Sally
l
Likes

Explicit Tuple Variables

Sometimes we need to refer to two or more copies of a relation.

- Use *tuple variables* as aliases of the relations.

Example

Find pairs of beers by the same manufacturer.

```
Beers(name, manf)

SELECT b1.name, b2.name
FROM Beers b1, Beers b2
WHERE b1.manf = b2.manf AND
    b1.name < b2.name;
```

- SQL permits `AS` between relation and its tuple variable; Oracle does not.
- Note that `b1.name < b2.name` is needed to avoid producing (Bud, Bud) and to avoid producing a pair in both orders.

Subqueries

Result of a select-from-where query can be used in the where-clause of another query.

Simplest Case: Subquery Returns a Single, Unary Tuple

Find bars that serve Miller at the same price Joe charges for Bud.

```
Sells(bar, beer, price)

SELECT bar
FROM Sells
WHERE beer = 'Miller' AND
    price =
        (SELECT price
         FROM Sells
         WHERE bar = 'Joe''s Bar' AND
             beer = 'Bud'
        );
```

- Notice the *scoping rule*: an attribute refers to the most closely nested relation with that attribute.
- Parentheses around subquery are essential.

The `IN` Operator

"Tuple `IN` relation" is true iff the tuple is in the relation.

Example

Find the name and manufacturer of beers that Fred likes.

```
Beers(name, manf)
Likes(drinker, beer)

SELECT *
FROM Beers
WHERE name IN
    (SELECT beer
     FROM Likes
     WHERE drinker = 'Fred'
    );
```

- Also: `NOT IN`.

`EXISTS`

"`EXISTS`(relation)" is true iff the relation is nonempty.

Example

Find the beers that are the unique beer by their manufacturer.

```
Beers(name, manf)

SELECT name
FROM Beers b1
WHERE NOT EXISTS(
    SELECT *
    FROM Beers
    WHERE manf = b1.manf AND
        name <> b1.name
);
```

- Note scoping rule: to refer to outer `Beers` in the inner subquery, we need to give the outer a tuple variable, `b1` in this example.
- A subquery that refers to values from a surrounding query is called a *correlated subquery*.

Quantifiers

`ANY` and `ALL` behave as existential and universal quantifiers, respectively.

- Beware: in common parlance, "any" and "all" seem to be synonyms, e.g., "I am fatter than any of you" vs. "I am fatter than all of you." But in SQL:

Example

Find the beer(s) sold for the highest price.

```
Sells(bar, beer, price)

SELECT beer
FROM Sells
WHERE price >= ALL(
    SELECT price
    FROM Sells
);
```

Class Problem

Find the beer(s) not sold for the lowest price.