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`.
- `SELECT` clause only lists tuples if the 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
```

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.

Outerjoin

$R \overset{\circ}{\bowtie} S = R \bowtie S$ with *dangling* tuples padded with nulls and included in the result.

- A tuple is dangling if it doesn't join with any other tuple.

$R =$

A	B
1	2
3	4

$S =$

B	C
2	5
2	6
7	8

$R \overset{\circ}{\bowtie} S =$

A	B	C
1	2	5
1	2	6
3	4	NULL
NULL	7	8

Outerjoin in SQL2

A number of forms are provided.

- Can be used either stand-alone (in place of a select-from-where) or to define a relation in the `FROM`-clause.

  R `NATURAL JOIN` S
  R `JOIN` S `ON` condition
  e.g., condition: $R.B = S.B$
  R `CROSS JOIN` S
  R `OUTER JOIN` S

- The last of these can be modified by:

  1. Optional `NATURAL` in front.
  2. Optional `ON` condition at end.
  3. Optional `LEFT`, `RIGHT`, or `FULL` before `OUTER`.

  ❖ `LEFT` = pad dangling tuples of R only; `RIGHT` = pad dangling tuples of S only.

Oracle Outerjoin

There is a rudimentary facility that allows either left or right outerjoin.

- Add (+) to one side of the equality that forms a join between two tables.

Example

List the beers sold by Joe's Bar, with their manufacturers, but include the beer even if the manufacturer is not known.

```
Beers(name, manf)
Sells(bar, beer, price)

SELECT beer, manf
FROM Sells, Beers
WHERE bar = 'Joe''s Bar' AND
    beer = name(+);
```

Constraints

Commercial relational systems allow much more "fine-tuning" of constraints than do the modeling languages we learned earlier.

- In essence: SQL programming is used to describe constraints.

Outline

1. Primary key declarations (covered).
2. Foreign-keys = referential integrity constraints.
3. Attribute- and tuple-based checks = constraints within relations.
4. SQL2 Assertions = global constraints.
   - Not found in Oracle.
5. Oracle Triggers.
   - A substitute for assertions.
6. SQL3 triggers and assertions.

Foreign Keys

In relation R a clause that "attribute A references $S(B)$" says that whatever values appear in the A column of R must also appear in the B column of relation S.

- B must be declared the primary key for S.

Example

```
CREATE TABLE Beers (
    name CHAR(20) PRIMARY KEY,
    manf CHAR(20)
);

CREATE TABLE Sells (
    bar CHAR(20),
    beer CHAR(20) REFERENCES
            Beers(name),
    price REAL
);
```

- Alternative: add another element declaring the foreign key, as:

```
CREATE TABLE Sells (
    bar CHAR(20),
    beer CHAR(20),
    price REAL,
    FOREIGN KEY beer REFERENCES
            Beers(name)
);
```

- Extra element essential if the foreign key is more than one attribute.

What Happens When a Foreign Key Constraint is Violated?

- Two ways:

1. Insert or update a `Sells` tuple so it refers to a nonexistent beer.
   - ❖ Always rejected.
2. Delete or update a `Beers` tuple that has a `beer` value some `Sells` tuples refer to.
   a) Default: reject.
   b) *Cascade*: Ripple changes to referring `Sells` tuple.

Example

- Delete "Bud." Cascade deletes all `Sells` tuples that mention Bud.
- Update "Bud" → "Budweiser." Change all `Sells` tuples with "Bud" in `beer` column to be "Budweiser."

c) *Set Null*: Change referring tuples to have `NULL` in referring components.

Example

- Delete "Bud." Set-null makes all `Sells` tuples with "Bud" in the `beer` component have `NULL` there.
- Update "Bud" → "Budweiser." Same change.

Selecting a Policy

Add `ON [DELETE, UPDATE] [CASCADE, SET NULL]` to declaration of foreign key.

Example

```
CREATE TABLE Sells (
    bar CHAR(20),
    beer CHAR(20),
    price REAL,
    FOREIGN KEY beer REFERENCES
        Beers(name)
        ON DELETE SET NULL
        ON UPDATE CASCADE
);
```

- "Correct" policy is a design decision.
  - E.g., what does it mean if a beer goes away? What if a beer changes its name?

Attribute-Based Checks

Follow an attribute by a condition that must hold for that attribute in each tuple of its relation.

- Form: `CHECK` (condition).
  - Condition may involve the checked attribute.
  - Other attributes and relations may be involved, but *only* in subqueries.
  - Oracle: *No subqueries allowed in condition.*
- Condition is checked only when the associated attribute changes (i.e., an insert or update occurs).

Example

```
CREATE TABLE Sells (
    bar CHAR(20),
    beer CHAR(20) CHECK(
        beer IN (SELECT name
            FROM Beers)
    ),
    price REAL CHECK(
        price <= 5.00
    )
);
```

- Check on `beer` is like a foreign-key constraint, except:
  - ❖ The check occurs only when we add a tuple or change the beer in an existing tuple, not when we delete a tuple from `Beers`.

Tuple-Based Checks

Separate element of table declaration.

- Form: like attribute-based check.
- But condition can refer to any attribute of the relation.
  - Or to other relations/attributes in subqueries.
  - Again: Oracle forbids the use of subqueries.
- Checked whenever a tuple is inserted or updated.

Example

Only Joe's Bar can sell beer for more than \$5.

```
CREATE TABLE Sells (
    bar CHAR(20),
    beer CHAR(20),
    price REAL,
    CHECK(bar = 'Joe''s Bar' OR
        price <= 5.00)
);
```