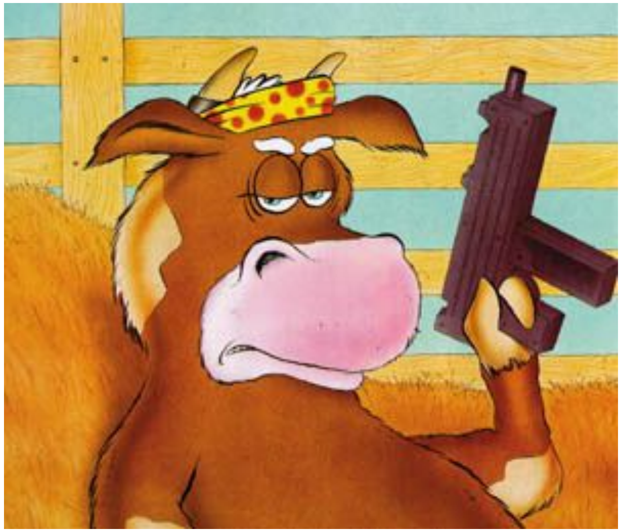
SQL: Joins, Constraints & Triggers

Problem Set #1 is due before midnight next Tuesday.

Problem Set #2 is posted either tonight or tomorrow morning.



Controlling Output Order

- SQL's "ORDER BY" clause is used to sort tuples in either ascending or descending order.
- ORDER BY specifies attributes used in the sort

```
SELECT *
FROM   Sailors
WHERE  age > 18
ORDER BY rating
```

```
SELECT *
FROM   Sailors
WHERE  age > 18
ORDER BY rating DESC
```

```
SELECT *
FROM   Sailors
WHERE  age > 18
ORDER  BY rating DESC, sname ASC
```

sid	sname	rating	age
29	Brutus	1	33.0
85			
95			
22			
64			
31			
32			
74			
58			

sid	sname	rating	age
58	Rusty	10	35.0
74			
31			
32			
22			
64			
85			
95			
29			

sid	sname	rating	age
58	Rusty	10	35.0
74	Horatio	9	35.0
32	Andy	8	25.5
31	Lubber	8	55.5
22	Dustin	7	45.0
64	Horatio	7	35.0
85	Art	3	25.5
95	Bob	3	63.5
29	Brutus	1	33.0

Controlling output size

- The "LIMIT" clause is used to limit the number of tuples returned by a "SELECT" statement
- Useful for seeing a small number of examples, or "top-X" in combination with "ORDER BY"

```
SELECT *
FROM Sailors
LIMIT 5
```

sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0

```
SELECT *
FROM Sailors
ORDER BY rating DESC
LIMIT 5
```

sid	sname	rating	age
58	Rusty	10	35.0
74	Horatio	9	35.0
31	Lubber	8	55.5
32	Andy	8	25.5
22	Dustin	7	45.0

Changing a table value

Thus far we've inserted entire rows into tables, but SQL also provides commands for UPDATEs

UPDATE	*relation*
SET	*attr-value-list*
WHERE	*qualification*

An attr-value-list is a comma separated list of

$$attribute_1 = expression_1, attribute_2 = expression_2$$

The WHERE qualification can be any valid set of filtering terms including nest queries with IN and EXCEPT, but usually it is a <primary key>=value

UPDATE example

UPDATE Sailors
SET rating=rating + 1
WHERE sid=85

UPDATE Sailors
SET rating=rating + 1
WHERE rating < 10
AND sname LIKE "%us%"

sid	sname	rating	age
29	Brutus	1	33.0
85	Art	3	25.5
95	Bob	3	63.5
22			
64			
31			
32			
74			
58			
71			

sid	sname	rating	age
29	Brutus	1	33.0
85	Art	4	25.5
95	Bob	3	63.5
22			
64			
31			
32			
74			
58			
71			

sid	sname	rating	age
29	Brutus	2	33.0
85	Art	4	25.5
95	Bob	3	63.5
22	Dustin	8	45.0
64	Horatio	7	35.0
31	Lubber	8	55.5
32	Andy	8	25.5
74	Horatio	9	35.0
58	Rusty	10	35.0
71	Zorba	10	16.0

Null Values

- Field values in a tuple are sometimes *unknown* (e.g., a rating has not been assigned) or *inapplicable* (e.g., no spouse's name).
  - SQL provides a special value *null* for such situations.
- The presence of *null* complicates many issues. e.g.:
  - Special operators needed to check if value is/is not *null*.
  - Is *rating>8* true or false when *rating* is equal to *null*? What about AND, OR and NOT connectives?
  - Creates the need for a 3-valued logic (true, false and *unknown*).
  - Meaning of constructs must be defined carefully. (e.g., WHERE clause eliminates rows that don't evaluate to true.)
- Joins can also generate *null* entries

Creating a Tiny database

Using iSQL.parser("tiny.db", mode='w'), you can execute the following:

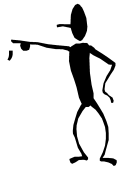
Sailors:

```
CREATE TABLE Sailors(
    sid INTEGER PRIMARY KEY,
    sname TEXT,
    rating INTEGER,
    age REAL)

INSERT INTO Sailors(sid,sname,rating,age)
    VALUES (22, 'dustin', 7, 45.0),
           (31, 'lubber', 8, 55.5),
           (58, 'rusty', 10, 35.0)

SELECT * FROM Sailors
```

The PRIMARY KEY designation is a simple CONSTRAINT in SQL. Each PRIMARY KEY must be unique, and whether it is is checked and enfoced on INSERTS



Creating a Tiny database

Using iSQL.parser("tiny.db", mode='w'), you can execute the following:

Boats:

```
CREATE TABLE Boats(
    bid INTEGER PRIMARY KEY,
    bname TEXT,
    color TEXT)

INSERT INTO Boats
    VALUES (101, 'Interlake', 'blue'),
           (102, 'Interlake', 'red'),
           (103, 'Clipper', 'green')

SELECT * FROM Boats
```

> The attribute list is optional on an INSERT if you fill every column in the same order given by the CREATE.

Creating a Tiny database

And now a relation between these two enities:

A composite PRIMARY KEY (i.e. composed of more than one attribute) is defined separately at the end of the CREATE.

Reserves:

```
CREATE TABLE Reserves(
    sid INTEGER,
    bid INTEGER,
    day DATE,
    PRIMARY KEY(sid,bid),
    FOREIGN KEY(sid) REFERENCES Sailors(sid),
    FOREIGN KEY(bid) REFERENCES Boats(bid)
);

INSERT INTO Reserves
    VALUES(22, 101, '1996-10-10'),
          (31, 103, '1996-11-12');

SELECT * FROM Reserves;
```

A FOREIGN KEY is another common constraint. It implies that this attribute is type compatiable with the referenced attribute in another table. Optionally it can disable insertions unless the value inserted matches a value in a row with the referenced table,

Types of JOINS

- Tables from our "tiny" sailor database

Sailors:

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

Reserves:

sid	bid	day
22	101	1996-10-10
31	103	1996-11-12

- An "implied" join (in the WHERE clause)

```
SELECT S.sname, R.day
FROM Sailors S, Reserves R
WHERE  S.sid=R.sid
```

sname	day
dustin	1996-10-10
rusty	1996-11-12

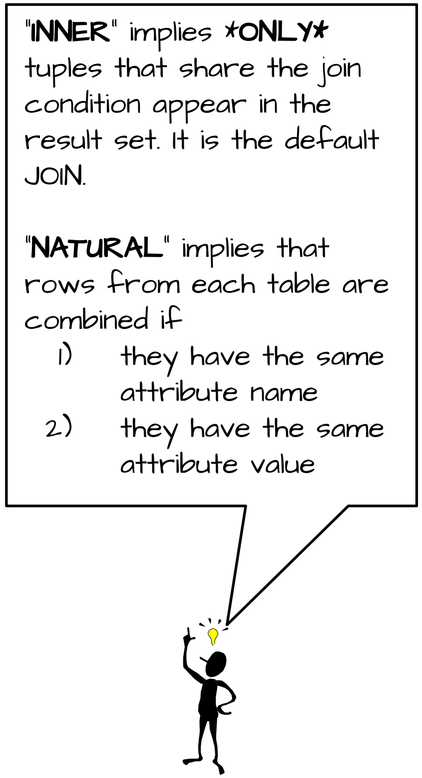
- An "explicit" join (in the FROM clause)

```
SELECT S.sname, R.day
FROM Sailors S JOIN Reserves R ON S.sid=R.sid

SELECT S.sname, R.day
FROM Sailors S INNER JOIN Reserves R ON S.sid=R.sid

SELECT S.sname, R.day
FROM Sailors S NATURAL JOIN Reserves R
```

sname	day
dustin	1996-10-10
rusty	1996-11-12



Left JOINS

Sailors:

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

Reserves:

sid	bid	day
22	101	1996-10-10
31	103	1996-11-12

Boats:

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green

- A “Left” JOIN returns a tuple for every row of the first, “left”, relation, even if it requires adding “Null” values to the output relations

```
SELECT S.sname, R.day
FROM Sailors S LEFT JOIN Reserves R ON S.sid=R.sid

SELECT S.sname, R.day
FROM Sailors S NATURAL LEFT JOIN Reserves R
```

sname	day
dustin	1996-10-10
lubber	Null
rusty	1996-11-12

- Notice that every row from Sailors has a corresponding row in the result (BTW *Null* maps to *None* in Python)

Right JOINS

Sailors:

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

Reserves:

sid	bid	day
22	101	1996-10-10
31	103	1996-11-12

Boats:

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green

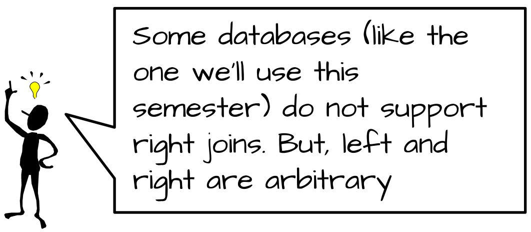
- Likewise a “Right” join returns a tuple for every row in the second, “right”, relation

```
SELECT R.day, B.bname
FROM Reserves R NATURAL RIGHT JOIN Boats B
```

day	bname
1996-10-10	Interlake
Null	Interlake
1996-11-12	Clipper

- Here there is a corresponding row in the result for every row in "Boats"

```
SELECT R.day, B.bname
FROM Boats B NATURAL LEFT JOIN Reserves R
```



FULL OUTER Joins

Sailors:

sid	sname	rating	age
22	dustin	7	45.0
31	lubber	8	55.5
58	rusty	10	35.0

Reserves:

sid	bid	day
22	101	1996-10-10
31	103	1996-11-12

Boats:

bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green

- The FULL OUTER JOIN keyword returns *all* rows from *all* tables with the specified attributes joined or *null* if there is no match

```
SELECT S.sname, R.day, B.bname
FROM (Sailors S NATURAL LEFT JOIN Reserves R)
      FULL OUTER JOIN Boats B ON R.bid=B.bid
```

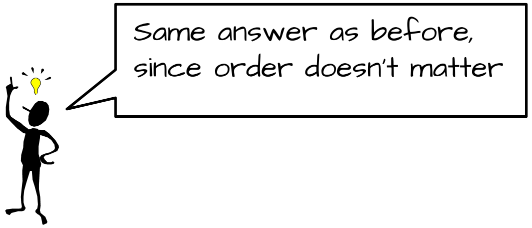
sname	day	bname
dustin	1996-10-10	Interlake
lubber	Null	Null
Null	Null	Interlake
rusty	1996-11-12	Clipper

Emulating FULL OUTER JOIN

We can always emulate a FULL JOIN using the UNION of two oriented JOINs

```
SELECT S.sname, R.day, B.bname
FROM (Sailors S NATURAL LEFT JOIN Reserves R) LEFT JOIN Boats B USING(bid)
UNION
SELECT S.sname, R.day, B.bname
FROM Boats B LEFT JOIN (Sailors S NATURAL LEFT JOIN Reserves R) USING(bid)
```

sname	day	bname
None	None	Interlake
dustin	1996-10-10	Interlake
lubber	1996-11-12	Clipper
rusty	None	None



Integrity Constraints (IC)

- An IC describes conditions that every *legal instance* of a relation must satisfy.
  - Inserts/deletes/updates that violate IC's are disallowed.
  - Can be used to ensure application semantics (e.g., *sid* is a key), or prevent inconsistencies (e.g., *sname* has to be a nonempty string, *age* must be < 200)
- *Types of IC's*: Domain constraints, primary key constraints, foreign key constraints, general constraints.
  - *Domain constraints*: Field values must be of right type. Always enforced.

General Constraint CHECKs

- CHECK clause
- Useful when more general ICs than keys are involved.
- Example: All ratings must be between 1 and 10

```
CREATE TABLE  Sailors(
    sid      INTEGER,
    sname    TEXT,
    rating   INTEGER,
    age      REAL,
    PRIMARY KEY  (sid),
    CHECK  (rating >= 1
        AND rating <= 10)
```

More complicated CHECKs

- Constraints can be named.
- Checks can contain nested subqueries
- Example: Disallow reservations of boats named "Interlake" by sailors with ratings less than 7
- "bid" and "sid" refer to values from the associated INSERT or UPDATE

```
CREATE TABLE  Reserves(
     sid   INTEGER,
     bid   INTEGER,
     day  DATE,
     PRIMARY KEY  (bid,day),
     CONSTRAINT  NoInterlakeIfLessThan7
     CHECK  ('Interlake' <> ( SELECT  B.bname
                              FROM     Boats B
                              WHERE  B.bid=bid)
                           OR 7  <= (SELECT S.rating
                                     FROM Sailor S
                                     WHERE S.sid=sid))
```

Constraints Over Multiple Relations

- Awkward and wrong!
- Check is done only when inserting Sailors. What about Boats?
- ASSERTION is the right solution; not associated with either table.

```
CREATE TABLE  Sailors(
  sid  INTEGER,
  sname  CHAR(10),
  rating  INTEGER,
  age  REAL,
  PRIMARY KEY  (sid),
  CHECK
  ( (SELECT COUNT (S.sid) FROM Sailors S)
  + (SELECT COUNT (B.bid) FROM Boats B) < 100 )
```

Number of boats plus number of sailors is < 100

```
CREATE ASSERTION  smallClub
CHECK
( (SELECT COUNT (S.sid) FROM Sailors S)
+ (SELECT COUNT (B.bid) FROM Boats B) < 100 )
```

Triggers

- Trigger: procedure that starts automatically if specified changes occur to the DBMS

- Triggers have three parts:
  - *Event* (that activates the trigger)
  - *Condition* (tests whether the triggers should run)
  - *Action* (what happens if the trigger runs)

Triggers: Example

- Suppose there was a rule that "*no one with a rating less than 5 can reserve a green boat*". The following trigger would enforce this rule, and generate a failure message:

```
CREATE TRIGGER RatingRuleForGreen
  BEFORE INSERT ON Reserves                                   Event
  BEGIN
     SELECT RAISE(FAIL, 'Sailor is not qualified')        Action
     WHERE EXISTS (SELECT * FROM Sailors, Boats        Condition
                          WHERE sid = new.sid AND rating < 5
                          AND bid = new.bid AND color = 'green');
  END;
```

- Note the special variable *new* is used for accessing parameters of the invoking INSERT query

Triggers: Another Example

- Changes in one table can cause side-effects in other tables via triggers
- Example “Event Logging”
- We know dates of reservations, but not when they were made. This can be remedied using a trigger as follows:

```
CREATE TRIGGER insertLog
AFTER INSERT ON Reserves
BEGIN
    INSERT INTO ReservesLog (sid, bid, resDate, madeDate)
    VALUES (new.sid, new.bid, new.date, DATE('NOW'));
END;
```

Summary

- NULLs provide a means for representing "unspecified" attribute values
- NULLs can be generated by special JOINs
- Wide range of JOIN operations-- Some retain the cardinality of specified relations
- SQL allows specification of rich integrity constraints
- Triggers respond to changes in the database