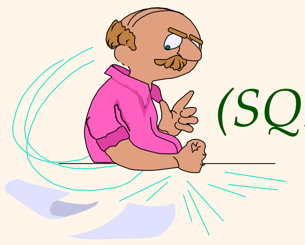
Introduction to Data Management



Lecture #16
(SQL, the Sequel's Sequel…)

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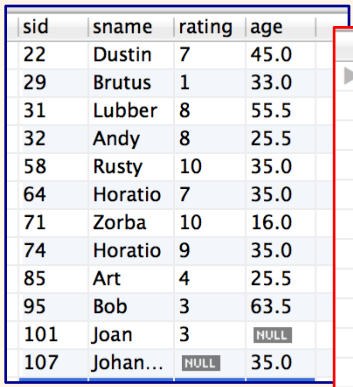
Announcements

- ❖ First SQL query HW is now underway
  - Hopefully everyone has MySQL working
  - Get the latest version of the questions! (*Sorry…!* ☹)
- ❖ Grading is in progress for many things
  - HW #2 should be done any minute (!)
  - Other HW's are in progress in parallel
  - Trying to get Midterm #1 done by week's end
  - (430 is a pretty big number…)

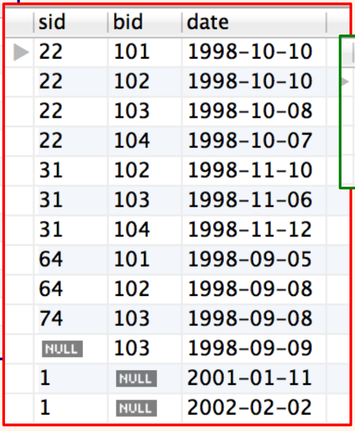
Example Data in MySQL

Sailors



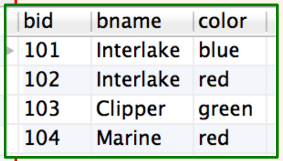
sid	sname	rating	age
22	Dustin	7	45.0
29	Brutus	1	33.0
31	Lubber	8	55.5
32	Andy	8	25.5
58	Rusty	10	35.0
64	Horatio	7	35.0
71	Zorba	10	16.0
74	Horatio	9	35.0
85	Art	4	25.5
95	Bob	3	63.5
101	Joan	3	NULL
107	Johan…	NULL	35.0

Reserves



sid	bid	date
22	101	1998-10-10
22	102	1998-10-10
22	103	1998-10-08
22	104	1998-10-07
31	102	1998-11-10
31	103	1998-11-06
31	104	1998-11-12
64	101	1998-09-05
64	102	1998-09-08
74	103	1998-09-08
NULL	103	1998-09-09
1	NULL	2001-01-11
1	NULL	2002-02-02

Boats



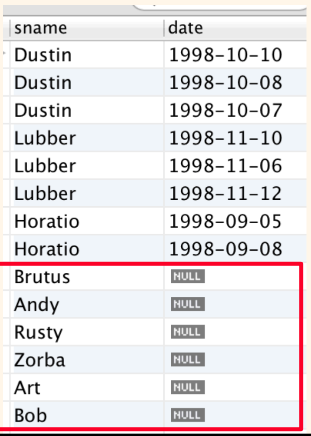
bid	bname	color
101	Interlake	blue
102	Interlake	red
103	Clipper	green
104	Marine	red

*Inner vs. **Outer** Joins in SQL (3)*

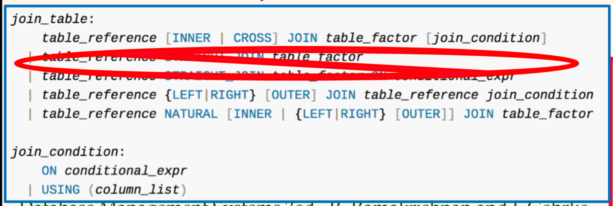
(1) SELECT DISTINCT s.sname, r.date
FROM Sailors s LEFT OUTER JOIN Reserves r ON s.sid = r.sid

(2) SELECT DISTINCT s.sname, r.date
FROM Reserves r RIGHT OUTER JOIN Sailors s ON s.sid = r.sid

- Variations on a theme:
  - JOIN (or INNER JOIN)
  - LEFT OUTER JOIN
  - RIGHT OUTER JOIN
  - FULL OUTER JOIN



sname	date
Dustin	1998-10-10
Dustin	1998-10-08
Dustin	1998-10-07
Lubber	1998-11-10
Lubber	1998-11-06
Lubber	1998-11-12
Horatio	1998-09-05
Horatio	1998-09-08
Brutus	NULL
Andy	NULL
Rusty	NULL
Zorba	NULL
Art	NULL
Bob	NULL



```
join_table:
    table_reference [INNER | CROSS] JOIN table_factor [join_condition]
  | ~~table_reference STRAIGHT_JOIN table_factor~~
  | ~~table_reference STRAIGHT_JOIN table_factor ON conditional_expr~~
  | table_reference {LEFT|RIGHT} [OUTER] JOIN table_reference join_condition
  | table_reference NATURAL [INNER | {LEFT|RIGHT} [OUTER]] JOIN table_factor

join_condition:
    ON conditional_expr
  | USING (column_list)
```

An Algebra Side Note...

- As a side note:
  - The underlying operations are also part of the extended relational algebra, which adds...
    - Outer joins (left, right, and full)
    - Ordering (sorting)
    - Grouping (w/aggregates)
    - ....
- You can play around with those extensions on the relational algebra (RelaX) site that you used for the recently completed RA HW (if you're curious)!
  - `https://dbis-uibk.github.io/relax/help.htm`

*Updates: Oh **CRUD***!*

*(***C**reate, **R**etrieve, **U**pdate, **D**elete)*

- Can add one or more tuples using INSERT:

```
INSERT INTO Students (sid, name, login, age, gpa)
VALUES (53688, 'Smith', 'smith@ee', 18, 3.2)

INSERT INTO Students (sid, name, login, age, gpa)
SELECT ... (your favorite SQL query goes here!) ...
```

- Can DELETE all tuples satisfying any SQL query condition:

```
DELETE FROM Students S
WHERE S.sid IN (SELECT X.sid FROM Banned X)
```

*Updates: Oh **CRUD**!* *(Cont.)*

❖ Can change one or more tuples using UPDATE:

```
UPDATE Sailors
SET  sname = 'King Arthur',
       rating = rating + 1
WHERE sname = 'Art';
```

❖ A few things to note:

- LHS of SET is column name, RHS is (any) expression
- WHERE predicate is any SQL condition, which again means SQL subqueries are available as a tool, e.g., to search for targets based on multiple tables' content

SQL Data Integrity (Largely Review)

❖ An *integrity constraint* describes a condition 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, *bid* refers to a known boat) or prevent inconsistencies (e.g., *sname* has to be a string, integer *age* must be < 120)

❖ *Types of IC's*: Domain constraints, primary key constraints, foreign key constraints, unique constraints, general constraints.

- *Domain constraints*: Field values must be of the right type (i.e., per the schema specification). Always enforced!

SQL Data Integrity (Cont.)

- So far we have been making good use of:
  - PRIMARY KEY
  - UNIQUE
  - NOT NULL
  - FOREIGN KEY

Note: MySQL with InnoDB actually permits a foreign key to reference any indexed column(s)...

- Other features for ensuring field value integrity:
  - DEFAULT (alternative to NULL for missing values)
  - CHECK (called "general" in the book, kind of...)
- More powerful integrity features include
  - ~~ASSERTION~~ (called "general" in the book, correctly ☺)
  - TRIGGER (a sledge hammer to use when all else fails!)

Some Integrity Related Examples

- CHECK is useful when more general ICs than just keys are involved.
- Could use SQL subqueries to express richer constraints (*if supported* ☺).
- Constraints can be named (to manage them).

```
CREATE TABLE  Sailors
        ( sid  INTEGER,
        sname  CHAR(10),
        rating  INTEGER,
        age  REAL **DEFAULT 18.0,**
        PRIMARY KEY  (sid),
        CHECK  ( rating >= 1
                 AND rating <= 10 ) )
```

```
CREATE TABLE  Reserves
        ( sname  CHAR(10),
        bid  INTEGER,
        day  DATE,
        PRIMARY KEY  (bid,day),
        ~~CONSTRAINT  noInterlakeRes~~
        ~~CHECK  (`Interlake' <>~~
                ~~( SELECT  B.bname~~
                ~~FROM  Boats B~~
                ~~WHERE  B.bid=bid))~~ )
```

Note: Unfortunately, MySQL currently ignores CHECK constraints…

Enforcing Referential Integrity (RI)

- Consider Sailors and Reserves; *sid* in Reserves is a foreign key that references Sailors.
- What should be done if a Reserves tuple with a non-existent sailor id is inserted? (**A:** *Reject it!*)
- What should be done if a Sailors tuple is deleted?
  - Also delete all Reserves tuples that refer to it, or
  - Disallow deletion of a Sailors that's being referred to, or
  - Set sid in Reserves tuples that refer to it to some *default sid*.
  - (In SQL, could also: Set sid in Reserves tuples that refer to it to *null*, denoting `*unknown*' or `*inapplicable*'.)
- Similar issue if the primary key of a Sailor is updated.

RI Enforcement in SQL (Reminder)

- SQL/92 and SQL:1999 support all 4 options on deletes and updates.
  - Default is NO ACTION (delete/update is rejected)
  - CASCADE (also delete all tuples that refer to the deleted tuple)
  - SET NULL / SET DEFAULT (set foreign key value of referencing tuple)

Ex:

```
CREATE TABLE Reserves
  (sid INTEGER,
   bid INTEGER,
   date DATE,
   ....
   FOREIGN KEY (sid)
   REFERENCES Sailors
       ON DELETE CASCADE
       ON UPDATE SET NULL)
```

Odd combo; just illustrating what's possible here…

Triggers in SQL

- Trigger: a procedure that runs automatically if specified changes occur to the DBMS
- Three parts:
  - Event (activates the trigger)
  - Condition (tests if the trigger should run)
  - Action (what happens if the trigger runs)
- Can be used to do "whatever"!
  - One SQL statement or sequence/flow of statements; can also cause the current update to bail out.
  - Details vary WIDELY from vendor to vendor (!)
  - Major source of "vendor lock-in", along with the *stored procedure language* (= trigger action language)

Trigger Syntax (MySQL)

CREATE [DEFINER = { *user* | CURRENT_USER }]
TRIGGER *trigger_name*
trigger_time trigger_event
ON *tbl_name*
FOR EACH ROW
[trigger_order]
trigger_body

trigger_time: { BEFORE | AFTER }
trigger_event: { INSERT | UPDATE | DELETE }
trigger_order: { FOLLOWS | PRECEDES } *other_trigger_name*

https://dev.mysql.com/doc/refman/8.0/en/trigger-syntax.html

Trigger Example (MySQL)

```
DELIMITER $$      -- Necessary to make semicolons great again... ☺
                  -- (Prevents them from ending the input statement!)

CREATE TRIGGER youngSailorUpdate
AFTER INSERT ON Sailors
FOR EACH ROW
BEGIN
   IF NEW.age < 18 THEN
      INSERT INTO YoungSailors (sid, sname, age, rating)
      VALUES (NEW.sid, NEW.sname, NEW.age, NEW.rating);
   END IF;
END;
```

Note: ***FOR EACH ROW*** provides less power than ***FOR EACH STATEMENT*** (e.g., can't compute average new age)

Trigger Example (MySQL, cont'd.)

☐
```
INSERT INTO Sailors(sid, sname, rating, age)
VALUES (777, 'Lucky', 7, 77);
```

☑
```
INSERT INTO Sailors(sid, sname, rating, age)
VALUES (778, 'Lucky Jr', 7, 7);
```

*(NOTE: Look at **YoungSailors** table content after each one!)*

Another Trigger Example (MySQL)

```
-- Let's implement a poor man's CHECK constraint!
DELIMITER $$

CREATE TRIGGER checkSailorAge
AFTER INSERT ON Sailors
FOR EACH ROW
BEGIN
   IF NEW.age < 18 THEN
      SIGNAL SQLSTATE '02000'
          SET MESSAGE_TEXT =
             'Warning: Sailors can not be under 18!';
   END IF;
END;
```