The Legend of Drunken Query Master

The Apprentice's Journey

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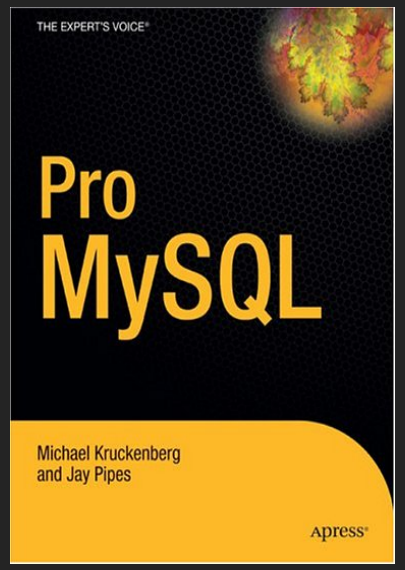
before we start

- Who am I?
  - Just some dude who works at MySQL (eh...Sun)
  - Oh, I co-wrote a book on MySQL
  - Active PHP/MySQL community member
  - Other than that, semi-normal geek, married, 2 dogs, 2 cats, blah blah
- This talk is about understanding and tuning SQL applications



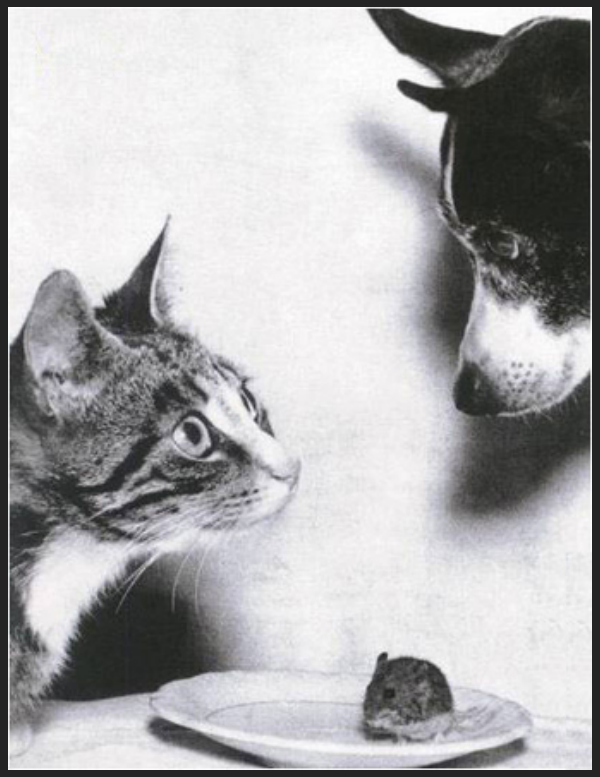
notes on this presentation

- Got a quick question?
  - Just ask it.
- Got a longer question?
  - Wait until the break or when the speaker forgets what he is talking about.
- Pictures of cute and cuddly animals are used frequently throughout presentation as a blatant attempt to improve your review of the speaker
  - If you hate cute and cuddly animals, you may want to leave now.

drunken query master says...

“...thou shalt not fight with the database, for it is thy friend”

can't we all just get along?



http://www.ringelkater.de/ringel_witzig/cat_dog_mouse.jpg

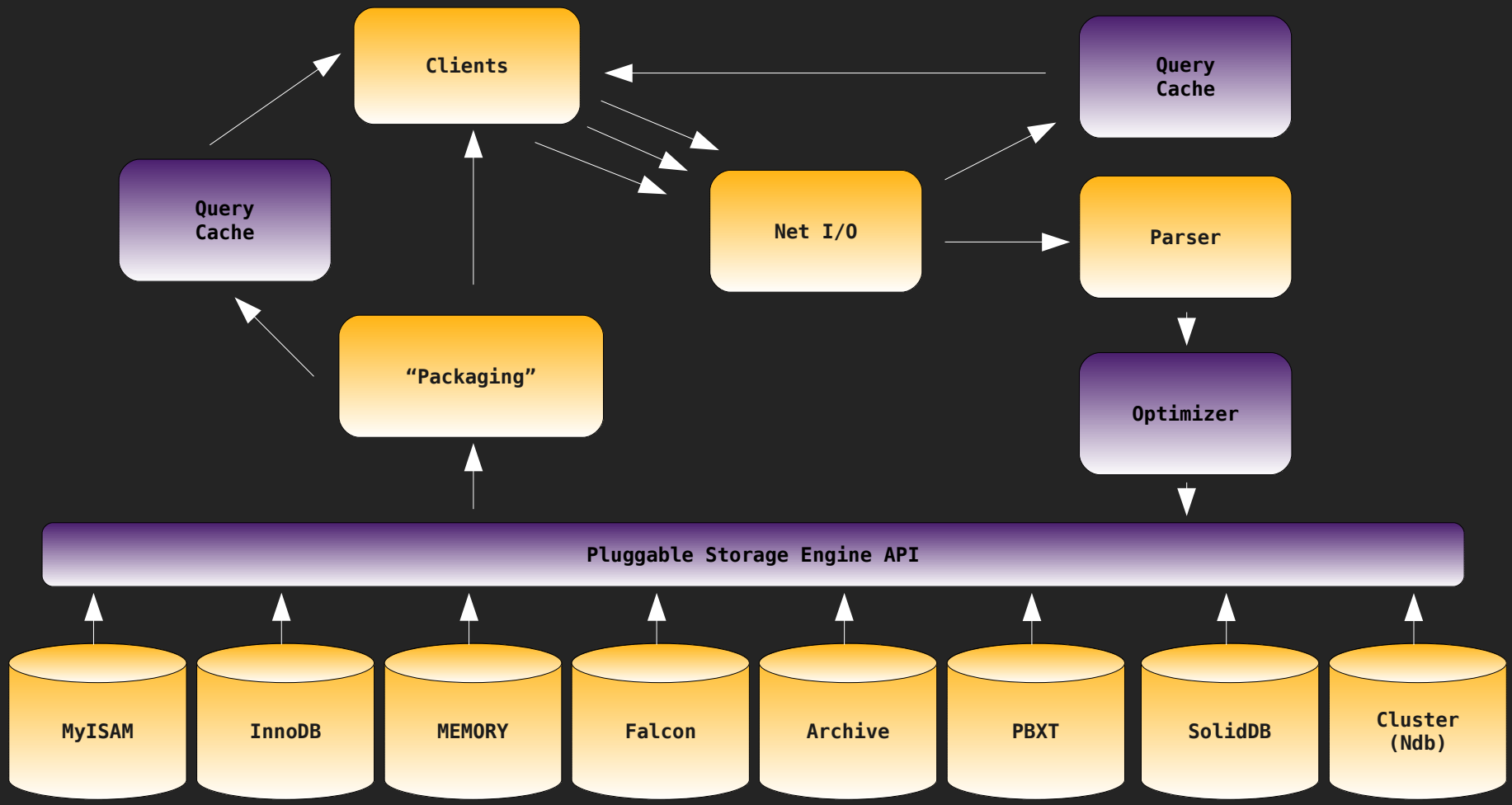
your friend, the database...

- Recognize the strengths and also the weaknesses of your database
- No database is perfect -- deal with it, you're not perfect either
- Think of both big things *and* small things
  - **BIG:** Architecture, surrounding servers, caching
  - **SMALL:** SQL coding, join rewrites, server config

expect the unexpected

- Some big things produce small results
  - Hardware changes can produce smaller improvements than many expect
- Some small things produce humungonormous results
  - Rewriting a poorly-constructed query can improve performance or scalability more than you might expect

system architecture of MySQL



keys to MySQL system architecture

- Understand storage engine abilities and weaknesses
- Understand how the query cache and important buffers works
- Understand optimizer's limitations
- Understand what should and should *not* be done at the application level
- If you understand the above, you'll start to see the database as a friend and not an enemy

drunken query master says...

"...poor skills in schema-kido shall lead to crushing defeat"

http://www.cold-moon.com/images/Motivators/GMs/defeat.jpg

the schema

- Basic foundation of performance
- Everything else depends on it
- Choose your data types wisely
- Conquer the schema through partitioning

The Leaning Tower of Pisa
from Wikipedia:

“Although intended to stand vertically, the tower began leaning to the southeast soon after the onset of construction in 1173 ***due to a poorly laid foundation*** and loose substrate that has allowed the foundation to shift direction.”

smaller, smaller, smaller

The Pygmy Marmoset
world's smallest monkey

This picture is a cheap stunt intended to induce kind feelings for the presenter.

Oh, and I *totally* want one of these guys for a pet.

The more records you can fit into a single page of memory/disk, the faster your seeks and scans will be

- Do you *really* need that **BIGINT**?
- Use **INT UNSIGNED** for IPv4 addresses
- Use **VARCHAR** carefully
  - Converted to **CHAR** when used in a temporary table
- Use **TEXT** sparingly
  - Consider separate tables
- Use **BLOB**s very sparingly
  - Use the filesystem for what it was intended

handling IPv4 addresses

```
CREATE TABLE Sessions (
  session_id INT UNSIGNED NOT NULL AUTO_INCREMENT
, ip_address INT UNSIGNED NOT NULL // Compare to CHAR(15)...
, session_data TEXT NOT NULL
, PRIMARY KEY (session_id)
, INDEX (ip_address)
) ENGINE=InnoDB;
```

```
// Insert a new dummy record
INSERT INTO Sessions VALUES
(NULL, INET_ATON('192.168.0.2'), 'some session data');
```

```
INSERT INTO Session VALUES (NULL, 3232235522, 'some session data');
```

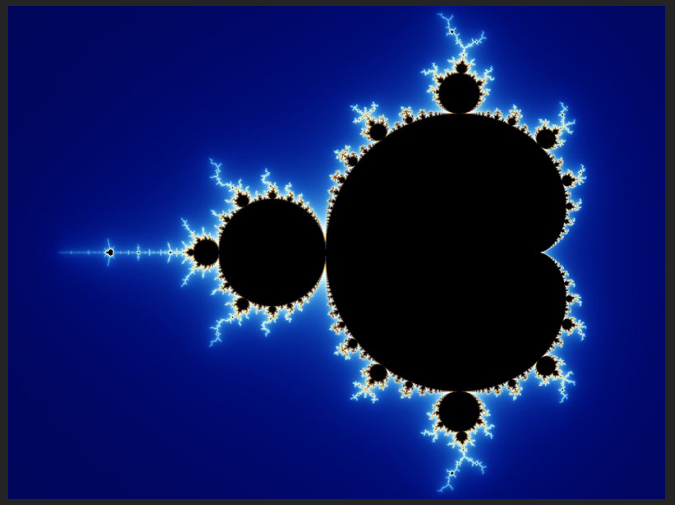
```
// Find all sessions coming from a local subnet
SELECT
  session_id
, ip_address as ip_raw
, INET_NTOA(ip_address) as ip
, session_data
FROM Sessions
WHERE ip_address
BETWEEN INET_ATON('192.168.0.1')
AND INET_ATON('192.168.0.255');
```

```
WHERE ip_address BETWEEN 3232235521 AND 3232235775
```

```
mysql> SELECT session_id, ip_address as ip_raw, INET_NTOA(ip_address) as ip, session_data
    -> FROM Sessions
    -> WHERE ip_address BETWEEN
    -> INET_ATON('192.168.0.1') AND INET_ATON('192.168.0.255');
+------------+------------+-------------+-------------------+
| session_id | ip_raw     | ip          | session_data      |
+------------+------------+-------------+-------------------+
|          1 | 3232235522 | 192.168.0.2 | some session data |
+------------+------------+-------------+-------------------+
```

SETs and ENUMs

- Drunken query master is not a big fan of SET and ENUM
- Sign of poor schema design
- Changing the definition of either will require a *full rebuild of the table*
- Search functions like FIND_IN_SET() are inefficient compared to index operations on a join



The Mandelbrot Set
Wikipedia

Rumour has it that the Mandelbrot Set will be a full-fledged column type in MySQL 9.1, making for some very interesting application uses in database graphics processing...

how much storage space is consumed?

- With this definition, how many bytes will the “a” column consume per row?

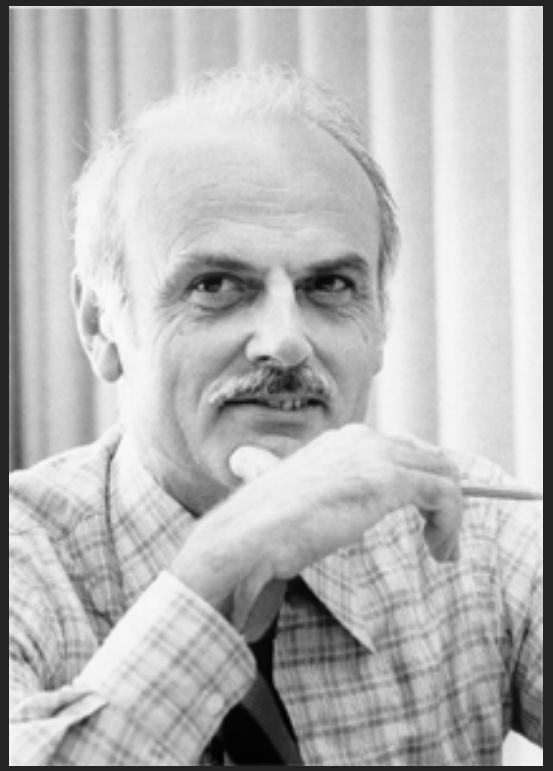
```
CREATE TABLE t1 (
  a INT(1) UNSIGNED NOT NULL
);
```

- The number in parentheses is the *ZEROFILL* argument, not the storage space
- INT takes 4 bytes of space
  - Regardless of the UNSIGNED or NOT NULL

drunken query master says...

“...table-kee-do shall show thee the Path of (De)Normalization”

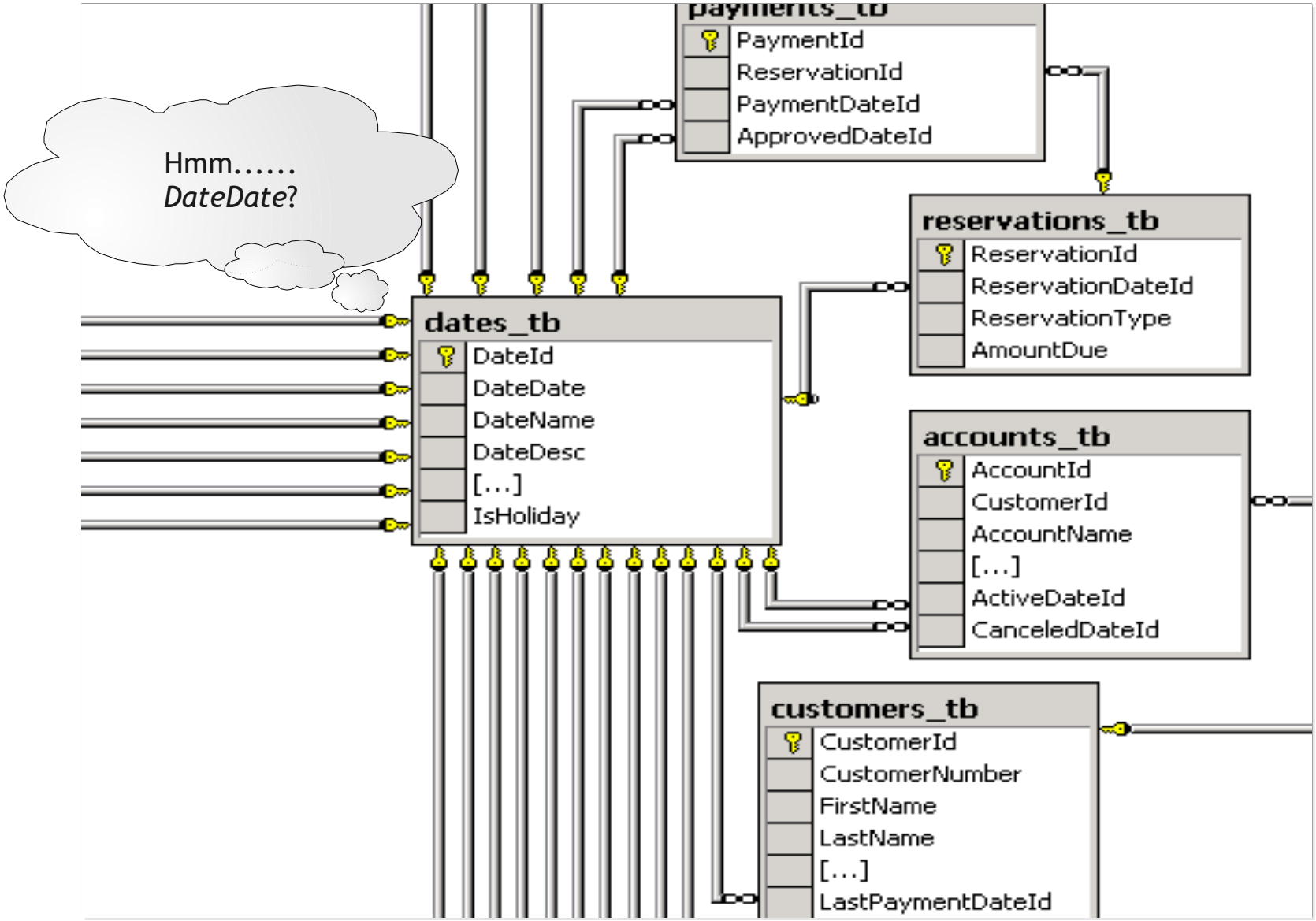
fifth-degree black-belt in join-fu -->



Edgar F. Codd
from Wikipedia:

“...while working for IBM, invented the relational model for database management, the theoretical basis for relational databases.”

taking normalization *way* too far

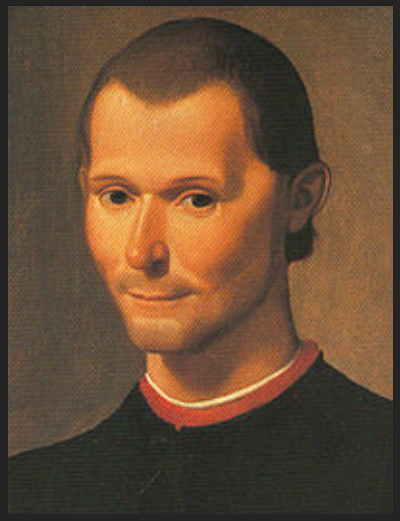


http://thedailywtf.com/forums/thread/75982.aspx

divide et impera

- Vertical partitioning
  - Split tables with many columns into multiple tables
- Horizontal partitioning
  - Split table with many rows into multiple tables
- Partitioning in MySQL 5.1 is transparent horizontal partitioning within the DB...

...and it's got issues at the moment.



Niccolò Machiavelli
The Art of War, (1519-1520):

"A Captain ought, among all the other actions of his, endeavor ***with every art to divide the forces of the enemy***, either by making him suspicious of his men in whom he trusted, or by giving him cause that he has to separate his forces, ***and, because of this, become weaker***."

vertical partitioning

```
CREATE TABLE Users (
  user_id INT NOT NULL AUTO_INCREMENT
, email VARCHAR(80) NOT NULL
, display_name VARCHAR(50) NOT NULL
, password CHAR(41) NOT NULL
, first_name VARCHAR(25) NOT NULL
, last_name VARCHAR(25) NOT NULL
, address VARCHAR(80) NOT NULL
, city VARCHAR(30) NOT NULL
, province CHAR(2) NOT NULL
, postcode CHAR(7) NOT NULL
, interests TEXT NULL
, bio TEXT NULL
, signature TEXT NULL
, skills TEXT NULL
, PRIMARY KEY (user_id)
, UNIQUE INDEX (email)
) ENGINE=InnoDB;
```

```
CREATE TABLE Users (
  user_id INT NOT NULL AUTO_INCREMENT
, email VARCHAR(80) NOT NULL
, display_name VARCHAR(50) NOT NULL
, password CHAR(41) NOT NULL
, PRIMARY KEY (user_id)
, UNIQUE INDEX (email)
) ENGINE=InnoDB;
```

```
CREATE TABLE UserExtra (
  user_id INT NOT NULL
, first_name VARCHAR(25) NOT NULL
, last_name VARCHAR(25) NOT NULL
, address VARCHAR(80) NOT NULL
, city VARCHAR(30) NOT NULL
, province CHAR(2) NOT NULL
, postcode CHAR(7) NOT NULL
, interests TEXT NULL
, bio TEXT NULL
, signature TEXT NULL
, skills TEXT NULL
, PRIMARY KEY (user_id)
, FULLTEXT KEY (interests, skills)
) ENGINE=MyISAM;
```

- Mixing frequently and infrequently accessed attributes in a single table?
- Space in buffer pool at a premium?
  - Splitting the table allows main records to consume the buffer pages without the extra data taking up space in memory
- Need **FULLTEXT** on your text columns?

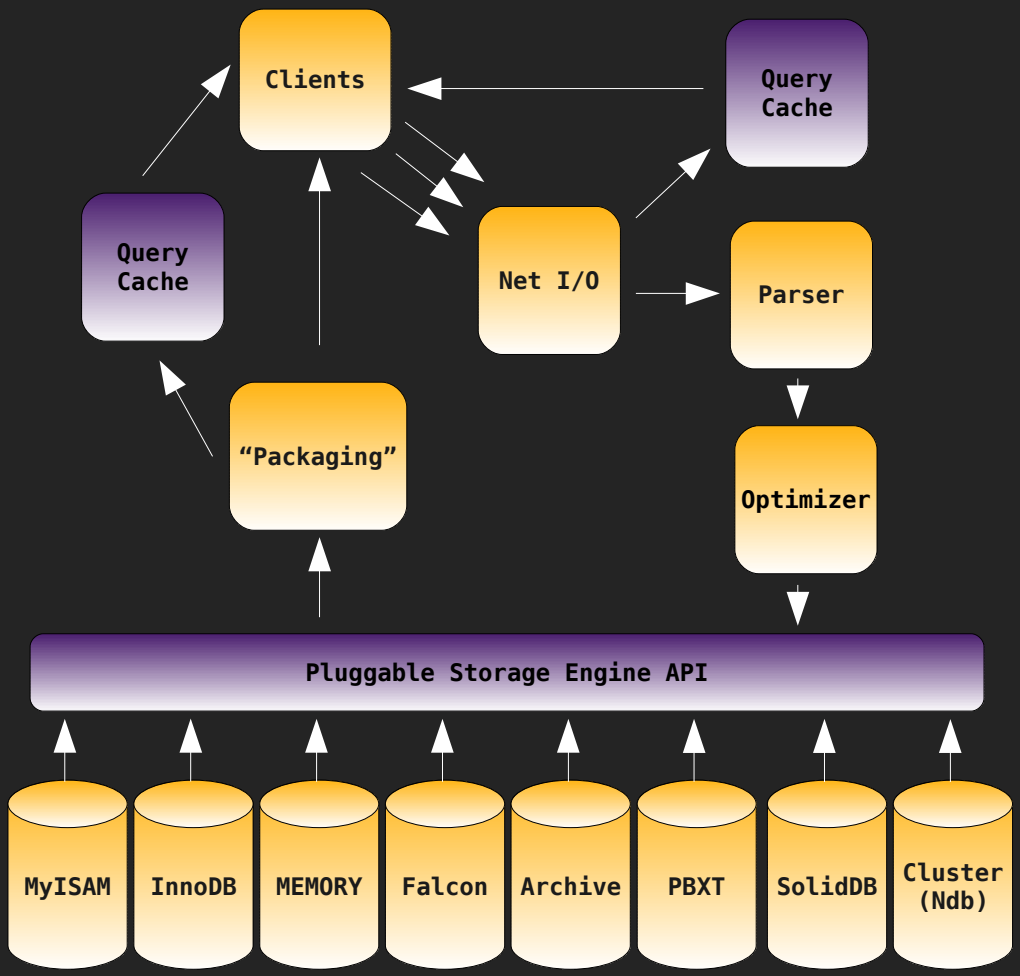
drunken query master says...

http://obsidianwings.blogs.com/obsidian_wings/kitten.jpg

Think kittens get angry?
Wait until you see what
the query cache can do.

"...thou shalt employ table-kee-do in order to avoid the Fury of the Query Cache"

the MySQL query cache



- *You* must understand your application's read/write patterns
- Internal query cache design is a compromise between CPU usage and read performance
- Stores the MYSQL_RESULT of a SELECT along with a hash of the SELECT SQL statement
- *Any modification* to *any* table involved in the SELECT invalidates the stored result
- Write applications to be aware of the query cache
  - Use **SELECT SQL_NO_CACHE**

vertical partitioning ... continued

```
CREATE TABLE Products (
  product_id INT NOT NULL
, name VARCHAR(80) NOT NULL
, unit_cost DECIMAL(7,2) NOT NULL
, description TEXT NULL
, image_path TEXT NULL
, num_views INT UNSIGNED NOT NULL
, num_in_stock INT UNSIGNED NOT NULL
, num_on_order INT UNSIGNED NOT NULL
, PRIMARY KEY (product_id)
, INDEX (name(20))
) ENGINE=InnoDB;

// Getting a simple COUNT of products
// easy on MyISAM, terrible on InnoDB
SELECT COUNT(*)
FROM Products;
```

```
CREATE TABLE Products (
  product_id INT NOT NULL
, name VARCHAR(80) NOT NULL
, unit_cost DECIMAL(7,2) NOT NULL
, description TEXT NULL
, image_path TEXT NULL
, PRIMARY KEY (product_id)
, INDEX (name(20))
) E
```

```
CREATE TABLE ProductCounts (
  product_id INT NOT NULL
, num_views INT UNSIGNED NOT NULL
, num_in_stock INT UNSIGNED NOT NULL
, num_on_order INT UNSIGNED NOT NULL
, PRIMARY KEY (product_id)
) ENGINE=InnoDB;
```

```
CREATE TABLE TableCounts (
  total_products INT UNSIGNED NOT NULL
) ENGINE=MEMORY;
```

- Mixing static attributes with frequently updated fields in a single table?
  - Thrashing occurs with query cache. Each time an update occurs on any record in the table, all queries referencing the table are invalidated in the query cache
- Doing **COUNT(*)** with no **WHERE** on an indexed field on an InnoDB table?
  - Complications with versioning make full table counts very slow

drunken query master says...

"...thou shalt not be afraid of SQL, for it is thy strongest weapon"

coding like a join-fu master

Did you know?
from *Wikipedia:*

Join-fu is a close cousin to **Jun Fan Gung Fu**, the method of martial arts Bruce Lee began teaching in 1959.

OK, not really.

- Be consistent (for crying out loud)
- Use ANSI SQL coding style
- Stop thinking in terms of iterators, for loops, while loops, etc
- Instead, think in terms of sets
- Break complex SQL statements (or business requests) into smaller, manageable chunks

SQL coding consistency

- Tabs and spacing
- Upper and lower case
- Keywords, function names
- Some columns aliased, some not

Nothing pisses off the query master like inconsistent SQL code!

```
SELECT
  a.first_name, a.last_name, COUNT(*) as num_rentals
FROM actor a
 INNER JOIN film f
  ON a.actor_id = fa.actor_id
GROUP BY a.actor_id
ORDER BY num_rentals DESC, a.last_name, a.first_name
LIMIT 10;

vs.

select first_name, a.last_name,
count(*) AS num_rentals
FROM actor a join film f on a.actor_id = fa.actor_id
 group by a.actor_id order by
num_rentals DESC, a.last_name, a.first_name
LIMIT 10;
```

- Consider your teammates
- Like your programming code, SQL is meant to be *read*, not written

join-fu guidelines

See, even bears practice join-fu.

- Always try variations on a theme
- Beware of join hints
  - Can get “out of date”
- Just because it *can* be done in a single SQL statement doesn't mean it should
- Always test and benchmark your solutions
  - Use **`http_load`** (simple and effective for web stuff)

ANSI vs. Theta SQL coding style

```
SELECT
  a.first_name, a.last_name, COUNT(*) as num_rentals
FROM actor a
 INNER JOIN film f
  ON a.actor_id = fa.actor_id
 INNER JOIN film_actor fa
  ON fa.film_id = f.film_id
 INNER JOIN inventory I
  ON f.film_id = i.film_id
 INNER JOIN rental r
  ON r.inventory_id = i.inventory_id
GROUP BY a.actor_id
ORDER BY num_rentals DESC, a.last_name, a.first_name
LIMIT 10;
```

ANSI STYLE

Explicitly declare JOIN conditions using the ON clause

Theta STYLE

Implicitly declare JOIN conditions in the WHERE clause

```
SELECT
  a.first_name, a.last_name, COUNT(*) as num_rentals
FROM actor a, film f, film_actor fa, inventory i, rental r
WHERE a.actor_id = fa.actor_id
AND fa.film_id = f.film_id
AND f.film_id = i.film_id
AND r.inventory_id = i.inventory_id
GROUP BY a.actor_id
ORDER BY num_rentals DESC, a.last_name, a.first_name
LIMIT 10;
```

why ANSI style's join-fu kicks Theta style's ass

- MySQL only supports the INNER and CROSS join for the Theta style
  - But, MySQL supports the INNER, CROSS, LEFT, RIGHT, and NATURAL joins of the ANSI style
  - Mixing and matching both styles can lead to hard-to-read SQL code
- It is supremely easy to miss a join condition with Theta style
  - especially when joining many tables together
  - Leaving off a join condition in the WHERE clause will lead to a cartesian product (not a good thing!)

drunken query master says...

"...Without the strength of explain-jitsu, thou shall perish in the Meadow of Misunderstanding"

chased by the Evil Army of Correlated Subqueries through the Meadow of Misunderstanding -->

http://i240.photobucket.com/albums/ff188/catsncheese/normal_domokuns-kitten.jpg

EXPLAIN Basics

- Provides the execution plan chosen by the MySQL optimizer for a specific SELECT statement
- Simply append the word EXPLAIN to the beginning of your SELECT statement
- Each row in output represents a set of information used in the SELECT
  - A real schema table
  - A *virtual* table (*derived table*) or temporary table
  - A subquery in SELECT or WHERE
  - A unioned set

EXPLAIN columns

- **select_type** - type of “set” the data in this row contains
- **table** - alias (or full table name if no alias) of the table or derived table from which the data in this set comes
- **type** - “access strategy” used to grab the data in this set
- **possible_keys** - keys available to optimizer for query
- **keys** - keys chosen by the optimizer
- **rows** - *estimate* of the number of rows in this set
- **Extra** - information the optimizer chooses to give you
- **ref** - shows the column used in join relations

Example EXPLAIN output

```
mysql> EXPLAIN SELECT f.film_id, f.title, c.name
    -> FROM film f INNER JOIN film_category fc
    -> ON f.film_id=fc.film_id INNER JOIN category c
    -> ON fc.category_id=c.category_id WHERE f.title LIKE 'T%' \G
*************************** 1. row ***************************
  select_type: SIMPLE
        table: c
         type: ALL
possible_keys: PRIMARY
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 16
        Extra:
*************************** 2. row ***************************
  select_type: SIMPLE
        table: fc
         type: ref
possible_keys: PRIMARY,fk_film_category_category
          key: fk_film_category_category
      key_len: 1
          ref: sakila.c.category_id
         rows: 1
        Extra: Using index
*************************** 3. row ***************************
  select_type: SIMPLE
        table: f
         type: eq_ref
possible_keys: PRIMARY,idx_title
          key: PRIMARY
      key_len: 2
          ref: sakila.fc.film_id
         rows: 1
        Extra: Using where
```

An *estimate* of rows in this set

The “access strategy” chosen

The available indexes, and the one(s) chosen

A **covering index** is used

Example #1 - the const access type

```
EXPLAIN SELECT * FROM rental WHERE rental_id = 13\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: rental
         type: const
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: const
         rows: 1
        Extra:
1 row in set (0.00 sec)
```

Constants in the optimizer

- a field indexed with a *unique non-nullable* key
- The access strategy of *system* is related to const and refers to when a table with only a single row is referenced in the SELECT
- Can be propogated across joined columns

Example #2 - constant propogation

```
EXPLAIN SELECT r.*, c.first_name, c.last_name
FROM rental r INNER JOIN customer c
ON r.customer_id = c.customer_id WHERE r.rental_id = 13\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: r
         type: const
possible_keys: PRIMARY,idx_fk_customer_id
          key: PRIMARY
      key_len: 4
          ref: const
         rows: 1
        Extra:
*************************** 2. row ***************************
           id: 1
  select_type: SIMPLE
        table: c
         type: const
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 2
          ref: const /* Here is where the propogation occurs...*/
         rows: 1
        Extra:
2 rows in set (0.00 sec)
```

Example #3 - the range access type

```
SELECT * FROM rental
WHERE rental_date BETWEEN '2005-06-14' AND '2005-06-16'\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: rental
         type: range
possible_keys: rental_date
          key: rental_date
      key_len: 8
          ref: NULL
         rows: 364
        Extra: Using where
1 row in set (0.00 sec)
```

Considerations with range accesses

- Index must be available on the field operated upon by a range operator
- If too many records are estimated to be returned by the condition, the range optimization won't be used
  - index or full table scan will be used instead
- The indexed field must not be operated on by a function call! (Important for all indexing)

The scan vs. seek dilemma

- A **seek** operation, generally speaking, jumps into a random place -- either on disk or in memory -- to fetch the data needed.
  - Repeat for each piece of data needed from disk or memory
- A **scan** operation, on the other hand, will jump to the start of a chunk of data, and sequentially read data -- either from disk or from memory -- until the end of the chunk of data
- *For large amounts of data, scan operations tend to be more efficient than multiple seek operations*

Example #4 - Full table scan

```
EXPLAIN SELECT * FROM rental
WHERE rental_date BETWEEN '2005-06-14' AND '2005-06-21'\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: rental
         type: ALL
possible_keys: rental_date /* larger range forces scan choice */
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 16298
        Extra: Using where
1 row in set (0.00 sec)
```

Why full table scans pop up

- No WHERE condition (duh.)
- No index on any field in WHERE condition
- Poor selectivity on an indexed field
- Too many records meet WHERE condition
- < MySQL 5.0 and using OR in a WHERE clause
- Using SELECT * FROM

Example #5 - Full index scan

```
EXPLAIN SELECT rental_id, rental_date FROM rental\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: rental
         type: index
possible_keys: NULL
          key: rental_date
      key_len: 13
          ref: NULL
         rows: 16325
        Extra: Using index
1 row in set (0.00 sec)
```

CAUTION!

Extra="Using index" is ***NOT*** the same as type="index"

Example #6 - eq_ref strategy

```
EXPLAIN SELECT r.*, c.first_name, c.last_name
FROM rental r INNER JOIN customer c ON r.customer_id = c.customer_id
WHERE r.rental_date BETWEEN '2005-06-14' AND '2005-06-16'\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: r
         type: range
possible_keys: idx_fk_customer_id,rental_date
          key: rental_date
      key_len: 8
          ref: NULL
         rows: 364
        Extra: Using where
*************************** 2. row ***************************
           id: 1
  select_type: SIMPLE
        table: c
         type: eq_ref
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 2
          ref: sakila.r.customer_id
         rows: 1
        Extra:
2 rows in set (0.00 sec)
```

When eq_ref pops up

- Joining two sets on a field where
  - One side has unique, non-nullable index
  - Other side has at least a non-nullable index
- In example #6, an eq_ref access strategy was chosen because a unique, non-nullable index is available on customer.customer_id *and* an index is available on the rental.customer_id field

Nested loops join algorithm

- For each record in outermost set
  - Fetch a record from the next set via a join column condition
  - Repeat until done with outermost set
- Main algorithm in optimizer
  - Main work in 5.1+ is in the area of subquery optimization and additional join algorithms like semi- and merge joins

Example #7 - ref strategy

```
EXPLAIN SELECT * FROM rental
WHERE rental_id IN (10,11,12)
AND rental_date = '2006-02-01' \G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: rental
         type: ref
possible_keys: PRIMARY,rental_date
          key: rental_date
      key_len: 8
          ref: const
         rows: 1
        Extra: Using where
1 row in set (0.02 sec)
```

OR conditions and the index merge

- Index merge best thing to happen in optimizer for 5.0
- Allows optimizer to use more than one index to satisfy a join condition
  - Prior to MySQl 5.0, only one index
  - In case of OR conditions in a WHERE, MySQL <5.0 would use a ***full table scan***

Example #8 - index_merge strategy

```
EXPLAIN SELECT * FROM rental
WHERE rental_id IN (10,11,12)
OR rental_date = '2006-02-01' \G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: rental
         type: index_merge
possible_keys: PRIMARY,rental_date
          key: rental_date,PRIMARY
      key_len: 8,4
          ref: NULL
         rows: 4
        Extra: Using sort_union(rental_date,PRIMARY); Using where
1 row in set (0.02 sec)
```

tired? break time...

http://jimburgessdesign.com/comics/images/news_pics/passed_out_corgi.jpg

ok, now that you've had a quick snack...

drunken query master says...

"...thou shall befriend the Index, for it is a Master of Join-fu and will protect thee from the Ravages of the Table Scan"

best coffee table. ever. -->

http://technabob.com/blog/wp-content/uploads/2008/05/nes_coffee_table.jpg

indexes – your schema's phone book

- Speed up SELECTs, but slow down modifications
- Ensure indexes on columns used in `WHERE`, `ON`, `GROUP BY` clauses
- Always ensure `JOIN` conditions are indexed (and have identical data types)
- Be careful of the column order
- Look for covering indexes
  - Occurs when all fields in one table needed by a `SELECT` are available in an index record

The Yellow Pages
from *Wikipedia*:

"The name and concept of "Yellow Pages" came about in 1883, when a printer in Cheyenne, Wyoming working on a regular telephone directory ran out of white paper and used yellow paper instead"

selectivity - the key to good, er...keys

- Selectivity
  - % of distinct values in a column
  - $S=d/n$
  - Unique/primary always 1.0
- If column has a low selectivity
  - It may still be put in a multi-column index
    - As a prefix?
    - As a suffix?
    - Depends on the application

remove crappy or redundant indexes

```
SELECT
  t.TABLE_SCHEMA AS `db`, t.TABLE_NAME AS `table`, s.INDEX_NAME AS `index name`
 , s.COLUMN_NAME AS `field name`, s.SEQ_IN_INDEX `seq in index`, s2.max_columns AS `# cols`
 , s.CARDINALITY AS `card`, t.TABLE_ROWS AS `est rows`
 , ROUND(((s.CARDINALITY / IFNULL(t.TABLE_ROWS, 0.01)) * 100), 2) AS `sel %`
FROM INFORMATION_SCHEMA.STATISTICS s
 INNER JOIN INFORMATION_SCHEMA.TABLES t
  ON s.TABLE_SCHEMA = t.TABLE_SCHEMA AND s.TABLE_NAME = t.TABLE_NAME
 INNER JOIN (
  SELECT TABLE_SCHEMA, TABLE_NAME, INDEX_NAME, MAX(SEQ_IN_INDEX) AS max_columns
  FROM INFORMATION_SCHEMA.STATISTICS WHERE TABLE_SCHEMA != 'mysql'
  GROUP BY TABLE_SCHEMA, TABLE_NAME, INDEX_NAME
 ) AS s2
 ON s.TABLE_SCHEMA = s2.TABLE_SCHEMA AND s.TABLE_NAME = s2.TABLE_NAME AND s.INDEX_NAME = s2.INDEX_NAME
WHERE t.TABLE_SCHEMA != 'mysql'       /* Filter out the mysql system DB */
AND t.TABLE_ROWS > 10                 /* Only tables with some rows */
AND s.CARDINALITY IS NOT NULL         /* Need at least one non-NULL value in the field */
AND (s.CARDINALITY / IFNULL(t.TABLE_ROWS, 0.01)) < 1.00 /* unique indexes are perfect anyway */
ORDER BY `sel %`, s.TABLE_SCHEMA, s.TABLE_NAME          /* DESC for best non-unique indexes */
LIMIT 10;
```

TABLE_SCHEMA	TABLE_NAME	INDEX_NAME	COLUMN_NAME	SEQ_IN_INDEX	COLS_IN_INDEX	CARD	ROWS	SEL %
worklog	**amendments**	**text**	**text**	**1**	**1**	**1**	**33794**	**0.00**
planetmysql	entries	categories	categories	1	3	1	4171	0.02
planetmysql	entries	categories	title	2	3	1	4171	0.02
planetmysql	entries	categories	content	3	3	1	4171	0.02
sakila	inventory	idx_store_id_film_id	store_id	1	2	1	4673	0.02
sakila	rental	idx_fk_staff_id	staff_id	1	1	3	16291	0.02
worklog	tasks	title	title	1	2	1	3567	0.03
worklog	tasks	title	description	2	2	1	3567	0.03
sakila	payment	idx_fk_staff_id	staff_id	1	1	6	15422	0.04
mysqlforge	mw_recentchanges	rc_ip	rc_ip	1	1	2	996	0.20

http://forge.mysql.com/tools/tool.php?id=85

indexed columns and functions don't mix

```
mysql> EXPLAIN SELECT * FROM film WHERE title LIKE 'Tr%'\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: film
         type: range
possible_keys: idx_title
          key: idx_title
      key_len: 767
          ref: NULL
         rows: 15
        Extra: Using where
```

- A fast *range* access strategy is chosen by the optimizer, and the index on title is used to *winnow* the query results down

```
mysql> EXPLAIN SELECT * FROM film WHERE LEFT(title,2) = 'Tr' \G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: film
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 951
        Extra: Using where
```

- A slow full table scan (the ALL access strategy) is used because a function (LEFT) is operating on the title column

solving multiple issues in a SELECT query

```
SELECT * FROM Orders WHERE TO_DAYS(CURRENT_DATE()) – TO_DAYS(order_created) <= 7;
```

- First, we are operating on an indexed column (order_created) with a function – let's fix that:

```
SELECT * FROM Orders WHERE order_created >= CURRENT_DATE() - INTERVAL 7 DAY;
```

- Although we rewrote the **WHERE** expression to remove the operating function, we still have a non-deterministic function in the statement, which eliminates this query from being placed in the query cache – let's fix that:

```
SELECT * FROM Orders WHERE order_created >= '2008-01-11' - INTERVAL 7 DAY;
```

- We replaced the function with a constant (probably using our application programming language). However, we are specifying **SELECT** * instead of the actual fields we need from the table.
- What if there is a **TEXT** field in Orders called order_memo that we don't need to see? Well, having it included in the result means a larger result set which may not fit into the query cache and may force a disk-based temporary table

```
SELECT order_id, customer_id, order_total, order_created
FROM Orders WHERE order_created >= '2008-01-11' - INTERVAL 7 DAY;
```

drunken query master says...

"...join-fu is thy best defense against the Evil Army of Correlated Subqueries"

general in the evil army -->

set-wise problem solving

"Show the last payment information for each customer"

```
CREATE TABLE `payment` (
  `payment_id` smallint(5) unsigned NOT NULL auto_increment,
  `customer_id` smallint(5) unsigned NOT NULL,
  `staff_id` tinyint(3) unsigned NOT NULL,
  `rental_id` int(11) default NULL,
  `amount` decimal(5,2) NOT NULL,
  `payment_date` datetime NOT NULL,
  `last_update` timestamp NOT NULL ... on update CURRENT_TIMESTAMP,
  PRIMARY KEY  (`payment_id`),
  KEY `idx_fk_staff_id` (`staff_id`),
  KEY `idx_fk_customer_id` (`customer_id`),
  KEY `fk_payment_rental` (`rental_id`),
  CONSTRAINT `fk_payment_rental` FOREIGN KEY (`rental_id`)
    REFERENCES `rental` (`rental_id`),
  CONSTRAINT `fk_payment_customer` FOREIGN KEY (`customer_id`)
    REFERENCES `customer` (`customer_id`) ,
  CONSTRAINT `fk_payment_staff` FOREIGN KEY (`staff_id`)
    REFERENCES `staff` (`staff_id`)
) ENGINE=InnoDB DEFAULT CHARSET=utf8
```

http://forge.mysql.com/wiki/SakilaSampleDB

thinking in terms of *foreach* loops...

OK, ***for each*** customer, find the maximum date the payment was made and get that payment record(s)

```
mysql> EXPLAIN SELECT
    -> p.*
    -> FROM payment p
    -> WHERE p.payment_date =
    -> ( SELECT MAX(payment_date)
    ->   FROM payment
    ->   WHERE customer_id=p.customer_id
    -> )\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: p
         type: ALL
         rows: 16567
        Extra: Using where
*************************** 2. row ***************************
           id: 2
  select_type: DEPENDENT SUBQUERY
        table: payment
         type: ref
possible_keys: idx_fk_customer_id
          key: idx_fk_customer_id
      key_len: 2
          ref: sakila.p.customer_id
         rows: 15
2 rows in set (0.00 sec)
```

- A *correlated* subquery in the **WHERE** clause is used
- It will be re-executed *for each* row in the primary table (payment)
- Produces 623 rows in an average of 1.03s

what about adding an index?

Will adding an index on (customer_id, payment_date) make a difference?

```
mysql> EXPLAIN SELECT
    -> p.*
    -> FROM payment p
    -> WHERE p.payment_date =
    -> ( SELECT MAX(payment_date)
    ->   FROM payment
    ->   WHERE customer_id=p.customer_id
    -> )\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: p
         type: ALL
         rows: 16567
        Extra: Using where
*************************** 2. row ***************************
           id: 2
  select_type: DEPENDENT SUBQUERY
        table: payment
         type: ref
possible_keys: idx_fk_customer_id
          key: idx_fk_customer_id
      key_len: 2
          ref: sakila.p.customer_id
         rows: 15

2 rows in set (0.00 sec)
```

```
mysql> EXPLAIN SELECT
    -> p.*
    -> FROM payment p
    -> WHERE p.payment_date =
    -> ( SELECT MAX(payment_date)
    ->   FROM payment
    ->   WHERE customer_id=p.customer_id
    -> )\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: p
         type: ALL
         rows: 15485
        Extra: Using where
*************************** 2. row ***************************
           id: 2
  select_type: DEPENDENT SUBQUERY
        table: payment
         type: ref
possible_keys: idx_fk_customer_id,ix_customer_paydate
          key: ix_customer_paydate
      key_len: 2
          ref: sakila.p.customer_id
         rows: 14
        Extra: Using index
2 rows in set (0.00 sec)
```

- Produces 623 rows in an average of 1.03s
- Produces 623 rows in an average of 0.45s

thinking in terms of sets...

OK, I have one set of last payments dates and another set containing payment information (so, how do I join these sets?)

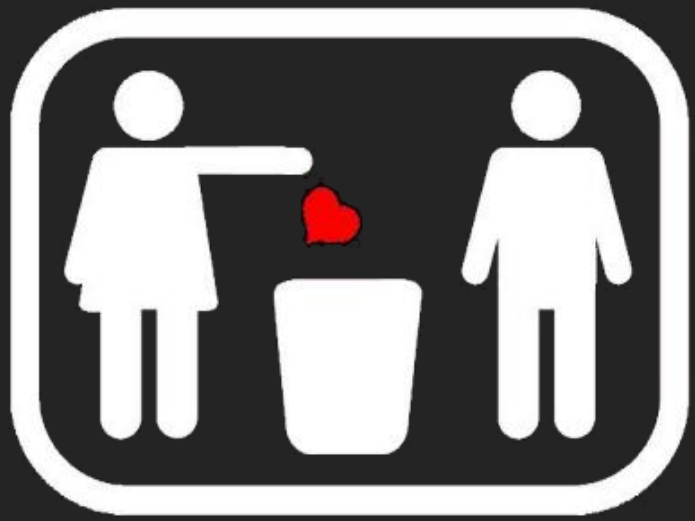
```
mysql> EXPLAIN SELECT
    -> p.*
    -> FROM (
    ->  SELECT customer_id, MAX(payment_date) as last_order
    ->  FROM payment
    ->  GROUP BY customer_id
    -> ) AS last_orders
    -> INNER JOIN payment p
    -> ON p.customer_id = last_orders.customer_id
    -> AND p.payment_date = last_orders.last_order\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: <derived2>
         type: ALL
         rows: 599
*************************** 2. row ***************************
           id: 1
  select_type: PRIMARY
        table: p
         type: ref
possible_keys: idx_fk_customer_id,ix_customer_paydate
          key: ix_customer_paydate
      key_len: 10
          ref: last_orders.customer_id,last_orders.last_order
         rows: 1
*************************** 3. row ***************************
           id: 2
  select_type: DERIVED
        table: payment
         type: range
          key: ix_customer_paydate
      key_len: 2
         rows: 1107
        Extra: Using index for group-by
3 rows in set (0.02 sec)
```

- A *derived table*, or subquery in the **FROM** clause, is used
- The derived table represents a set: last payment dates of customers
- Produces 623 rows in an average of 0.03s

drunken query master says...

"...join-fu shall assist you in your N:M relationships"

...but it won't help your other relationships



http://onlineportaldating.com/wp-content/uploads/2007/10/leaving.bmp

working with “mapping” or N:M tables

```
CREATE TABLE Project (
  project_id INT UNSIGNED NOT NULL AUTO_INCREMENT
, name VARCHAR(50) NOT NULL
, url TEXT NOT NULL
, PRIMARY KEY (project_id)
) ENGINE=MyISAM;
```

```
CREATE TABLE Tags (
  tag_id INT UNSIGNED NOT NULL AUTO_INCREMENT
, tag_text VARCHAR(50) NOT NULL
, PRIMARY KEY (tag_id)
, INDEX (tag_text)
) ENGINE=MyISAM;
```

```
CREATE TABLE Tag2Project (
  tag INT UNSIGNED NOT NULL
, project INT UNSIGNED NOT NULL
, PRIMARY KEY (tag, project)
, INDEX rv_primary (project, tag)
) ENGINE=MyISAM;
```

- The next few slides will walk through examples of querying across the above relationship
  - dealing with OR conditions
  - dealing with AND conditions

dealing with OR conditions

Grab all project names which are tagged with “mysql” ***OR*** “php”

```
mysql> SELECT p.name FROM Project p
    -> INNER JOIN Tag2Project t2p
    -> ON p.project_id = t2p.project
    -> INNER JOIN Tag t
    -> ON t2p.tag = t.tag_id
    -> WHERE t.tag_text IN ('mysql','php');
+-------------------------------------------------------------+
| name                                                        |
+-------------------------------------------------------------+
| phpMyAdmin                                                  |
...
| MySQL Stored Procedures Auto Generator                      |
+-------------------------------------------------------------+
90 rows in set (0.05 sec)
```

```
+----+-------------+-------+--------+----------------------+-------------+---------+-------------+------+-------------+
| id | select_type | table | type   | possible_keys        | key         | key_len | ref         | rows | Extra       |
+----+-------------+-------+--------+----------------------+-------------+---------+-------------+------+-------------+
|  1 | SIMPLE      | t     | range  | PRIMARY,uix_tag_text | uix_tag_text | 52      | NULL        |    2 | Using where |
|  1 | SIMPLE      | t2p   | ref    | PRIMARY,rv_primary   | PRIMARY      | 4       | t.tag_id    |   10 | Using index |
|  1 | SIMPLE      | p     | eq_ref | PRIMARY              | PRIMARY      | 4       | t2p.project |    1 |             |
+----+-------------+-------+--------+----------------------+-------------+---------+-------------+------+-------------+
3 rows in set (0.00 sec)
```

- Note the order in which the optimizer chose to join the tables is exactly the opposite of how we wrote our SELECT

dealing with AND conditions

Grab all project names which are tagged with “storage engine” *AND* “plugin”

- A little more complex, let's grab the project names which match both the “mysql” tag and the “php” tag
- Here is perhaps the most common method – using a HAVING COUNT(*) against a GROUP BY on the relationship table
- EXPLAIN on next page...

```
mysql> SELECT p.name FROM Project p
    -> INNER JOIN (
    ->  SELECT t2p.project
    ->  FROM Tag2Project t2p
    ->  INNER JOIN Tag t
    ->  ON t2p.tag = t.tag_id
    ->  WHERE t.tag_text IN ('plugin','storage engine')
    ->  GROUP BY t2p.project
    ->  HAVING COUNT(*) = 2
    -> ) AS projects_having_all_tags
    -> ON p.project_id = projects_having_all_tags.project;
+-----------------------------------+
| name                              |
+-----------------------------------+
| Automatic data revision           |
| memcache storage engine for MySQL |
+-----------------------------------+
2 rows in set (0.01 sec)
```

the dang filesort

- The EXPLAIN plan shows the execution plan using a derived table containing the project IDs having records in the Tag2Project table with both the “plugin” and “storage engine” tags
- Note that a filesort is needed on the Tag table rows since we use the index on tag_text but need a sorted list of tag_id values to use in the join

```
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: <derived2>
         type: ALL
         rows: 2
*************************** 2. row ***************************
           id: 1
  select_type: PRIMARY
        table: p
         type: eq_ref
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: projects_having_all_tags.project
         rows: 1
*************************** 3. row ***************************
           id: 2
  select_type: DERIVED
        table: t
         type: range
possible_keys: PRIMARY,uix_tag_text
          key: uix_tag_text
      key_len: 52
         rows: 2
        Extra: Using where; Using index; Using temporary; Using filesort
*************************** 4. row ***************************
           id: 2
  select_type: DERIVED
        table: t2p
         type: ref
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: mysqlforge.t.tag_id
         rows: 1
        Extra: Using index
4 rows in set (0.00 sec)
```

removing the filesort using CROSS JOIN

- We can use a CROSS JOIN technique to remove the filesort
  - We winnow down two copies of the Tag table (t1 and t2) by supplying constants in the WHERE condition
- This means no need for a sorted list of tag IDs since we already have the two tag IDs available from the CROSS JOINs...so no more filesort

```
mysql> EXPLAIN SELECT p.name
    -> FROM Project p
    -> CROSS JOIN Tag t1
    -> CROSS JOIN Tag t2
    -> INNER JOIN Tag2Project t2p
    -> ON p.project_id = t2p.project
    -> AND t2p.tag = t1.tag_id
    -> INNER JOIN Tag2Project t2p2
    -> ON t2p.project = t2p2.project
    -> AND t2p2.tag = t2.tag_id
    -> WHERE t1.tag_text = "plugin"
    -> AND t2.tag_text = "storage engine";
+----+-------------+-------+--------+----------------------+--------------+---------+-------------------------------+------+-------------+
| id | select_type | table | type   | possible_keys        | key          | key_len | ref                           | rows | Extra       |
+----+-------------+-------+--------+----------------------+--------------+---------+-------------------------------+------+-------------+
|  1 | SIMPLE      | t1    | const  | PRIMARY,uix_tag_text | uix_tag_text | 52      | const                         |    1 | Using index |
|  1 | SIMPLE      | t2    | const  | PRIMARY,uix_tag_text | uix_tag_text | 52      | const                         |    1 | Using index |
|  1 | SIMPLE      | t2p   | ref    | PRIMARY,rv_primary   | PRIMARY      | 4       | const                         |    9 | Using index |
|  1 | SIMPLE      | t2p2  | eq_ref | PRIMARY,rv_primary   | PRIMARY      | 8       | const,mysqlforge.t2p.project  |    1 | Using index |
|  1 | SIMPLE      | p     | eq_ref | PRIMARY              | PRIMARY      | 4       | mysqlforge.t2p2.project       |    1 | Using where |
+----+-------------+-------+--------+----------------------+--------------+---------+-------------------------------+------+-------------+
5 rows in set (0.00 sec)
```

another technique for dealing with ANDs

- Do two separate queries – one which grabs tag_id values based on the tag text and another which does a self-join after the application has the tag_id values in memory

```
mysql> SELECT t.tag_id FROM Tag t
    -> WHERE tag_text IN ("plugin","storage engine");
+--------+
| tag_id |
+--------+
|    173 |
|    259 |
+--------+
2 rows in set (0.00 sec)
```

Benefit #1

- If we assume the Tag2Project table is updated 10X more than the Tag table is updated, the first query on Tag will be cached more effectively in the query cache

```
mysql> SELECT p.name FROM Project p
    -> INNER JOIN Tag2Project t2p
    -> ON p.project_id = t2p.project
    -> AND t2p.tag = 173
    -> INNER JOIN Tag2Project t2p2
    -> ON t2p.project = t2p2.project
    -> AND t2p2.tag = 259;
+-----------------------------------+
| name                              |
+-----------------------------------+
| Automatic data revision           |
| memcache storage engine for MySQL |
+-----------------------------------+
2 rows in set (0.00 sec)
```

Benefit #2

- The EXPLAIN on the self-join query is ***much*** better than the HAVING COUNT(*) derived table solution

```
mysql> EXPLAIN SELECT p.name FROM Project p
    -> INNER JOIN Tag2Project t2p
    -> ON p.project_id = t2p.project
    -> AND t2p.tag = 173
    -> INNER JOIN Tag2Project t2p2
    -> ON t2p.project = t2p2.project
    -> AND t2p2.tag = 259;
+----+-------------+-------+--------+-------------------+---------+---------+-----------------------------+------+-------------+
| id | select_type | table | type   | possible_keys     | key     | key_len | ref                         | rows | Extra       |
+----+-------------+-------+--------+-------------------+---------+---------+-----------------------------+------+-------------+
|  1 | SIMPLE      | t2p   | ref    | PRIMARY,rv_primary | PRIMARY | 4       | const                       |    9 | Using index |
|  1 | SIMPLE      | t2p2  | eq_ref | PRIMARY,rv_primary | PRIMARY | 8       | const,mysqlforge.t2p.project |    1 | Using index |
|  1 | SIMPLE      | p     | eq_ref | PRIMARY           | PRIMARY | 4       | mysqlforge.t2p2.project     |    1 | Using where |
+----+-------------+-------+--------+-------------------+---------+---------+-----------------------------+------+-------------+
```

understanding LEFT-join-fu

```
CREATE TABLE Project (
  project_id INT UNSIGNED NOT NULL AUTO_INCREMENT
, name VARCHAR(50) NOT NULL
, url TEXT NOT NULL
, PRIMARY KEY (project_id)
) ENGINE=MyISAM;
```

```
CREATE TABLE Tags (
  tag_id INT UNSIGNED NOT NULL AUTO_INCREMENT
, tag_text VARCHAR(50) NOT NULL
, PRIMARY KEY (tag_id)
, INDEX (tag_text)
) ENGINE=MyISAM;
```

```
CREATE TABLE Tag2Project (
  tag INT UNSIGNED NOT NULL
, project INT UNSIGNED NOT NULL
, PRIMARY KEY (tag, project)
, INDEX rv_primary (project, tag)
) ENGINE=MyISAM;
```

- Get the tag phrases which are not related to any project
- Get the tag phrases which are not related to any project ***OR*** the tag phrase is related to project #75
- Get the tag phrases not related to project #75

LEFT join-fu: starting simple...the NOT EXISTS

```
mysql> EXPLAIN SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.project IS NULL
    -> GROUP BY t.tag_text\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: t
         type: index
possible_keys: NULL
          key: uix_tag_text
      key_len: 52
         rows: 1126
        Extra: Using index
*************************** 2. row ***************************
           id: 1
  select_type: SIMPLE
        table: t2p
         type: ref
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: mysqlforge.t.tag_id
         rows: 1
        Extra: Using where; Using index; Not exists
2 rows in set (0.00 sec)

mysql> SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.project IS NULL
    -> GROUP BY t.tag_text;
+--------------------------------------+
| tag_text                             |
+--------------------------------------+
<snip>
+--------------------------------------+
153 rows in set (0.01 sec)
```

- Get the tag phrases which are not related to any project
- LEFT JOIN ... WHERE x IS NULL
- WHERE x IS NOT NULL would yield tag phrases that *are* related to a project
  - But, then, you'd want to use an **INNER JOIN**

LEFT join-fu: a little harder

```
mysql> EXPLAIN SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.project IS NULL
    -> OR t2p.project = 75
    -> GROUP BY t.tag_text\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: t
         type: index
          key: uix_tag_text
      key_len: 52
          ref: NULL
         rows: 1126
        Extra: Using index
*************************** 2. row ***************************
           id: 1
  select_type: SIMPLE
        table: t2p
         type: ref
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: mysqlforge.t.tag_id
         rows: 1
        Extra: Using where; Using index
2 rows in set (0.00 sec)

mysql> SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.project IS NULL
    -> OR t2p.project = 75
    -> GROUP BY t.tag_text;
+-------------------------------------+
| tag_text                            |
+-------------------------------------+
<snip>
+-------------------------------------+
184 rows in set (0.00 sec)
```

- Get the tag phrases which are not related to any project ***OR*** the tag phrase is related to project #75
- No more NOT EXISTS optimization :(
- But, isn't this essentially a UNION?

LEFT join-fu: a UNION returns us to optimization

```
mysql> EXPLAIN SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.project IS NULL
    -> GROUP BY t.tag_text
    -> UNION ALL
    -> SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> INNER JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.project = 75\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: t
         type: index
          key: uix_tag_text
      key_len: 52
         rows: 1126
        Extra: Using index
*************************** 2. row ***************************
           id: 1
  select_type: PRIMARY
        table: t2p
         type: ref
          key: PRIMARY
      key_len: 4
          ref: mysqlforge.t.tag_id
         rows: 1
        Extra: Using where; Using index; Not exists
*************************** 3. row ***************************
           id: 2
  select_type: UNION
        table: t2p
         type: ref
possible_keys: PRIMARY,rv_primary
          key: rv_primary
      key_len: 4
          ref: const
         rows: 31
        Extra: Using index
*************************** 4. row ***************************
           id: 2
  select_type: UNION
        table: t
         type: eq_ref
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: mysqlforge.t2p.tag
         rows: 1
        Extra:
*************************** 5. row ***************************
           id: NULL
  select_type: UNION RESULT
        table: <union1,2>
5 rows in set (0.00 sec)


mysql> SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.project IS NULL
    -> GROUP BY t.tag_text
    -> UNION ALL
    -> SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> INNER JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.project = 75;
+-------------------------------------+
| tag_text                            |
+-------------------------------------+
<snip>
+-------------------------------------+
184 rows in set (0.00 sec)
```

LEFT join-fu: the trickiest part...

```
mysql> SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.tag IS NULL
    -> AND t2p.project= 75
    -> GROUP BY t.tag_text;
Empty set (0.00 sec)

mysql> EXPLAIN SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> WHERE t2p.tag IS NULL
    -> AND t2p.project= 75
    -> GROUP BY t.tag_text\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: NULL
         type: NULL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: NULL
        Extra: Impossible WHERE noticed after reading const tables
1 row in set (0.00 sec)
```

- Get the tag phrases which are not related to project #75
- Shown to the left is the most common mistake made with LEFT JOINs
- The problem is *where* the filter on project_id is done...

LEFT join-fu: the trickiest part...fixed

```
mysql> EXPLAIN SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> AND t2p.project= 75
    -> WHERE t2p.tag IS NULL
    -> GROUP BY t.tag_text\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: t
         type: index
possible_keys: NULL
          key: uix_tag_text
      key_len: 52
         rows: 1126
        Extra: Using index
*************************** 2. row ***************************
           id: 1
  select_type: SIMPLE
        table: t2p
         type: eq_ref
possible_keys: PRIMARY,rv_primary
          key: rv_primary
      key_len: 8
          ref: const,mysqlforge.t.tag_id
         rows: 1
        Extra: Using where; Using index; Not exists
2 rows in set (0.00 sec)

mysql> SELECT
    ->   t.tag_text
    -> FROM Tag t
    -> LEFT JOIN Tag2Project t2p
    -> ON t.tag_id = t2p.tag
    -> AND t2p.project= 75
    -> WHERE t2p.tag IS NULL
    -> GROUP BY t.tag_text;
+-----------------+
| tag_text        |
+-----------------+
<snip>
+-----------------------------------------+
674 rows in set (0.01 sec)
```

- Filters on the LEFT joined set must be placed in the ON clause
- Filter is applied *before* the LEFT JOIN and NOT EXISTs is evaluated, resulting in fewer rows in the evaluation, and better performance

some intermediate join-fu

Practical examples, but meant to show *techniques of SQL problem solving*

- Handling hierarchical queries
  - Adjacency lists
  - Nested sets
- Reporting query techniques
  - Running sums and aggregates
  - Ranking return results

drunken query master says...

"...join-fu and the Nested Sets Model shall shall deliver thee from the Adjacency List Model"

querying hierarchical structures

- Graphs and trees don't fit the relational model well
- Common solutions tend to use either of two techniques
  - Recursion (yuck.)
  - Application layer coding (ok.)
- A good solution blends two common tree-storage models
  - Adjacency list
  - Nested sets

adjacency list model

- Very common but doesn't scale
- Easy to query for:
  - Who is my parent?
  - Who are my children?
- Difficult to query for:
  - How many levels are in my tree?
  - Who are ALL the descendants of my grandfather's brother?

```
CREATE TABLE People (
  person_id INT UNSIGNED NOT NULL
, name VARCHAR(50) NOT NULL
, parent INT UNSIGNED NULL
, PRIMARY KEY (person_id)
, INDEX (parent)
) ENGINE=InnoDB;
```

```
mysql> SELECT * FROM People;
+-----------+-------------------+--------+
| person_id | name              | parent |
+-----------+-------------------+--------+
|         1 | Great grandfather |   NULL |
|         2 | Grandfather       |      1 |
|         3 | Great Uncle       |      1 |
|         4 | Father            |      2 |
|         5 | Uncle             |      2 |
|         6 | Me                |      4 |
|         7 | Brother           |      4 |
+-----------+-------------------+--------+
7 rows in set (0.00 sec)
```

adjacency list model – easy stuff

- Who is my parent?

```
mysql> SELECT p2.*
    -> FROM People p1
    -> INNER JOIN People p2
    -> ON p1.parent = p2.person_id
    -> WHERE p1.person_id = 6;
+-----------+--------+--------+
| person_id | name   | parent |
+-----------+--------+--------+
|         4 | Father |      2 |
+-----------+--------+--------+
```

- Who are my father's children?

```
mysql> SELECT p.*
    -> FROM People p
    -> WHERE p.parent = 4;
+-----------+---------+--------+
| person_id | name    | parent |
+-----------+---------+--------+
|         6 | Me      |      4 |
|         7 | Brother |      4 |
+-----------+---------+--------+
```

- Who are my father's father's grandchildren?

```
mysql> SELECT p3.*
    -> FROM People p1
    -> INNER JOIN People p2
    -> ON p1.person_id = p2.parent
    -> INNER JOIN People p3
    -> ON p2.person_id = p3.parent
    -> WHERE p1.person_id = 2;
+-----------+---------+--------+
| person_id | name    | parent |
+-----------+---------+--------+
|         6 | Me      |      4 |
|         7 | Brother |      4 |
+-----------+---------+--------+
```

adjacency list model – hard stuff

- How many levels in my hierarchy?
  - Told you. Yuck.
- Find all descendants of a specific person
  - Double yuck.
- Basic join-fu how **not** to do SQL?
  - Avoid cursors, iterators, etc

```
DELIMITER //
CREATE PROCEDURE get_max_levels()
BEGIN
SET @lowest_parent :=
  (SELECT MAX(parent) FROM People WHERE parent IS NOT NULL);
SET @levels := 1;

SET @current_parent = @lowest_parent;

WHILE @current_parent IS NOT NULL DO
  SET @current_parent :=
    (SELECT parent FROM People WHERE person_id = @current_parent);
  SET @levels := @levels + 1;
END WHILE;

SELECT @levels;
END //
```

```
DELIMITER //
CREATE PROCEDURE get_node_descendants(IN to_find INT)
BEGIN
DROP TEMPORARY TABLE IF EXISTS child_ids;
CREATE TEMPORARY TABLE child_ids (child_id INT UNSIGNED NOT NULL);
  ...
WHILE @last_count_children > @new_count_children DO
  ...
  INSERT INTO child_ids
  SELECT person_id FROM new_children WHERE blah blah...;
  SET @new_count_children := (SELECT COUNT(*) FROM child_ids);
END WHILE;

SELECT p.* FROM People
INNER JOIN child_ids
ON person_id = child_id;

END //
```

nested sets model

- Uncommon because it is hard to grasp at first, but it really scales
- Easy to query for:
  - How many levels are in my tree?
  - Who are ALL the descendants of my grandfather's brother?
  - Various complex queries that would be impossible for the adjacency list model

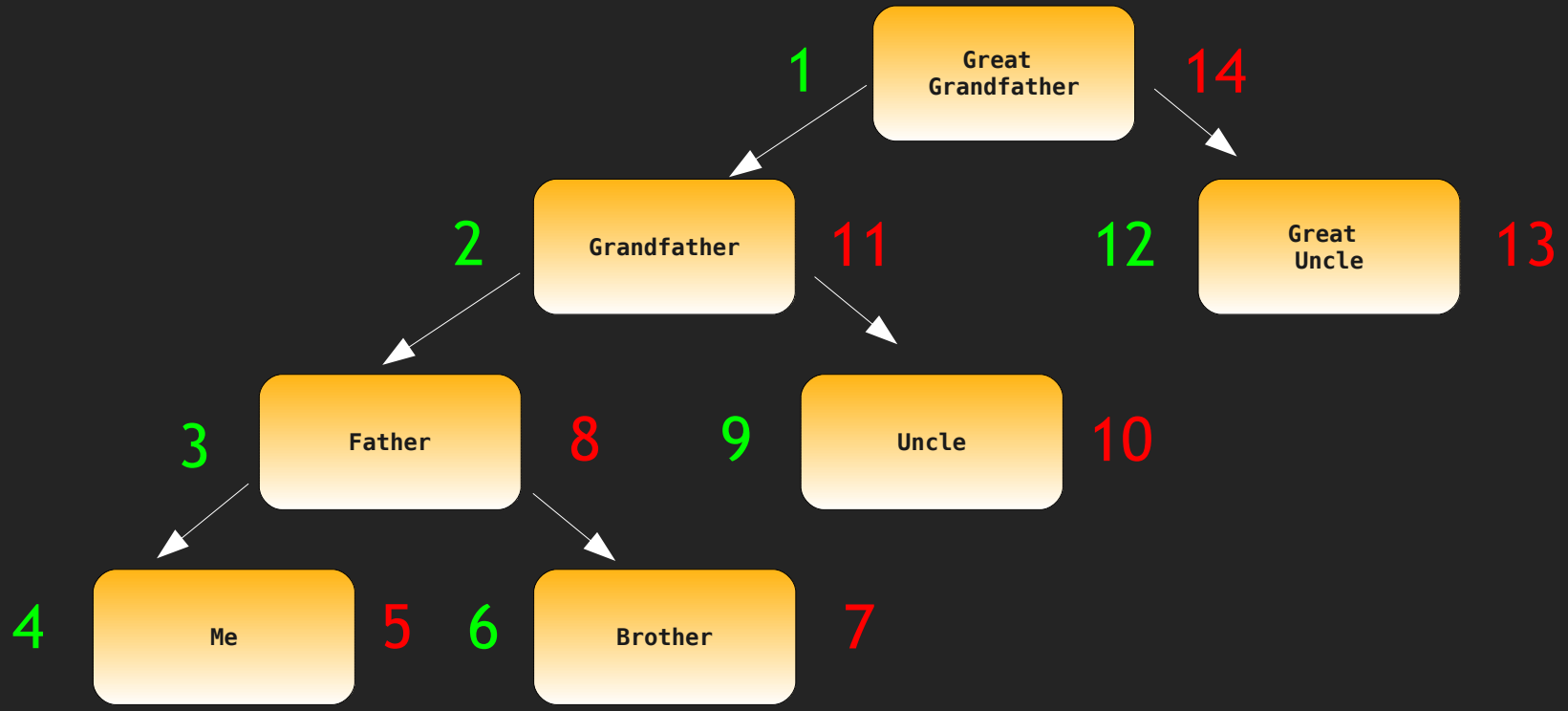
```
CREATE TABLE People (
  person_id INT UNSIGNED NOT NULL
, name VARCHAR(50) NOT NULL
, left_side INT UNSIGNED NOT NULL
, right_side INT UNSIGNED NOT NULL
, PRIMARY KEY (person_id)
, INDEX (parent)
) ENGINE=InnoDB;
```

```
mysql> SELECT * FROM People;
+-----------+-------------------+--------+
| person_id | name              | parent |
+-----------+-------------------+--------+
|         1 | Great grandfather |   NULL |
|         2 | Grandfather       |      1 |
|         3 | Great Uncle       |      1 |
|         4 | Father            |      2 |
|         5 | Uncle             |      2 |
|         6 | Me                |      4 |
|         7 | Brother           |      4 |
+-----------+-------------------+--------+
7 rows in set (0.00 sec)
```

nested sets model

- Each node in tree stores info about its location
  - Each node stores a “left” and a “right”
    - For the root node, “left” is always 1, “right” is always 2*_n_, where _n_ is the number of nodes in the tree
    - For all other nodes, “right” is always equal to the “left” + (2*_n_) + 1, where _n_ is the total number of child nodes of this node
      - So...all “leaf” nodes in a tree have a “right” = “left” + 1
  - Allows SQL to “walk” the tree's nodes
- OK, got all that? :)

nested sets model



- For the root node, “left” is always 1, “right” is always 2*n, where n is the number of nodes in the tree
- For all other nodes, “right” is always equal to the “left” + (2*n) + 1, where n is the total number of child nodes of this node

so, how is this easier?

- Easy to query for:
  - How many levels are in my tree?
  - Who are ALL the descendants of my grandfather's brother?
  - Various complex queries that would be impossible for the adjacency list model
- Efficient processing via set-based logic
  - Versus inefficient iterative/recursive model
- Basic operation is a BETWEEN predicate in a self join condition

nested list model - sets, not procedures...

- What is the depth of each node?
  - Notice the BETWEEN predicate in use
- What about the EXPLAIN output?
  - Oops
  - Add an index...

```
mysql> SELECT p1.person_id, p1.name, COUNT(*) AS depth
    -> FROM People p1
    -> INNER JOIN People p2
    -> ON p1.left_side BETWEEN p2.left_side AND p2.right_side
    -> GROUP BY p1.person_id;
+-----------+-------------------+-------+
| person_id | name              | depth |
+-----------+-------------------+-------+
|         1 | Great grandfather |     1 |
|         2 | Grandfather       |     2 |
|         3 | Great Uncle       |     2 |
|         4 | Father            |     3 |
|         5 | Uncle             |     3 |
|         6 | Me                |     4 |
|         7 | Brother           |     4 |
+-----------+-------------------+-------+
```

```
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: p1
         type: ALL
         rows: 7
        Extra: Using temporary; Using filesort
*************************** 2. row ***************************
           id: 1
  select_type: SIMPLE
        table: p2
         type: ALL
         rows: 7
        Extra: Using where

ALTER TABLE People ADD UNIQUE INDEX ix_nsm (left_side, right_side);
```

drunken query master says...

"...thou shalt build queries based on results you already know are correct"

find the max depth of the whole tree

- How do I find the max depth of the tree?
  - If the last query showed the depth of each node...then we build on the last query

```
mysql> SELECT MAX(level) AS max_level FROM (
    ->  SELECT p1.person_id, COUNT(*) AS level
    ->  FROM People p1
    ->  INNER JOIN People p2
    ->  ON p1.left_side BETWEEN p2.left_side AND p2.right_side
    ->  GROUP BY p1.person_id
    -> ) AS derived;
+-----------+
| max_level |
+-----------+
|         4 |
+-----------+
1 row in set (0.00 sec)
```

- Use this technique when solving set-based problems
  - Build on a known correct set and then intersect, union, aggregate, etc against that set

good, but could be better...

```
mysql> EXPLAIN SELECT MAX(level) AS max_level FROM (
    -> SELECT p1.person_id, COUNT(*) AS level
    -> FROM People p1
    -> INNER JOIN People p2
    -> ON p1.left_side BETWEEN p2.left_side AND p2.right_side
    -> GROUP BY p1.person_id
    -> ) AS derived\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: <derived2>
         type: ALL
         rows: 7
*************************** 2. row ***************************
           id: 2
  select_type: DERIVED
        table: p1
         type: index
possible_keys: ix_nsm
          key: ix_nsm
      key_len: 8
         rows: 7
        Extra: Using index; Using temporary; Using filesort
*************************** 3. row ***************************
           id: 2
  select_type: DERIVED
        table: p2
         type: index
possible_keys: ix_nsm
          key: ix_nsm
      key_len: 8
         rows: 7
        Extra: Using where; Using index
```

- Using covering indexes for everything
  - “Using index”
- Unfortunately, we've got a filesort
  - “Using filesort”

attacking unnecessary filesorts

```
mysql> EXPLAIN SELECT MAX(level) AS max_level FROM (
    -> SELECT p1.person_id, COUNT(*) AS level
    -> FROM People p1
    -> INNER JOIN People p2
    -> ON p1.left_side BETWEEN p2.left_side AND p2.right_side
    -> GROUP BY p1.person_id
    -> ORDER BY NULL
    -> ) AS derived\G
*************************** 1. row ***************************
           id: 1
  select_type: PRIMARY
        table: <derived2>
         type: ALL
         rows: 7
*************************** 2. row ***************************
           id: 2
  select_type: DERIVED
        table: p1
         type: index
possible_keys: ix_nsm
          key: ix_nsm
      key_len: 8
         rows: 7
        Extra: Using index; Using temporary;
*************************** 3. row ***************************
           id: 2
  select_type: DERIVED
        table: p2
         type: index
possible_keys: ix_nsm
          key: ix_nsm
      key_len: 8
         rows: 7
        Extra: Using where; Using index
```

- GROUP BY implicitly orders the results
- If you don't need that sort, remove it it using ORDER BY NULL

finding a node's descendants

- Who are ALL my grandfather's descendants?
  - Remember the nasty recursive solution we had?

```
mysql> SELECT p1.name
    -> FROM People p1
    -> INNER JOIN People p2
    -> ON p1.left_side
    -> BETWEEN p2.left_side AND p2.right_side
    -> WHERE p2.person_id = @to_find
    -> AND p1.person_id <> @to_find;
+---------+
| name    |
+---------+
| Father  |
| Uncle   |
| Me      |
| Brother |
+---------+
4 rows in set (0.00 sec)
```

```
mysql> EXPLAIN SELECT p1.name
    -> FROM People p1
    -> INNER JOIN People p2
    -> ON p1.left_side BETWEEN p2.left_side AND p2.right_side
    -> WHERE p2.person_id = @to_find
    -> AND p1.person_id <> @to_find\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: p2
         type: const
possible_keys: PRIMARY,ix_nsm
          key: PRIMARY
      key_len: 4
          ref: const
         rows: 1
*************************** 2. row ***************************
           id: 1
  select_type: SIMPLE
        table: p1
         type: range
possible_keys: PRIMARY,ix_nsm
          key: PRIMARY
      key_len: 4
         rows: 4
        Extra: Using where
```

finding all nodes *above* a specific node

- Who are ALL my grandfather's *predecessors*?
- Look familiar to the last query?
  - What has changed?

```
mysql> SELECT p2.name
    -> FROM People p1
    -> INNER JOIN People p2
    -> ON p1.left_side
    -> BETWEEN p2.left_side AND p2.right_side
    -> WHERE p1.person_id = @to_find
    -> AND p2.person_id <> @to_find;
+-------------------+
| name              |
+-------------------+
| Great grandfather |
+-------------------+
1 row in set (0.00 sec)
```

- What about now?

```
SELECT p2.name
FROM People p1
INNER JOIN People p2
ON p1.left_side
BETWEEN p2.left_side AND p2.right_side
WHERE p1.person_id = @to_find
AND p2.person_id <> @to_find;
```

summarizing trees and graphs

- Lots more we could do with trees
  - How to insert/delete/move a node in the tree
  - How to connect the tree to aggregate reporting results
  - But not right now...
- Best practice
  - Use *both* adjacency list and nested sets for various query types
    - Little storage overhead
    - Best of both worlds

drunken query master says...

“...thou shalt study the practice of set-based formula replacement”

http://www.cat-pics.net/data/media/5/bottle%20drinking%20baby%20cat%20pics.jpg

formula replacement

- Take a formula you know works, and replace the variables with known sets
- Reduces errors significantly
- Forces you to think in terms of sets, instead of those darn FOR loops
- Examples:
  - Running aggregates
  - Ranking of results

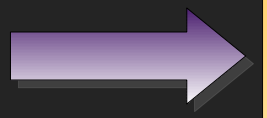
reporting techniques

- Running aggregates
  - Without user variables
  - Running sums and averages
- Ranking of results
  - Using user variables
  - Using JOINs!

running aggregates

- When we want to have a column which “runs” a sum during the result set

```
SELECT
  MONTHNAME(created) AS Month
, COUNT(*) AS Added
FROM feeds
WHERE created >= '2007-01-01'
GROUP BY MONTH(created);
+----------+-------+
| Month    | Added |
+----------+-------+
| January  |     1 |
| February |     1 |
| March    |    11 |
| April    |     8 |
| May      |    18 |
| June     |     3 |
+----------+-------+
6 rows in set (0.00 sec)
```



```
????

+----------+-------+-------+
| Month    | Added | Total |
+----------+-------+-------+
| January  |     1 |     1 |
| February |     1 |     2 |
| March    |    11 |    13 |
| April    |     8 |    21 |
| May      |    18 |    39 |
| June     |     3 |    42 |
+----------+-------+-------+
6 rows in set (0.00 sec)
```

basic formula for running aggregates

```
SELECT
  x1.key
, x1.some_column
, AGGREGATE_FN(x2.some_column) AS running_aggregate
FROM x AS x1
INNER JOIN x AS x2
ON x1.key >= x2.key
GROUP BY x1.key;
```

- Join a set (table) to itself using a >= predicate
  - ON x1.key >= x2.key
- Problem, though, when we are working with *pre-aggregated* data
  - Obviously, you can't do two GROUP BYs...

replacing sets in the running aggregate formula

```
SELECT
  x1.key
, x1.some_column
, AGGREGATE_FN(x2.some_column)
FROM x AS x1
INNER JOIN x AS x2
ON x1.key >= x2.key
GROUP BY x1.key;
```

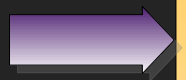
- Stick to the formula, but replace sets x1 and x2 with your pre-aggregated sets as derived tables
  - The right shows replacing x with derived

```
SELECT
  x1.key
, x1.some_column
, AGGREGATE_FN(x2.some_column)
FROM (
SELECT
  MONTH(created) AS MonthNo
, MONTHNAME(created) AS MonthName
, COUNT(*) AS Added
FROM feeds
WHERE created >= '2007-01-01'
GROUP BY MONTH(created)
) AS x1
INNER JOIN (
SELECT
  MONTH(created) AS MonthNo
, MONTHNAME(created) AS MonthName
, COUNT(*) AS Added
FROM feeds
WHERE created >= '2007-01-01'
GROUP BY MONTH(created)
) AS x2
ON x1.key >= x2.key
GROUP BY x1.key;
```

finally, replace SELECT, ON and outer GROUP BY

- Replace the greyed-out area with the correct fields

```
SELECT
  x1.key
, x1.some_column
, AGGREGATE_FN(x2.some_column)
FROM (
SELECT
  MONTH(created) AS MonthNo
, MONTHNAME(created) AS MonthName
, COUNT(*) AS Added
FROM feeds
WHERE created >= '2007-01-01'
GROUP BY MONTH(created)
) AS x1
INNER JOIN (
SELECT
  MONTH(created) AS MonthNo
, MONTHNAME(created) AS MonthName
, COUNT(*) AS Added
FROM feeds
WHERE created >= '2007-01-01'
GROUP BY MONTH(created)
) AS x2
ON x1.key >= x2.key
GROUP BY x1.key;
```



```
SELECT
x1.MonthNo
, x1.MonthName
, x1.Added
, SUM(x2.Added) AS RunningTotal
FROM (
SELECT
  MONTH(created) AS MonthNo
, MONTHNAME(created) AS MonthName
, COUNT(*) AS Added
FROM feeds
WHERE created >= '2007-01-01'
GROUP BY MONTH(created)
) AS x1
INNER JOIN (
SELECT
  MONTH(created) AS MonthNo
, MONTHNAME(created) AS MonthName
, COUNT(*) AS Added
FROM feeds
WHERE created >= '2007-01-01'
GROUP BY MONTH(created)
) AS x2
ON x1.MonthNo >= x2.MonthNo
GROUP BY x1.MonthNo;
```

and the running results...

```
+---------+-----------+-------+--------------+
| MonthNo | MonthName | Added | RunningTotal |
+---------+-----------+-------+--------------+
|       1 | January   |     1 |            1 |
|       2 | February  |     1 |            2 |
|       3 | March     |    11 |           13 |
|       4 | April     |     8 |           21 |
|       5 | May       |    18 |           39 |
|       6 | June      |     3 |           42 |
+---------+-----------+-------+--------------+
6 rows in set (0.00 sec)
```

- Easy enough to add running averages
  - Simply add a column for AVG(x2.Added)
- Lesson to learn: stick to a known formula, then replace formula elements with known sets of data (Keep it simple!)

ranking of results

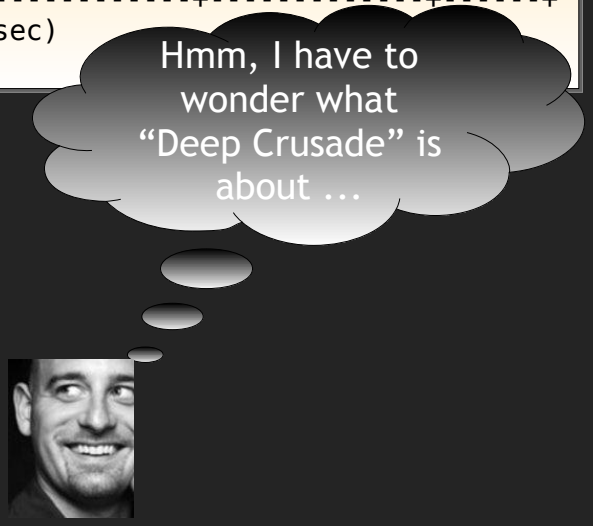
- Using user variables
  - We set a @rank user variable and increment it for each returned result
- Very easy to do in both SQL and in your programming language code
  - But, in SQL, you can use that produced set to join with other results...

ranking with user variables

- Easy enough
  - But what about ties in the ranking?
- Notice that some of the films have identical prices, and so should be tied...
  - Go ahead and try to produce a *clean* way of dealing with ties using user variables...

```
mysql> SET @rank = 0;
Query OK, 0 rows affected (0.00 sec)

mysql> SELECT film_id, LEFT(title, 30) as title
    -> , rental_rate, (@rank:= @rank + 1) as rank
    -> FROM film
    -> ORDER BY rental_rate DESC
    -> LIMIT 10;
+---------+----------------------+-------------+------+
| film_id | title                | rental_rate | rank |
+---------+----------------------+-------------+------+
|     243 | DOORS PRESIDENT      |        7.77 |    1 |
|      93 | BRANNIGAN SUNRISE    |        7.70 |    2 |
|     321 | FLASH WARS           |        7.50 |    3 |
|     938 | VELVET TERMINATOR    |        7.50 |    4 |
|     933 | VAMPIRE WHALE        |        7.49 |    5 |
|     246 | DOUBTFIRE LABYRINTH  |        7.45 |    6 |
|     253 | DRIFTER COMMANDMENTS |        7.44 |    7 |
|     676 | PHILADELPHIA WIFE    |        7.44 |    8 |
|     961 | WASH HEAVENLY        |        7.41 |    9 |
|     219 | DEEP CRUSADE         |        7.40 |   10 |
+---------+----------------------+-------------+------+
10 rows in set (0.00 sec)
```



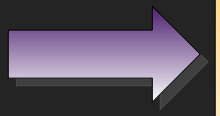
ranking with SQL – the formula

- Again, we use a formula to compute ranked results
- Technique: use a known formulaic solution and replace formula values with known result sets
- The formula takes ties into account with the >= predicate in the join condition

```
SELECT
x1.key_field
, x1.other_field
, COUNT(*) AS rank
FROM x AS x1
INNER JOIN x AS x2
  ON x1.rank_field <= x2.rank_field
GROUP BY
x1.key_field
ORDER BY
x1.rank_field DESC;
```

replace variables in the formula

```
SELECT
x1.key_field
, x1.other_field
, COUNT(*) AS rank
FROM x AS x1
INNER JOIN x AS x2
  ON x1.rank_field <= x2.rank_field
GROUP BY
x1.key_field
ORDER BY
x1.rank_field DESCC
LIMIT 10;
```



```
SELECT
x1.film_id
, x1.title
, x1.rental_rate
, COUNT(*) AS rank
FROM film AS x1
INNER JOIN film AS x2
  ON x1.rental_rate <= x2.rental_rate
GROUP BY
x1.film_id
ORDER BY
x1.rental_rate DESC
LIMIT 10;
```

- Ties are now accounted for
- Easy to grab a “window” of the rankings
  - Just change LIMIT and OFFSET

film_id	title	rental_rate	rank
243	DOORS PRESIDENT	7.77	1
93	BRANNIGAN SUNRISE	7.70	2
938	VELVET TERMINATOR	7.50	4
321	FLASH WARS	7.50	4
933	VAMPIRE WHALE	7.49	5
246	DOUBTFIRE LABYRINTH	7.45	6
676	PHILADELPHIA WIFE	7.44	8
253	DRIFTER COMMANDMENTS	7.44	8
961	WASH HEAVENLY	7.41	9
219	DEEP CRUSADE	7.40	10

refining the performance...

- EXPLAIN produces:

```
+----+-------------+-------+------+---------------+------+---------+------+------+---------------------------------+
| id | select_type | table | type | possible_keys | key  | key_len | ref  | rows | Extra                           |
+----+-------------+-------+------+---------------+------+---------+------+------+---------------------------------+
|  1 | SIMPLE      | x2    | ALL  | PRIMARY       | NULL | NULL    | NULL |  952 | Using temporary; Using filesort |
|  1 | SIMPLE      | x1    | ALL  | PRIMARY       | NULL | NULL    | NULL |  952 | Using where                     |
+----+-------------+-------+------+---------------+------+---------+------+------+---------------------------------+
```

- And the query ran in 1.49s (that's bad, mkay...)
- No indexes being used
  - We add an index on `film (film_id, rental_rate)`

```
+-------+-------+-----------------+-----------------+---------+------+------+-------------------------------------------------+
| table | type  | possible_keys   | key             | key_len | ref  | rows | Extra                                           |
+-------+-------+-----------------+-----------------+---------+------+------+-------------------------------------------------+
| x2    | index | ix_film_id      | ix_film_id_rate | 4       | NULL |  967 | Using index; Using temporary; Using filesort    |
| x1    | ALL   | ix_rate_film_id | NULL            | NULL    | NULL |  967 | Using where |
+-------+-------+-----------------+-----------------+---------+------+------+-------------------------------------------------+
```

- Results: slightly better performance of 0.80s
  - But, different GROUP and ORDER BY makes it slow

resources and thank you!

- PlanetMySQL
  - 300+ writers on MySQL topics
  - http://planetmysql.com
- MySQL Forge
  - Code snippets, project listings, wiki, worklog
  - http://forge.mysql.org

Baron Schwartz
http://xaprb.com

MySQL performance guru and co-author of High Performance MySQL, 2nd Edition (O'Reilly, 2008)

“xarpb” is Baron spelled on a Dvorak keyboard...