Join-fu: The Art of SQL

Part I - Basic Join-Fu

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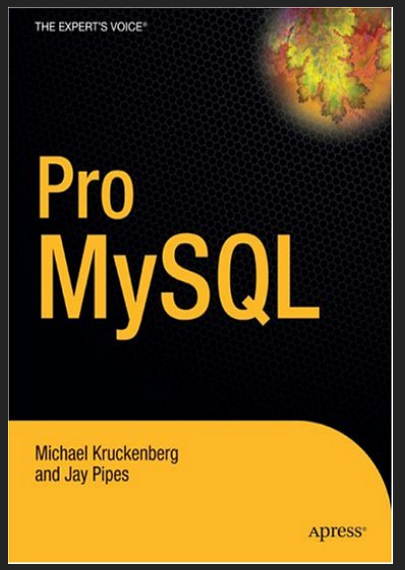
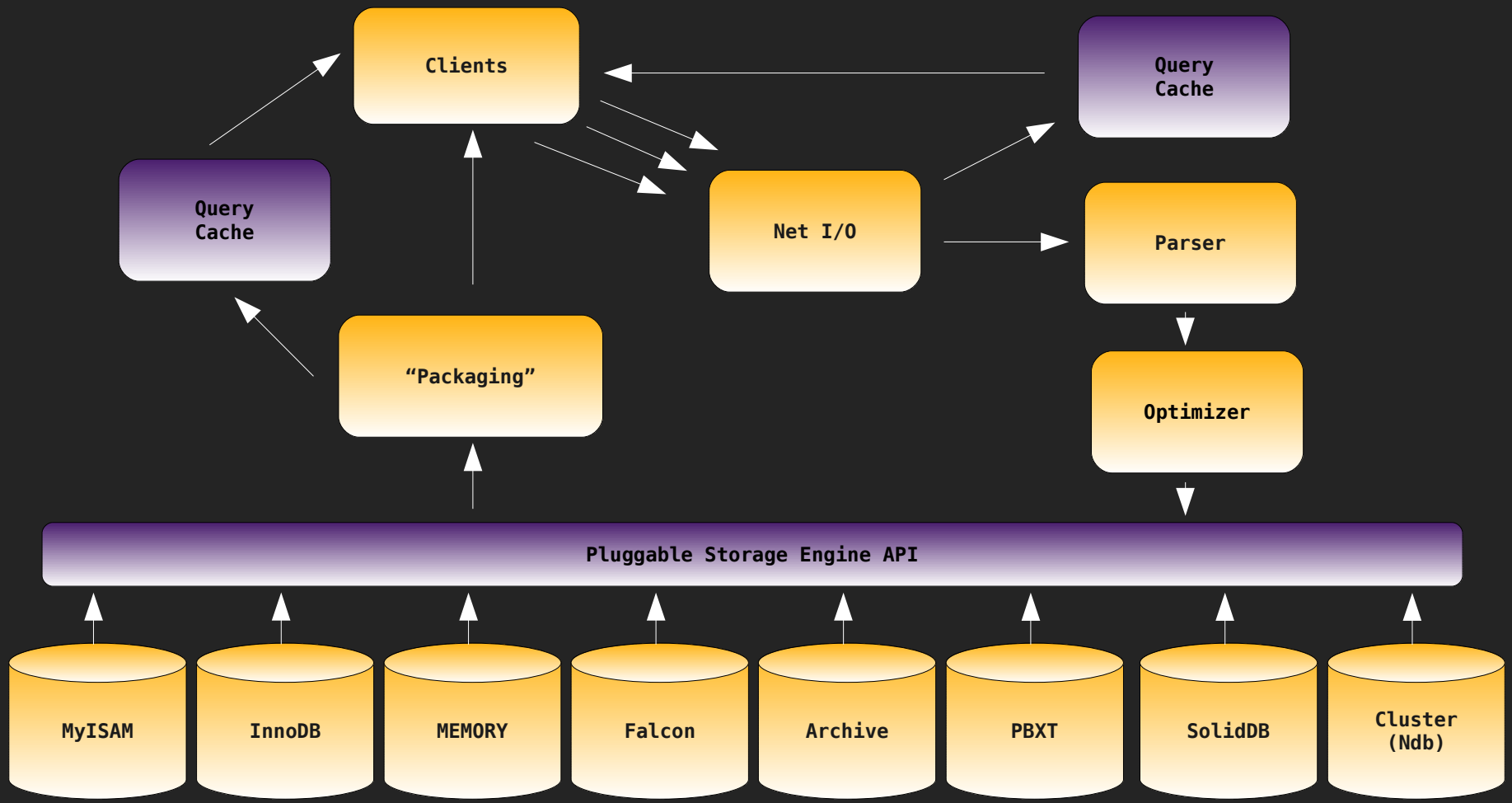
before we start

- 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 how to code your app to get the best performance out of your (My)SQL



system architecture of MySQL



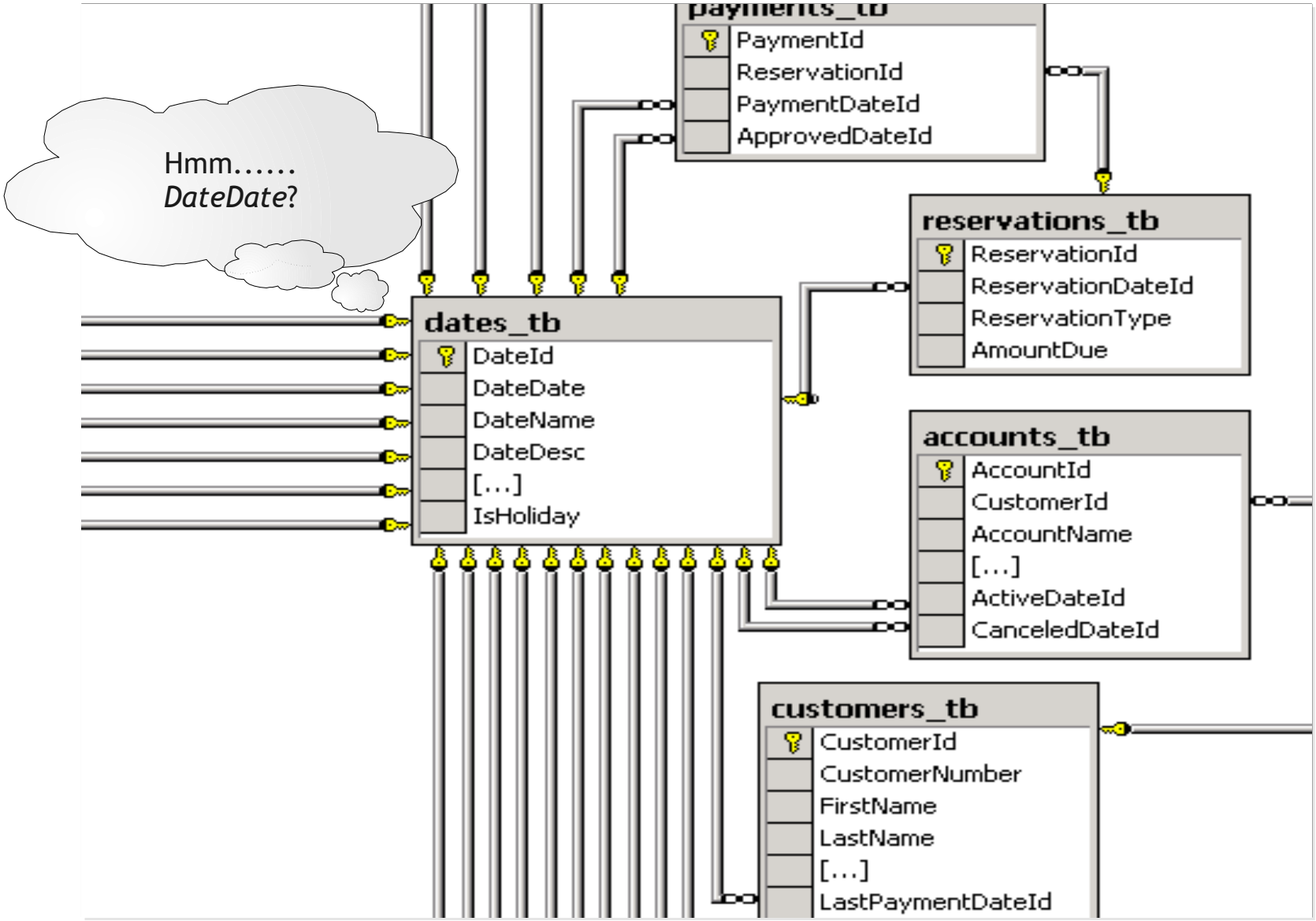
the schema

- Basic foundation of performance
- Normalize first, de-normalize later
- Smaller, smaller, smaller
- Divide and conquer
- Understand benefits and disadvantages of different storage engines

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."

taking normalization *way* too far



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

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');
```

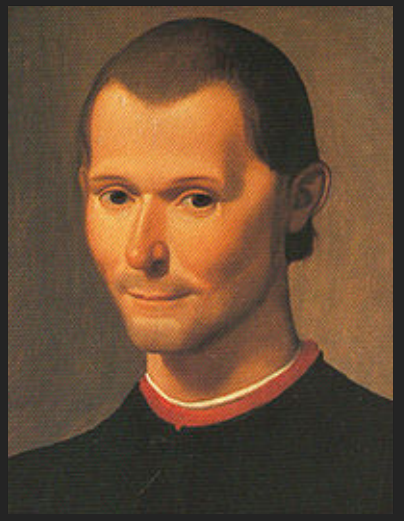
```
WHERE ip_address BETWEEN 3232235521 AND 3232235775
```

```
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 |
+------------+------------+-------------+--------------------+
```

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.

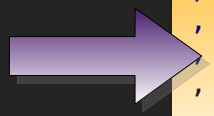


Niccolò Machiavelli
The Art of War, (1519-1520):

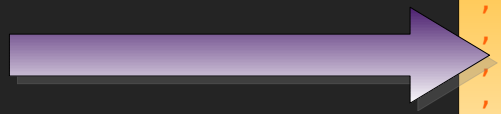
"A Captain ought, among all the other actions of his, endeavor ***with every art to divide the forces of the enemy***, either by making him suspicious of his men in whom he trusted, or by giving him cause that he has to separate his forces, ***and, because of this, become weaker***."

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;
```



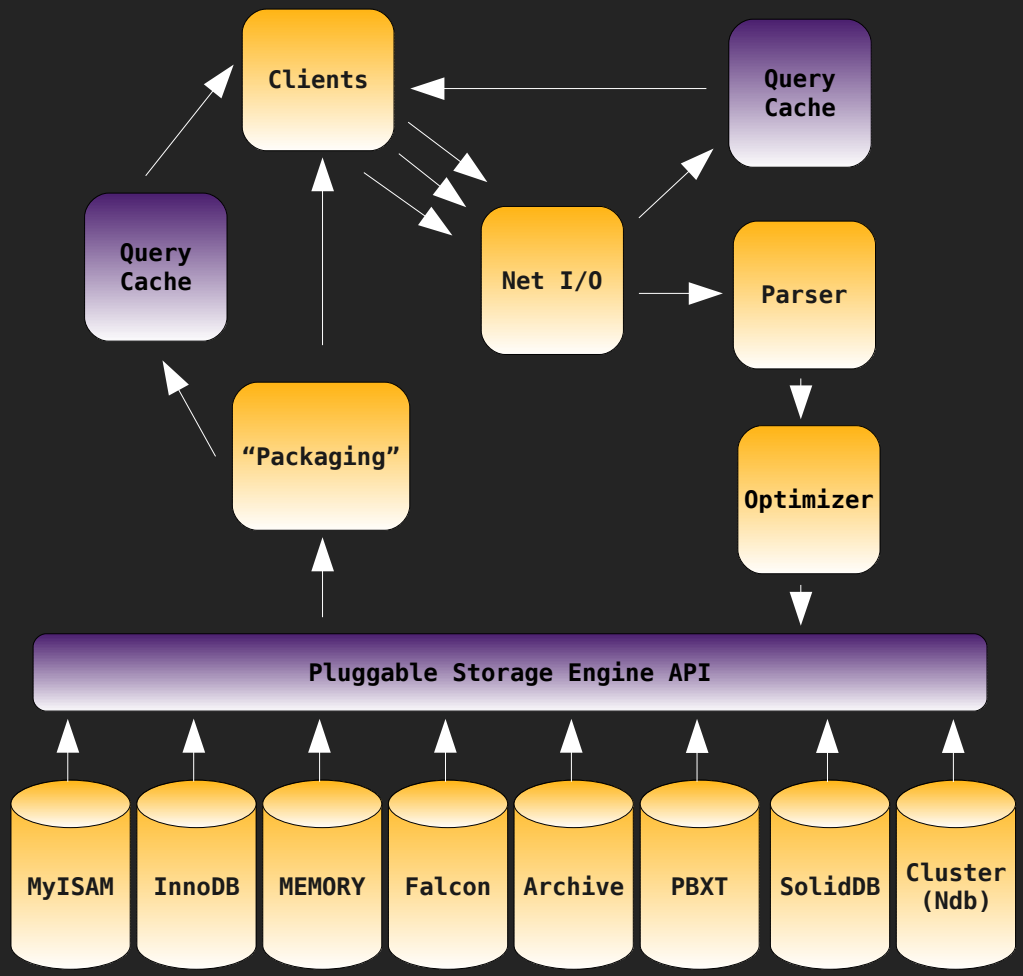
```
CREATE TABLE Users (
  user_id INT NOT NULL AUTO_INCREMENT
, email VARCHAR(80) NOT NULL
, display_name VARCHAR(50) NOT NULL
, password CHAR(41) NOT NULL
, PRIMARY KEY (user_id)
, UNIQUE INDEX (email)
) ENGINE=InnoDB;
```



```
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?

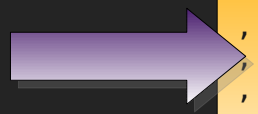
the MySQL query cache



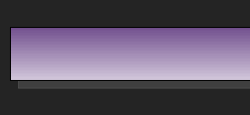
- *You* must understand your application's read/write patterns
- Internal query cache design is a compromise between CPU usage and read performance
- Stores the MYSQL_RESULT of a SELECT along with a hash of the SELECT SQL statement
- *Any modification* to *any* table involved in the SELECT invalidates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

vertical partitioning ... continued

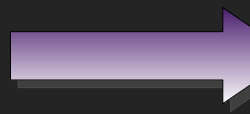
```
CREATE TABLE Products (
  product_id INT NOT NULL
, name VARCHAR(80) NOT NULL
, unit_cost DECIMAL(7,2) NOT NULL
, description TEXT NULL
, image_path TEXT NULL
, num_views INT UNSIGNED NOT NULL
, num_in_stock INT UNSIGNED NOT NULL
, num_on_order INT UNSIGNED NOT NULL
, PRIMARY KEY (product_id)
, INDEX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

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.

- Building upon the foundation of the schema
- Use ANSI SQL coding style
- Do not think 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

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 by accident in the WHERE clause will lead to a cartesian product (not a good thing!)

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;
```

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)
```

- Produces 623 rows in an average of 1.03s

```
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 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

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)
```

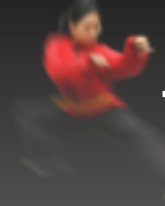
- Note the order in which the optimizer chose to join the tables is exactly the opposite of how we wrote our SELECT

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 |
+----+-------------+-------+--------+-------------------+---------+---------+-----------------------------+------+-------------+
3 rows in set (0.00 sec)
```

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