Tagging and Folksonomy
Schema Design for Scalability and Performance

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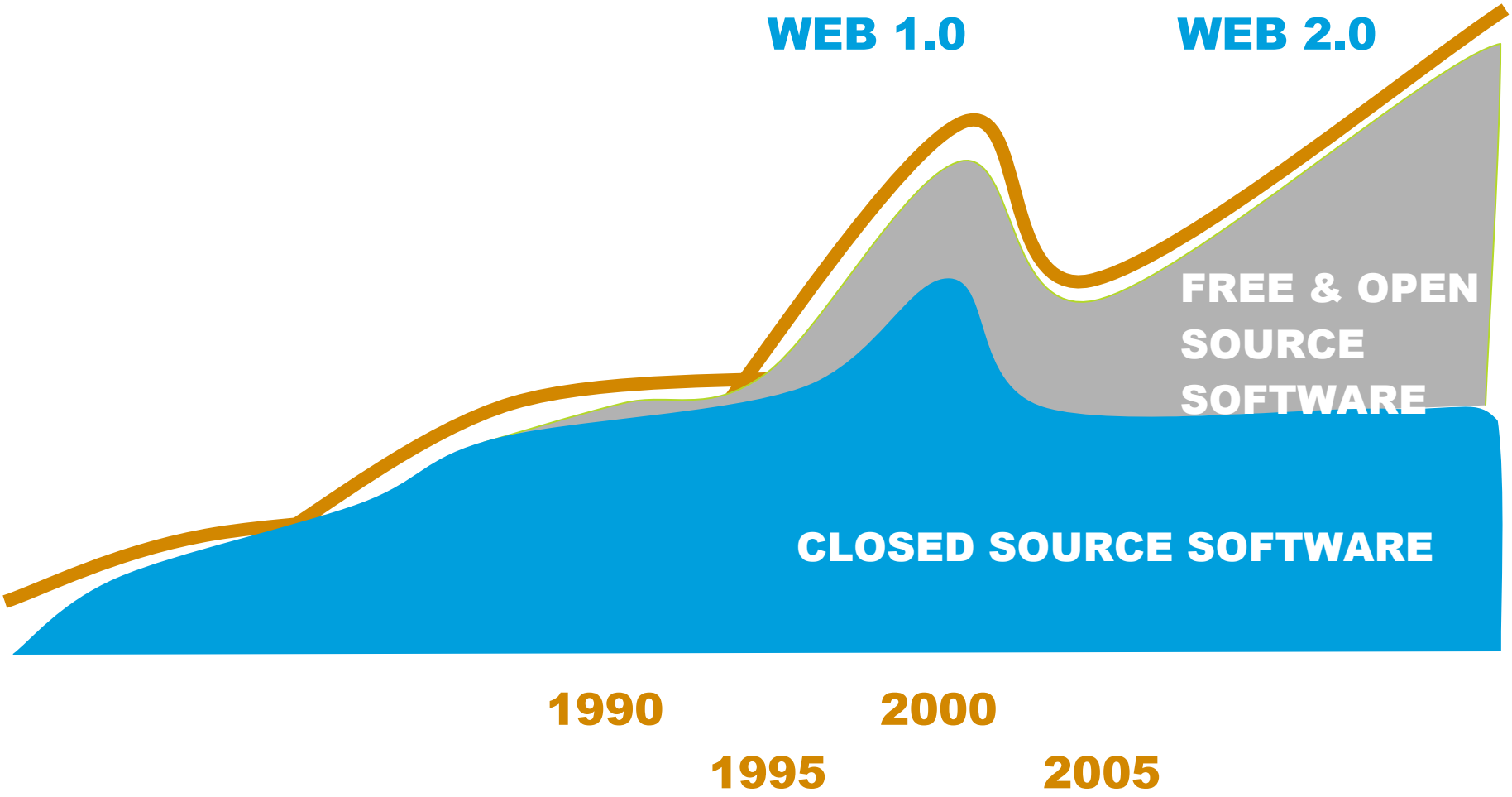
Software Industry Evolution



How MySQL Enables Web 2.0

lower tco

ubiquitous with developers

large objects

tag databases

lamp

full-text search

XML

language support

ease of use

world-wide community

performance

scale out

interoperable

connectors

bundled

open source

replication

reliability

session management

partitioning (5.1)

pluggable storage engines

query cache

Agenda

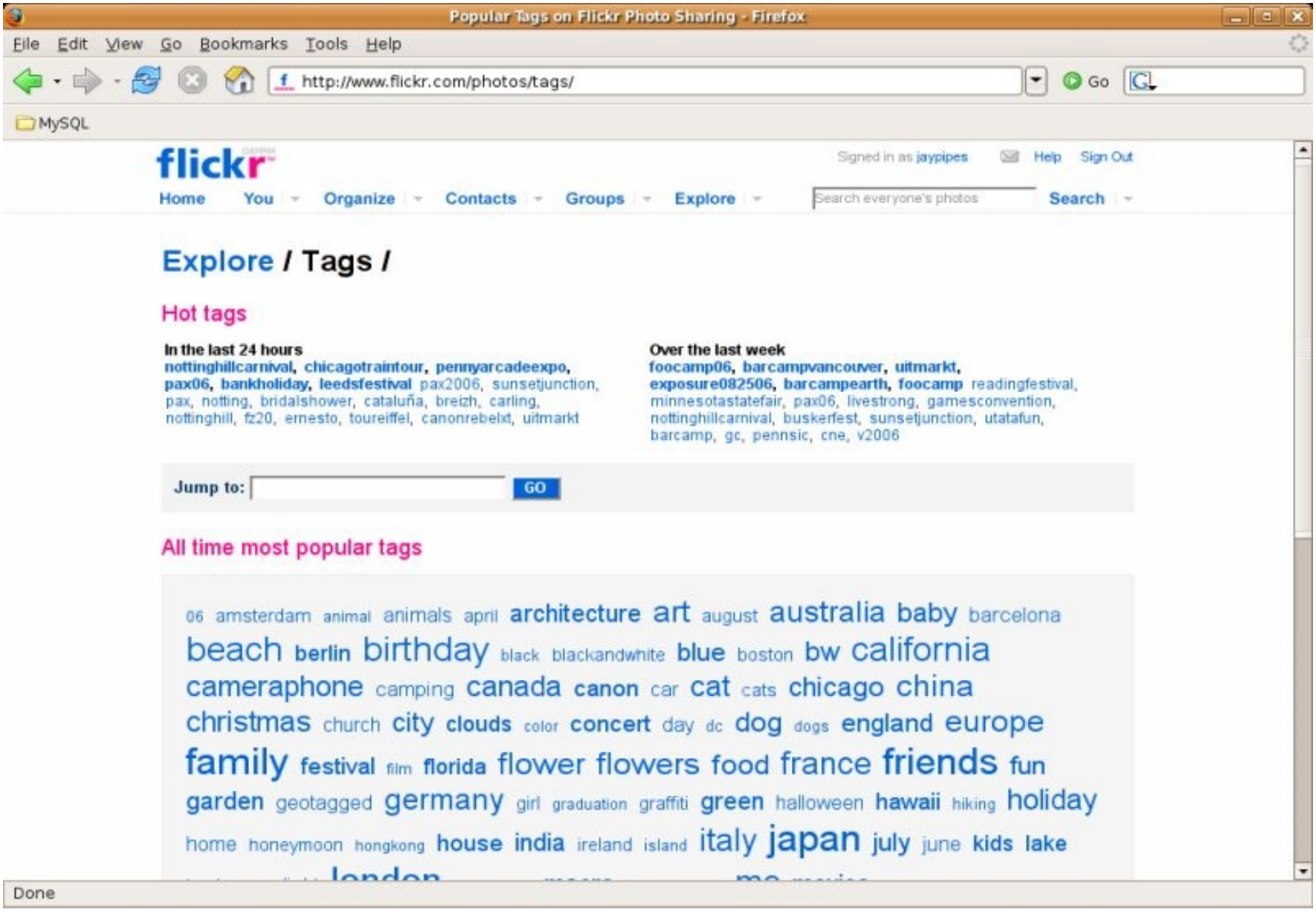
- Web 2.0: more than just rounded corners
- Tagging Concepts in SQL
- Folksonomy Concepts in SQL
- Scaling out sensibly

More than just rounded corners

- What is Web 2.0?
  - Participation
  - Interaction
  - Connection
- A changing of design patterns
  - AJAX and XML-RPC are changing the way data is queried
  - Rich web-based clients
  - Everyone's got an API
  - API leads to increased requests per second. Must deal with growth!

AJAX and XML-RPC change the game

- Traditional (Web 1.0) page request builds entire page
  - Lots of HTML, style **and** data in each page request
  - Lots of data processed or queried in each request
  - Complex page requests and application logic
- AJAX/XML-RPC request returns small data set, or page fragment
  - Smaller amount of data being passed on each request
  - But, often many more requests compared to Web 1.0!
  - Exposed APIs mean data services distribute your data to syndicated sites
  - RSS feeds supply data, not full web page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Help
Sign Out
Home
You
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Contacts
Groups
Explore
Search everyone's photos
Search
Explore / Tags /
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Over the last week
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Done

Participation, Interaction and Connection

- Multiple users editing the same content
  - Content explosion
  - Lots of textual data to manage. How do we organize it?
- User-driven data
  - “Tracked” pages/items
  - Allows interlinking of content via the user to user relationship (folksonomy)
- Tags becoming the new categorization/filing of this content
  - Anyone can tag the data
  - Tags connect one thing to another, similar to the way that the folksonomy relationships link users together
- So, the common concept here is “linking”...

What The User Dimension Gives You

- Folksonomy adds the “user dimension”
- Tags often provide the “glue” between user and item dimensions
- Answers questions such as:
  - Who shares my interests
  - What are the other interests of users who share my interests
  - Someone tagged my bookmark (or any other item) with something. What other items did that person tag with the same thing?
  - What is the user's immediate “ecosystem”? What are the fringes of that ecosystem?
    - Ecosystem radius expansion (like zipcode radius expansion...)
- Marks a new aspect of web applications into the world of data warehousing and analysis

Linking Is the “R” in RDBMS

- The schema becomes the absolute driving force behind Web 2.0 applications
- Understanding of many-to-many relationships is critical
- Take advantage of MySQL's architecture so that our schema is as efficient as possible
- Ensure your data store is normalized, standardized, and consistent
- So, let's digg in! (pun intended)

Comparison of Tag Schema Designs

- "MySQLicious"
  - Entirely denormalized
  - One main fact table with one field storing delimited list of tags
  - Unless using FULLTEXT indexing, does not scale well at all
  - Very inflexible
- "Scuttle" solution
  - Two tables. Lookup one-way from item table to tag table
  - Somewhat inflexible
  - Doesn't represent a many-to-many relationship correctly
- "Toxi" solution
  - Almost gets it right, except uses surrogate keys in mapping tables ...
  - Flexible, normalized approach
  - Closest to our recommended architecture ...

Tagging Concepts in SQL

The Tags Table

- The “Tags” table is the foundational table upon which all tag links are built
- Lean and mean
- Make primary key an INT!

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

Example Tag2Post Mapping Table

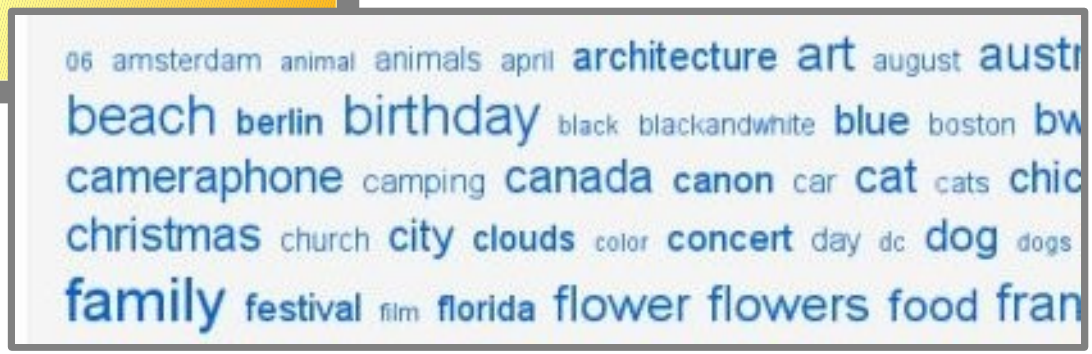
- The mapping table creates the link between a tag and anything else
- In other terms, it maps a many-to-many relationship
- Important to index from both “sides”

```
CREATE TABLE Tag2Post (
tag_id INT UNSIGNED NOT NULL
, post_id INT UNSIGNED NOT NULL
, PRIMARY KEY pk_Tag2Post (tag_id, post_id)
, INDEX (post_id)
) ENGINE=InnoDB;
```

The Tag Cloud

- Tag density typically represented by larger fonts or different colors

```
SELECT tag_text
, COUNT(*) as num_tags
FROM Tag2Post t2p
INNER JOIN Tags t
ON t2p.tag_id = t.tag_id
GROUP BY tag_text;
```



Efficiency Issues with the Tag Cloud

- With InnoDB tables, you don't want to be issuing COUNT() queries, even on an indexed field

```
CREATE TABLE TagStat
tag_id INT UNSIGNED NOT NULL
, num_posts INT UNSIGNED NOT NULL
// ... num_xxx INT UNSIGNED NOT NULL
, PRIMARY KEY (tag_id)
) ENGINE=InnoDB;
```

```
SELECT tag_text, ts.num_posts
FROM Tag2Post t2p
INNER JOIN Tags t
ON t2p.tag_id = t.tag_id
INNER JOIN TagStat ts
ON t.tag_id = ts.tag_id
GROUP BY tag_text;
```

The Typical Related Items Query

- Get all posts tagged with any tag attached to Post #6
- In other words “Get me all posts related to post #6”

```
SELECT p2.post_id
FROM Tag2Post p1
INNER JOIN Tag2Post p2
ON p1.tag_id = p2.tag_id
WHERE p1.post_id = 6
GROUP BY p2.post_id;
```

Problems With Related Items Query

- Joining small to medium sized “tag sets” works great
- But... when you've got a large tag set on either “side” of the join, problems can occur with scalablity
- One way to solve is via derived tables

```
SELECT p2.post_id
FROM (
SELECT tag_id FROM Tag2Post
WHERE post_id = 6 LIMIT 10
) AS p1
INNER JOIN Tag2Post p2
ON p1.tag_id = p2.tag_id
GROUP BY p2.post_id LIMIT 10;
```

The Typical Related Tags Query

- Get all tags related to a particular tag via an item
- The “reverse” of the related items query; we want a set of related tags, not related posts

```
SELECT t2p2.tag_id, t2.tag_text
FROM (SELECT post_id FROM Tags t1
INNER JOIN Tag2Post
ON t1.tag_id = Tag2Post.tag_id
WHERE t1.tag_text = 'beach' LIMIT 10
) AS t2p1
INNER JOIN Tag2Post t2p2
ON t2p1.post_id = t2p2.post_id
INNER JOIN Tags t2
ON t2p2.tag_id = t2.tag_id
GROUP BY t2p2.tag_id LIMIT 10;
```

Dealing With More Than One Tag

- What if we want only items related to each of a set of tags?
- Here is the typical way of dealing with this problem

```
SELECT t2p.post_id
FROM Tags t1
INNER JOIN Tag2Post t2p
ON t1.tag_id = t2p.tag_id
WHERE t1.tag_text IN ('beach','cloud')
GROUP BY t2p.post_id
HAVING COUNT(DISTINCT t2p.tag_id) = 2;
```

Dealing With More Than One Tag (cont'd)

- The GROUP BY and the HAVING COUNT(DISTINCT ...) can be eliminated through joins
- Thus, you eliminate the Using temporary, using filesort in the query execution

```
SELECT t2p2.post_id
FROM Tags t1 CROSS JOIN Tags t2
INNER JOIN Tag2Post t2p1
ON t1.tag_id = t2p1.tag_id
INNER JOIN Tag2Post t2p2
ON t2p1.post_id = t2p2.post_id
AND t2p2.tag_id = t2.tag_id
WHERE t1.tag_text = 'beach'
AND t2.tag_text = 'cloud';
```

Excluding Tags From A Resultset

- Here, we want have a search query like “Give me all posts tagged with “beach” and “cloud” but not tagged with “flower”. Typical solution you will see:

```
SELECT t2p1.post_id
FROM Tag2Post t2p1
INNER JOIN Tags t1 ON t2p1.tag_id = t1.tag_id
WHERE t1.tag_text IN ('beach','cloud')
AND t2p1.post_id NOT IN
(SELECT post_id FROM Tag2Post t2p2
INNER JOIN Tags t2
ON t2p2.tag_id = t2.tag_id
WHERE t2.tag_text = 'flower')
GROUP BY t2p1.post_id
HAVING COUNT(DISTINCT t2p1.tag_id) = 2;
```

Excluding Tags From A Resultset (cont'd)

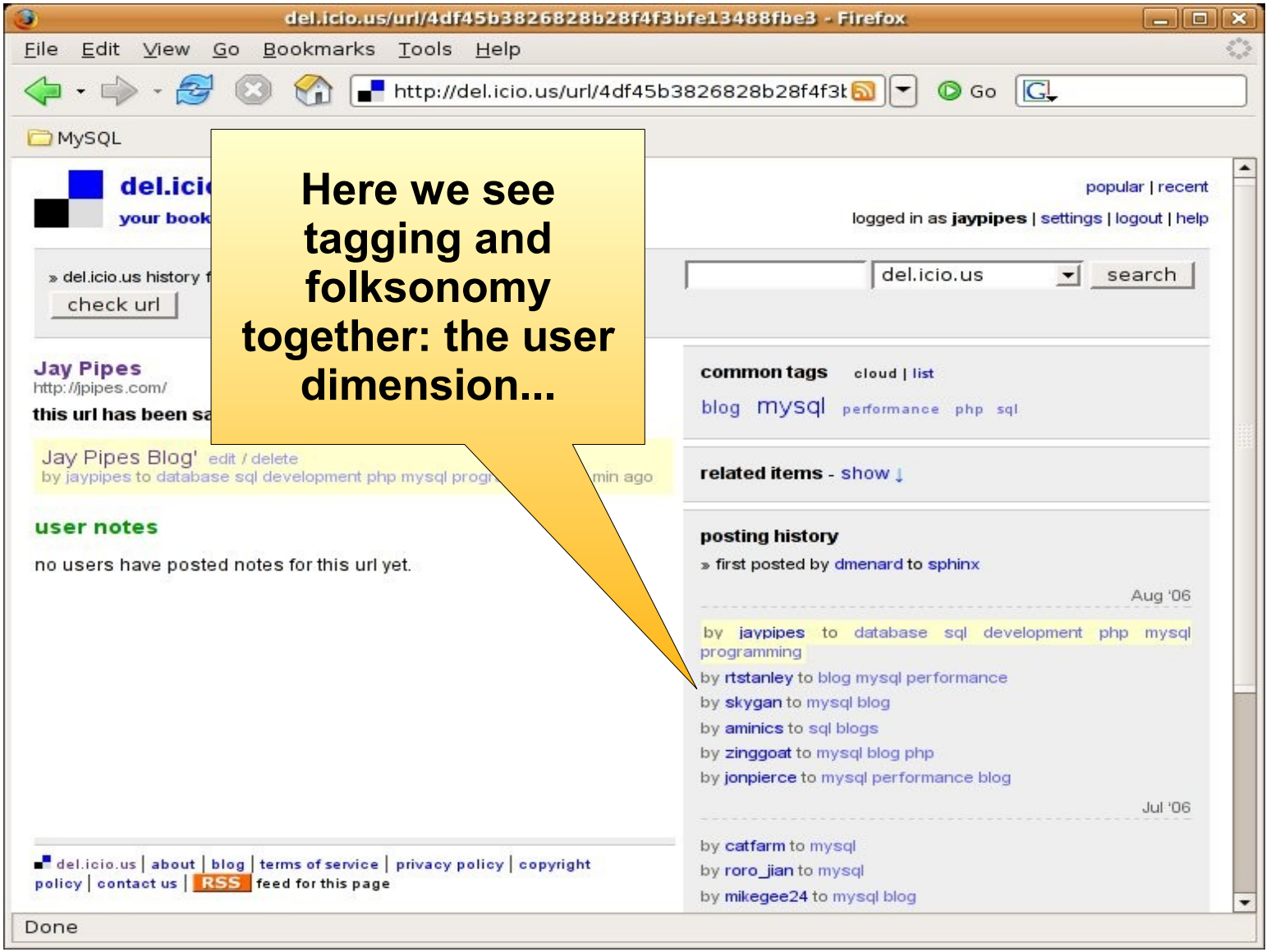
- More efficient to use an outer join to filter out the "minus" operator, plus get rid of the GROUP BY...

```
SELECT t2p2.post_id
FROM Tags t1 CROSS JOIN Tags t2 CROSS JOIN Tags t3
INNER JOIN Tag2Post t2p1
ON t1.tag_id = t2p1.tag_id
INNER JOIN Tag2Post t2p2
ON t2p1.post_id = t2p2.post_id
AND t2p2.tag_id = t2.tag_id
LEFT JOIN Tag2Post t2p3
ON t2p2.post_id = t2p3.post_id
AND t2p3.tag_id = t3.tag_id
WHERE t1.tag_text = 'beach'
AND t2.tag_text = 'cloud'
AND t3.tag_text = 'flower'
AND t2p3.post_id IS NULL;
```

Summary of SQL Tips for Tagging

- Index fields in mapping tables properly. Ensure that each GROUP BY can access an index from the left side of the index
- Use summary or statistic tables to eliminate the use of COUNT(*) expressions in tag clouding
- Get rid of GROUP BY and HAVING COUNT(...) by using standard join techniques
- Get rid of NOT IN expressions via a standard outer join
- Use derived tables with an internal LIMIT expression to prevent wild relation queries from breaking scalability

Folksonomy Concepts in SQL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Done
Here we see tagging and folksonomy together: the user dimension...

Folksonomy Adds The User Dimension

- Adding the user dimension to our schema
- The tag is the relationship glue between the user and item dimensions

```
CREATE TABLE UserTagPost (
user_id INT UNSIGNED NOT NULL
, tag_id INT UNSIGNED NOT NULL
, post_id INT UNSIGNED NOT NULL
, PRIMARY KEY (user_id, tag_id, post_id)
, INDEX (tag_id)
, INDEX (post_id)
) ENGINE=InnoDB;
```

Who Shares My Interest Directly?

- Find out the users who have linked to the same item I have
- Direct link; we don't go through the tag glue

```
SELECT user_id
FROM UserTagPost
WHERE post_id = @my_post_id;
```

Who Shares My Interests Indirectly?

- Find out the users who have similar tag sets...
- But, how much matching do we want to do? In other words, what *radius* do we want to match on...
- The first step is to find *my* tags that are within the search radius... this yields my “top” or most popular tags

```
SELECT tag_id
FROM UserTagPost
WHERE user_id = @my_user_id
GROUP BY tag_id
HAVING COUNT(tag_id) >= @radius;
```

Who Shares My Interests (cont'd)

- Now that we have our “top” tag set, we want to find users who match all of our top tags:

```
SELECT others.user_id
FROM UserTagPost others
INNER JOIN (SELECT tag_id
FROM UserTagPost
WHERE user_id = @my_user_id
GROUP BY tag_id
HAVING COUNT(tag_id) >= @radius) AS my_tags
ON others.tag_id = my_tags.tag_id
GROUP BY others.user_id;
```

Ranking Ecosystem Matches

- What about finding our “closest” ecosystem matches
- We can “rank” other users based on whether they have tagged items a number of times similar to ourselves

```
SELECT others.user_id
, (COUNT(*) - my_tags.num_tags) AS rank
FROM UserTagPost others
INNER JOIN (
SELECT tag_id, COUNT(*) AS num_tags
FROM UserTagPost
WHERE user_id = @my_user_id
GROUP BY tag_id
HAVING COUNT(tag_id) >= @radius
) AS my_tags
ON others.tag_id = my_tags.tag_id
GROUP BY others.user_id
ORDER BY rank DESC;
```

Ranking Ecosystem Matches Efficiently

- But... we've still got our COUNT(*) problem
- How about another summary table ...

```
CREATE TABLE UserTagStat (
user_id INT UNSIGNED NOT NULL
, tag_id INT UNSIGNED NOT NUL
, num_posts INT UNSIGNED NOT NULL
, PRIMARY KEY (user_id, tag_id)
, INDEX (tag_id)
) ENGINE=InnoDB;
```

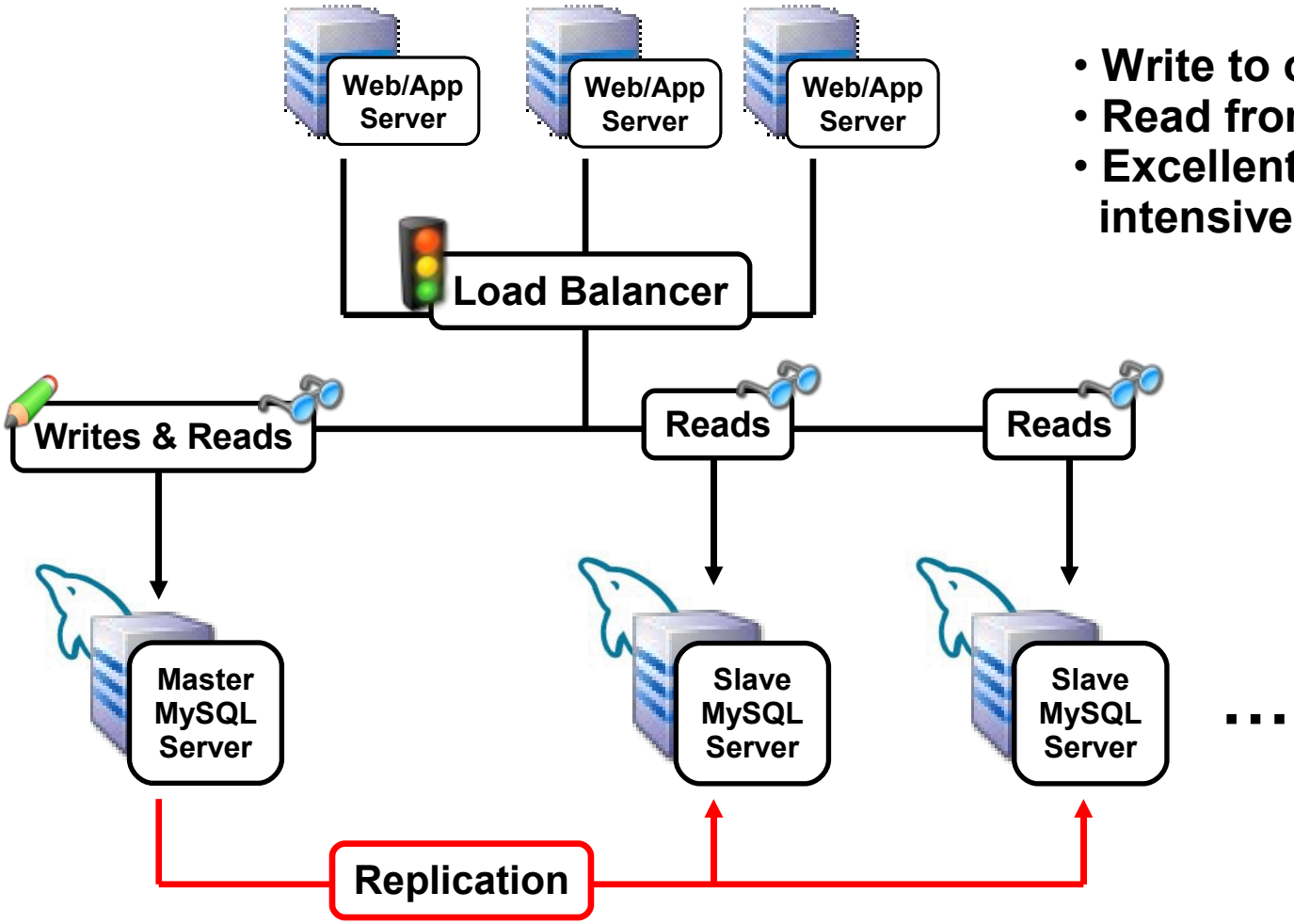
Ranking Ecosystem Matches Efficiently 2

- Hey, we've eliminated the aggregation!

```
SELECT others.user_id
, (others.num_posts - my_tags.num_posts) AS rank
FROM UserTagStat others
INNER JOIN (
SELECT tag_id, num_posts
FROM UserTagStat
WHERE user_id = @my_user_id
AND  num_posts >= @radius
) AS my_tags
ON others.tag_id = my_tags.tag_id
ORDER BY rank DESC;
```

Scaling Out Sensibly

MySQL Replication (Scale Out)

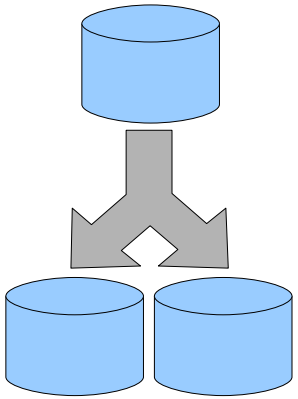


- Write to one master
- Read from many slaves
- Excellent for read intensive apps

Scale Out Using Replication

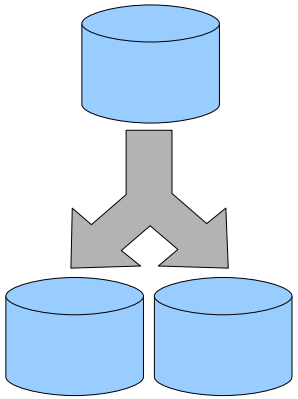
- Master DB stores all writes
- Master has InnoDB tables
- Slaves handle aggregate reads, non-realtime reads
- Web servers can be load balanced (directed) to one or more slaves
- Just plug in another slave to increase read performance (that's scaling out...)
- Slave can provide hot standby as well as backup server

Scale Out Strategies



- Slave storage engine can differ from Master!
  - InnoDB on Master (great update/insert/delete performance)
  - MyISAM on Slave (fantastic read performance and well as excellent concurrent insert performance, plus can use FULLTEXT indexing)
- Push aggregated summary data in batches onto slaves for excellent read performance of semi-static data
  - Example: “this week's popular tags”
    - Generate the data via cron job on each slave. No need to burden the master server
    - Truncate every week

Scale Out Strategies (cont'd)



- Offload FULLTEXT indexing onto a FT indexer such as Apache Lucene, Mnogosearch, Sphinx FT Engine, etc.
- Use Partitioning feature of 5.1 to segment tag data across multiple partitions, allowing you to spread disk load sensibly based on your tag text density
- Use the MySQL Query Cache effectively
  - Use SQL_NO_CACHE when selecting from frequently updated tables (ex: TagStat)
  - Very effective for high-read environments: can yield 200-250% performance improvement

Questions?

MySQL Forge
http://forge.mysql.com/

MySQL Forge Tag Schema Wiki pages
http://forge.mysql.com/wiki/TagSchema

PlanetMySQL
http://www.planetmysql.org

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