Web Performance and Scalability with MySQL

Ask Bjørn Hansen
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Real World Web Scalability

MySQL Edition

Ask Bjørn Hansen
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Hello.

- I'm Ask Bjørn Hansen
- Tutorial in ~~a box~~ 44 minutes!
- 53* brilliant° tips to make your website keep working past X requests/transactions per T time
  - Requiring minimal extra work! (or money)
  - Concepts applicable to ~all languages and platforms!

* Estimate, your mileage may vary

° Well, a lot of them are pretty good

Construction Ahead!

- Conflicting advice ahead
- Not everything is applicable to every situation
- Ways to “think scalable” rather than end-all-be-all solutions

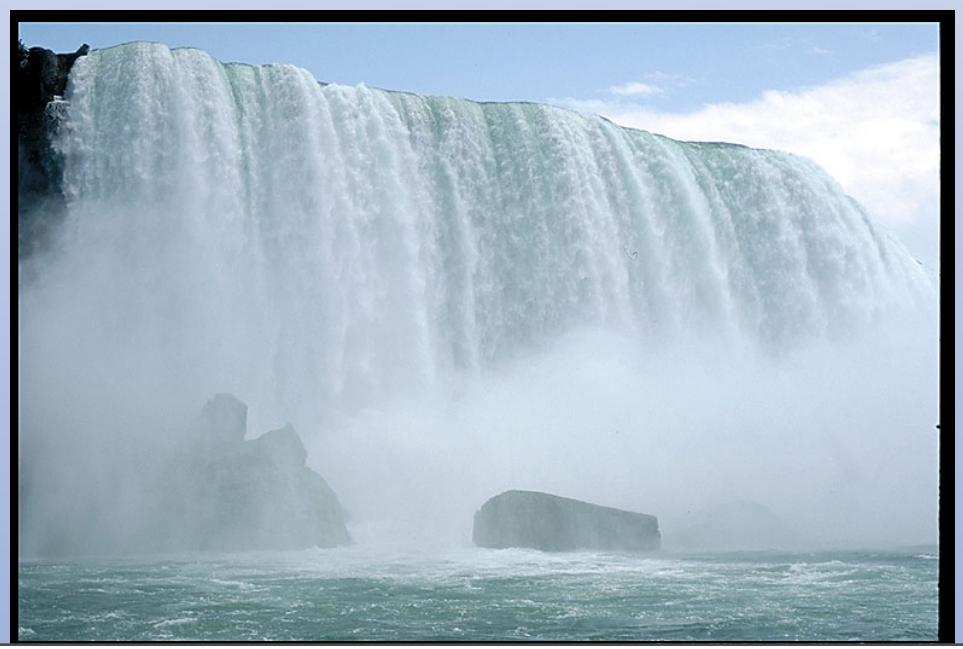
Questions ...

- How many saw my talk last year?
- ... Brian Akers replication talk earlier today?
- ... Second Life talk a few hours ago?
- How many are using Perl? PHP? Python? Java? Ruby?
- ... Oracle? PostgreSQL?

- Lesson number 1

• Think Horizontal!

- Everything in your architecture, not just the front end web servers
- Micro optimizations and other implementation details — Bzzzzt! Boring!



Benchmarking techniques

- Scalability isn't the same as processing time
  - Not “how fast” but “how many”
  - Test “force”, not speed. Think amps, not voltage
  - Test *scalability*, not just performance
- Use a realistic load
- Test with “slow clients”

Vertical scaling

- "Get a bigger server"
- "Use faster CPUs"
- Can only help so much (with bad scale/$ value)
- A server twice as fast is more than twice as expensive
- Super computers are horizontally scaled!

Horizontal scaling

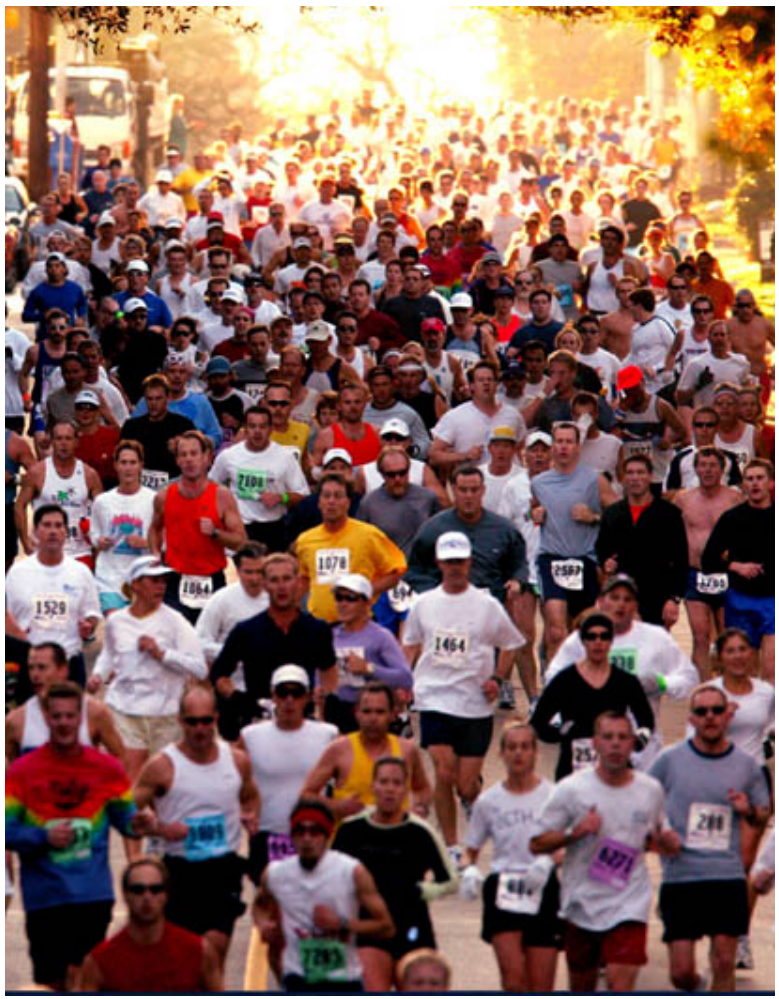
- "Just add another box" (or another thousand or ...)
- Good to great ...
  - **Implementation**, scale your system **a few** times
  - **Architecture**, scale dozens or **hundreds** of times
- Get the big picture right first, do micro optimizations later

Scalable Application Servers

Don't paint yourself into a corner from the start

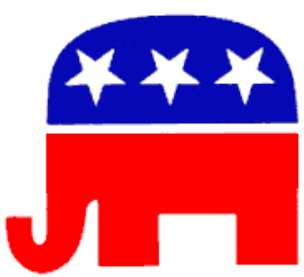
Run Many of Them

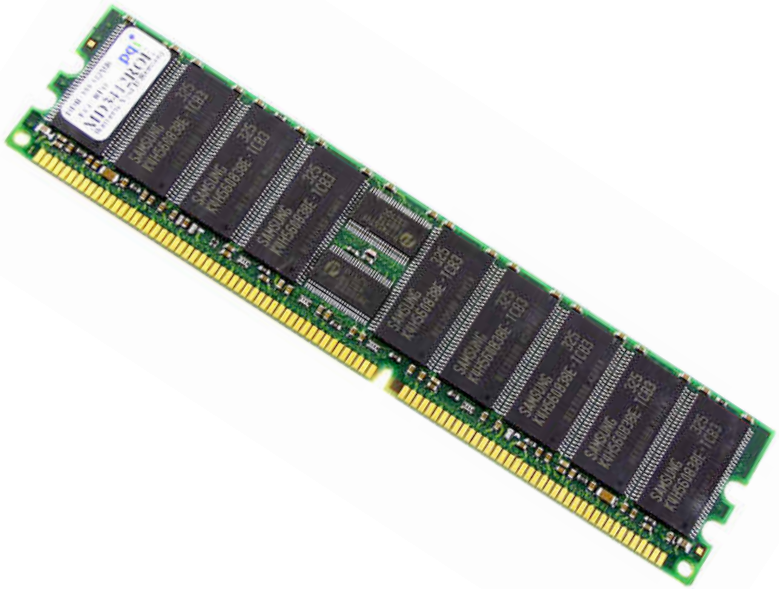
- For your application...
- Avoid having *The Server* for anything
- Everything should (be able to) run on any number of boxes



Stateless vs Stateful

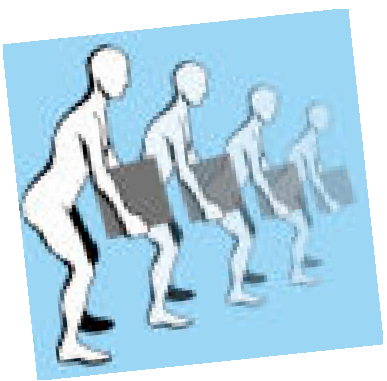
- "Shared Nothing"
- Don't keep state within the application server (or at least be Really Careful)
- Do you use PHP or mod_perl (or something else that's running in Apache HTTPD)?
  - You get that for free! (usually)





Caching

How to not do all that work again and again and again...



Generate **Static** Pages

- Ultimate Performance: Make all pages static
- Generate them from templates nightly or when updated
- Doesn't work well if you have millions of pages or page variations

Cache **full** pages

(or responses if it's an API)

- Cache full output **in the application**
- Include cookies etc. in the "cache key"
- Fine tuned application level control
- The most flexible
  - "use cache when this, not when that"
  - Use regular expressions to insert customized content into the cached page

Cache **full** pages 2

- Front end cache (**mod_cache, squid**, ...) stores generated content
  - Set Expires header to control cache times
- ***or*** Rewrite rule to generate page if the cached file doesn't exist (this is what Rails does)

```
RewriteCond %{REQUEST_FILENAME} !-s
RewriteCond %{REQUEST_FILENAME}/index.html !-s
RewriteRule (^/.*)  /dynamic_handler/$1 [PT]
```

- Still doesn't work for dynamic content per user *("6 items in your cart")*
- Great for caching "dynamic" images!

Cache **partial** pages

- Pre-generate static page "snippets"
  (this is what my.yahoo.com does or used to do...)
  - Have the handler just assemble pieces ready to go
- Cache little page snippets (say the sidebar)
- Be careful, easy to spend more time managing the cache snippets than you save!
- "Regexp" dynamic content into an otherwise cached page

Cache **data**

- Cache data that's slow to query, fetch or calculate
- Generate page from the cached data
- Use the same data to generate API responses!
- Moves load to cache servers
  - (For better or worse)
- Good for slow data used across many pages
  ("todays bestsellers in $category")

Cache **hit-ratios**

- Start with things you hit all the time
- Look at database logs
- Don't cache if you'll spend more energy writing to the cache than you save
- Do cache if it'll help you when that one single page gets a million hits in a few hours

Caching Tools

Where to put the cache data ...

A couple of bad ideas

Don't do this!

- Process memory (`$cache{foo}`)
  - Not shared!
- Shared memory? Local file system?
  - Limited to one machine (likewise for a file system cache)
  - Some implementations are really fast
- MySQL query cache
  - Flushed on each update
  - Nice if it helps; don't depend on it

MySQL cache table

- Write into one or more cache tables
- id is the “cache key”
- type is the “namespace”
- metadata for things like headers for cached http responses
- purge_key to make it easier to delete data from the cache

```
CREATE TABLE `cache` (
  `id` varchar(128) NOT NULL,
  `type` varchar(128) NOT NULL default '',
  `created` timestamp NOT NULL,
  `purge_key` varchar(64) default NULL,
  `data` mediumblob NOT NULL,
  `metadata` mediumblob,
  `serialized` tinyint(1) NOT NULL default '0',
  `expires` datetime NOT NULL,
  PRIMARY KEY  (`id`,`type`),
  KEY `expire_idx` (`expire`),
  KEY `purge_idx` (`purge_key`)
) ENGINE=InnoDB
```

MySQL Cache Fails

- Scaling and availability issues
  - How do you load balance?
  - How do you deal with a cache box going away?
- Partition the cache to spread the write load
- Use Spread to *write* to the cache and distribute configuration

MySQL Cache Scales

- Most of the usual "scale the database" tricks apply
- Partitioning
- Master-Master replication for availability
- .... more on those things in a moment
- memcached scheme for partitioning and fail-over

memcached

- LiveJournal's distributed caching system
  (also used at slashdot, wikipedia, etc etc)
- memory based
- Linux 2.6 (epoll) or FreeBSD (kqueue)
  - Low overhead for many many connections
- Run it on boxes with free memory
- No "master"
- Simple lightweight protocol
  - perl, java, php, python, ruby, ...
- Performance (roughly) similar to a MySQL cache
- Scaling and high-availability is "built-in"

Database scaling

How to avoid buying that gazillion dollar Sun box

~$3,500,000
Vertical

~$2,000
*(= **1750** for $3.5M!)*
Horizontal

Be Simple

- Use MySQL
  - It's fast and it's easy to manage and tune
  - Easy to setup development environments

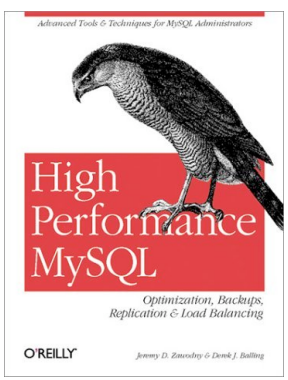
- *PostgreSQL is fast too :-)*

Replication

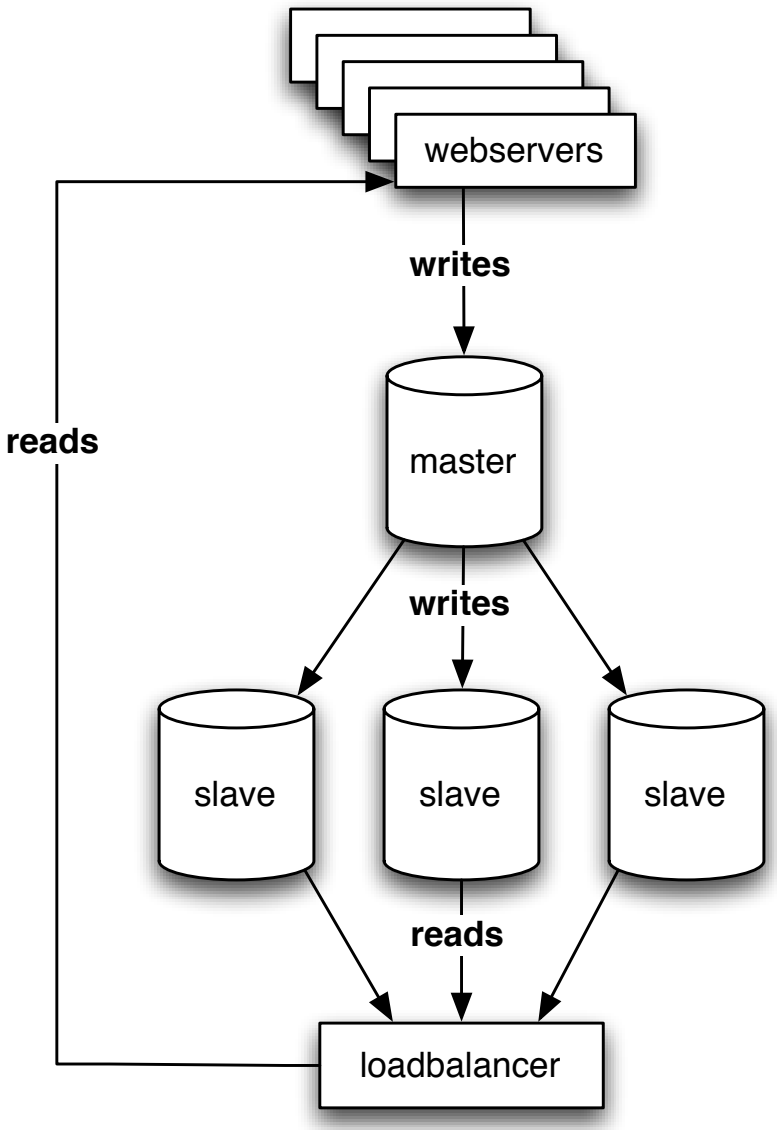
More data more places!
Share the ~~love~~ load

Basic Replication

- Write to one master
- Read from many slaves
- Great for read intensive applications

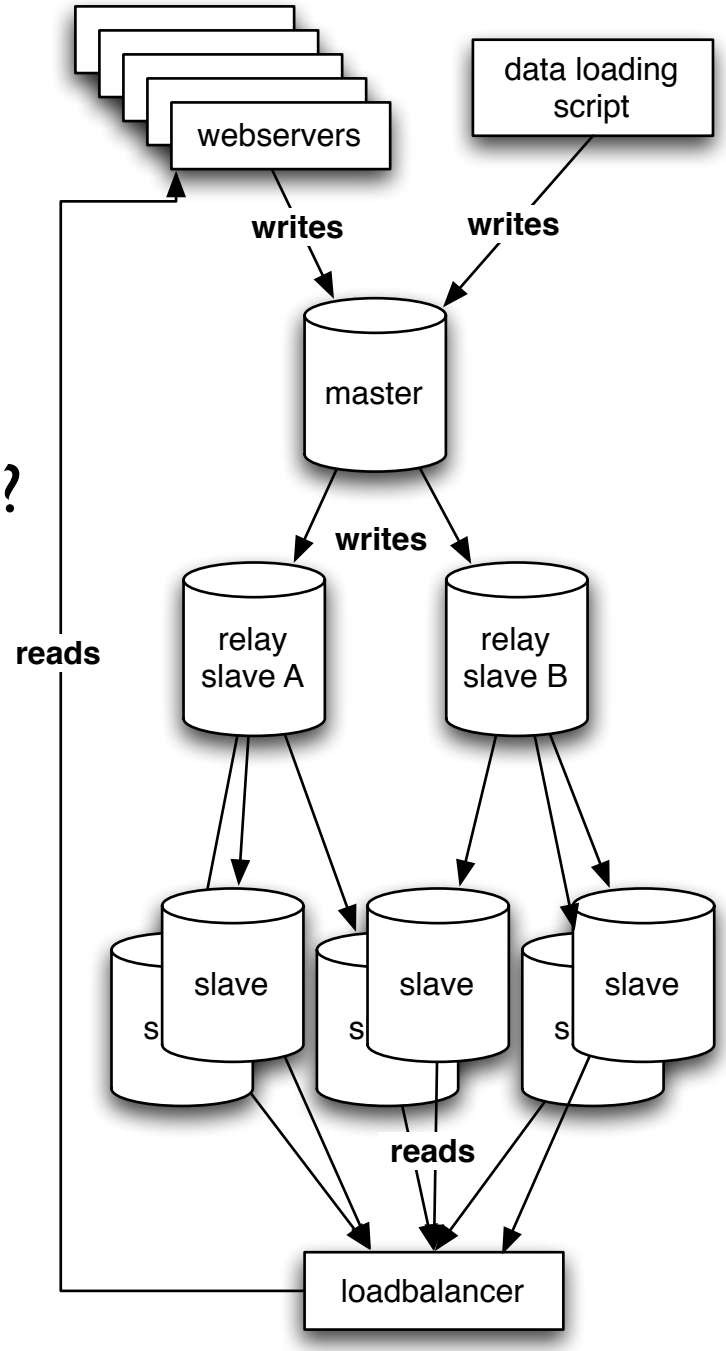


Lots more details in
"High Performance MySQL"



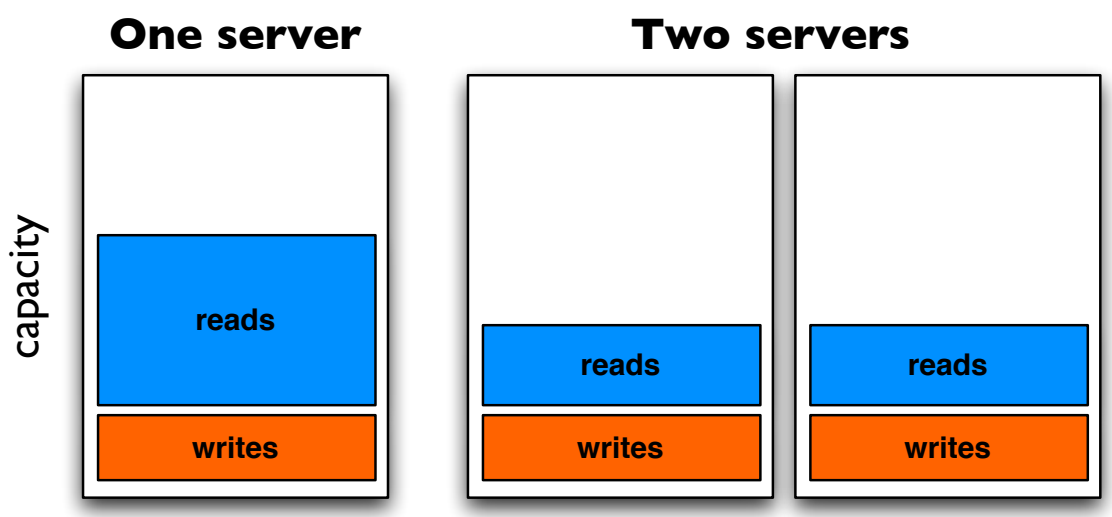
Relay slave replication

- Running out of bandwidth on the master?
- Replicating to multiple data centers?
- A "replication slave" can be master to other slaves
- Almost any possible replication scenario can be setup (circular, star replication, ...)



Replication Scaling – Reads

- Reading scales well with replication
- Great for (mostly) read-only applications

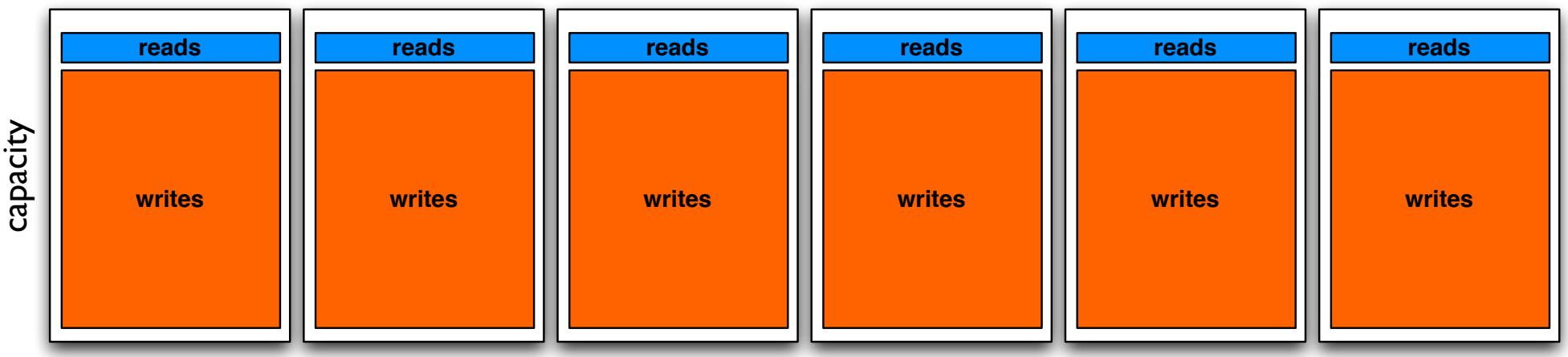


(thanks to Brad Fitzpatrick!)

Replication Scaling – Writes

(aka when replication sucks)

- Writing doesn't scale with replication
- All servers needs to do the same writes



Partition the data

Divide and Conquer!

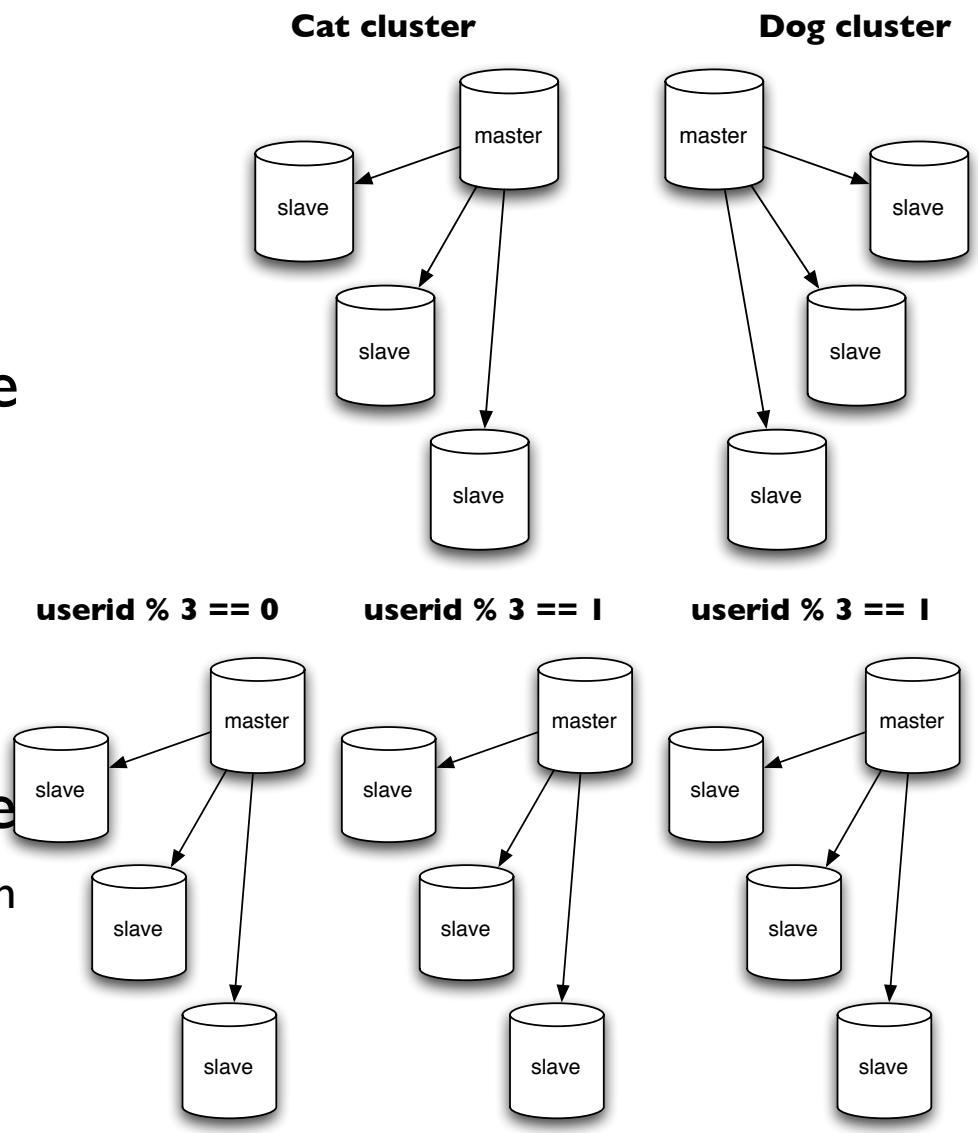
or

Web 2.0 Buzzword Compliant!

Now free with purchase of milk!!

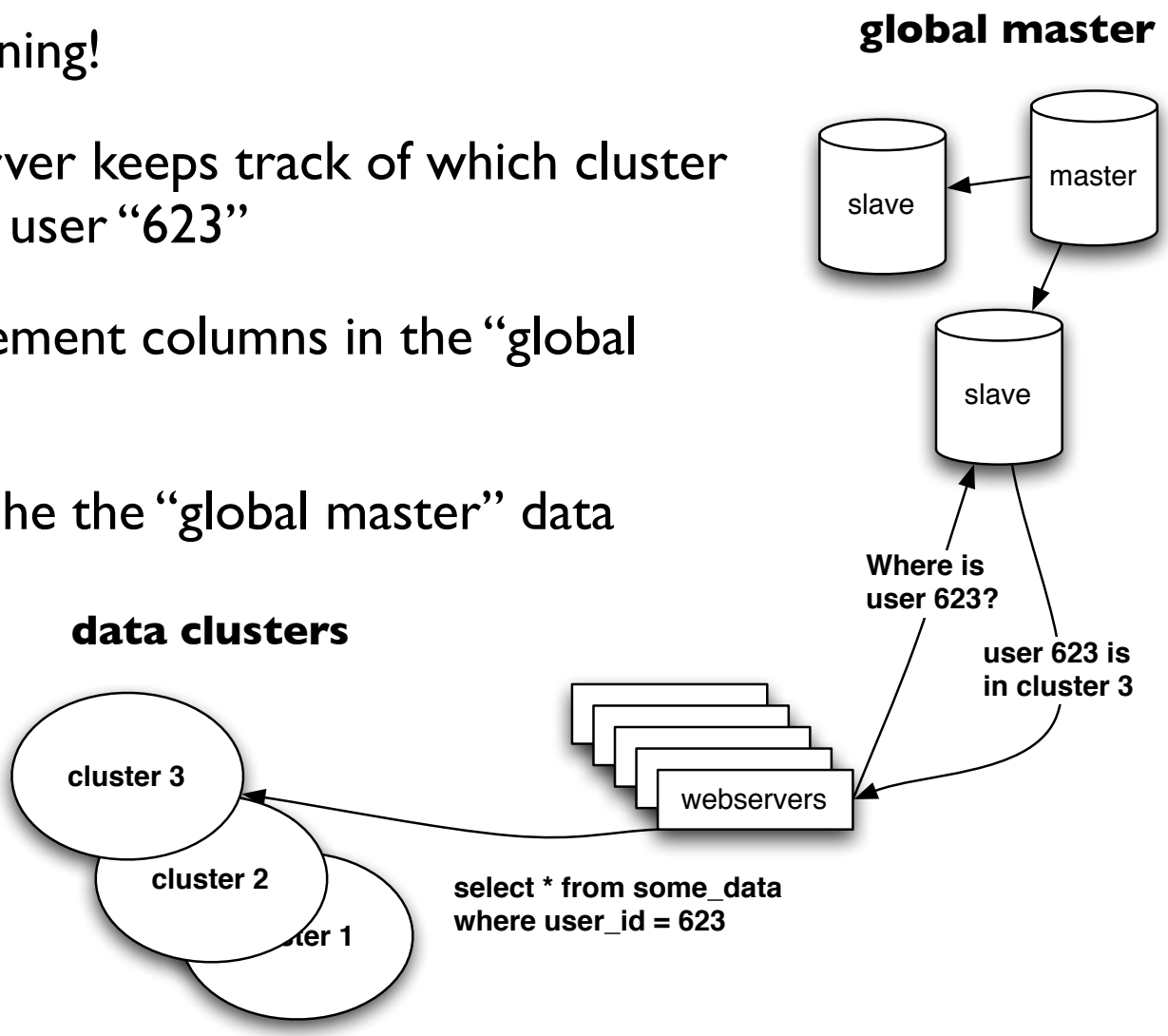
Partition your data

- 99% read application? Skip this step...
- Solution to the too many writes problem: Don't have all data on all servers
- Use a separate cluster for different data sets
- Split your data up in differe clusters (don't do it like it's done in the illustration)



Cluster data with a master server

- Can't divide data up in "dogs" and "cats"?
- Flexible partitioning!
- The "global" server keeps track of which cluster has the data for user "623"
- Only auto_increment columns in the "global master"
- Aggressively cache the "global master" data



How this helps "Web 2.0"

- Don't have replication slaves!
- Use a **master-master** setup in each "cluster"
- master-master for redundancy
- No latency from commit to data being available
- Get IDs from the global master
- If you are careful you can write to both!
  - Make each user always use the same master (as long as it's running)

Hacks!

Don't be afraid of the data-duplication monster

Summary tables!

- Find queries that do things with COUNT(*) and GROUP BY and create tables with the results!
  - Data loading process updates both tables
  - or hourly/daily/... updates
- Variation: Duplicate data in a different "partition"
  - Data affecting both a "user" and a "group" goes in both the "user" and the "group" partition (Flickr does this)

Summary databases!

- Don’t just create summary tables
- Use summary databases!
- Copy the data into special databases optimized for special queries
  - full text searches
  - index with both cats and dogs
  - anything spanning all clusters
- Different databases for different latency requirements (RSS feeds from replicated slave DB)

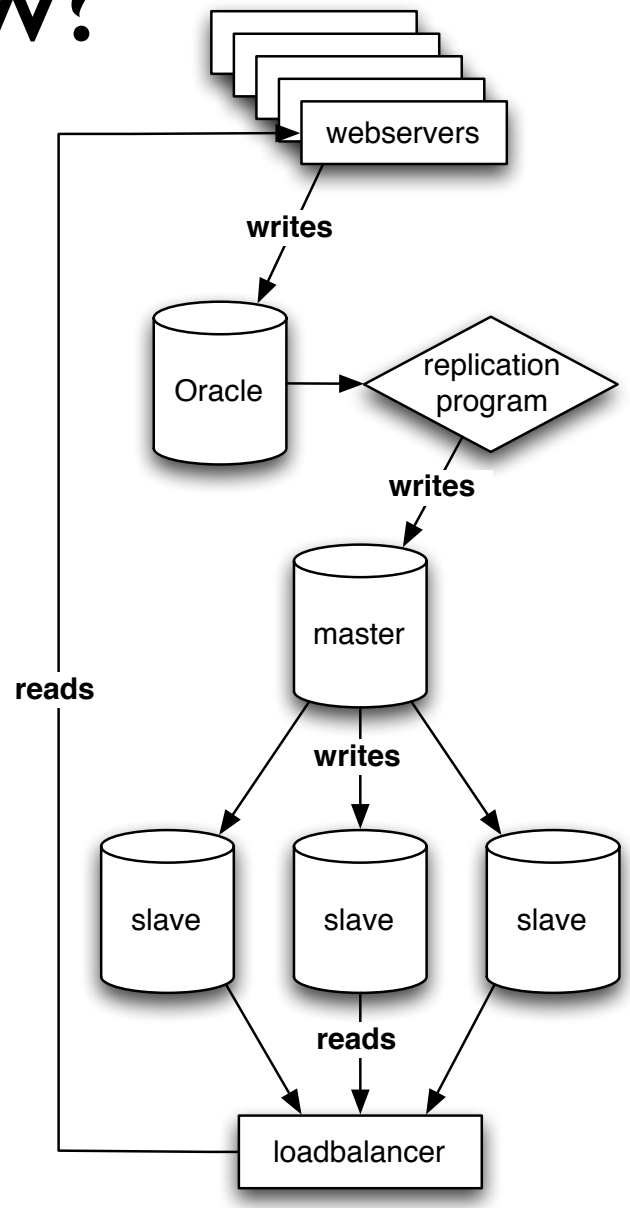
“Manual” replication

- Save data to multiple “partitions”
- Application writes two places *or*
- last_updated and deleted columns *or*
- Use triggers to add to “replication_queue” table
- Background program to copy data based on the queue table or the last_updated column
- Build summery tables or databases in this process
- Build star/spoke replication system

a brief diversion ...

Running Oracle now?

- Move read operations to MySQL!
- Replicate from Oracle to a MySQL cluster with "manual replication"
- Use triggers to keep track of changed rows in Oracle
- Copy them to the MySQL master server with a replication program
- Good way to "sneak" MySQL in ...



Make everything repeatable

- Script failed in the middle of the nightly processing job?
  (they will sooner or later, no matter what)
- How do you restart it?
- Build your "summary" and "load" scripts so they always can be run again! (and again and again)
- One "authoritative" copy of a data piece – summaries and copies are (re)created from there

More MySQL

Faster, faster, faster ....

Table Choice

- Short version:
  Use InnoDB, it's harder to make them fall over
- Long version:
  Use InnoDB except for
  - Big read-only tables (smaller, less IO)
  - High volume streaming tables (think logging)
    - Locked tables / `INSERT DELAYED`
  - Specialized engines for special needs
  - More engines in the future
  - For now: InnoDB

Multiple MySQL instances

- Run different MySQL instances for different workloads
  - Even when they share the same server anyway!
- Moving to separate hardware easier
- Optimizing MySQL for the particular workload easier
- Simpler replication
- Very easy to setup with the instance manager or mysqld_multi
- mysql.com init scripts supports the instance manager

Asynchronous data loading

- Updating counts? Loading logs?
- Don't talk directly to the database, send updates through Spread (or whatever) to a daemon loading data
- Don't update for each request

```
update counts set count=count+1 where id=37
```

- Aggregate 1000 records or 2 minutes data and do fewer database changes

```
update counts set count=count+42 where id=37
```

- Being disconnected from the DB will let the frontend keep running if the DB is down!

Preload, -dump and -process

- Let the servers do as much as possible without touching the database directly
  - Data structures in memory – ultimate cache!
  - Dump never changing data structures to JS files for the client to cache
- Dump smaller read-only often accessed data sets to SQLite or BerkeleyDB and rsync to each webserver (or use NFS, but...)
  - Or a MySQL replica on each webserver

Stored Procedures Dangerous

- Not horizontal
- Work in the database server bad (unless it's read-only and replicated)
- Work on one of the scalable web fronts good
- Only do stored procedures if they save the database work (network-io work > SP work)

Reconsider Persistent DB Connections

- DB connection = thread = memory
- With partitioning all httpd processes talk to all DBs
- With lots of caching you might not need the main database that often
- MySQL connections are fast
- Always use persistent connections with Oracle!
  - Commercial connection pooling products

InnoDB configuration

- `innodb_file_per_table`
  Splits your innodb data into a file per table instead of one big annoying file
  - Makes `optimize table `table`` clear unused space
- `innodb_buffer_pool_size=($MEM*0.80)`
- `innodb_flush_log_at_trx_commit` setting
- `innodb_log_file_size`
- `transaction-isolation = READ-COMMITTED`

Store Large Binary Objects

(aka how to store images)

- Meta-data table (name, size, ...)
- Store images either in the file system
  - meta data says "server '123', filename 'abc'"
  - Replication issues! (mogilefs, clustered NFS, ...)
- ***OR*** store images in other (MyISAM) tables
  - Split data up so each table don't get bigger than ~4GB
- Include "last modified date" in meta data
  - Include it in your URLs to optimize caching (squid!)
    (/images/$timestamp/$id.jpg)

Random Application Notes

- Everything is Unicode, please!
  - (DBD::mysql ... oops)
- Make everything use UTC – it'll never be easier to change your app than now
- My new favorite feature:
  - Make MySQL picky about bad input!
  - `SET sql_mode = 'STRICT_TRANS_TABLES'`

Don’t overwork the DB

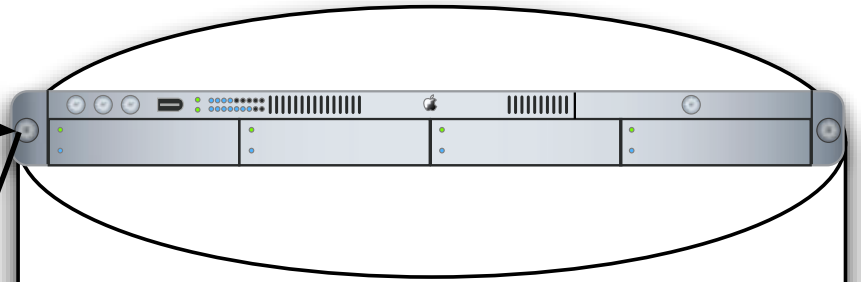
- Databases don’t easily scale
- Don’t make the database do a ton of work
- Referential integrity is good
  - Tons of extra procedures to validate and process data maybe not so much
- Don’t be too afraid of de-normalized data – sometimes it’s worth the tradeoffs (call them summary tables and the DBAs won’t notice)

Sessions

"The key to be stateless"
or
"What goes where"

Evil Session

Cookie: session_id=12345



Web/application server
with local
Session store

```
...
12345 => {
    user =>
      { username => 'joe',
        email => 'joe@example.com',
        id => 987,
    },
    shopping_cart => { ... },
    last_viewed_items => { ... },
    background_color => 'blue',
},
12346 => { ... },
....
```

What's wrong with this?

Evil Session

Cookie: session_id=12345

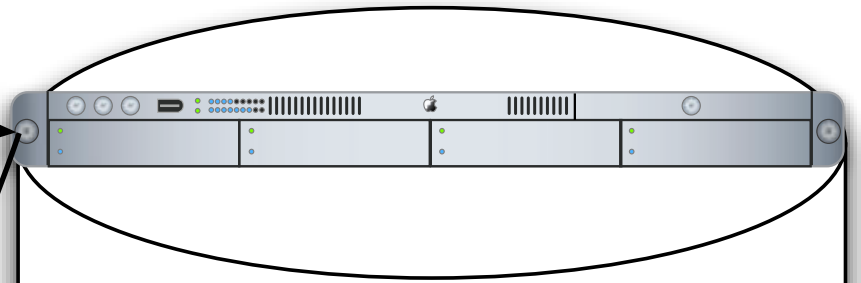
Easy to guess cookie id

Saving state on one server!

Duplicate data from a DB table

Big blob of junk!

What's wrong with this?



Web/application server with local Session store

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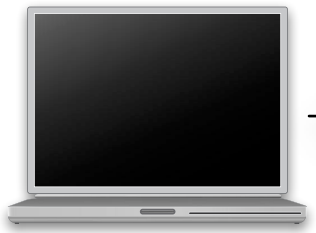
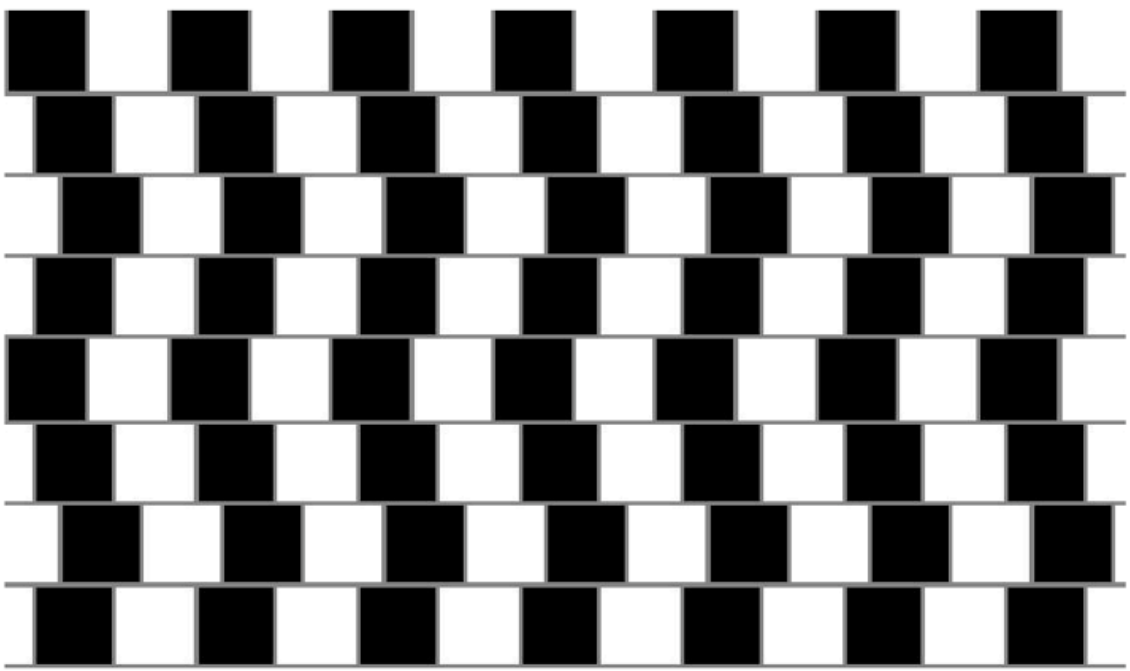
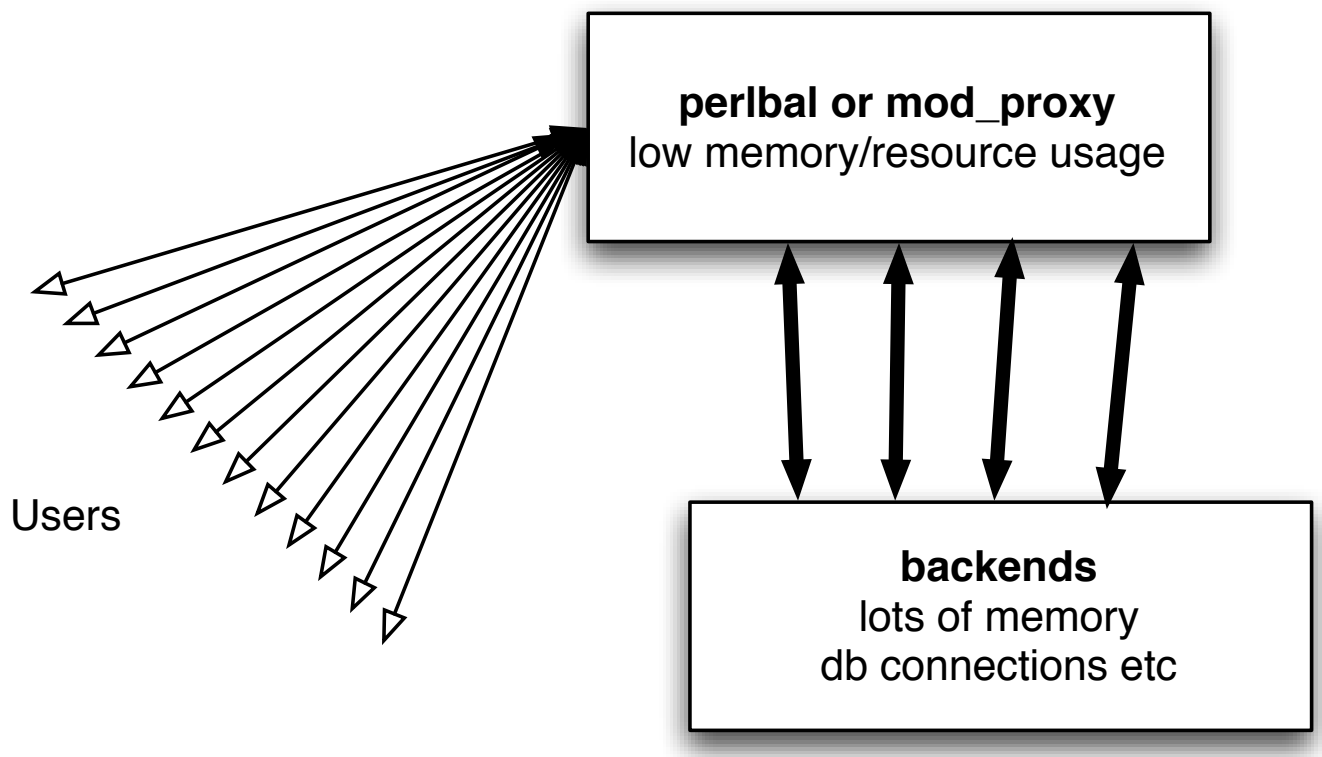
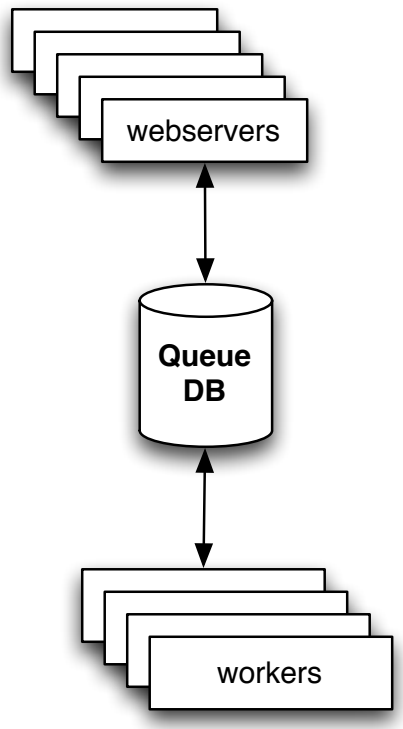
....
```

Good Session!



Cookie: sid=seh568fzkj5k09z;
user=987-65abc;
bg_color=blue;
cart=...;

Web/application server

Database(s)

Users
987 =>
{ username => 'joe',
email => 'joe@example.com',
},
...

Shopping Carts
...

- Stateless web server!
- Important data in a database
- Individual expiration on session objects
- Small data items in cookies

memcached cache

seh568fzkj5k09z =>
{ last_viewed_items => {...},
... other "junk" ...
},
....

Safe cookies

- Worried about manipulated cookies?
- Use checksums and timestamps to validate them!
  - `cookie=1/value/1123157440/ABCD1234`
  - `cookie=1/user::987/cart::943/ts::1123.../EFGH9876`
  - `cookie=$cookie_format_version`
    `/$key::$value[/$key::$value]`
    `/ts::$timestamp`
    `/$md5`
- Encrypt them if you must (rarely worth the trouble and CPU cycles)

Use your resources wisely

don't implode when things run warm

Resource management

- Balance how you use the hardware
  - Use memory to save CPU or IO
  - Balance your resource use (CPU vs RAM vs IO)
- Don’t swap memory to disk. Ever.

Do the work in parallel

- Split the work into smaller (but reasonable) pieces and run them on different boxes
- Send the sub-requests off as soon as possible, do something else and then retrieve the results



Are the horizontal lines parallel or do they slope?

Use light processes for light tasks

- Thin proxy servers or threads for "network buffers"
- Goes between the user and your heavier backend application
- httpd with mod_proxy / mod_backhand
  - perlbal
    – new & improved, now with vhost support!
  - squid, ~~pound~~, ...

Proxy illustration



Light processes

- Save memory and database connections
- This works spectacularly well. Really!
- Can also serve static files and cache responses!
- Avoid starting your main application as root
- Load balancing
- Very important if your backend processes are “heavy”

Light processes

- Apache 2 makes it **Really Easy**
- ```
  ProxyPreserveHost On
  <VirtualHost *>
    ServerName combust.c2.askask.com
    ServerAlias *.c2.askask.com
    RewriteEngine on
    RewriteRule (.*) http://localhost:8230$1 [P]
  </VirtualHost>
  ```
- Easy to have different "backend environments" on one IP
- Backend setup (Apache 1.x)

  ```
  Listen 127.0.0.1:8230
  Port 80
  ```


  ```

Job queues

- Processing time too long for the user to wait?
- Can only do N jobs in parallel?
- Use queues (and an external worker process)
- AJAX can make this really spiffy

Job Queues

- Database "queue"
  - Webserver submits job
  - First available "worker" picks it up and returns the result to the queue
  - Webserver polls for status
- Other ways...
  - gearman
  - Spread
  - MQ / Java Messaging Service(?) / ...



Log http requests!

- Log slow http transactions to a database
  time, **response_time**, uri, remote_ip, user_agent, request_args, user, svn_branch_revision, log_reason (a "SET" column), ...
- Log 2% of all requests!
- Log all 4xx and 5xx requests
- Great for statistical analysis!
  - Which requests are slower
  - Is the site getting faster or slower?
- Time::HiRes in Perl, microseconds from `gettimeofday` system call

Get good deals on servers

- **Silicon Mechanics**
  http://www.siliconmechanics.com/
- Server vendor of LiveJournal and lots others
- Small, but not too small

remember

Think Horizontal!

Hiring!

- Contractors and dedicated moonlighters!
- Help me with $client_project ($$)
- Help me with $super_secret_startup (fun!)
  - Perl / MySQL
  - Javascript/AJAX
- ask@develooper.com
  (resume in text or pdf, code samples)

Thanks!

- Direct and indirect help from ...
  - Cal Henderson, Flickr
  - Brad Fitzpatrick, LiveJournal
  - Kevin Scaldeferri, ~~Overture~~ Yahoo!
  - Perrin Harkins, Plus Three
  - Tim Bunce
  - David Wheeler, Tom Metro

– The End –

Questions?

Thank you!

More questions? Need consulting?

ask@perl.org
ask@develooper.com

`http://develooper.com/talks/`