Inside LiveJournal's Backend

or,

“holy hell that's a lot of hits!”

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Danga Interactive

danga.com / livejournal.com

The Plan

- LiveJournal overview
- Scaling history
- Perlbal
  - load balancer
- memcached
  - distributed caching
- MogileFS
  - distributed filesystem

Before we begin...

- Question Policy
  - Anytime... interrupt!
- Pace
  - told to go slow
  - too bad
  - too much
  - hold on tight

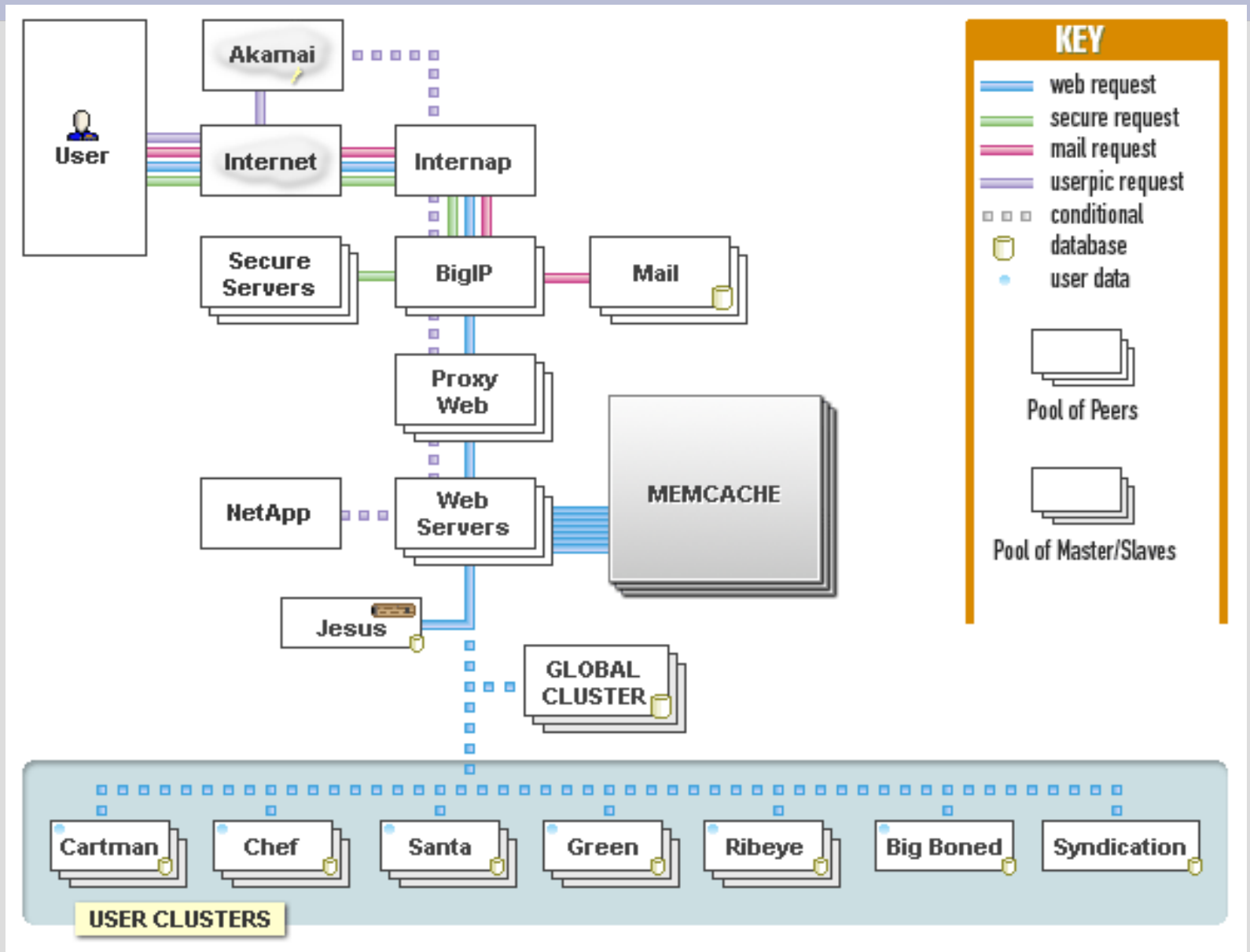
http://www.danga.com/words/

LiveJournal Overview

- college hobby project, Apr 1999
- blogging, forums
- aggregator, social-networking ('friends')
- 3.9 million accounts; ~half active
- 50M+ dynamic page views/day. 1k+/s at peak hours
- why it's interesting to you...
  - 90+ servers, working together
  - lots of MySQL usage
  - lots of failover
  - Open Source implementations of otherwise commercial solutions

LiveJournal Backend

(as of a few months ago)

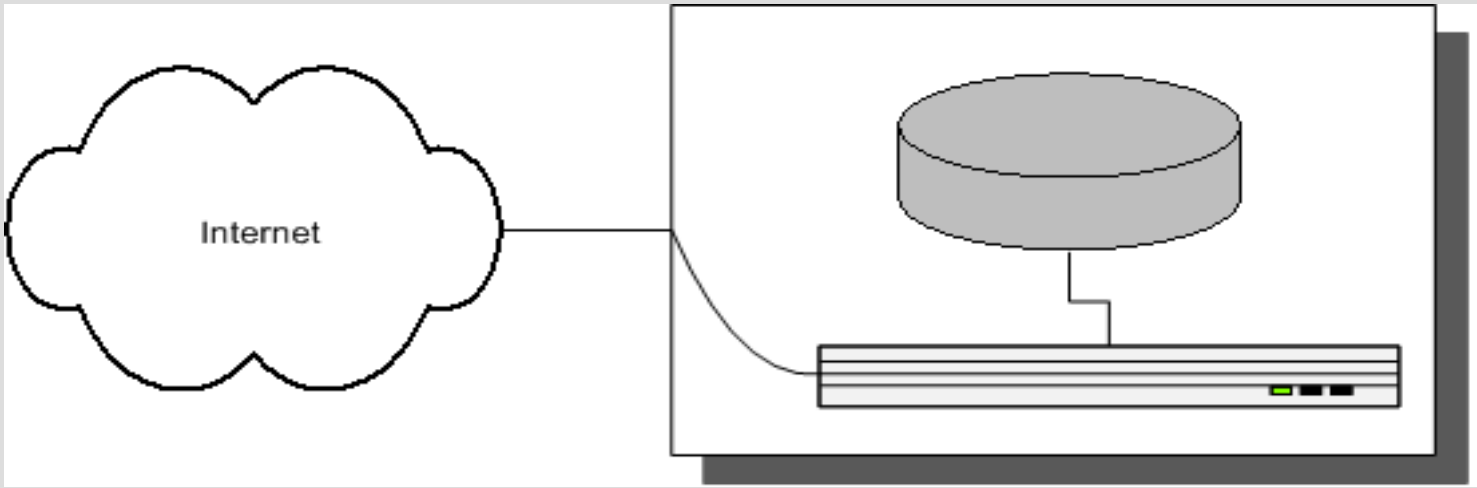


Backend Evolution

- From 1 server to 90+....
  - where it hurts
  - how to fix
- Learn from this!
  - don't repeat my mistakes
  - can implement much of our design on a single server

One Server

- shared server (killed it)
- dedicated server (killed it)
  - still hurting, but could tune it
  - learned Unix pretty quickly
  - CGI to FastCGI
- Simple

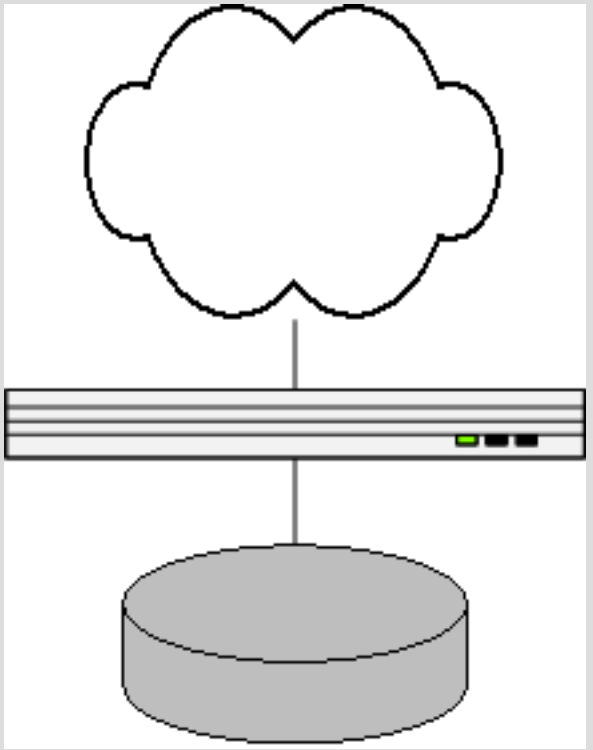


One Server - Problems

- Site gets slow eventually.
  - reach point where tuning doesn't help
- single point of failure
- Need servers
  - start “paid accounts”

Two Servers

- Paid account revenue buys:
  - Kenny: 6U Dell web server
  - Cartman: 6U Dell database server
    - bigger / extra disks
- Network simple
  - 2 NICs each
- Cartman runs MySQL on internal network

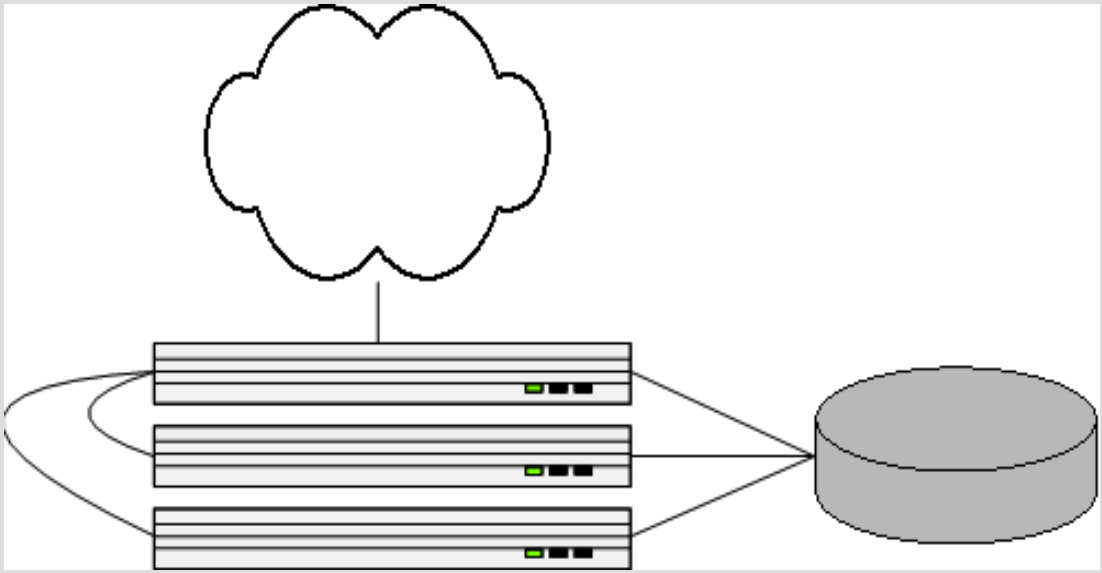


Two Servers - Problems

- Two points of failure
- No hot or cold spares
- Site gets slow again.
  - CPU-bound on web node
  - need more web nodes...

Four Servers

- Buy two more web nodes (1U this time)
  - Kyle, Stan
- Overview: 3 webs, 1 db
- Now we need to load-balance!
  - Kept Kenny as gateway to outside world
  - mod_backhand amongst 'em all



mod_backhand

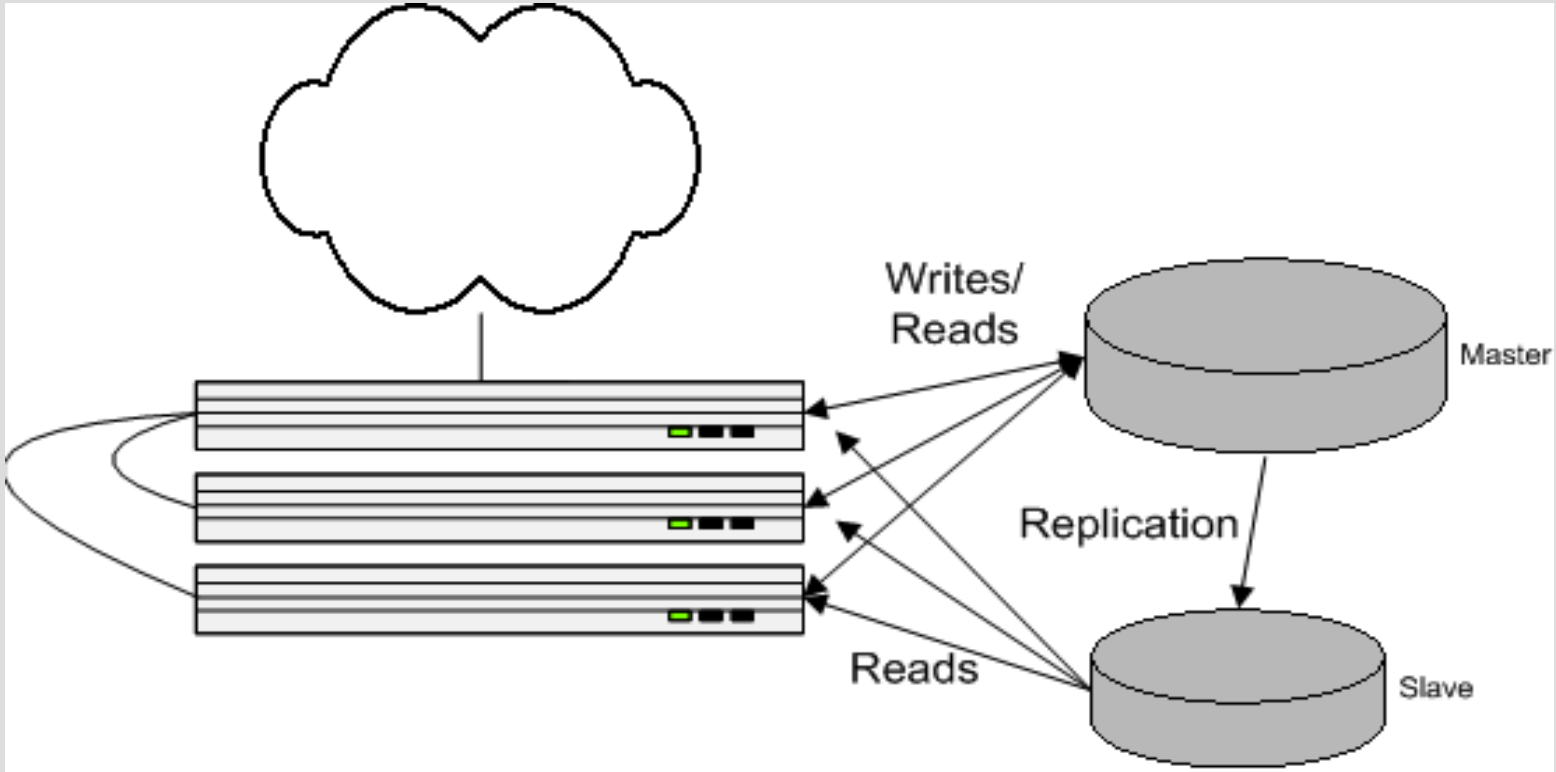
- web nodes broadcasting their state
  - free/busy apache children
  - system load
  - ...
- internally proxying requests around
  - network cheap

Four Servers - Problems

- Points of failure:
  - database
  - kenny (but could switch to another gateway easily when needed, or used heartbeat, but we didn't)
- Site gets slow...
  - IO-bound
  - need another database server ...
  - ... how to use another database?

Five Servers
introducing MySQL replication

- We buy a new database server
- MySQL replication
- Writes to Cartman (master)
- Reads from both

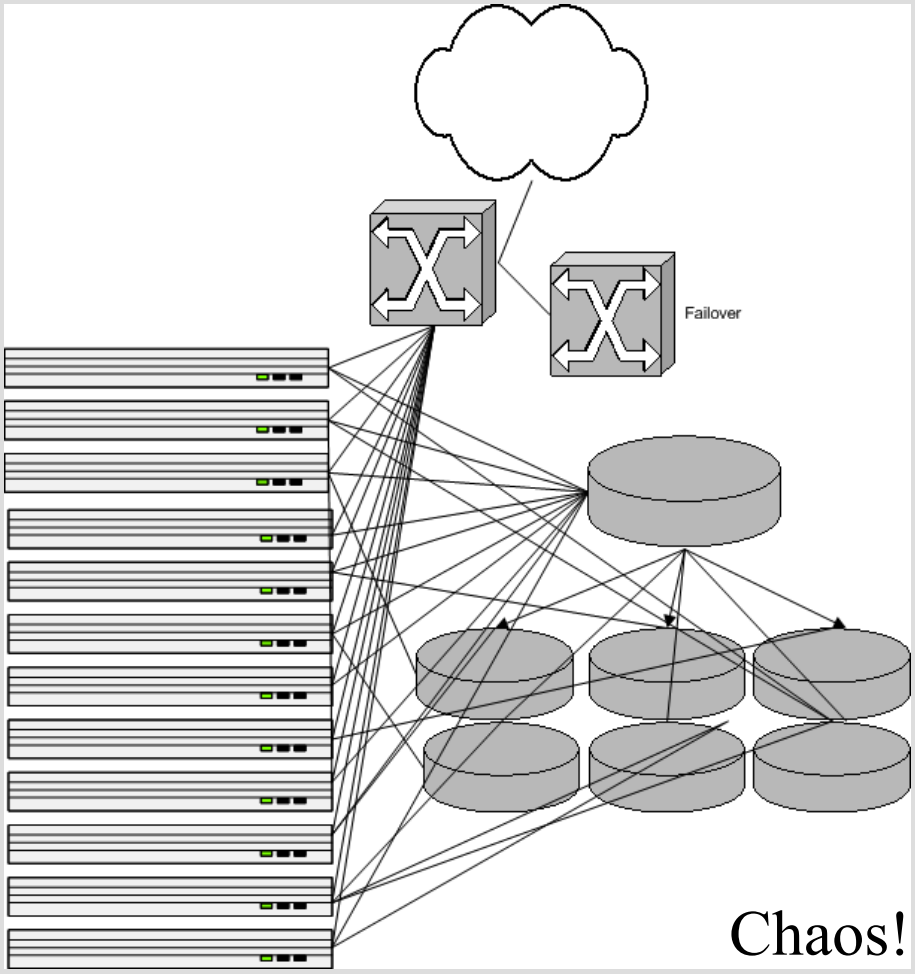


Replication Implementation

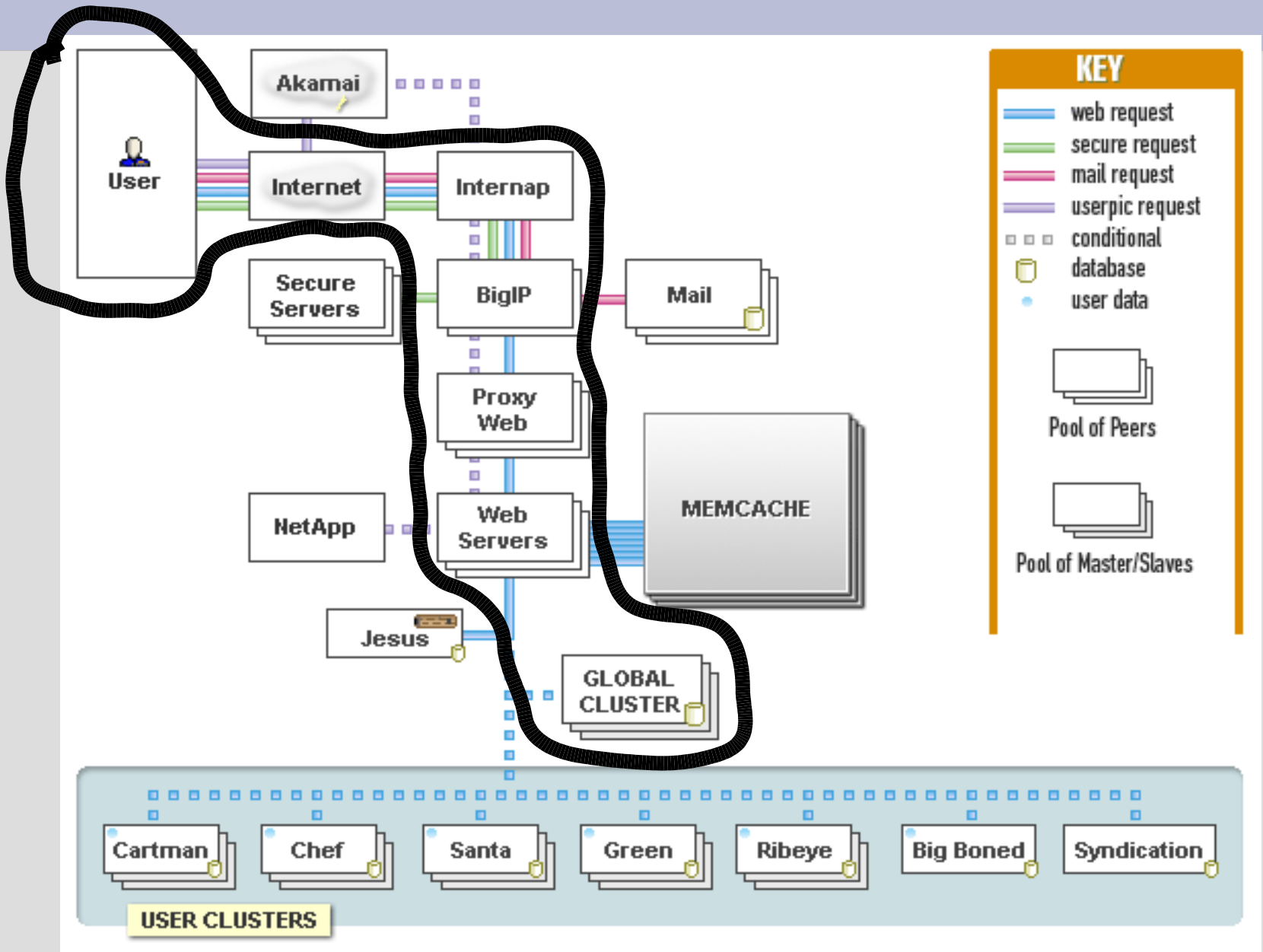
- get_db_handle() : $dbh
  - existing
- get_db_reader() : $dbr
  - transition to this
  - weighted selection
- permissions: slaves select-only
  - mysql option for this now
- be prepared for replication lag
  - easy to detect in MySQL 4.x
  - user actions from $dbh, not $dbr

More Servers

- Site's fast for a while,
- Then slow
- More web servers,
- More database slaves,
- ...
- IO vs CPU fight
- BIG-IP load balancers
  - cheap from usenet
  - LVS would work too
  - nowadays: wackamole



Where we're at...

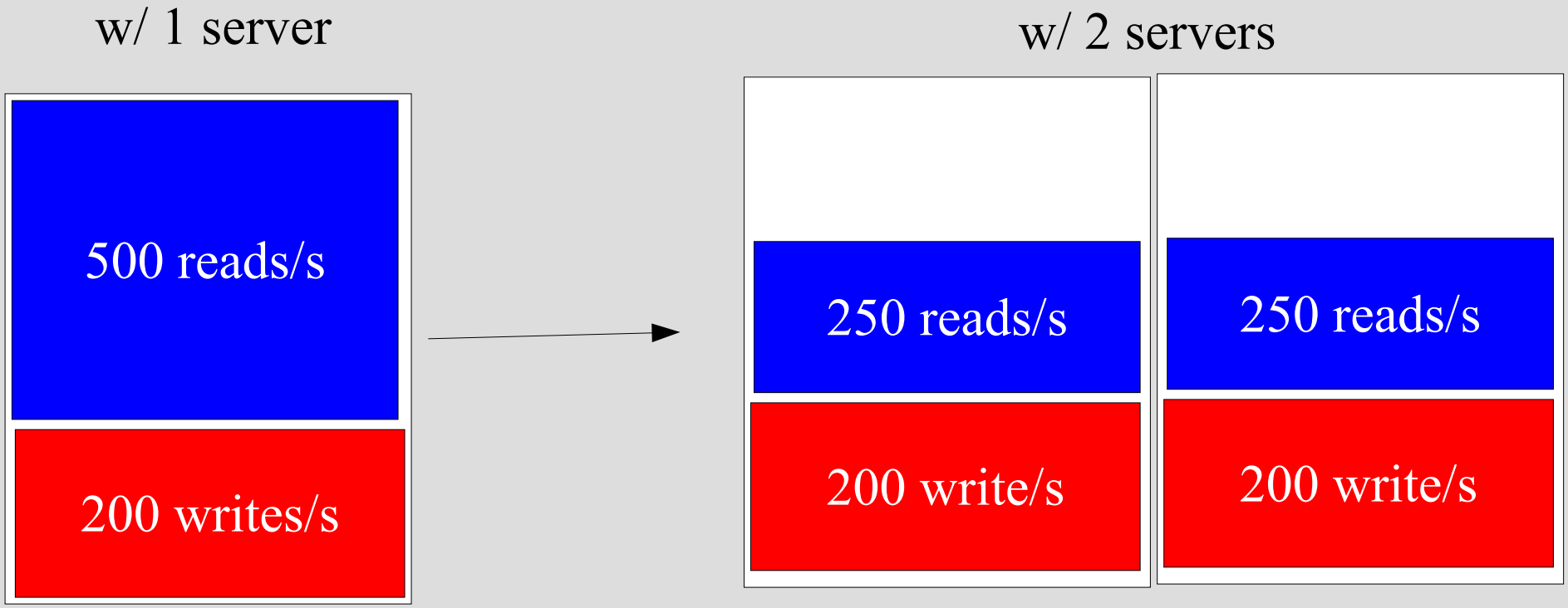


Problems with Architecture

or,

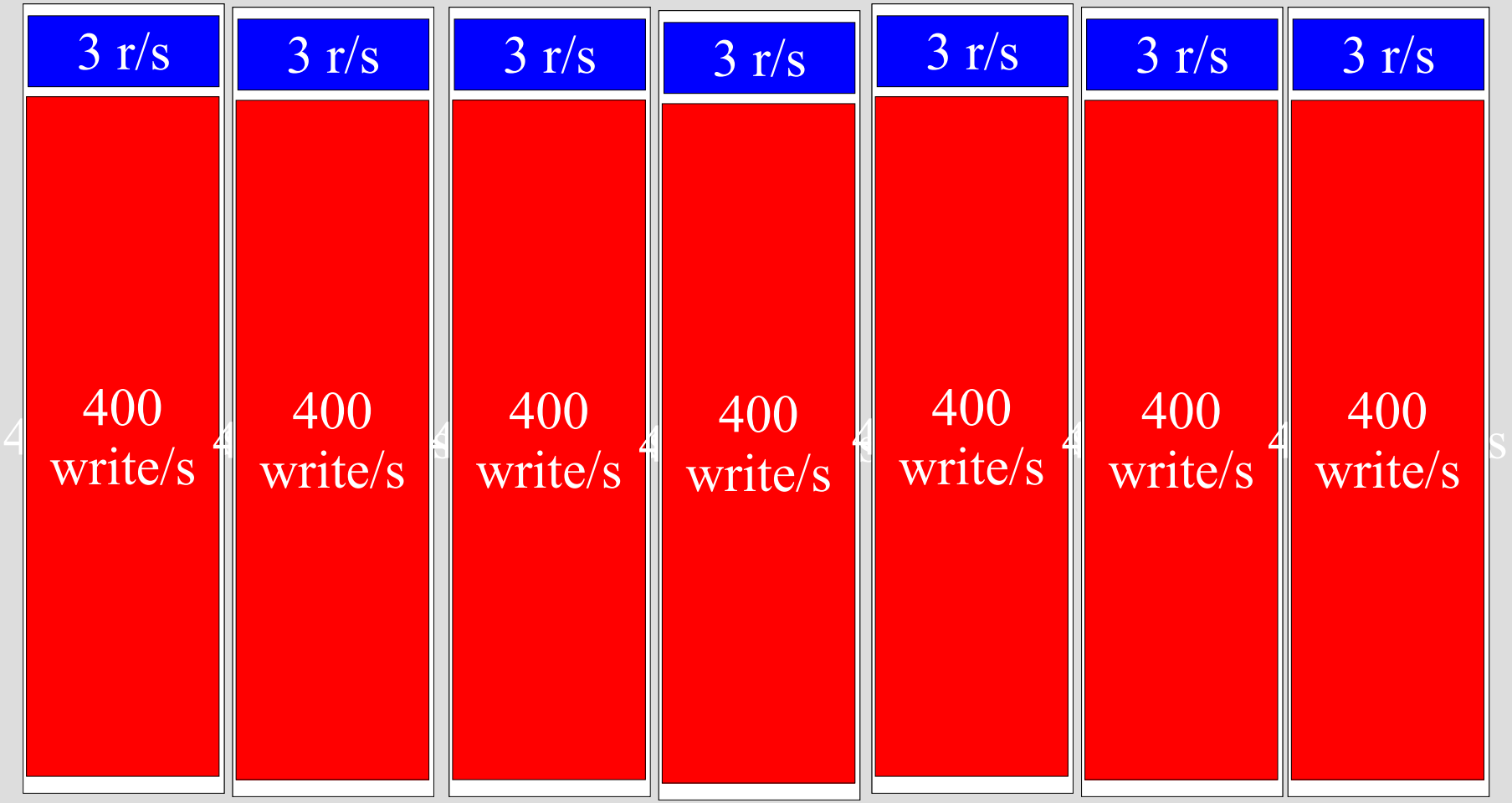
"This don't scale..."

- Slaves upon slaves doesn't scale well...
  - only spreads reads



Eventually...

- databases eventual consumed by writing



Not to mention,

- Database master is point of failure
- Reparenting slaves on master failure tricky at best
  - (without downtime)

Spreading Writes

- Our database machines already did RAID
- We did backups
- So why put user data on 6+ slave machines? (~12+ disks)
  - overkill redundancy
  - wasting time writing everywhere

Introducing User Clusters

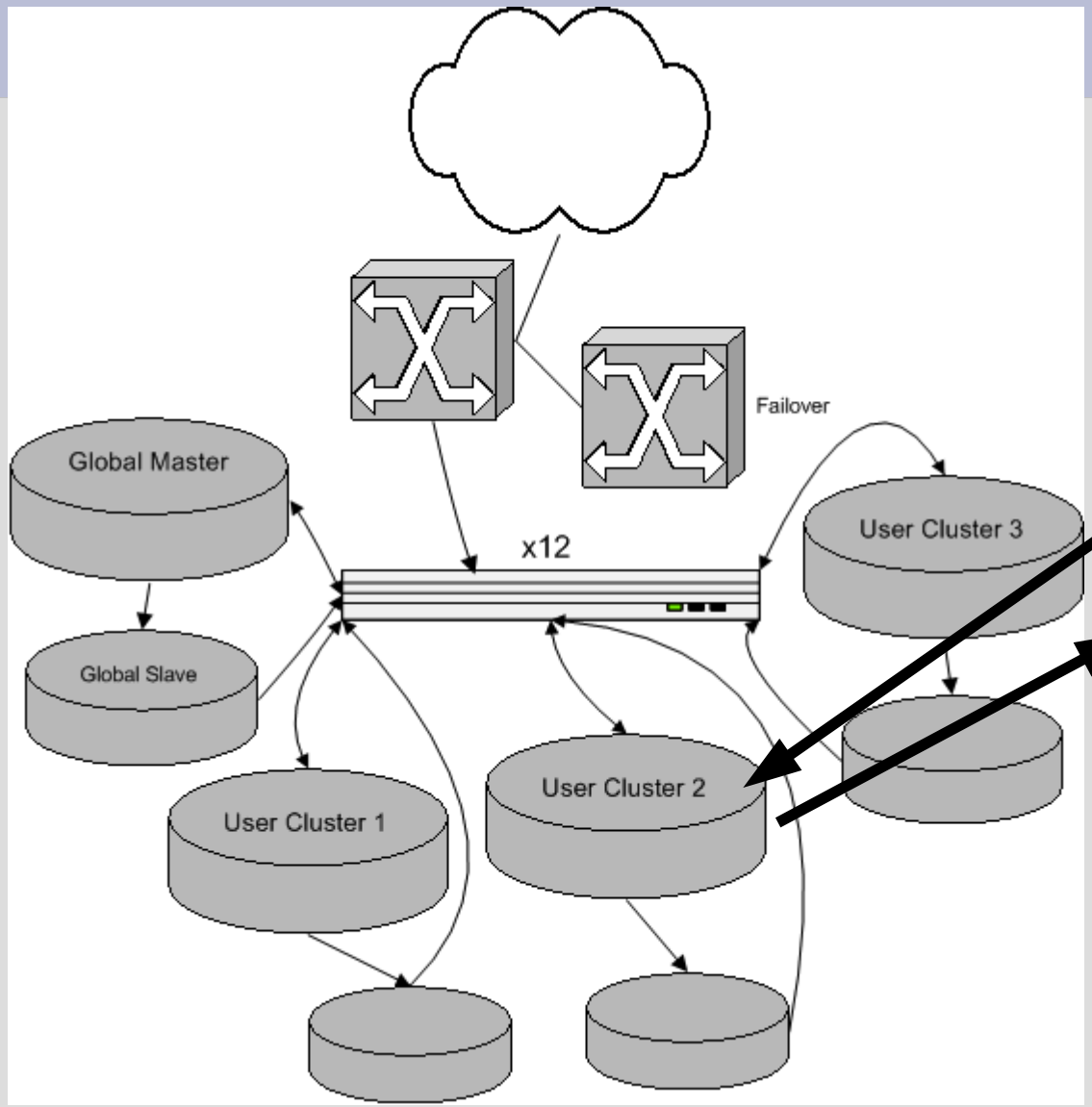
- Already had get_db_handle() vs get_db_reader()
- Specialized handles:
- Partition dataset
  - can't join. don't care. never join user data w/ other user data
- Each user assigned to a cluster number
- Each cluster has multiple machines
  - writes self-contained in cluster (writing to 2-3 machines, not 6)

User Cluster Implementation

- $u = LJ::load_user(“brad”)
  - hits global cluster
  - $u object contains its clusterid
- $dbcm = LJ::get_cluster_master($u)
  - writes
  - definitive reads
- $dbcr = LJ::get_cluster_reader($u)
  - reads

User Clusters

```
SELECT userid,
clusterid FROM
user WHERE
user='bob'
```




```
userid: 839
clusterid: 2
```

```
SELECT ....
FROM ...
WHERE
userid=839 ...
```

```
OMG i like
totally hate
my parents
they just
dont
understand me
and i h8 the
world omg lol
rofl *! :^-
^^;
```

- almost resembles today's architecture

```
add me as a
friend!!!
```

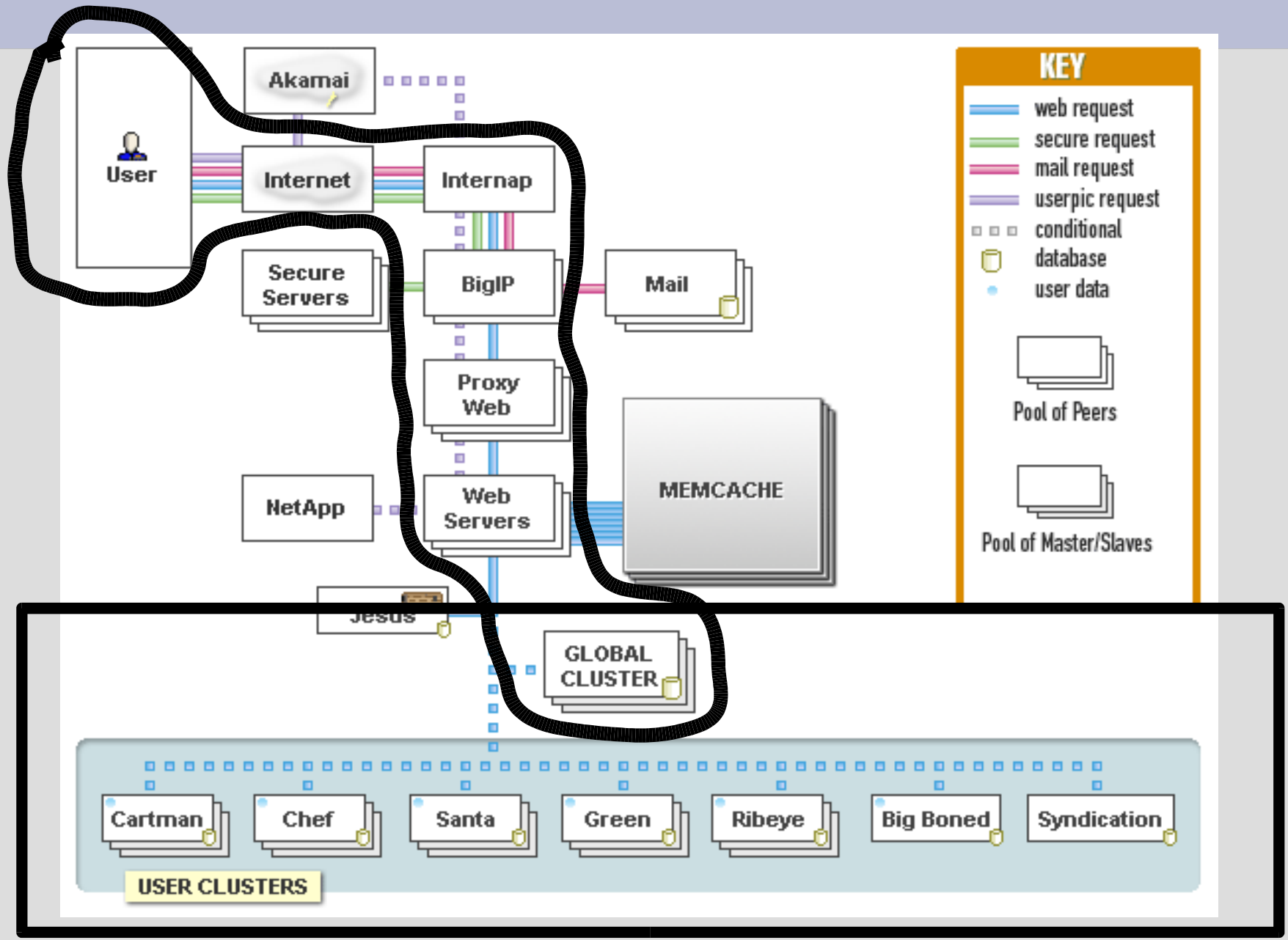
User Cluster Implementation

- per-user numberspaces
  - can't use AUTO_INCREMENT
  - avoid it also on final column in multi-col index: (MyISAM-only feature)
    - CREATE TABLE foo (uid INT, postid INT AUTO_INCREMENT, PRIMARY KEY (userid, postid))
- moving users around clusters
  - balancing disk IO
  - balance disk space
  - monitor everything
    - cricket
    - nagios
    - ...whatever works

DBI::Role – DB Load Balancing

- Our library on top of DBI
  - GPL; not packaged anywhere but our cvs
- Returns handles given a role name
  - master (writes), slave (reads)
  - directory (innodb), ...
  - cluster<n>{,slave,a,b}
  - Can cache connections within a request or forever
- Verifies connections from previous request
- Realtime balancing of DB nodes within a role
  - web / CLI interfaces (not part of library)
  - dynamic reweighting when node down

Where we're at...



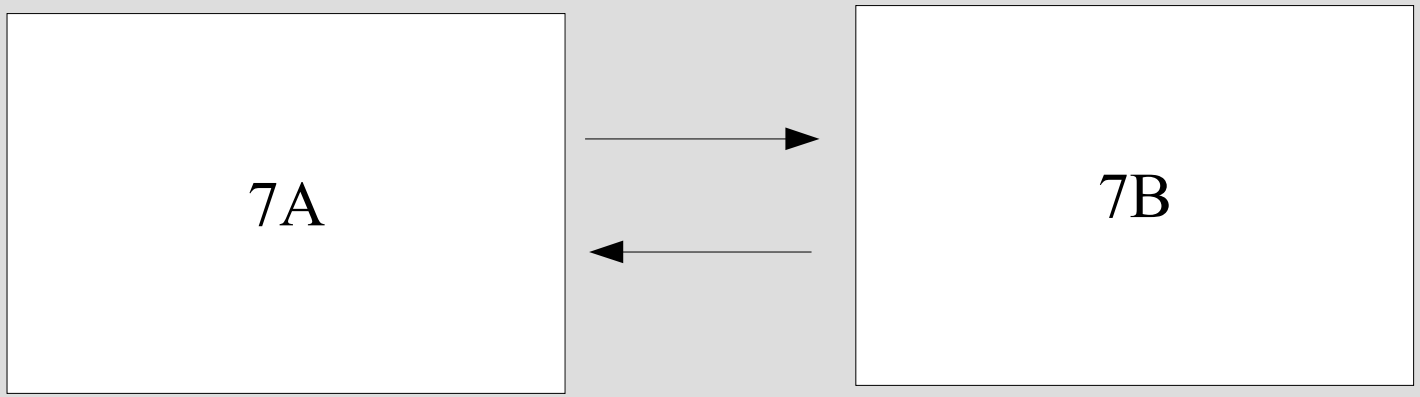
Points of Failure

- 1 x Global master
  - lame
- *n* x User cluster masters
  - *n* x lame.
- Slave reliance
  - one dies, others reading too much

Solution?

Master-Master Clusters!

- two identical machines per cluster
  - both “good” machines
- do all reads/writes to one at a time, both replicate from each other
- intentionally only use half our DB hardware at a time to be prepared for crashes
- easy maintenance by flipping active node
- backup from inactive node

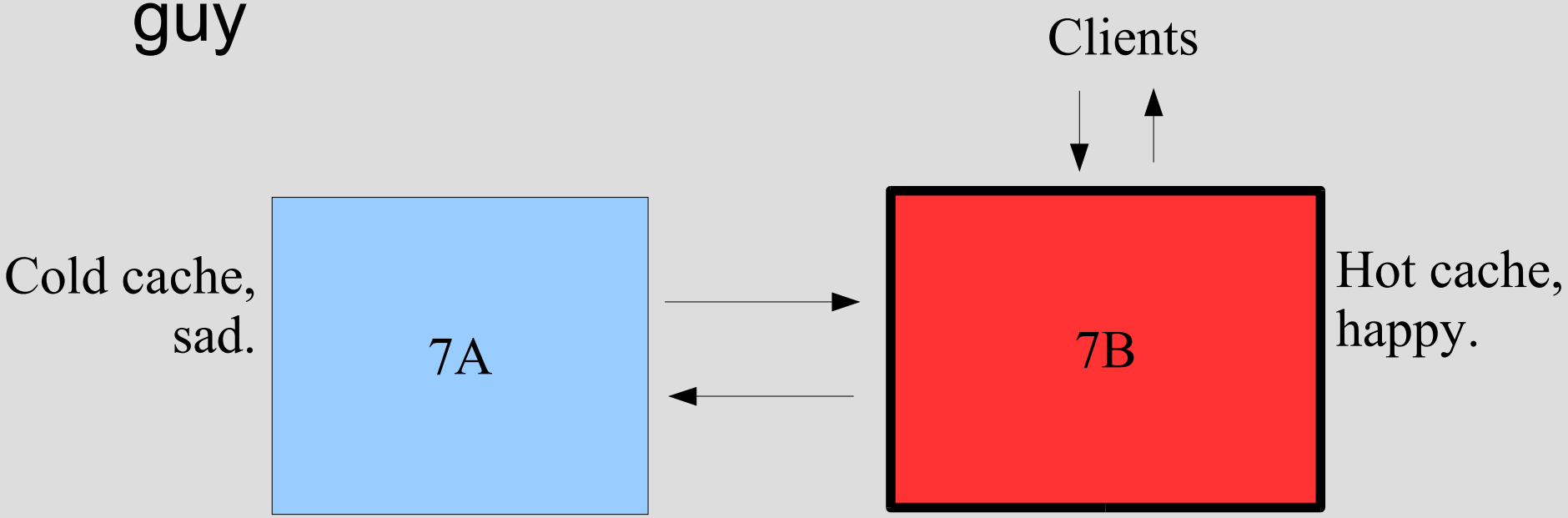


Master-Master Prereqs

- failover can't break replication, be it:
  - automatic
    - be prepared for flapping
  - by hand
    - probably have other problems if swapping, don't need more breakage
- fun/tricky part is number allocation
  - same number allocated on both pairs
  - avoid AUTO_INCREMENT
  - cross-replicate, explode.
  - do your own sequence generation w/ locking, 3rd party arbitrator, odd/even, etc...

Cold Co-Master

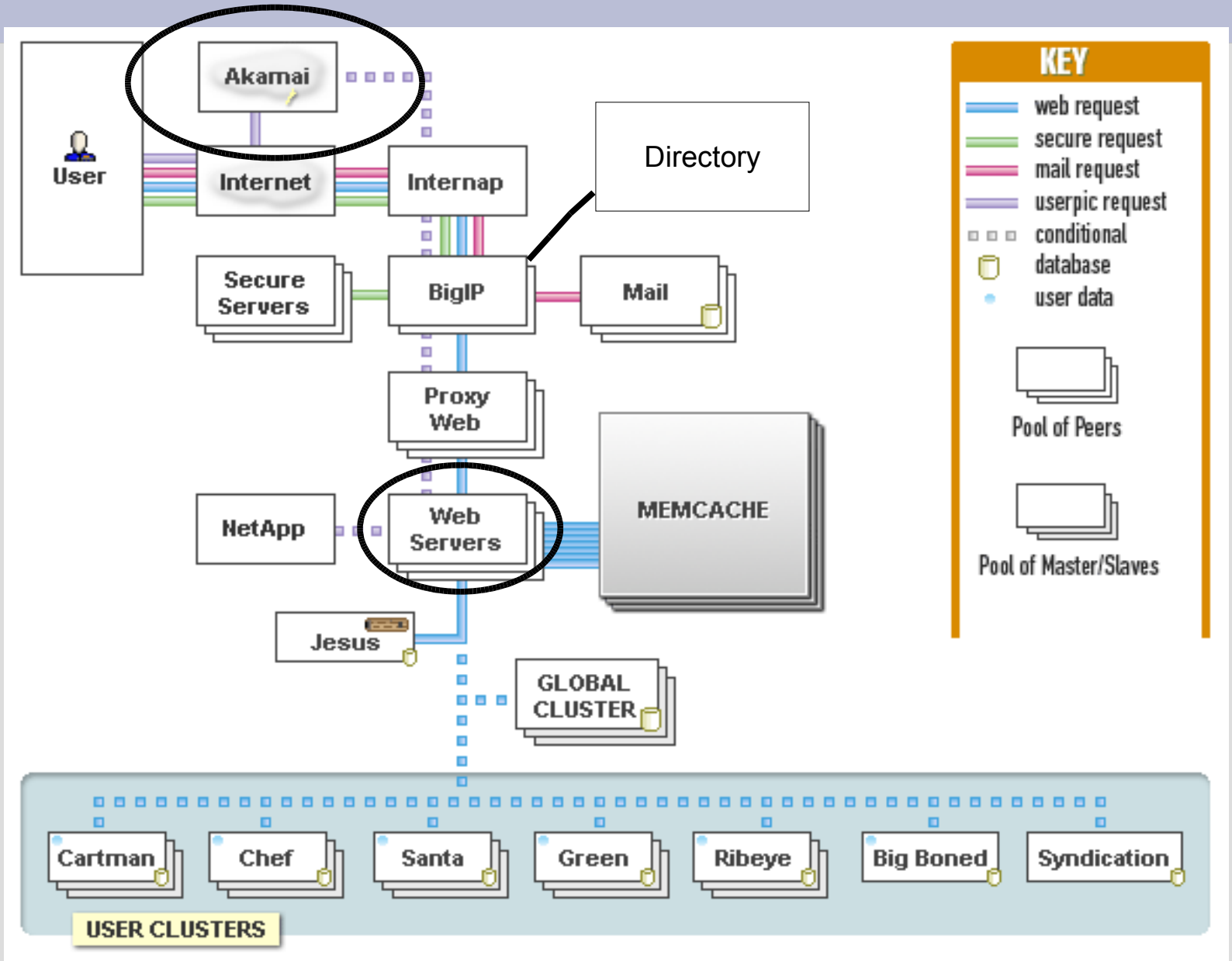
- inactive pair isn't getting reads
- after switching active machine, caches full, but not useful (few min to hours)
- switch at night, or
- sniff reads on active pair, replay to inactive guy



Summary Thus Far

- Dual BIG-IPs (or LVS+heartbeat, or..)
- ~40 web servers
- 1 “global cluster”:
  - non-user/multi-user data
  - what user is where?
  - master-slave (lame)
    - point of failure; only cold spares
    - pretty small dataset (<4 GB)
      - future: MySQL Cluster!
        - in memory, shared-nothing, 99.999% uptime
- bunch of “user clusters”:
  - master-slave (old ones)
  - master-master (new ones)
- ...

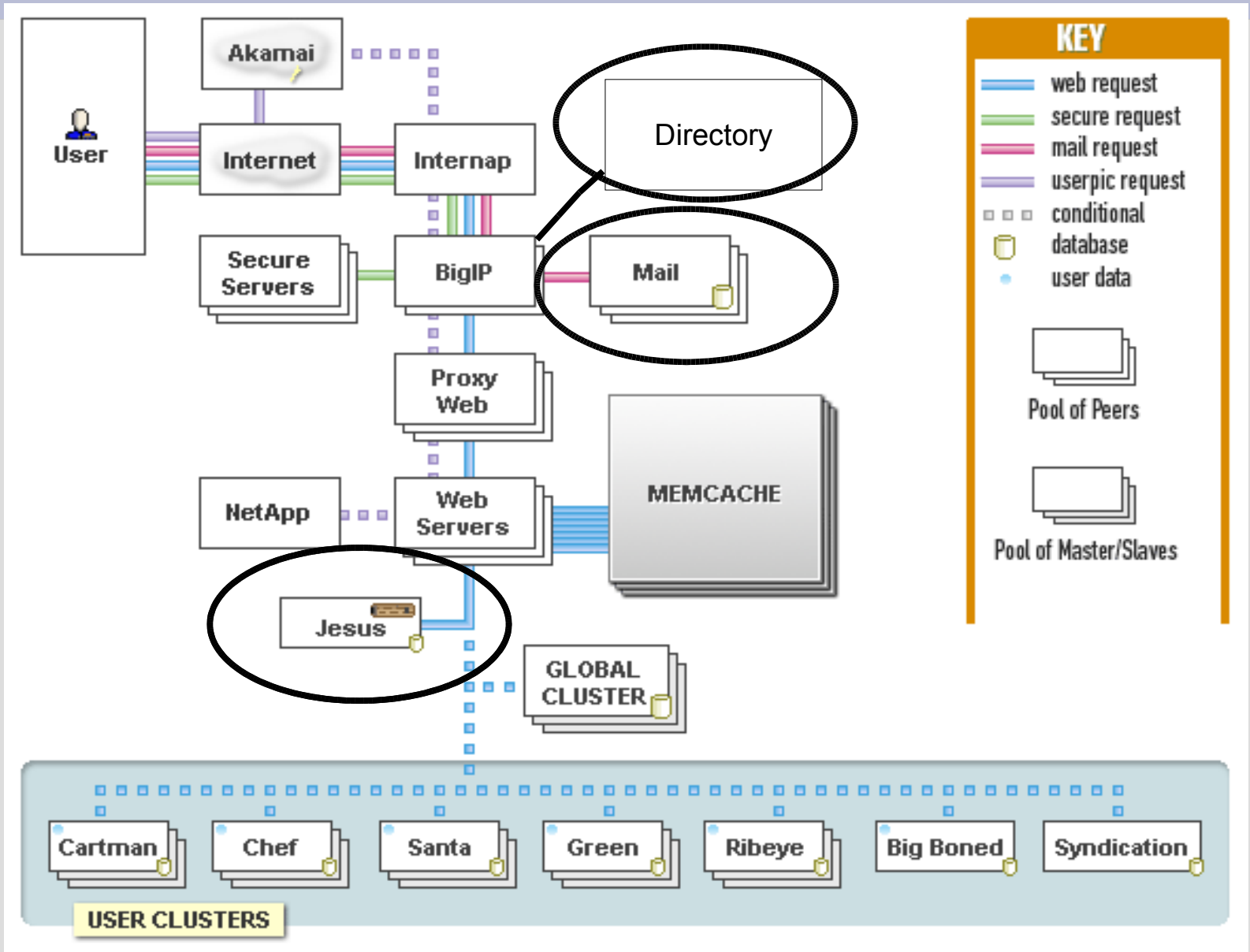
Static files...



Dynamic vs. Static Content

- static content
  - images, CSS
  - TUX, epoll-thttpd, etc. w/ thousands conns
  - boring, easy
- dynamic content
  - session-aware
    - site theme
    - browsing language
  - security on items
  - deal with heavy (memory hog) processes
  - exciting, harder

Misc MySQL Machines



MyISAM vs. InnoDB

- We use both
- MyISAM
  - fast for reading xor writing,
  - bad concurrency, compact,
  - no foreign keys, constraints, etc
  - easy to admin
- InnoDB
  - ACID
  - good concurrency
    - long slow queries while updates continue
    - directory server
- Mix-and-match.

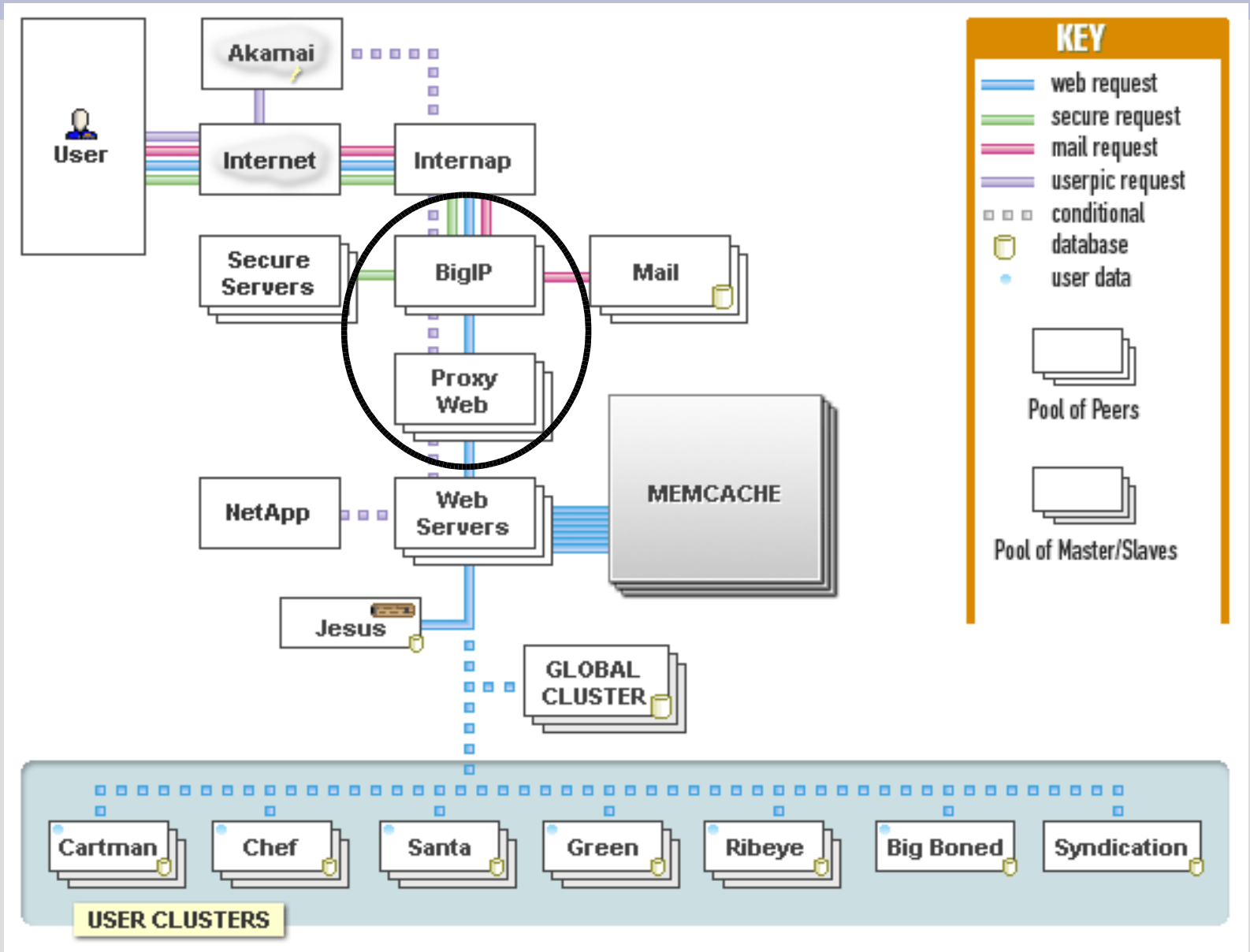
Postfix & MySQL

- 4 postfix servers
  - load balance incoming connections w/ BIG-IP
  - each runs tiny MySQL install
    - replicates one table (email_aliases)
- Incoming mail uses mysql map type
  - To: brad@livejournal.com
  - SELECT email FROM email_aliases WHERE alias='brad@livejournal.com'
- Don't have rebuild huge DBM files every few minutes

Logging to MySQL

- mod_perl logging handler
- new table per hour
  - MyISAM
- Apache access logging off
  - diskless web nodes, PXE boot
  - apache error logs through syslog-ng
- INSERT DELAYED
  - increase your insert buffer if querying
- minimal/no indexes
  - table scans are fine
- background job doing log analysis/rotation

Load Balancing!



Load Balancing Problem Overview

- slow clients (hogging mod_perl/php)
  - even DSL/Cable is “slow”
  - need to spoon-feed clients
    - who will buffer?
- heterogeneous hardware and response latencies
  - load balancing algorithms
  - unlucky, clogged nodes
- dealing with backend failures
- The “Listen Backlog Problem”
  - is proxy/client talking to kernel or apache?
- live config changes

Two proxy / load balancing layers

- 1: IP-level proxy
  - little or no buffering
    - 1 or 2 machines
      - hot spare, stateful failover
    - finite memory
  - Gbps+ switching
- 2: HTTP-level proxy
  - more machines
  - buffer here

Proxy layer 1: IP-level

- Options:
  - Commercial:
    - BIG-IP, Alteon, Foundry, etc, etc...
  - Open Source:
    - Linux Virtual Server, Wackamole*
- load balance methods:
  - round robin, weighted round robin
  - least connections
- some have L7 capabilities
  - useful, but still need another proxy layer...

Proxy layer 2: HTTP-level

- Options:
  - mod_proxy
    - “typical” setup with mod_perl
    - to one host by default
    - mod_rewrite + external map program (prg:) with mod_proxy dest ([P])
      - broadcast Apache free/idle status from Apache scoreboard
      - flakey
    - “proxy connect error” to clients
  - pound
  - mod_backhand
  - Squid
  - plb (pure load balancer)
- Frustrated, needy, we wrote our own...

Perlbal

- Perl
- uses Linux 2.6's epoll
- single threaded, event-based
- console / HTTP remote management
  - live config changes
- handles dead nodes
- static webserver mode
  - sendfile(), async stat() / open()
- plug-ins
  - GIF/PNG altering
- ...

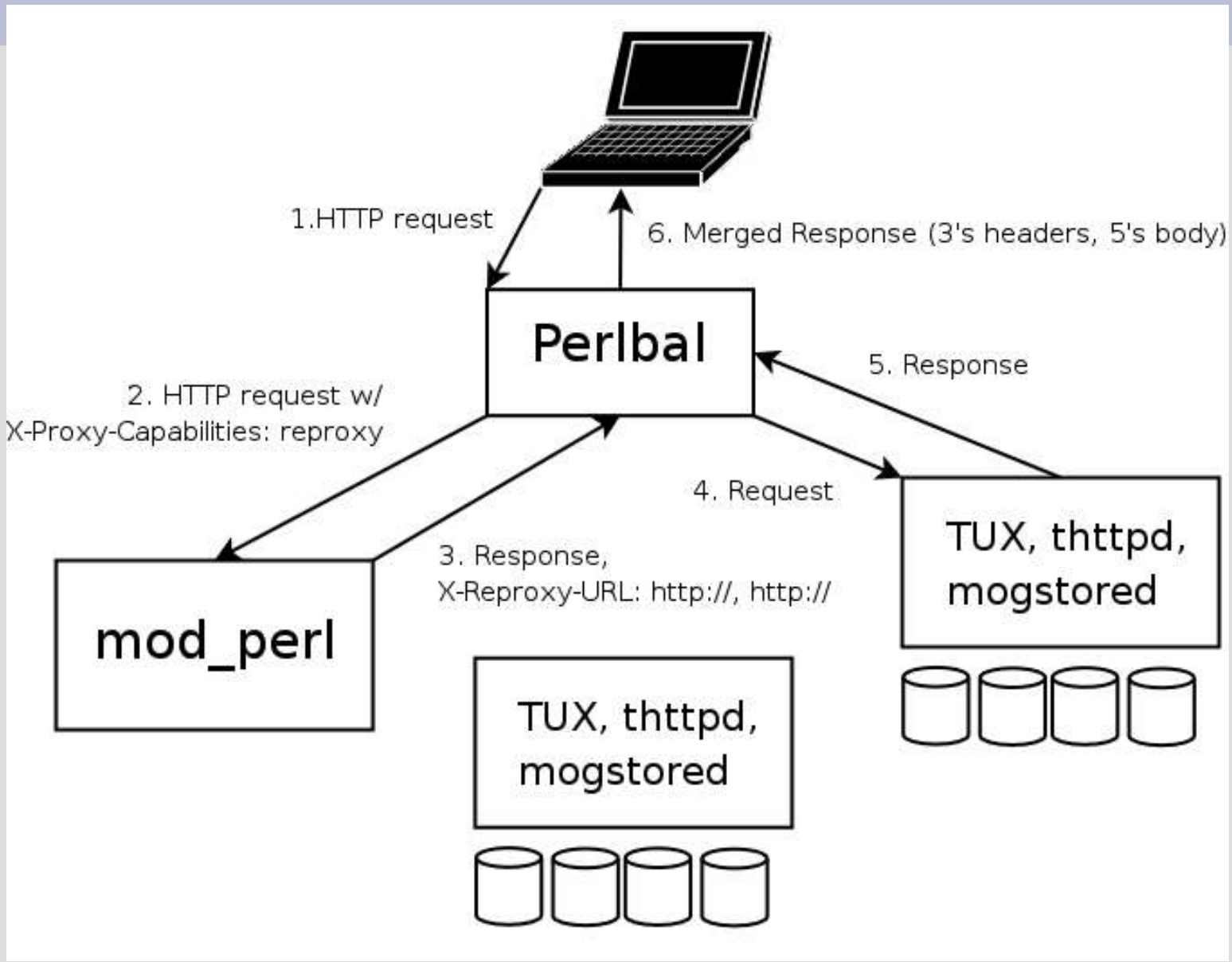
Perlbal: Persistent Connections

- persistent connections
  - perlbal to backends (mod_perls)
  - know exactly when a connection is ready for a new request
    - keeps backends busy
    - connection known good
      - tied to mod_perl, not kernel
- verifies new connections
  - one new pending connect per backend
  - verifies backend connection
    - OPTIONS request w/ keep-alive
    - response quick for apache
- multiple queues
  - free vs. paid user queues

Perlbal: cooperative large file serving

- large file serving w/ mod_perl bad...
  - buffering
- internal redirects
  - to URLs (plural) or file path
    - (hence Perlbal's web server mode)
  - client sees no HTTP redirect
- The path:
  - Perlbal advertises “X-Proxy-Capability: reproxy” to backend
  - backend (mod_perl) does path trans & auth, sees proxy capability, sends URL/path back in header, not response
    - let mod_perl do hard stuff, not push bytes around

Internal redirect picture



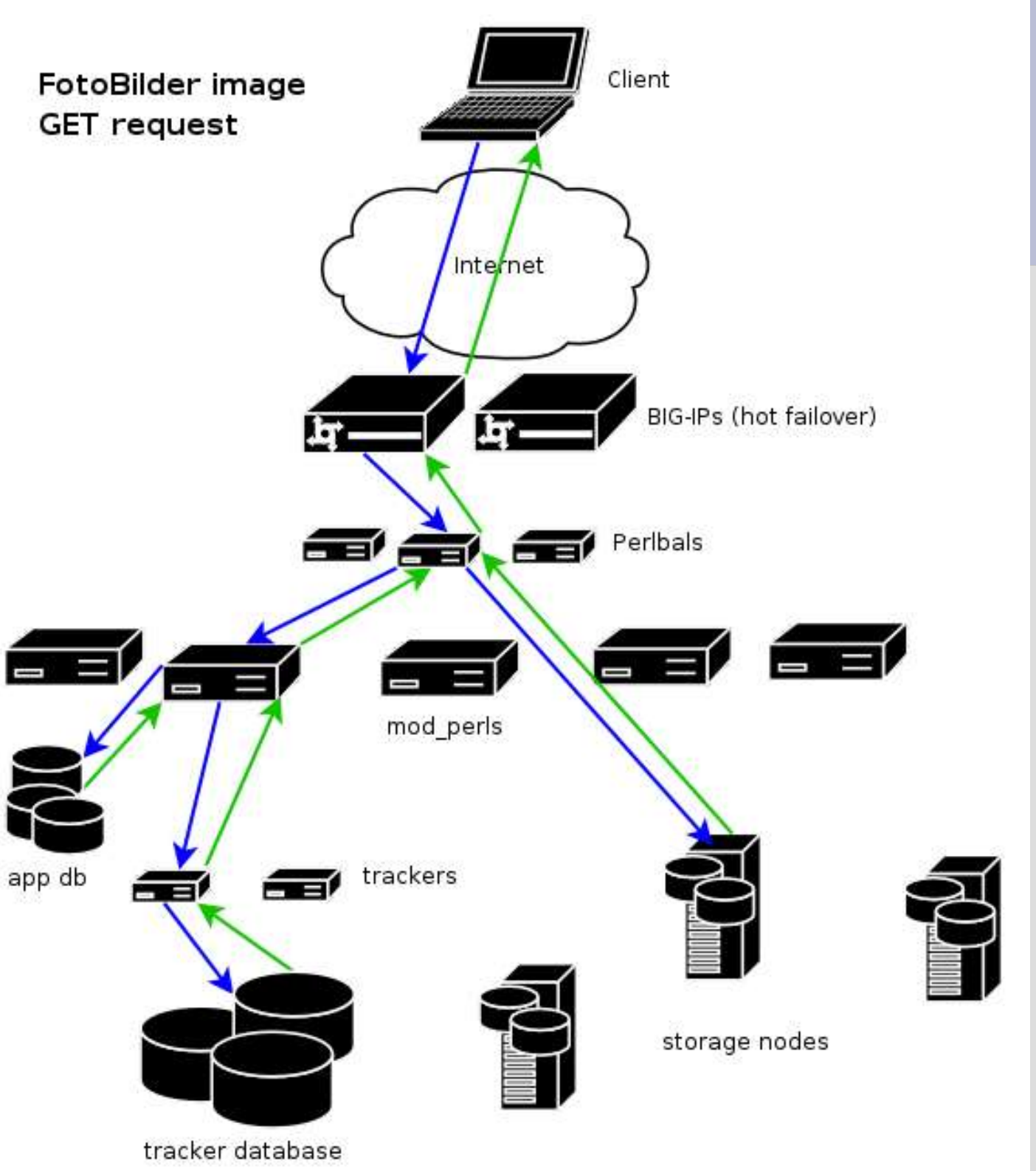
MogileFS: distributed filesystem

- looked into Lustre, GFS, scared of in-development status
- MogileFS main ideas:
  - files belong to classes
    - classes: minimum replica counts (thumbnails == 1)
  - track what devices (disks) files are on
    - states: up, temp_down, dead
  - keep replicas on devices on different hosts
    - Screw RAID! (for this, for databases it's good.)
  - multiple tracker databases
    - all share same MySQL cluster database
  - big, cheap disks (12 x 250GB SATA in 3U)
  - dumb storage nodes

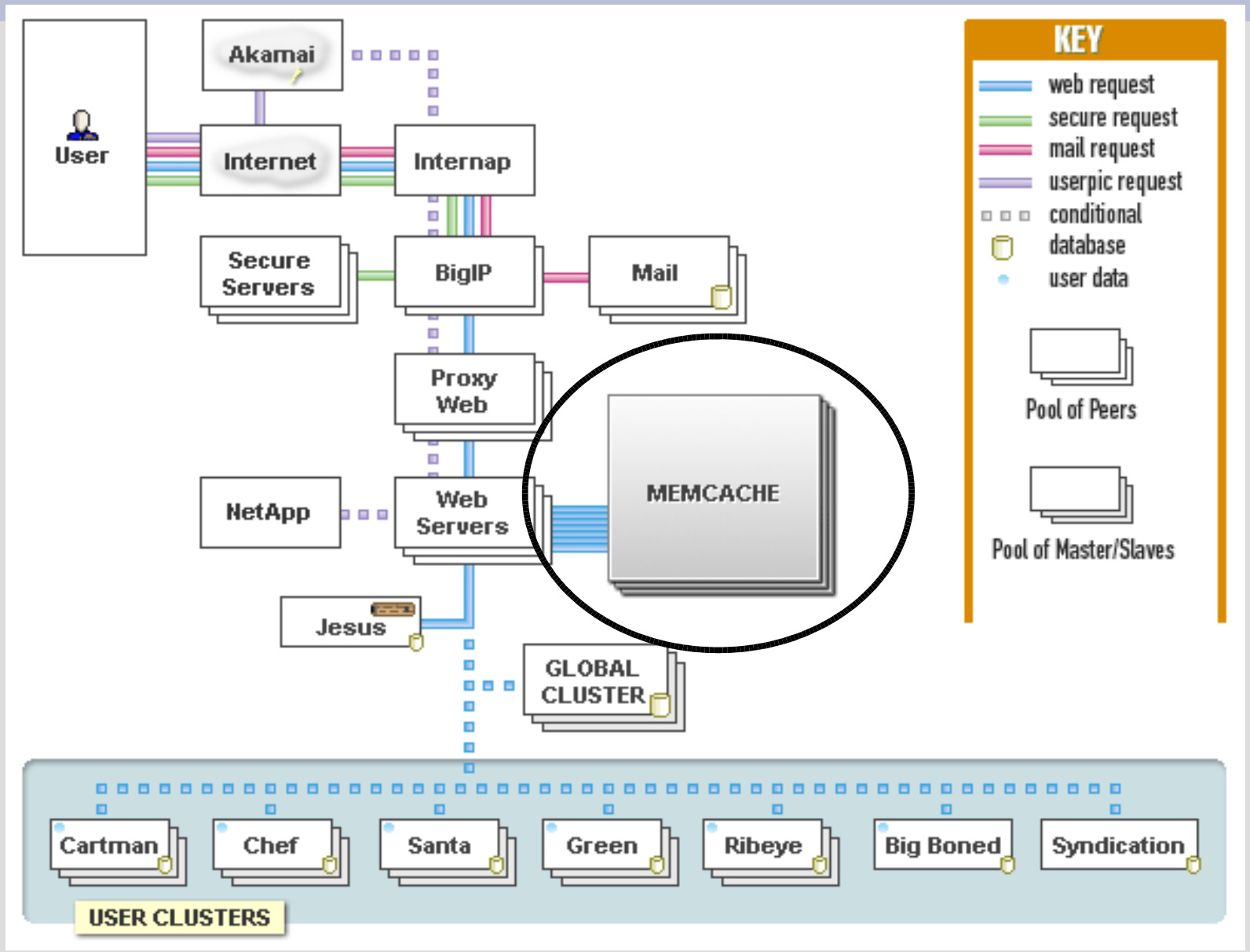
MogileFS components

- clients
  - small, simple Perl library
  - FUSE filesystem driver (unfinished)
- trackers
  - interface between client protocol and MySQL Cluster
- MySQL Cluster
  - in memory, multiple machines
- Storage nodes
  - NFS or HTTP transport
    - [Linux] NFS *incredibly* problematic
  - HTTP transport is Perlbal with PUT & DELETE enabled

Large file GET request



Caching!


User
Akamai
Internet
Internap
Secure Servers
BigIP
Mail
Proxy Web
MEMCACHE
NetApp
Web Servers
Jesus
GLOBAL CLUSTER
Cartman
Chef
Santa
Green
Ribeye
Big Boned
Syndication
USER CLUSTERS
KEY
web request
secure request
mail request
userpic request
conditional
database
user data
Pool of Peers
Pool of Master/Slaves

Caching

- caching's key to performance
- can't hit the DB all the time
  - MyISAM: major r/w concurrency problems
  - InnoDB: good concurrency
    - not as fast as memory
  - MySQL has to parse your queries all the time
    - better with new MySQL 4.1 binary protocol
- Where to cache?
  - mod_perl caching (address space per apache child)
  - shared memory (limited to single machine, same with Java/C#/Mono)
  - MySQL query cache: flushed per update, small max size
  - HEAP tables: fixed length rows, small max size

memcached

http://www.danga.com/memcached/

- our Open Source, distributed caching system
- run instances wherever there's free memory
- no “master node”
- clients distribute requests
- In use by:
  - LiveJournal, Slashdot, Wikipedia, Meetup, mail systems, etc...
- protocol simple and XML-free; clients for:
  - perl, java, php(x3), python, ruby, C(?)...

How memcached works

- requests hashed out amongst instance “buckets”
  - CRC32(“key”) = 383472 % num_buckets = 6
  - bucket 23 ... server 10.1.0.23: send: “key” = “value”

3 hosts, 7 buckets; 512 MB = 1 bucket (arbitrary)

10.1.0.18 1024 MB; buckets 0-1	10.1.0.20 2048 MB; buckets 2-5	10.1.0.23 512 MB; bucket 6

weather = dismal
tu:29323 = 1091029955

key = value

memcached – speed

- C
  - prototype Perl version proved concept, too slow
- async IO, event-driven, single-threaded
- libevent (epoll, kqueue, select, poll...)
  - run-time mode selection
- lockless, refcounted objects
- slab allocator
  - glibc malloc died after 7~8 days
    - variable sized allocations, long life = difficult
  - slabs: no address space fragmentation ever.
- O(1) operations
  - hash table, LRU cache
- multi-server parallel fetch (can't do in DBI)

LiveJournal and memcached

- 10 unique hosts
  - none dedicated
- 28 instances (512 MB = 1 bucket)
- 30 GB of cached data
- 90-93% hit rate
  - not necessarily 90-93% less queries:
    - FROM foo WHERE id IN (1, 2, 3)
    - would be 3 memcache hits; 1 mysql query
  - 90-93% potential disk seeks?
- 12 GB machine w/ five 2GB instances
  - left-over 'big' machines from our learn-to-scale-out days

What to Cache

- Everything?
- Start with stuff that's hot
- Look at your logs
  - query log
  - update log
  - slow log
- Control MySQL logging at runtime
  - can't
    - (been bugging them)
  - sniff the queries! Net::Pcap
- count
  - add identifiers: SELECT /* name=foo */

Caching Disadvantages

- more code
  - using
  - populating
  - invalidating
  - easy, if your API is clean
- conceptually lame
  - database should do it
    - kinda.
    - database doesn't know object lifetimes
      - putting memcached between app and DB doesn't work
- more stuff to admin
  - but memcached is easy
  - one real option: memory to use

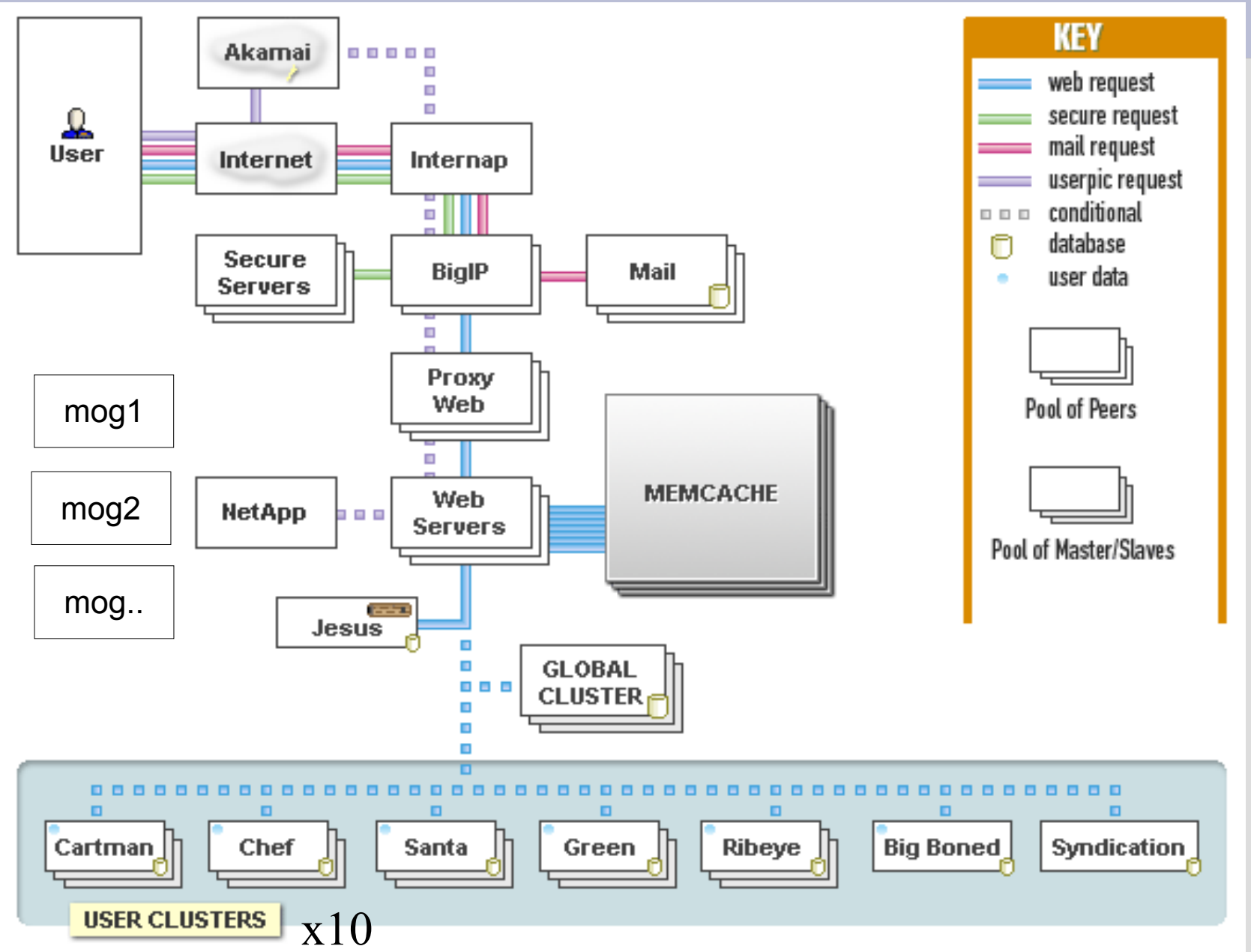
MySQL Persistent Connection Woes

- connections == threads == memory
- max threads
  - limit max memory
- with 10 user clusters:
  - Bob is on cluster 5
  - Alice on cluser 6
  - Do you need Bob's DB handles alive while you process Alice's request?
- Major wins by disabling persistent conns
  - still use persistent memcached conns
  - db hits are rare
  - mysql conns quick (opposed to, say, Oracle)

Software Overview

- BIG-IPs
- Debian
  - Linux 2.4
  - Linux 2.6 (epoll)
- mod_perl
- MySQL
- Perlbal
- MogileFS

Questions?


User
Akamai
Internet
Internap
Secure Servers
BigIP
Mail
Proxy Web
mog1
mog2
mog..
NetApp
Web Servers
MEMCACHE
Jesus
GLOBAL CLUSTER
Cartman
Chef
Santa
Green
Ribeye
Big Boned
Syndication
USER CLUSTERS
x10
KEY
web request
secure request
mail request
userpic request
conditional
database
user data
Pool of Peers
Pool of Master/Slaves

Thank you!

Questions to...
brad@danga.com

Slides linked off:
http://www.danga.com/words/