all the little pieces

distributed systems with PHP

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Who is this guy?

- Open Source Fellow @ Digg
- PHP Core Developer since 1999
- Architect of the Unicode/i18n support
- Release Manager for PHP 6
- Beer lover (and brewer)

Why distributed?

- Because Moore's Law will not save you
- Despite what DHH says

Share nothing

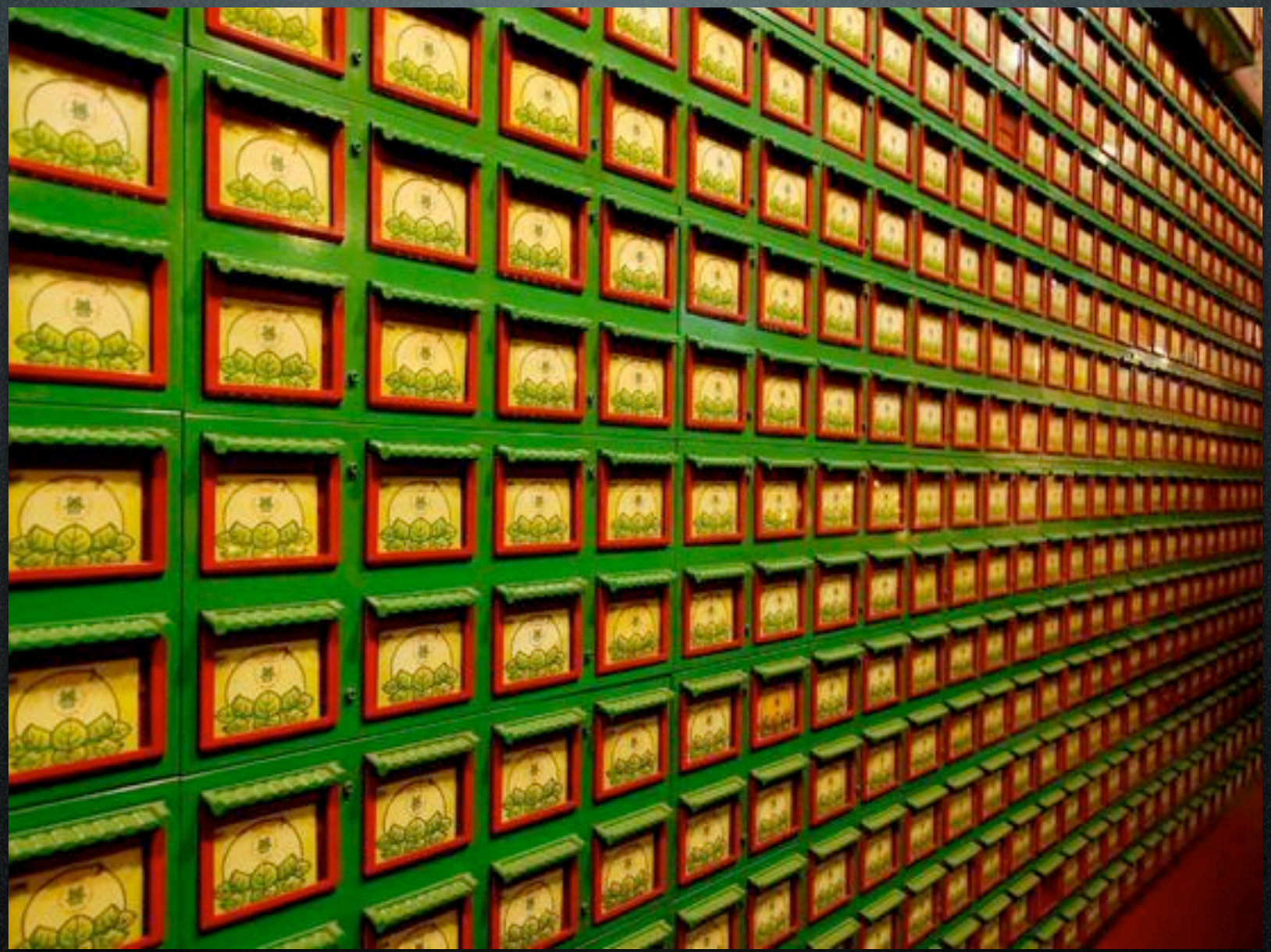
- Your Mom was wrong
- No shared data on application servers
- Distribute it to shared systems

distribute...

- memory (memcached)
- storage (mogilefs)
- work (gearman)

Building blocks

- GLAMMP - have you heard of it?
- Gearman + LAMP + Memcached
- Throw in Mogile too



memcached

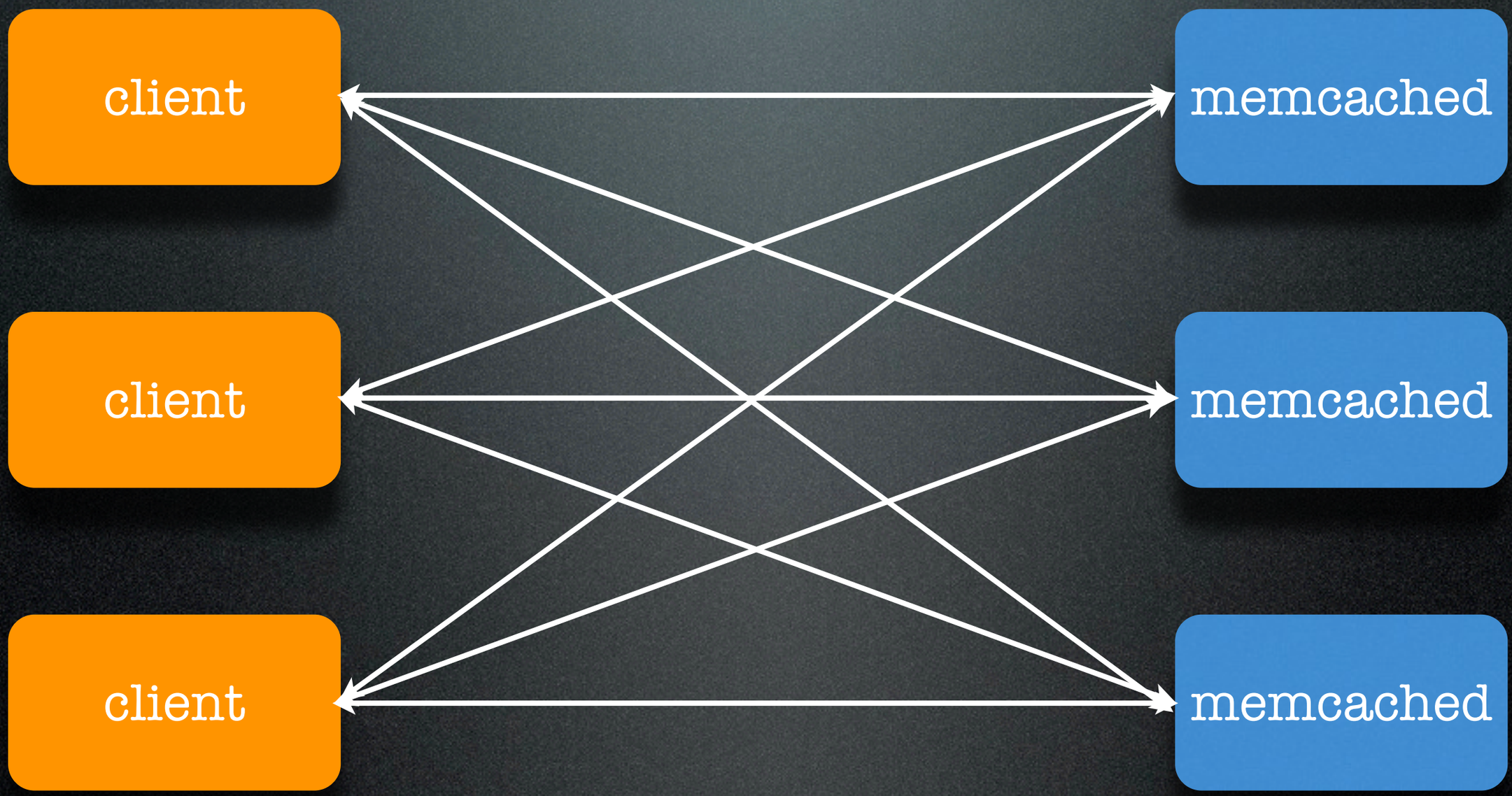
background

- created by Danga Interactive
- high-performance, distributed memory object caching system
- sustains Digg, Facebook, LiveJournal, Yahoo!, and many others
- if you aren't using it, you are crazy

background

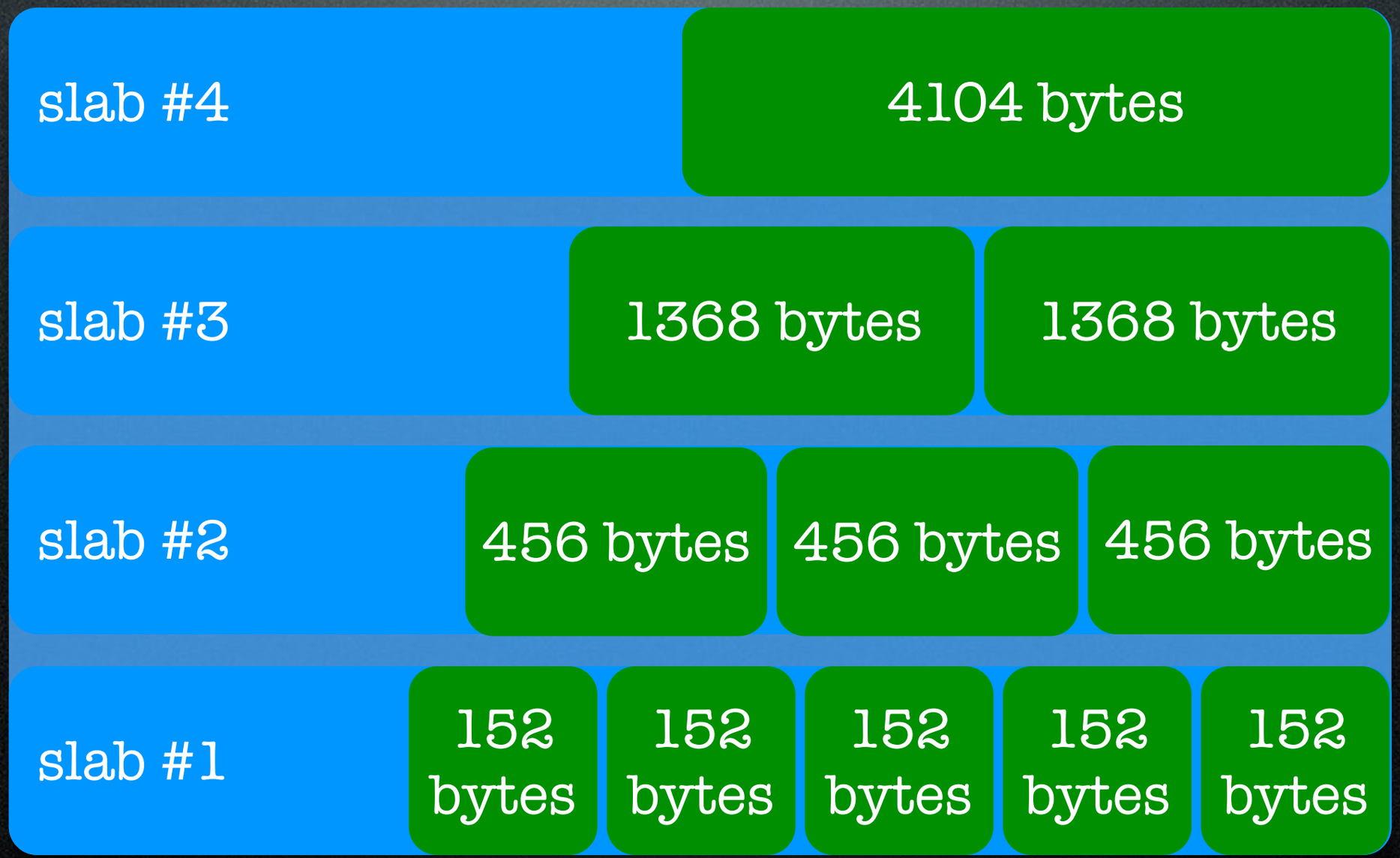
- Very fast over the network and very easy to set up
- Designed to be transient
- You still need a database

architecture



architecture

memcached


slab #4
4104 bytes
slab #3
1368 bytes
1368 bytes
slab #2
456 bytes
456 bytes
456 bytes
slab #1
152 bytes
152 bytes
152 bytes
152 bytes
152 bytes

memory architecture

- memory allocated on startup, released on shutdown
- variable sized slabs (30+ by default)
- each object is stored in the slab most fitting its size
- fragmentation can be problematic

memory architecture

- items are deleted:
  - on set
  - on get, if it's expired
  - if slab is full, then use LRU

applications

- object cache
- output cache
- action flood control / rate limiting
- simple queue
- and much more

PHP clients

- a few private ones (Facebook, Yahoo!, etc)
- pecl/memcache
- pecl/memcached

pecl/memcached

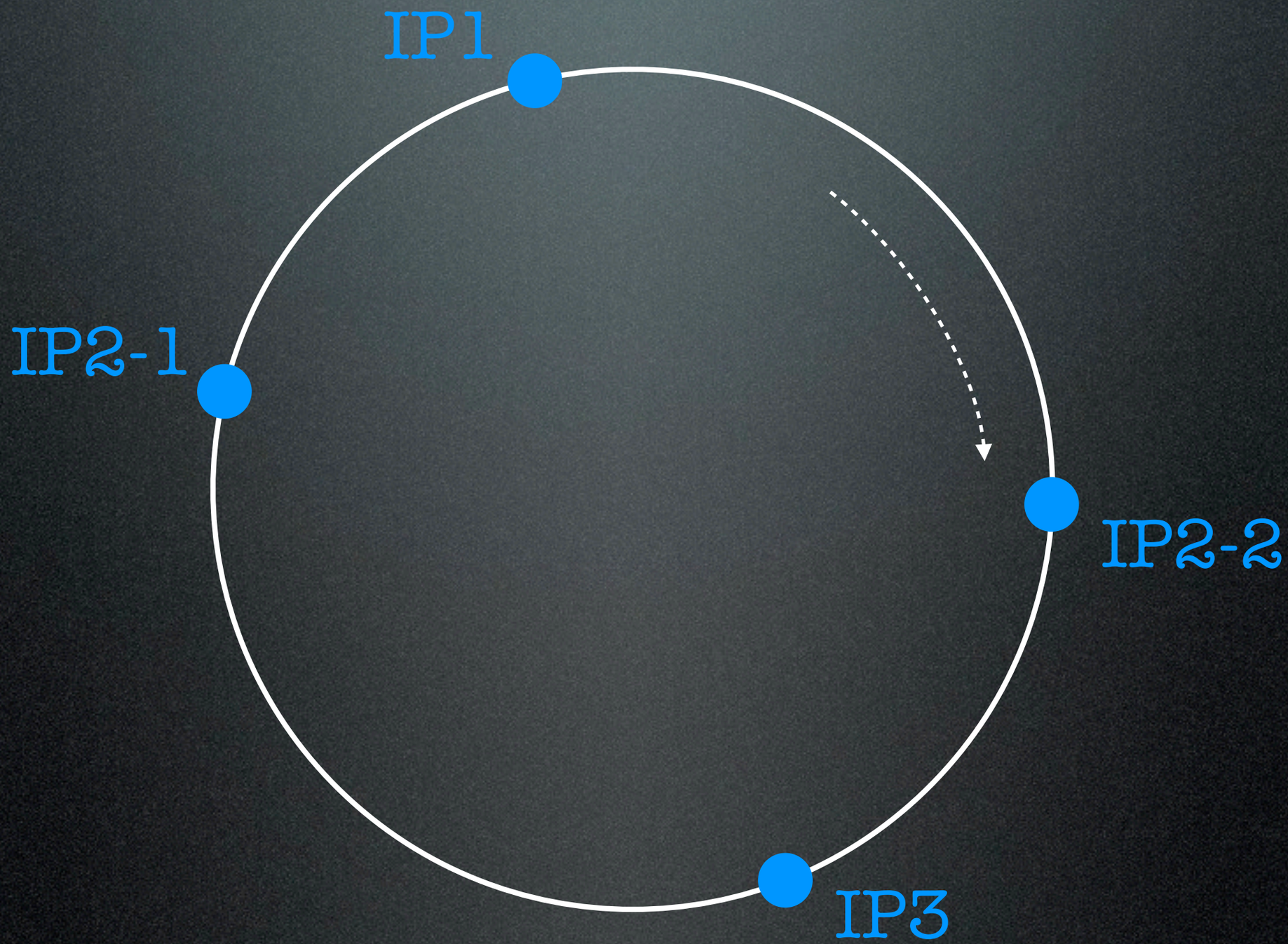
- based on libmemcached
- released in January 2009
- surface API similarity to pecl/memcache
- parity with other languages

API

- get
- set
- add
- replace
- delete
- append
- prepend

- cas
- *_by_key
- getMulti
- setMulti
- getDelayed / fetch*
- callbacks

consistent hashing



compare-and-swap (cas)

- “check and set”
- no update if object changed
- relies on CAS token

compare-and-swap (cas)

```php
$m = new Memcached();
$m->addServer('localhost', 11211);

do {
    $ips = $m->get('ip_block', null, $cas);

    if ($m->getResultCode() == Memcached::RES_NOTFOUND) {

        $ips = array($_SERVER['REMOTE_ADDR']);
        $m->add('ip_block', $ips);

    } else {

        $ips[] = $_SERVER['REMOTE_ADDR'];
        $m->cas($cas, 'ip_block', $ips);
    }

} while ($m->getResultCode() != Memcached::RES_SUCCESS);
```

delayed “lazy” fetching

- issue request with `getDelayed()`
- do other work
- fetch results with `fetch()` or `fetchAll()`

binary protocol

- performance
  - every request is parsed
  - can happen thousands times a second
- extensibility
  - support more data in the protocol

callbacks

- read-through cache callback
- if key is not found, invoke callback, save value to memcache and return it

callbacks

- result callback
- invoked by `getDelayed()` for every found item
- should not call `fetch()` in this case

buffered writes

- queue up write requests
- send when a threshold is exceeded or a ‘get’ command is issued

key prefixing

- optional prefix prepended to all the keys automatically
- allows for namespacing, versioning, etc.

key locality

- allows mapping a set of keys to a specific server

multiple serializers

- PHP
- igbinary
- JSON (soon)

future

- UDP support
- replication
- server management (ejection, status callback)

tips & tricks

- 32-bit systems with > 4GB memory:

```
memcached -m4096 -p11211
memcached -m4096 -p11212
memcached -m4096 -p11213
```

tips & tricks

- write-through or write-back cache
- Warm up the cache on code push
- Version the keys (if necessary)

tips & tricks

- Don’t think row-level DB-style caching; think complex objects
- Don’t run memcached on your DB server — your DBAs might send you threatening notes
- Use multi-get — run things in parallel

delete by namespace

```
1  $ns_key = $memcache->get("foo_namespace_key");
2  // if not set, initialize it
3  if ($ns_key === false)
4      $memcache->set("foo_namespace_key",
5        rand(1, 10000));
6  // cleverly use the ns_key
7  $my_key = "foo_".$ns_key."_12345";
8  $my_val = $memcache->get($my_key);
9  // to clear the namespace:
10 $memcache->increment("foo_namespace_key");
```

storing lists of data

- Store items under indexed keys: comment.12, comment.23, etc
- Then store the list of item IDs in another key: comments
- To retrieve, fetch comments and then multi-get the comment IDs

preventing stampeding

- embedded probabilistic timeout
- gearman unique task trick

optimization

- watch stats (eviction rate, fill, etc)
  - getStats()
  - telnet + “stats” commands
  - peep (heap inspector)

slabs

- Tune slab sizes to your needs:
  - **-f** chunk size growth factor (default 1.25)
  - **-n** minimum space allocated for key +value+flags (default 48)

slabs

```
slab class   1: chunk size     104 perslab 10082
slab class   2: chunk size     136 perslab  7710
slab class   3: chunk size     176 perslab  5957
slab class   4: chunk size     224 perslab  4681
...
slab class  38: chunk size 394840 perslab     2
slab class  39: chunk size 493552 perslab     2
```

Default: 38 slabs

slabs

Most objects: ~1-2KB, some larger

```
slab class   1: chunk size   1048 perslab  1000
slab class   2: chunk size   1064 perslab   985
slab class   3: chunk size   1080 perslab   970
slab class   4: chunk size   1096 perslab   956
...
slab class 198: chunk size   9224 perslab   113
slab class 199: chunk size   9320 perslab   112
```

`memcached -n 1000 -f 1.01`

memcached @ digg

ops

- memcached on each app server (2GB)
- the process is niced to a lower level
- separate pool for sessions
- 2 servers keep track of cluster health

key prefixes

- global key prefix for apc, memcached, etc
- each pool has additional, versioned prefix: `.sess.2`
- the key version is incremented on each release
- global prefix can invalidate all caches

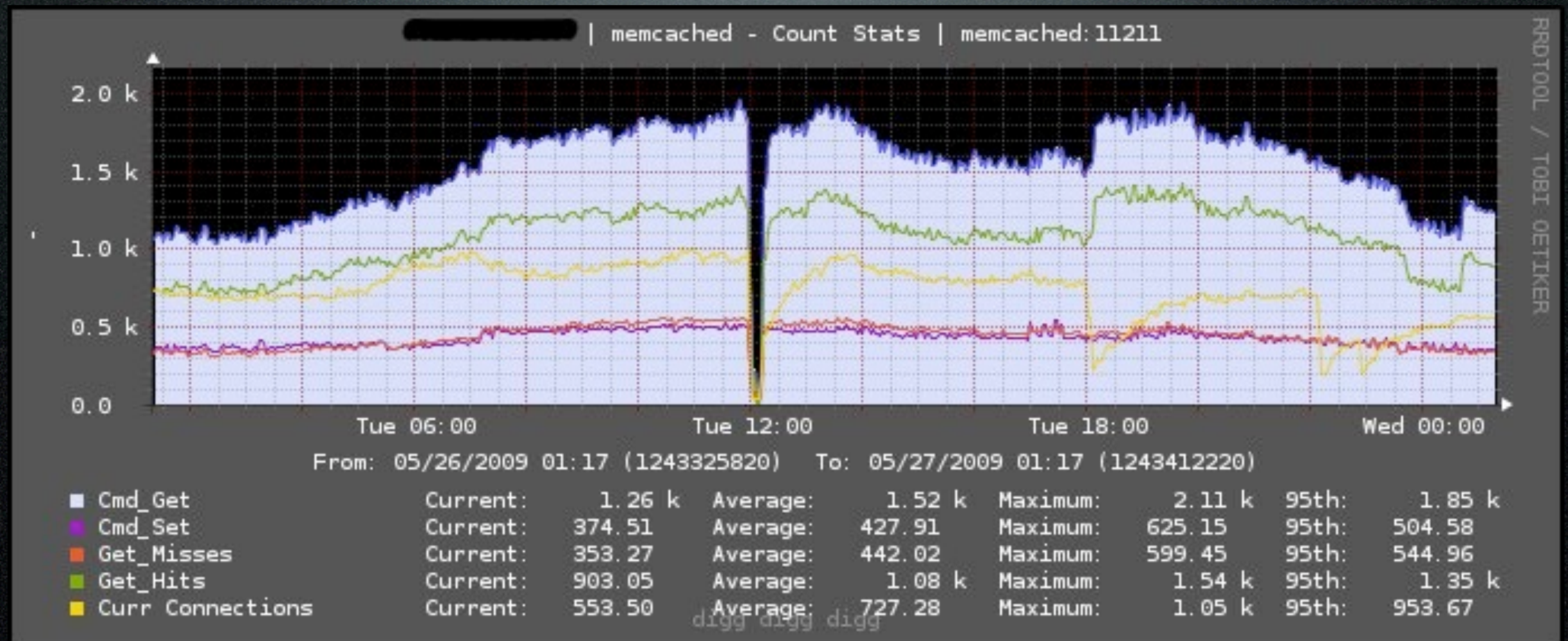
cache chain

- multi-level caching: globals, APC, memcached, etc.
- all cache access is through Cache_Chain class
- various configurations:
  - APC ➡ memcached
  - $GLOBALS ➡ APC

other

- large objects (> 1MB)
- split on the client side
- save the partial keys in a master one

stats


[redacted] | memcached - Count Stats | memcached:11211
2.0 k
1.5 k
1.0 k
0.5 k
0.0
Tue 06:00
Tue 12:00
Tue 18:00
Wed 00:00
From: 05/26/2009 01:17 (1243325820) To: 05/27/2009 01:17 (1243412220)
Cmd_Get Current: 1.26 k Average: 1.52 k Maximum: 2.11 k 95th: 1.85 k
Cmd_Set Current: 374.51 Average: 427.91 Maximum: 625.15 95th: 504.58
Get_Misses Current: 353.27 Average: 442.02 Maximum: 599.45 95th: 544.96
Get_Hits Current: 903.05 Average: 1.08 k Maximum: 1.54 k 95th: 1.35 k
Curr Connections Current: 553.50 Average: 727.28 Maximum: 1.05 k 95th: 953.67
digg digg digg
RRDTOOL / TOBI OETIKER

moxi - memcached proxy

- homogenization
- multi-get escalation
- protocol pipelining
- statistics, etc

alternatives

- in-memory: Tokyo Tyrant, Scalaris
- persistent: Hypertable, Cassandra, MemcacheDB
- document-oriented: CouchDB

mogile

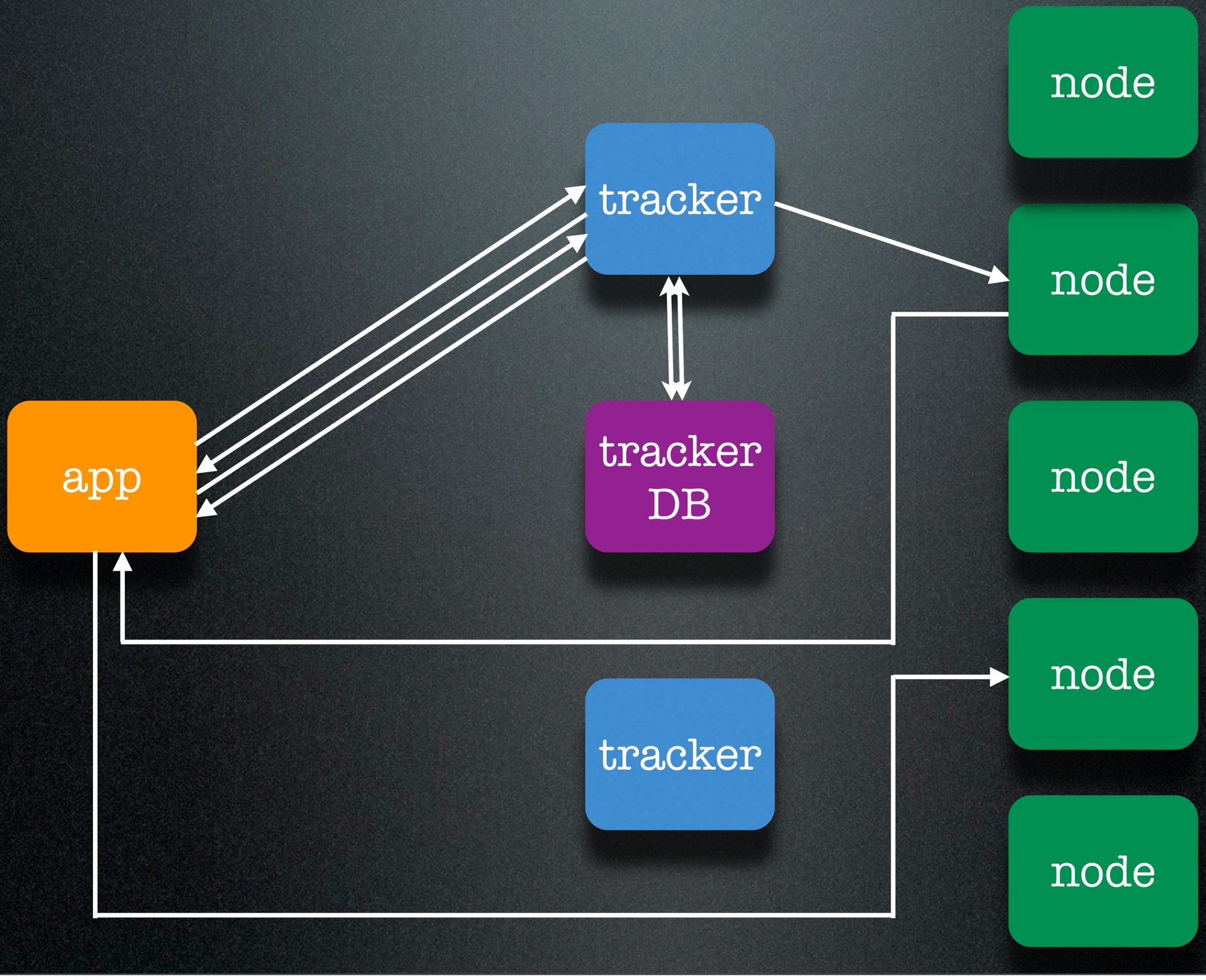
background

- created by Danga Interactive
- application-level distributed filesystem
- used at Digg, LiveJournal, etc
- a form of “cloud caching”
- scales very well

background

- automatic file replication with custom policies
- no single point of failure
- flat namespace
- local filesystem agnostic
- not meant for speed

architecture



applications

- images
- document storage
- backing store for certain caches

PHP client

- File_Mogile in PEAR
- MediaWiki one (not maintained)

Example

```
$hosts = array('172.10.1.1', '172.10.1.2');
$m = new File_Mogile($hosts, 'profiles');
$m->storeFile('user1234', 'image',
              '/tmp/image1234.jpg');

...

$paths = $m->getPaths('user1234');
```

mogile @ digg

mogile @ digg

- Wrapper around File_Mogile to cache entries in memcache
- fairly standard set-up
- trackers run on storage nodes

mogile @ digg

- not huge (about 3.5 TB of data)
- files are replicated 3x
- the user profile images are cached on Netscaler (1.5 GB cache)
- mogile cluster load is light

gearman

background

- created by Danga Interactive
- anagram of “manager”
- a system for distributing work
- a form of RPC mechanism

background

- parallel, asynchronous, scales well
- fire and forget, decentralized
- avoid tying up Apache processes

background

- dispatch function calls to machines that are better suited to do work
- do work in parallel
- load balance lots of function calls
- invoke functions in other languages

architecture

client

client

client

gearmand

worker

worker

worker

applications

- thumbnail generation
- asynchronous logging
- cache warm-up
- DB jobs, data migration
- sending email

servers

- Gearman-Server (Perl)
- gearmand (C)

clients

- Net_Gearman
  - simplified, pretty stable
- pecl/gearman
  - more powerful, complex, somewhat unstable (under development)

Concepts

- Job
- Worker
- Task
- Client

Net_Gearman

- Net_Gearman_Job
- Net_Gearman_Worker
- Net_Gearman_Task
- Net_Gearman_Set
- Net_Gearman_Client

Echo Job

```php
class Net_Gearman_Job_Echo extends Net_Gearman_Job_Common
{
    public function run($arg)
    {
        var_export($arg);
        echo "\n";
    }
}
```

Echo.php

Reverse Job

```
class Net_Gearman_Job_Reverse extends Net_Gearman_Job_Common
{
    public function run($arg)
    {
        $result = array();
        $n = count($arg);
        $i = 0;
        while ($value = array_pop($arg)) {
            $result[] = $value;
            $i++;
            $this->status($i, $n);
        }

        return $result;
    }
}
```

Reverse.php

Worker

```php
define('NET_GEARMAN_JOB_PATH', './');

require 'Net/Gearman/Worker.php';

try {
    $worker = new Net_Gearman_Worker(array('localhost:4730'));
    $worker->addAbility('Reverse');
    $worker->addAbility('Echo');
    $worker->beginWork();
} catch (Net_Gearman_Exception $e) {
    echo $e->getMessage() . "\n";
    exit;
}
```

Client

```
require_once 'Net/Gearman/Client.php';

function complete($job, $handle, $result) {
    echo "$job complete, result: ".var_export($result,
true)."\n";
}

function status($job, $handle, $n, $d)
{
    echo "$n/$d\n";
}
```

continued..

Client

```php
$client = new Net_Gearman_Client(array('lager:4730'));

$task = new Net_Gearman_Task('Reverse', range(1,5));
$task->attachCallback("complete",Net_Gearman_Task::TASK_COMPLETE);
$task->attachCallback("status",Net_Gearman_Task::TASK_STATUS);
```

continued..

Client

```
$set = new Net_Gearman_Set();
$set->addTask($task);

$client->runSet($set);

$client->Echo('Mmm... beer');
```

pecl/gearman

- More complex API
- Jobs aren't separated into files

Worker

```php
$gmworker= new gearman_worker();
$gmworker->add_server();
$gmworker->add_function("reverse", "reverse_fn");

while (1)
{
  $ret= $gmworker->work();
  if ($ret != GEARMAN_SUCCESS)
    break;
}

function reverse_fn($job)
{
  $workload= $job->workload();
  echo "Received job: " . $job->handle() . "\n";
  echo "Workload: $workload\n";
  $result= strrev($workload);
  echo "Result: $result\n";
  return $result;
}
```

Client

```
$gmclient= new gearman_client();

$gmclient->add_server('lager');

echo "Sending job\n";

list($ret, $result) = $gmclient->do("reverse", "Hello!");

if ($ret == GEARMAN_SUCCESS)
  echo "Success: $result\n";
```

gearman @ digg

gearman @ digg

- 400,000 jobs a day
- Jobs: crawling, DB job, FB sync, memcache manipulation, Twitter post, IDDB migration, etc.
- Each application server has its own Gearman daemon + workers

tips and tricks

- you can daemonize the workers easily with daemon or supervisord
- run workers in different groups, don't block on job A waiting on job B
- Make workers exit after N jobs to free up memory (supervisord will restart them)

Thrift

background

- NOT developed by Danga (Facebook)
- cross-language services
- RPC-based

background

- interface description language
- bindings: C++, C#, Cocoa, Erlang, Haskell, Java, OCaml, Perl, PHP, Python, Ruby, Smalltalk
- data types: base, structs, constants, services, exceptions

IDL

Demo

Thank You

http://gravitonic.com/talks