Gearman

OSCON 2009

Eric Day – Sun Microsystems
http://www.oddments.org/

Brian Aker – Sun Microsystems
http://krow.net/

Tutorial Software

- Gearman C Server and Library
  - Packages available (Ubuntu, Debian/sid)
  - https://launchpad.net/gearmand
  - ./configure; make; make install
- Gearman PHP Extension
  - http://pecl.php.net/package/gearman
  - Follow README
- PHP command line interface
  - php5-cli package (Ubuntu, Debian)

Gearman Overview

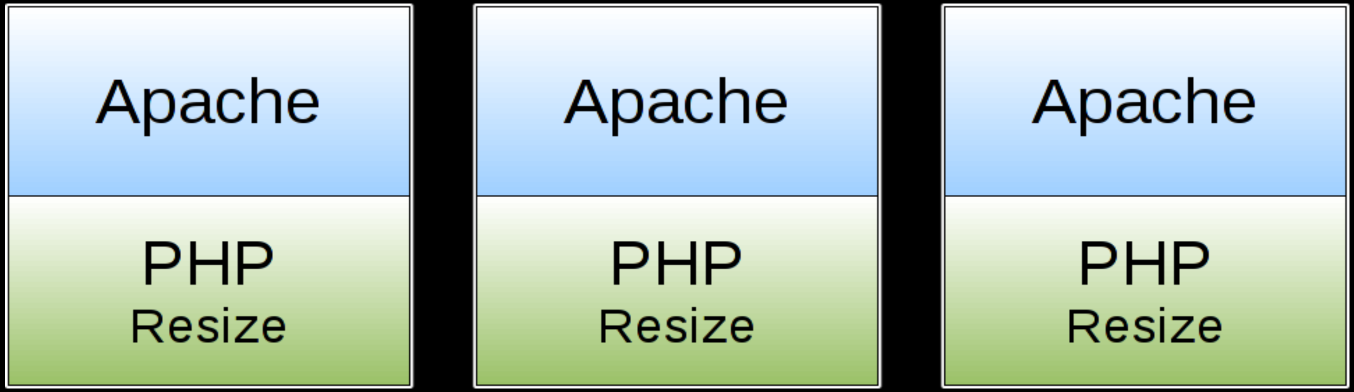
- History
- Basics
- Example
- API
  - Client
  - Worker
- Job Server

Gearman Overview

- Applications
  - Map/Reduce
  - Log Analysis
  - Asynchronous Queues
  - Narada
- Roadmap

Kittens!

(LiveJournal.com Image Processing)



Apache

PHP

Resize

Apache

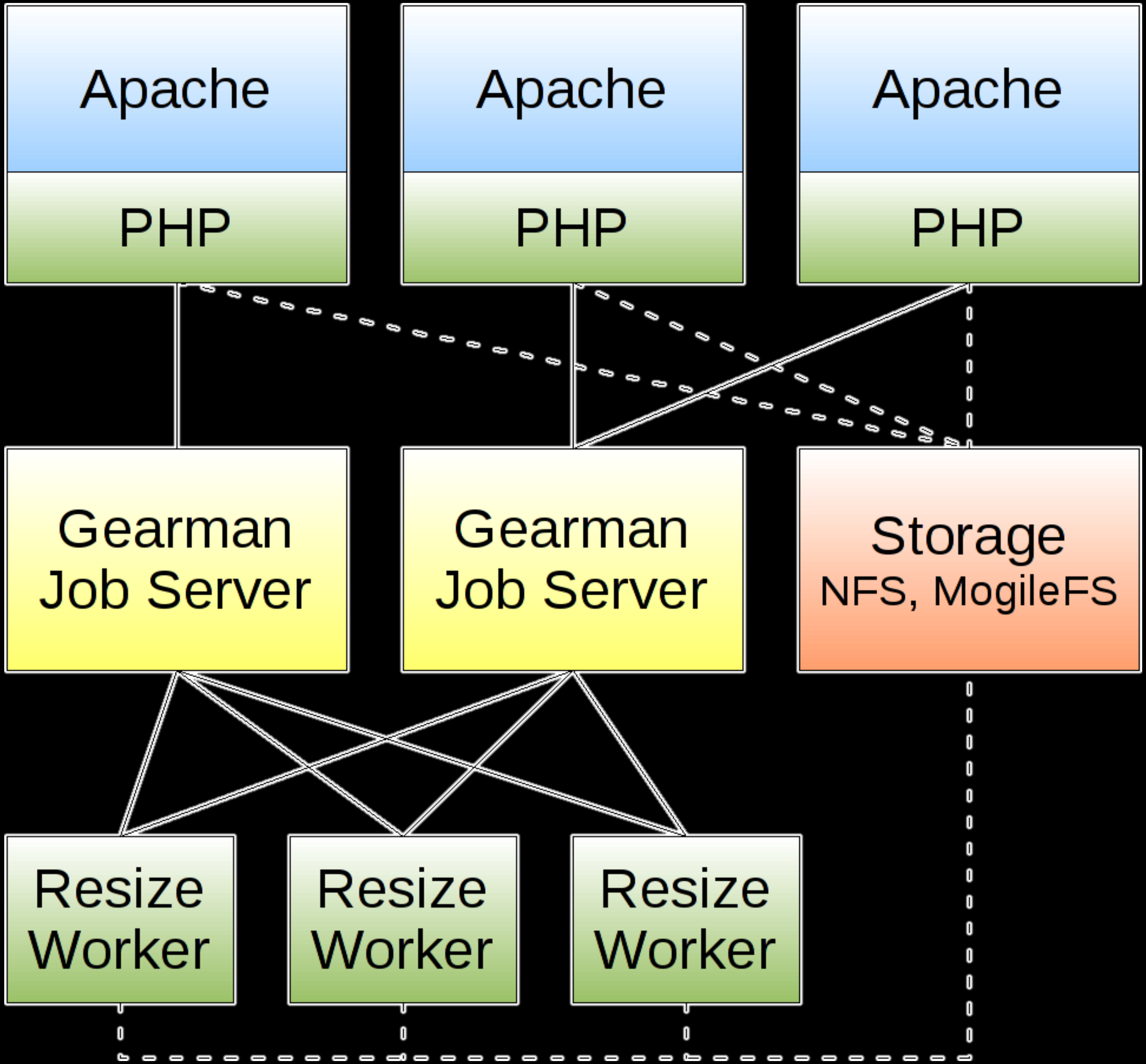
PHP

Resize

Apache

PHP

Resize


Apache
PHP
Apache
PHP
Apache
PHP
Gearman
Job Server
Gearman
Job Server
Storage
NFS, MogileFS
Resize
Worker
Resize
Worker
Resize
Worker

“The way I like to think of Gearman is as a massively distributed, massively fault tolerant fork mechanism.”

- Joe Stump, Digg

History

- Danga – Brad Fitzpatrick & company
  - Related to memcached, MogileFS, ...
- Anagram for “manager”
  - Gearman, like managers, assign the tasks but do none of the real work themselves
- Digg: 45+ servers, 400K jobs/day
- Yahoo: 60+ servers, 6M jobs/day
- LiveJournal, SixApart, DealNews, ...

Recent Development

- Rewrite in C
- New language APIs
  - PHP ext, Perl XS, Drizzle, MySQL, PostgreSQL
- Command line tool
- Protocol additions
- Multi-threaded (50k jobs/second)
- Persistent queues
- Pluggable protocol

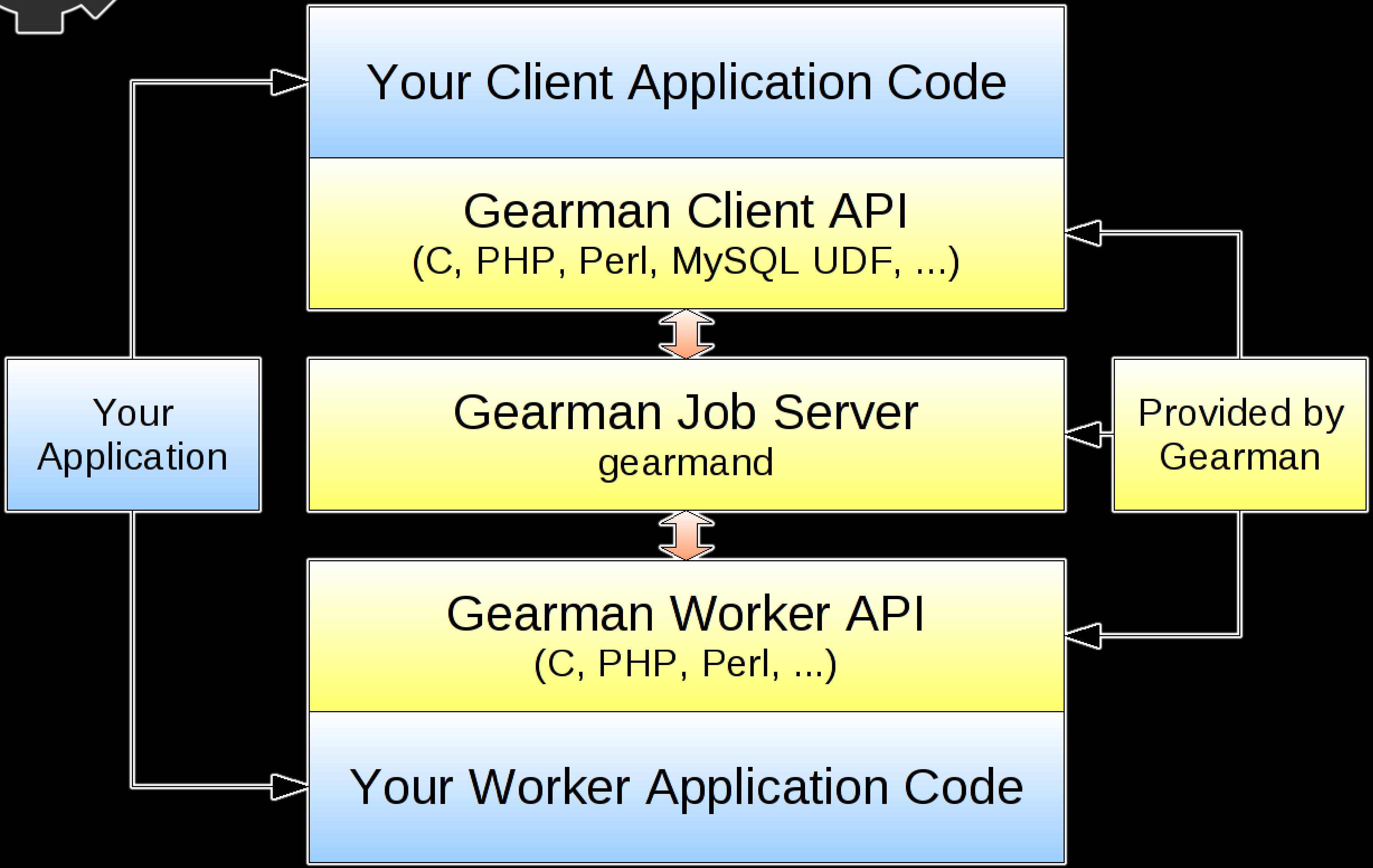
Features

- Open Source (mostly BSD)
- Multi-language
  - Mix clients and workers from different APIs
- Flexible Application Design
  - Not restricted to a single distributed model
- Simple & Fast
- Embeddable
  - Small & lightweight for applications of all sizes
- No Single Point of Failure

Basics

- Gearman provides a distributed application framework
- Uses TCP port 4730 (was port 7003)
- **Client** – Create jobs to be run and send them to a job server
- **Worker** – Register with a job server and grab jobs to run
- **Job Server** – Coordinate the assignment from clients to workers, handle restarts

Gearman Stack



Your Client Application Code

Gearman Client API
(C, PHP, Perl, MySQL UDF, ...)

Gearman Job Server
gearmand

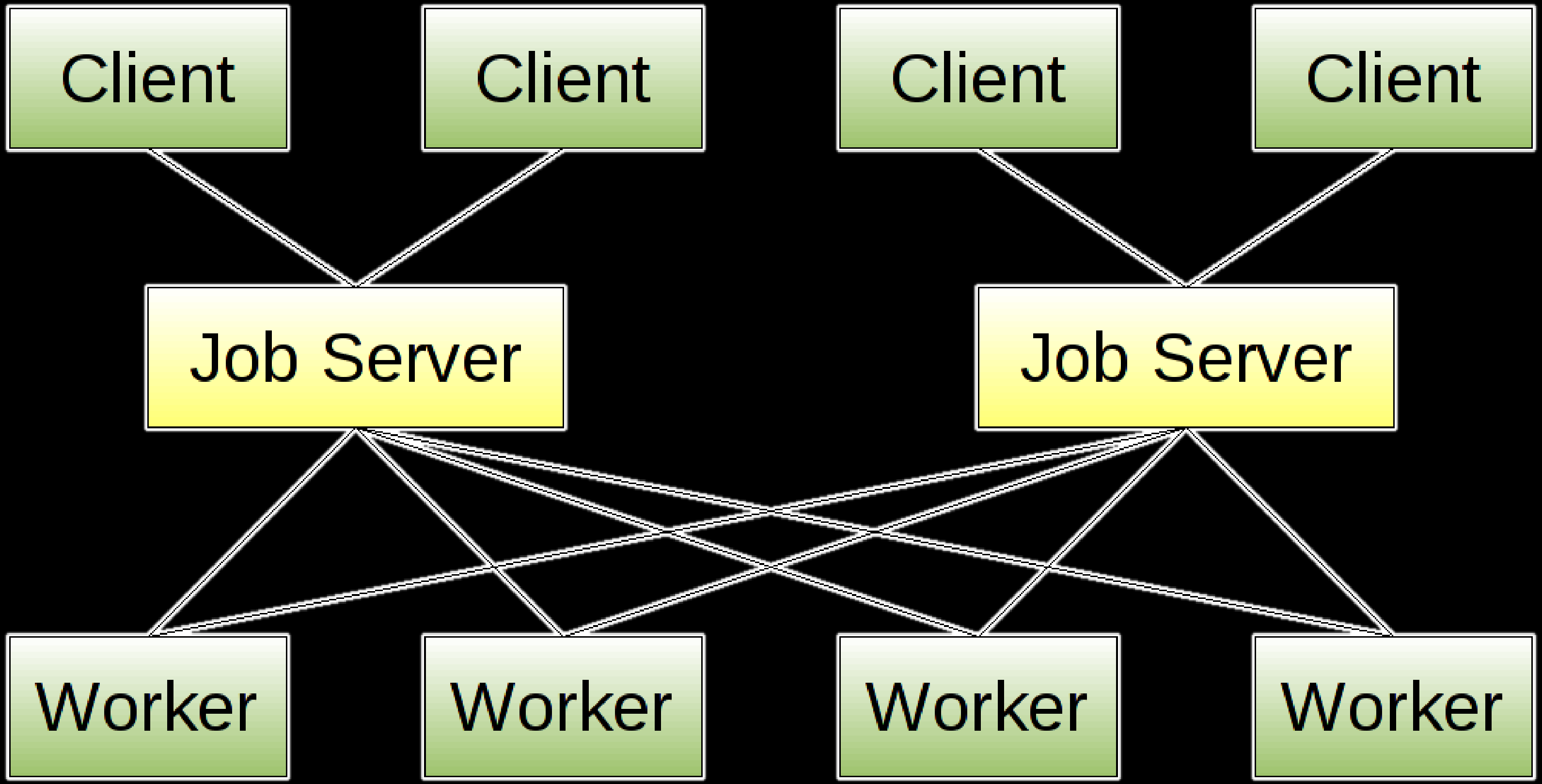
Gearman Worker API
(C, PHP, Perl, ...)

Your Worker Application Code

Your Application

Provided by Gearman

No Single Point of Failure



Hello World

```
$client= new GearmanClient();
$client->addServer();
print $client->do("reverse", "Hello World!");
```

```
$worker= new GearmanWorker();
$worker->addServer();
$worker->addFunction("reverse", "my_reverse_function");
while ($worker->work());

function my_reverse_function($job)
{
  return strrev($job->workload());
}
```

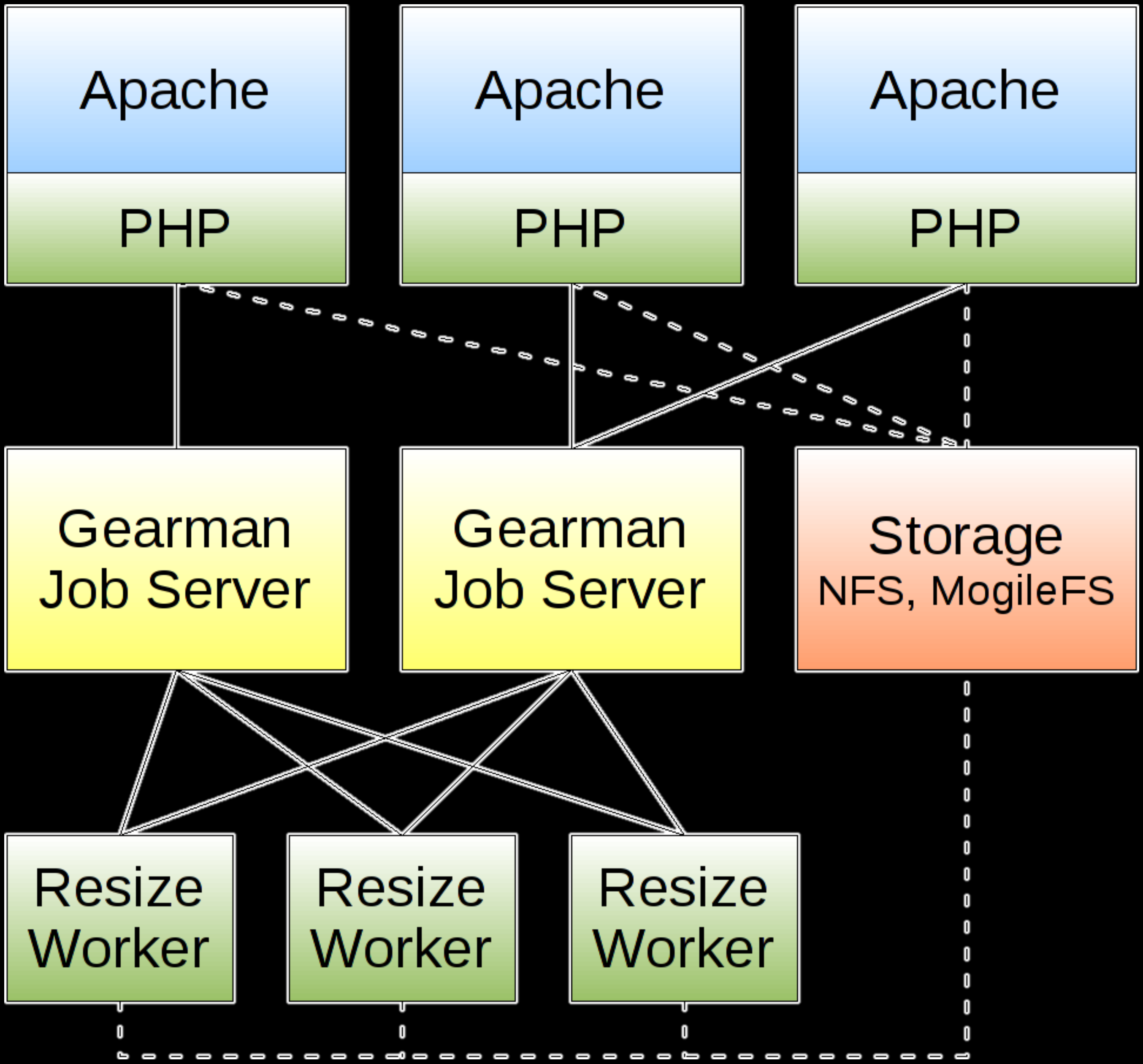
Hello World

```
shell$ gearmand -d

shell$ php worker.php &
[1] 17510

shell$ php client.php
!dlroW olleH
```

How Is This Useful?

- Provides a distributed nervous system
- Natural load balancing
  - Workers are notified and ask for work, not forced
- Multi-language integration
- Distribute processing
  - Possibly closer to data
- Synchronous and Asynchronous queues

Back to the Kittens


Apache
PHP
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Gearman
Job Server
Storage
NFS, MogileFS
Resize
Worker
Resize
Worker
Resize
Worker

Image Resize Worker

```
$worker= new GearmanWorker();
$worker->addServer();
$worker->addFunction("resize", "my_resize_function");
while ($worker->work());

function my_resize_function($job)
{
  $thumb = new Imagick();
  $thumb->readImageBlob($job->workload());
  $thumb->scaleImage(200, 150);
  return $thumb->getImageBlob();
}
```

Image Resize Worker

```
shell$ gearmand -d

shell$ php resize.php &
[1] 17524

shell$ gearman -f resize < large.jpg > thumb.jpg

shell$ ls -sh large.jpg thumb.jpg
3.0M large.jpg   32K thumb.jpg
```

APIs

APIs

- Focus on OO PHP extension API
  - PHP extension also has procedural
  - $client->do(...) == gearman_client_do($client, ...)
- Other implementations similar
  - Same concepts
  - Similar function names
- C (libgearman), Native Perl, Perl::XS, Native PHP, Java, JMS, Native Python, Drizzle, MySQL, PostgreSQL, ...
- New C-based Python, Ruby, and others soon!

Command Line Tool

- gearman
  - Included in C server and library package
  - Command line and shell script interface
- Client mode
  - ls | gearman -f function
  - gearman -f function < file
  - gearman -f function "some data"
- Worker mode
  - gearman -w -f function -- wc -l
  - gearman -w -f function ./script.sh

Command Line Tool

```
shell$ gearmand -d

shell$ gearman -w -f test -- grep lib &
[1] 7622

shell$ ls / | gearman -f test
lib
lib32
lib64
```

Client API

Client API

- Create client object
  - Can have multiple objects in an application
  - Server lists, options, ...

```
$client= new GearmanClient();
$client->addServer();
```

```
$client= new GearmanClient();
$client->addServer("10.0.0.1");
$client->addServer("10.0.0.2", 7003);
```

```
$client= new GearmanClient();
$client->addServers("10.0.0.1,10.0.0.2:7003");
```

Client API

- One job at a time
  - *do* functions and methods

```
$client= new GearmanClient();
$client->addServer();

print $client->do("reverse", "Hello World!") . "\n";

print $client->doHigh("reverse", "Hello High!") . "\n";

print $client->doLow("reverse", "Hello Low!") . "\n";
```

Client API

- Multiple jobs at a time
  - *task* functions and methods

```
$client= new GearmanClient();
$client->addServer();

$client->addTask("reverse", "Hello World!");
$client->addTaskHigh("reverse", "Hello High!");
$client->addTaskLow("reverse", "Hello Low!");

$client->setCompleteCallback("complete");
$client->runTasks();

function complete($task)
{
  print $task->data() . "\n";
}
```

Tasks vs Jobs

- A job is a task
- A task is not always a job
- Check status of background job
  - Not a job, but is a task
  - Send job handle, receive status
  - $client->jobStatus()
  - $client->addTaskStatus()
- Clients deal with tasks
- Workers deal with jobs

Job Attributes

- Foreground (Synchronous)
  - $client->do()
- Background (Asynchronous)
  - $client->doBackground()
- High and Low priority
  - $client->doHigh()
  - $client->doLow()
- Mix and match
  - $client->doHighBackground(), ...

Job Attributes

- Application data/state for tasks
- Optional Unique Key
  - UUID generated if none given
  - Coalesce jobs in job server
  - Only one worker per key at any time
  - All clients get the same response
  - Resizing an image
    - Multiple clients submit job at the same time
    - Worker runs once, all clients get thumbnail

Concurrent Task API

- Queue jobs to run
- Register callbacks for interested events
- Run tasks
  - $client->runTasks();
  - Returns when all tasks are complete
- No guarantee on response order

Concurrent Task API

- Available Callbacks
  - setWorkloadCallback() - Streaming job workload
  - setCreatedCallback() - Job created in server
  - setDataCallback() - Partial data response
  - setWarningCallback() - Partial warning response
  - setStatusCallback() - Status (X/Y done)
  - setCompleteCallback() - Job complete
  - setExceptionCallback() - Exception caught (Perl)
  - setFailCallback() - Job failed
  - clearCallbacks() - Clear all set callbacks

Concurrent Task API

```
$client= new GearmanClient();
$client->addServer();

$client->addTask("reverse", "Hello World 1!");
$client->addTask("reverse", "Hello World 2!");
$client->addTask("reverse", "Hello World 3!");

$client->setCreatedCallback("created");
$client->setCompleteCallback("complete");
$client->runTasks();

function created($task)
{
  print "Created: " . $task->jobHandle() . "\n";
}

function complete($task)
{
  print "Complete: " . $task->data() . "\n";
}
```

Concurrent Task API

- Start gearmand
- Start multiple reverse workers

```
shell$ php task.php
Created: H:lap:108
Created: H:lap:109
Created: H:lap:110
Complete: !2 dlroW olleH
Complete: !3 dlroW olleH
Complete: !1 dlroW olleH
```

Task Application Data

- Pass application data and state variables

```
$client= new GearmanClient();
$client->addServer();

$count= 0;
$client->addTask("reverse", "Hello World 1!", &$count);
$client->addTask("reverse", "Hello World 2!", &$count);
$client->addTask("reverse", "Hello World 3!", &$count);

$client->setCompleteCallback("complete");
$client->runTasks();
print "Completed $count tasks\n";

function complete($task, $count)
{
  print "$count: " . $task->data() . "\n";
  $count++;
}
```

Task Application Data

- Pass variables by reference
- $count incremented for each job

```
shell$ php app_data.php
0: !2 dlroW olleH
1: !3 dlroW olleH
2: !1 dlroW olleH
Completed 3 tasks
```

Worker API

Worker API

- Create worker object
  - Can have multiple objects in an application
  - Server lists, options, ...

```
$worker= new GearmanWorker();
$worker->addServer();
```

```
$worker= new GearmanWorker();
$worker->addServer("10.0.0.1");
$worker->addServer("10.0.0.2", 7003);
```

```
$worker= new GearmanWorker();
$worker->addServers("10.0.0.1,10.0.0.2:7003");
```

Worker API

- Register function abilities
  - Function name
  - Local callback function
- Wait for jobs on those functions
- Will only run one job at a time

```
$worker= new GearmanWorker();
$worker->addServer();
$worker->addFunction("function1", "first_callback");
$worker->addFunction("function2", "common_callback");
$worker->addFunction("function3", "common_callback");
while ($worker->work());
```

Worker Callback Function

- Have access to $job object
- Get job information
  - $job->workload() - Get job workload
  - $job->functionName() - Get function name
  - $job->unique() - Get unique key
  - $job->handle() - Get job handle

Worker Callback Function

- Send intermediate job responses
  - $job->data(...) - Send partial result
  - $job->warning(...) - Send warning
  - $job->status(X, Y) – Send X/Y status
- Return value sent back to caller (if any)
- Don't bother if it's a background job
  - Except $job->status(X, Y)

Worker Callback Function

- Can also return failure

```
$worker= new GearmanWorker();
$worker->addServer();
$worker->addFunction("reverse", "always_fail");
while ($worker->work());

function always_fail($job)
{
  $job->setReturn(GEARMAN_WORK_FAIL);
}
```

Worker Application Data

- Pass data or state variable into callback

```
$worker= new GearmanWorker();
$worker->addServer();
$count= 0;
$worker->addFunction("reverse", "reverse_cb", &$count);
while ($worker->work());

function reverse_cb($job, $count)
{
  $count++;
  return "$count: " . strrev($job->workload());
}
```

```
shell$ gearman -f reverse hello
1: olleh
shell$ gearman -f reverse hello
2: olleh
...
```

Job Server

Job Server

- Listens on port 4730
- Clients and workers connect
- Handle job assignment
- Restart jobs on worker failure
- Advanced features
  - Pluggable persistent queue
  - Pluggable protocols

Job Server

- gearmand --help
- Common options

```
-d, --daemon
-h, --help
-l, --log-file=FILE
-p, --port=PORT
-P, --pid-file=FILE
-t, --threads=THREADS
-u, --user=USER
-v, --verbose
```

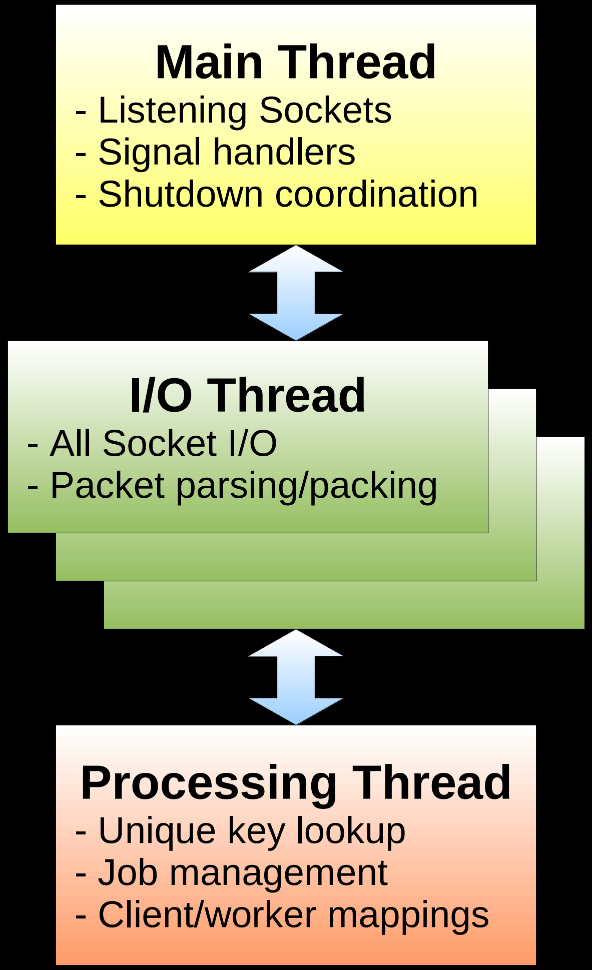
Verbose Option

- Can specify multiple -v
- Very useful for debugging

```
shell$ gearmand -vvvv
 INFO Starting up
DEBUG Initializing libevent for main thread
DEBUG Method for libevent: epoll
DEBUG Trying to listen on :::4730
 INFO Listening on :::4730 (6)
DEBUG Trying to listen on 0.0.0.0:4730
 INFO Creating wakeup pipe
DEBUG Creating 0 threads
 INFO Creating IO thread wakeup pipe
 INFO Adding event for listening socket (6)
 INFO Adding event for wakeup pipe
 INFO Entering main event loop
...
```

Threading Model

- Can run single threaded
- The -t option sets threads
  - I/O thread count
  - Default is -t 0
  - One thread/core
- Processing thread
  - Hashes and other state
  - No systems calls
  - Non-blocking



Main Thread
- Listening Sockets
- Signal handlers
- Shutdown coordination

I/O Thread
- All Socket I/O
- Packet parsing/packing

Processing Thread
- Unique key lookup
- Job management
- Client/worker mappings

Persistent Queues

- Only for background jobs
- Specify -q <queue> option
- libdrizzle module for Drizzle and MySQL

```
shell$ gearmand -vvv -q libdrizzle
 INFO Initializing libdrizzle module
 INFO libdrizzle module using table 'test.queue'
...
 INFO libdrizzle replay start
...
DEBUG libdrizzle add: 3ec068d9-293c-4af8-943f-d265138e67f8
DEBUG libdrizzle flush
...
DEBUG libdrizzle done: 3ec068d9-293c-4af8-943f-d265138e67f8
```

Persistent Queues

- libdrizzle queue is as robust as your DB
- Can create your own table

```
libdrizzle Options:

     --libdrizzle-host=HOST
     --libdrizzle-port=PORT
     --libdrizzle-uds=UDS
     --libdrizzle-user=USER
     --libdrizzle-password=PASSWORD
     --libdrizzle-db=DB
     --libdrizzle-table=TABLE
     --libdrizzle-mysql

shell$ gearmand -q libdrizzle ...
```

Persistent Queues

- libmemcached
- PostgreSQL
- sqlite3
- Flat file
- Easy to add your own!

Pluggable Protocol

- Handle packet parsing and packing
- Optionally handle raw socket I/O
- HTTP protocol
- Others coming soon
  - memcached
  - XMPP
  - ?

HTTP Protocol

- GET and POST requests
  - Send workload with POST, Content-Length
- Function name from URL
- Optional headers
  - X-Gearman-Unique: <unique key>
  - X-Gearman-Background: true
  - X-Gearman-Priority: <high|low>
- Other headers ignored for now

HTTP Protocol

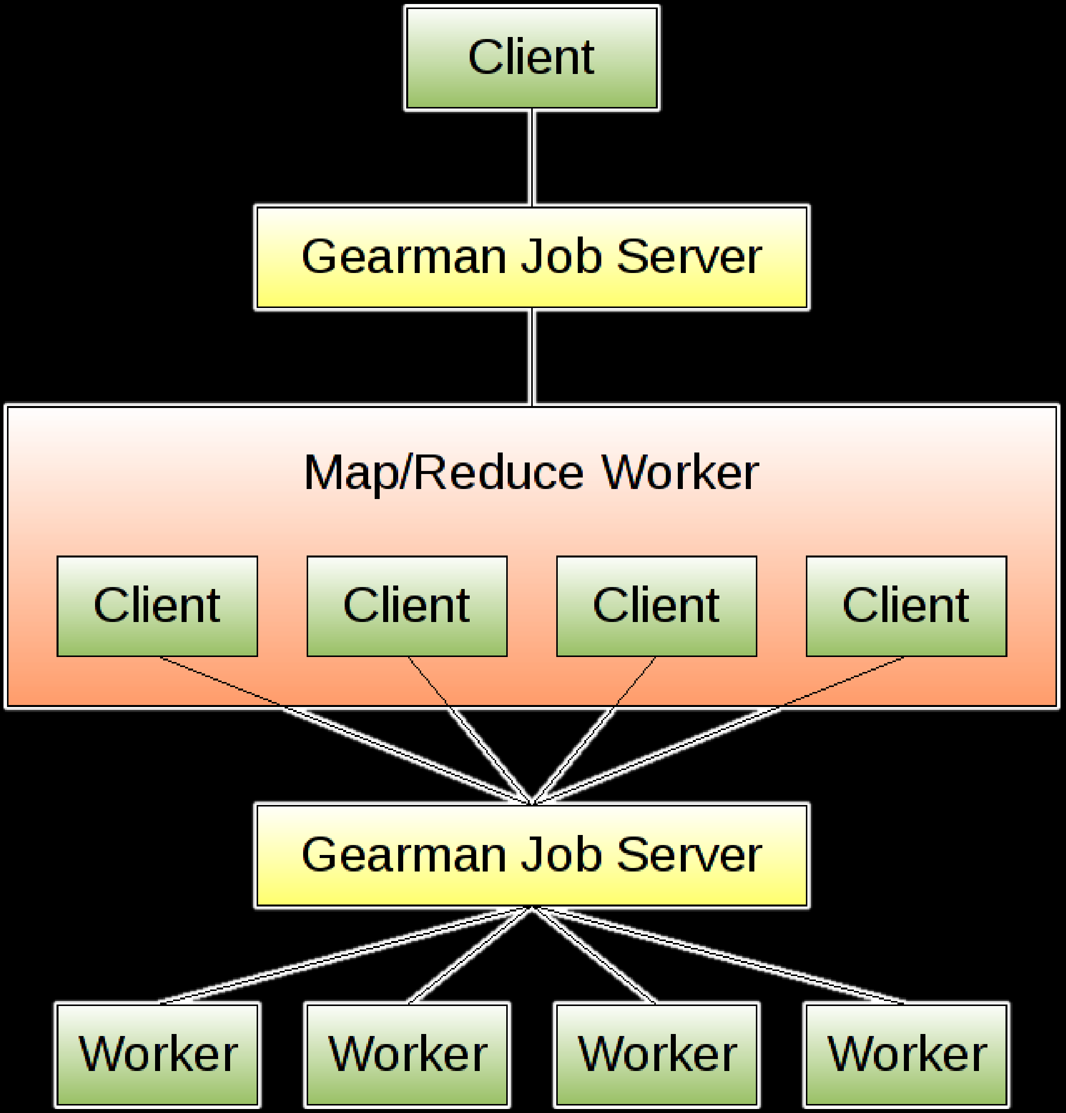
```
shell$ gearmand -r http &

<start reverse worker>

shell$ nc localhost 8080
POST /reverse HTTP/1.1
Content-Length: 12

Hello World!

HTTP/1.0 200 OK
X-Gearman-Job-Handle: H:lap:1
Content-Length: 12
Server: Gearman/0.9

!dlroW olleH
```

Applications

Prototype!

- Command line tool is your friend
- Or use simple scripting language
- Rewrite if needed
  - Faster
  - Security
  - More features
  - More robust

Map/Reduce


Client
Gearman Job Server
Map/Reduce Worker
Client
Client
Client
Client
Gearman Job Server
Worker
Worker
Worker
Worker

Map/Reduce

- Can be multi-tier
- Fan-out depends on application
- Don't need to follow strict MR model
  - Not Google API (paper) or Hadoop
  - Can be ad-hoc
- Use any Gearman API (mix/match)

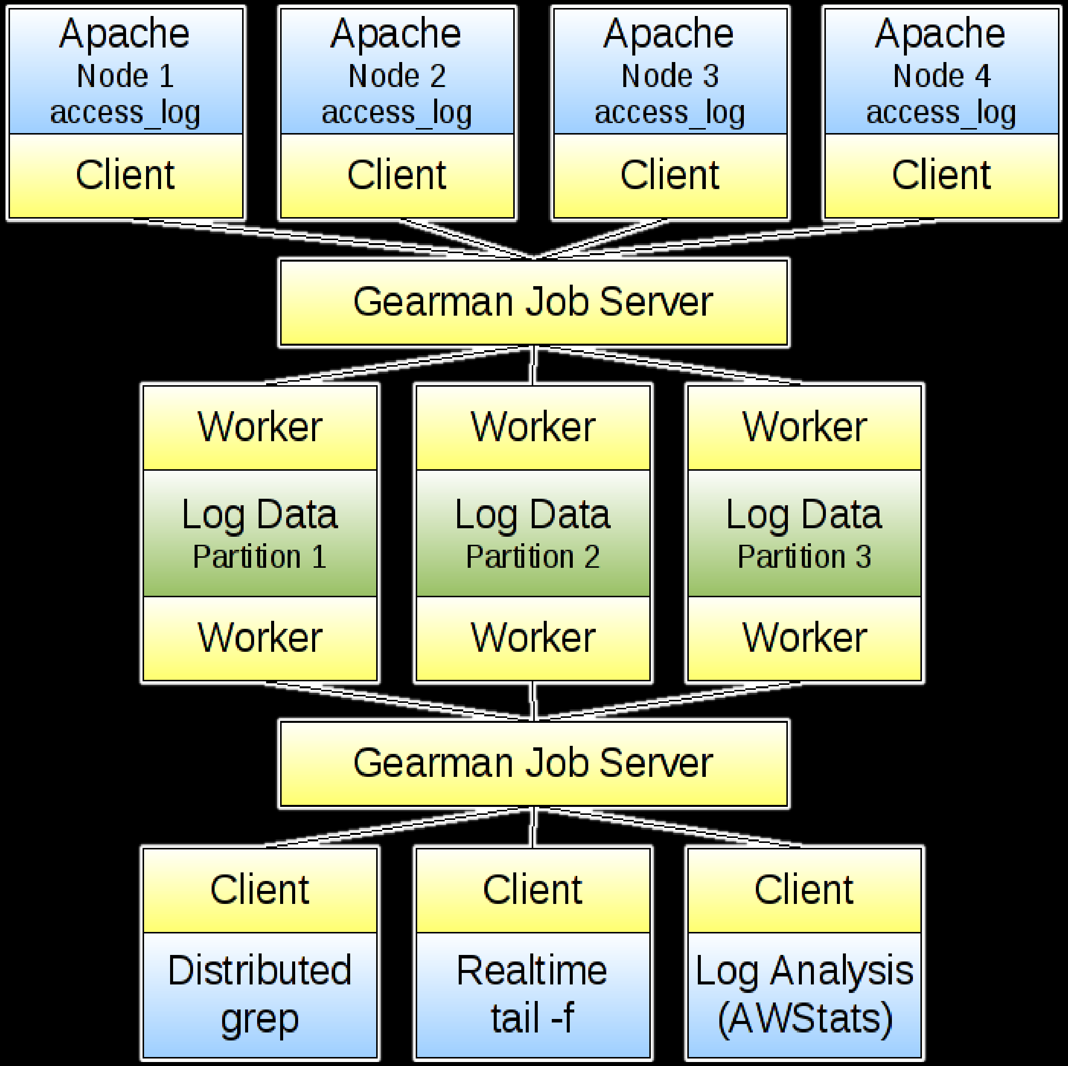
Log Processing

- Bring Map/Reduce to Apache logs
- Get log storage off Apache nodes
- Push processing to log storage nodes
- Combine data in some meaningful way
  - Summary
  - Distributed merge-sort algorithms

Log Processing

- Collection
  - tail -f access_log | gearman -n -f logger
  - CustomLog "| gearman -n -f logger" common
  - Write a Gearman Apache logging module
- Processing
  - Distributed/parallel grep
  - Log Analysis (AWStats, Webalizer, ...)
  - Custom data mining & click analysis

Log Processing



Apache Node 1 access_log

Client

Apache Node 2 access_log

Client

Apache Node 3 access_log

Client

Apache Node 4 access_log

Client

Gearman Job Server

Worker

Log Data Partition 1

Worker

Worker

Log Data Partition 2

Worker

Worker

Log Data Partition 3

Worker

Gearman Job Server

Client

Distributed grep

Client

Realtime tail -f

Client

Log Analysis (AWStats)

Log Processing

- Simple shell version
- Provide remote storage and distributed grep
- Send logs as mentioned before
  - tail -f access_log | gearman -h host -f logger
- On each log collection machine
  - gearman -w -h host -f logger > log_file
  - gearman -w -h host -f logger1 ./dgrep.sh

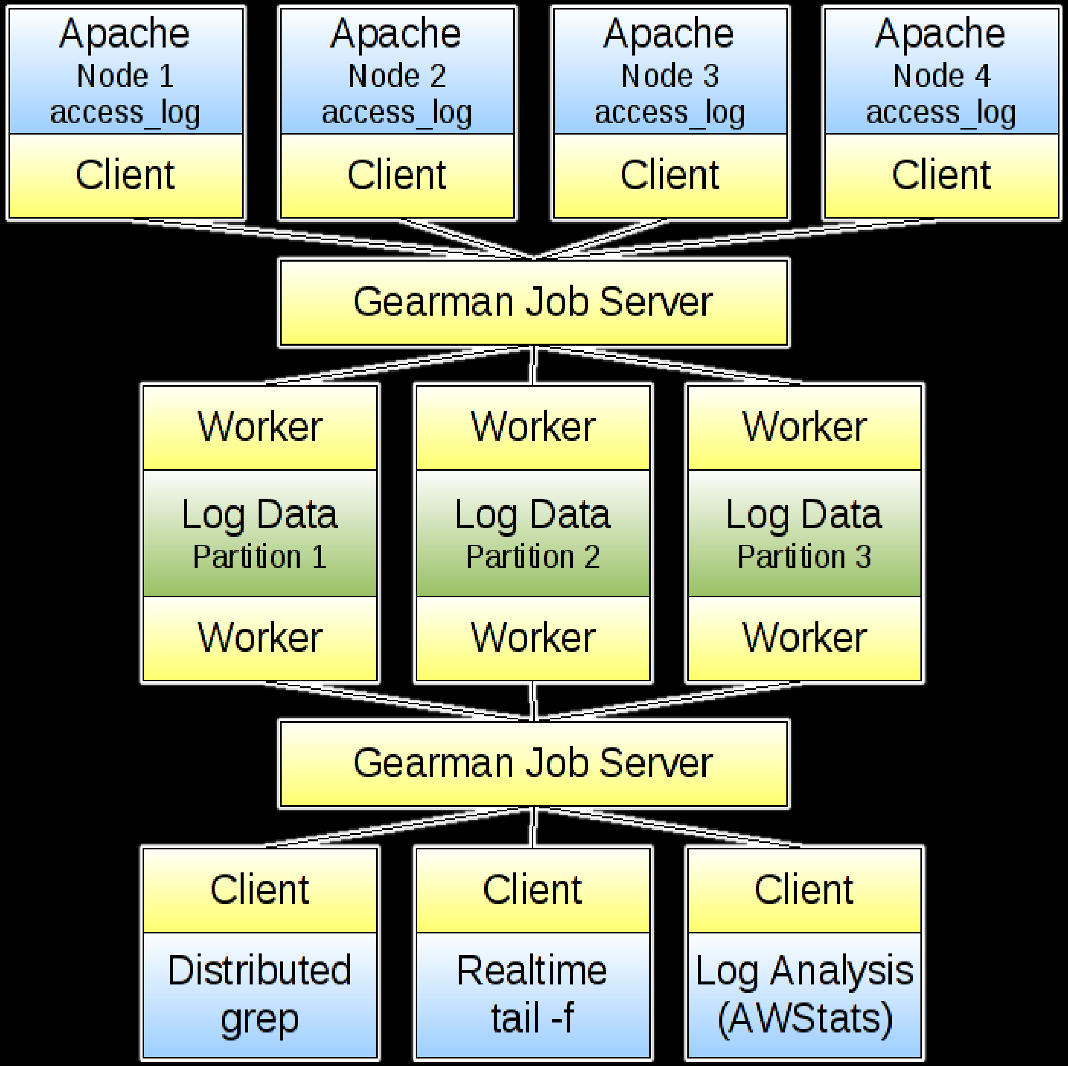
```
#!/bin/sh
read pattern
grep $pattern log_file
```

Log Processing

- Query logging machines
  - gearman -h host -f logger1 -f logger2 ... pattern

```
shell$ gearman -h host -f logger1 -f logger2 -f logger3 \
               news_archive | cut -f 4,5,7 -d' '

[06/Jul/2009:18:22:57 -0700] /bzr/narada/eday-dev/php/in
dex.php?q=&u=http%3A%2F%2Flocalhost%2Fsrc%2Fnwveg%2Fnews
_archive.php&s=Submit
[06/Jul/2009:18:23:03 -0700] /src/nwveg/news_archive.php
[06/Jul/2009:18:23:54 -0700] /src/nwveg/news_archive.php
[06/Jul/2009:18:24:12 -0700] /src/nwveg/news_archive.php
[06/Jul/2009:18:31:37 -0700] /bzr/narada/eday-dev/php/in
dex.php?q=news&s=Search&u=
...
```

Log Processing



Asynchronous Queues

- Background Tasks
- They help you scale
- Distributed data storage
  - Eventually consistent data models
  - Choose “AP” in “CAP”
    - Consistency
    - Availability
    - Partitions (tolerance to network partitions)
  - Make eventual consistency work
  - Conflict resolution if needed

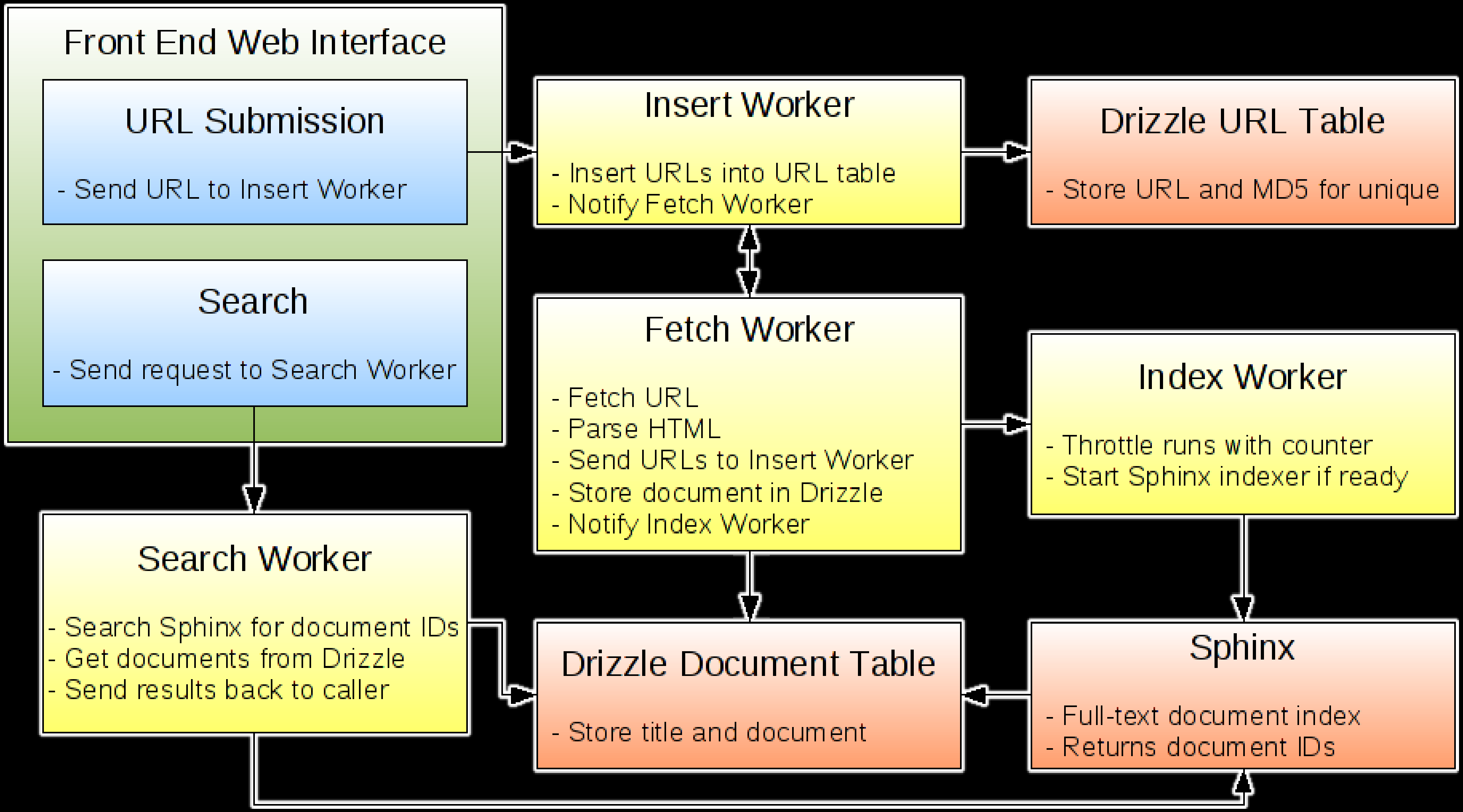
Asynchronous Queues

- Not everything needs immediate action
  - E-Mail notifications
  - Tweets
  - Certain types of database updates
  - RSS aggregation
  - Search indexing
- Allows for batch operations

Narada

- Example in Patrick Galbraith's book
- Custom search engine
- Perl, PHP, and Java implementations
- Asynchronous queues
- Drizzle or MySQL
- Optionally use memcached
- Easy to integrate into existing projects
- https://launchpad.net/narada

Narada



Front End Web Interface

URL Submission

- Send URL to Insert Worker

Search

- Send request to Search Worker

Insert Worker

- Insert URLs into URL table
- Notify Fetch Worker

Drizzle URL Table

- Store URL and MD5 for unique

Fetch Worker

- Fetch URL
- Parse HTML
- Send URLs to Insert Worker
- Store document in Drizzle
- Notify Index Worker

Index Worker

- Throttle runs with counter
- Start Sphinx indexer if ready

Search Worker

- Search Sphinx for document IDs
- Get documents from Drizzle
- Send results back to caller

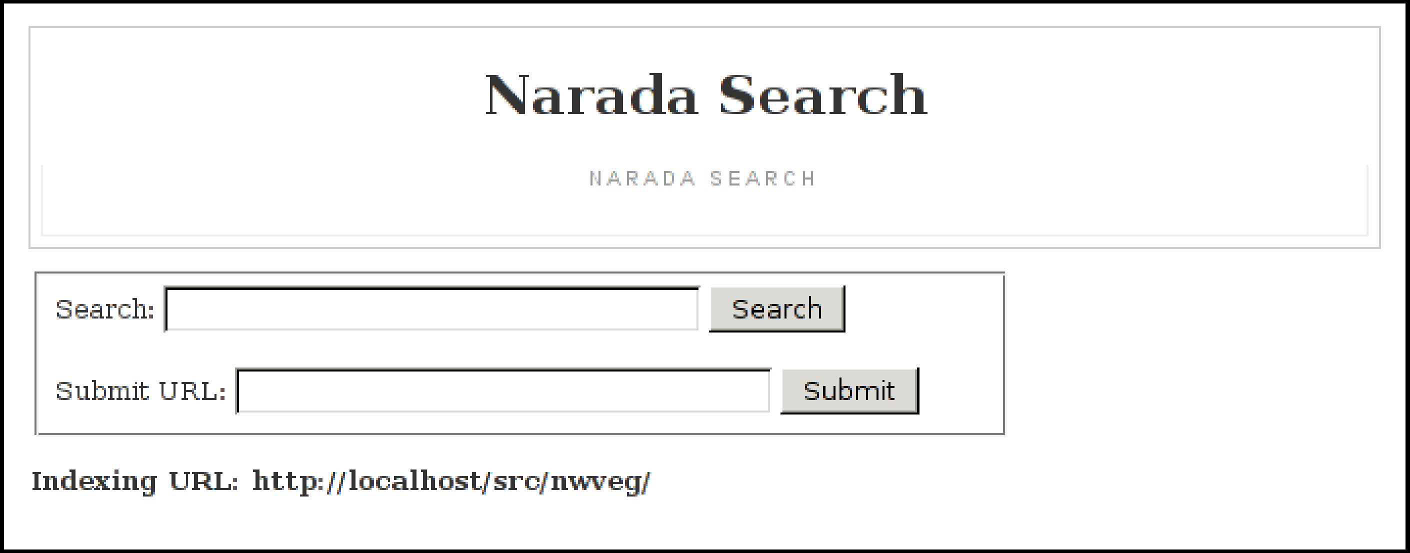
Drizzle Document Table

- Store title and document

Sphinx

- Full-text document index
- Returns document IDs

URL Submission



Indexing URL: http://localhost/src/nwveg/

Insert Worker

- Insert URL into table
- Notify Fetch Worker

```
shell$ php NaradaInsert.php
Insert URL: http://localhost/src/nwveg/
```

Fetch Worker

- Fetch URL, process HTML, find more URLs
- Store document and notify Index Worker

```
shell$ php NaradaFetch.php
Fetching: http://localhost/src/nwveg/
Protocol: http://
Domain: localhost
Path: /src/nwveg/
File:
Local URL: http://localhost/src/nwveg/index.php
Local URL: http://localhost/src/nwveg/news.php
Local URL: http://localhost/src/nwveg/whyveg.php
Local URL: http://localhost/src/nwveg/board.php
Local URL: http://localhost/src/nwveg/subscribe.php
Local URL: http://localhost/src/nwveg/discounts.php
...
Skipping Remote URL: http://twitter.com/northwestveg
Title: Northwest VEG - Home
```

Insert Worker

- More URLs from Fetch Worker

```
shell$ php NaradaInsert.php
Insert URL: http://localhost/src/nwveg/
Insert URL: http://localhost/src/nwveg/index.php
Insert URL: http://localhost/src/nwveg/news.php
Insert URL: http://localhost/src/nwveg/whyveg.php
Insert URL: http://localhost/src/nwveg/mvp.php
Insert URL: http://localhost/src/nwveg/veg101.php
Insert URL: http://localhost/src/nwveg/join.php
Insert URL: http://localhost/src/nwveg/volunteer.php
Insert URL: http://localhost/src/nwveg/events.php
...
```

Insert/Fetch Workers

- URL Feedback Loop
- Filter at some point
  - Recursion level
  - Restrict to given domain
- Now ready to index
- ...then search!

Index Worker

- Don't run indexer for every document

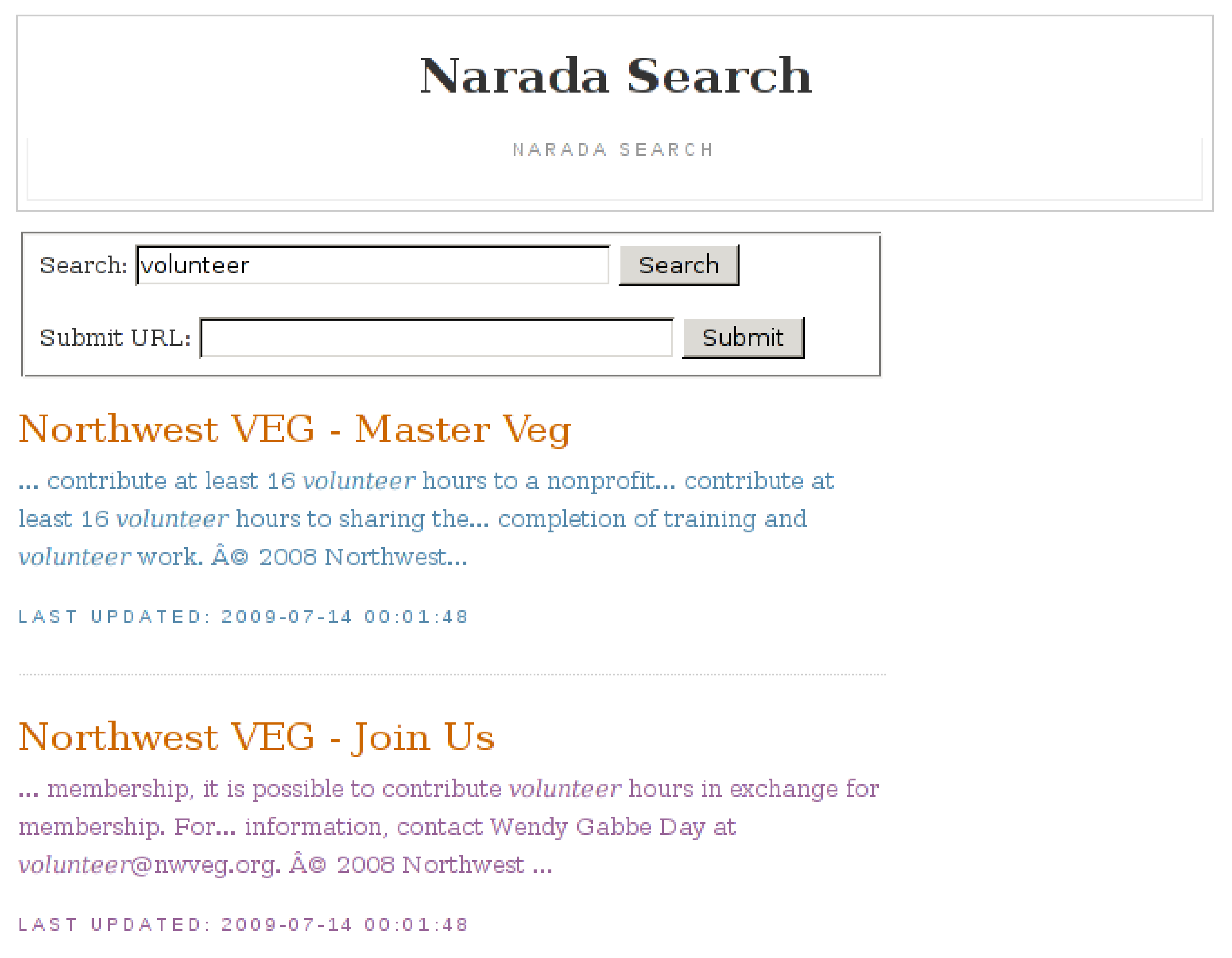
```
shell$ php NaradaIndex.php
Index Count: 1
...
Index Count: 10
Running Index
Sphinx 0.9.9-rc2 (r1785)
Copyright (c) 2001-2009, Andrew Aksyonoff

using config file '/home/eday/other/sphinx/etc/sphinx.conf'...
indexing index 'url'...
collected 25 docs, 0.1 MB
sorted 0.0 Mhits, 100.0% done
total 25 docs, 61524 bytes
total 0.085 sec, 718134 bytes/sec, 291.81 docs/sec
indexing index 'url_delta'...
collected 0 docs, 0.0 MB
total 0 docs, 0 bytes
total 0.045 sec, 0 bytes/sec, 0.00 docs/sec
distributed index 'dist_url' can not be directly indexed; skipping.
total 3 reads, 0.000 sec, 30.4 kb/call avg, 0.0 msec/call avg
total 9 writes, 0.000 sec, 8.3 kb/call avg, 0.0 msec/call avg
rotating indices: succesfully sent SIGHUP to searchd (pid=17010).
```

Search Worker

- Query Sphinx for document IDs
- Get documents from Drizzle
  - Soon will get from memcached too

```
shell$ php NaradaSearch.php
1 Documents matched 'nonprofit'
2 Documents matched 'board'
5 Documents matched 'oregon'
3 Documents matched 'vegfest'
7 Documents matched 'volunteer'
```

Search



Narada Search

NARADA SEARCH

Search: volunteer

Submit URL:

Northwest VEG - Master Veg

... contribute at least 16 *volunteer* hours to a nonprofit... contribute at least 16 *volunteer* hours to sharing the... completion of training and *volunteer* work. Â© 2008 Northwest...

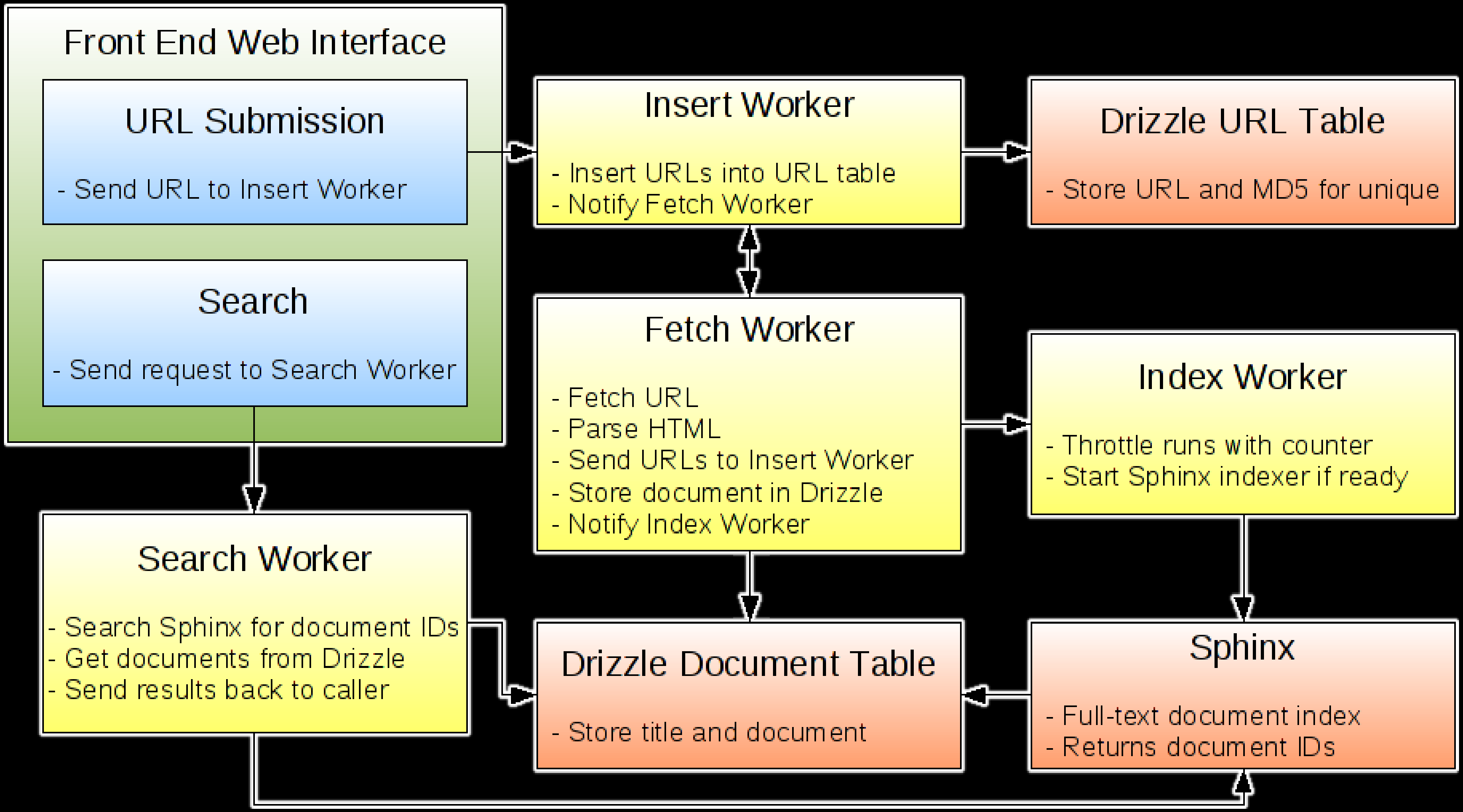
LAST UPDATED: 2009-07-14 00:01:48

Northwest VEG - Join Us

... membership, it is possible to contribute *volunteer* hours in exchange for membership. For... information, contact Wendy Gabbe Day at *volunteer*@nwveg.org. Â© 2008 Northwest ...

LAST UPDATED: 2009-07-14 00:01:48

Narada



Front End Web Interface

URL Submission

- Send URL to Insert Worker

Search

- Send request to Search Worker

Insert Worker

- Insert URLs into URL table
- Notify Fetch Worker

Drizzle URL Table

- Store URL and MD5 for unique

Fetch Worker

- Fetch URL
- Parse HTML
- Send URLs to Insert Worker
- Store document in Drizzle
- Notify Index Worker

Index Worker

- Throttle runs with counter
- Start Sphinx indexer if ready

Search Worker

- Search Sphinx for document IDs
- Get documents from Drizzle
- Send results back to caller

Drizzle Document Table

- Store title and document

Sphinx

- Full-text document index
- Returns document IDs

Other Applications

- MogileFS
- Distributed e-mail storage
- Gearman Monitor Project
  - Configuration management (elastic)
  - Statistics gathering
  - Monitoring
  - Modular (integrate existing tools)
- What will you build?

What's Next?

- More protocol and queue modules
- TLS, SASL, multi-tenancy
- Replication (job relay)
- Job result cache (think memcached)
- Improved statistics gathering and reporting
- Event notification hooks
- Monitor service

Get involved

- http://gearman.org/
- #gearman on irc.freenode.net
- http://groups.google.com/group/gearman
- Gearman @ OSCON
    - 45 Minute Session (similar material)
    - Birds of a Feather (BoF)
    - Expo Hall Booth