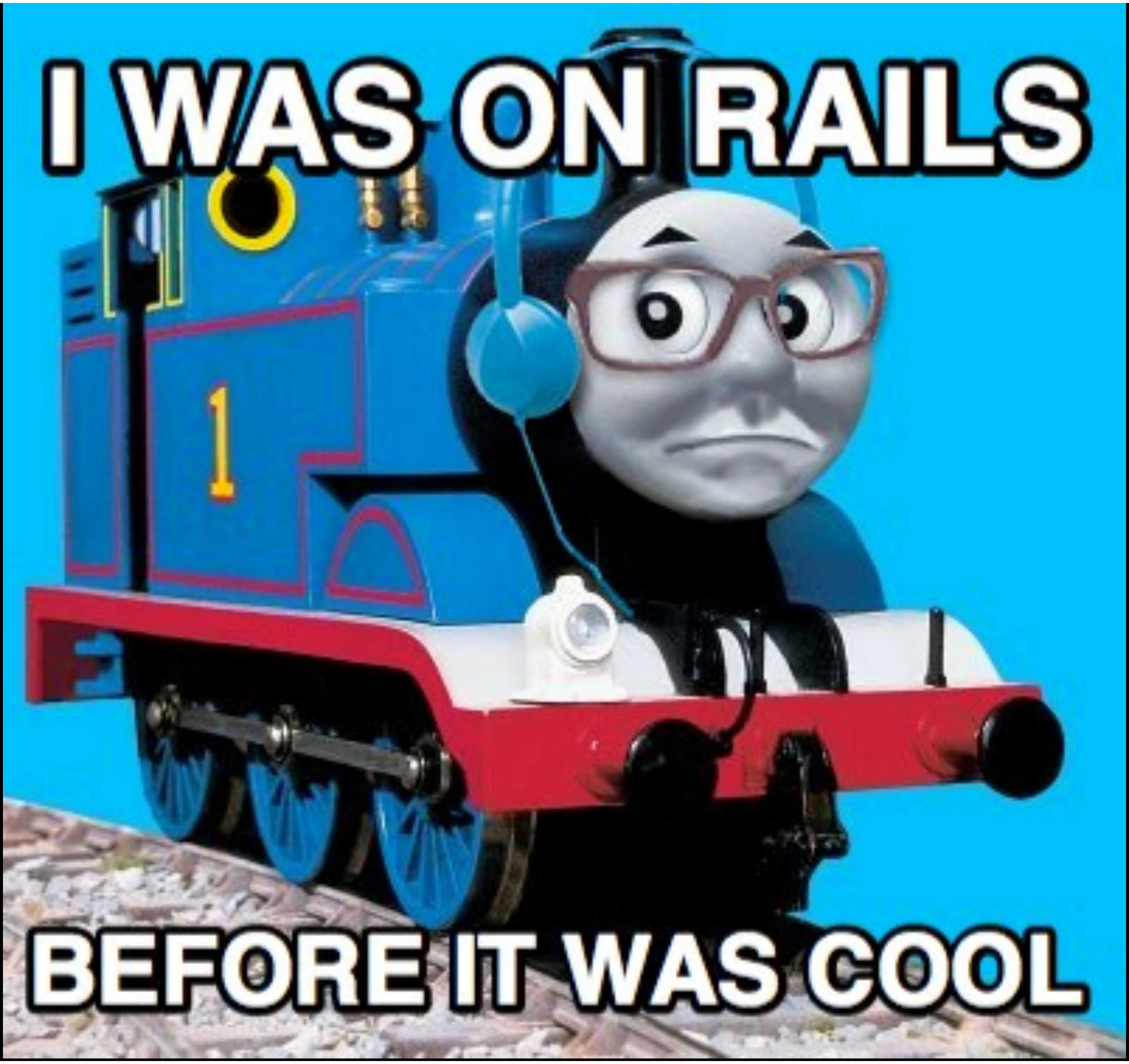
The Holy Grail of Databases

The Secret of Perfect Data Management

“Sponsored” By


I WAS ON RAILS
1
BEFORE IT WAS COOL

Who I am

- Eric Redmond
- “Seven Databases in Seven Weeks”
  - Pragmatic Press
  - Out by the end of Summer

Complex Data

Complex Data

"Complexity is a symptom of confusion, not a cause."

-- Jeff Hawkins (of Palm Pilot fame)

What is the Holy Grail?

Terms

- Database
  - a system intended to organize, store, and retrieve large amounts of data easily. It consists of an organized collection of data for one or more uses… - wikipedia
- Datastore
  - A data store is a data repository of a set of integrated objects. These objects are modeled using classes defined in database schemas. - wikipedia
  - Clearly this second sentence is wrong – it wouldn't include Riak or CouchDB.

Terms

- SQL
  - Not NoSQL
- NoSQL
  - Linear Scalability (business decision: known estimate-able requirements to grow in a consistent way)
  - Ability to be Distributed
  - Low Latency

Acronyms

- ACID
  - Transaction-based (generally SQL)
- BASE
  - Request-based (NoSQL)
- CAP
  - Consistency
  - Availability
  - Partition Tolerance

ACID

- **A**tomic
  - Transactions are “all or nothing”
- **C**onsistent
  - The system data will have integrity – data will never be in an ***in***consistent state
- **I**solated
  - Transactions cannot see each other – data from one transaction is unavailable until it is complete
- **D**urable
  - Can recover from failures – generally some underlying disk writes

BASE

- **B**asically **A**vailable
- **S**oft state
- **E**ventual consistency

CAP Theorem

- Brewer's Conjecture and the Feasibility of Consistent, Available, Partition-Tolerant Web Services
  - Nancy Lynch and Seth Gilbert
  - "…it is impossible to reliably provide atomic, consistent data when there are partitions in the network. It is feasible, however, to achieve any two of the three properties: consistency, availability, and partition tolerance."

Consistency

- A request to any connectable node in the system returns the same data
- Strong Consistency
  - aka: Strict, Linearizable or Atomic
  - When an update completes, subsequent access returns the new result
- Weak Consistency
  - For most NoSQL purposes, we mean Eventual
    - When an update completes, subsequent access will eventually return the new result

Correct Consistency

- List of cities
- DNS is eventually consistent

Availability

- Colloquial definition
  - The data is available when I want it.
  - Wrong! (latency) It could take forever
- “Technical-er” definition
  - Nodes which may sustain pack-loss continue serving requests.
  - Or: Is it possible to be ***un***available?

Partition Tolerance

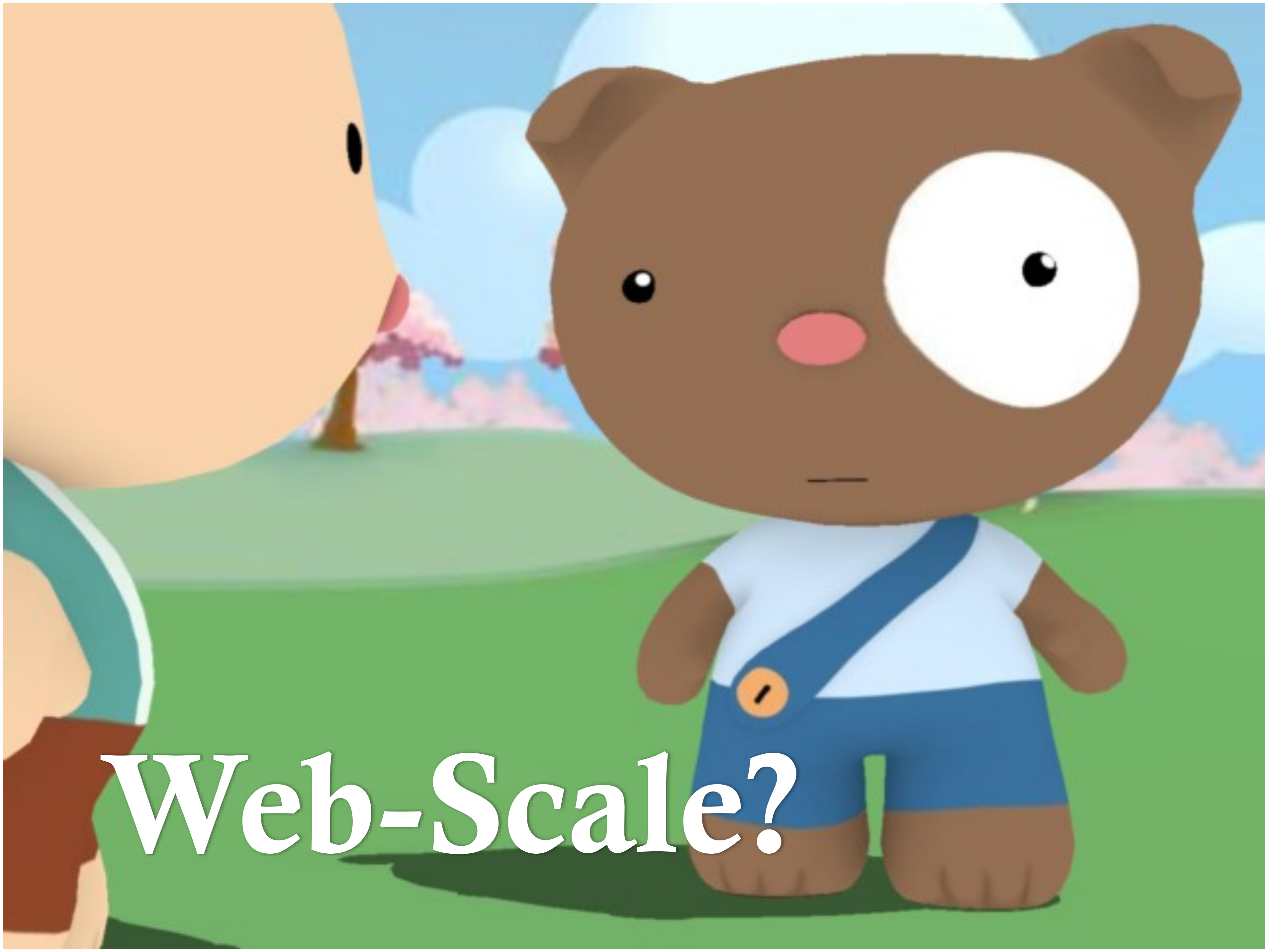
- Despite message loss, the DB continues to operate.
- A DB is either P or not.
- "…the choice is almost always between sequential consistency and high availability"
  - http://www.cloudera.com/blog/2010/04/cap-confusion-problems-with-partition-tolerance

Consistency & Availability

Eventual Consistency

Other Concerns: Latency

- Not addressed in CAP
- The focus of many “web-scale” NoSQL solutions
- Case in point:
  - PNUTS (Yahoo database) gives up BOTH C and A



Web-Scale?

Common Patterns

- Replication
- N/R/W
- Consistent Hashing
- Mapreduce

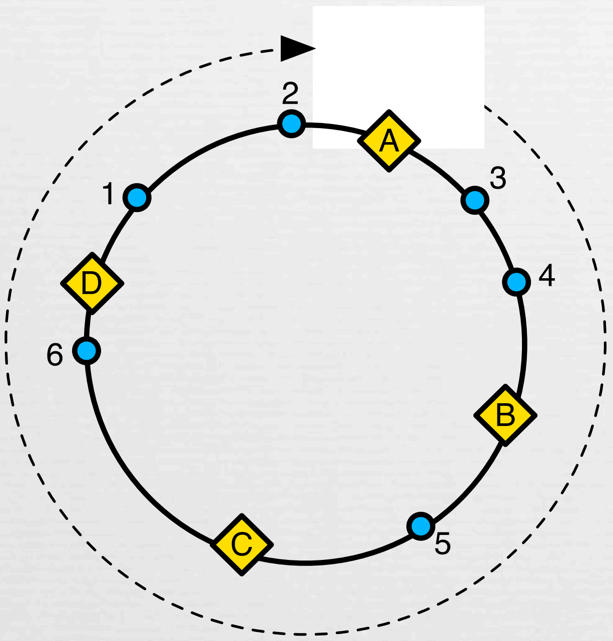
Replication

- Copying data amongst nodes in a distributed database
- Lazy (Optimistic) replication
  - Gossip (nodes communicate to stay in sync)
- Master/Slave
- Master/Master
  - Vector Clocks (keep track of write order per client)
  - MVCC (subversion)

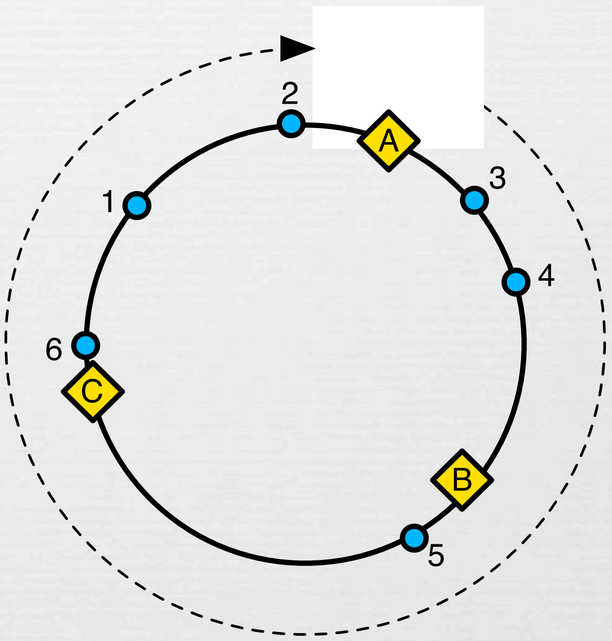
N/R/W

- N/R/W
  - N = Nodes to write to (per bucket)
  - W = Nodes written to before success
  - R = Nodes read from before success
- Support both CP and AP in one database
- Used by Cassandra and Riak

Consistent Hashing

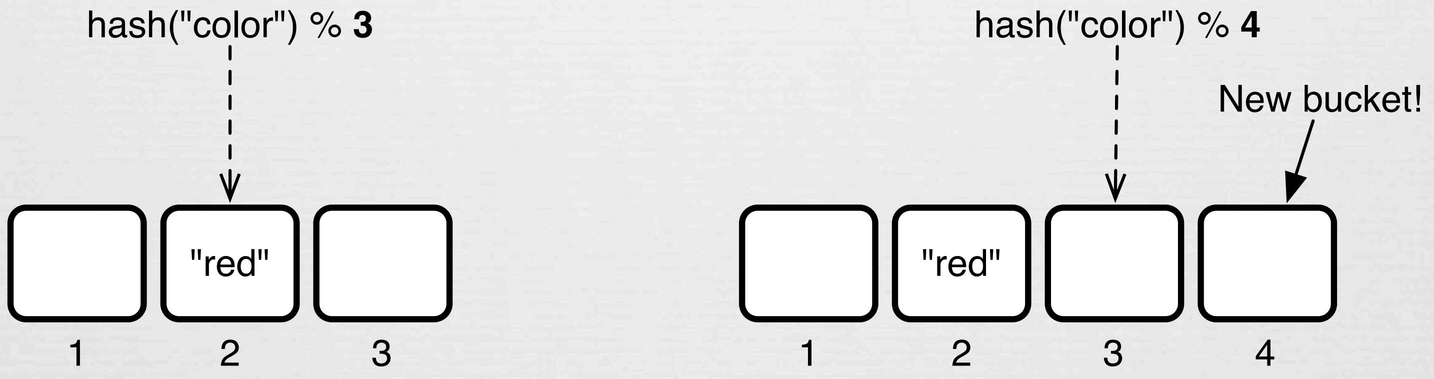


A = [1, 2]
B = [3, 4]
C = [5]
D = [6]



A = [1, 2, 6]
B = [3, 4]
C = [5]
D = []

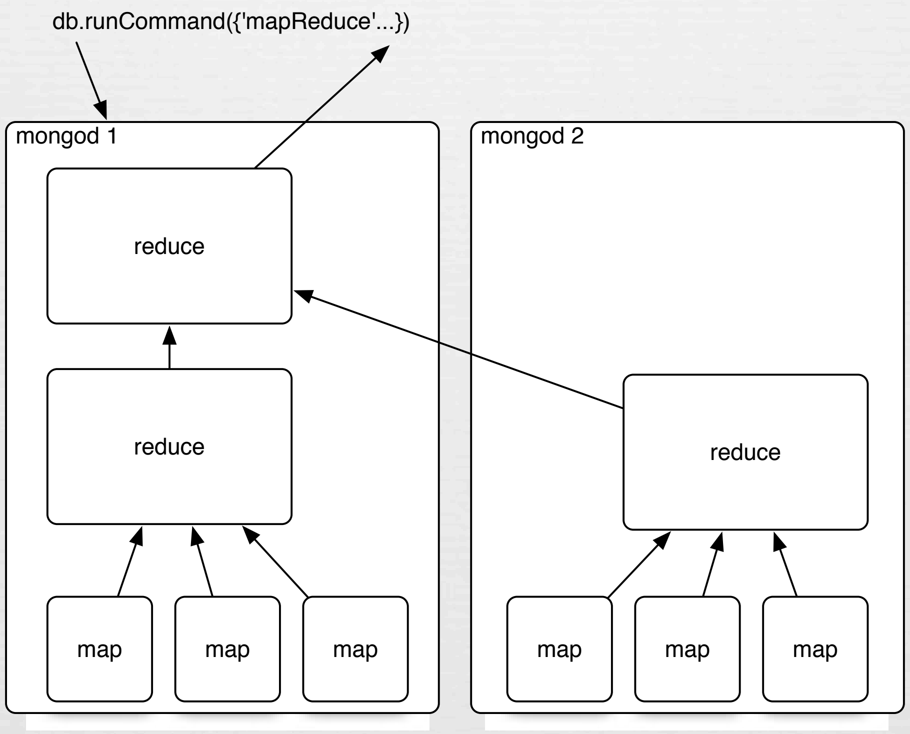
(in)Consistent Hashing



Mapreduce

```
rooms = Room.all

caps = rooms.map{|room| room.capacity }

result = caps.reduce(0){|sum, capacity| sum+capacity}
```

Mapreduce


db.runCommand({'mapReduce'...})
mongod 1
reduce
reduce
map
map
map
mongod 2
reduce
map
map
map

The Holy Grail of DBs is

Coming Soon

Our Fine Selection

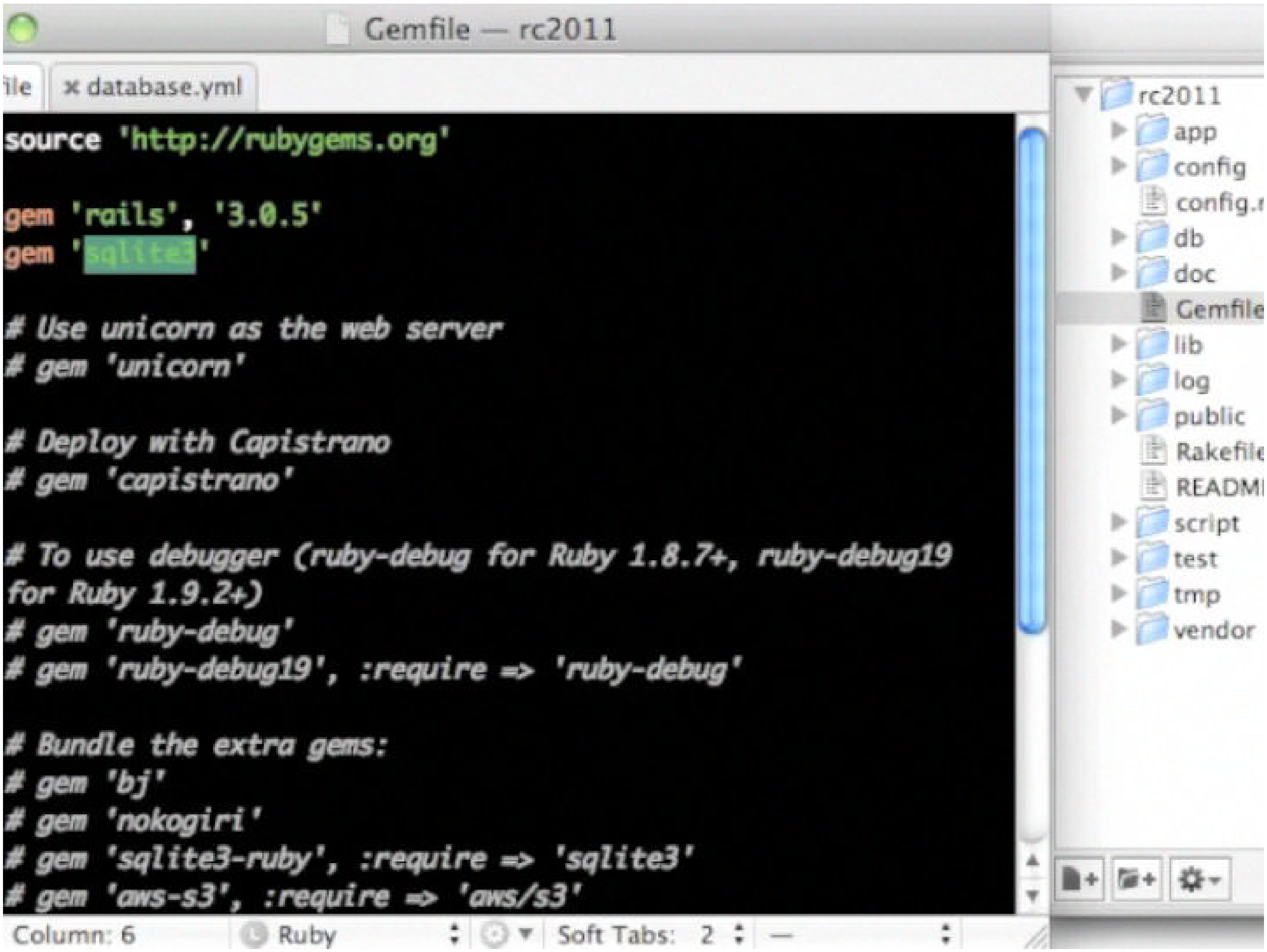
Column A	Column B
MySQL	CouchDB
PostgreSQL	Neo4j
Riak	FlockDB
Cassandra	Memcached
HBase	Kyoto Cabinet
MongoDB	Redis

Relational Models

- PostgreSQL (full featured)
  - http://bitbucket.org/ged/ruby-pg
  - http://github.com/Casecommons/pg_search
  - http://github.com/tenderlove/texticle
- MySQL (lighter)
  - http://rubygems.org/gems/mysql <= turd
  - http://github.com/brianmario/mysql2
  - http://github.com/oldmoe/mysqlplus
  - https://github.com/igrigorik/em-mysqlplus <= defunct
- Drizzle (lightest)
  - http://drizzle.org/
  - https://github.com/jakedouglas/libdrizzle-ruby-ffi

Benchmark / Numbers

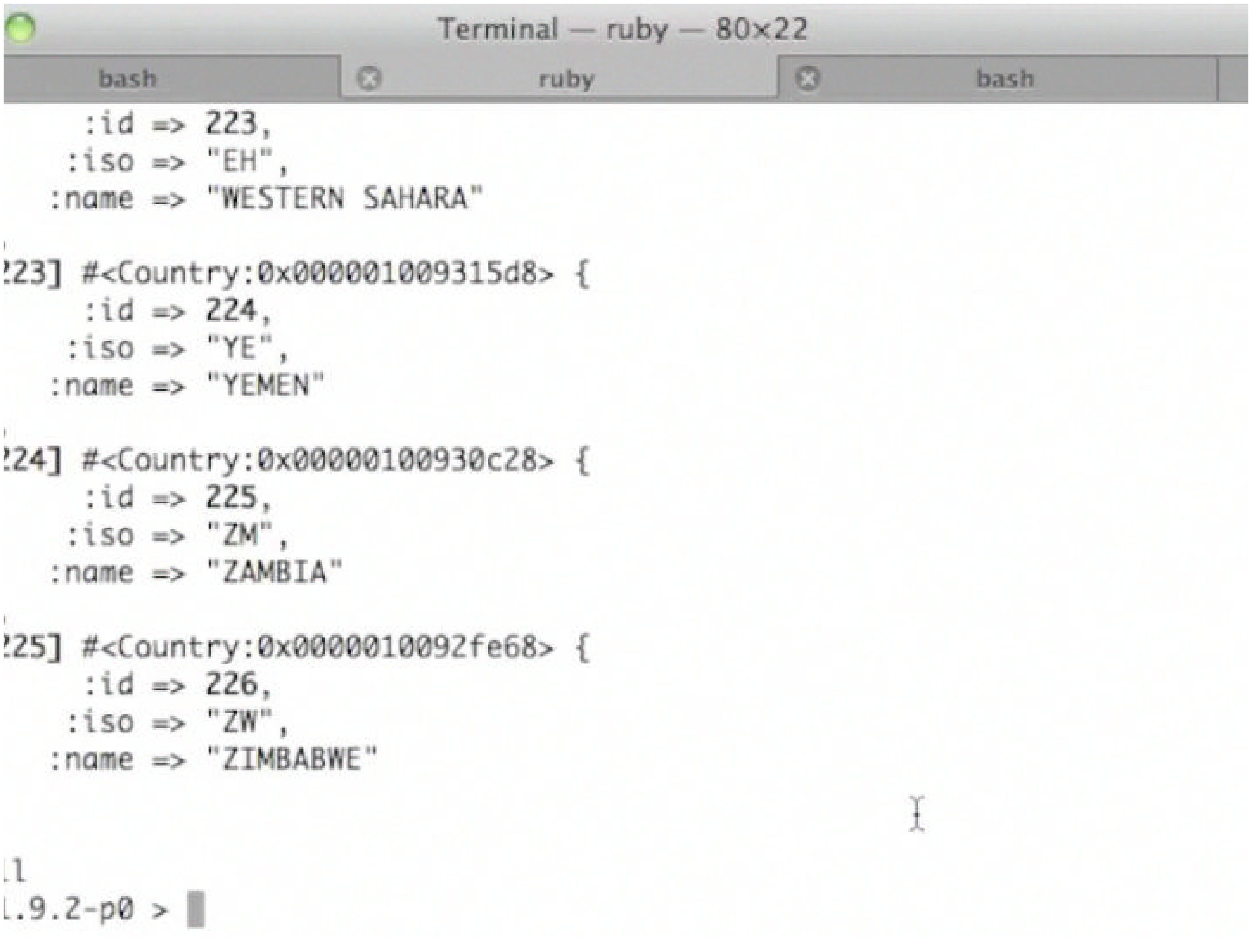
```
             user       system      total         real
Mysql2
 0.750000   0.180000   0.930000   (1.821655)
do_mysql
 1.650000   0.200000   1.850000   (2.811357)
Mysql
 7.500000   0.210000   7.710000   (8.065871)
```



```
source 'http://rubygems.org'

gem 'rails', '3.0.5'
gem 'sqlite3'

# Use unicorn as the web server
# gem 'unicorn'

# Deploy with Capistrano
# gem 'capistrano'

# To use debugger (ruby-debug for Ruby 1.8.7+, ruby-debug19
for Ruby 1.9.2+)
# gem 'ruby-debug'
# gem 'ruby-debug19', :require => 'ruby-debug'

# Bundle the extra gems:
# gem 'bj'
# gem 'nokogiri'
# gem 'sqlite3-ruby', :require => 'sqlite3'
# gem 'aws-s3', :require => 'aws/s3'
```

Sounds Like “kristmus”

- Trigram
  - Algorithm for misspellings
- Metaphone
  - Algorithm for similar sounds



```
      :id => 223,
     :iso => "EH",
    :name => "WESTERN SAHARA"
,
223] #<Country:0x000001009315d8> {
      :id => 224,
     :iso => "YE",
    :name => "YEMEN"
,
224] #<Country:0x00000100930c28> {
      :id => 225,
     :iso => "ZM",
    :name => "ZAMBIA"
,
225] #<Country:0x0000010092fe68> {
      :id => 226,
     :iso => "ZW",
    :name => "ZIMBABWE"


l1
.9.2-p0 >
```

ARel?

```
SELECT *, cube_distance(ranks, '1,0,0') dist

FROM movie_genres

WHERE cube_enlarge('(1,0,0)'::cube, 0, 3) @> ranks

ORDER BY dist;
```

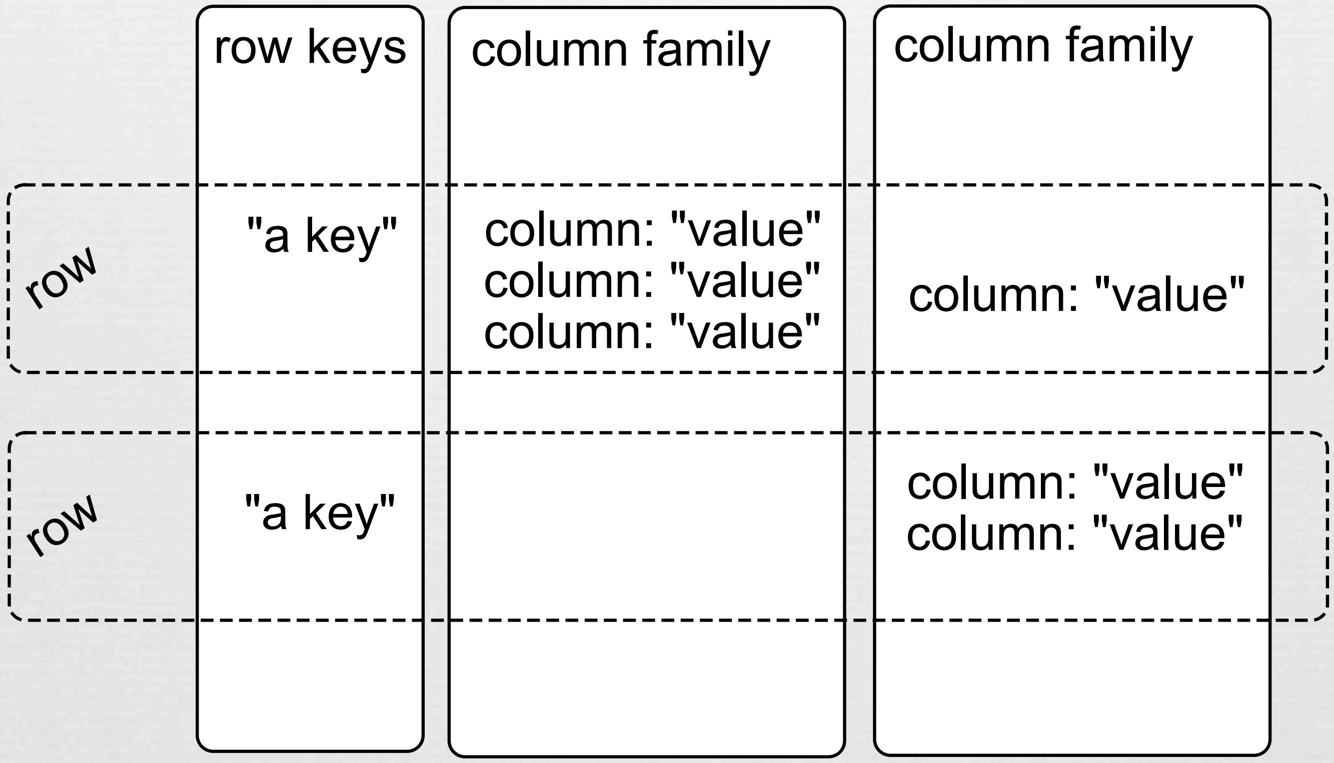
Bigtable/Columnar Style

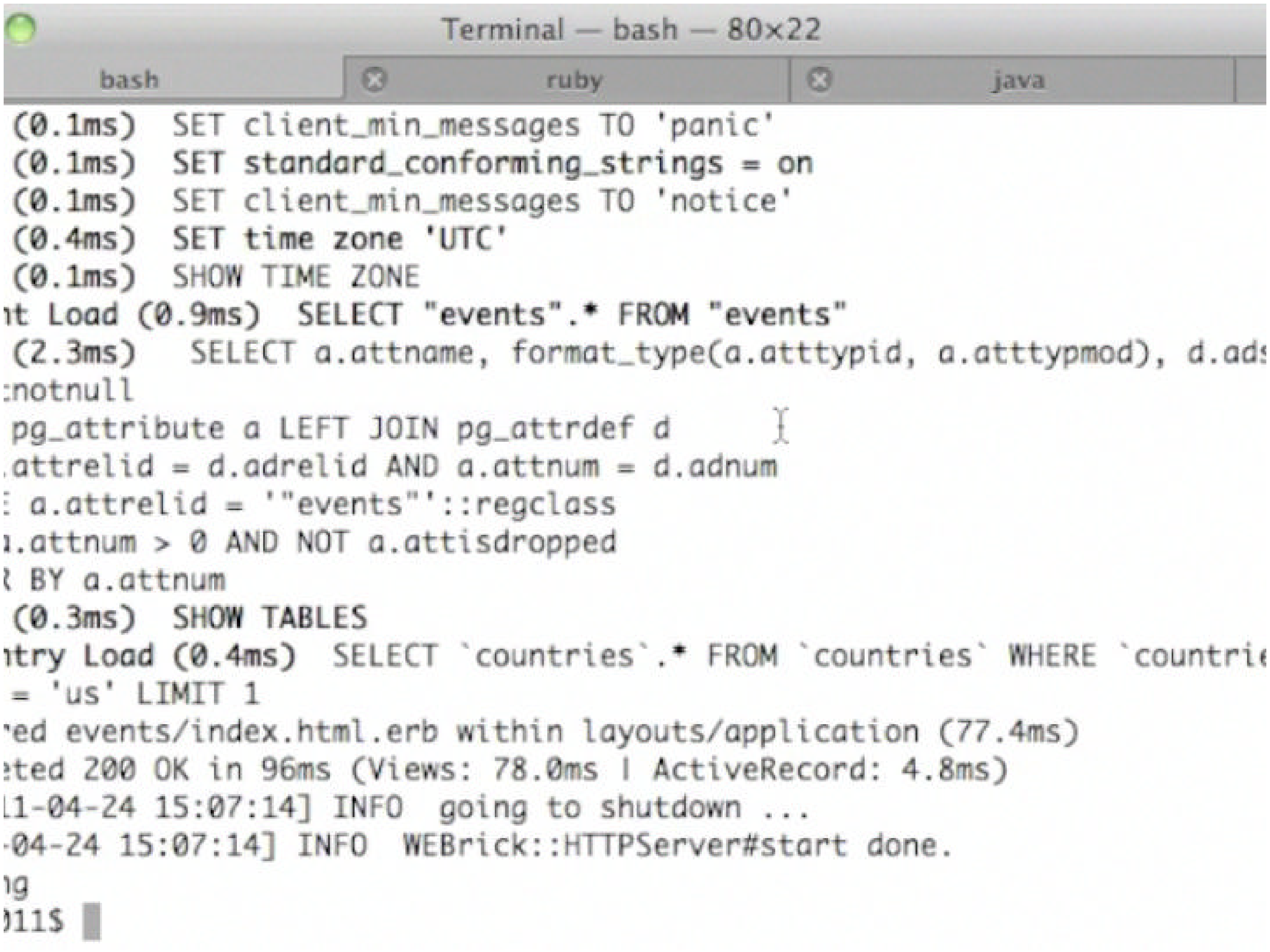
- HBase
  - http://github.com/greglu/hbase-stargate (slow)
  - http://github.com/sqs/rhino (defunct)
  - http://rubygems.org/gems/thrift
- Cassandra
  - Hybrid. Node architecture like dynamo – data structure like BigTable w/ column families
  - http://github.com/fauna/cassandra
  - http://github.com/NZKoz/cassandra_object

HBase

- Google BigTable implementation
- Born of Hadoop (Java mapreduce engine)
- JRuby CLI!

"BigTable" Columns





```
 (0.1ms)  SET client_min_messages TO 'panic'
 (0.1ms)  SET standard_conforming_strings = on
 (0.1ms)  SET client_min_messages TO 'notice'
 (0.4ms)  SET time zone 'UTC'
 (0.1ms)  SHOW TIME ZONE
nt Load (0.9ms)  SELECT "events".* FROM "events"
 (2.3ms)   SELECT a.attname, format_type(a.atttypid, a.atttypmod), d.ads
:notnull
 pg_attribute a LEFT JOIN pg_attrdef d
.attrelid = d.adrelid AND a.attnum = d.adnum
: a.attrelid = '"events"'::regclass
a.attnum > 0 AND NOT a.attisdropped
R BY a.attnum
 (0.3ms)  SHOW TABLES
ntry Load (0.4ms)  SELECT `countries`.* FROM `countries` WHERE `countrie
 = 'us' LIMIT 1
red events/index.html.erb within layouts/application (77.4ms)
eted 200 OK in 96ms (Views: 78.0ms | ActiveRecord: 4.8ms)
11-04-24 15:07:14] INFO  going to shutdown ...
-04-24 15:07:14] INFO  WEBrick::HTTPServer#start done.
ng
011$ 
```

launch_hbase.rb

```
require 'hbase'
class Object
  include Apache::Hadoop::Hbase::Thrift
  def thrift
    unless defined?(@@hclient)
      @@tsocket = Thrift::Socket.new( '127.0.0.1', 9090 )
      @@ttransport = Thrift::BufferedTransport.new( @@tsocket )
      @@tprotocol = Thrift::BinaryProtocol.new( @@ttransport )
      @@hclient = Hbase::Client.new( @@tprotocol )
    end
    @@ttransport.open
    yield @@hclient
  ensure
    @@ttransport.close
  end
end
```

Hbase Migration

```
class CreateWikis < ActiveRecord::Migration
  def self.up
    thrift do |hbase|
      hbase.createTable( 'wiki', [
        ColumnDescriptor.new(:name => 'text:', :maxVersions=>10),
        ColumnDescriptor.new(:name => 'title:')
      ])
    end
  end
```

wiki.rb

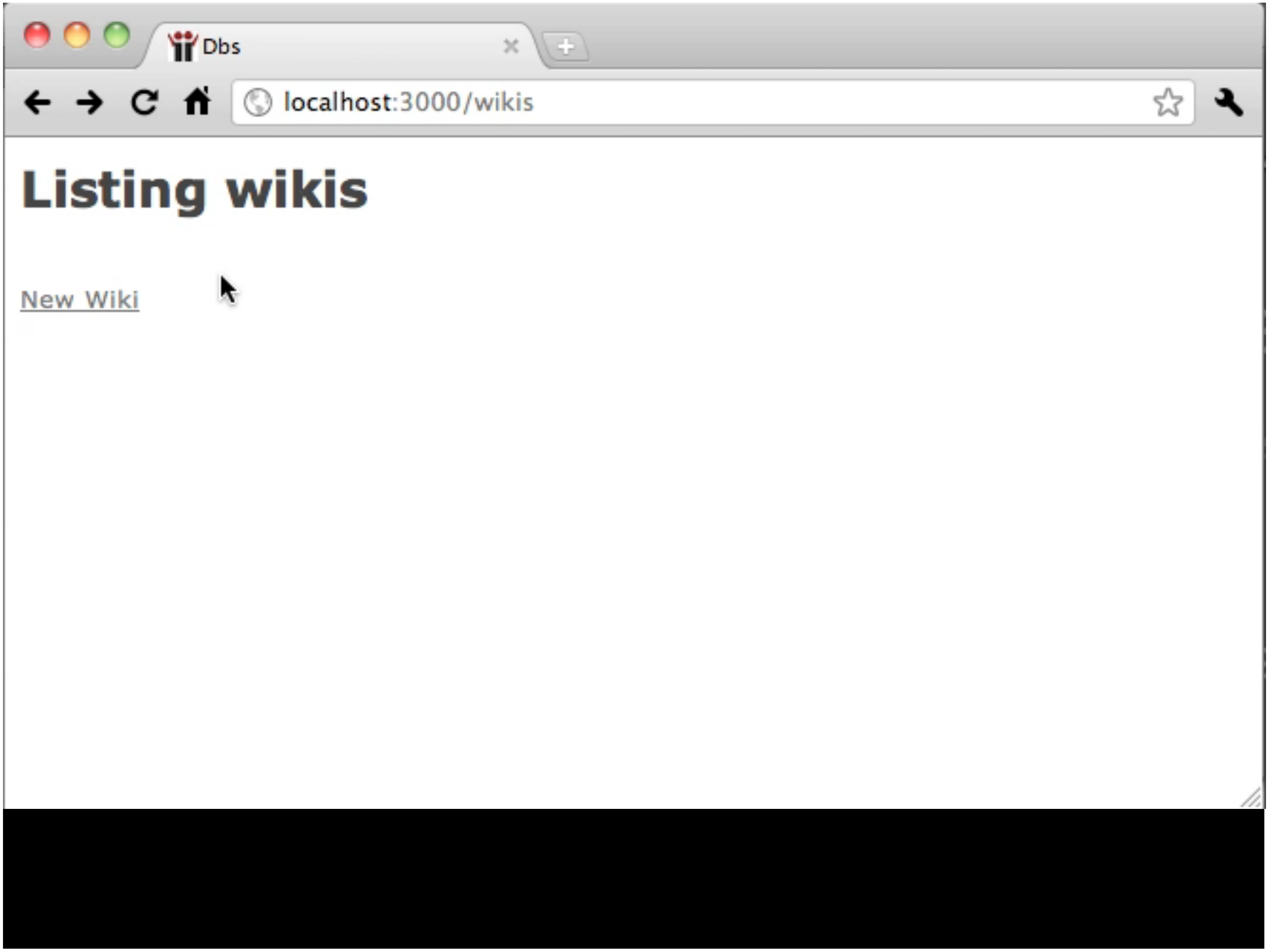
```
def self.all( start = '' )
  wikis = []
  thrift do |hbase|
    scanner = hbase.scannerOpen( 'wiki', start, ['title:', 'text:'] )
    while (row = hbase.scannerGet(scanner) ).present?
      row.each do |v|
        wikis << Wiki.new( :title => v.columns['title:'].value,
                           :text => v.columns['text:'].value)
      end
    end
  end
  wikis
end
```

wiki.rb

```
def self.find(title)
  thrift do |hbase|
    hbase.getRow('wiki', title).each do |v|
      return Wiki.new( :title => v.columns['title:'].value,
                       :text => v.columns['text:'].value )
    end
  end
end
```

wiki.rb

```
def history
   historical_text = []
   thrift do |hbase|
     hbase.getVer( 'wiki', title, 'text:', 10 ).each do |v|
       historical_text << v.value.dup
     end
   end
   historical_text
 end
```



Listing wikis

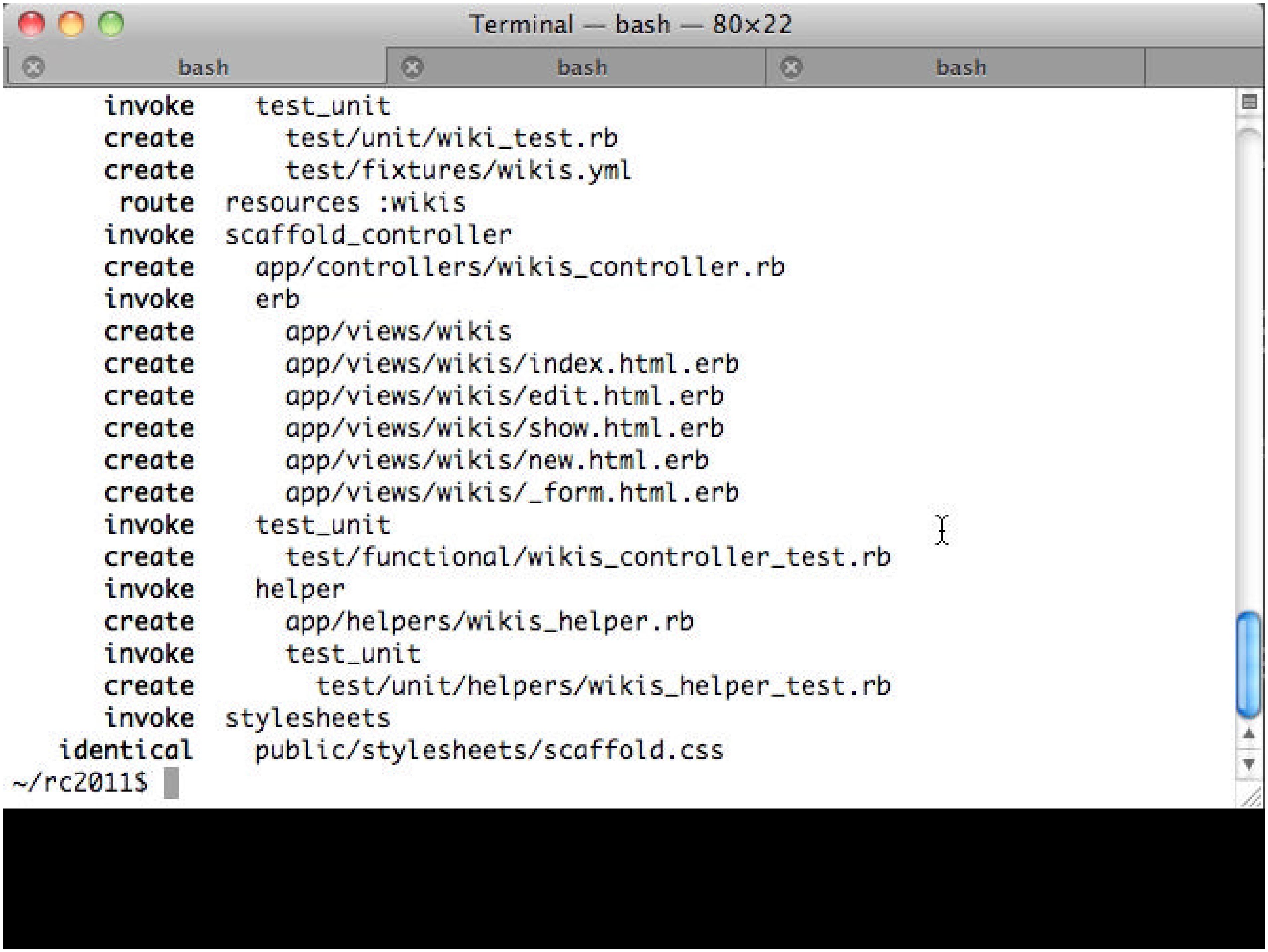
New Wiki

HBase Benefits

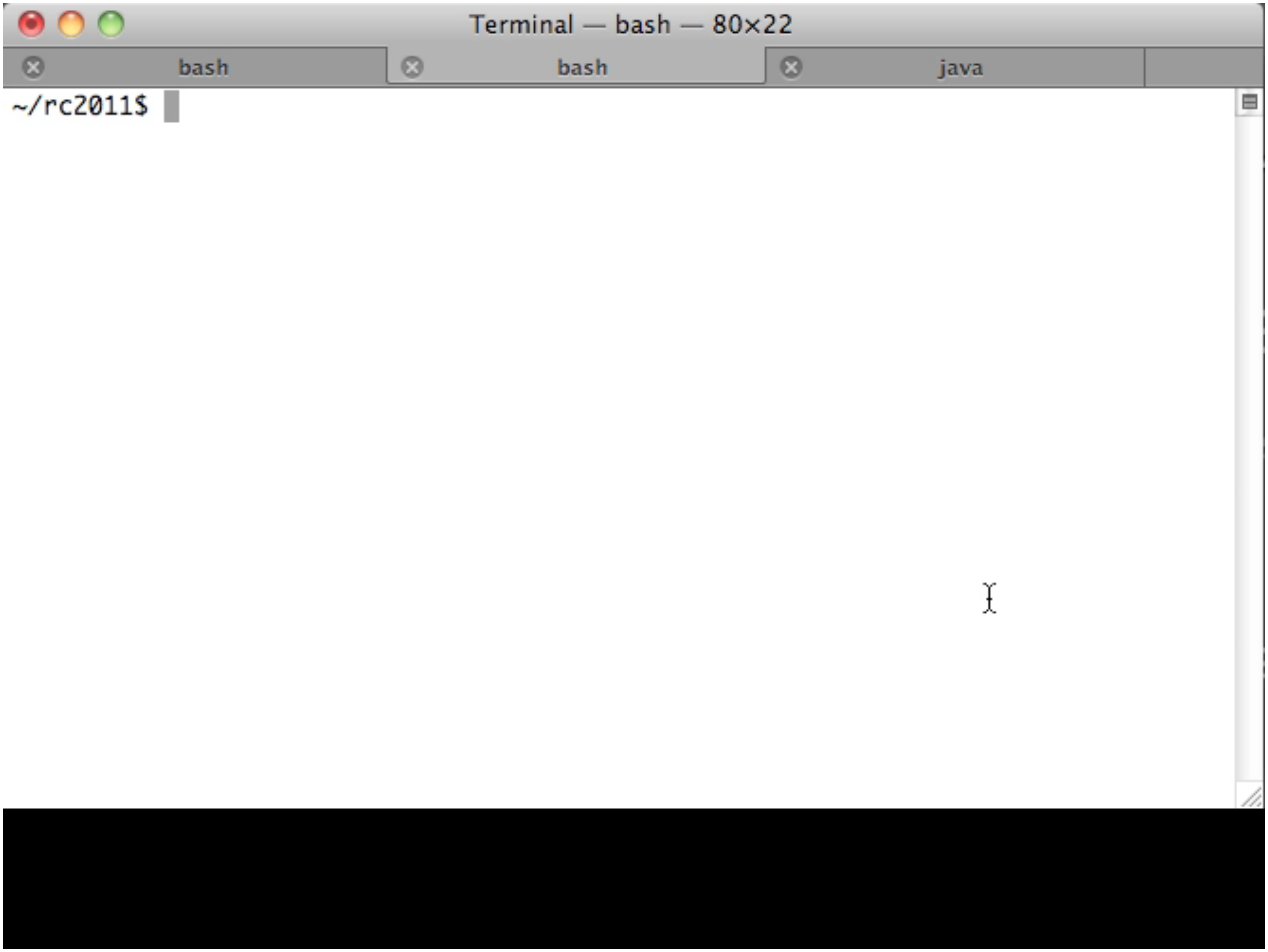
- Strong (and flexible) columnar schema
- Sequential Reads and Column Versioning
- Mapreduce via Hadoop integration
- Consistent (configurable to Available)
- Great for Wide Area Networks
- *(Google, Facebook)*

storage-conf.xml ☹

```
<Keyspace Name="CassandraObject">
  <ColumnFamily CompareWith="UTF8Type" Name="Customers"/>
  <ColumnFamily CompareWith="TimeUUIDType"
Name="CustomersByLastName" />
  <ColumnFamily CompareWith="UTF8Type”
Name="Appointments" />
  …
</Keyspace>
```



```
      invoke    test_unit
      create      test/unit/wiki_test.rb
      create      test/fixtures/wikis.yml
       route  resources :wikis
      invoke  scaffold_controller
      create    app/controllers/wikis_controller.rb
      invoke    erb
      create      app/views/wikis
      create      app/views/wikis/index.html.erb
      create      app/views/wikis/edit.html.erb
      create      app/views/wikis/show.html.erb
      create      app/views/wikis/new.html.erb
      create      app/views/wikis/_form.html.erb
      invoke    test_unit
      create      test/functional/wikis_controller_test.rb
      invoke    helper
      create      app/helpers/wikis_helper.rb
      invoke      test_unit
      create        test/unit/helpers/wikis_helper_test.rb
      invoke  stylesheets
   identical    public/stylesheets/scaffold.css
~/rc2011$ 
```



```
~/rc2011$ 
```

Cassandra

- Sequential Reads of Ordered Keys (scannable)
- Columnar schema
- Built-in versioning
- Available (configurable to Consistent)
- Optimized for hundreds of nodes
- *(Digg, Twitter)*

INTERMISSION

Let’s Enjoy Some Art

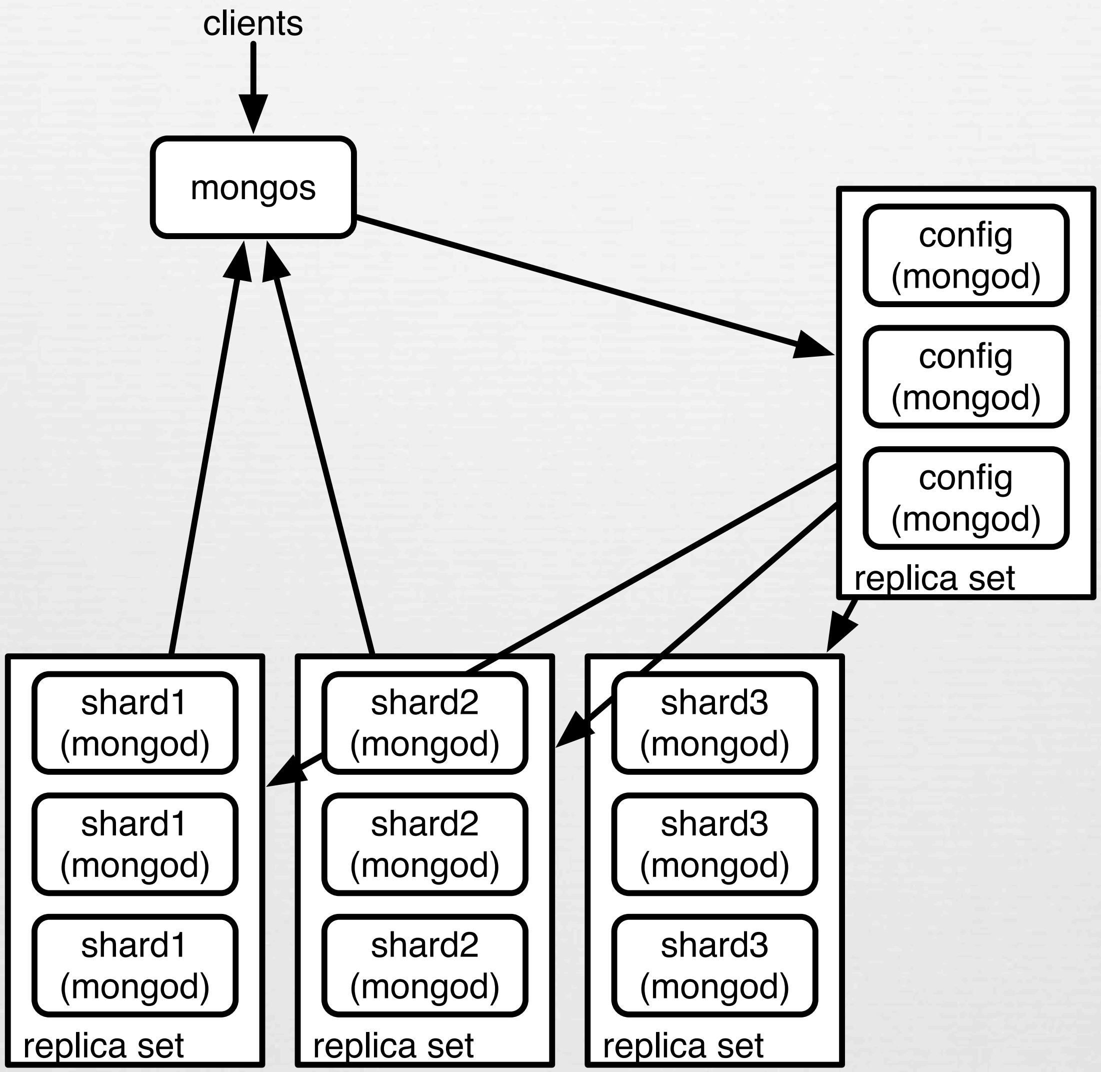
ps -ef | grep
Ceci n'est pas une pipe.

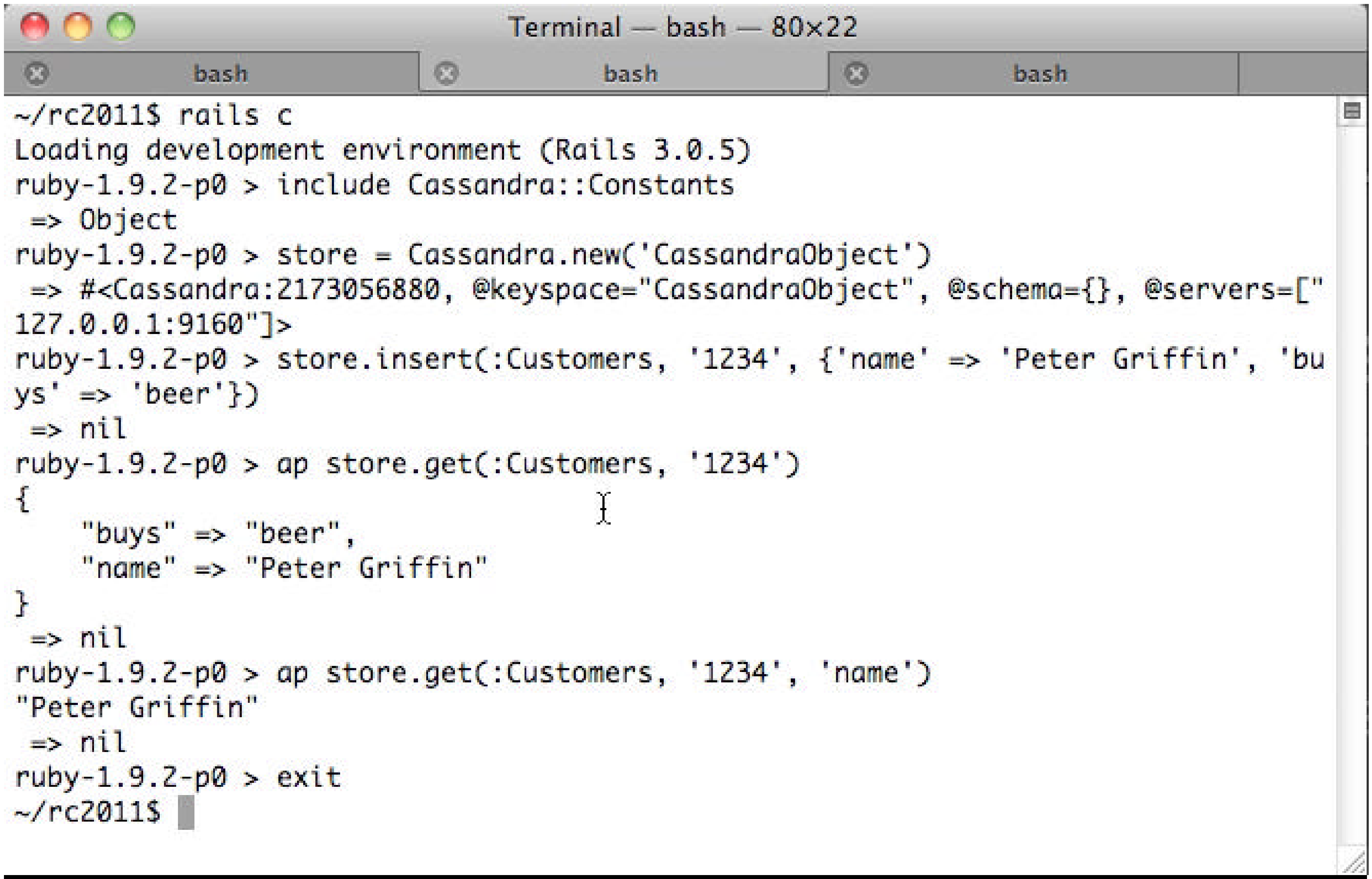
Document Datastore

- MongoDB
  - http://mongoid.org/
  - http://mongomapper.com/ (rails3 branch)
- CouchDB
  - http://github.com/couchrest/couchrest_model
  - http://github.com/peritor/simply_stored
  - http://tilgovi.github.com/couchdb-lounge/ (clustering)

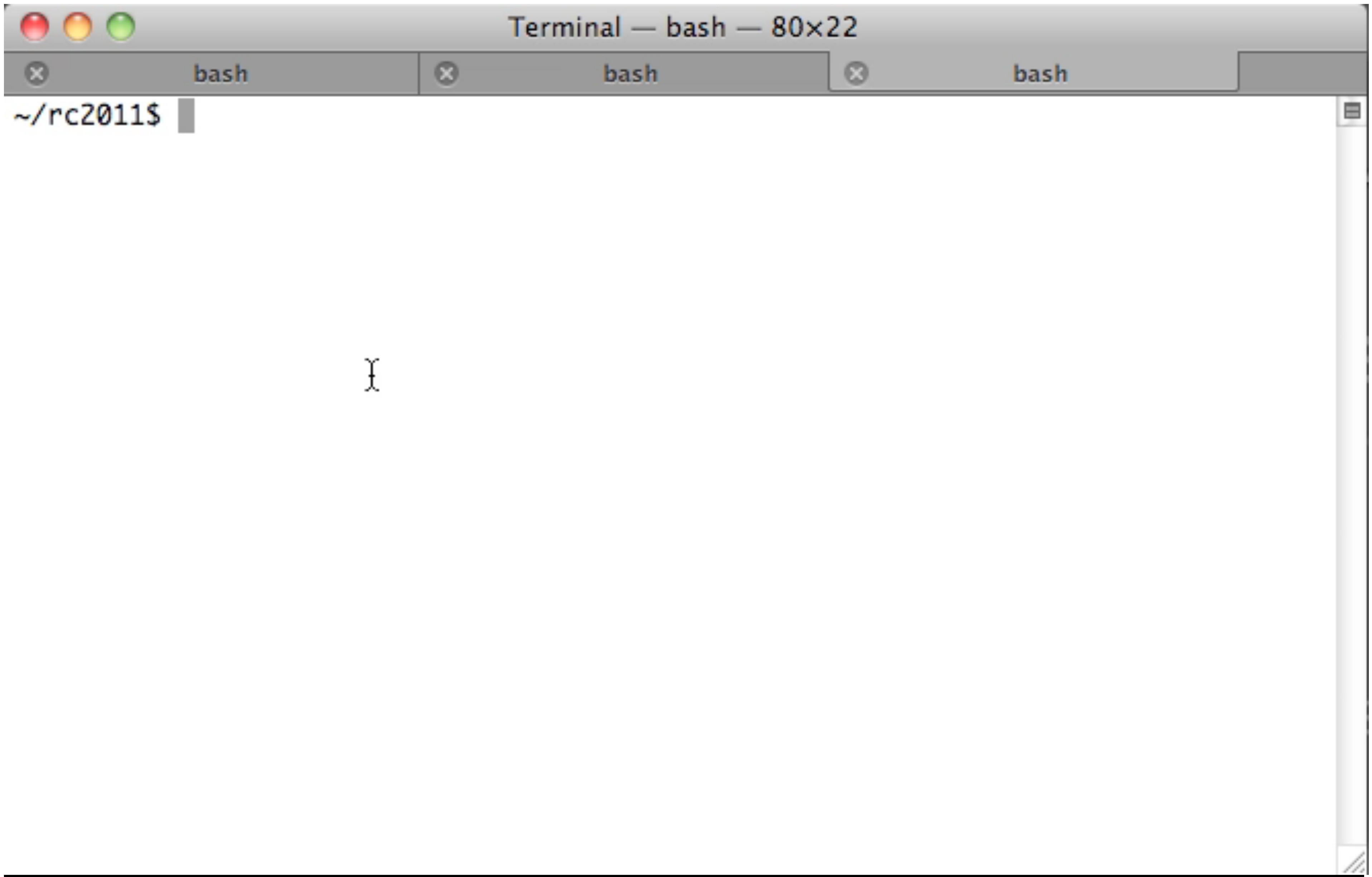
Document

```
{
    "_id" : ObjectId("4db7ca268e236e5bf9a52224"),
    "_rev" : "2612672603",
    "name" : "Sant Julià de Lòria",
    "country" : "AD",
    "timezone" : "Europe/Andorra",
    "population" : 8022,
    "location" : {
        "latitude" : 42.46372,
        "longitude" : 1.49129
    }
}
```

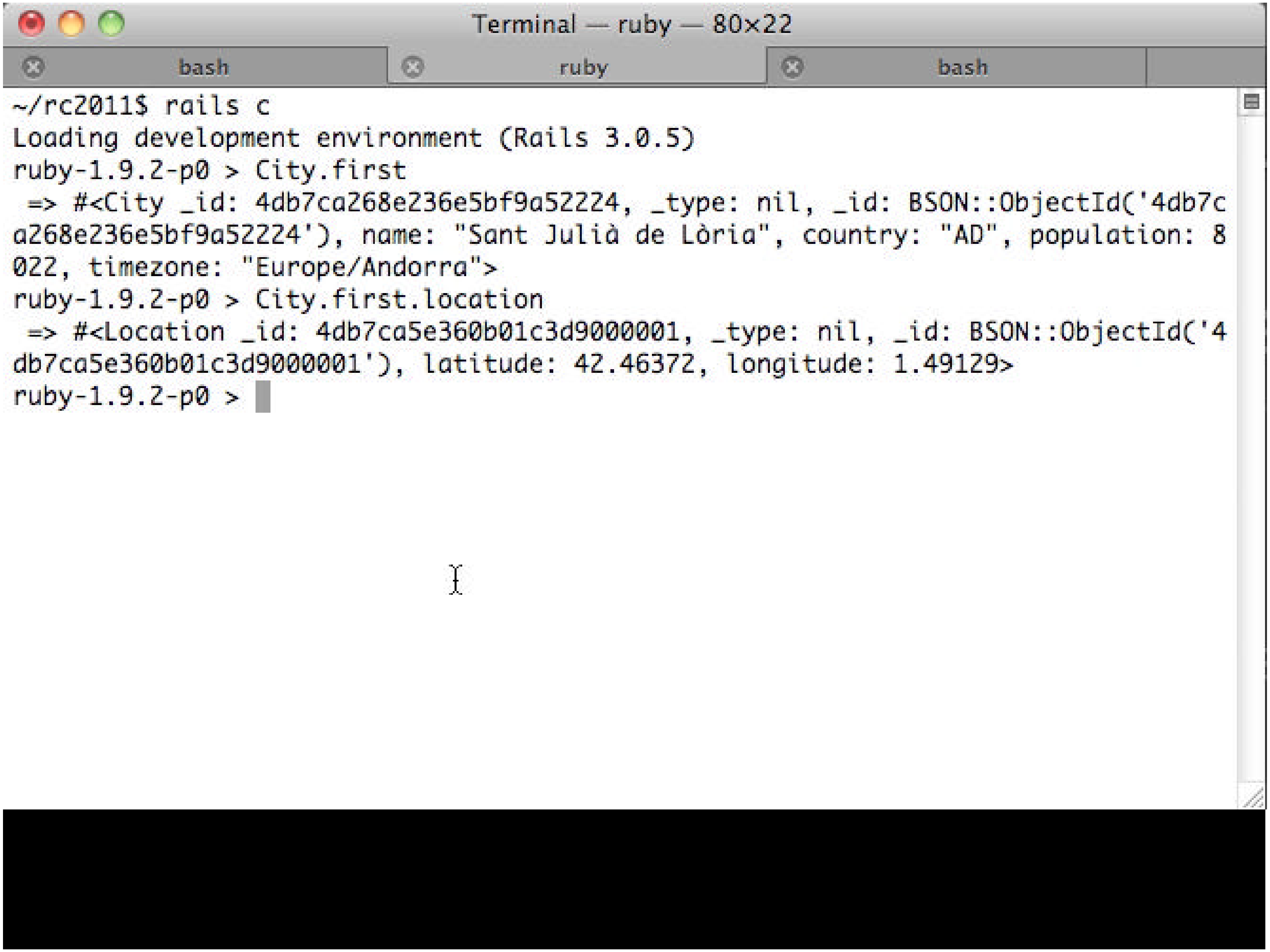

clients
mongos
config (mongod)
config (mongod)
config (mongod)
replica set
shard1 (mongod)
shard1 (mongod)
shard1 (mongod)
replica set
shard2 (mongod)
shard2 (mongod)
shard2 (mongod)
replica set
shard3 (mongod)
shard3 (mongod)
shard3 (mongod)
replica set



```
~/rc2011$ rails c
Loading development environment (Rails 3.0.5)
ruby-1.9.2-p0 > include Cassandra::Constants
 => Object
ruby-1.9.2-p0 > store = Cassandra.new('CassandraObject')
 => #<Cassandra:2173056880, @keyspace="CassandraObject", @schema={}, @servers=["
127.0.0.1:9160"]>
ruby-1.9.2-p0 > store.insert(:Customers, '1234', {'name' => 'Peter Griffin', 'bu
ys' => 'beer'})
 => nil
ruby-1.9.2-p0 > ap store.get(:Customers, '1234')
{
    "buys" => "beer",
    "name" => "Peter Griffin"
}
 => nil
ruby-1.9.2-p0 > ap store.get(:Customers, '1234', 'name')
"Peter Griffin"
 => nil
ruby-1.9.2-p0 > exit
~/rc2011$
```



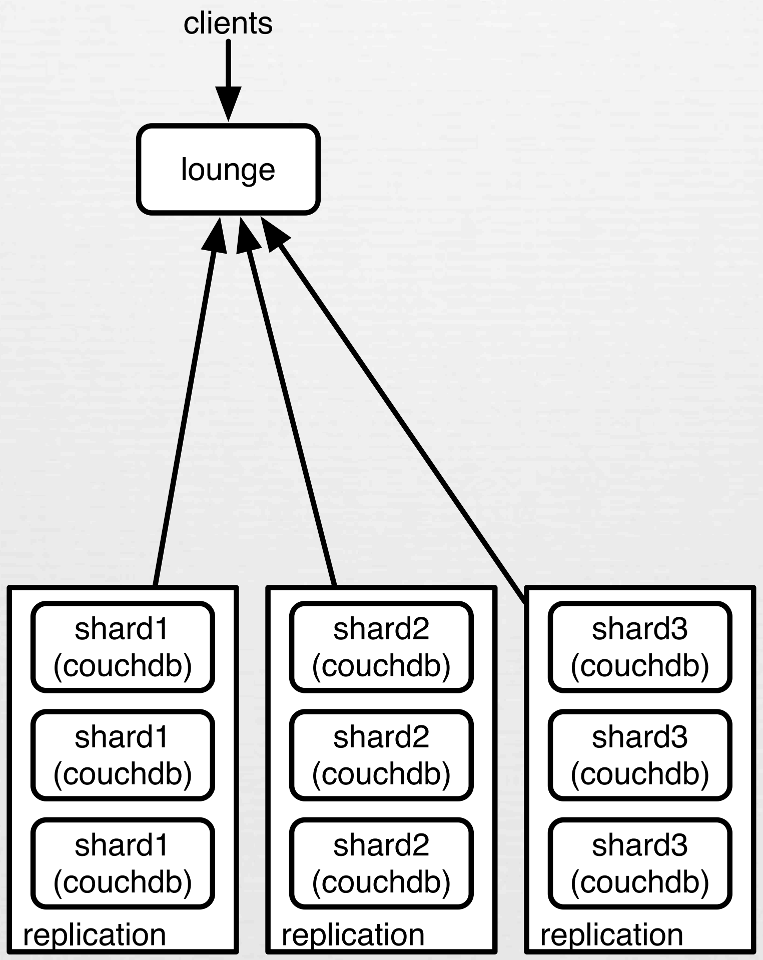
```
~/rc2011$
```

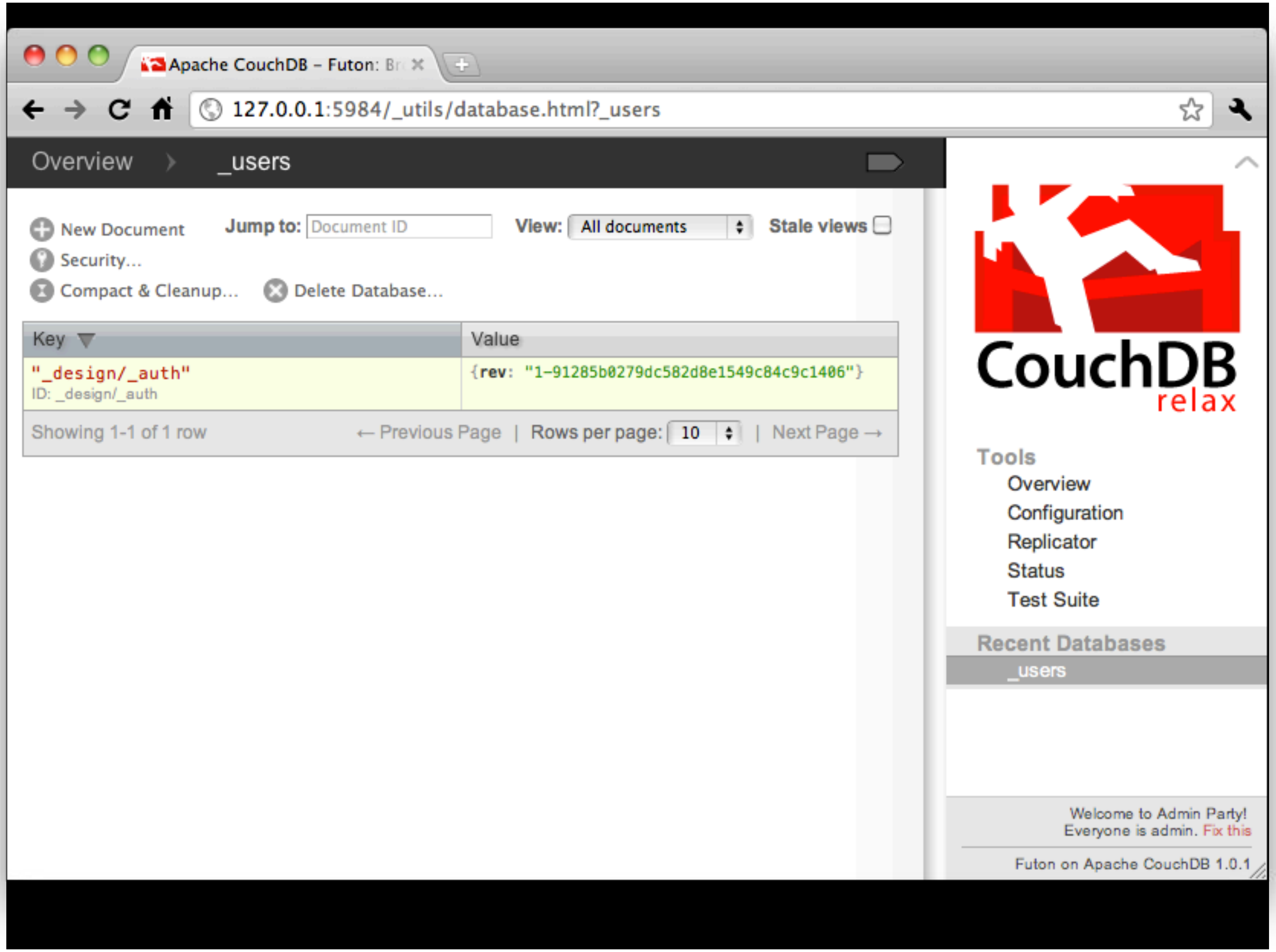


```
~/rc2011$ rails c
Loading development environment (Rails 3.0.5)
ruby-1.9.2-p0 > City.first
 => #<City _id: 4db7ca268e236e5bf9a52224, _type: nil, _id: BSON::ObjectId('4db7c
a268e236e5bf9a52224'), name: "Sant Julià de Lòria", country: "AD", population: 8
022, timezone: "Europe/Andorra">
ruby-1.9.2-p0 > City.first.location
 => #<Location _id: 4db7ca5e360b01c3d9000001, _type: nil, _id: BSON::ObjectId('4
db7ca5e360b01c3d9000001'), latitude: 42.46372, longitude: 1.49129>
ruby-1.9.2-p0 >
```

Couch

- Interacting with Couch in Rails is similar to Mongo. The difference is a heavier reliance on map/reduce to create views.
- Futon (web console)
- Lounge (clustering, sharding)
- BigCouch (Dynamo-style NRW)


clients
lounge
shard1 (couchdb)
shard1 (couchdb)
shard1 (couchdb)
replication
shard2 (couchdb)
shard2 (couchdb)
shard2 (couchdb)
replication
shard3 (couchdb)
shard3 (couchdb)
shard3 (couchdb)
replication



Key	Value
"_design/_auth" ID: _design/_auth	{rev: "1-91285b0279dc582d8e1549c84c9c1406"}

Showing 1-1 of 1 row ← Previous Page | Rows per page: 10 | Next Page →

Relax

```
$ sudo couchdb
Apache CouchDB 1.0.1 (LogLevel=info) is starting.
Apache CouchDB has started. Time to relax.
[info] [<0.31.0>] Apache CouchDB has started on
    http://127.0.0.1:5984/

$ curl http://127.0.0.1:5984/
{"couchdb":"Welcome","version":"1.0.1"}
```

Mongo v Couch

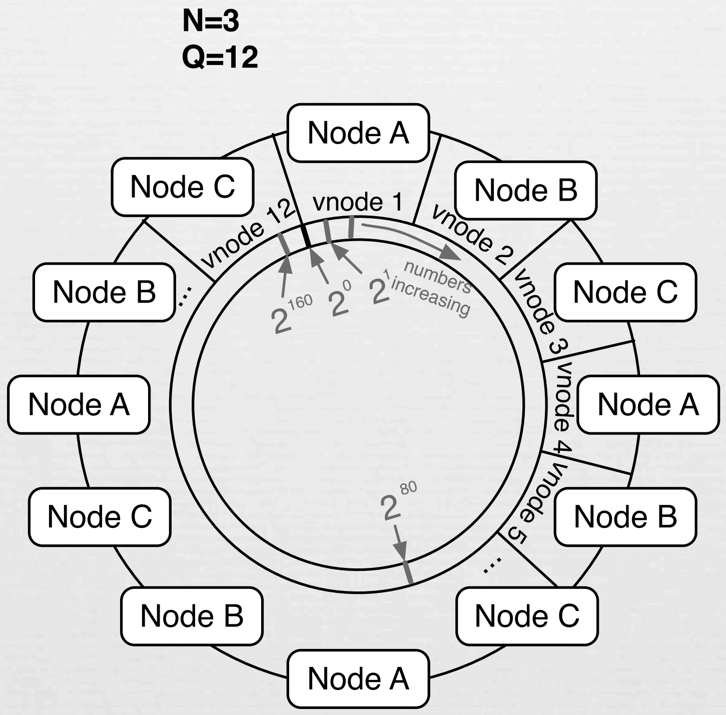
- Consistency Focused
  - Master/Slave
- Ad-hoc queries
- Comfortable to SQL users
- Built to run on clusters

- Availability Focused
  - Master/Master
- Mapreduce views
- Comfortable to client/server authors
- Runs on nearly anything

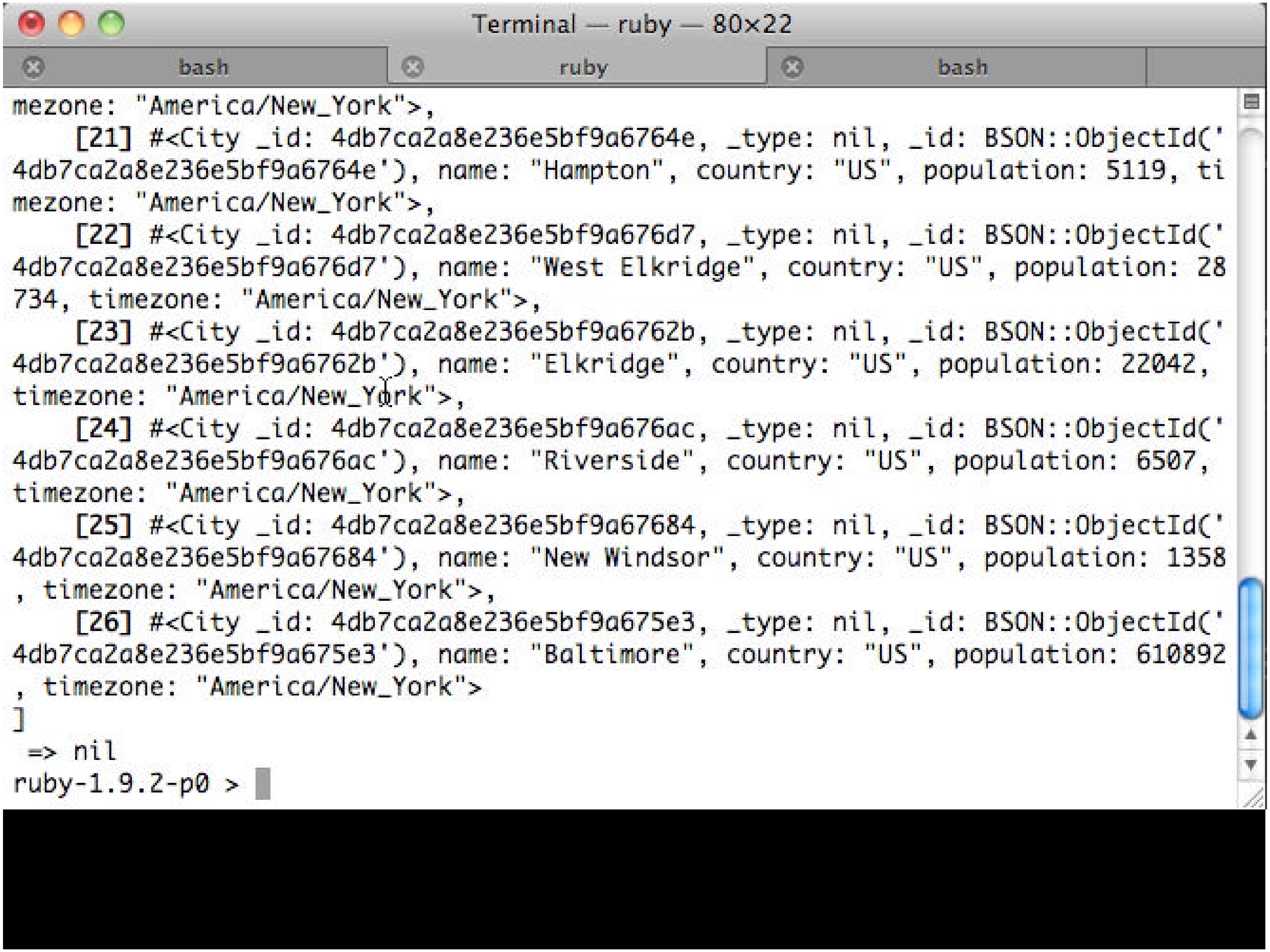
Dynamo K/V Style

- Riak
  - Pretty “documenty”
  - Risky https://github.com/aphyr/risky
  - Ripple http://seancribbs.github.com/ripple
  - Riak Session http://rubygems.org/gems/riak-sessions

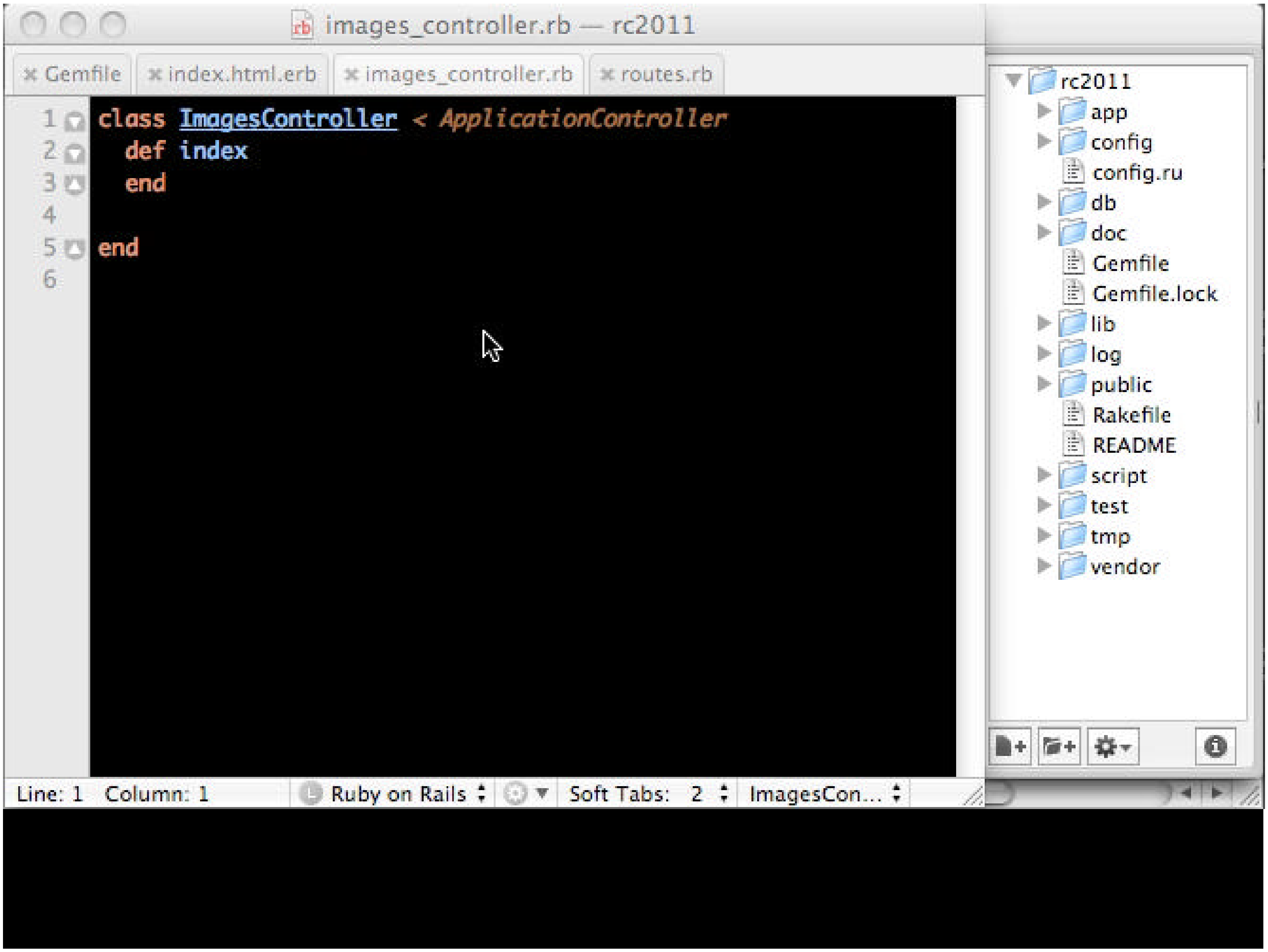
"The Ring"



N=3
Q=12
Node A
Node B
Node C
Node A
Node B
Node C
Node A
Node B
Node C
Node A
Node B
Node C
vnode 1
vnode 2
vnode 3
vnode 4
vnode 5
vnode 12
...
...
2^{160}
2^0
2^1
numbers increasing
2^{80}



```
mezone: "America/New_York">,
    [21] #<City _id: 4db7ca2a8e236e5bf9a6764e, _type: nil, _id: BSON::ObjectId('
4db7ca2a8e236e5bf9a6764e'), name: "Hampton", country: "US", population: 5119, ti
mezone: "America/New_York">,
    [22] #<City _id: 4db7ca2a8e236e5bf9a676d7, _type: nil, _id: BSON::ObjectId('
4db7ca2a8e236e5bf9a676d7'), name: "West Elkridge", country: "US", population: 28
734, timezone: "America/New_York">,
    [23] #<City _id: 4db7ca2a8e236e5bf9a6762b, _type: nil, _id: BSON::ObjectId('
4db7ca2a8e236e5bf9a6762b'), name: "Elkridge", country: "US", population: 22042,
timezone: "America/New_York">,
    [24] #<City _id: 4db7ca2a8e236e5bf9a676ac, _type: nil, _id: BSON::ObjectId('
4db7ca2a8e236e5bf9a676ac'), name: "Riverside", country: "US", population: 6507,
timezone: "America/New_York">,
    [25] #<City _id: 4db7ca2a8e236e5bf9a67684, _type: nil, _id: BSON::ObjectId('
4db7ca2a8e236e5bf9a67684'), name: "New Windsor", country: "US", population: 1358
, timezone: "America/New_York">,
    [26] #<City _id: 4db7ca2a8e236e5bf9a675e3, _type: nil, _id: BSON::ObjectId('
4db7ca2a8e236e5bf9a675e3'), name: "Baltimore", country: "US", population: 610892
, timezone: "America/New_York">
]
 => nil
ruby-1.9.2-p0 >
```



images_controller.rb — rc2011

Gemfile | index.html.erb | images_controller.rb | routes.rb

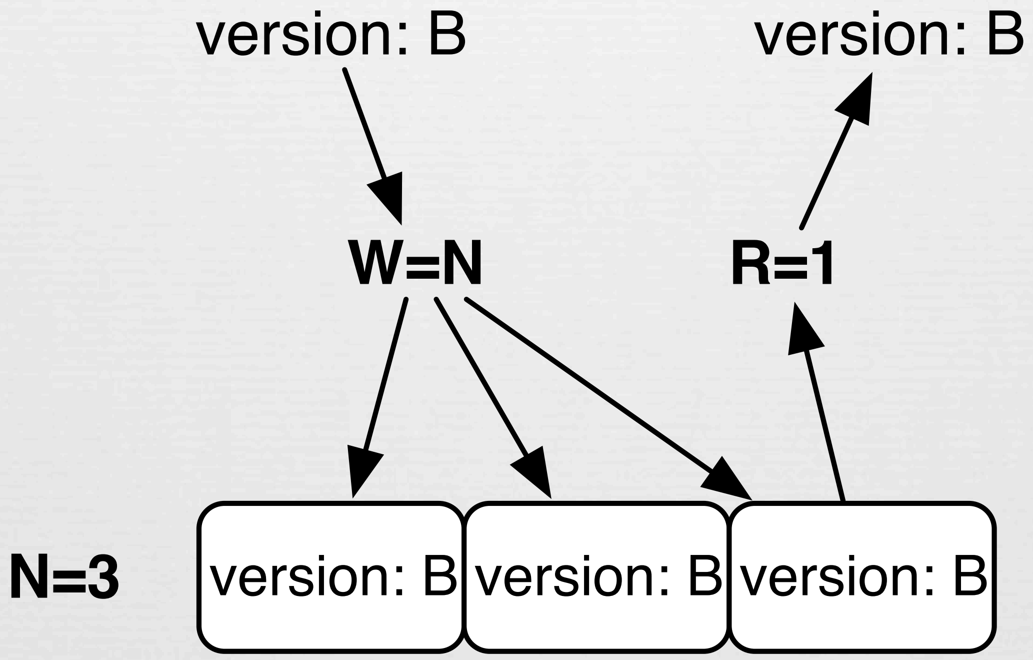
```ruby
class ImagesController < ApplicationController
  def index
  end

end
```

Line: 1 Column: 1 | Ruby on Rails | Soft Tabs: 2 | ImagesCon…

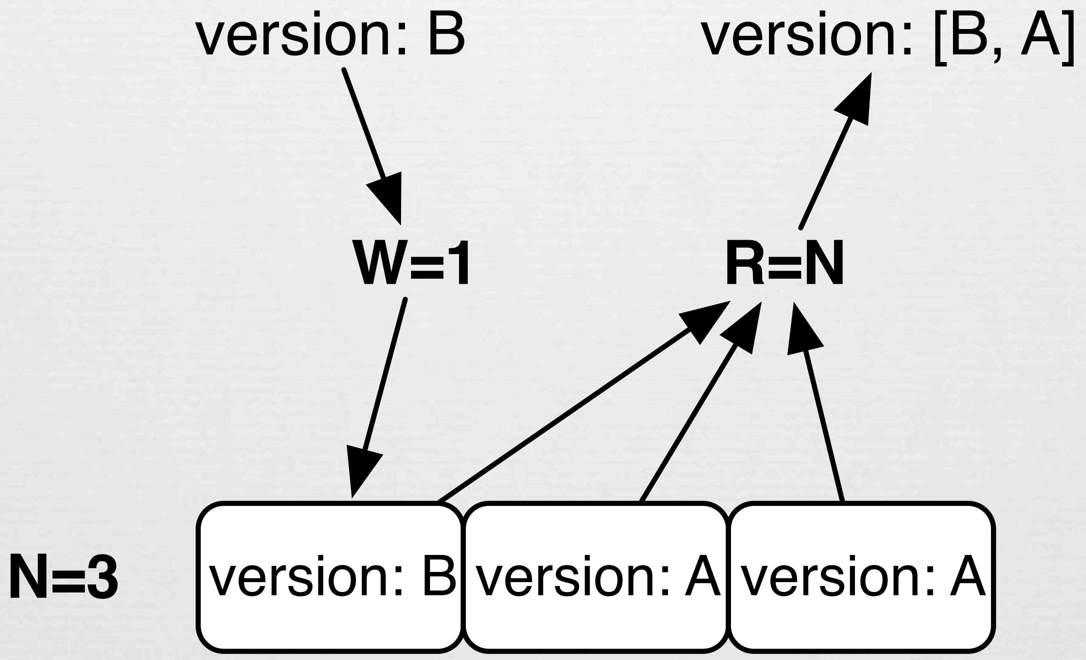
N/R/W

- CAP can't be beat – but it can be tweaked
- N/R/W
  - N = Nodes to write to (per bucket)
  - W = Nodes written to before success
  - R = Nodes read from before success
- What does this mean?
  - Support both CP and AP in one database

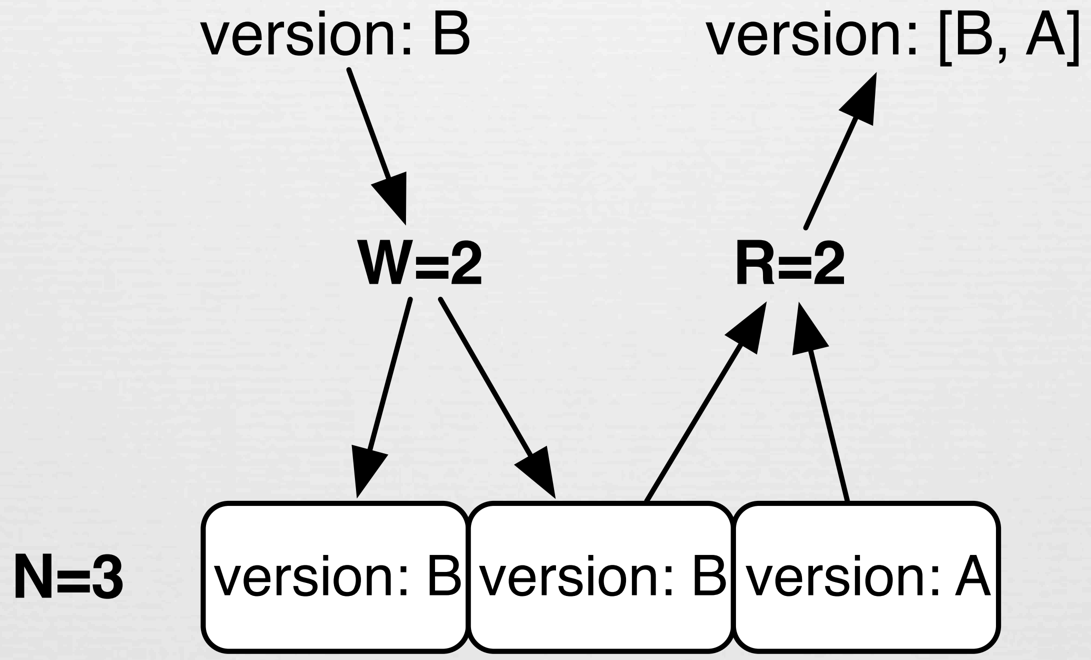
Write Consistency



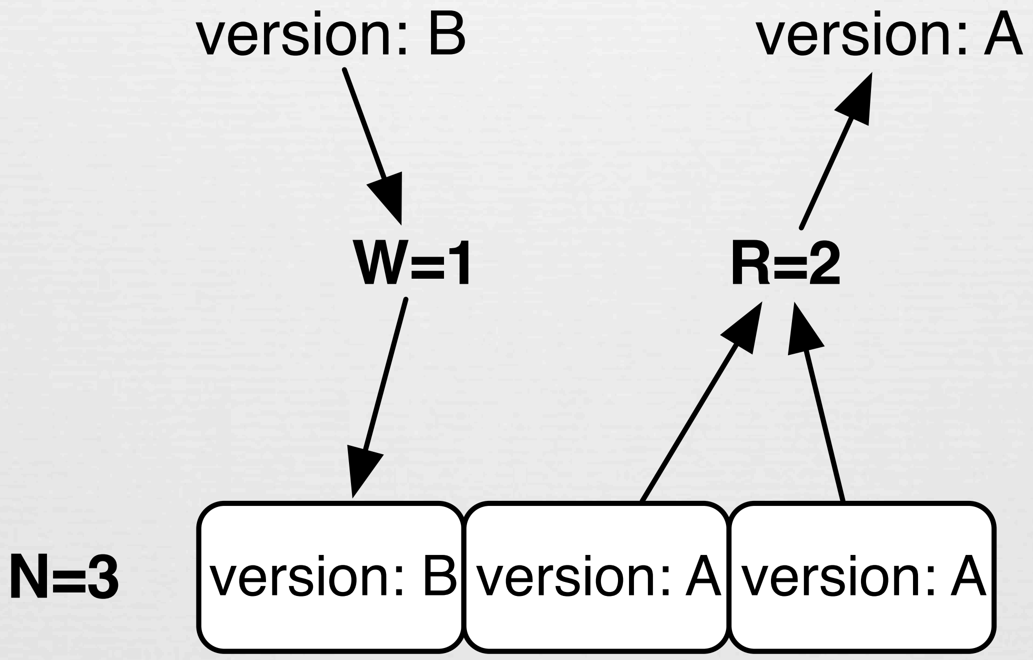
Read Consistency

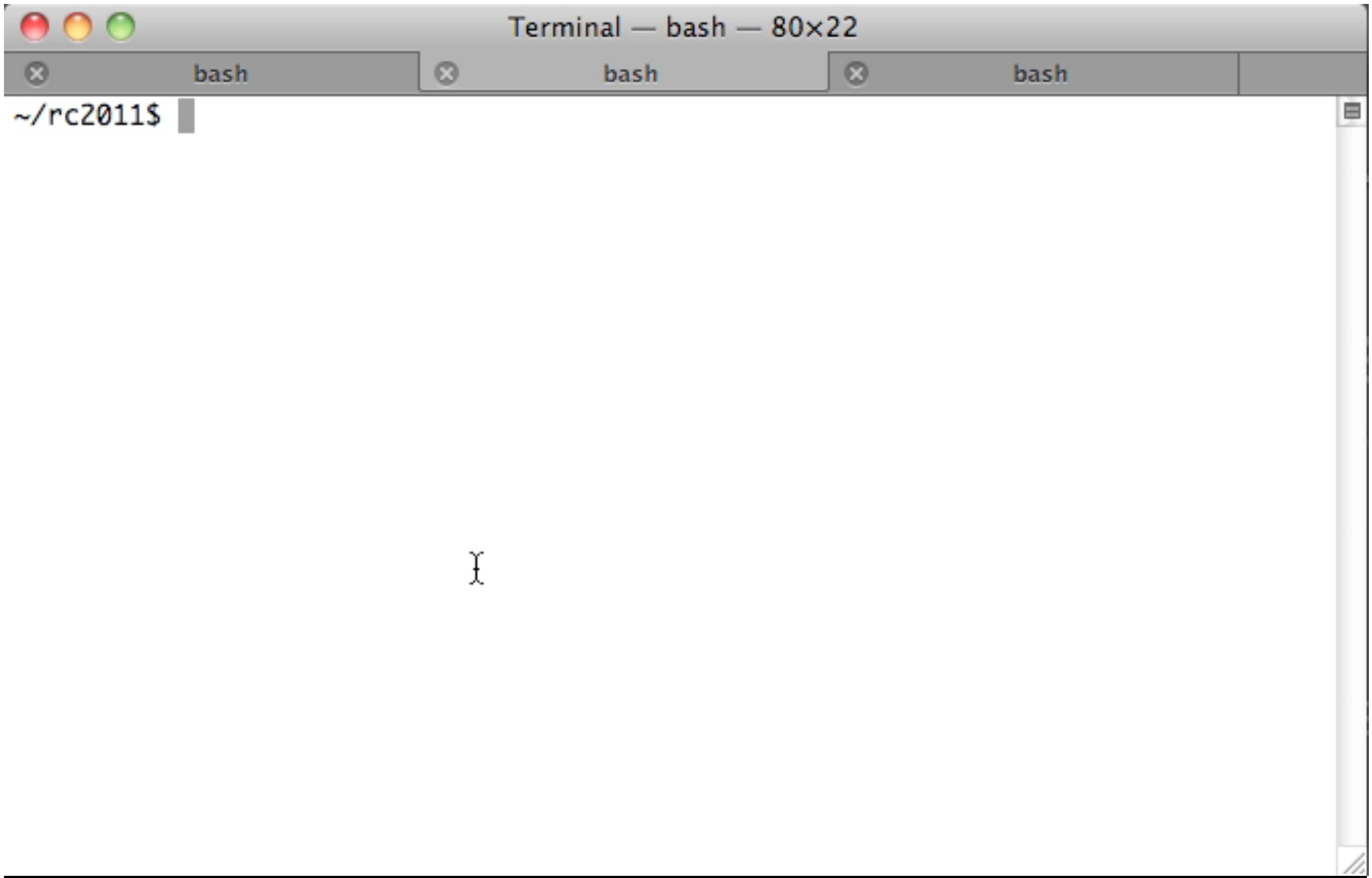


Quorum



Weak Consistency





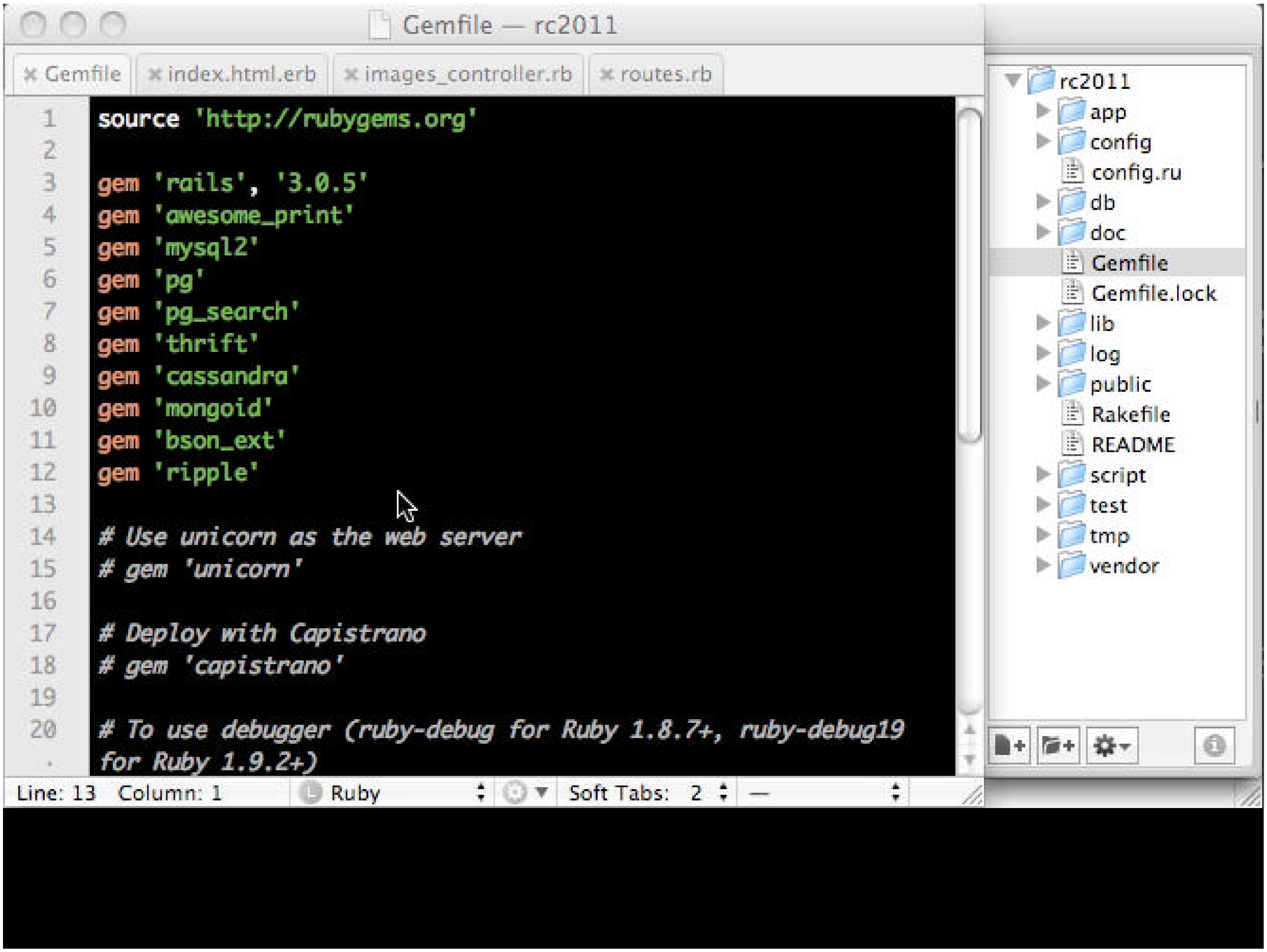
```
~/rc2011$
```

Key/Value Stores

- Memcached
- Kyoto Cabinet
- Redis
  - http://github.com/ezmobius/redis-rb
  - http://github.com/nateware/redis-objects
  - http://github.com/jodosha/redis-store
  - http://github.com/defunkt/resque
  - http://www.paperplanes.de/2010/2/16/a_collection_of_redis_use_cases.html

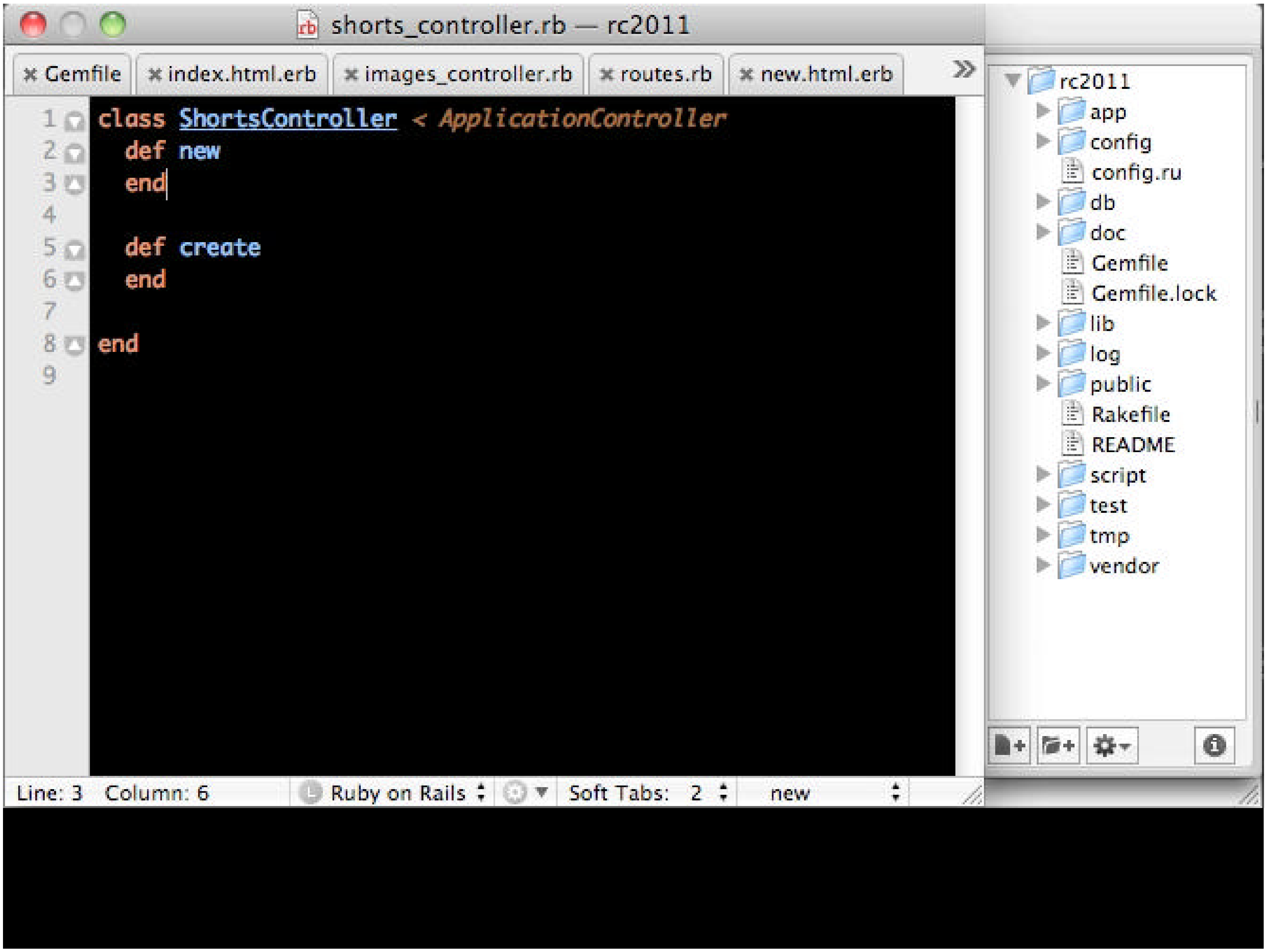
Redis Knows Sets

- redis.sadd 'person', 'Eric'
- redis.sadd 'person', 'Jim'
- redis.smembers 'person'
  - ['Eric', 'Jim']
- redis.sadd 'owns_pet', 'Eric'
- redis.sinter 'person', 'owns_pet'
  - ['Eric']



```ruby
source 'http://rubygems.org'

gem 'rails', '3.0.5'
gem 'awesome_print'
gem 'mysql2'
gem 'pg'
gem 'pg_search'
gem 'thrift'
gem 'cassandra'
gem 'mongoid'
gem 'bson_ext'
gem 'ripple'

# Use unicorn as the web server
# gem 'unicorn'

# Deploy with Capistrano
# gem 'capistrano'

# To use debugger (ruby-debug for Ruby 1.8.7+, ruby-debug19
for Ruby 1.9.2+)
```

Line: 13 Column: 1 Ruby Soft Tabs: 2



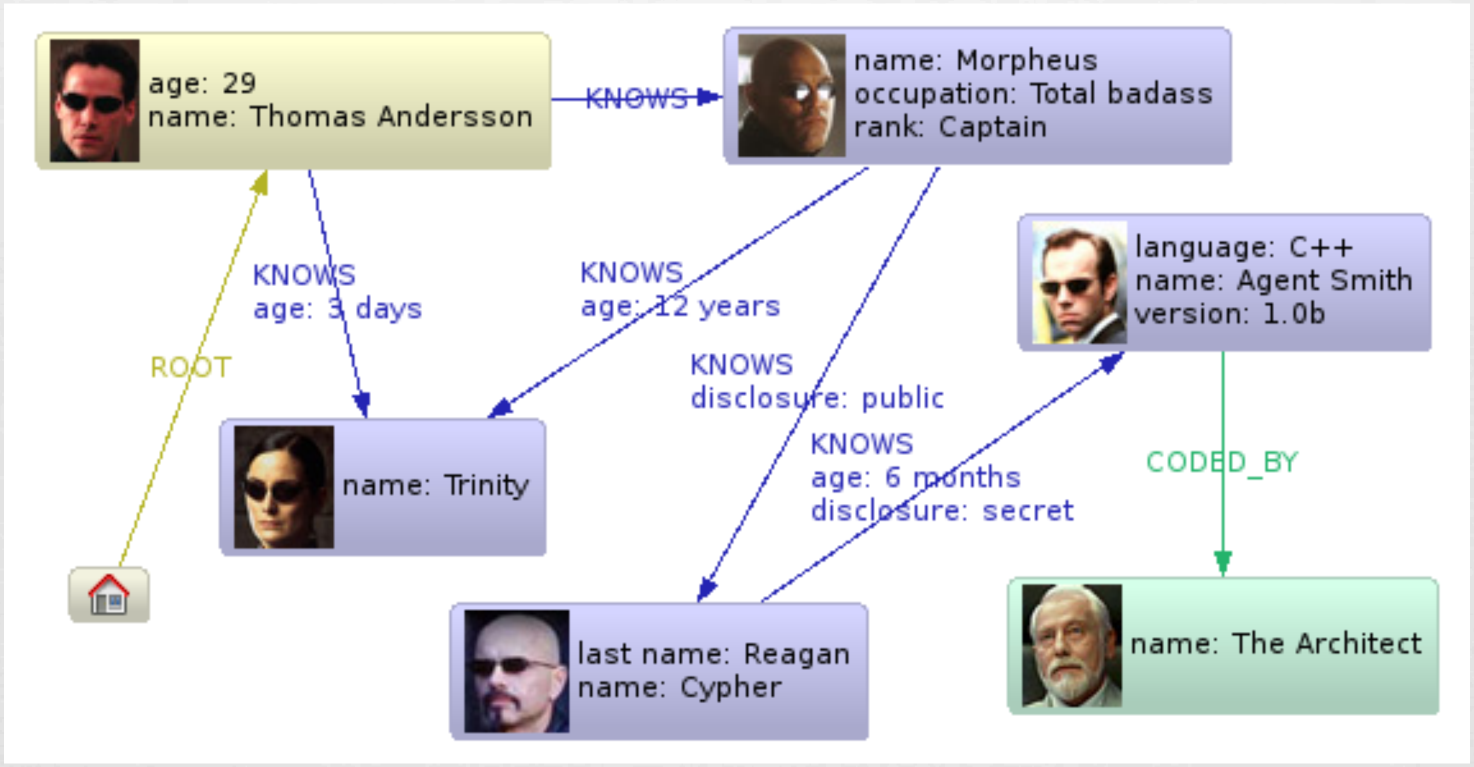
```
class ShortsController < ApplicationController
  def new
  end

  def create
  end

end
```

Line: 3 Column: 6 Ruby on Rails Soft Tabs: 2 new

Graph Datastore

- Neo4j
  - Neo4j.rb http://github.com/andreasronge/neo4j
  - Neography http://github.com/maxdemarzi/neography
- FlockDB
  - FockDB client http://github.com/twitter/flockdb-client

The Matrix


age: 29
name: Thomas Andersson
KNOWS
name: Morpheus
occupation: Total badass
rank: Captain
KNOWS
age: 3 days
KNOWS
age: 12 years
ROOT
language: C++
name: Agent Smith
version: 1.0b
KNOWS
disclosure: public
name: Trinity
KNOWS
age: 6 months
disclosure: secret
CODED_BY
last name: Reagan
name: Cypher
name: The Architect

Neo4j Shell (JRuby)

```
neo4j-sh (3, Morpheus)$ cd 4
neo4j-sh (4)$ set name Cypher
neo4j-sh (4, Cypher)$ mkrel -ct KNOWS
neo4j-sh (4, Cypher)$ ls -rd out
(me) --<KNOWS>--> (5)
neo4j-sh (4, Cypher)$ cd 5
neo4j-sh (5)$ set name "Agent Smith"
neo-sh (5, Agent Smith)$ mkrel -cvt CODED_BY
Node (6) created
Relationship <6, CODED_BY> created
neo4j-sh (5, Agent Smith)$ cd 6
neo4j-sh (6)$ set name "The Architect"
neo4j-sh (6, The Architect)$
```

DB Tools

- DataMapper
  - http://github.com/datamapper/dm-rails
- Chimera
  - http://github.com/benmyles/chimera

Try Them All!

- Why not? It’s a big decision.
- Download the example from this talk @

MySQL/ Postgres	CA	relational	bank
Hbase	CP	columnar	search engine
Cassandra	AP	columnar	SETI
Mongo	CP	document	insurance
Couch	AP	document	mobile interfaces
Neo4j	CA	graph	genealogy
FlockDB	AP	graph	social network
Riak	AP	key/value	huge catalog
Memcached/ Kyoto Cabinet/ Redis	AP	key/value	session data

Education

You know what? Just use RDBMS…

Sites

- http://nosql-database.org/
  - A great list
- http://sevenweeks.org/
  - The book website (it’s a wiki!)
- https://github.com/coderoshi/holy-grail-dbs
  - The project
  - The slides

Papers

- Brewer's Conjecture and the Feasibility of Consistent, Available, Partition-Tolerant Web Services
  - people.csail.mit.edu/sethg/pubs/BrewersConjecture-SigAct.pdf
- Dynamo: Amazon's Highly Available Key-value Store
  - allthingsdistributed.com/files/amazon-dynamo-sosp2007.pdf
- Bigtable: A Distributed Storage System for Structured Data
  - labs.google.com/papers/bigtable-osdi06.pdf
- MapReduce: Simplified Data Processing on Large Clusters
  - labs.google.com/papers/mapreduce.html

Papers

- Megastore: Providing Scalable, Highly Available Storage for Interactive Services
  - http://www.cidrdb.org/cidr2011/Papers/CIDR11_Paper32.pdf
- Design and Evaluation of a Continuous Consistency Model for Replicated Services
  - http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.34.7743&rep=rep1&type=pdf
- Indexed Database API
  - http://www.w3.org/TR/IndexedDB

PS: Get a Mac

- brew install mysql
- brew install postgresql
- brew install hbase
- brew install cassandra
- brew install riak
- brew install mongodb
- brew install couchdb
- brew install memcached
- brew install kyoto-cabinet
- brew install redis