Running Java applications on the Amazon Elastic Compute Cloud

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Founder of Cloud Tools
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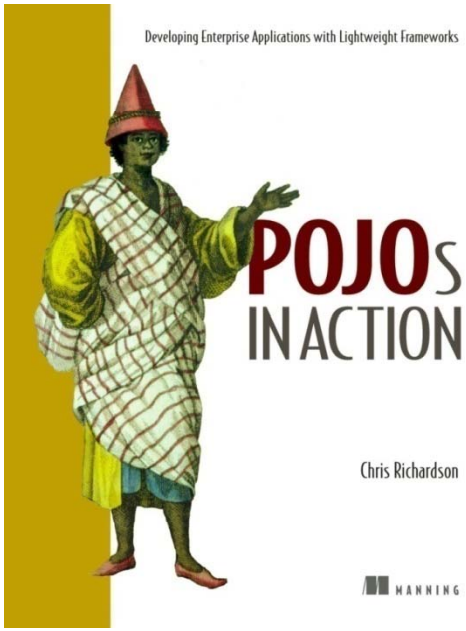
Overall presentation goal

Show how to use

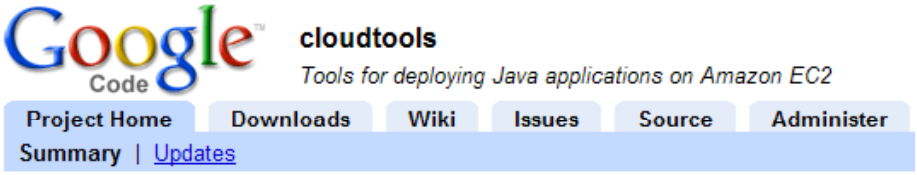
Amazon Elastic Compute Cloud

for developing and deploying Java applications

About Chris



- Grew up in England and live in Oakland, CA
- Over twenty years of software development experience
  - Building object-oriented software since 1986
  - Using Java since 1996
  - Using J2EE since 1999
- Author of POJOs in Action
- Speaker at JavaOne, SpringOne, NFJS, JavaPolis, Spring Experience, etc.
- Chair of the eBIG Java SIG in Oakland (www.ebig.org)
- Run a consulting and training company that helps organizations build better software faster and deploy it on Amazon EC2
- Founder of Cloud Tools, an open-source project for deploying Java applications on Amazon EC2: http://code.google.com/p/cloudtools



Agenda

- **Cloud computing with Amazon EC2**
- Using Amazon EC2
- Overview of Cloud Tools
- Developing on Amazon EC2
- Deploying on Amazon EC2

Computing has come a long way

Past

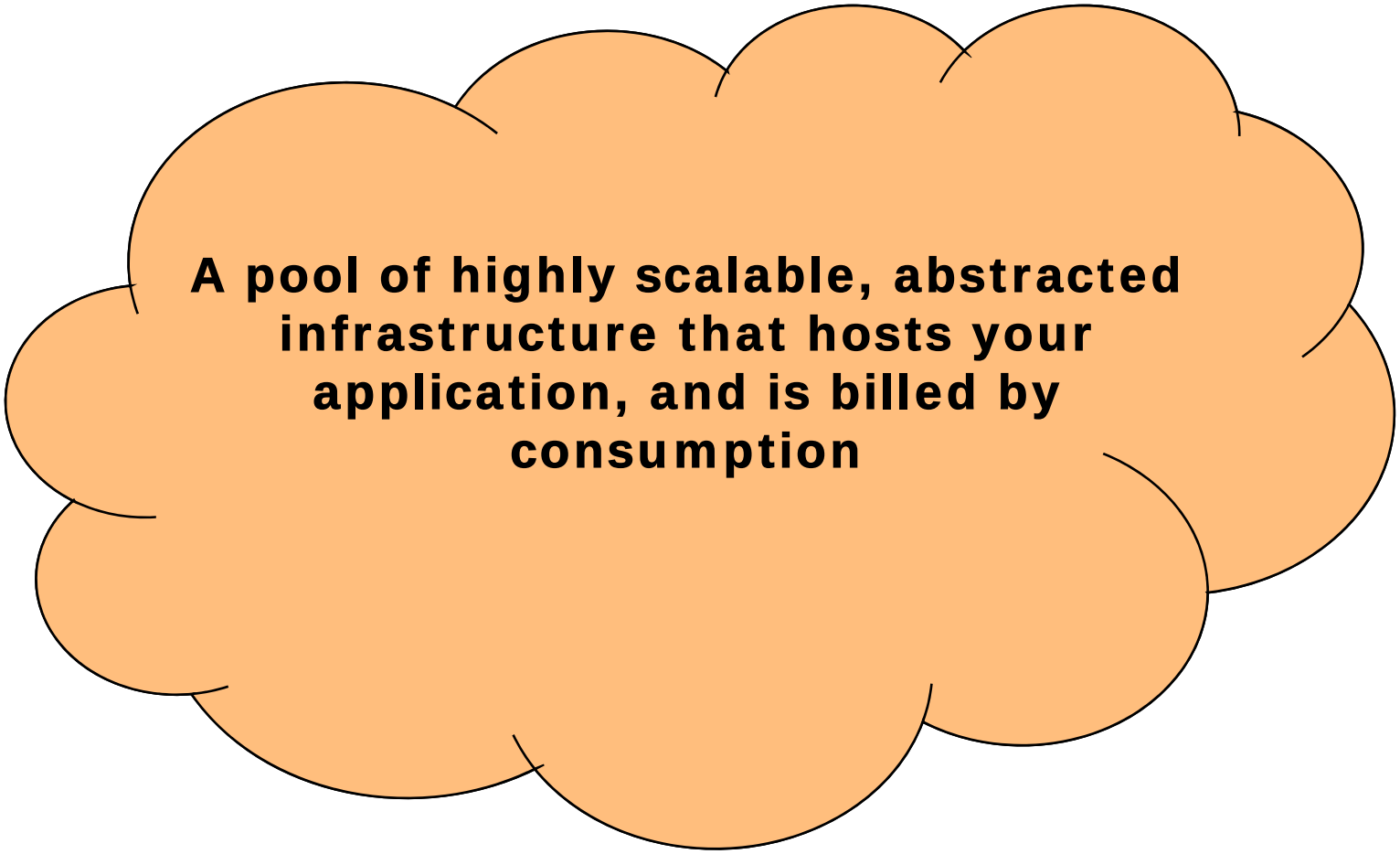
www.computermuseum.org.uk

Present

www.dell.com

Yet we rarely have enough

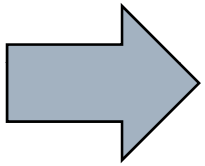
Cloud computing



By James Staten of Forrester Research

Power generation

Past



Present

Amazon-Style Cloud Computing

- Elastic Compute Cloud (EC2)
  - On-demand computing
- Elastic Block Storage (EBS)
  - "SAN on demand"
- Simple Storage Service (S3)
  - Stores blobs of data
- Simple Queue Service (SQS)
  - Hosted queue-based messaging system
- SimpleDB
  - Store data sets
  - Execute queries

Pay per use services managed by Amazon

What is Amazon EC2?

- Virtualized computing environment
- Server instances managed through a web service API
- IP addresses and host names assigned dynamically
- Pay by the hour ($0.10-0.80/hour) + external bandwidth ($0.10-0.18/Gbyte)

```
https://ec2.amazonaws.com/?Action=RunInstances
  &ImageId=ami-398438493
  &MaxCount=3
  &MinCount=3
```

```
<RunInstancesResponse>
...
</RunInstancesResponse>
```

```
cer@arrakis ~
$ ssh ... root@ec2-67-202-41-150.compute-1.amazonaws.com
Last login: Sun Dec 30 18:54:43 2007 from 71.131.29.181
[root@domU-12-31-36-00-38-23:~]
```

Instance types

	Virtual Cores	Compute Units /core*	32/ 64 Bit	Memory	Storage	$/hr
Small	1	1	32 bit	1.7G	160G	0.10
High-CPU Medium	2	2.5	32 bit	1.7G	350G	0.20
Large	2	2	64 bit	7.5G	850G	0.40
Extra Large	4	2	64 bit	15G	1690G	0.80
High-CPU XL	8	2.5	64 bit	7G	1690G	0.80

* EC2 Compute Unit = 1.0-1.2 GHz 2007 Opteron or 2007 Xeon processor

Operating systems

- Use Amazon provided Machine Image (AMI)
  - 32-bit Fedora Core 4
  - 64-bit Fedora Core 6
- Many 3rd parties have public AMIs
  - Various Linux distributions
  - E.g. Redhat, RightScale
- Sun provides OpenSolaris
- Windows is private beta
- Build your own Linux:
  - Install applications starting with someone else's AMI and save it
  - Create an AMI from scratch

One minor thing…

Terminate your instance

$\Rightarrow$

your **local** data is lost.

Either very good or very bad

Elastic Block Storage

- Mountable storage volumes
  - "On-demand SAN"
  - Size: 1 GB to 1 TB
  - Mount on a single instance
- Create snapshots
  - Stored in S3
  - Create new volumes from the snapshot
- Cost:
  - $0.10/GByte/month
  - $0.10 per 1 million I/O requests

Elastic IP addresses

- Instance IP addresses are dynamically allocated on start-up
  - Does not work well for publicly accessible services, e.g. a website
- Elastic IP addresses:
  - Statically allocated addresses
  - Associated with your account (max. 5)
  - Attached to an instance (e.g. public facing web server)
  - You configure DNS to resolve to the elastic IP address
- Pricing:
  - Non-attached Elastic IP address - $0.01/hour
  - $0.10 per remap (if > 100 in a month)

Regions and availability zones

- By default, your database master and slave could run on the same physical host!
- Regions:
  - Geographically dispersed locations
  - Currently only one
- Availability zone:
  - Part of a region
  - Engineered to be insulated from failure in other zones
- Specify availability zone when launching instances:
  - Same zone as other instances for free data transfer
  - Different zone for higher-availability

What is the Amazon Simple Storage Service (S3)?

- Flat storage model consisting of buckets and objects
  - Bucket – has a name and contains objects
  - Objects – has a key, stores 1 byte - 5G
  - Object key can look like a path ☺
- Cost:
  - $0.15/GB-Month
  - $0.10-0.18/GB of data transferred
  - $0.00001-$0.000001/Web Service call
  - Data transfers between EC2 and S3 are free of bandwidth charges
- Buckets and objects can be:
  - Public – accessible by anyone
  - Private – accessible to owner, acl member

S3 REST API

```
PUT / HTTP/1.1
Host: <BucketName>.s3.amazonaws.com
Authorization: AWS AWSAccessKeyId:Signature
...
```

Create a bucket

```
PUT /<ObjectName> HTTP/1.1
Host: <BucketName>.s3.amazonaws.com
Authorization: AWS AWSAccessKeyId:Signature
...
...Bytes...
```

Create an item in a bucket

```
GET /<ObjectName> HTTP/1.1
Host: <BucketName>.s3.amazonaws.com
Authorization: AWS AWSAccessKeyId:Signature
...
```

Download an item

```
DELETE /<ObjectName> HTTP/1.1
Host: <BucketName>.s3.amazonaws.com
Authorization: AWS AWSAccessKeyId:Signature
...
```

Delete an item

Using EC2 and S3 together

- AMIs are stored in S3
- EC2 instances use S3:
  - Use REST API
  - Store database snapshots in S3
  - Use 3rd party Linux file system that stores data in S3
  - Store EBS volume snapshots in S3

So what does this mean?

- For developers
  - Immediate access to many servers
  - Simplified setup
  - Great for testing
- For deployment
  - Eliminates capital expenses
  - Reduces risk of success catastrophe

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- **Using Amazon EC2**
- Overview of Cloud Tools
- Developing on Amazon EC2
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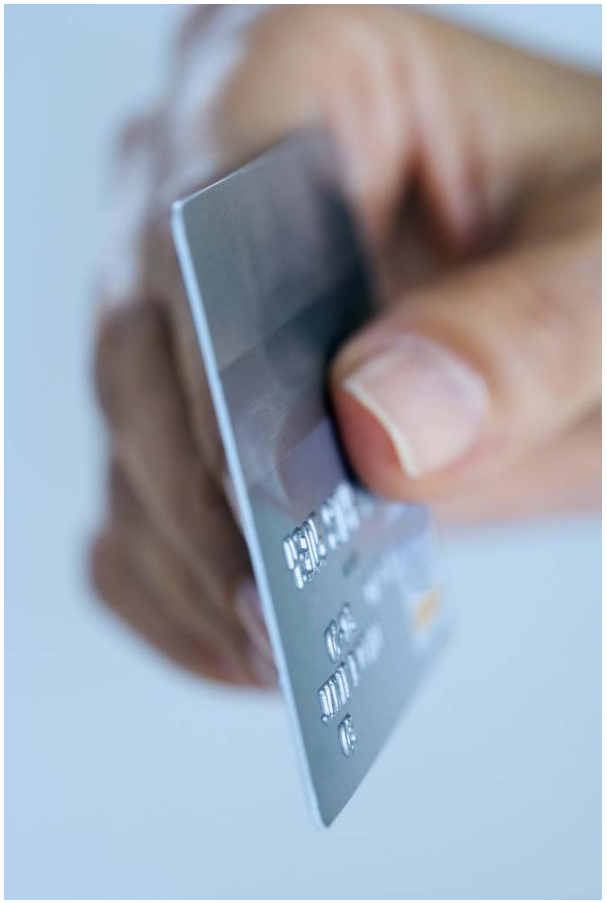
Signing up for Amazon Web Services



- AWS access identifiers:
  - Account Id
  - Access Id
  - Secret key
  - Private key and certificate
- Only takes a few minutes

EC2 API and Tools

- SOAP and Query APIs
  - Launch and manage instances etc
- Amazon provided CLI tools
  - CLI equivalents of APIs
  - AMI creation tools
- AWS CLI tools from Tim Kay
  - CLI for S3 and EC2
  - Alternatives to Amazon CLI tools
- ElasticFox
  - Awesome Firefox plugin
  - Launch and manage instances

Using the Query API

- https://ec2.amazonaws.com/?queryparameters...
- Mandatory parameters:
  - Action – what to do
  - AWSAccessKeyId – your access id
  - Version – API version
  - Timestamp – when request was made
  - Expires – when it expires
  - Signature – digest of parameters and secret key
  - SignatureVersion – set to 1
- Other parameters depend on Action
- Returns an XML document

Example EC2 requests

Action	Parameters
RunInstances	MinCount, MaxCount, ImageId, InstanceType, ...
TerminateInstances	InstanceId.n
DescribeInstances	InstanceId.n
CreateSecurityGroup	GroupName, GroupDescription
AuthorizeSecurityGroupIngress	GroupName, SourceSecurityGroupName, IpProtocol
DeauthorizeSecurityGroupIngress	...
...	

aws - simple access to EC2 and S3

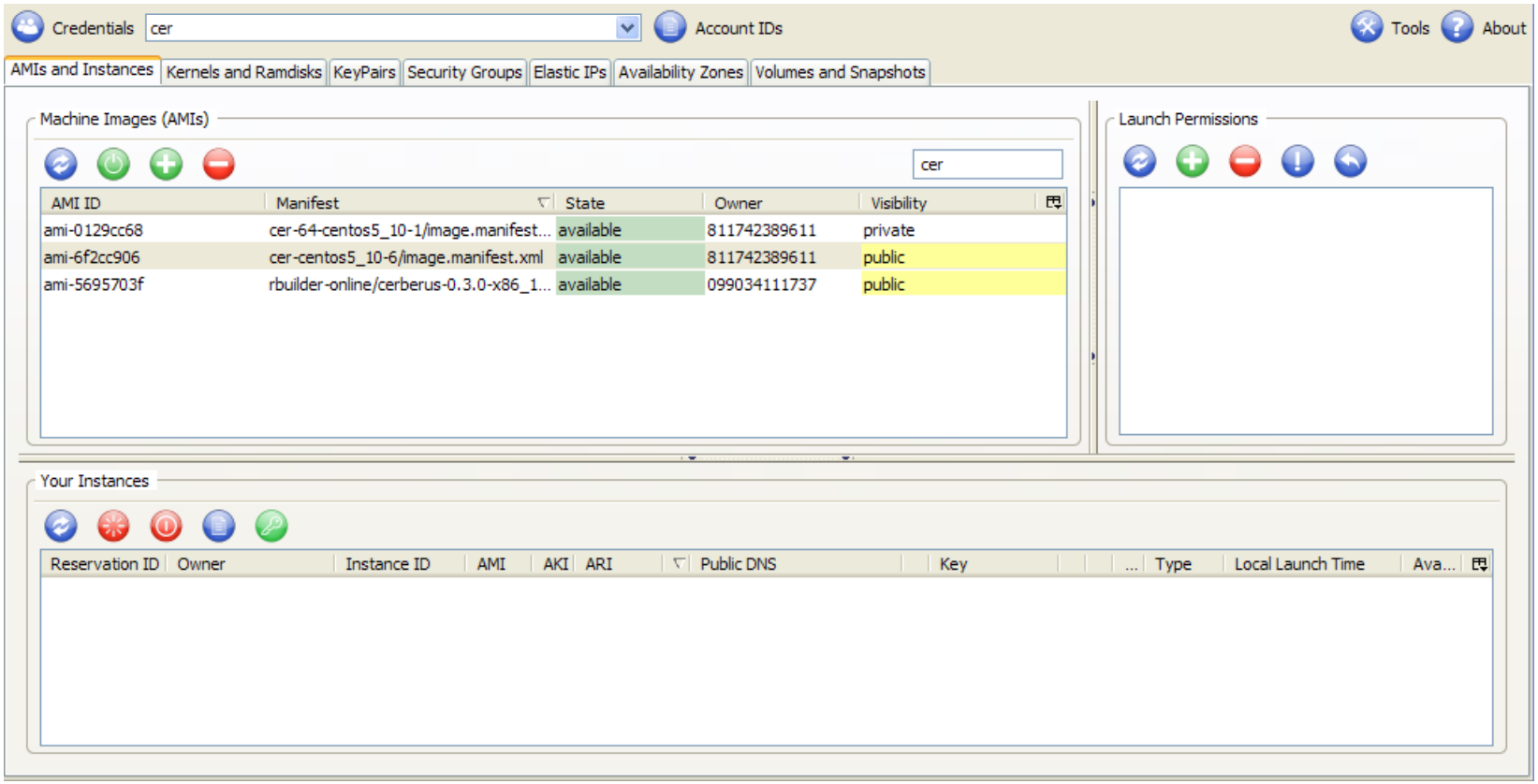
- http://timkay.com/aws/
- Easy to use CLI for EC2 and S3
- Implemented in Perl
- Authenticates using access id and secret key stored in ~/.awssecret

```
$ aws describe-instances
+------------+--------------+------------------------+--
--------------------+
| instanceId |   imageId    |      instanceState      |
   launchTime        |
+------------+--------------+------------------------+--
--------------------+
| i-82728eeb | ami-6f2cc906 | code=48 name=terminated | U
-02-14T01:42:42.000Z |
| i-85728eec | ami-6f2cc906 | code=48 name=terminated | U
```

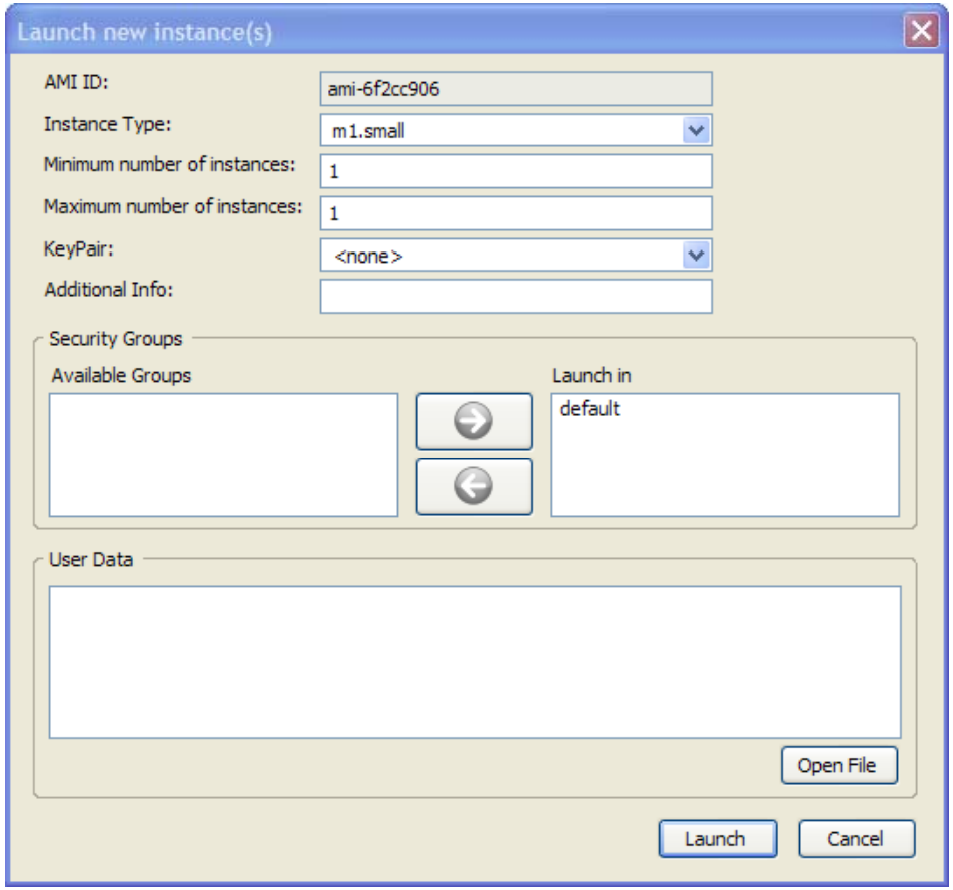
```
$ aws terminate-instances i-42b24c2b
+------------+-------------------------------+----------------------+
| instanceId |       shutdownState           |    previousState     |
+------------+-------------------------------+----------------------+
| i-42b24c2b | code=32 name=shutting-down | code=16 name=running |
+------------+-------------------------------+----------------------+

cer@arrakis ~
$
```

ElasticFox– Firefox plugin



Launching instances



TIP: launch with a key pair or else you won't have access

Creating your own image

- Easier: Modify an existing AMI
  - Launch AMI
  - Configure: e.g. yum install ...
- Harder: Build one from scratch
  - Launch AMI
  - Create a file to contain OS installation
  - Mount as a loopback file
  - Install OS: yum –-installroot
- Use AMI tools to bundle and upload to S3

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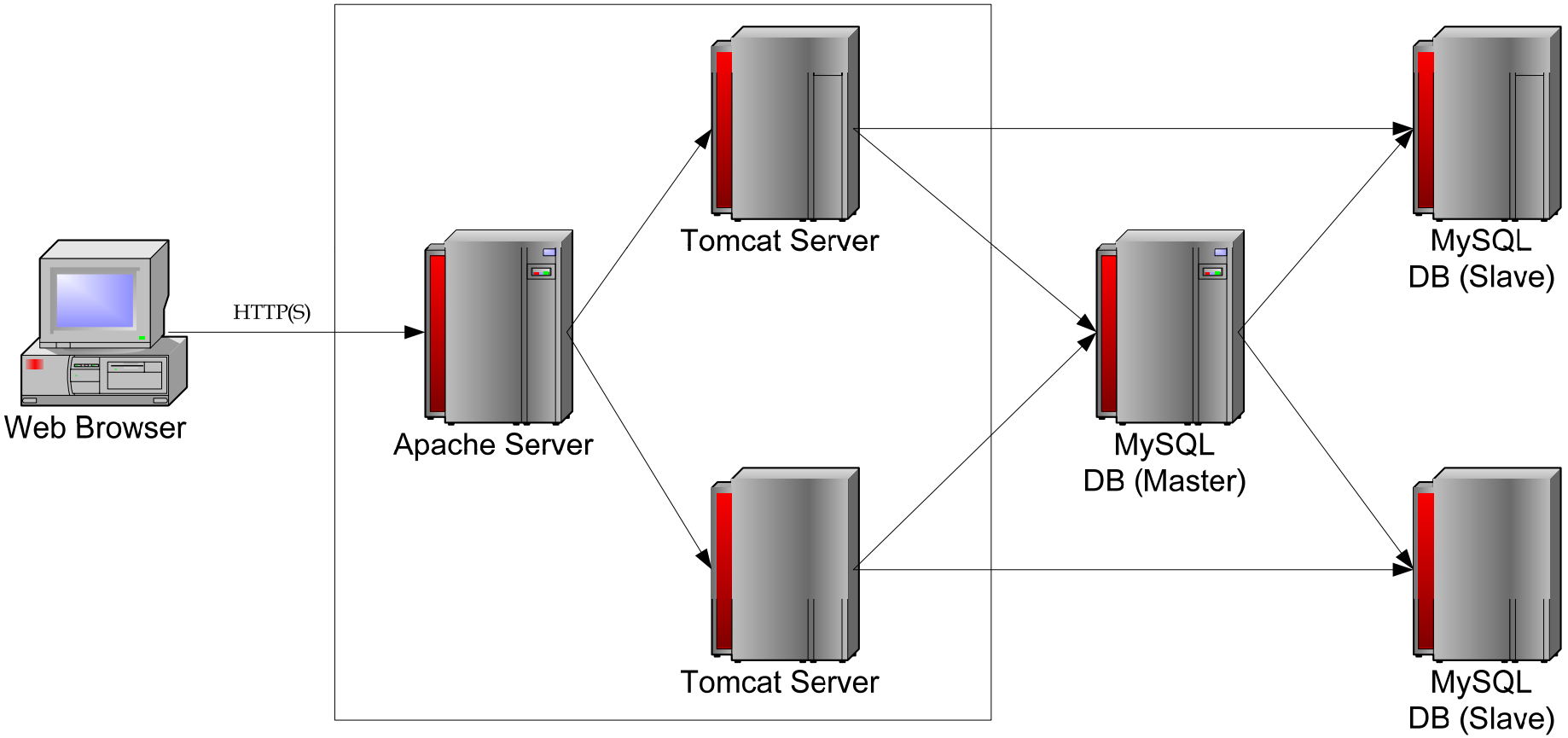
Deploying a web application on EC2



Not rocket science but there are many servers to configure and multiple files to upload

What's Cloud Tools?

- Open source project
- 32 and 64 bit AMIs
  - CentOS 5.10
  - Apache/Tomcat/MySQL/JMeter/JetS3t installed
- EC2Deploy framework
  - Launches instances
  - Configures Tomcat, MySQL, Apache
  - Deploys web applications
  - Runs Jmeter tests
  - Written in Groovy
- Maven and Grails plugins
  - Quick and easy deployment to EC2

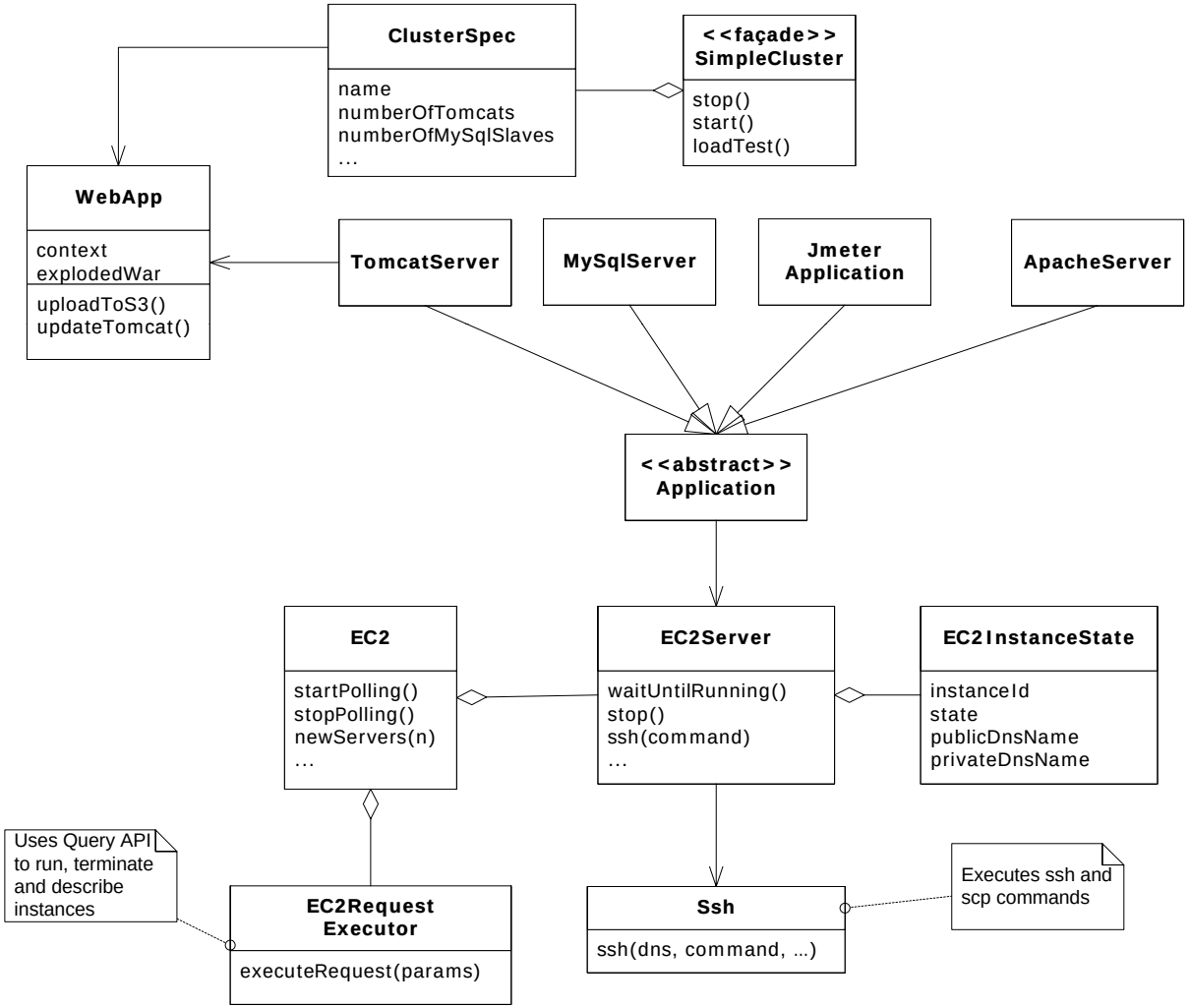
EC2Deploy framework

- Provides a DSL for describing a cluster:
  - Number of Tomcats, MySQL slaves
  - Database scripts
  - Location of web applications
- Launches EC2 instances
- Configures MySQL
- Configures Tomcat and deploys web applications
- Configures Apache to proxy the Tomcat servers
- Runs JMeter tests

Example EC2Deploy Script

```
def ec2 = new EC2(…)

ClusterSpec clusterSpec = new ClusterSpec()
          .tomcats(1)
          .instanceType(EC2InstanceType.SMALL)
          .slaves(1)
          .webApp('/home/cer/…/ptrack', "ptrack")
          .catalinaOptsBuilder({optsBuilder, databaseHost, slaves ->
                    optsBuilder.arg("-Xmx500m")
                    optsBuilder.prop("jdbc.db.server", databaseHost)})
          .schema("ptrack", ["ptrack": "ptrack"],
                    ["src/test/resources/testdml1.sql",
                     "src/test/resources/testdml2.sql"])

SimpleCluster cluster = new SimpleCluster(ec2, clusterSpec)

cluster.start()

cluster.loadTest("/home/cer/…/jmeter/SimpleTest.jmx", [5, 10, 15])

cluster.stop()
```

Domain model



Configuration DSL

```
class ApacheServer extends Application {

 def configure() {
        writeFile fileName: "$apacheConfDir/cluster.conf",
             templateName: "/templates/cluster.conf",
             templateArgs:  [tomcats: tomcats]
        exec "$apacheBinDir/apachectl restart"
        waitForHttp port:80, path: tomcats[0].contexts[0]
  }
…
}
```

```
class MySqlServer extends Application {

 def configureAsMaster() {
        writeFile fileName: "/etc/my.cnf", templateName: "/templates/master.my.cnf"

        restartService "mysqld"

        exec command: "mysql -u root",
            templateName: "/templates/createSchema.sql",
            templateArgs: [schemaSpec: schemaSpec]

        executeSchemaScripts()
    }
}
```

Efficiently uploading web applications, etc.

- Non-durable disks = upload the entire web application
  - 20+ MBs of jars, etc.
  - Takes a long time (over a DSL connection)
- Web application consists of:
  - 90% 3rd party libraries – rarely changing
  - 10% application code and content – only some of it changes
- Use JetS3t to accelerate uploads
  - Incremental upload of exploded web application to S3 bucket
  - Incremental download to Tomcat webapps/ directory
  - First upload is slow but subsequent uploads are fast

Maven Plugin

```
<plugin>
   <groupId>net.chrisrichardson</groupId>
   <artifactId>cloudtools-maven-plugin</artifactId>
   <configuration>
     <schemaName>ptrack</schemaName>
     <schemaUsers>
       <param>ptrack:ptrack</param>
     </schemaUsers>
     <catalinaOptsBuilder>
       {builder, databasePrivateDnsName ->
            builder.arg("-Xmx1000m")
          builder.prop("jdbc.db.server", databasePrivateDnsName)}
       </catalinaOptsBuilder>
     </configuration>
</plugin>
```

Goals:
- deploy
- redeploy
- stop
- dbsave
- dbrestore
- jmeter

```
mvn cloudtools:deploy
```

Grails Plugin

- Packages E2Deploy as a Grails framework plugin
- Deploys a Grails application to EC2

```
$ grails install-plugin <path to plugin>
$ grails cloud-tools-deploy
```

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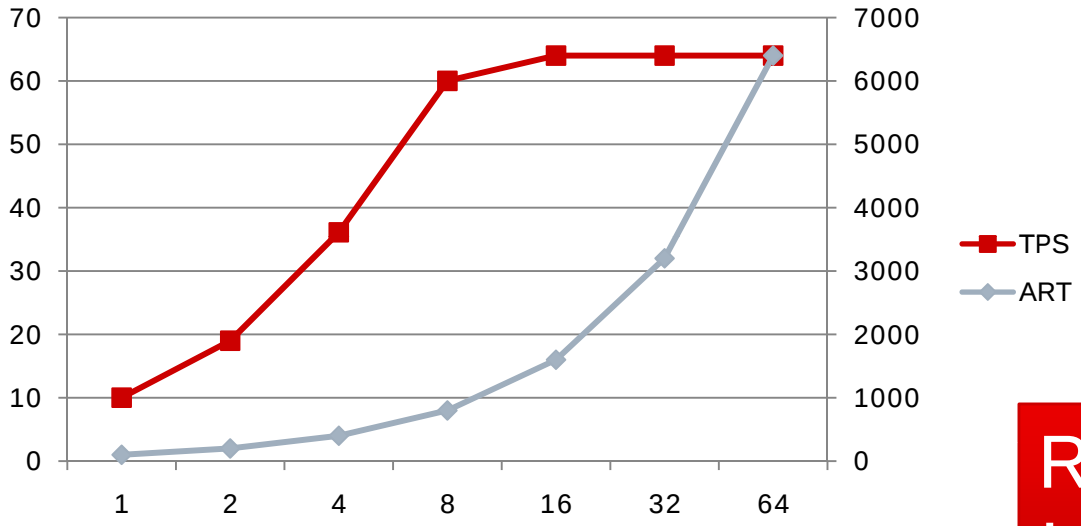
Collecting performance metrics



Requires hardware
Time consuming

Measure transactions/second (TPS), average response time (ART), utilization, etc.

Multiple test runs with different loads, number of servers, etc.

Load testing with Cloud Tools

- Runs JMeter with specified number of threads
- Collects machine utilization stats
- Generates reports
- Executes multiple test runs simultaneously

```
<performanceReport>
  <cpus>1</cpus>
  <threads>10</threads>
  <host>
    <name>database</name>
    <cpuUtil>3.2757014224403784</cpuUtil>
  </host>
  <host>
    <name>tomcat0</name>
    <cpuUtil>94.32473318917411</cpuUtil>
  </host>
  <host>
    <name>apache</name>
    <cpuUtil>0.12280614752518504</cpuUtil>
  </host>
  <host>
    <name>jmeter</name>
    <cpuUtil>7.033683910704496</cpuUtil>
  </host>
  …
  <duration>557.943</duration>
  <tps>10.753786677133686</tps>
  <art>916.6578333333</art>
</performanceReport>
```

```
mvn cloudtools:jmeter -Dcloudtools.thread.count=1,4,8
```

Other kinds of testing

- Testing failover
  - Launch cluster
  - Take down servers
  - Test recovery scripts, e.g. MySQL slave->master
- Testing database upgrades
  - Launch cluster
  - Install snapshot of production data
  - Apply database migration script
  - Verify that it works

Functional testing

- Tests can be slow, e.g.
  - Web tests
  - Database intensive tests
- Run tests in parallel on EC2
  - Multiple test drivers, app servers, DBs
  - Relatively cheap: >$75/hour developer vs. $0.10/hour machine
- Selenium Grid from Thoughtworks
  - Open Source framework
  - Runs Selenium web tests in parallel on EC2
- Stay tuned for more general solutions

Building on a fresh machine

- Debug builds that fail because of a missing dependency
  - Maven dependency
  - Manually installed 3rd party library
- Build on a fresh EC2 instance
- Great for open-source projects

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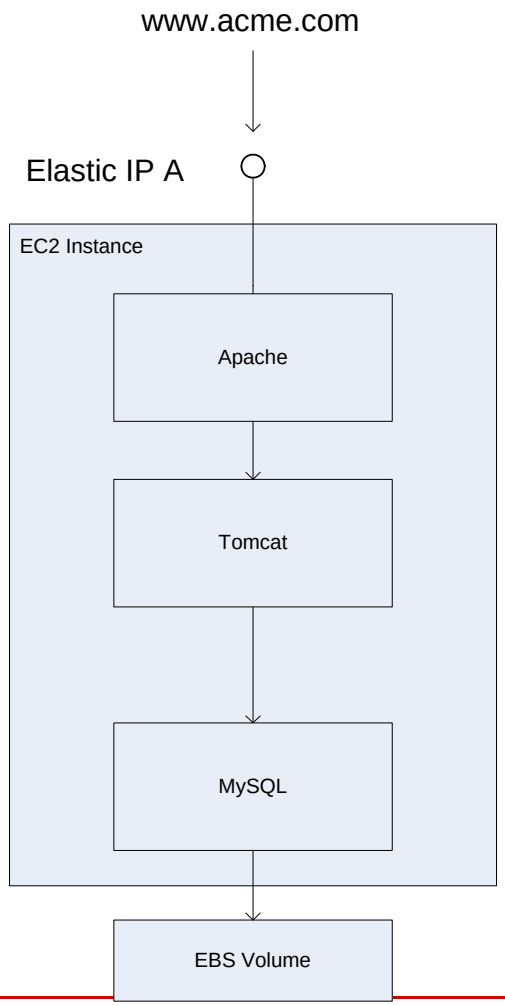
Deploying applications on Amazon EC2

- Great for startups (especially those without a business model)
  - Get up and running ready quickly
  - No upfront hardware costs
  - Scale up/down with load
  - Reduces the risk of a **success catastrophe**
- Great for enterprises
  - No need to wait for corporate IT
  - Use for short-term projects

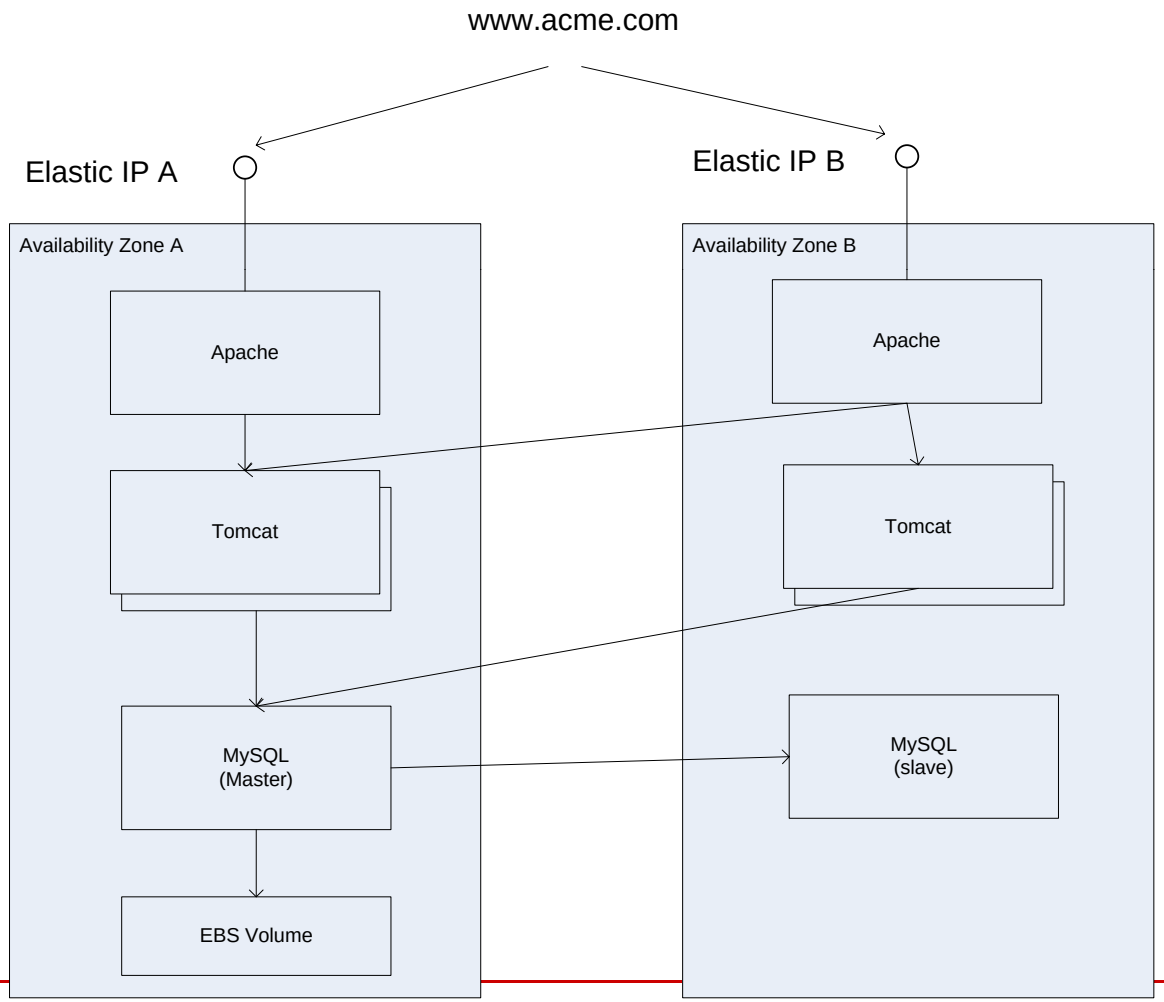
Issues with AWS

- Security:
  - Lack of PCI compliance
  - Discomfort with sending customer data to a 3rd party
- Technology:
  - Not yet suitable for extremely large relational databases
  - Lack of very large machines, e.g. 64G memory
  - Lack of multicast
- Financials:
  - Cost of bandwidth
  - Steady state costs > your own hardware

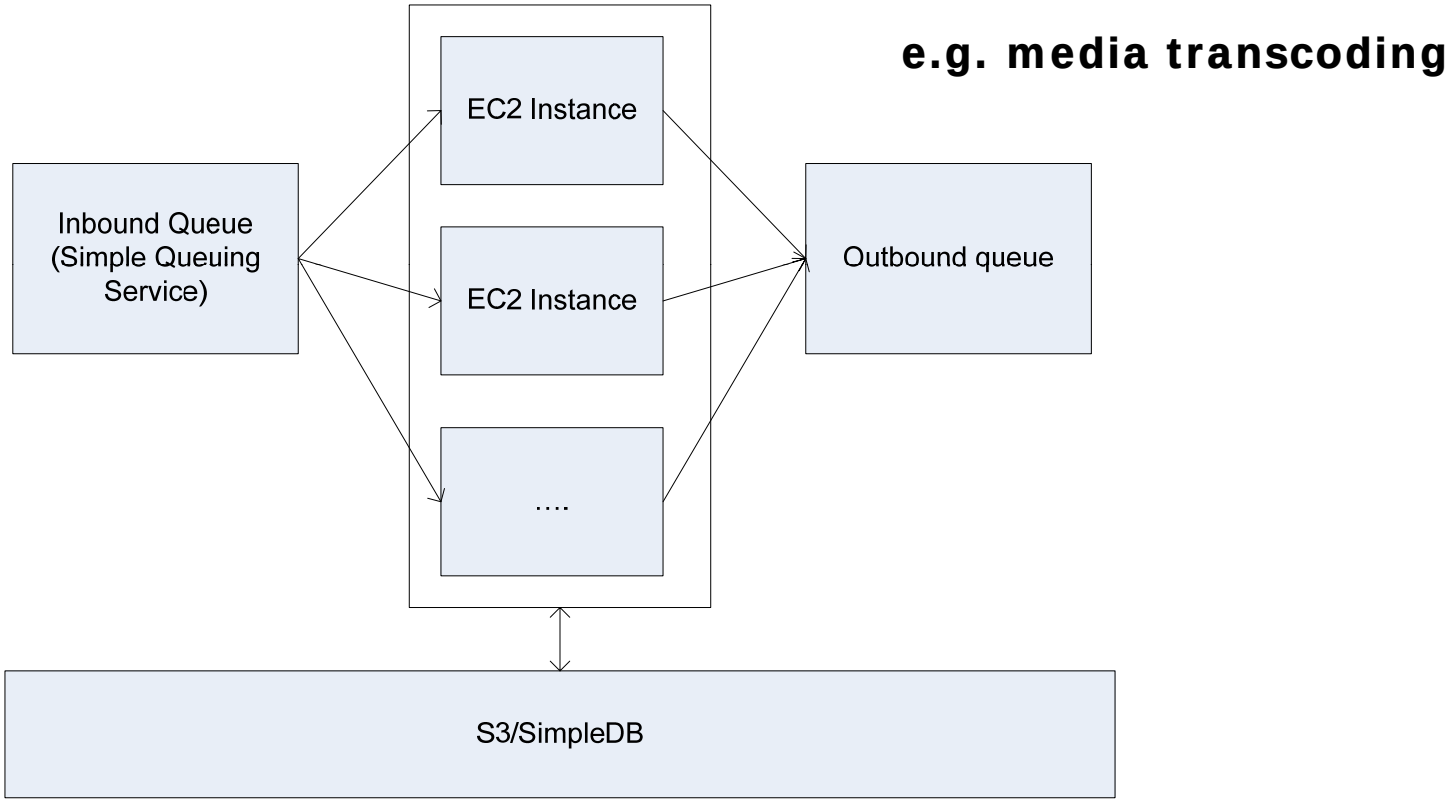
Starter website - $



Highly available - $$



Batch processing architecture



Easy upgrades

- Clone production environment
- Apply upgrades
- Terminate old instances once you are sure that everything works

Cloud bursting

- Host application on your own hardware
- Use AWS for short-term spikes
  - e.g. use EC2 instances with slave DBs to handle read-only requests
- Periodic batch jobs
  - E.g. content rendering/transformation

Using AWS in your application

- Simple Storage Service (S3)
  - Stores blobs of data
  - Eg. Photo sharing website
  - Store media
  - Hand out URLs to S3 objects
- Simple Queue Service (SQS)
  - Hosted queue-based messaging system
  - Alternative to JMS
  - Loosely coupling between systems
- SimpleDB
  - Store data sets
  - Execute queries

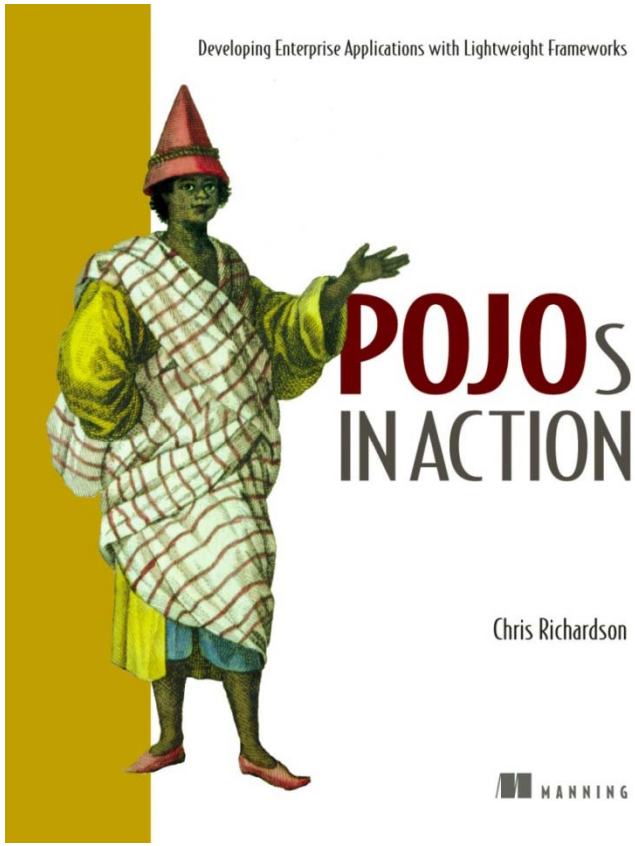
Java libraries for AWS

- Generate the REST/SOAP requests manually
- JetS3t
  - Rich API for accessing S3
  - https://jets3t.dev.java.net/
- Typica
  - API for SQS, EC2, SimpleDB
  - http://code.google.com/p/typica/
- SimpleJPA
  - Subset of JPA on Simple DB
  - http://code.google.com/p/simplejpa/

Summary

- Cloud Computing
  - Immediate access to many servers
  - Pay as you go – no upfront investment/commitment required
  - Easily scale up/down
- Cloud Tools
  - Easy deployment and testing from Maven and Grails
  - Configure multiple clusters
  - Run JMeter tests in parallel

Final thoughts



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