

# Intro to Amazon EC2 Cloud Computing

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# The Data Deluge



# Pandemic Simulation

AMIA Annu Symp Proc. 2011; 2011: 364–373.

PMCID: PMC3243184

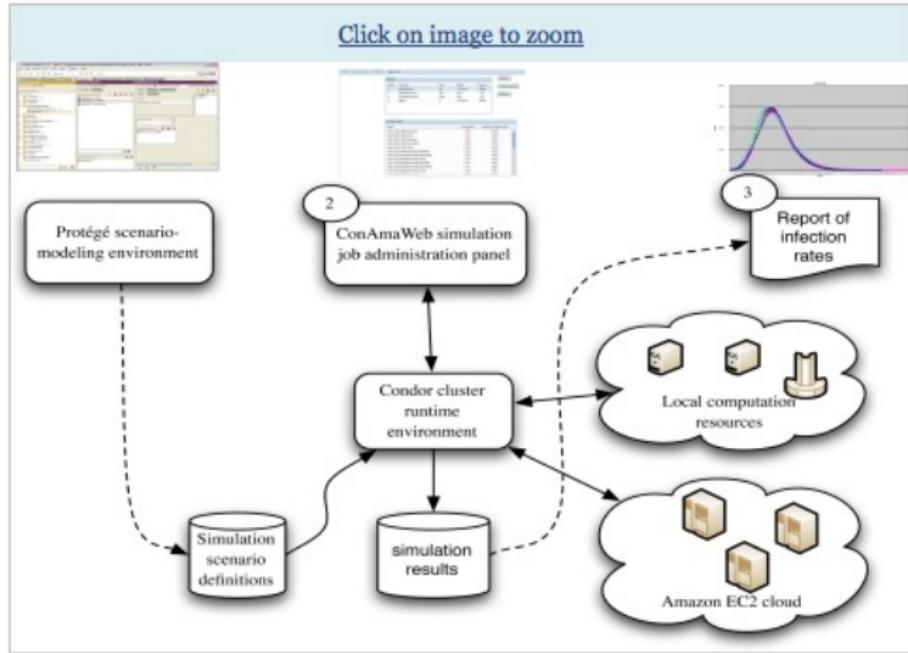
Published online 2011 October 22.

## A Cloud-Based Simulation Architecture for Pandemic Influenza Simulation

Henrik Eriksson, PhD,<sup>1</sup> Massimiliano Raciti, MSc,<sup>1</sup> Maurizio Basile, MSc,<sup>1</sup> Alessandro Cunsolo, MSc,<sup>1</sup> Anders Fröberg, MSc,<sup>1</sup> Ola Leifler, MSc,<sup>1</sup> Joakim Ekberg, MSc,<sup>2</sup> and Toomas Timpka, MD, PhD<sup>1,2</sup>

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# Pandemic Simulation Workflow



# Conclusion

## Conclusion

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The cloud-based architecture illustrates that it is possible to develop a scalable simulation execution environment that uses cloud-based solutions, while providing an easy-to-use web-based user interface. The use of commercial hosting solutions, such as Amazon EC2, allows smaller organizations, for example county-level public-health administrations, to take advantage of simulation resources without building and maintaining their own dedicated infrastructure. Alternatively, organizations can use a combination of preexisting infrastructure and rented machines. The evaluation shows that rented EC2 virtual machines have sufficient performance to act as worker nodes and that this solution is a viable alternative economically. Finally, we believe that pandemic response can benefit from local and regional simulation models combined with the relevant population data. Although a complete solution would require further research, our approach demonstrates the feasibility of a corresponding simulation execution environment.

# BioMedical Cloud Computing

PLoS Comput Biol. 2011 August; 7(8): e1002147.

PMCID: PMC3161908

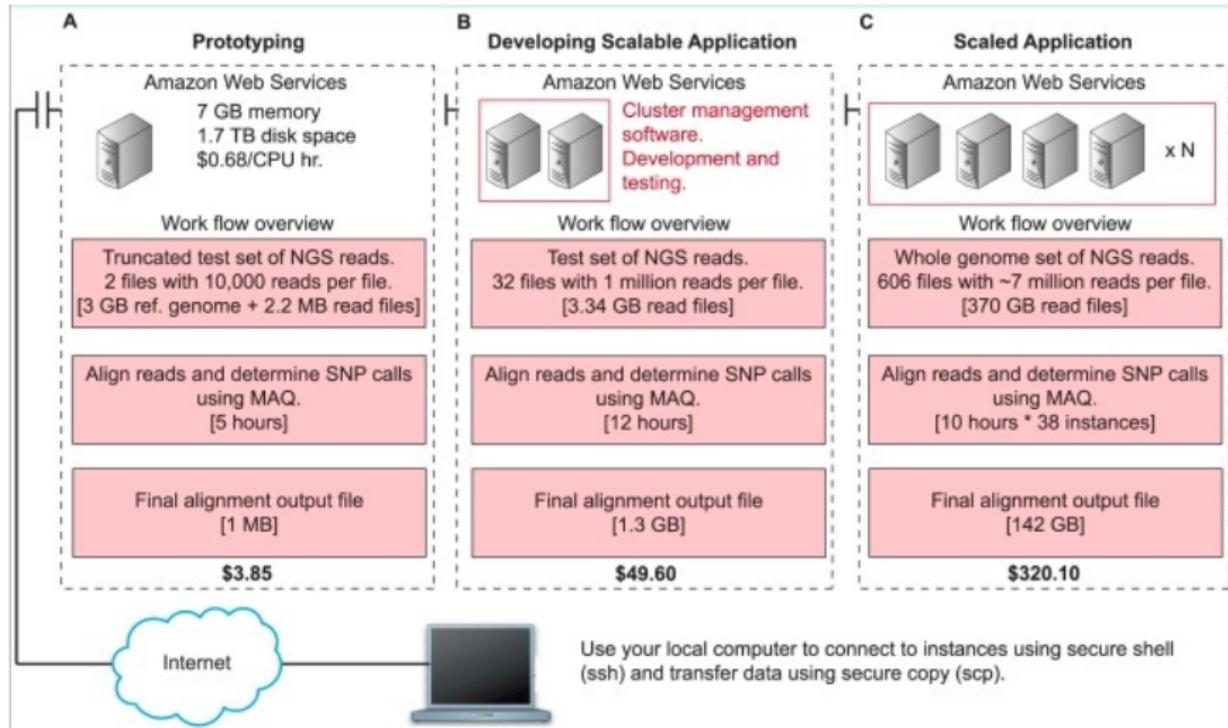
Published online 2011 August 25. doi: [10.1371/journal.pcbi.1002147](https://doi.org/10.1371/journal.pcbi.1002147)

## Biomedical Cloud Computing With Amazon Web Services

Vincent A. Fusaro,<sup>1,\*</sup> Prasad Patil,<sup>1</sup> Erik Gafni,<sup>1</sup> Dennis P. Wall,<sup>1,2</sup> and Peter J. Tonellato<sup>1,2</sup>

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# BioMedical Cloud Computing



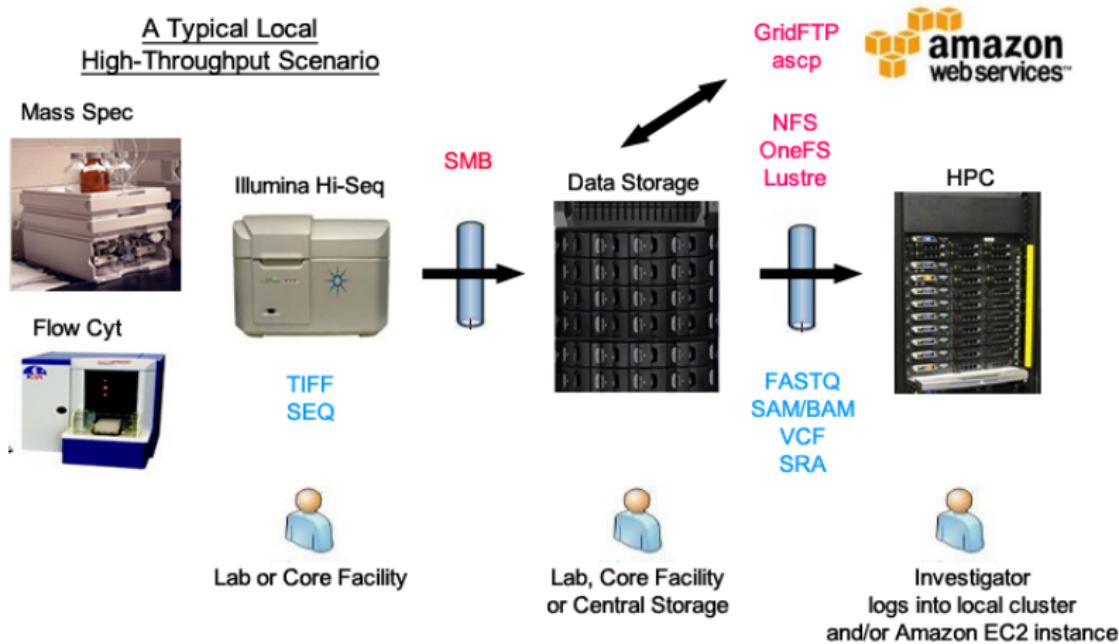
# BioMedical Cloud Computing

## Summary

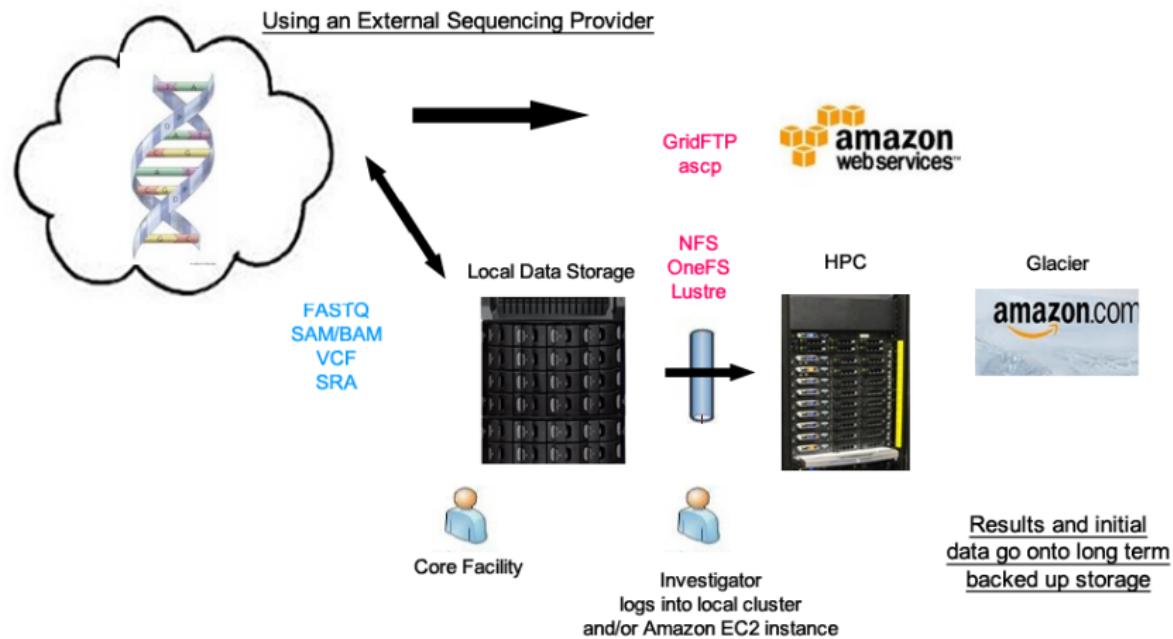
Go to:

In this overview to biomedical computing in the cloud, we discussed two primary ways to use the cloud (a single instance or cluster), provided a detailed example using NGS mapping, and highlighted the associated costs. While many users new to the cloud may assume that entry is as straightforward as uploading an application and selecting an instance type and storage options, we illustrated that there is substantial up-front effort required before an application can make full use of the cloud's vast resources. Our intention was to provide a set of best practices and to illustrate how those apply to a typical application pipeline for biomedical informatics, but also general enough for extrapolation to other types of computational problems. Our mapping example was intended to illustrate how to develop a scalable project and not to compare and contrast alignment algorithms for read mapping and genome assembly. Indeed, with a newer aligner such as Bowtie [9], it is possible to map the entire African genome using one m2.2xlarge instance in 48 hours for a total cost of approximately \$48 in computation time. In our

# Sequencing



# Sequencing



# 1,000 Genomes

PRESS RELEASE

March 29, 2012, 9:00 a.m. EDT

## **Amazon Web Services and the US National Institutes of Health Announce the Largest Catalog of Human Genetics is Now Available in the Cloud**

Researchers worldwide now have instant access to the complete 1000 Genomes Project on AWS, enabling scientists to accelerate disease research

# Clinical Data

**Clinical: Genomics: Proteomics**  
1: 100 : 10,000

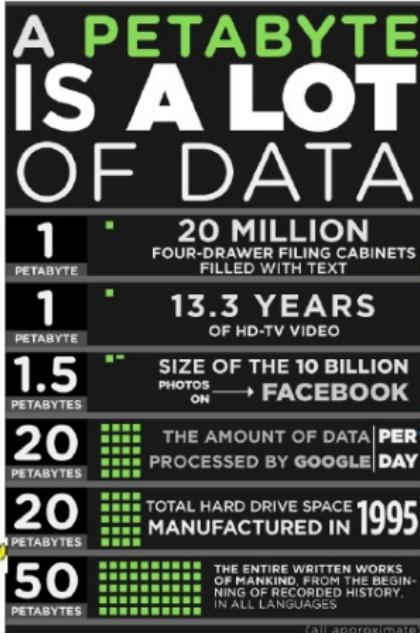
- **200 clinical data-points + Imaging**  
5GB
- **20,000 genes: whole genome**  
500 GB (*raw file is base call, compressed*)
- **2 million proteins?**  
>50 TB? (*each protein is >25GB compressed*)

**Humans are the ultimate Big Data engines:**

*4 to 6 Big Data snapshots over lifetime with small data ongoing surveillance*

# Petabytes

**Size**



All CT scans in US in 2003  
One Gene Sequencer in 2011

25x

All CT scans in US in 2011  
EMC Isilon storage at BROAD Inst.  
Single Directory

Large Healthcare Organization  
Or Community Cloud in 2020?

Derived From: EMC collateral



ISD Life Sciences

EMC<sup>2</sup>

Hmmmm...

So what is it ?



# Horizontal Computing

- It solves the horizontal computing problem
- Horizontal computing = Utility Computing (usually)



# Utility Computing

- Popular solution to the problem of horizontal scalability
- Amazon provides "Infrastructure as a Service" commonly abbreviated as IaaS.
- Let the "other guy" buy all the equipment, house it, power it, and cool it. You just come and use it when you want.
- It has an API. You create resources via a Web interface, programmatically, or from the command line from your desktop or laptop.
- No human intervention at the vendor level is required

# Paradigm Shift

- Most local resources are setup and optimized for a general set of services.
- The utility computing service turns this around: You setup and optimize a storage and computational environment for your needs in particular.
- Invest in the Task Not the Technology

# Definitions

- Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services.
- The datacenter hardware and software is what we will call a Cloud. When a Cloud is made available in a pay-as-you-go manner to the general public, we call it a Public Cloud; the service being sold is Utility Computing.

<http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf>

# Aspects

Three aspects are new in Cloud Computing:

- The illusion of infinite computing resources available on demand. No need to plan far ahead in advance for hardware.
- The elimination of an up-front commitment by Cloud users, thereby allowing companies to start small and increase hardware resources only when there is an increase in their needs.
- The ability to pay for use of computing resources on a short-term basis as needed (processors by the hour, storage by the day). They can be released at any time, thereby rewarding conservation by letting machines and storage go when they are no longer needed.

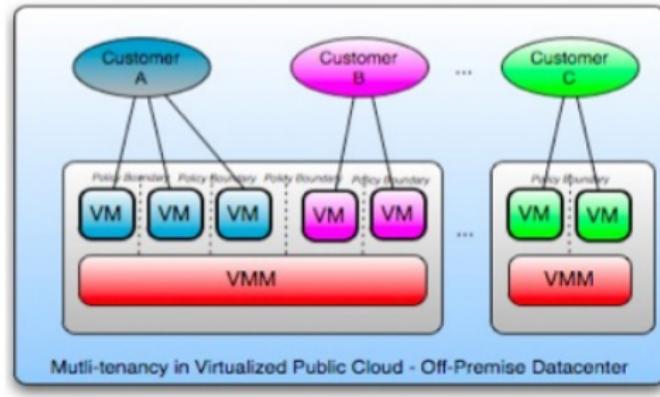
<http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf>

# Characteristics

- Minimizes the time between requesting and obtaining resources and storage. Boot instances in minutes.
- Select pre-configured AMI (Amazon Machine Instance) or create your own
- Start, monitor, and terminate many instances using Web interface or API

# Virtualization

- VMs Virtual Machines (VMs) are commonly used but not essential
- Multi-tenancy implies use of the same resources or applications by multiple consumers that may or may not belong to the same organization.



# Amazon The Company

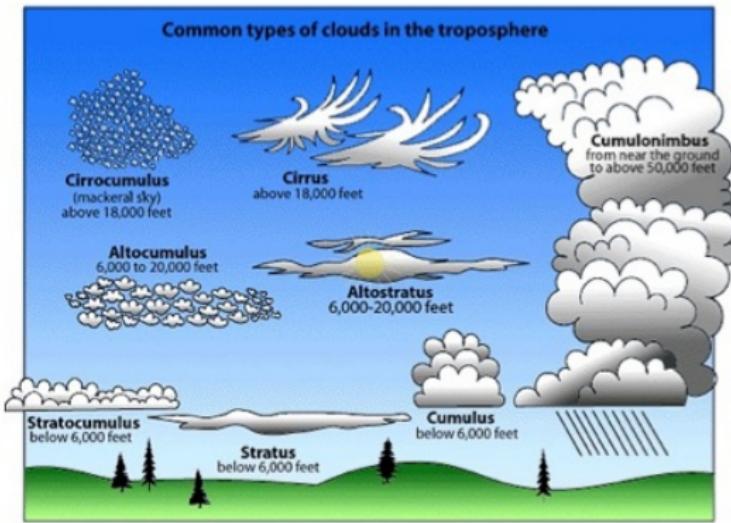
- Started in 2002, added EC2 in 2006 They have a head start
- AWS EC2 is a very popular cloud solution in Bioinformatics assisted research.
- Easy to overflow into EC2 from local resources (lots of companies provide software to conveniently support this)

# Competitors



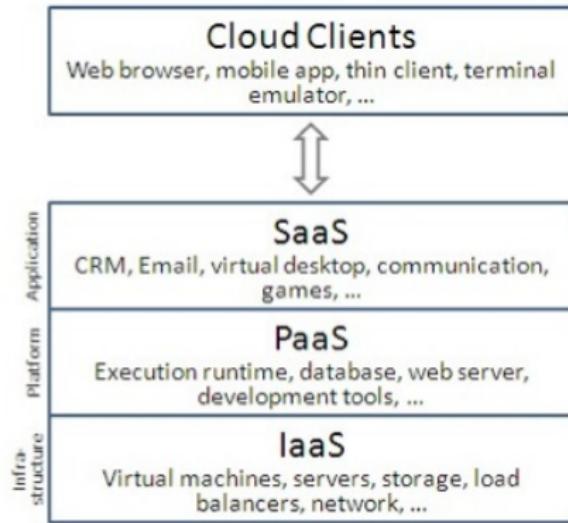
<http://blog.cloudharmony.com/2010/05/what-is-ecu-cpu-benchmarking-in-cloud.html>

# Know Your Clouds

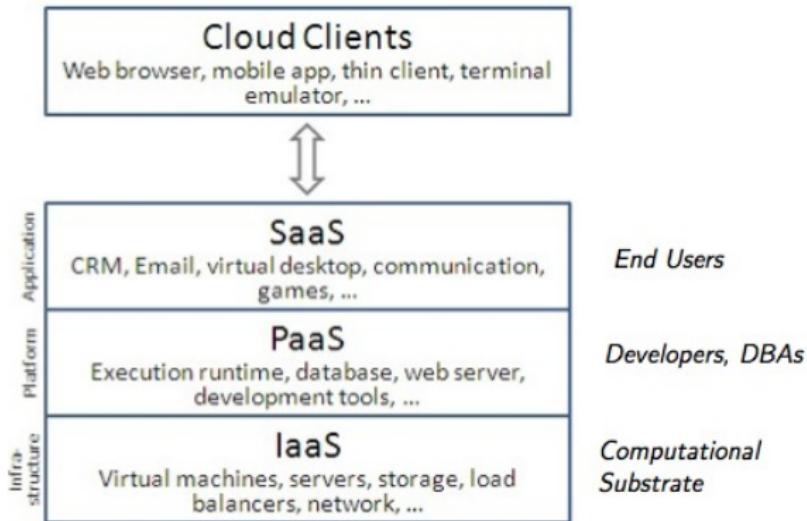


<http://eo.ucar.edu/webweather/cloud3.html>

# Service Levels



# Service Levels



# Service Levels

***Infrastructure as a Service (IaaS),*** delivers computer infrastructure (typically a platform virtualization environment) as a service, along with raw storage and networking. Rather than purchasing servers, software, data-center space, or network equipment, clients instead buy those resources as a fully outsourced service.

***Software as a service (SaaS),*** sometimes referred to as "on-demand software," is a software delivery model in which software and its associated data are hosted centrally (typically in the (Internet) cloud) and are typically accessed by users using a thin client, normally using a web browser over the Internet.

# Service Levels

***Platform as a service (PaaS)***, is the delivery of a computing platform and solution stack as a service. PaaS offerings facilitate deployment of applications without the cost and complexity of buying and managing the underlying hardware and software and provisioning hosting capabilities. This provides all of the facilities required to support the complete life cycle of building and delivering web applications and services entirely available from the Internet.

# Infrastructure Services



# Platform Services



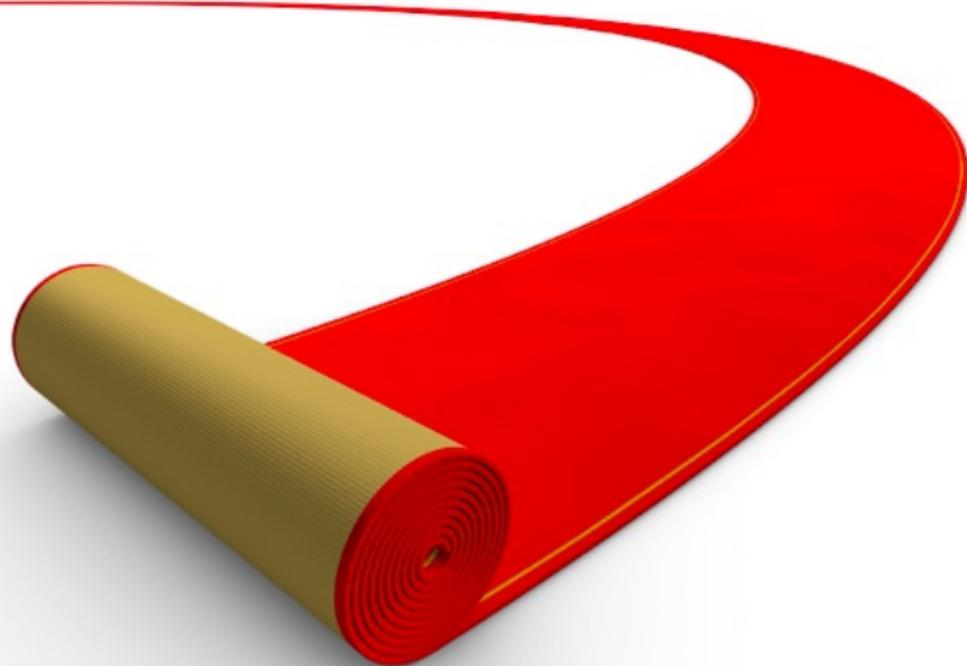
# Software Services



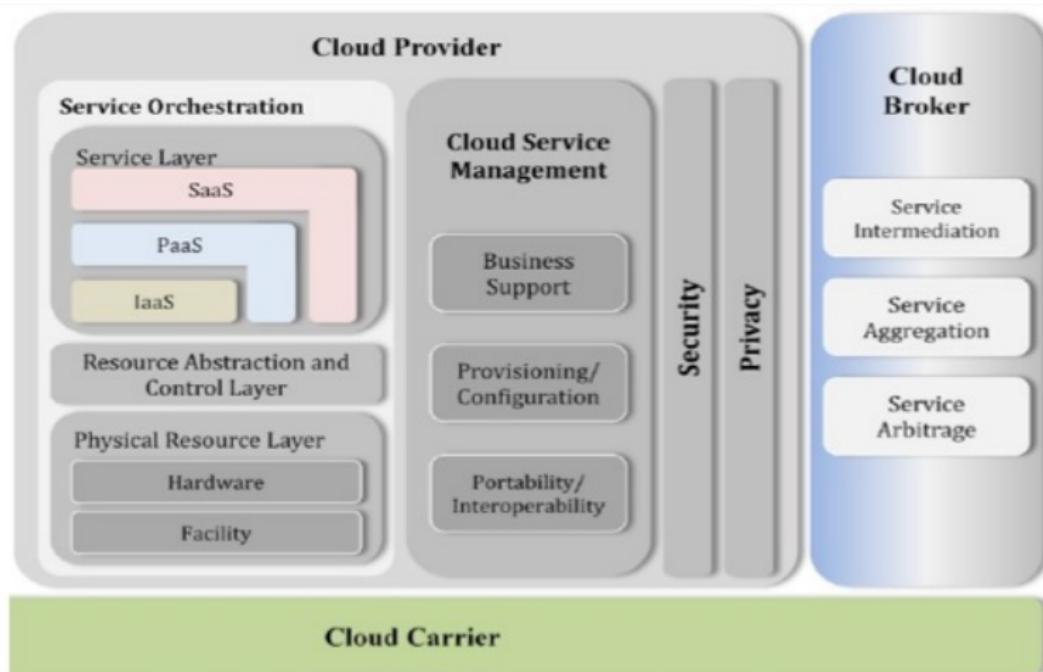
# Cloud Software



# Rolling it Out



# Cloud Deployment



# Deployment Models

## Deployment models

- *Public Cloud.* The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
- *Private Cloud.* The cloud infrastructure is operated solely for a single organization. It may be managed by the organization or by a third party and may be located on-premise or off-premise.
- *Community Cloud.* The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, or compliance considerations). It may be managed by the organizations or by a third party and may be located on-premise or off-premise.
- *Hybrid Cloud.* The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).

# Deployment Models

|                   | Infrastructure Managed By <sup>1</sup>          | Infrastructure Owned By <sup>2</sup>            | Infrastructure Located <sup>3</sup> | Accessible and Consumed By <sup>4</sup> |
|-------------------|---|---|-------------------------------------|---|
| Public            | Third Party Provider                            | Third Party Provider                            | Off-Premise                         | Untrusted                               |
| Private/Community | Organization<br>Or<br>Third Party Provider      | Organization<br>Third Party Provider            | On-Premise<br>Off-Premise           | Trusted                                 |
| Hybrid            | <u>Both</u> Organization & Third Party Provider | <u>Both</u> Organization & Third Party Provider | Both On-Premise & Off-Premise       | Trusted & Untrusted                     |

<sup>1</sup> Management includes: governance, operations, security, compliance, etc...

<sup>2</sup> Infrastructure implies physical infrastructure such as facilities, compute, network & storage equipment

<sup>3</sup> Infrastructure Location is both physical and relative to an Organization's management umbrella and speaks to ownership versus control

<sup>4</sup> Trusted consumers of service are those who are considered part of an organization's legal/contractual/policy umbrella including employees, contractors, & business partners. Untrusted consumers are those that may be authorized to consume some/all services but are not logical extensions of the organization.

# Private Cloud



OpenNebula



EUCALYPTUS



# Hybrid Cloud

- One can continue to use existing local services while also using Cloud services - The "Best of Both Worlds" approach.
- A blended approach is great for expansion since you don't have to buy a bunch of infrastructure. And you don't have to give up what you have in your "back yard".
- If using a cloud broker then make sure they support the Amazon API

# Hybrid Cloud



*Open source and Commercial products that allow you to orchestrate and automate local and external clouds using approaches that overlay the AWS tools.*

# Wanna Move to the Cloud ?

- Do you have external collaborators who need access to a common infrastructure set ?
- Do you know the profile of your proposed computational work ? Are you running "all out" for long stretches of time or sporadically ?
- Do you use a large set of bioinformatics tools or just a few ? Does your computational activity assume a specific OS image and application set ?
- To what extent are you (or want to be) reliant upon support and/or system administration staff ?

# Wanna Move to the Cloud ?

- The more predictable your computational research cycle is the easier it is to transport elsewhere.
- Develop prototypes then extend into the cloud for longer computation.
- Or develop prototypes in the cloud and use cheaper local resources for longer computation.
- Better yet - use both when local resources deplete or don't scale as rapidly as you need them to.

# Be Fickle



- Go to the Cloud, use what you want, when you want, for as long as you want.
- And then go running back to your local resources because they seem more attractive.
- Then do it all again.

# Complaints



# Money

The Meter is Always Running, It Costs Real Money !!!



# Outage

- Last year's outage took everyone by surprise.
- Companies like Reddit, Heroku, Foursquare, Instagram, Fab, Quora, Turntable.fm, Netflix were down

## Amazon Web Services Apologizes, Explains Outage

The company said it will provide 10 days of service credit for customers using AWS resources in the affected region because of the multi-day outage.

By Thomas Claburn  InformationWeek  
April 29, 2011 03:00 PM

Eight days after Amazon Web Services (AWS) experienced a major multi-day service outage in its East Coast region, the on-demand computing infrastructure company has published a detailed post-mortem and apologized.



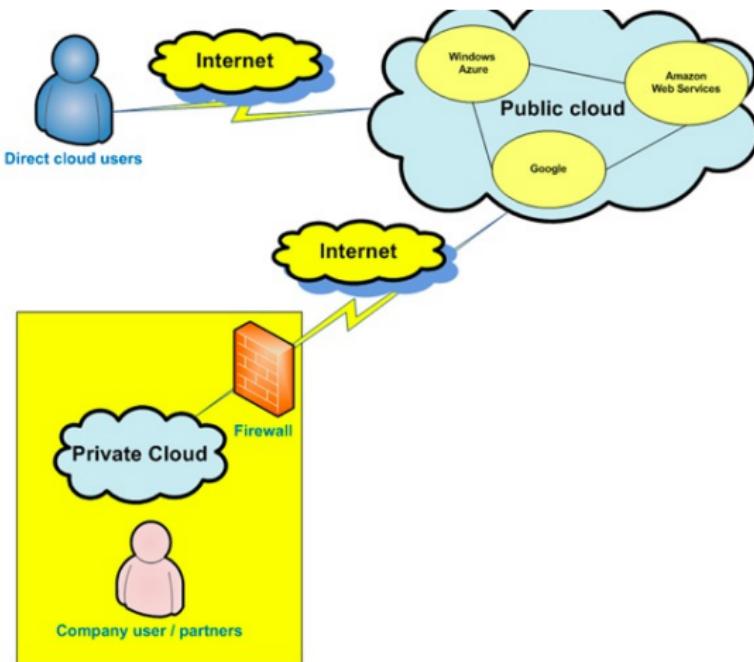
# Security

- "It's the Wild West" ! Really ?
- Usability and Security must be balanced



# Security

That's what hybrid clouds are for...



## CDC creates 'HIPAA-compliant public cloud'

April 13, 2012 — 2:38pm ET | By Dan Bowman



### TOOLS

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Beth Israel Deaconess Medical Center CIO John Halamka talks about the benefits of "a secure, HIPAA-compliant public cloud that includes healthcare information exchange gateways and analytical tools" in his latest blog post. The Centers for Disease Control and Prevention, notes Halamka, is "the first government agency to complete all the rigorous certification needed to host sensitive data in the public cloud." CDC's initiatives include [Biosense 2.0](#), which uses [Amazon's AWS GovCloud](#) to create a national repository of syndromic surveillance data

# Companies

See <http://aws.amazon.com/solutions/case-studies>

# Universities

- 
- › University of Maryland,  
College Park
- › University of California at  
Berkeley
- › Harvard Medical School
- › University of Texas at Austin
- › Harvard University
- › University of Oxford
- › Carnegie Mellon University
- › University of California, San  
Diego
- › Stanford University

Note that this does not imply an enterprise-wide adoption



## Venturing into the Computing Cloud

Duke offers new options for research computing

TOPICS FOR THIS STORY: [TECHNOLOGY & COMPUTING](#), [FACULTY](#), [RESEARCH](#), [STAFF](#), [STUDENTS](#)

May 25, 2011 | By Cara Bonnett

<http://today.duke.edu/2011/05/dukecloud>

Note that Duke's cloud is a combination of technology

# Duke

"We wanted to be in a position where our researchers have a menu of options, and they can choose what's most suitable for how they do their computing," said Jim Siedow, Duke's vice provost for research. "One of those options should be the cloud."

Computing "in the cloud" allows users to access hardware and infrastructure on demand over the Internet, paying only for what they use.

But the new model, approved by the provost this spring and administered by Duke's **Scalable Computing Support Center (SCSC)**, will include two new options:

- A private Duke "cloud," where researchers can purchase high-priority cycles as needed from a pool of machines and pay per CPU hour (similar to the pricing model for Amazon's cloud).
- An economy cloud option - or what Lombardi jokingly calls a "fog" - where researchers can purchase low-priority cycles only, for a lower per-CPU rate.

<https://wiki.duke.edu/display/SCSC/Service+Descriptions>

# Education Programs

- AWS in Education will review and support selected research projects with grants that offer free access to most AWS infrastructure services
- AWS offers Teaching Grants supporting free usage of AWS for students in eligible courses. Will provide educators up to 100 USD in free usage for each student enrolled in courses with Amazon Web Services.
- Amazon offers a free tier that is useful for trying out the service before spending "real" money.

# Products

## Solutions

[View all AWS Solutions](#)

The AWS cloud computing platform provides the flexibility to launch your application regardless of your use case or industry. Learn more about popular solutions customers are running on AWS:

### **Application Hosting**

Use reliable, on-demand infrastructure to power your applications, from hosted internal applications to SaaS offerings.

### **Backup and Storage**

Store data and build dependable backup solutions using AWS's inexpensive data storage services.

### **Content Delivery**

Quickly and easily distribute content to end users worldwide, with low costs and high data transfer speeds.

### **Web Hosting**

Satisfy your dynamic web hosting needs with AWS's scalable infrastructure platform.

### **Enterprise IT**

Host internal- or external-facing IT applications in AWS's secure environment.

### **Databases**

Take advantage of a variety of scalable database solutions, from hosted enterprise database software or non-relational database solutions.

# Signing Up

## Step 1: Sign Up for the Service

If you don't already have an AWS account, you'll need to get one. Your AWS account gives you access to all services, but you will be charged only for the resources that you use. For this example walkthrough, the charges will be minimal.

### To sign up for AWS

1. Go to <http://aws.amazon.com> and click **Sign Up Now**.
2. Follow the on-screen instructions.

AWS notifies you by email when your account is active and available for you to use.

The credentials for your AWS account give you access to all the resources that you have deployed.

# Login



## Sign In or Create an AWS Account

You may sign in using your existing Amazon.com account or you can create a new account by selecting "I am a new user."

My e-mail address is:

I am a new user.

I am a returning user  
and my password is:

[Sign in using our secure server](#)

[Forgot your password?](#)

[Has your e-mail address changed?](#)

# Key Pair

See <http://aws.amazon.com/documentation/gettingstarted/>

## Step 2: Create a Key Pair

For security reasons, EC2 instances use a public/private key pair, rather than a user name and password, to authenticate connection requests. The public key half of this pair is embedded in the instance, so you can use the private key to log in securely without a password. In this step we will use the AWS Management Console to create a key pair.

### To generate a key pair

1. Open the Amazon EC2 console at <https://console.aws.amazon.com/ec2/>.
2. In the **Navigation** pane, in the **Region** box, click US East (Virginia).
3. In the **Navigation** pane, under Network and Security, click **Key Pairs**.
4. Click **Create Key Pair**.
5. In the **Key Pair** dialog box, in the **Key Pair Name** box, type "newkeypair" for the new key pair and then click **Create**.
6. Download the private key file, which is named newkeypair.pem, and keep it in a safe place. You will need it to access any instances that you launch with this key pair.

# Dashboard

[AWS Elastic Beanstalk](#) [Amazon S3](#) [Amazon EC2](#) [Amazon VPC](#) [Amazon CloudWatch](#) [Amazon Elastic MapReduce](#) [Amazon CloudFront](#) [AWS CloudFormation](#) [Amazon RDS](#) [Amazon ElastiCache](#) [Amazon SQS](#) [AWS IAM](#) [Amazon SNS](#) [Amazon SES](#) [Amazon Route 53](#) [More...](#)

[Amazon DynamoDB](#)  
[Amazon Storage Gateway](#)  
[AWS CloudWatch Metrics](#)  
[Amazon SWF](#)  
[Amazon CloudSearch](#)

**Welcome**

The AWS Management Console provides a graphical interface to Amazon Web Services. Learn more about how to use our services to meet your needs, or get started by selecting a service.

[Getting started guides](#)

[Reference architectures](#)

[Free Usage Tier](#)

**Set Start Page**

[Console Home](#)

**Amazon Web Services**

|  |  |
|--|--|
| <b>Compute &amp; Networking</b>                                | <b>Deployment &amp; Management</b>                                 |
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| <a href="#"> Elastic MapReduce</a><br>Managed Hadoop Framework | <a href="#"> CloudWatch</a><br>Resource & Application Monitoring   |
| <a href="#"> Route 53</a><br>Scalable Domain Name System       | <a href="#"> Elastic Beanstalk</a><br>AWS Application Container    |
| <a href="#"> VPC</a><br>Isolated Cloud Resources               | <a href="#"> IAM</a><br>Secure AWS Access Control                  |

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|---|--|
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| <a href="#"> CloudFront</a><br>Global Content Delivery Network                                | <a href="#"> CloudSearch</a><br>Managed Search Service |
| <a href="#"> S3</a><br>Scalable Storage in the Cloud  | <a href="#"> SES</a><br>Email Sending Service          |
| <a href="#"> Storage Gateway</a><br>Integrates on-premises IT environments with Cloud storage | <a href="#"> SNS</a><br>Push Notification Service      |
|   | <a href="#"> SQS</a><br>Message Queue Service          |

**Announcements**

Amazon RDS announces support for MySQL Read Replica in Amazon VPC

AWS Elastic Beanstalk Now Available in the EU (Ireland) Region

[More...](#)

**Service Health**

Click [Edit](#) to add at least one service and at least one region to monitor.

[Service Health Dashboard](#)

# Launching

Amazon EC2 Console Dashboard

### Getting Started

To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.

**Launch Instance**

Note: Your instances will launch in the US East (Virginia) region.

### My Resources

You are using the following Amazon EC2 resources in the US East (Virginia) region:

|                     |                   |
|---------------------|-------------------|
| 0 Running Instances | 0 Elastic IPs     |
| 0 EBS Volumes       | 0 EBS Snapshots   |
| 5 Key Pairs         | 0 Load Balancers  |
| 0 Placement Groups  | 4 Security Groups |

[Refresh](#)

### Service Health

Service Status

| Current Status                     | Details                       |
|------------------------------------|-------------------------------|
| Amazon EC2 (US East - N. Virginia) | Service is operating normally |

[View complete service health details](#)

### Events

US East (Virginia): No events

[Refresh](#)

### Related Links

[Getting Started Guide](#)

## S3 - Description

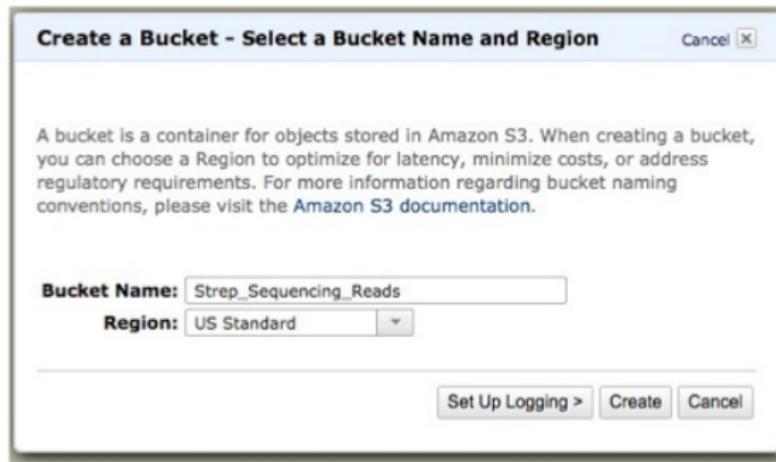
- Amazon S3 provides a simple web services interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web.
- Write, read, and delete objects containing from 1 byte to 5 terabytes of data each. The number of objects you can store is unlimited.
- Each object is stored in a bucket and retrieved via a unique, developer-assigned key. Options for secure data upload/download and encryption of data at rest are provided for additional data protection.
- Authentication mechanisms are provided to ensure that data is kept secure from unauthorized access.
- Options for secure data upload/download and encryption of data at rest are provided for additional data protection.

## S3 - Features

- Relative to sensitive data - talk to someone locally BEFORE you think about pushing out sensitive data. When in doubt - leave it out !
- Content Storage And Distribution: Supports variable content, unlimited number of storage objects. Can be public, private, or secured with authentication and encryption. Uses REST and SOAP interfaces.
- Storage for data analysis: Keep data safe and then send to EBS storage for analysis using EC2 computational resources.
- Authentication mechanisms are provided to ensure that data is kept secure from unauthorized access.
- Backup, Archiving, Disaster Recovery: Use the AWS Import/Export service to move large amounts of data in and out.

# S3 - Management

- Use AWS Web Console to manage your storage buckets:



# S3 - AWS Console S3

- Use AWS Web Console to manage your storage buckets:

AWS Management Console > Amazon S3

Buckets

Create Bucket Actions ▾

SequenceReads

Objects and Folders

Upload Create Folder Actions ▾ Refresh

SequenceReads

| Name  | Size |
|-------|------|
| FASTA | --   |
| RCode | --   |
| SOLID | --   |

# S3 - Clients

Or you can use one of the many free clients to manage the objects

|   | Bucket        | Creation Date            | Owner        | All Users     | Authenticated Users |
|---|---------------|--------------------------|--------------|---------------|---------------------|
| 1 | SequenceReads | Tue May 22 16:33:14 E... | FULL_CONTROL | No Permission | No Permission       |

|   | File                                | Size      | Last Modified   | Owner        | All Users     | Authenticated U... |
|---|-------------------------------------|-----------|-----------------|--------------|---------------|--------------------|
| 1 | FASTA/                              | 0.00 B    | Tue May 22 1... | FULL_CONTROL | No Permission | No Permission      |
| 2 | FASTA/Streptococcus suis genome.... | 1.95 MB   | Tue May 22 1... | FULL_CONTROL | No Permission | No Permission      |
| 3 | RCode/                              | 0.00 B    | Tue May 22 1... | FULL_CONTROL | No Permission | No Permission      |
| 4 | RCode/BB_phys_stats_ex1.R           | 2.69 KB   | Tue May 22 1... | FULL_CONTROL | No Permission | No Permission      |
| 5 | SOLID/                              | 0.00 B    | Tue May 22 1... | FULL_CONTROL | No Permission | No Permission      |
| 6 | SOLID/GRAVE20070409_Suis-frag-...   | 204.96 MB | Tue May 22 1... | FULL_CONTROL | No Permission | No Permission      |

# Command Line API

Command line access from your laptop/desktop is also possible

```
fenders-macbook:~ fender$ ./aws ls
+-----+-----+
|     Name      | CreationDate      |
+-----+-----+
| SequenceReads | 2012-05-22T20:33:14.000Z |
+-----+-----+
fenders-macbook:~ fender$ █
```

# S3 - Pricing

- Current Pricing Info at: <http://aws.amazon.com/s3/pricing/>



# S3 - Rates

| Region:              | US Standard      | :                          |
|----------------------|------------------|----------------------------|
|                      | Standard Storage | Reduced Redundancy Storage |
| First 1 TB / month   | \$0.125 per GB   | \$0.093 per GB             |
| Next 49 TB / month   | \$0.110 per GB   | \$0.083 per GB             |
| Next 450 TB / month  | \$0.095 per GB   | \$0.073 per GB             |
| Next 500 TB / month  | \$0.090 per GB   | \$0.063 per GB             |
| Next 4000 TB / month | \$0.080 per GB   | \$0.053 per GB             |
| Over 5000 TB / month | \$0.055 per GB   | \$0.037 per GB             |

| Pricing                  |                |
|--------------------------|----------------|
| <b>Data Transfer IN</b>  |                |
| All data transfer in     | \$0.000 per GB |
| <b>Data Transfer OUT</b> |                |
| First 1 GB / month       | \$0.000 per GB |
| Up to 10 TB / month      | \$0.120 per GB |
| Next 40 TB / month       | \$0.090 per GB |
| Next 100 TB / month      | \$0.070 per GB |
| Next 350 TB / month      | \$0.050 per GB |

# EBS

- Amazon Elastic Block Store (EBS) provides block level storage volumes for use with Amazon EC2 instances. EBS volumes are off-instance storage that can persist independently of an instance.
- Amazon EBS is particularly suited for applications that require a database, file system, or access to raw block level storage.
- Amazon EBS allows you to create storage volumes that can be mounted as devices by Amazon EC2 instances. Multiple volumes can be mounted to the same instance.
- Amazon EBS provides the ability to create point-in-time snapshots of volumes, which are persisted to Amazon S3. These snapshots can be used as the starting point for new Amazon EBS volumes

# Glacier

- Glacier is a very new service for the long term archival of infrequently accessed data. It is intended for safe archival for as little as once cent per GB per month.
- Use the AWS Management Console or the Amazon Glacier APIs to create vaults. You use vaults to organize the archives you upload to Glacier.
- Use the Amazon Glacier APIs to upload and retrieve archives.
- Monitor the status of your Amazon Glacier jobs using the Amazon Glacier APIs.

# Description



# Features

- Amazon EC2 - a virtual computing environment. Use web services to launch instances of different operating systems, install your stack, scale up multiple instances.
- Select templated-images AMIs: Different versions of popular OS along with domain specific images for bioinformatics, statistics, chemistry, etc
- Establish security policies: Firewalls and access points are configurable
- Use EBS to maintain persistent storage across instances. You can stop or destroy your instances while maintaining data. Pick back up where left off
- Create Beowulf style HPC environments in the cloud - StarCluster

# Free Tier

## Free Tier\*

As part of AWS's Free Usage Tier, new AWS customers can get started with Amazon EC2 for free. Upon sign-up, new AWS customers receive the following EC2 services each month for one year:

- 750 hours of EC2 running Linux/Unix Micro instance usage
- 750 hours of EC2 running Microsoft Windows Server Micro instance usage
- 750 hours of Elastic Load Balancing plus 15 GB data processing
- 30 GB of Amazon Elastic Block Storage (EBS) plus 2 million IOs and 1 GB snapshot storage
- 15 GB of bandwidth out aggregated across all AWS services
- 1 GB of Regional Data Transfer



# Prices

|  | Linux/UNIX Usage | Windows Usage    |
|--|------------------|------------------|
| <b>Standard On-Demand Instances</b>    |                  |                  |
| Small (Default)                        | \$0.080 per Hour | \$0.115 per Hour |
| Medium                                 | \$0.160 per Hour | \$0.230 per Hour |
| Large                                  | \$0.320 per Hour | \$0.460 per Hour |
| Extra Large                            | \$0.640 per Hour | \$0.920 per Hour |
| <b>High-Memory On-Demand Instances</b> |                  |                  |
| Extra Large                            | \$0.450 per Hour | \$0.570 per Hour |
| Double Extra Large                     | \$0.900 per Hour | \$1.140 per Hour |
| Quadruple Extra Large                  | \$1.800 per Hour | \$2.280 per Hour |
| <b>High-CPU On-Demand Instances</b>    |                  |                  |
| Medium                                 | \$0.165 per Hour | \$0.285 per Hour |
| Extra Large                            | \$0.660 per Hour | \$1.140 per Hour |

# Instance Descriptions

| Type   |  | CPU Units    | CPU Cores | Memory  |
|--|--|--------------|-----------|---------|
| Micro (t1.micro)                               |  Free tier eligible | Up to 2 ECUs | 1 Core    | 613 MB  |
| Small (m1.small)                               |  | 1 ECU        | 1 Core    | 1.7 GB  |
| High-CPU Medium (c1.medium)                    |  | 5 ECUs       | 2 Cores   | 1.7 GB  |
| Medium (m1.medium)                             |  | 2 ECUs       | 1 Core    | 3.7 GB  |
| Large (m1.large)                               |  | 4 ECUs       | 2 Cores   | 7.5 GB  |
| Extra Large (m1.xlarge)                        |  | 8 ECUs       | 4 Cores   | 15 GB   |
| High-Memory Extra Large (m2.xlarge)            |  | 6.5 ECUs     | 2 Cores   | 17.1 GB |
| High-Memory Double Extra Large (m2.2xlarge)    |  | 13 ECUs      | 4 Cores   | 34.2 GB |
| High-Memory Quadruple Extra Large (m2.4xlarge) |  | 26 ECUs      | 8 Cores   | 68.4 GB |
| High-CPU Extra Large (c1.xlarge)               |  | 20 ECUs      | 8 Cores   | 7 GB    |

1 ECU = 1 Opteron or Xeon 1.0-1.2 GHz 2007 CPU (Dual Core)

See URL for comparisons between compute units of different utility computing providers:

<http://blog.cloudharmony.com/2010/05/what-is-ecu-cpu-benchmarking-in-cloud.html>

# Launch the Wizard

## Launch with the Classic Wizard

**Request Instances Wizard**

Choose an Amazon Machine Image (AMI) from one of the tabbed lists below by clicking its **Select** button.

**Quick Start**   **My AMIs**   **Community AMIs**

|   |  |               |
|---|--|---------------|
| <b>Basic 32-bit Amazon Linux AMI 2011.02.1 Beta</b> [AMI Id: ami-bc1fece8]  |  | <b>Select</b> |
| Amazon Linux AMI Base 2011.02.1, EBS boot, 32-bit architecture with Amazon EC2 AMI Tools.<br>Root Device Size: 8 GB   |  |               |
| <b>Basic 64-bit Amazon Linux AMI 2011.02.1 Beta</b> [AMI Id: ami-bc1fece7]  |  | <b>Select</b> |
| Amazon Linux AMI Base 2011.02.1, EBS boot, 64-bit architecture with Amazon EC2 AMI Tools.<br>Root Device Size: 8 GB   |  |               |
| <b>Red Hat Enterprise Linux 6.1 32 bit</b> [AMI Id: ami-0cbb4265]   |  | <b>Select</b> |
| Red Hat Enterprise Linux version 6.1, EBS-boot, 32-bit architecture.<br>Root Device Size: 7 GB  |  |               |
| <b>Red Hat Enterprise Linux 6.1 64 bit</b> [AMI Id: ami-5e837937]   |  | <b>Select</b> |
| Red Hat Enterprise Linux version 6.1, EBS-boot, 64-bit architecture.<br>Root Device Size: 6 GB  |  |               |
| <b>SUSE Linux Enterprise Server 11 64-bit</b> [AMI Id: ami-e4a257d6]  |  | <b>Select</b> |
| SUSE Linux Enterprise Server 11 Service Pack 1 basic install, EBS-boot, 64-bit architecture with Amazon EC2 AMI Tools preinstalled; Apache 2.2, MySQL 5.0, PHP 5.3, Ruby 1.8.2, and Rails 2.3.<br>Root Device Size: 15 GB |  |               |

**Free tier eligible if used with a micro instance. See [AWS Free tier](#) for complete details and terms.**

**Continue**

# Select

**Request Instances Wizard**

Cancel

CHOOSE AN AMI   INSTANCE DETAILS   CREATE KEY PAIR   CONFIGURE FIREWALL   REVIEW

Choose an Amazon Machine Image (AMI) from one of the tabbed lists below by clicking its **Select** button.

Quick Start   My AMIs   **Community AMIs**

Find and buy software from well known sellers. Search AMIs on AWS Marketplace

| Viewing:     |             | All Images                                  | 1000Human   | 1 to 1 of 1 Items | > |
|--------------|-------------|---|-------------|-------------------|---|
| AMI ID       | Root Device | Manifest                                    | Platform    |                   |   |
| ami-06845b6f | ebs         | 467153740619/1000HumanGenomes-CloudBioLinux | Other Linux | <b>Select</b>     |   |

# Options

**Request Instances Wizard**

CHOOSE AN AMI    INSTANCE DETAILS    CREATE KEY PAIR    CONFIGURE FIREWALL    REVIEW

**Number of Instances:** 1

**Availability Zone:** us-east-1a

---

**Advanced Instance Options**

Here you can choose a specific kernel or RAM disk to use with your instances. You can also choose to enable CloudWatch Detailed Monitoring or enter data that will be available from your instances once they launch.

**Kernel ID:**     **RAM Disk ID:**

**Monitoring:**  Enable CloudWatch detailed monitoring for this instance  
(additional charges will apply)

**User Data:** testpass  
 as text  
 as file  
 base64 encoded

**Termination Protection:**  Prevention against accidental termination.

**Shutdown Behavior:**   
Choose the behavior when the instance is shutdown from within the instance.

## Confirm

|   |   |                  |                     |     |          |         |                 |      |              |
|---|---|------------------|---------------------|-----|----------|---------|-----------------|------|--------------|
| <input checked="" type="checkbox"/>                                       | empty   | i-419bc427       | ami-06845b6f        | ebs | m1.large | running | initializing... | none | basicdefault |
| <b>1 EC2 Instance selected.</b>   |   |                  |                     |     |          |         |                 |      |              |
| <b>EC2 Instance:</b> i-419bc427 ec2-107-20-68-148.compute-1.amazonaws.com |   |                  |                     |     |          |         |                 |      |              |
| <b>Description</b> <b>Status Checks</b> <b>Monitoring</b> <b>Tags</b>     |   |                  |                     |     |          |         |                 |      |              |
| AMI:  | 1000HumanGenomes-CloudBioLinux-NCBI-JCVI (ami-06845b6f) | Alarm Status:    | none                |     |          |         |                 |      |              |
| Zone:   | us-east-1a  | Security Groups: | default, view rules |     |          |         |                 |      |              |
| Type:   | m1.large  | State:           | running             |     |          |         |                 |      |              |
| Scheduled Events:   | No scheduled events                                     | Owner:           | 288753929945        |     |          |         |                 |      |              |

# Connect

**EC2**   **VPC**   **CloudWatch**   **Elastic MapReduce**   **CloudFront**   **CloudFormation**   **RDS**   **ElastiCache**

**My Instances**

**Viewing:** All Instances

| Name  | Type | State      |
|-------|------|------------|
| empty | i-   | terminated |
| empty | i-   | running    |

**1 EC2 Instance selected**

**EC2 Instances**

**Description**

**AMI:** 1000HumanGenome

**Zone:** us-east-1

**Instance Management**

- Connect
- Get System Log
- Get Windows Admin Password
- Create Image (EBS AMI)
- Add/Edit Tags
- Change Security Group
- Change Source/Dest. Check
- Bundle Instance (instance store AMI)
- Launch More Like This
- Disassociate IP Address
- Change Termination Protection
- View/Change User Data
- Change Instance Type
- Change Shutdown Behavior
- Attach Network Interface
- Detach Network Interface

**Instance Actions**

Terminate  
Reboot  
Stop  
Start

148.compute-1.us-east-1

6f)   **Alarm Status:**

**Security Groups:**

# Command Line Access

```
fenders-macbook:~ fender$ ssh ubuntu@ec2-107-20-68-148.compute-1.amazonaws.com
The authenticity of host 'ec2-107-20-68-148.compute-1.amazonaws.com (107.20.68.148)' can't be established.
RSA key fingerprint is c7:2c:05:43:id:02:3b:76:3e:74:b2:07:fd:6e:57:77.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'ec2-107-20-68-148.compute-1.amazonaws.com,107.20.68.148' (RSA) to the list of known hosts.
ubuntu@ec2-107-20-68-148.compute-1.amazonaws.com's password:
Welcome to Ubuntu 11.10 (GNU/Linux 3.0.0-12-virtual x86_64)

 * Documentation: https://help.ubuntu.com/
```

System information as of Wed May 23 04:02:57 UTC 2012

|               |                  |                      |            |
|---------------|------------------|----------------------|------------|
| System load:  | 0.01             | Processes:           | 116        |
| Usage of /:   | 86.6% of 19.69GB | Users logged in:     | 0          |
| Memory usage: | 2%               | IP address for eth0: | 10.122.5.9 |
| Swap usage:   | 0%               |                      |            |

```
ubuntu@ip-10-122-5-9:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/xvda1       20G   17G   1.9G  91% /
udev            3.7G   4.0K  3.7G  1% /dev
tmpfs           1.5G  648K  1.5G  1% /run
none             5.0M    0  5.0M  0% /run/lock
none             3.7G    0  3.7G  0% /run/shm
/dev/xvdb       414G  199M  393G  1% /mnt
s3fs            256T    0  256T  0% /mnt/1000genomes
ubuntu@ip-10-122-5-9:~$
```

# Analyze the Data

```
ubuntu@ip-10-122-5-9:~$ ls /mnt/1000genomes/
alignment.index    current.tree          pilot_data           README.populations   sequence_indices
alignment_indices   data                README.alignment_data README.sequence_data technical
CHANGELOG           exome.alignment.index README.ftp_structure release
changelog_details   phase1             README.pilot_data  sequence.index
ubuntu@ip-10-122-5-9:~$
```

*Next - start analyzing the data using built in NGS tools built into BioLinux*

CloudBioLinux offers genome analysis resources for cloud computing platforms such as Amazon EC2. We develop freely available, community maintained software images and data repositories for biological analysis.



Many bioinformatics workflows involve large datasets in which high performance computing is needed. Cloud computing provides researchers with the ability to perform computations using a practically unlimited pool of virtual machines, using platforms such as [Amazon EC2](#), [Eucalyptus](#) or [VirtualBox](#). CloudBioLinux utilizes these resources to enable instant access to biological software, programming libraries and data.

# Open Data Sets

There are other open data sets available

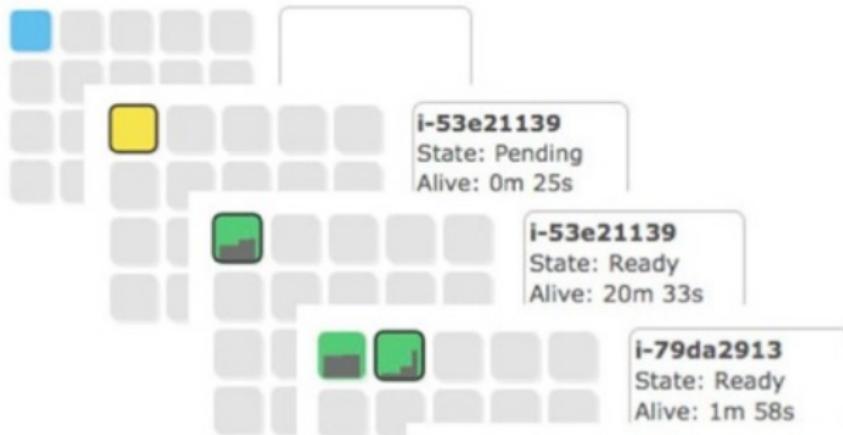
| EBS Snapshots            |       |                           |          |                                   |                                |
|--------------------------|-------|---------------------------|----------|-----------------------------------|--------------------------------|
|                          |       | Viewing: Public Snapshots |          | Search                            |                                |
|                          | Name  | Snapshot ID               | Capacity | Description                       | Status                         |
| <input type="checkbox"/> | empty | snap-92d333fb             | 200 GiB  | 2000 US Census (Linux)            | completed 2008-11-21 04:27 EDT |
| <input type="checkbox"/> | empty | snap-4edd3d27             | 220 GiB  | 2003-2006 Economic Data (Windows) | completed 2008-11-21 20:22 EDT |
| <input type="checkbox"/> | empty | snap-40dd3d29             | 70 GiB   | PubChem 3D (Windows)              | completed 2008-11-21 20:23 EDT |
| <input type="checkbox"/> | empty | snap-a8dd3dc1             | 70 GiB   | PubChem 3D (Linux)                | completed 2008-11-21 21:45 EDT |
| <input type="checkbox"/> | empty | snap-0bdf3f62             | 220 GiB  | 2003-2006 Economic Data (Linux)   | completed 2008-11-22 01:25 EDT |
| <input type="checkbox"/> | empty | snap-c48380ad             | 172 GiB  | Ensembl BioMart (Linux)           | completed 2008-12-04 08:20 EDT |
| <input type="checkbox"/> | empty | snap-c78380ae             | 550 GiB  | Main Ensembl (Linux)              | completed 2008-12-04 08:20 EDT |
| <input type="checkbox"/> | empty | snap-60d83b09             | 10 GiB   | UniGene (Windows)                 | completed 2008-12-10 12:26 EDT |
| <input type="checkbox"/> | empty | snap-63d83b0a             | 230 GiB  | Pubchem Library (Windows)         | completed 2008-12-10 12:27 EDT |
| <input type="checkbox"/> | empty | snap-5ad83b33             | 10 GiB   | UniGene (Linux)                   | completed 2008-12-10 12:52 EDT |
| <input type="checkbox"/> | empty | snap-e6df3c8f             | 230 GiB  | Pubchem Library (Linux)           | completed 2008-12-10 15:07 EDT |

# Open Data Sets

*You can attach any of these snapshots to a running  
EC2 / compute  
Instance.*

# Cloudman

- Create an Amazon Web Services (AWS) account
- Use the AWS Management Console to start a master EC2 instance
- Use the CloudMan web console on the master instance to manage the cluster size.



# Configuration

## Initial Cluster Configuration

Welcome to CloudMan. This application will allow you to manage this cluster and the services provided within. To get started, choose the type of cluster you'd like to work with and provide the associated value, if any.

- Galaxy Cluster:** Galaxy application, available tools, reference datasets, SGE job manager, and a data volume. Specify the initial storage size (in Gigabytes):

100 GB

[Show more startup options](#)

[Start Cluster](#)

# Status

## Galaxy Cloudman Console

Welcome to Galaxy Cloudman. This application allows you to manage this instance of Galaxy CloudMan. Your previous data store has been reconnected. Once the cluster has initialized, use the controls below to add and remove 'worker' nodes for running jobs.

[Terminate cluster](#)[Add nodes ▾](#)[Remove nodes](#)[Access Galaxy](#)

## Status

**Cluster name:** steve\_galaxy

**Disk status:** 51M / 100G (1%)

**Worker status:** Idle: 0 Available: 0 Requested: 0

**Service status:** Applications Data



Autoscaling is **off**.  
Turn [on](#)?

[Cluster status log](#)

# Terminating

## EC2 Cluster Configuration

Are you sure you want to power the cluster off?

This action will shut down all services on the cluster and terminate any worker nodes (instances) associated with this cluster. Unless you choose to have the cluster deleted, all of your data will be preserved beyond the life of this instance. Next time you wish to start this same cluster, simply use the same user data (i.e., cluster name and AWS account) and CloudMan will reactivate your cluster with your data.

**Automatically terminate the master instance?**

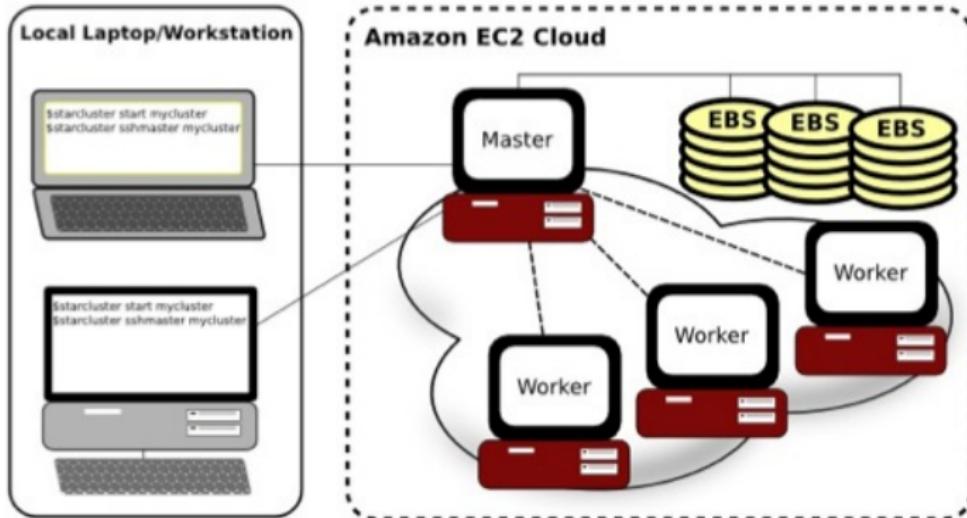
If checked, this master instance will automatically terminate after all services have been shut down. If not checked, you should manually terminate this instance after all services have been shut down.

**Also delete this cluster?**

If checked, this cluster will be deleted. **This action is irreversible!** All your data will be deleted.

**Yes, power off**

# HPC



# Features



StarCluster is an open source cluster-computing toolkit for Amazon's Elastic Compute Cloud (EC2) released under the [LGPL license](#).

StarCluster has been designed to automate and simplify the process of building, configuring, and managing clusters of virtual machines on [Amazon's EC2 cloud](#). StarCluster allows anyone to easily create a cluster computing environment in the cloud suited for distributed and parallel computing applications and systems.

- *Single Start Command*
- *Includes OpenMPI, ATLAS, Lapack, NumPy, SciPy,*
- *Elastic Load Balancing*
- *Configured with NFS, Sun Grid Engine, and ssh between nodes*
- *Security Group Permissions*

# Images

## StarCluster Machine Images (AMIs)

In addition to automatic cluster configuration, StarCluster also ships with its own Amazon machine images (AMIs) that contain applications and libraries for scientific computing and software development. The AMIs currently consist of the following scientific libraries:

1. [OpenMPI](#) - Library for writing parallel applications
2. [ATLAS](#) optimized for the larger Amazon EC2 instance types
3. [NumPy/SciPy](#) compiled against the optimized ATLAS install
4. [IPython](#) - interactive parallel computing in Python

StarCluster AMIs also exist for the Cluster Compute and Cluster GPU instance types that come with the [CUDA SDK](#) as well as [PyCUDA](#). To get a list of all of StarCluster's available AMIs use the `listpublic` command:

# Starting

## Create and Manage Clusters

StarCluster allows easily creating one or more clusters of virtual machines in the cloud:

```
$ starcluster start -s 10 mycluster
```

Use the *listclusters* command to keep track of your clusters:

```
$ starcluster listclusters
```

Login to the master node of your cluster:

```
$ starcluster sshmaster mycluster
```

Add additional nodes to your cluster for more compute power:

```
$ starcluster addnode mycluster
```

# Booting

```
fenders-macbook:~ fender$ starcluster start -s 5 mycluster
StarCluster - (http://web.mit.edu/starcluster) (v. 0.93.3)
Software Tools for Academics and Researchers (STAR)
Please submit bug reports to starcluster@mit.edu
```

```
>>> Using default cluster template: smallcluster
>>> Validating cluster template settings...
>>> Cluster template settings are valid
>>> Starting cluster...
>>> Launching a 5-node cluster...
>>> Creating security group @sc-mycluster...
Reservation:r-4bb2e229
>>> Waiting for cluster to come up... (updating every 30s)
>>> Waiting for all nodes to be in a 'running' state...
5/5 █████████████████████████████████████████████████████████████████ 100%
>>> Waiting for SSH to come up on all nodes...
5/5 █████████████████████████████████████████████████████████████████ 100%
```

# Finished

```
>>> Configuring /etc/hosts on each node
5/5 █████████████████████████████████████████████████████████████████ 100%
>>> Starting NFS server on master
>>> Configuring NFS exports path(s):
/home
>>> Mounting all NFS export path(s) on 4 worker node(s)
4/4 █████████████████████████████████████████████████████████████████ 100%
>>> Setting up NFS took 0.143 mins
>>> Configuring passwordless ssh for root
>>> Configuring passwordless ssh for sgeadmin
>>> Shutting down threads...
20/20 █████████████████████████████████████████████████████████████████ 100%
>>> Configuring SGE...
>>> Configuring NFS exports path(s):
/opt/sge6
>>> Mounting all NFS export path(s) on 4 worker node(s)
4/4 █████████████████████████████████████████████████████████████████ 100%
>>> Setting up NFS took 0.024 mins
>>> Installing Sun Grid Engine...
4/4 █████████████████████████████████████████████████████████████████ 100%
>>> Creating SGE parallel environment 'orte'
5/5 █████████████████████████████████████████████████████████████████ 100%
>>> Adding parallel environment 'orte' to queue 'all.q'
>>> Shutting down threads...
20/20 █████████████████████████████████████████████████████████████████ 100%
>>> Configuring cluster took 1.967 mins
>>> Starting cluster took 4.083 mins
```

# Console View

The AWS Management Console View:

| Name                             | Instance   | AMI ID       | Root Device | Type     | State   | Status Checks | Alarm Status | Mon   |
|----------------------------------|------------|--------------|-------------|----------|---------|---------------|--------------|-------|
| <input type="checkbox"/> master  | i-bbebcfdd | ami-899d49e0 | ebs         | m1.small | running | 2/2 checks pa | none         | basic |
| <input type="checkbox"/> node001 | i-b9ebcdf  | ami-899d49e0 | ebs         | m1.small | running | 2/2 checks pa | none         | basic |
| <input type="checkbox"/> node002 | i-87ebcfe1 | ami-899d49e0 | ebs         | m1.small | running | 2/2 checks pa | none         | basic |
| <input type="checkbox"/> node003 | i-85ebcfe3 | ami-899d49e0 | ebs         | m1.small | running | 2/2 checks pa | none         | basic |
| <input type="checkbox"/> node004 | i-83ebcfe5 | ami-899d49e0 | ebs         | m1.small | running | 2/2 checks pa | none         | basic |

# Logging In

```
fenders-macbook:~ fender$ starcluster sshmaster mycluster
StarCluster - (http://web.mit.edu/starcluster) (v. 0.93.3)
Software Tools for Academics and Researchers (STAR)
Please submit bug reports to starcluster@mit.edu
```

```
The authenticity of host 'ec2-23-22-132-109.compute-1.amazonaws.com (23.22.132.109)' can't be established
RSA key fingerprint is 99:dc:dc:92:ce:7e:fd:1c:ef:74:62:30:c4:b5:32:90.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'ec2-23-22-132-109.compute-1.amazonaws.com,23.22.132.109' (RSA) to the list of
known hosts.
```



```
root@master:~# ghost
      HOSTNAME          ARCH      NCPU      LOAD      MEMTOT      MEMUSE      SWAPTO      SWAPUS
-----+-----+-----+-----+-----+-----+-----+-----+
global           -        -       -       -       -       -       -       -
master          linux-x86     1  0.33    1.6G   41.0M  896.0M     0.0
node001         linux-x86     1  0.25    1.6G   33.9M  896.0M     0.0
node002         linux-x86     1  0.09    1.6G   33.6M  896.0M     0.0
node003         linux-x86     1  0.14    1.6G   33.8M  896.0M     0.0
node004         linux-x86     1  0.09    1.6G   33.7M  896.0M     0.0
```

```
root@master:~#
```

# Playing the Market

- Amazon EC2 Spot Instances is a pricing model targeted for batch processing use cases, which provides customers with the ad-hoc provisioning capability with a discount.
- Spot Instances enable you to bid for unused Amazon EC2 capacity. Instances are charged the Spot Price set by Amazon EC2, which fluctuates periodically depending on the supply of and demand for Spot Instance capacity.
- Discounts are attractive but its possible the instance could be reclaimed during the run if on-demand "demand" is high. This is why Spot Instances are good for large batch runs.

# Using the API

- Let's check the spot prices for the m2.xlarge instances in the Eastern Region between April 01, 2012 and May 15, 2012. This might give us some idea about what we would bid. Remember the posted on-demand price for this instance is 45 cents per hour for a Linux instance. <http://www.ec2instances.info/>

```
fenders-macbook:bin fender$ ec2-describe-spot-price-history --start-time 2012-04-01T23:00:00 --end-time 2012-05-15T23:00:00 -t m2.xlarge -a us-east-1a -d Linux/UNIX | awk '{tot += $2; count++} END {print tot/count}'  
0.20759
```

- So the average price for this instance is 20 cents less than half the on-demand price. So you now have a baseline for your bid logic.

# Cycle Computing

September 19, 2011

## New CycleCloud HPC Cluster Is a Triple Threat: 30000 cores, \$1279/Hour, & Grill monitoring GUI for Chef

| Resource            | Count                           |
|---------------------|---------------------------------|
| c1.xlarge instances | 3,809                           |
| cores               | 30,472                          |
| RAM                 | 26.7-TB                         |
| AWS Regions         | 3 ( us-east, us-west, eu-west ) |

<http://blog.cyclecomputing.com/2011/09/new-cyclecloud-cluster-is-a-triple-threat-30000-cores-massive-spot-instances-grill-chef-monitoring-g.html>