
Basics of Cloud Computing – Lecture 2

# Cloud Providers

Satish Srirama

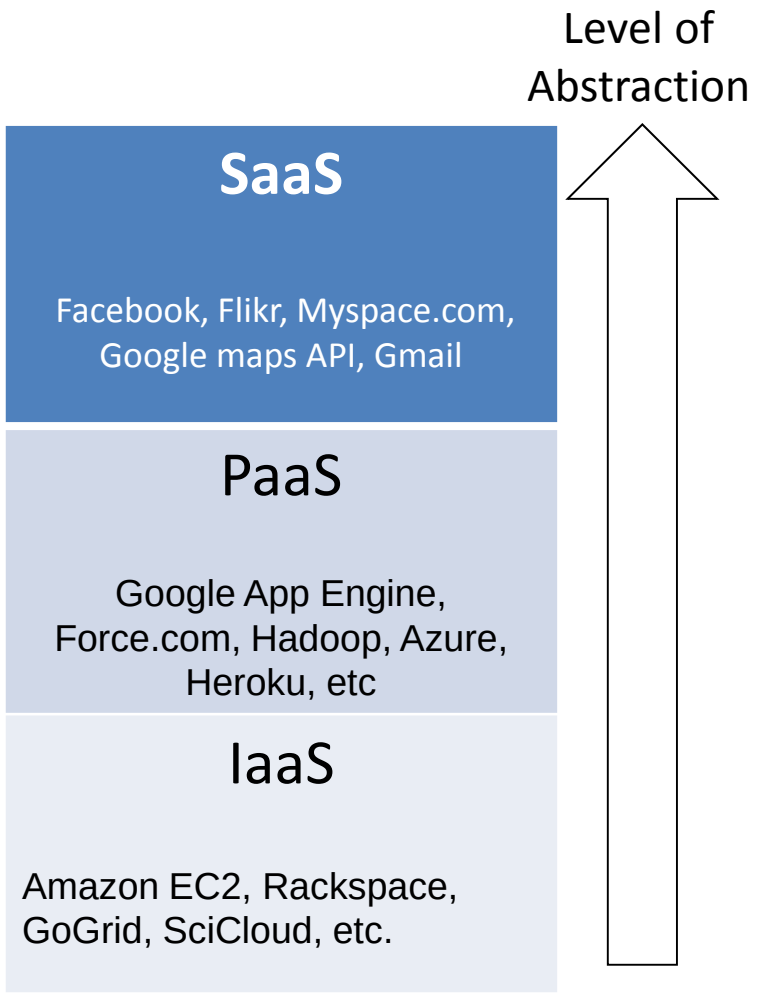
Mobile & Cloud Lab

# Outline

- Cloud computing services – recap
- Amazon cloud services
  - Elastic Compute Cloud (EC2)
  - Storage services - Amazon S3 and EBS
- Cloud managers
- Eucalyptus

# Cloud Computing - Services

- Software as a Service – SaaS
  - A way to access applications hosted on the web through your web browser
- Platform as a Service – PaaS
  - Provides a computing platform and a solution stack (e.g. LAMP) as a service
- Infrastructure as a Service – IaaS
  - Use of commodity computers, distributed across Internet, to perform parallel processing, distributed storage, indexing and mining of data
  - Virtualization



# Cloud Infrastructure

- Provisioning of computing resources
  - CPU, Memory, Processing
  - Basically an “Operating System” on demand
- Usually billed on a per-hour usage model
- Players in this space
  - Amazon EC2, Microsoft Azure, Rackspace, GoGrid, Eucalyptus/Openstack based SciCloud
- Management providers: RightScale, HybridFox, ElasticFox, Amazon Management Console

# Cloud Storage

- Provisioning of data storage
  - Either file/object based or Database like functionality
- Billed on bandwidth and storage consumed
- Players in the space
  - Amazon S3, Amazon EBS
  - Amazon's SimpleDB, Google's BigTable, Apache Cassandra
- Management Providers: Amazon Management Console, Jungle Disk, Elephant Disk, PutPlace.com

# Cloud Platforms

- Provides a complete software stack
  - Provides a computing platform and a solution stack
  - An IDE for the cloud
- Takes care of: Runtimes, Load balancing, Resource provisioning
- Players in the space
  - Google AppEngine - Python (initially, now also Java)
  - Heroku
  - Force.com (SalesForce)

# Cloud Applications

- Applications that are completely ‘online’
- Operate on data that is stored in the ‘cloud’ or ‘ether’
- No client software generally required
- Billing: Ad. Revenue, Premium Services
- Players in this space
  - Google Apps - Gmail / Google Docs
  - Apple’s MobileMe
  - Microsoft’s Live - Hotmail, Live Spaces
  - SalesForce.com

# Other cloud services

- Provides services, which other applications can utilize
- Usually free for non-commercial use
- Players in the space
  - Google/Yahoo Maps
  - Google/Yahoo Web Services
  - Amazon Merchant Services
  - Amazon Simple Queue Service

# Providers we focus at

- Amazon Web Services (AWS)
  - Amazon EC2
  - Amazon S3
  - Amazon EBS
- Private cloud enabling technologies
  - Eucalyptus
  - OpenStack
  - SciCloud
- Management providers
  - ElasticFox
  - AWS Management Console

# Amazon Elastic Compute Cloud (EC2)

- One of the very early pioneers of cloud computing
- In a nutshell:
  - On Demand “Operating System”
- Complete virtual computer with CPU, Memory and disk space
  - Based on the XEN virtual image platform
- Variety of operating systems available
  - Linux (Fedora, Ubuntu, CentOS, etc.)
  - Open Solaris
  - Microsoft Windows

# EC2 continued…

- Very simple pricing structure
  - CPU hours
  - Machine size
  - Bandwidth in and out of cloud
- Extremely FAST start up
  - 2-3 minutes from start to finish
- Instance snapshotting
- Very large/generous disk space provisioning
  - 160GB minimum for the standard instances
- Flexible API to control everything
- Wide range of virtual machine types

# EC2 Instance types – General purpose*

| Instance | CPU | Memory | Storage | Platform | API Name | Price (per h.) |
|---|---|---|---|---|---|---|
| Small (default) | 1 EC2 computing unit | 2.0 GB | EBS Only | 32/64 bit | t2.small | $0.023 (*nix)<br>$0.032 (win) |
| Medium | ~3 EC2 units (Variable) | 4 GB | EBS Only | 32/64 bit | t2.medium | $0.0464(*nix)<br>$0.0644(win) |
| Large | 8 EC2 units | 8 GB | EBS Only | 64 bit | m5.large | $0.096 (*nix)<br>$0.188 (win) |
| Extra Large | 16 EC2 units | 16 GB | EBS Only | 64 bit | m5.xlarge | $0.192 (*nix)<br>$0.376 (win) |
| Micro | 1 EC2 unit | 1 GB | EBS storage only | 32/64 bit | t2.micro | $0.0116(*nix)<br>$0.017 (win) |

*Data taken on 18.02.2019

http://aws.amazon.com/ec2/instance-types/

# EC2 advanced Instance types*

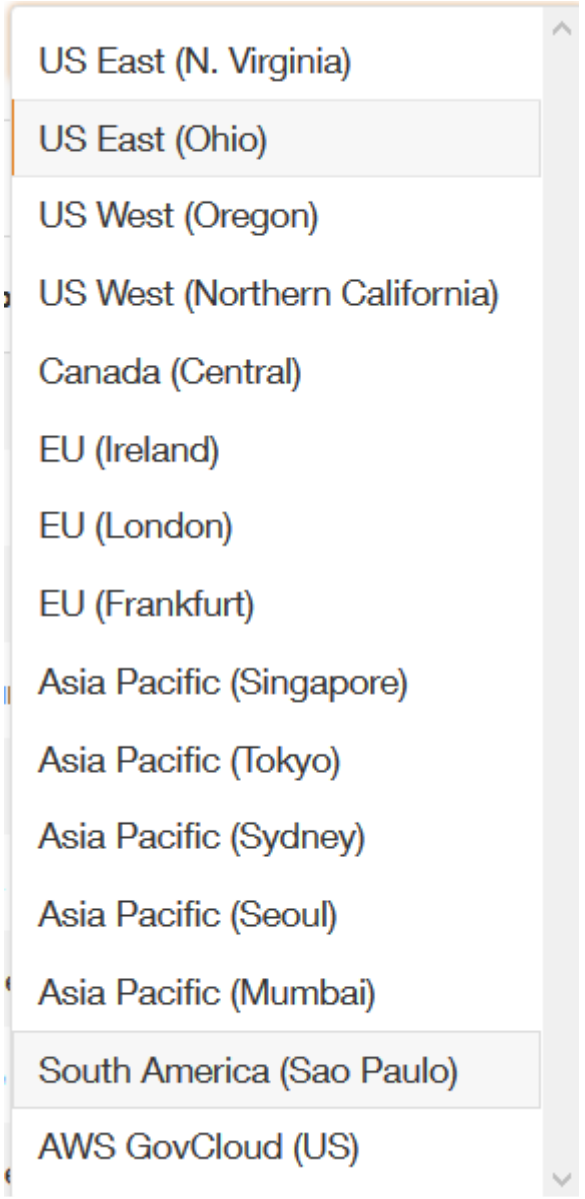
| Instance | CPU | Memory | Storage | Platform | API Name | Price (per h.) |
|---|---|---|---|---|---|---|
| High-Memory Instances | 7 - 347EC2 units | 16– 1952 GB | Upto 2 X 1920 GB SSD | 64 bit | r5.large r5.xlarge r5.2xlarge etc. | Available at: http://aws.amazon.com/ec2/pricing/ |
| High-CPU Instances | 2 – 72 EC2 units | 4 -192 GB | EBS Only | 64 bit | c5.large c5.xlarge etc. | Same as above |

- Other types
  - High I/O Instances
  - High Storage Instances
  - Cluster Compute Instances
  - GPU Instances

*Data taken on 18.02.2019 http://aws.amazon.com/ec2/instance-types/

# EC2 Terminology

- Having an account
  - Access Key, Secret Key, Security group
- Availability Zone (~16)
- Amazon Machine Image (AMI)
  - A Virtual Machine File
  - ami-XXXX
  - Stored in a special bucket in Amazon's S3
- Public and Private instances available
  - Private instances incur only S3 storage costs
- A Running Machine
  - Amazon Instance ( i-XXXX )
  - Booted/Created from an Amazon Image
- Elastic IP addresses



# EC2 Pricing Models

- On-Demand
  - Good for applications with short-term, spiky, or unpredictable workloads that cannot be interrupted
- Spot instances
  - Allows you to request spare EC2 instances for up to 90% off the On-Demand price
  - Users with urgent computing needs for large amounts of additional capacity
- Reserved Instances
  - Customers that can commit to using EC2 over a 1 or 3 year term to reduce their total computing costs
- Dedicated Hosts
  - A physical EC2 server dedicated for your use
- Per Second Billing
  - To manage instances running for irregular periods of time, such as dev/testing, data processing, analytics, batch processing etc.

# Troubles with EC2

- On power-off all hard disk data is lost
- IP addresses are assigned at random
- Can’t turn off public IP address
- Do not forget to terminate the instances

# Simple Storage Service (S3)

- Enables you to upload, download, and store data across the Internet
- Buckets store data
  - Buckets are the fundamental container in Amazon S3 for data storage
  - 100 buckets for account
  - No limit on no of objects that can be stored in a bucket
  - Can store up to 5 TB of data in one object
  - Object stores Data and Metadata
  - Objects stored in a Region never leave the Region
  - You cannot modify or append data to an existing object

# Simple Storage Service (S3) - continued

- Objects are retrieved via a unique, developer-assigned key
- Keys
  - Example: http://**doc**.s3.amazonaws.com/**2006-03-01/AmazonS3.wsdl** "doc" is the bucket name and "2006-03-01/AmazonS3.wsdl" is the key.
- Prices
  - Storage: $0.023 per GB/Month up to first 50 TB
  - Next 450 TB / month $0.022 per GB/Month
  - Data Transfer 0ut from S3 to AWS different zone: ~ $0.01/GB
  - PUT, COPY, POST, or LIST Requests: $0.005 per 1,000 Requests
  - GET requests: $0.0004 per 1,000 Requests
- Download Data
  - Downloading is possible from any where
  - You can enable others to download and can charge them (Using Amazon DevPay)

http://aws.amazon.com/s3/

# Elastic Block Storage (EBS)

- The answer to the persistence problem
- Raw unformatted external block devices
- Allocate 1GB to 16TB volumes with several recent updates
- 20 volumes per account
- Format with your own choice of file system
- Attach to running instances in the same availability zone
- Automatically replicated to prevent data loss
- Create snapshots for backup, or to create new volumes from

https://aws.amazon.com/ebs/

# Basic ec2-api-tools

- ec2-describe-images
- ec2-describe-instances
- ec2-run-instances
- ec2-create-volume
- ec2-attach-volume
- ec2-allocate-address
- ec2-associate-address
- ec2-terminate-instances

# Other cloud services from Amazon

- AWS management console
- Amazon  Simple Queue Service (SQS)
- Amazon DynamoDB
- Amazon Relational Database Service
- Amazon CloudWatch
- Amazon Elastic MapReduce
- Elastic Load Balancing
- etc.

# Getting started

- Signup for an AWS account
  - Use your existing Amazon.com account if you want
- Register a credit card
  - Billed on the 1st of every month for previous month usage
- http://aws.amazon.com/ec2

# Account Activity

View Previous Statement

## Summary of This Month's Activity as of October 18, 2009

**Billing Cycle for this Report:** October 1 - October 31, 2009
*AWS service usage charges on this page currently show activity through approximately 10/18/2009 14:59 GMT.*

**Expand All | Collapse All**

| | Rate | Usage | Totals |
|---|---|---|---|
| **Amazon Elastic Compute Cloud** View/Edit Service | | | |
| **United States** | | | |
| **Elastic IP Addresses** | | | |
| | $0.00 per Elastic IP address remap - first 100 remaps / month | 13 Count | 0.00 |
| | | | **0.00** |
| **European Union** | | | |
| **Amazon EC2 running Linux/UNIX** | | | |
| | $0.44 per Large Instance (m1.large) instance-hour (or partial hour) | 154 Hrs | 67.76 |
| **Amazon EC2 Bandwidth** | | | |
| | $0.100 per GB Internet Data Transfer - all data transfer into Amazon EC2 | 1.338 GB | 0.13 |
| | $0.170 per GB Internet Data Transfer - first 10 TB / month data transfer out of Amazon EC2 | 0.351 GB | 0.06 |
| **Amazon EC2 EBS** | | | |
| | $0.11 per GB-month of provisioned storage | 22.742 GB-Mo | 2.50 |
| | $0.11 per 1 million I/O requests | 778,528 IOs | 0.09 |
| **Elastic IP Addresses** | | | |
| | $0.01 per non-attached Elastic IP address per complete hour | 269 Hrs | 2.69 |
| | | | **73.23** |
| | | View Usage Report | 73.23 |
| **Amazon Simple Storage Service** View/Edit Service | | | |
| **United States** | | | |
| | $0.170 per GB - first 10 TB / month data transfer out | 0.000053 GB | 0.01 |
| | $0.01 per 1,000 PUT, COPY, POST, or LIST requests | 10 Requests | 0.01 |
| | $0.01 per 10,000 GET and all other requests | 4 Requests | 0.01 |
| | | | **0.03** |
| **European Union** | | | |
| | $0.18 per GB - first 50 TB / month of storage used | 0.451 GB-Mo | 0.08 |
| | $0.170 per GB - first 10 TB / month data transfer out | 0.000739 GB | 0.01 |
| | $0.012 per 1,000 PUT, COPY, POST, or LIST requests | 78 Requests | 0.01 |
| | $0.012 per 10,000 GET and all other requests | 90 Requests | 0.01 |
| | | | **0.11** |
| | | View Usage Report | 0.14 |
| Taxes Estimated Taxes (Due November 1, 2009) | | | 0.00 |
| Charges due on November 1, 2009† | | | 73.37 |

# Getting started – for free

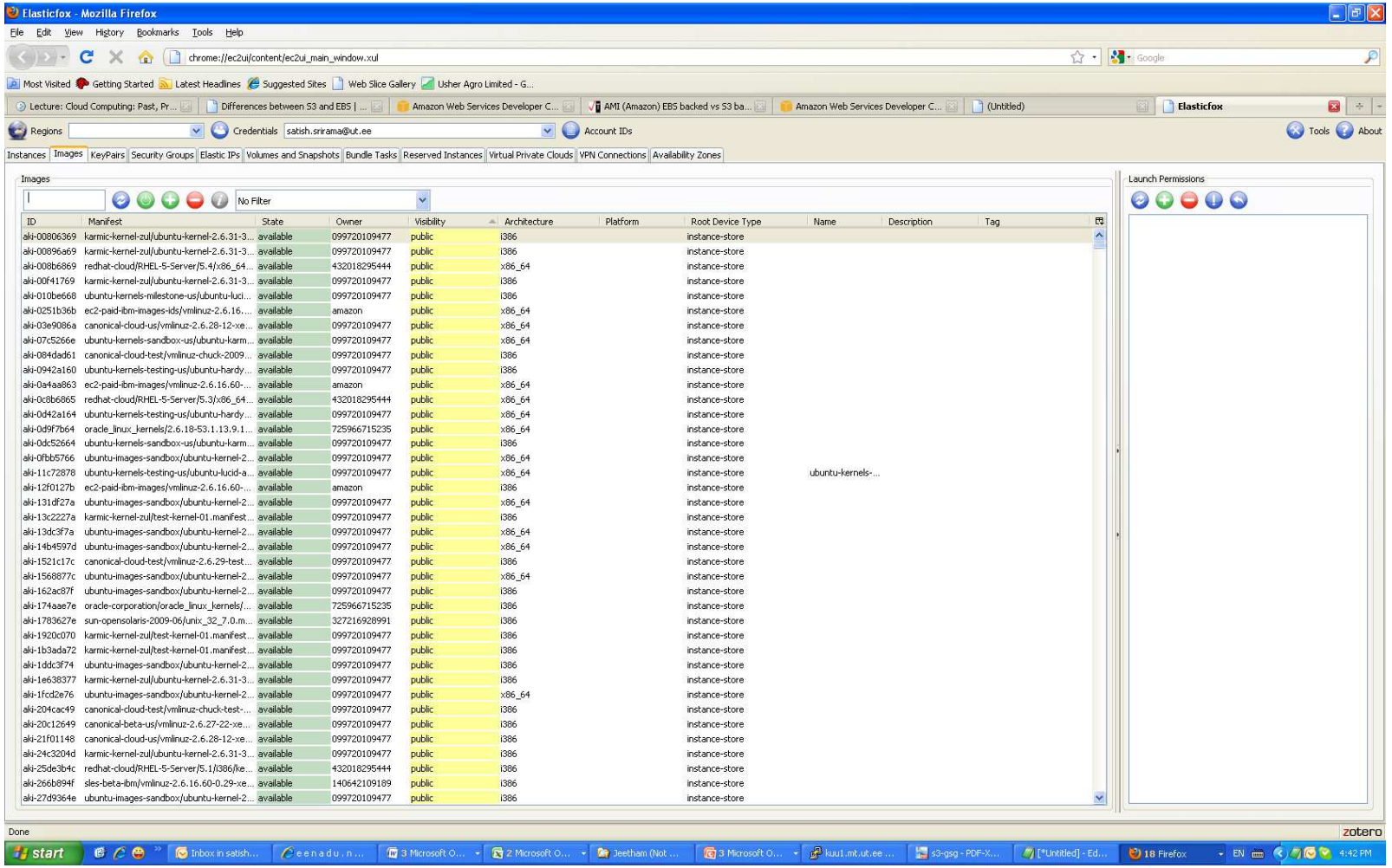
- http://aws.amazon.com/free/ - free tier
- Valid for 12 months
- 750 hours / month of EC2 Linux Micro Instance usage
- 5 GB of S3 standard storage, 20,000 Get Requests, and 2,000 Put Requests
- 30 GB of Amazon EBS
- 1 GB Regional Data transfer
- Several other AWS features can be tried
- Be careful
  - You cross the limits, you are charged without any notice

Note: All values get updated regularly

# ElasticFox

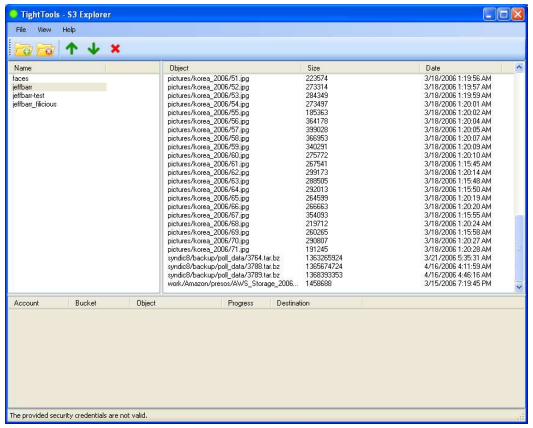
- Mozilla Firefox extension for managing your Amazon EC2 account
- HybridFox  is a Fork of ElasticFox
- Supported services
  - List available AMIs
  - List your running instances
  - Launch new instances of an AMI
  - Manage security groups and launch permissions associated with your instances
  - Manage Amazon EBS volumes

# ElasticFox - GUI

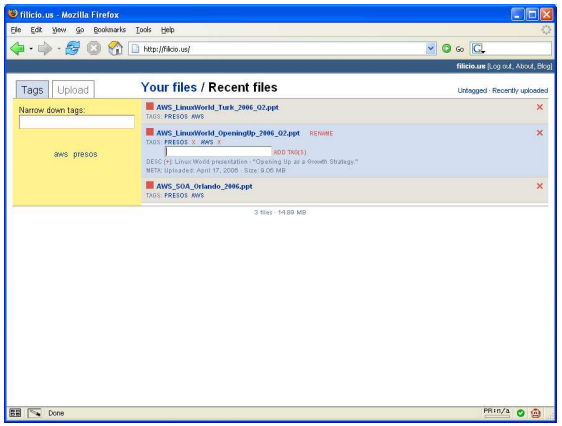


# Independent software vendors (ISV) for S3

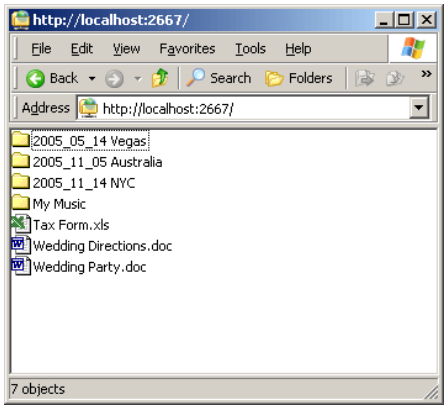
**S3 Explorer**



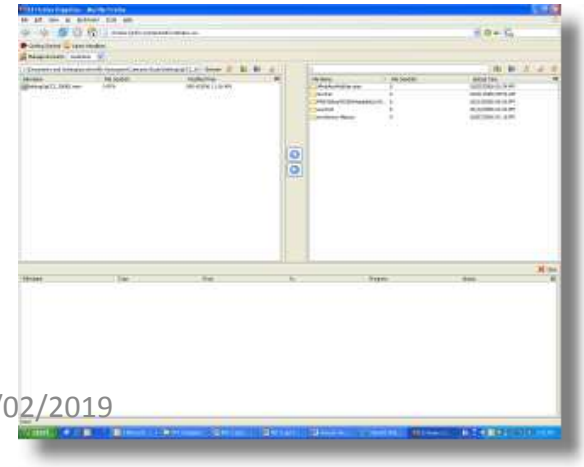

**filicio.us**



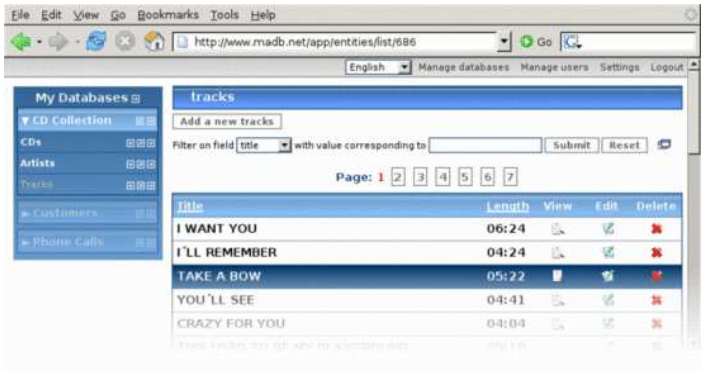

**Jungle Disk**




**S3 Firefox Organizer**



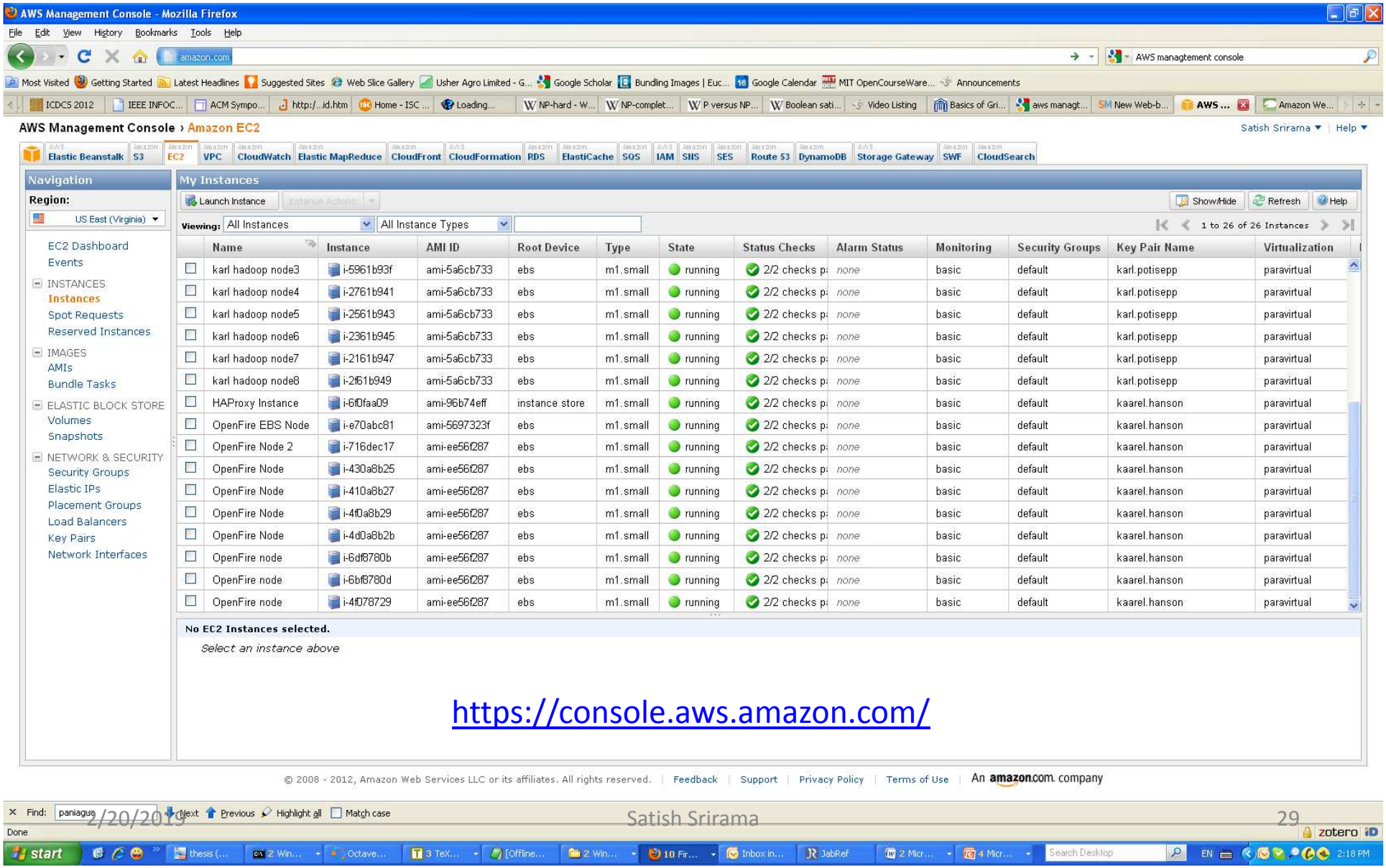
**MyOwnDB**



# AWS Management Console

- You can manage your complete Amazon account with management console (Similar to Hybridfox)
  - AMI Management
  - Instance Management
  - Security Group Management
  - Elastic IP Management
  - Elastic Block Store
  - Key Pair management etc.
- Have different panes for different services

# AWS Management Console - screenshot




| Name | Instance | AMI ID | Root Device | Type | State | Status Checks | Alarm Status | Monitoring | Security Groups | Key Pair Name | Virtualization |
|---|---|---|---|---|---|---|---|---|---|---|---|
| karl hadoop node3 | i-5961b93f | ami-5a6cb733 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | karl.potisepp | paravirtual |
| karl hadoop node4 | i-2761b941 | ami-5a6cb733 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | karl.potisepp | paravirtual |
| karl hadoop node5 | i-2561b943 | ami-5a6cb733 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | karl.potisepp | paravirtual |
| karl hadoop node6 | i-2361b945 | ami-5a6cb733 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | karl.potisepp | paravirtual |
| karl hadoop node7 | i-2161b947 | ami-5a6cb733 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | karl.potisepp | paravirtual |
| karl hadoop node8 | i-2f61b949 | ami-5a6cb733 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | karl.potisepp | paravirtual |
| HAProxy Instance | i-6f0faa09 | ami-96b74eff | instance store | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire EBS Node | i-e70abc81 | ami-5697323f | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire Node 2 | i-716dec17 | ami-ee56f287 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire Node | i-430a8b25 | ami-ee56f287 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire Node | i-410a8b27 | ami-ee56f287 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire Node | i-4f0a8b29 | ami-ee56f287 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire Node | i-4d0a8b2b | ami-ee56f287 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire node | i-6df8780b | ami-ee56f287 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire node | i-6bf8780d | ami-ee56f287 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |
| OpenFire node | i-4f078729 | ami-ee56f287 | ebs | m1.small | running | 2/2 checks pa | none | basic | default | kaarel.hanson | paravirtual |

https://console.aws.amazon.com/

# PRIVATE CLOUD ENABLING TECHNOLOGIES

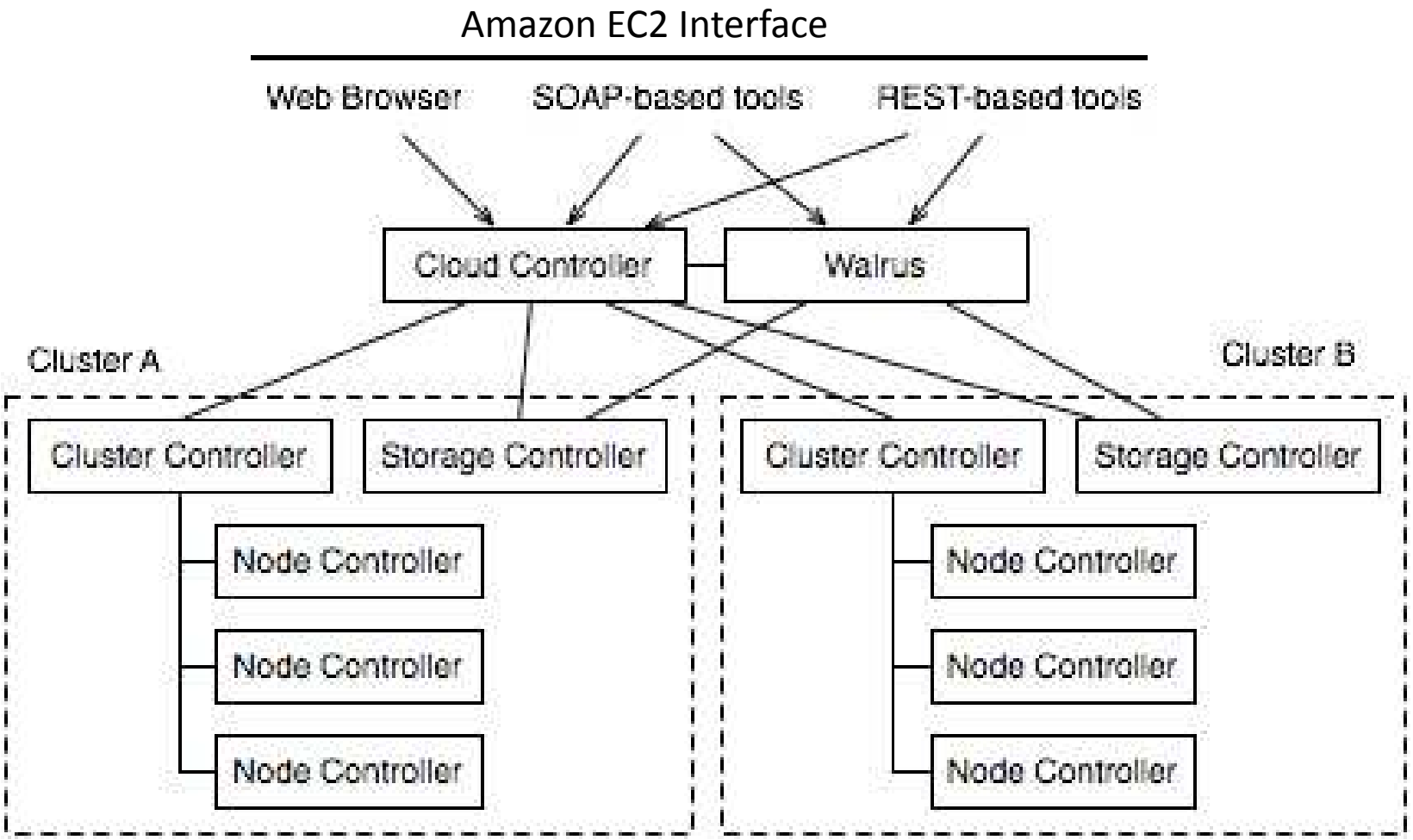
# Eucalyptus

- Are you OK with using your credit card?
- Open source project
- Elastic Utility Computing Architecture Linking Your Programs To Useful Systems
- Web services based implementation of EC2 infrastructure
- For establishing private clouds
- Functions as a software overlay
  - Existing installation should not be violated (too much)
- Focus on installation and maintenance

# Eucalyptus Usage

- Experimentation vehicle prior to buying commercial services
  - Provide development, debugging, and “tech preview” platform for Public Clouds
- Homogenize local IT environment with Public Clouds
  - AWS functionality locally makes moving & using Amazon AWS easier, cheaper, and more sustainable
- Provide a basic software development platform for the open source community
  - E.g. the “Linux Experience”
- Not designed as a replacement technology for AWS or any other Public Cloud service

# Eucalyptus - architecture



# Basic euca2ools

- euca-describe-images
- euca-describe-instances
- euca-run-instances
- euca-create-volume
- euca-attach-volume
- euca-terminate-instances
- euca-describe-availability-zones

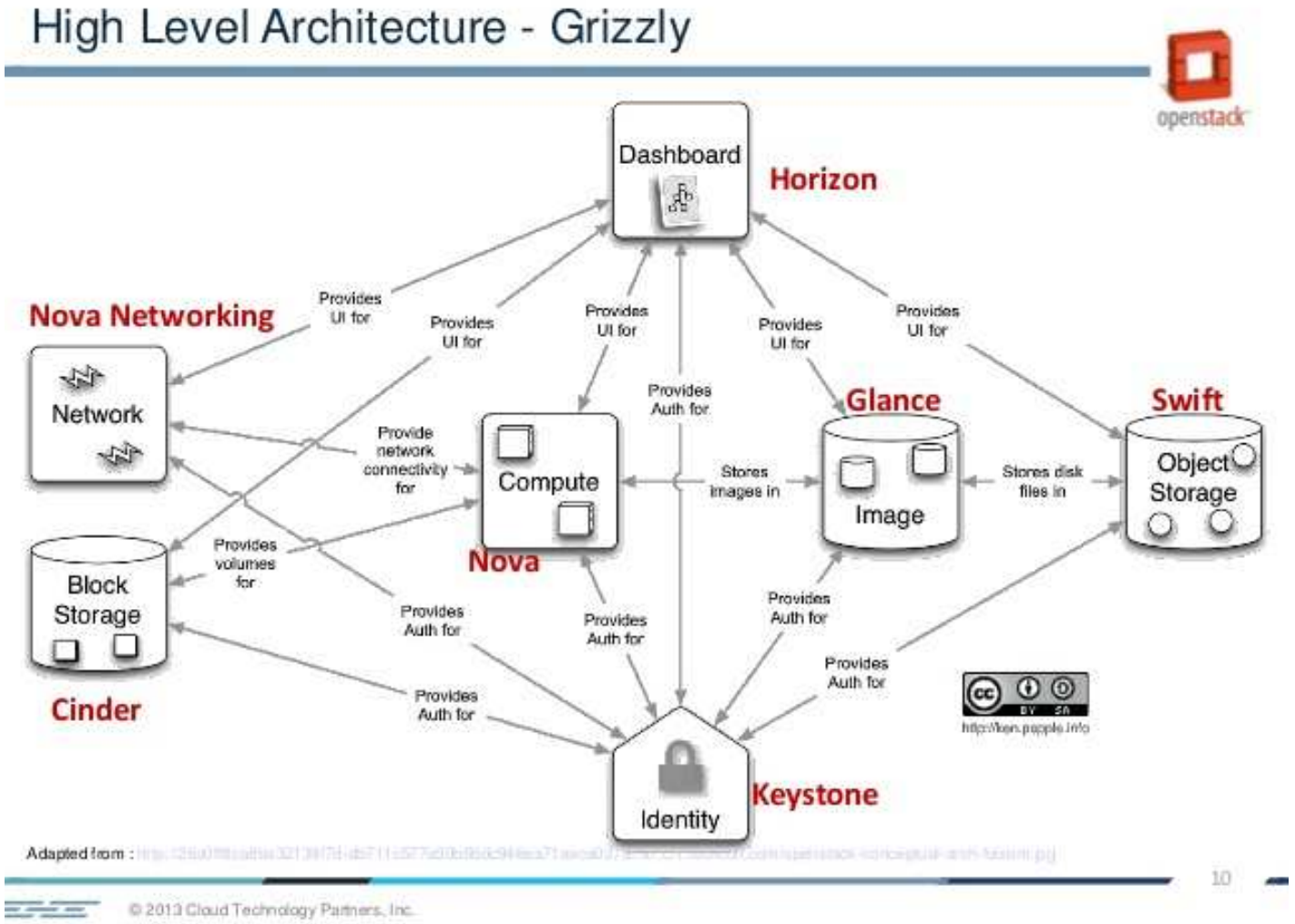
# OpenStack

- Founded by **NASA** and **Rackspace**
- The open source cloud computing platform
- Feature-rich and massively scalable
- Powers cloud storage, compute, and networking
- A world-wide open source collaboration

# OpenStack has 105+ participating companies


…and over 1,350 individual contributors. [source: Piston]

# OpenStack - High level overview



# 3 Major OpenStack Components

- Compute ("**Nova**")
  - Orchestrates large networks of Virtual Machines.
  - Responsible for VM instance lifecycle, network management, and user access control.
- Object Storage ("**Swift**")
  - Provides scalable, redundant, long-term storage for things like VM images, data archives, and multimedia.
- Image Service ("**Glance**")
  - Manages VM disk images.
  - Can be a stand-alone service.
  - Supports private/public permissions, and can handle a variety of disk image formats.
- Other components: Dashboard, Load Balancing, Authentication...

# Scientific Computing Cloud (SciCloud)

[Srirama et al, CCGrid 2010]

- Mobile & Cloud Lab owned private cloud infrastructure
- Collection of smaller clouds built using Eucalyptus/OpenStack platforms
- Goal of the project
  - To efficiently use the already existing resources of universities
  - To address computationally intensive scientific, mathematical, and academic problems

http://mc.cs.ut.ee/mcsite/projects/scicloud

# Working with OpenStack

- Last week keys are created for you all
- You already worked with the OpenStack private cloud
- Just like Eucalyptus euca2ools are sufficient to invoke the OpenStack services

# This week in lab

- You work with SciCloud
  - Creating security groups
  - Installing software
  - Configuring floating IPs
  - Preparing snapshots

# Next Lecture

- Scale on cloud

# References


- Amazon Web (Cloud) Services – documentation http://aws.amazon.com/documentation/
- SciCloud – homepage http://mc.cs.ut.ee/mcsite/projects/scicloud
- Eucalyptus Documentation https://docs.eucalyptus.cloud/eucalyptus/4.4.5/index.html
- OpenStack https://www.openstack.org/
- S. N. Srirama, O. Batrashev, E. Vainikko: SciCloud: Scientific Computing on the Cloud, 10th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2010), May 17-20, 2010, pp. 579. IEEE CS.