



Computing Infrastructures



POLITECNICO DI MILANO



Software Infrastructures: Cloud Computing and Edge/Fog Computing



The topics of the course: what are we going to see today?

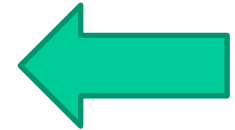
2

A. HW Infrastructures:

- **System-level**: Computing Infrastructures and Data Center Architectures, Rack/Structure;
- **Node-level**: Server (computation, HW accelerators), Storage (Type, technology), Networking (architecture and technology);
- **Building-level**: Cooling systems, power supply, failure recovery

B. SW Infrastructures:

- Virtualization: Process/System VM, Virtualization Mechanisms (Hypervisor, Para/Full virtualization)
- Computing Architectures: Cloud Computing (types, characteristics), Edge/Fog Computing, X-as-a service
- Machine and deep learning-as-a-service



C. Methods:

- **Reliability and availability of datacenters** (definition, fundamental laws, RBDs)
- **Disk performance** (Type, Performance, RAID)
- **Scalability and performance of datacenters** (definitions, fundamental laws, queuing network theory)



From Virtualization to the Cloud...
... servers consolidation



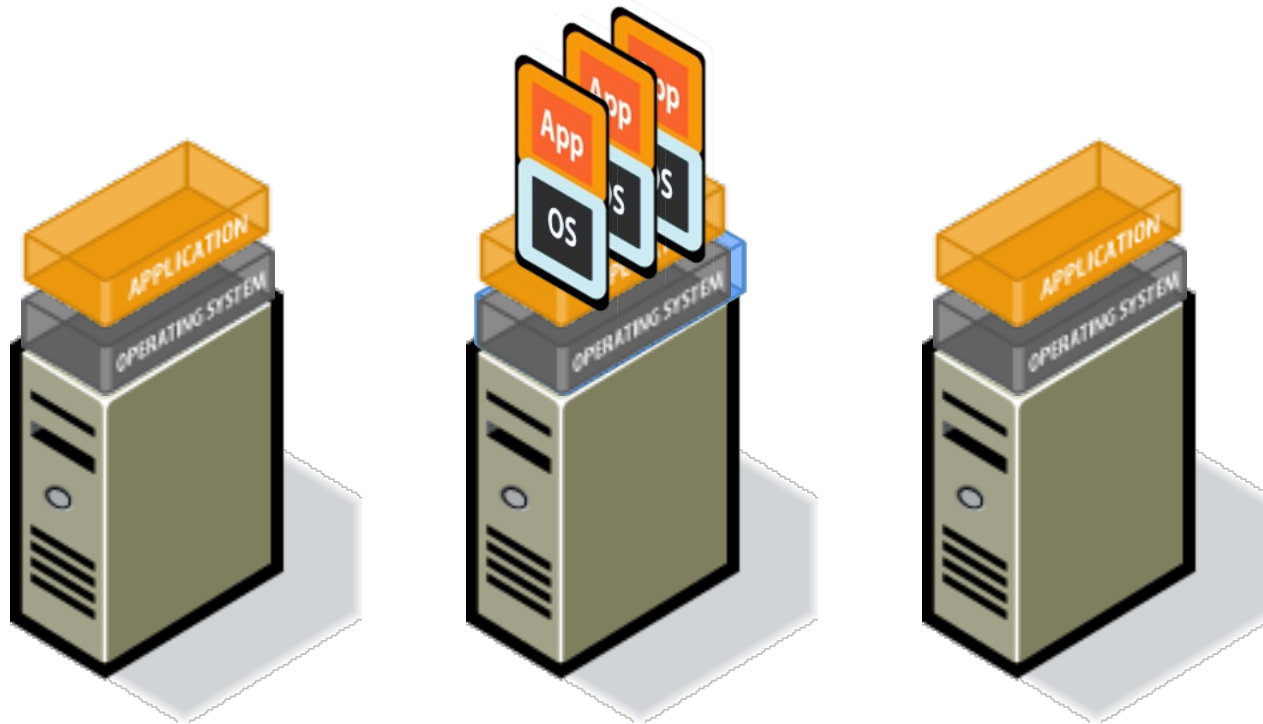
Virtualization Consequences

Without virtualization:

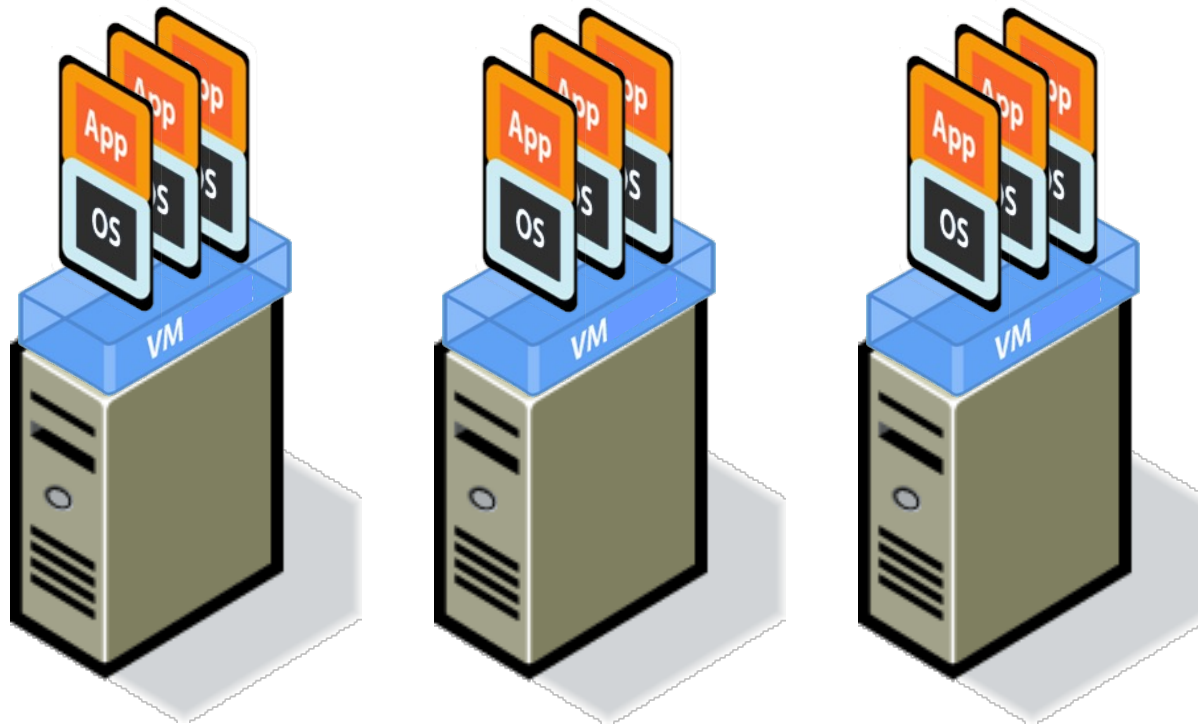
- Software strongly linked/related with hardware
 - Move/change an application not a easy task
- To isolate failure/crash the classical model is:
 - 1 server
 - 1 operative system (OS)
 - 1 application, with a resulting low CPU utilization (10-15%)
- Low flexibility

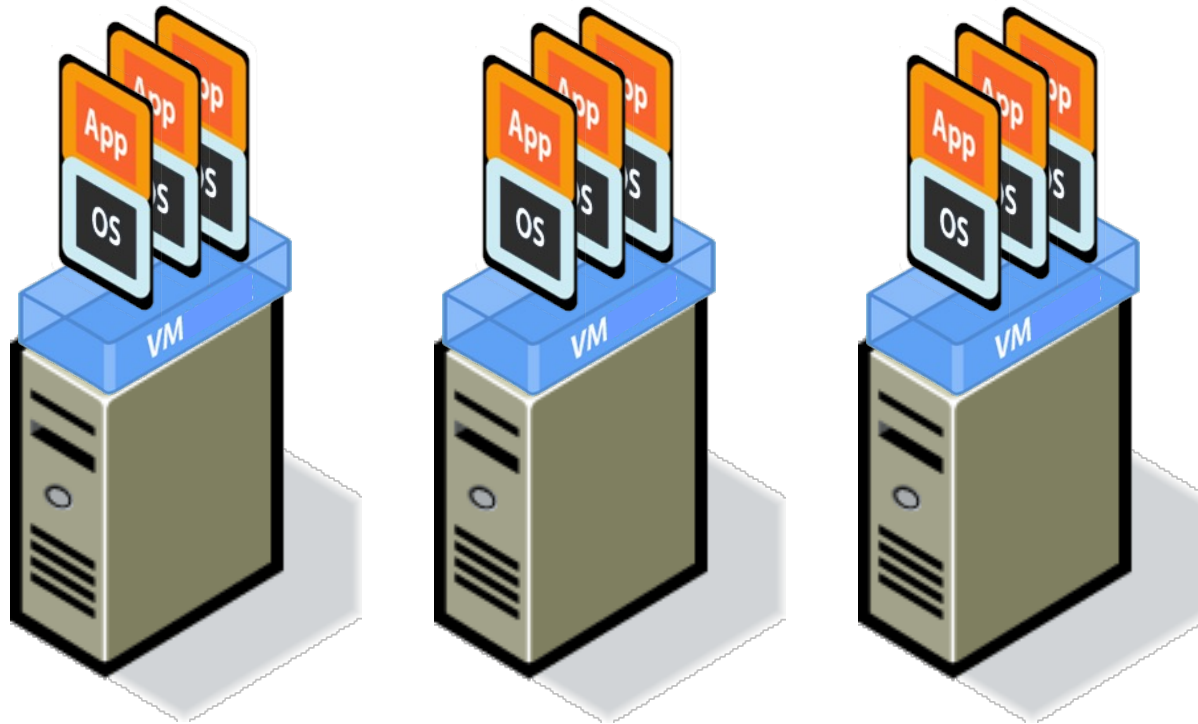
With Virtualization:

- Hw-independence: software/hardware no longer strongly related
- High flexibility thanks to pre-built VMs
- OS and applications can be handled as a «*single entity*»



Animation source: VMWare website.

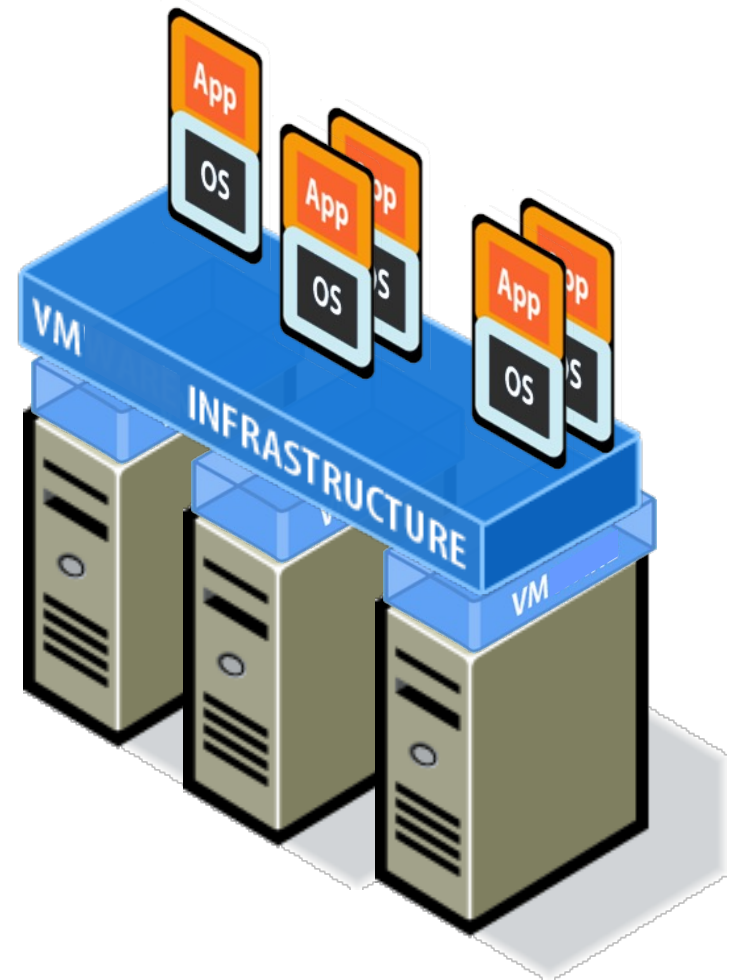


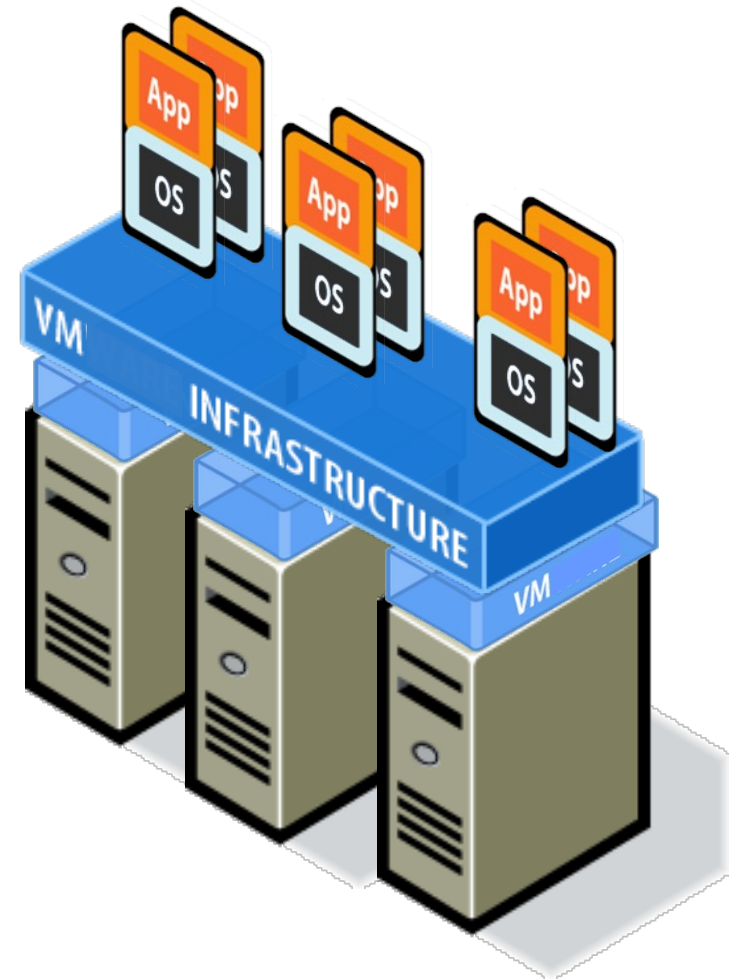




Migration from Physical to Virtual

Consolidation Management:
migration from physical to
virtual machines

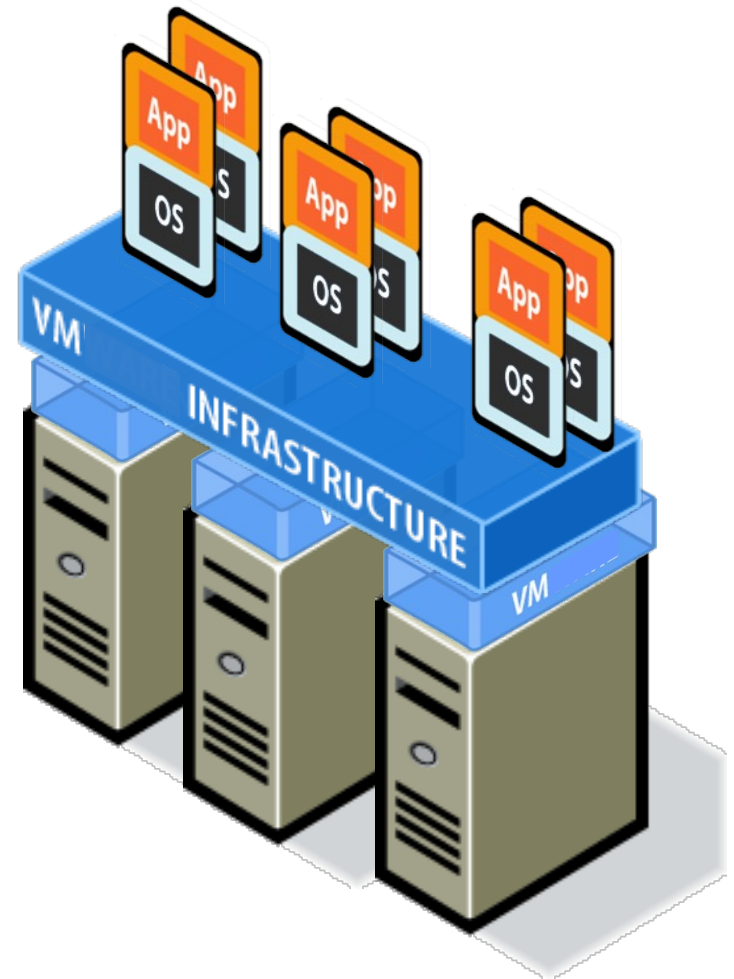




It is possible to move Virtual Machines, without interrupting the applications running inside



It is possible to automatically balance the Workloads according to set limits and guarantees



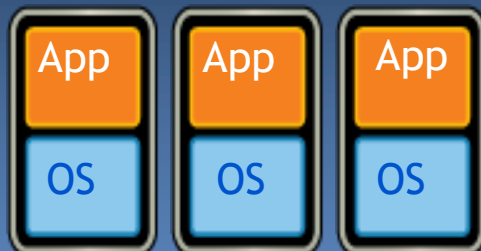


Discover

Monitor

Remediate

IT Service



75
Users

4
Servers

1
Database

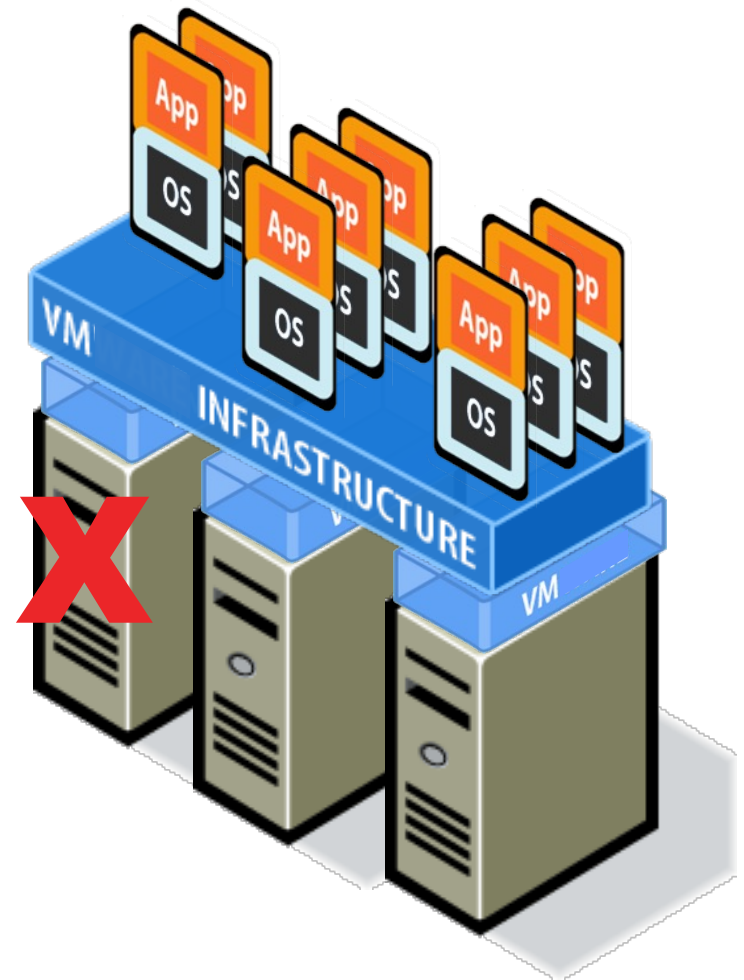
Quality of Service



Provision 2 more servers



Servers and Applications
are protected against
component and system
failure





Advantages of consolidation

Consolidation

- Different OS can run on the same hardware
- Higher hardware utilization
 - Less hardware is needed
 - Acquiring costs
 - Management costs(human resources, power, cooling)
 - Green IT-oriented
- Continue to use legacy software (e.g., software for WIN on Linux machines thanks to VMs)
- Application independent from the hardware



Cloud Computing



Cloud computing is a model for enabling

- convenient
- on-demand

network access to a shared pool of configurable computing resources, like for example:

- Networks
- Servers
- Storage
- Applications
- Services

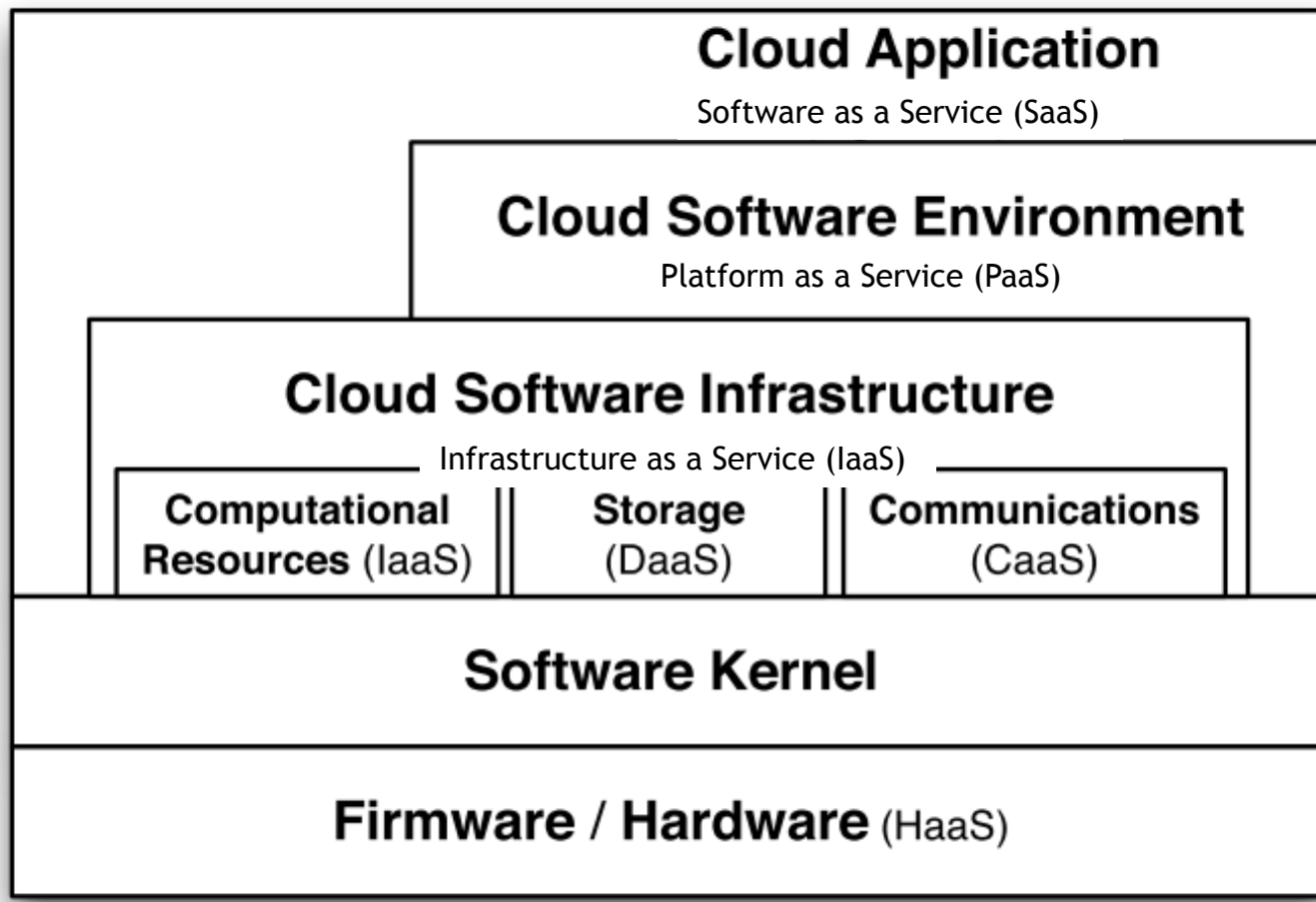
that can be rapidly provisioned and released with minimal management effort or service provider interaction.



Three main services provided by Cloud ...

“Toward a Unified Ontology of Cloud Computing”

[L. Youseff, M. Butrico, and D. Da Silva]





A variety of 'as-a-Service' terms to describe services offered in Clouds

17

AaaS	-	Architecture as a Service
BaaS	-	Business as a Service
CaaS	-	Communication as a Service
CRMAaS	-	CRM as a Service
DaaS	-	Data as a Service
DBaaS	-	Database as a Service
EaaS	-	Ethernet as a Service
FaaS	-	Frameworks as a Service
GaaS	-	Globalization or Governance as a Service
HaaS	-	Hardware as a Service
IaaS	-	Infrastructure or Integration as a Service
IDaaS	-	Identity as a Service
ITaaS	-	IT as a Service
LaaS	-	Lending as a Service
MaaS	-	Mashups as a Service
OaaS	-	Organization or Operations as a Service
SaaS	-	Software as a Service
StaaS	-	Storage as a Service
PaaS	-	Platform as a Service
TaaS	-	Technology or Testing as a Service
VaaS	-	Voice as a Service



Cloud Application Layer

Cloud Application Layer

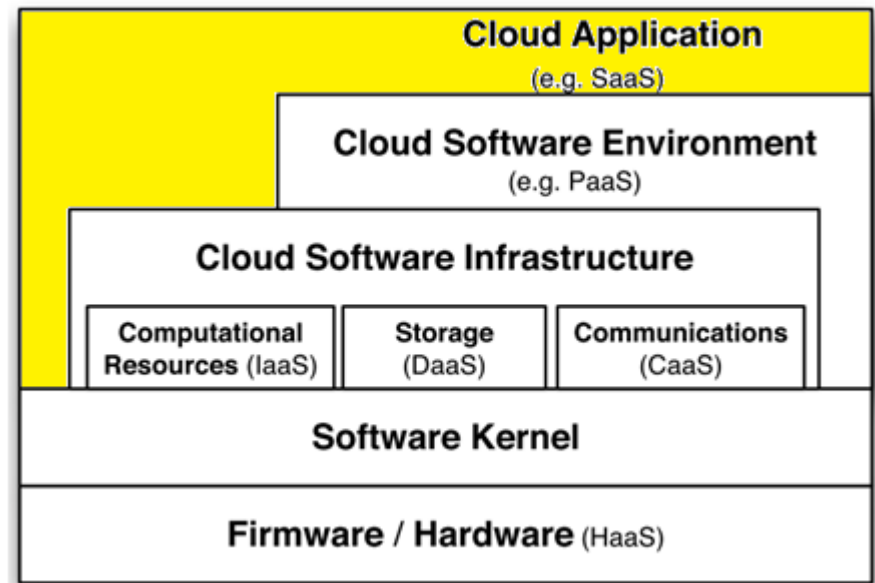
- SaaS

Users access the services provided by this layer through web-portals, and are *sometimes* required to pay fees to use them.

Cloud applications can be developed on the cloud software environments or infrastructure components

Example:

- GMail
- Google Docs and related apps (online office)
- Salesforce.com (CRMaaS)





Cloud Software Environment Layer

Cloud Software Environment Layer

- PaaS

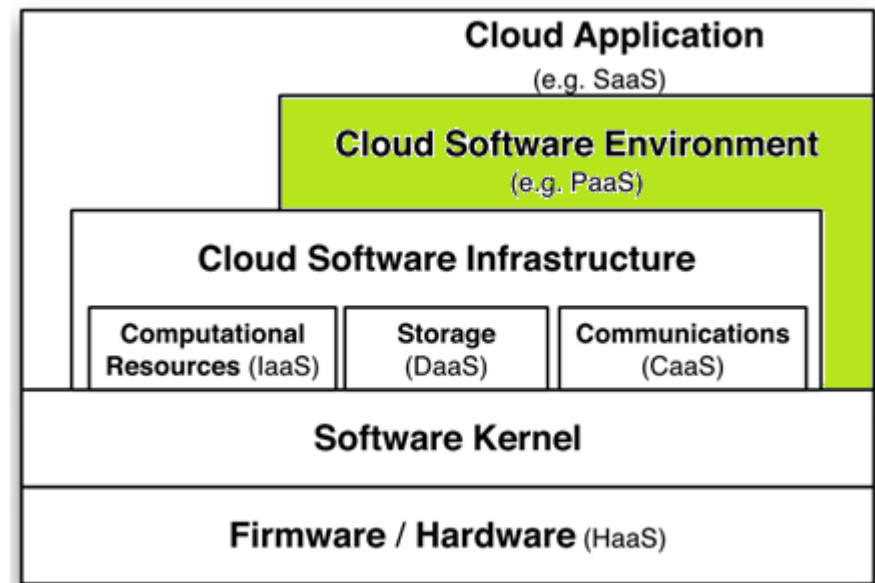
Users are *application developers*

Providers supply developers with a *programming-language-level environment* with well-defined a **API**

- Facilitate interaction between environment and apps
- Accelerate the deployment
- Support scalability

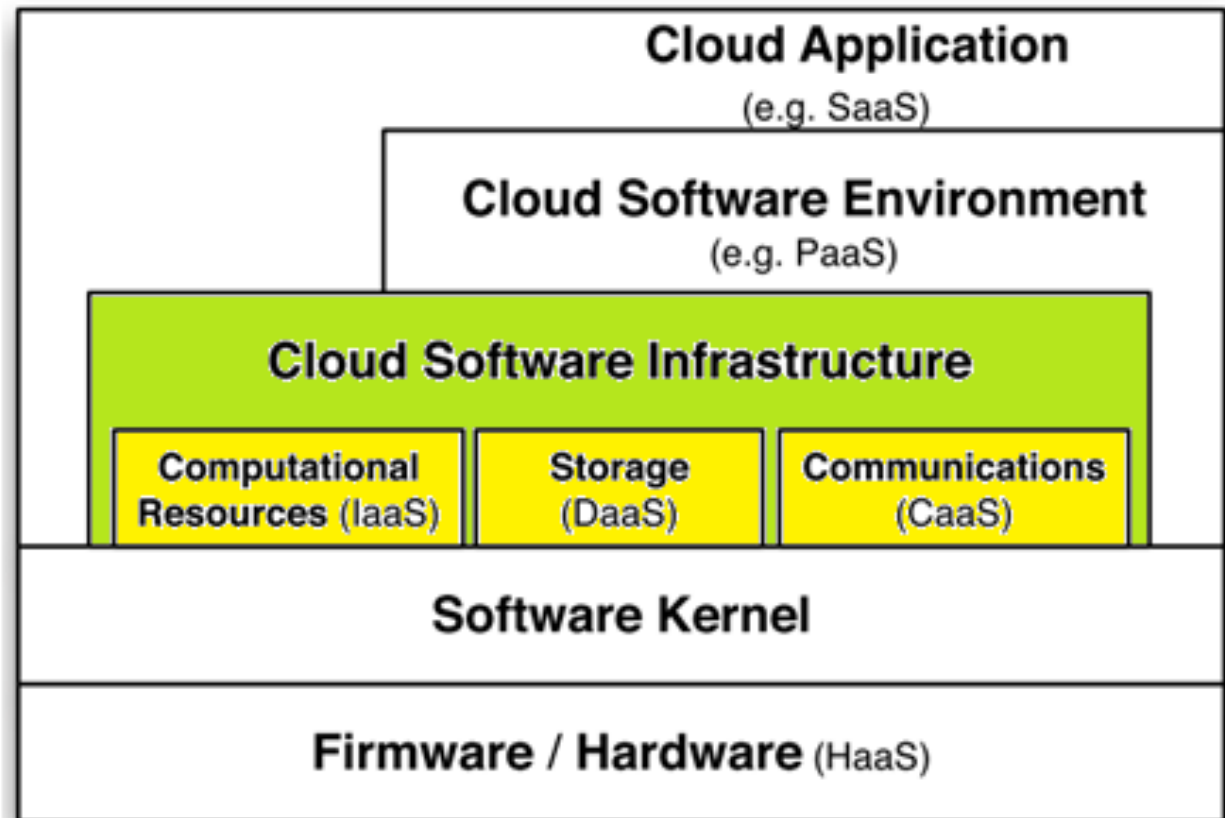
Examples in Deep Learning:

- Amazon SageMaker
- Microsoft Azure Machine Learning
- Google AI: TensorFlow





Cloud Software Infrastructure Layer





Cloud Software Infrastructure Layer

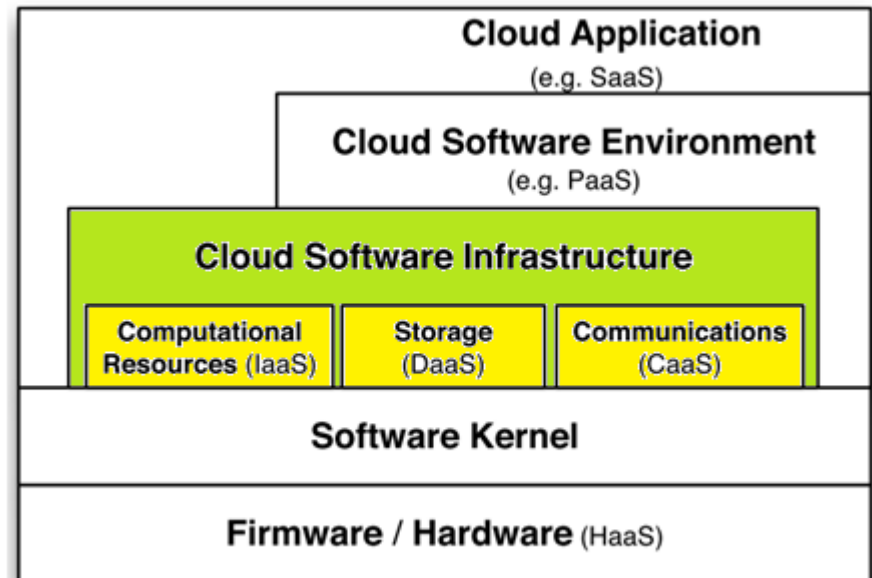
Cloud Software Infrastructure Layer

- IaaS: computational
- DaaS: storage
- CaaS: communications

Provides resources to the higher-level layers (i.e., Software and Software Environment)

Note that Cloud Apps and Cloud SW might *bypass* Cloud SW Infrastructure

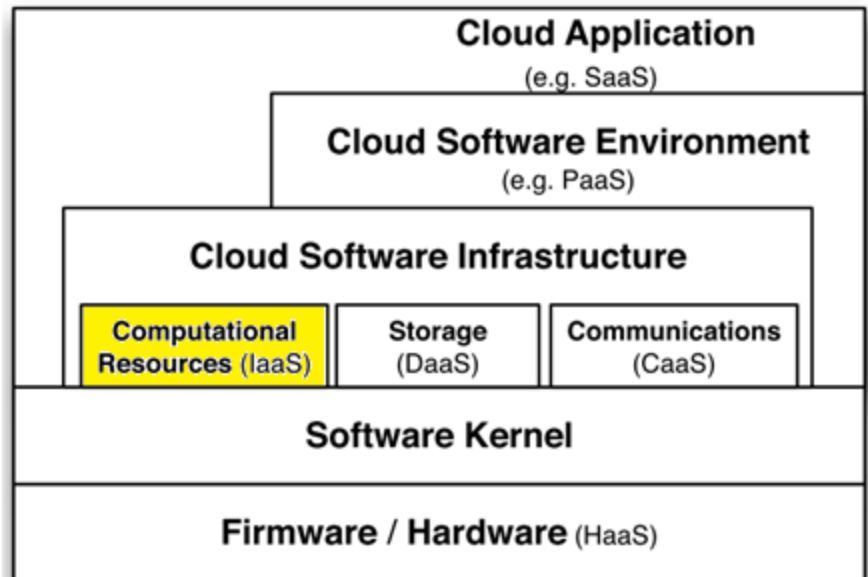
- However, this would reduce
 - Simplicity
 - Development efforts





Virtual Machines (VM) vs dedicated hardware

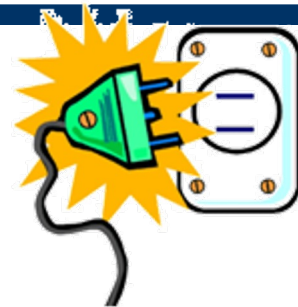
- VM's benefits
 - Flexibility
 - Super-user (root) access to VM for fine granularity settings and customization of installed sw
- VM's issues
 - Performance interference
 - Inability to provide strong guarantees about SLAs





Infrastructure as a Service (IaaS): examples

- Commercial solutions
 - Amazon Elastic Cloud (EC2)
 - Full virtualization
 - Based on Xen
 - Windows Azure.
 - Not just windows-based: it allows also to start VMs for other OSs.
 - Google Compute Engine.
 - Same infrastructure as Google.
 - Rackspace Open Cloud.
 - IBM SmartCloud Enterprise.
 - HP Enterprise Converged Infrastructure.
- Open-source projects
 - Eucalyptus Systems
 - Apache CloudStack
 - Open Stack
 - The project aims to deliver solutions for all types of clouds (private or public) by being simple to implement, massively scalable, and feature rich.



Allows users to

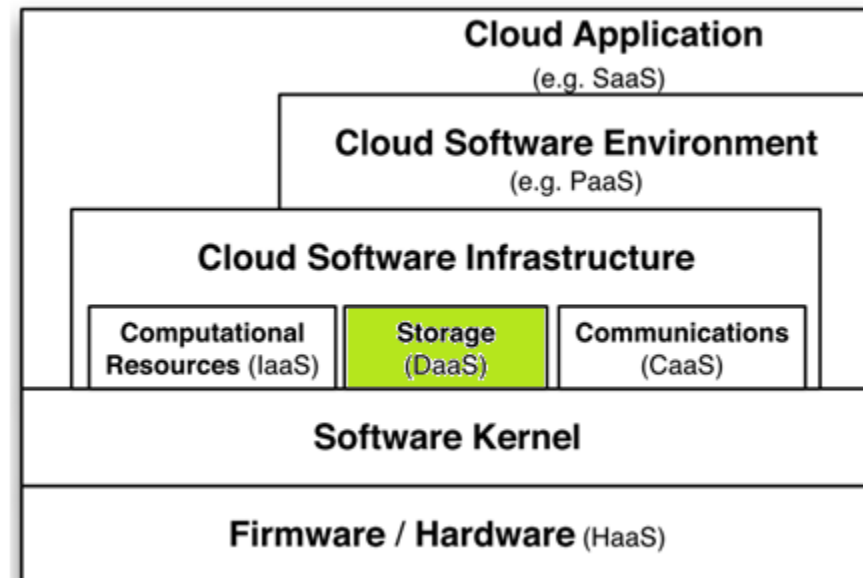
- store their data at remote disks
- access data anytime from any place

Facilitates cloud applications to scale beyond their limited servers requirements:

- High dependability: availability, reliability, performance (scalability)
- Replication
- Data consistency

DropBox, iCloud, GoogleDrive are examples of DaaS.

CEPH is an open source solution.



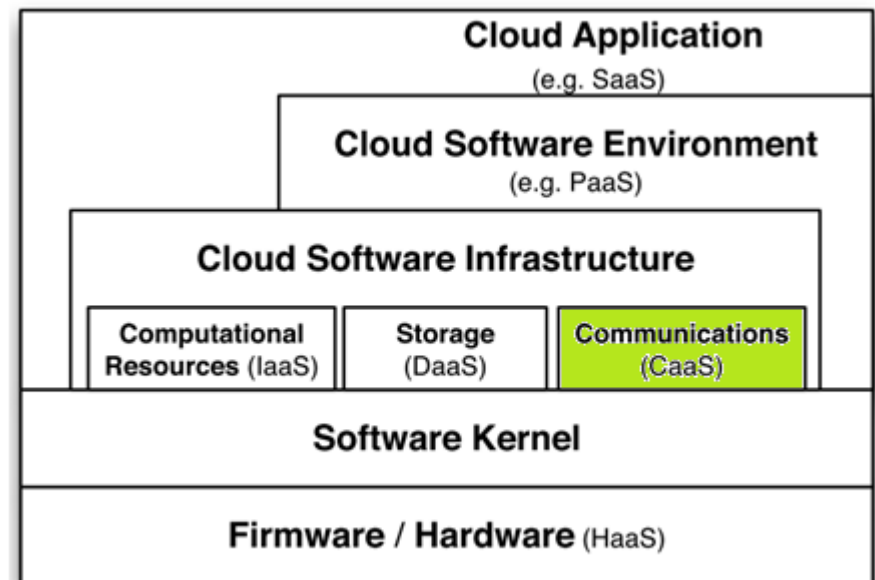


Communications as a Service (CaaS)

Communications becomes a vital component in guaranteeing QoS

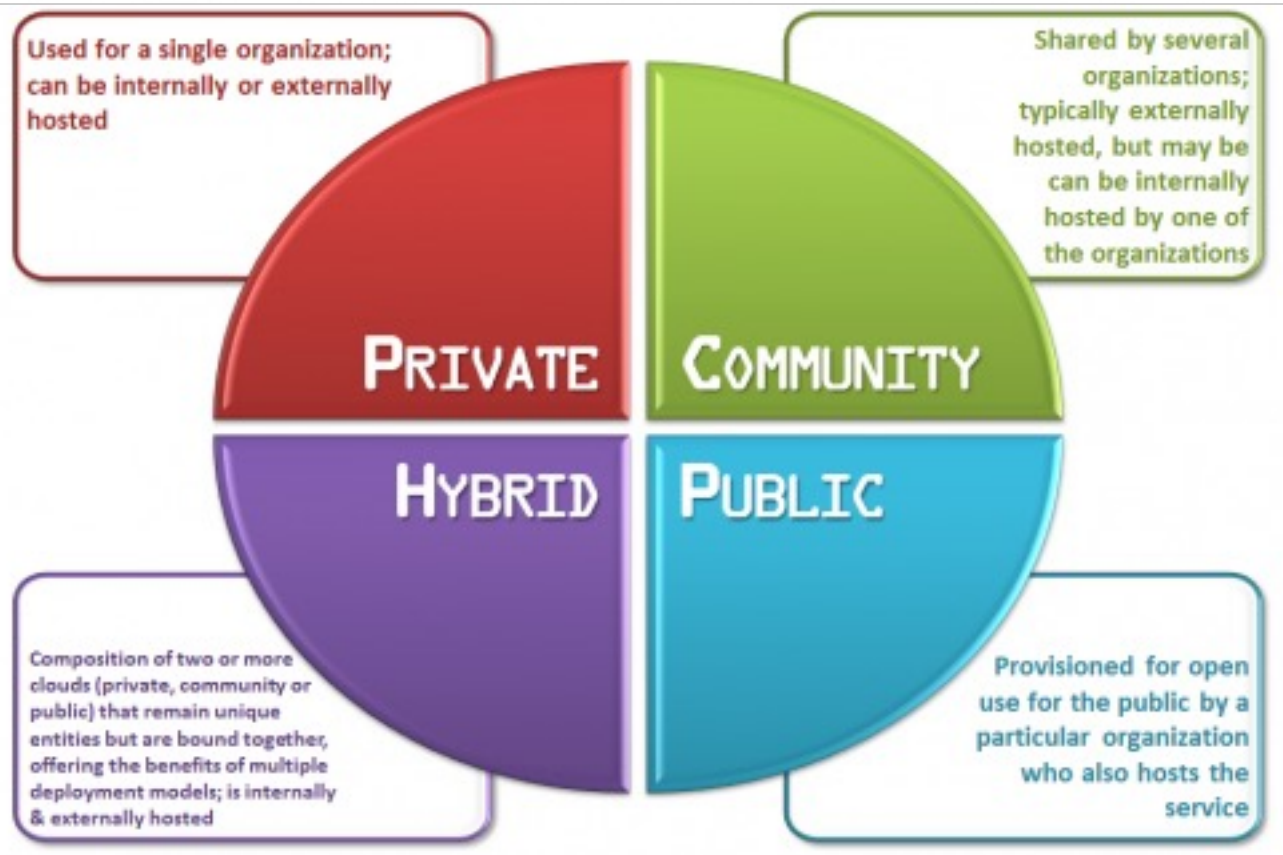
- CaaS is part of a larger category of services known as software as a service (SaaS), in which vendors offer software products and services over the Internet.
- The core concept of CaaS is that accessing these services over the internet is extremely convenient.

Types of CaaS include Voice over Internet Protocol (VoIP) or internet telephone solutions, and video conferencing services.





Types of Clouds





Public Clouds

Large scale infrastructure available on a rental basis

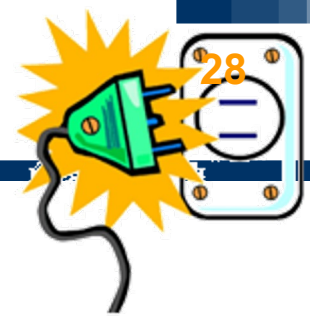
- Operating System virtualization (e.g. Xen) provides CPU isolation
- “Roll-your-own” network provisioning provides network isolation
- Locally specific storage abstractions

Fully customer self-service

- Service Level Agreements (SLAs) are advertized
- Requests are accepted and resources granted via web services
- Customers access resources remotely via the Internet

Accountability is e-commerce based

- Web-based transaction
- “Pay-as-you-go” and flat-rate subscription
- Customer service, refunds, etc.



Internally managed data centers

The organization sets up a **virtualization** environment on its **own servers**

- in its data center
- in the data center of a managed service provider

Key benefits

- you have **total control over every aspect** of the infrastructure
- you gain advantages of virtualization

Issues

- It lacks the freedom from
 - capital investment
 - Flexibility (“almost infinite” grow of cloud computing)

Useful for companies that have significant existing IT investments



Community Clouds

A single cloud managed by several federated organizations

- Combining together several organizations allows economy of scale.
- Resources can be shared and used by one organization, while the others are not using them.

Technically similar to private cloud:

- They share the same software and the same issues
- A more complex accounting system is however required

Hosted locally or externally:

- Typically community clouds shares infrastructures of the participants.
- However they can be hosted by a separate specific organization, or only by a small subset of the partners.



Hybrid Clouds

Hybrid clouds are the combination of any of the previous types.

- Usually are companies that holds their private cloud, but that they can be subject to unpredictable peaks of load.
- In this case, the company rents resources from other types of cloud

Common interfaces

- To simplify the deployment process, the way in which VMs are started, terminated, address is given and storage is accessed, must be as similar as possible.
- Many standards are being developed in this directions, but none is globally accepted yet.
- Currently, the Amazon EC2 model is the one with more compliant infrastructures.



Cloud Computing - The commercial case: Amazon EC2



Elastic Compute Cloud

Rent virtual machine instances to run your software. Monitor and increase / decrease the number of VMs as demand changes

How to use:

- Create an Amazon Machine Image (AMI): applications, libraries, data and associated settings
- Upload AMI to Amazon S3 (simple storage service)
- Use Amazon EC2 web service to configure security and network access
- Choose OS, start AMI instances
- Monitor & control via web interface or APIs



EC2 is an Amazon Web Service

The screenshot displays the AWS Management Console interface. At the top, there's a navigation bar with the AWS logo, a dropdown menu, and links for 'Services' and 'Edit'. Below this, the 'Amazon Web Services' page is shown, categorized into several groups:

- Compute**
 - EC2** (Virtual Servers in the Cloud) - This item is circled in red.
 - EC2 Container Service (Run and Manage Docker Containers)
 - Elastic Beanstalk (Run and Manage Web Apps)
 - Lambda (Run Code in Response to Events)
- Storage & Content Delivery**
 - S3 (Scalable Storage in the Cloud)
 - CloudFront (Global Content Delivery Network)
 - Elastic File System **PREVIEW** (Fully Managed File System for EC2)
 - Glacier (Archive Storage in the Cloud)
 - Import/Export Snowball (Large Scale Data Transport)
 - Storage Gateway (Integrates On-Premises IT Environments with Cloud Storage)
- Database**
 - RDS (Managed Relational Database Service)
 - DynamoDB (Predictable and Scalable NoSQL Data Store)
 - ElastiCache (In-Memory Cache)
 - Redshift (Managed Petabyte-Scale Data Warehouse Service)
- Networking**
 - VPC (Isolated Cloud Resources)
 - Direct Connect (Dedicated Network Connection to AWS)
 - Route 53 (Scalable DNS and Domain Name Registration)
- Developer Tools**
 - CodeCommit (Store Code in Private Git Repositories)
 - CodeDeploy (Automate Code Deployments)
 - CodePipeline (Release Software using Continuous Delivery)
- Management Tools**
 - CloudWatch (Monitor Resources and Applications)
 - CloudFormation (Create and Manage Resources with Templates)
 - CloudTrail (Track User Activity and API Usage)
 - Config (Track Resource Inventory and Changes)
 - OpsWorks (Automate Operations with Chef)
 - Service Catalog (Create and Use Standardized Products)
 - Trusted Advisor (Optimize Performance and Security)
- Security & Identity**
 - Identity & Access Management (Manage User Access and Encryption Keys)
 - Directory Service (Host and Manage Active Directory)
 - Inspector **PREVIEW** (Analyze Application Security)
 - WAF (Filter Malicious Web Traffic)
- Analytics**
 - EMR (Managed Hadoop Framework)
 - Data Pipeline (Orchestration for Data-Driven Workflows)
 - Elasticsearch Service (Run and Scale Elasticsearch Clusters)
 - Kinesis (Work with Real-time Streaming data)
 - Machine Learning (Build Smart Applications Quickly and Easily)
- Internet of Things**
 - AWS IoT **BETA** (Connect Devices to the cloud)
- Mobile Services**
 - Mobile Hub **BETA** (Build, Test, and Monitor Mobile apps)
 - Cognito (User Identity and App Data Synchronization)
 - Device Farm (Test Android, Fire OS, and iOS apps on real devices in the Cloud)
 - Mobile Analytics (Collect, View and Export App Analytics)
 - SNS (Push Notification Service)
- Application Services**
 - API Gateway (Build, Deploy and Manage APIs)
 - AppStream (Low Latency Application Streaming)
 - CloudSearch (Managed Search Service)
 - Elastic Transcoder (Easy-to-use Scalable Media Transcoding)
 - SES (Email Sending Service)
 - SQS (Message Queue Service)
 - SWF (Workflow Service for Coordinating Application Components)
- Enterprise Applications**
 - WorkSpaces (Desktops in the Cloud)
 - WorkDocs (Secure Enterprise Storage and Sharing Service)
 - WorkMail **PREVIEW** (Secure Email and Calendaring Service)



Amazon EC2: the console

34

The screenshot shows the Amazon EC2 Management Console interface. The browser window title is "EC2 Management Console - Mozilla Firefox". The address bar shows the URL "https://console.aws.amazon.com/ec2/v2/home?region=us-west-2". The console header includes a "Services" dropdown, an "Edit" button, and user information for "Roberto Canonico" in the "Oregon" region. The left sidebar contains a navigation menu with categories like "EC2 Dashboard", "INSTANCES", "IMAGES", "ELASTIC BLOCK STORE", and "NETWORK & SECURITY". The main content area is divided into several sections: "Resources" showing counts for Running Instances, Elastic IPs, Volumes, Snapshots, Key Pairs, Load Balancers, Placement Groups, and Security Groups; "Create Instance" with a "Launch Instance" button; "Service Health" showing the status of the US West (Oregon) region and its availability zones; "Scheduled Events" showing no events; "Account Attributes" showing supported platforms and default VPC; and "Additional Information" with links to guides, documentation, and forums. At the bottom, there is a copyright notice for 2008-2013 Amazon Web Services, Inc., and a "Feedback" button.

EC2 Management Console - Mozilla Firefox

File Modifica Visualizza Cronologia Segnalibri Strumenti Aiuto

EC2 Management Console

https://console.aws.amazon.com/ec2/v2/home?region=us-west-2

Services Edit Roberto Canonico Oregon Help

EC2 Dashboard

- Events
- Tags
- INSTANCES
 - Instances
 - Spot Requests
 - Reserved Instances
- IMAGES
 - AMIs
 - Bundle Tasks
- ELASTIC BLOCK STORE
 - Volumes
 - Snapshots
- NETWORK & SECURITY
 - Security Groups
 - Elastic IPs
 - Placement Groups
 - Load Balancers
 - Key Pairs
 - Network Interfaces

Resources

You are using the following Amazon EC2 resources in the US West (Oregon) region:

- 0 Running Instances
- 0 Elastic IPs
- 0 Volumes
- 0 Snapshots
- 0 Key Pairs
- 0 Load Balancers
- 0 Placement Groups
- 1 Security Group

Optimize your resources' cost, performance and security with [AWS Trusted Advisor](#) [Hide](#)

Create Instance

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 West (Oregon) region

Service Health

Service Status:

- US West (Oregon): This service is operating normally

Availability Zone Status:

- us-west-2a: Availability zone is operating normally
- us-west-2b: Availability zone is operating normally

Scheduled Events

US West (Oregon):

- No events

Account Attributes

Supported Platforms

- VPC

Default VPC

- vpc-f0d4c092

Additional Information

- [Getting Started Guide](#)
- [Documentation](#)
- [All EC2 Resources](#)
- [Forums](#)
- [Pricing](#)
- [Contact Us](#)

Popular AMIs on AWS Marketplace

- [CentOS 6 4 \(i386\) - Release Media](#)
- Provided by CentOS.org
- Rating ★★★★★
- Free Software, pay only for AWS usage
- [View all Operating Systems](#)
- [Couchbase Server - Community Edition](#)
- Provided by Couchbase
- Rating ★★★★★
- Free Software, pay only for AWS

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Amazon EC2: the Service Charges

Amazon Web Services - Mozilla Firefox

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EC2 Management Console Amazon Web Services

https://portal.aws.amazon.com/gp/aws/developer/account/index.html

Personal Information
Security Credentials
Usage Reports
Billing Alerts
Billing Preferences

Statement Period: September 1 - September 30, 2013

Select a different statement: September 1 - September 30, 2013

Summary

You have no billable activity for this statement period.

Total new charges for this statement	\$0.00
---	---------------

No payments received to date.

Outstanding balance for this statement	\$0.00
---	---------------

Details

Expand All Services | Collapse All Services [Printer Friendly Version](#)

AWS Service Charges	\$0.00
----------------------------	---------------

☒ **Amazon Elastic Compute Cloud** [Download Usage Report](#) **\$0.00**

US East (Northern Virginia) Region

Amazon EC2 running Linux/UNIX

\$0.00 per Linux/RHEL Micro Instance (t1.micro) instance-hour (or partial hour) under monthly free tier	3 Hrs	0.00
---	-------	------

Amazon EC2 EBS

\$0.00 per GB-month of provisioned storage under monthly free tier	2,511 GB-Mo	0.00
\$0.00 for the first 2 million I/O requests under monthly free tier	18,045 IOs	0.00

Amazon CloudWatch

\$0.00 per alarm-month - first 10 alarms	0.315 Alarms	0.00
--	--------------	------

☒ **Amazon SimpleDB** [Download Usage Report](#) **\$0.00**

☒ **Amazon Simple Notification Service** [Download Usage Report](#) **\$0.00**



Amazon EC2: selecting the AMI

EC2 Management Console - Mozilla Firefox

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EC2 Management Console

https://console.aws.amazon.com/ec2/v2/home?region=us-west-2#LaunchInstanceWizard

Services Edit Roberto Canonico Oregon Help

1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Tag Instance 6. Configure Security Group 7. Review

Step 1: Choose an Amazon Machine Image (AMI)

[Cancel and Exit](#)

An AMI is a template that contains the software configuration (operating system, application server, and applications) required to launch your instance. You can select an AMI provided by AWS, our user community, or the AWS Marketplace; or you can select one of your own AMIs.

Quick Start

- My AMIs
- AWS Marketplace
- Community AMIs
- ☐ Free tier only ⓘ

 Amazon Linux Free tier eligible	Amazon Linux AMI 2013.09.1 - ami-be1c848e (64-bit) / ami-4c1c847c (32-bit) The Amazon Linux AMI is an EBS-backed, PV-GRUB image. It includes Linux 3.4, AWS tools, and repository access to multiple versions of MySQL, PostgreSQL, Python, Ruby, and Tomcat. Root device type: ebs Virtualization type: paravirtual	Select <input checked="" type="radio"/> 64-bit <input type="radio"/> 32-bit
 Red Hat Free tier eligible	Red Hat Enterprise Linux 6.4 - ami-b8a63b88 (64-bit) / ami-baa63b8a (32-bit) Red Hat Enterprise Linux version 6.4, EBS-boot. Root device type: ebs Virtualization type: paravirtual	Select <input checked="" type="radio"/> 64-bit <input type="radio"/> 32-bit
 SUSE Linux Free tier eligible	SUSE Linux Enterprise Server 11 - ami-d8b429e8 (64-bit) / ami-9eb429ae (32-bit) SUSE Linux Enterprise Server 11 Service Pack 3 basic install, EBS boot with Amazon EC2 AMI Tools preinstalled, Apache 2.2, MySQL 5.5, PHP 5.3, and Ruby 1.8.7 available Root device type: ebs Virtualization type: paravirtual	Select <input checked="" type="radio"/> 64-bit <input type="radio"/> 32-bit
 Ubuntu Free tier eligible	Ubuntu Server 12.04.3 LTS - ami-6aad335a (64-bit) / ami-68ad3358 (32-bit) Ubuntu Server 12.04.3 LTS, with support available from Canonical (http://www.ubuntu.com/cloud/services). Root device type: ebs Virtualization type: paravirtual	Select <input checked="" type="radio"/> 64-bit <input type="radio"/> 32-bit

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Amazon EC2: creating an instance

EC2 Management Console - Mozilla Firefox

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EC2 Management Console

https://console.aws.amazon.com/ec2/v2/home?region=us-west-2#LaunchInstanceWizard

Services Edit Roberto Canonico Oregon Help

1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Tag Instance 6. Configure Security Group 7. Review

Step 2: Choose an Instance Type

Amazon EC2 provides a wide selection of instance types optimized to fit different use cases. Instances are virtual servers that can run applications. They have varying combinations of CPU, memory, storage, and networking capacity, and give you the flexibility to choose the appropriate mix of resources for your applications. [Learn more](#) about instance types and how they can meet your computing needs.

Currently selected: t1.micro (up to 2 ECUs, 1 vCPUs, 0.613 GiB memory, EBS only)

All instance types

Micro instances

Free tier eligible

General purpose

Memory optimized

Storage optimized

Compute optimized

Micro instances

Micro instances are a low-cost instance option, providing a small amount of CPU resources. They are suited for lower throughput applications, and websites that require additional compute cycles periodically, but are not appropriate for applications that require sustained CPU performance. Popular uses for micro instances include low traffic websites or blogs, small administrative applications, bastion hosts, and free trials to explore EC2 functionality.

Size	ECUs ⓘ	vCPUs ⓘ	Memory (GiB)	Instance Storage (GiB) ⓘ	EBS-Optimized Available ⓘ	Network Performance ⓘ
t1.micro	up to 2	1	0.613	EBS only	-	Very Low

Micro instances are eligible for the AWS free usage tier. For the first 12 months following your AWS sign-up date, you get up to 750 hours of micro instances each month. When your free usage tier expires or if your usage exceeds the free tier restrictions, you pay standard, pay-as-you-go service rates. [Learn more](#) about free usage tier eligibility and restrictions

Cancel Previous **Review and Launch** Next: Configure Instance Details

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Amazon instance types

Instances are divided into *types*, that corresponds to different performance characteristics, and different pricing.

Speed of the instances is measured in vCPU: an Hyperthread of an Intel Xeon core.

	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
General Purpose - Current Generation					
t2.nano	1	Variable	0.5	EBS Only	\$0.0059 per Hour
t2.micro	1	Variable	1	EBS Only	\$0.012 per Hour
t2.small	1	Variable	2	EBS Only	\$0.023 per Hour
t2.medium	2	Variable	4	EBS Only	\$0.047 per Hour
t2.large	2	Variable	8	EBS Only	\$0.094 per Hour
t2.xlarge	4	Variable	16	EBS Only	\$0.188 per Hour
t2.2xlarge	8	Variable	32	EBS Only	\$0.376 per Hour
m4.large	2	6.5	8	EBS Only	\$0.108 per Hour
m4.xlarge	4	13	16	EBS Only	\$0.215 per Hour
m4.2xlarge	8	26	32	EBS Only	\$0.431 per Hour
m4.4xlarge	16	53.5	64	EBS Only	\$0.862 per Hour
m4.10xlarge	40	124.5	160	EBS Only	\$2.155 per Hour
m4.16xlarge	64	188	256	EBS Only	\$3.447 per Hour



Amazon EC2: configuring an instance (2)

EC2 Management Console - Mozilla Firefox

File Modifica Visualizza Cronologia Segnalibri Strumenti Aiuto

EC2 Management Console

https://console.aws.amazon.com/ec2/v2/home?region=us-west-2#LaunchInstanceWizard

Services Edit Roberto Canonico Oregon Help

1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Tag Instance 6. Configure Security Group 7. Review

Step 3: Configure Instance Details

Configure the instance to suit your requirements. You can launch multiple instances from the same AMI, request Spot Instances to take advantage of the lower pricing, assign an access management role to the instance, and more.

Number of instances ⓘ 1

Purchasing option ⓘ ☐ Request Spot Instances

Network ⓘ vpc-f0d4c092 (172.31.0.0/16) (default) [Create new VPC](#)

Subnet ⓘ No preference (default subnet in any Availability Zone) [Create new subnet](#)

Public IP ⓘ ☒ Automatically assign a public IP address to your instances

IAM role ⓘ None

Shutdown behavior ⓘ Stop

Enable termination protection ⓘ ☐ Protect against accidental termination

Monitoring ⓘ ☐ Enable CloudWatch detailed monitoring
[Additional charges apply.](#)

Tenancy ⓘ Shared tenancy (multi-tenant hardware)
[Additional charges will apply for dedicated tenancy.](#)

▶ Advanced Details

Cancel Previous **Review and Launch** Next: Add Storage

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Amazon EC2: adding a storage

The screenshot shows the Amazon EC2 Management Console in a Mozilla Firefox browser. The page is titled "Step 4: Add Storage" and is part of a wizard with seven steps: 1. Choose AMI, 2. Choose Instance Type, 3. Configure Instance, 4. Add Storage (current step), 5. Tag Instance, 6. Configure Security Group, and 7. Review. The user is logged in as Roberto Canonico in the Oregon region.

The main content area shows the following storage settings:

Type	Device	Snapshot	Size (GB)	Volume Type	IOPS	Delete on Termination
Root	/dev/sda1	snap-911898ad	8	Standard	N/A	<input checked="" type="checkbox"/>

Below the table is a button labeled "Add New Volume".

A blue box contains a message: "Free tier eligible customers can get up to 30 GB of EBS storage. [Learn more](#) about free usage tier eligibility and usage restrictions."

At the bottom of the page, there are navigation buttons: "Cancel", "Previous", "Review and Launch" (highlighted in blue), and "Next: Tag Instance".

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Amazon EC2: launching the instance(s)

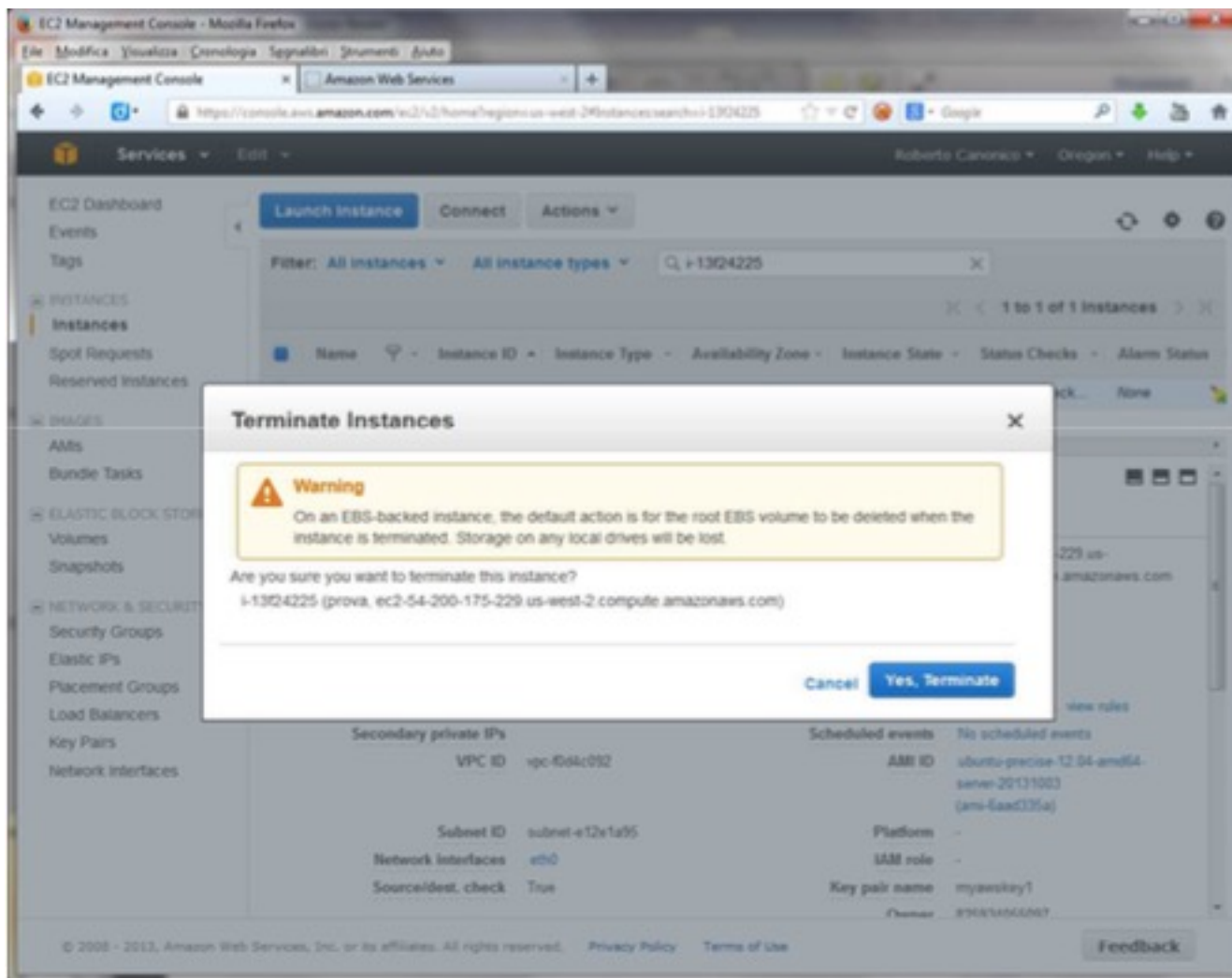
The screenshot displays the Amazon EC2 Management Console in a Mozilla Firefox browser. The console shows a list of instances with one instance named 'prova' (ID: i-13f24225) in a 'running' state. The instance details for 'prova' are shown below the list, including its public and private DNS, IP addresses, availability zone, security groups, and other configuration details.

Instance Details:

Property	Value
Instance ID	i-13f24225
Instance state	running
Instance type	t1.micro
Private DNS	ip-172-31-30-178.us-west-2.compute.internal
Private IPs	172.31.30.178
Secondary private IPs	
VPC ID	vpc-f0d4c092
Subnet ID	subnet-e12e1a95
Network interfaces	eth0
Source/dest. check	True
Public DNS	ec2-54-200-175-229.us-west-2.compute.amazonaws.com
Public IP	54.200.175.229
Elastic IP	-
Availability zone	us-west-2b
Security groups	launch-wizard-1. view rules
Scheduled events	No scheduled events
AMI ID	ubuntu-precise-12.04-amd64-server-20131003 (ami-6aad335a)
Platform	-
IAM role	-
Key pair name	myawskey1
Owner	825934055097



Amazon EC2: instance termination





From Cloud to Edge and Fog Computing



Advantages of Cloud Computing

- Lower IT costs
- Improved performance
- Instant software updates
- “Unlimited” storage capacity
- Increased data reliability
- Universal document access
- Device Independence



What about disadvantages?



Disdvantages of Cloud Computing

- Requires a constant Internet connection
- Does not work well with low-speed connections
- Features might be limited
- Can be slow
- Stored data might not be secure
- Stored data can be lost



Fog/Edge Computing

