

# Computing Infrastructures

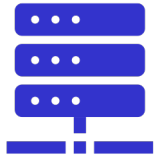
 **POLITECNICO DI MILANO**

## Software Infrastructures: Cloud Computing and Edge/Fog Computing



# The topics of the course

## A. HW Infrastructures:

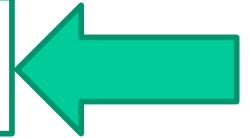


- **System-level:** Computing Infrastructures and Data Center Architectures, Rack/Structure;
- **Node-level:** Server (computation, HW accelerators), Storage (Type, technology), Networking (architecture and technology)
- **Building-level:** Cooling systems, power supply, failure recovery

## B. SW Infrastructures:



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



# What is Cloud Computing?

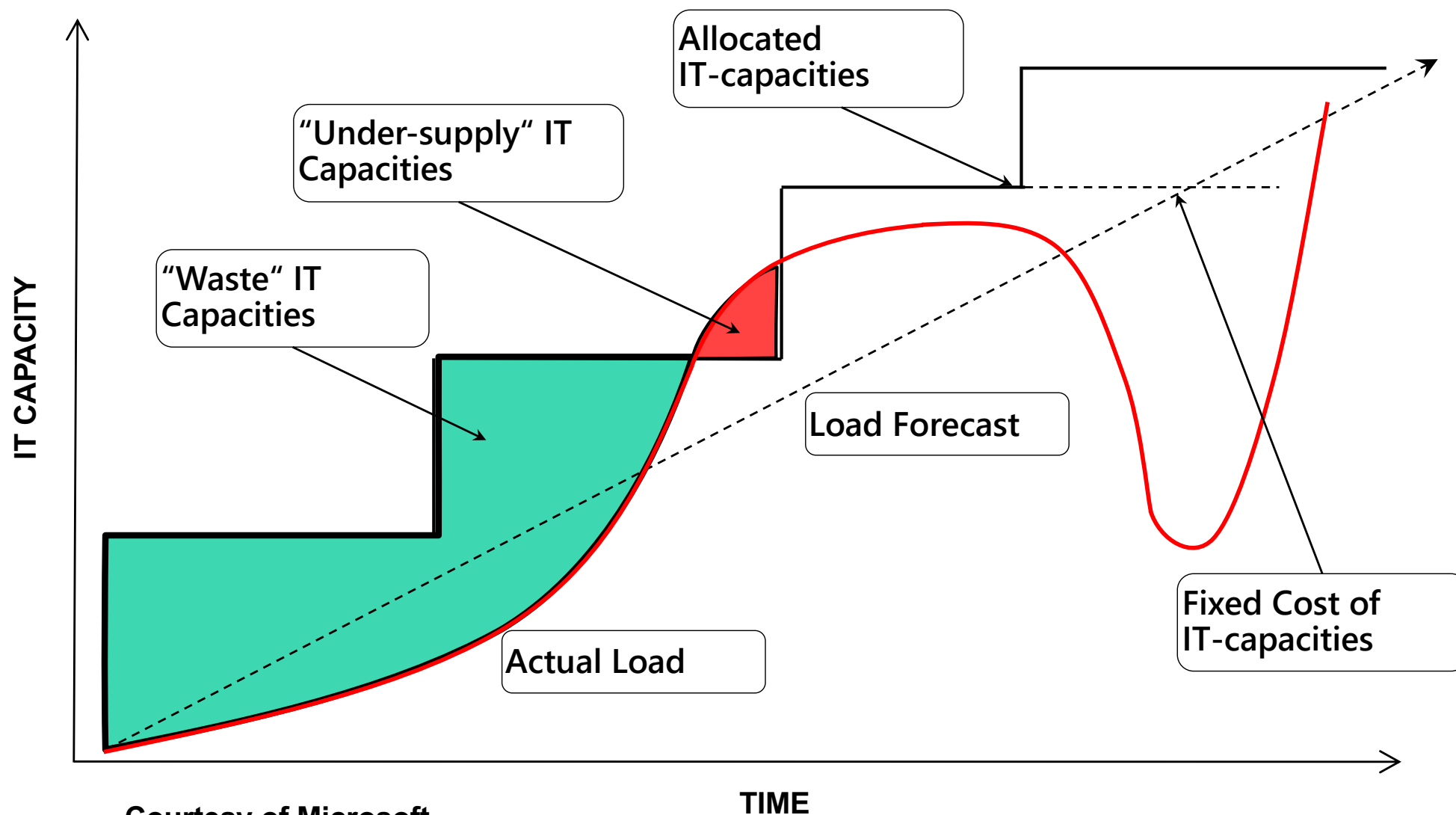
- A coherent, large-scale, publicly accessible collection of computing, storage, and networking resources
- Available via Web service calls through the Internet
- Short- or long-term access on a pay-per-use basis





# Over-provisioning - Out of Cloud

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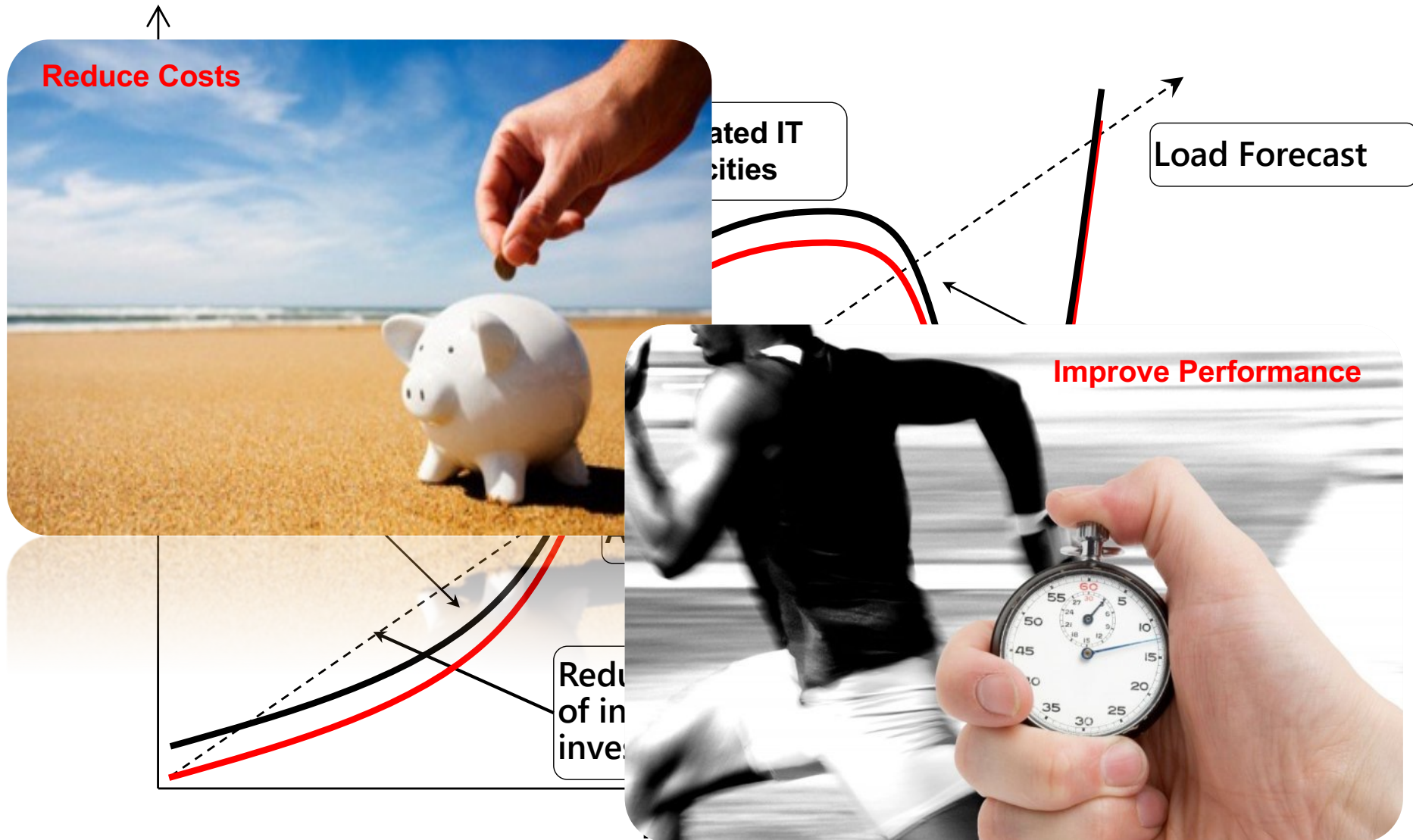


Courtesy of Microsoft

TIME



# Cloud-provisioning

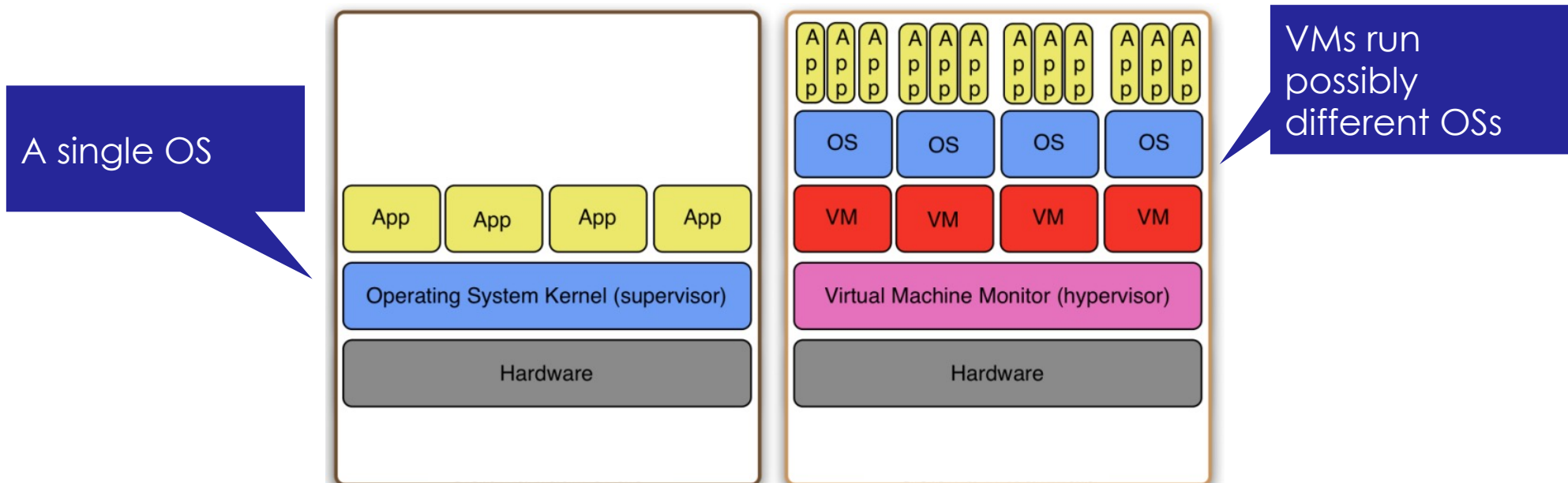


Courtesy of Microsoft



## How is Cloud implemented? Virtualization

- Hardware resources (CPU, RAM, ecc...) are partitioned and shared among multiple **virtual machines** (VMs)
- The virtual machine monitor (VMM) governs the access to the physical resources among running VMs
- Performance isolation and security







## Virtualization Consequences

### Without virtualization:

- Software strongly linked/related with hardware
  - Move/change an application not an easy task
- To isolate failure/crash the classical model is:
  - 1 server
  - 1 operating 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*»



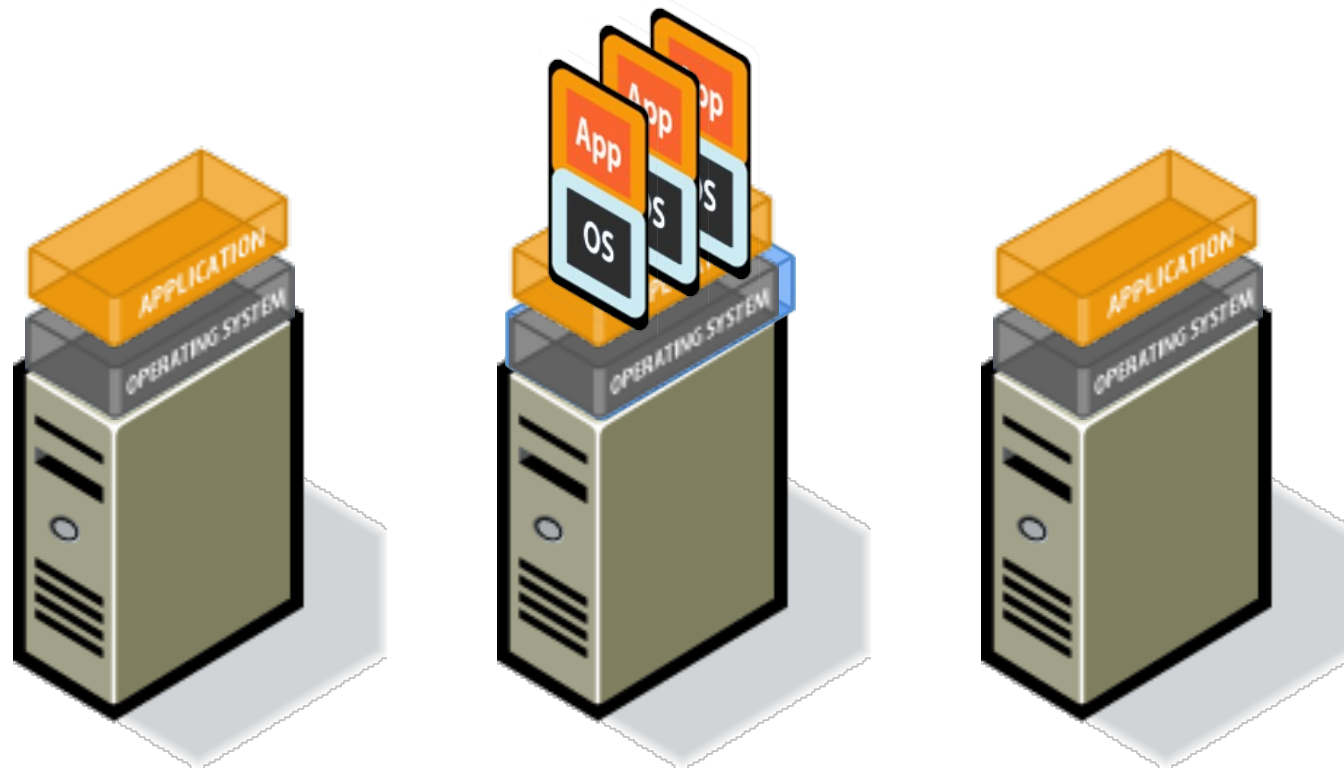
## Impact of Virtualization on the evolution of IT systems:

- Server consolidation
- Cloud computing

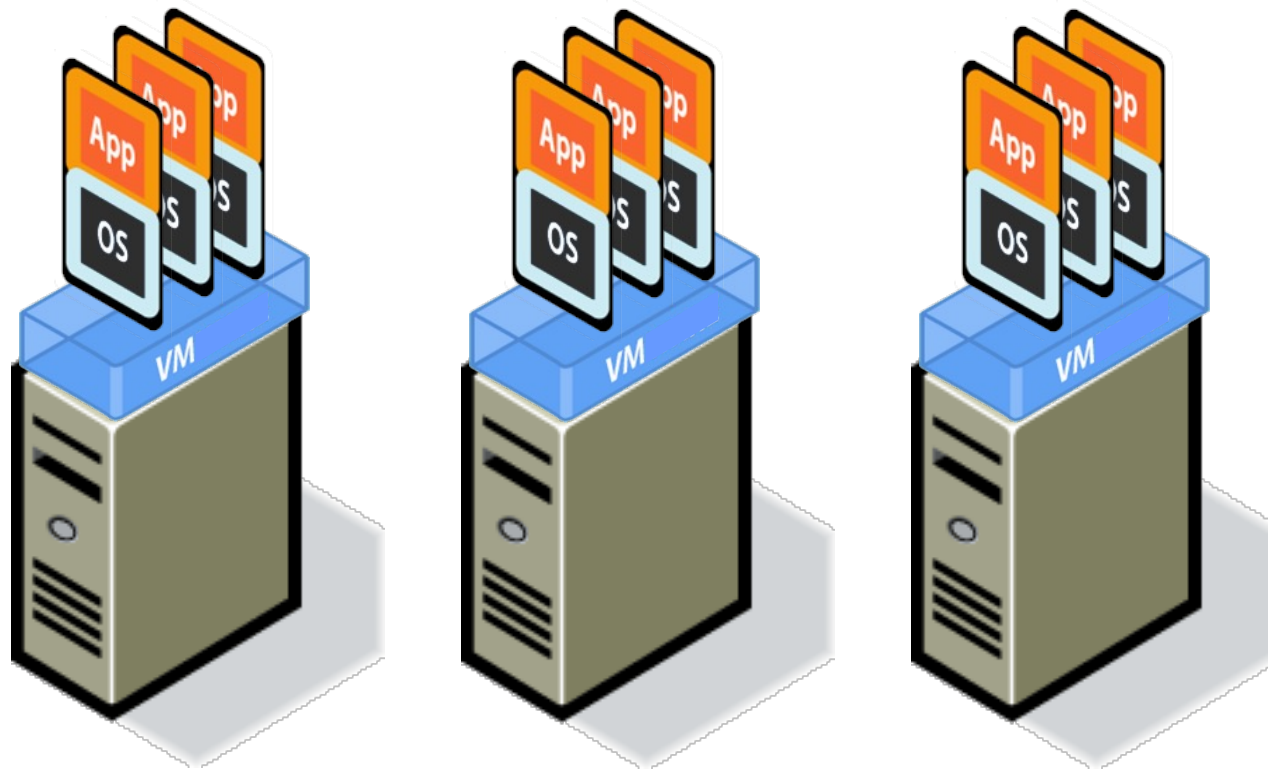


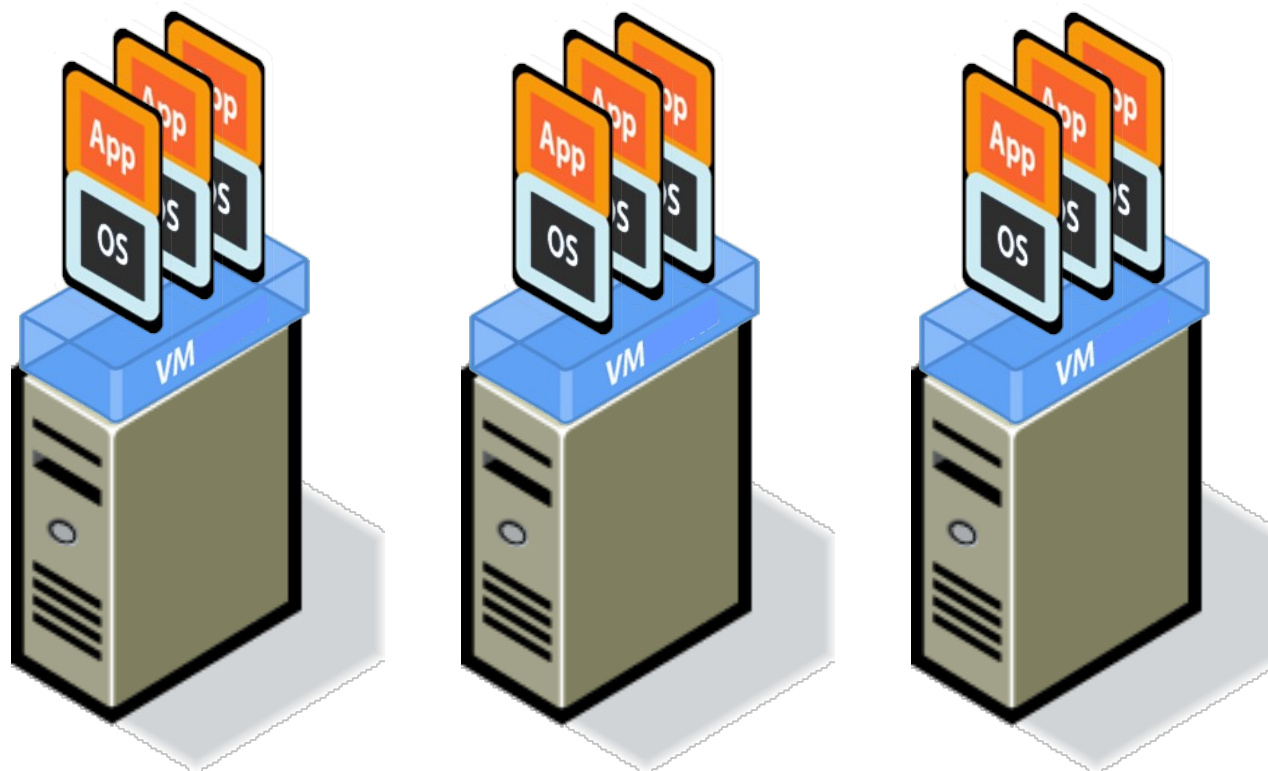


# Server Consolidation



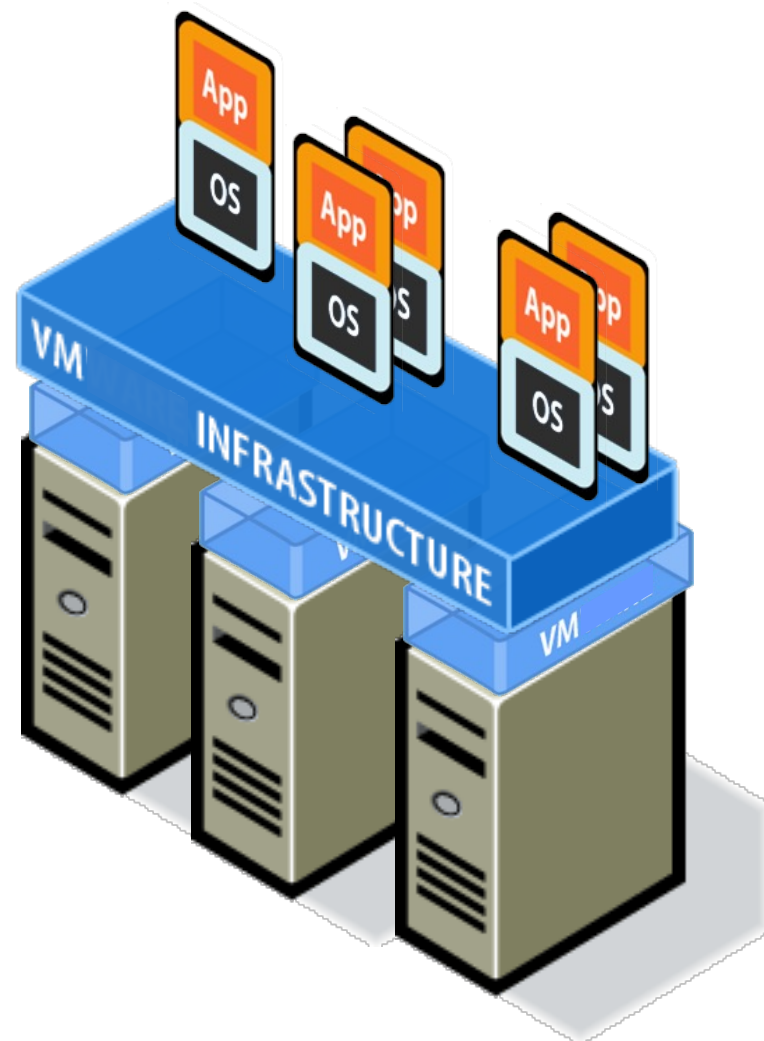
Animation source: VMWare website.





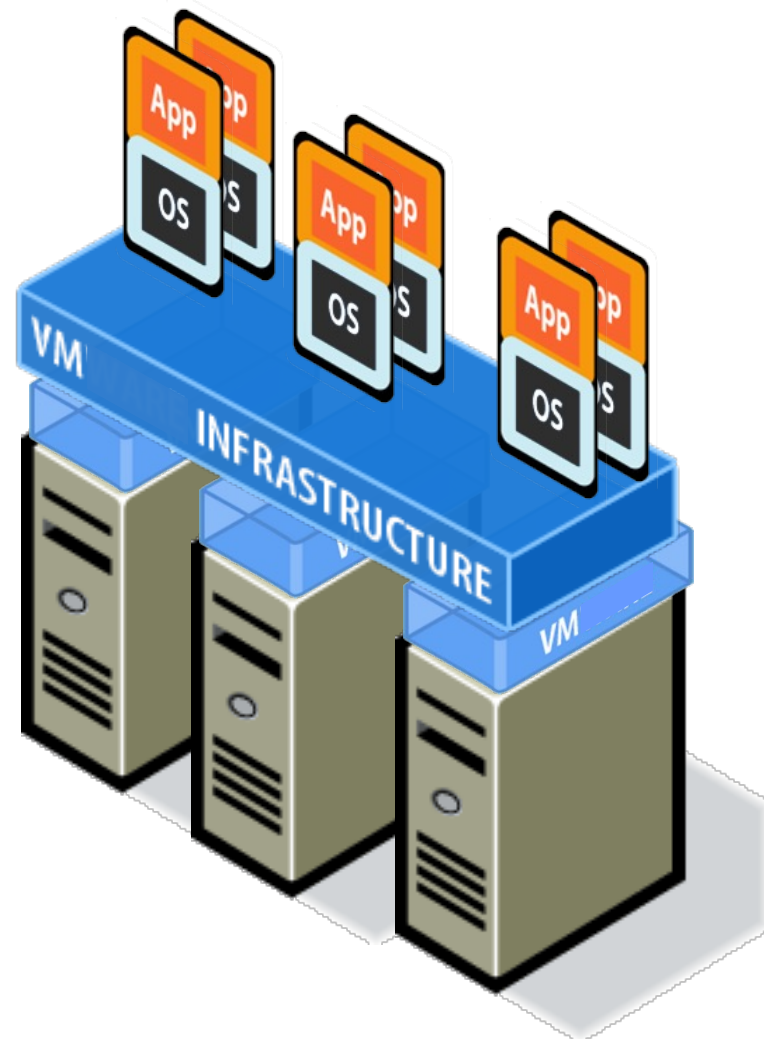


Consolidation Management:  
migration from physical to  
virtual machines



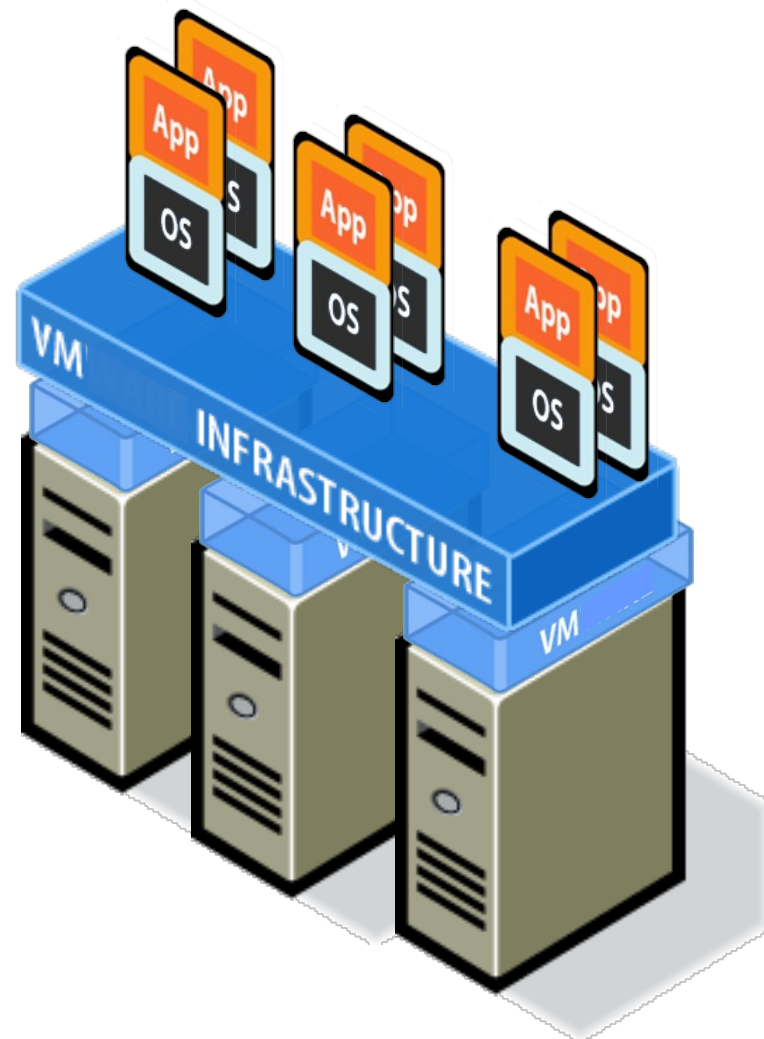


It is possible to move  
Virtual Machines, without  
interrupting the  
applications running inside





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





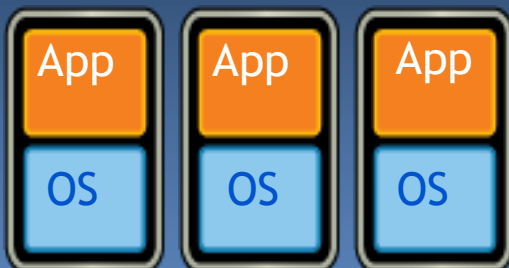


Discover

Monitor

Remediate

IT Service



75 Users  
4 Servers  
1 Database

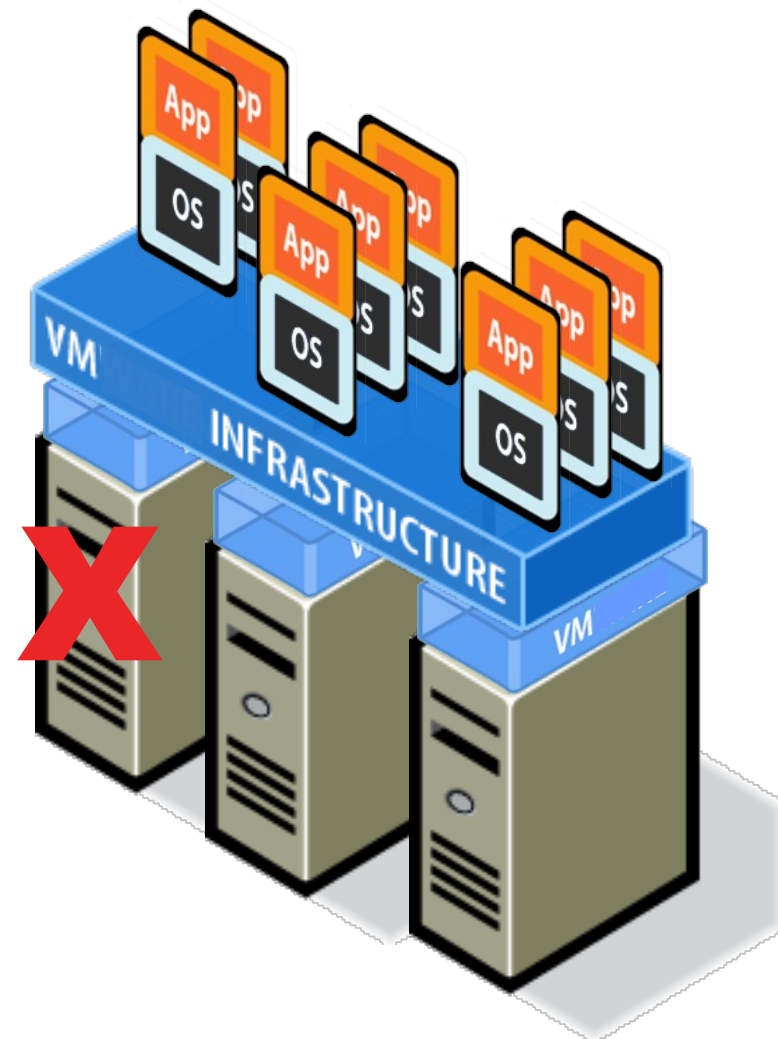
Quality of Service



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
    - Acquisition 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: resources as utilities

**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



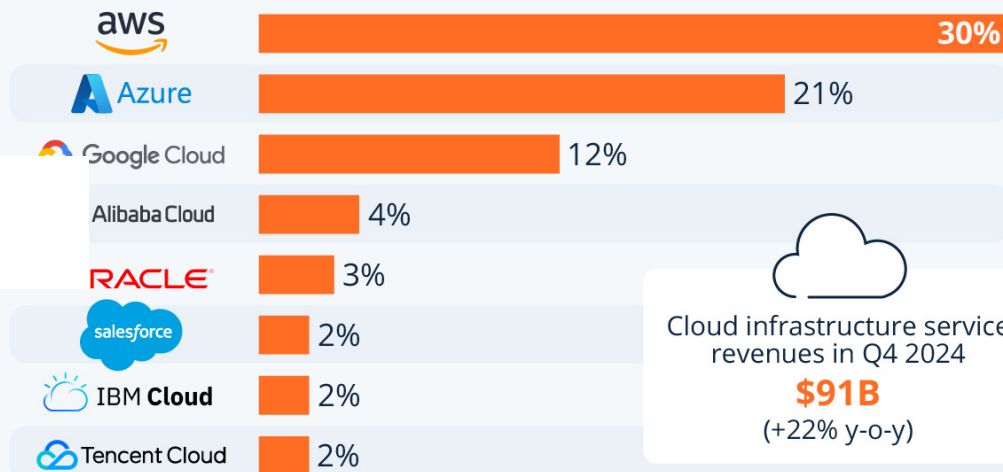
# Cloud Computing Growth

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## Amazon and Microsoft Stay Ahead in Global Cloud Market

Worldwide market share of leading cloud infrastructure service providers in Q4 2024\*



\* Includes platform as a service (PaaS) and infrastructure as a service (IaaS) as well as hosted private cloud services

Source: Synergy Research Group



statista

- Compound Annual Growth Rate (CAGR) 22%
- \$330 billion market: Despite its size, the cloud market is still growing strongly
- **Increased emphasis on multi-cloud strategy:** According to Accenture, **93% of enterprises** have built up to a multi-cloud strategy
- **Increase adoption of hybrid cloud services:** Enterprises having their existing infrastructure are moving toward the adoption of cloud computing services and are willing to adopt the hybrid approach (about **87%** of enterprises have already adopted hybrid cloud strategies)
- **Boosting the adoption of edge computing technology:** Most enterprises focus on edge computing as it minimizes delays, which is one of the major factors for any real-time application to perform efficiently.
- **AI growth favours cloud growth:** New AI-oriented services and technology are helping the major cloud providers to ride a wave. New capabilities lead to increased demand, which leads to increased revenues, which then enables more investments

Source:

<https://www.statista.com/chart/18819/worldwide-market-share-of-leading-cloud-infrastructure-service-providers/>



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

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AaaS	-	Architecture as a Service
BaaS	-	Business as a Service
CaaS	-	Communication as a Service
CRMAaaS	-	CRM as a Service
DaaS	-	Data as a Service
DBaaS	-	Database as a Service
EaaS	-	Ethernet as a Service
FaaS	-	Function as a Service
GaaS	-	Globalization or Governance as a Service
HaaS	-	Hardware as a Service
IaaS	-	Infrastructure 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

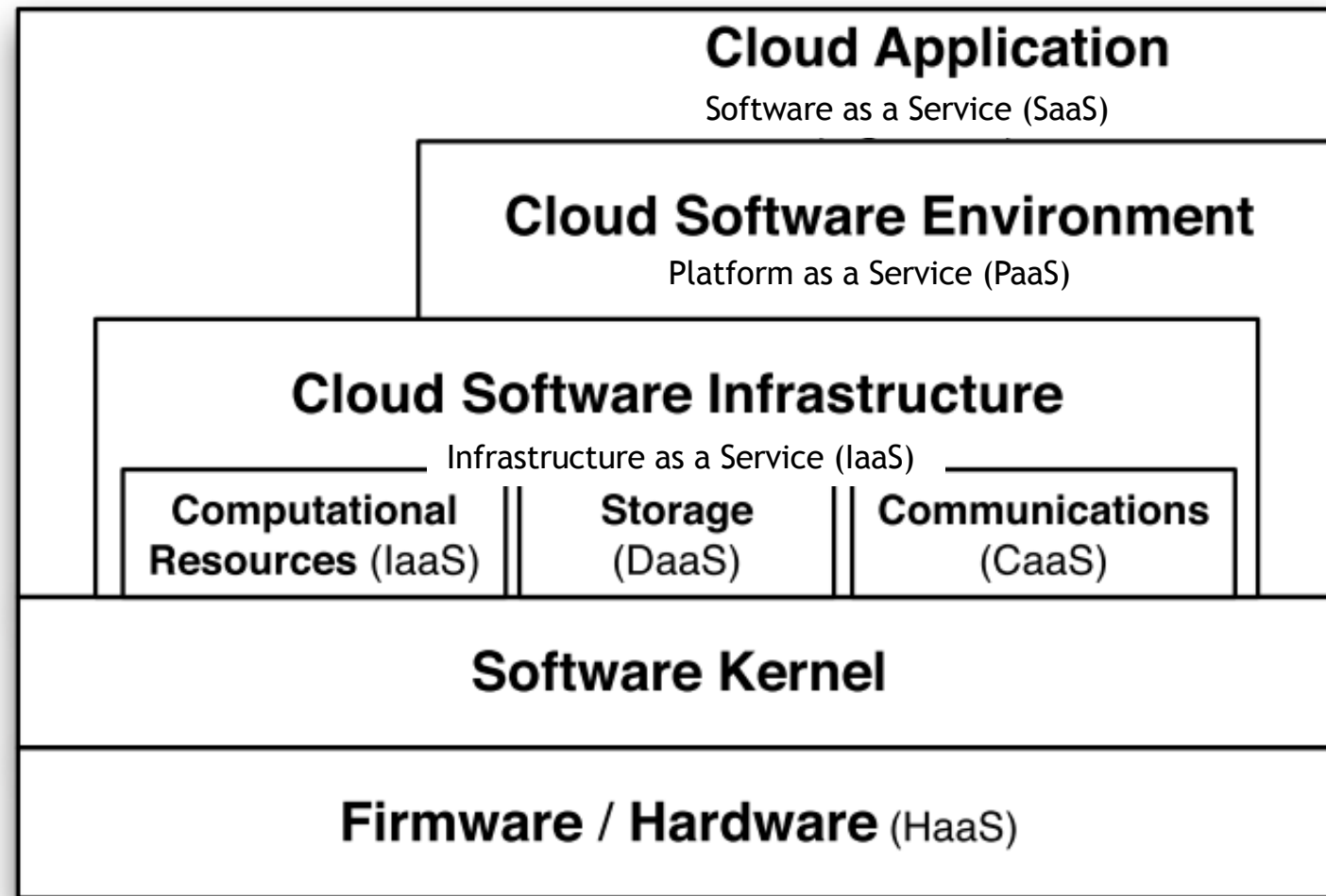




## Three main services provided by Cloud ...

### “Toward a Unified Ontology of Cloud Computing”

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





### *Cloud Application Layer*

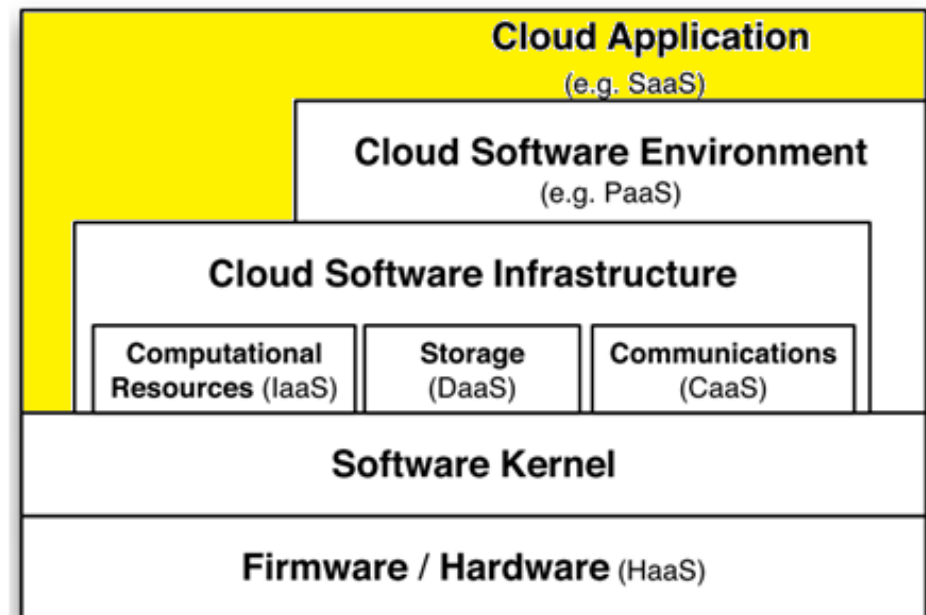
- SaaS

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*

- PaaS

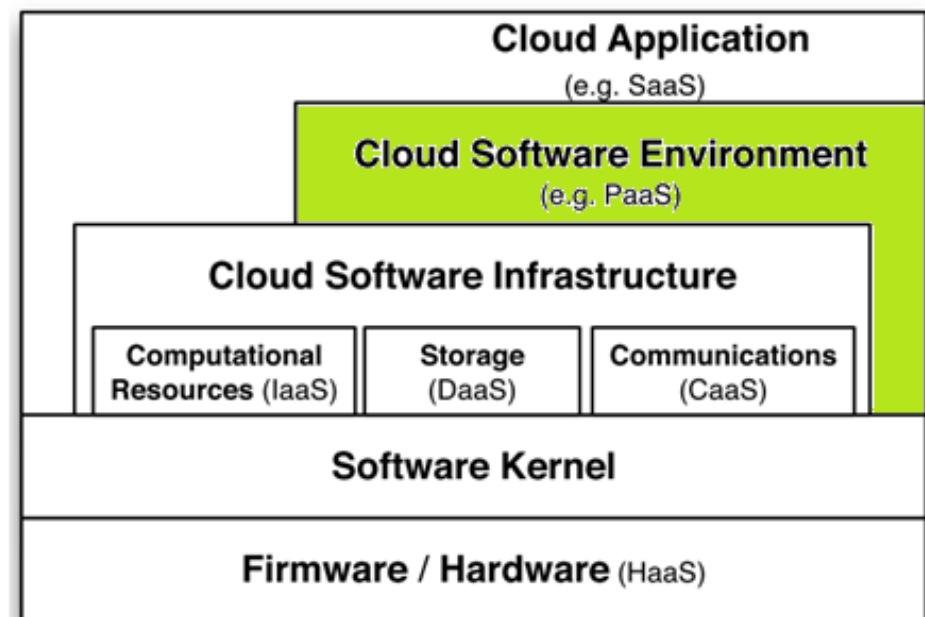
Users are *application developers*

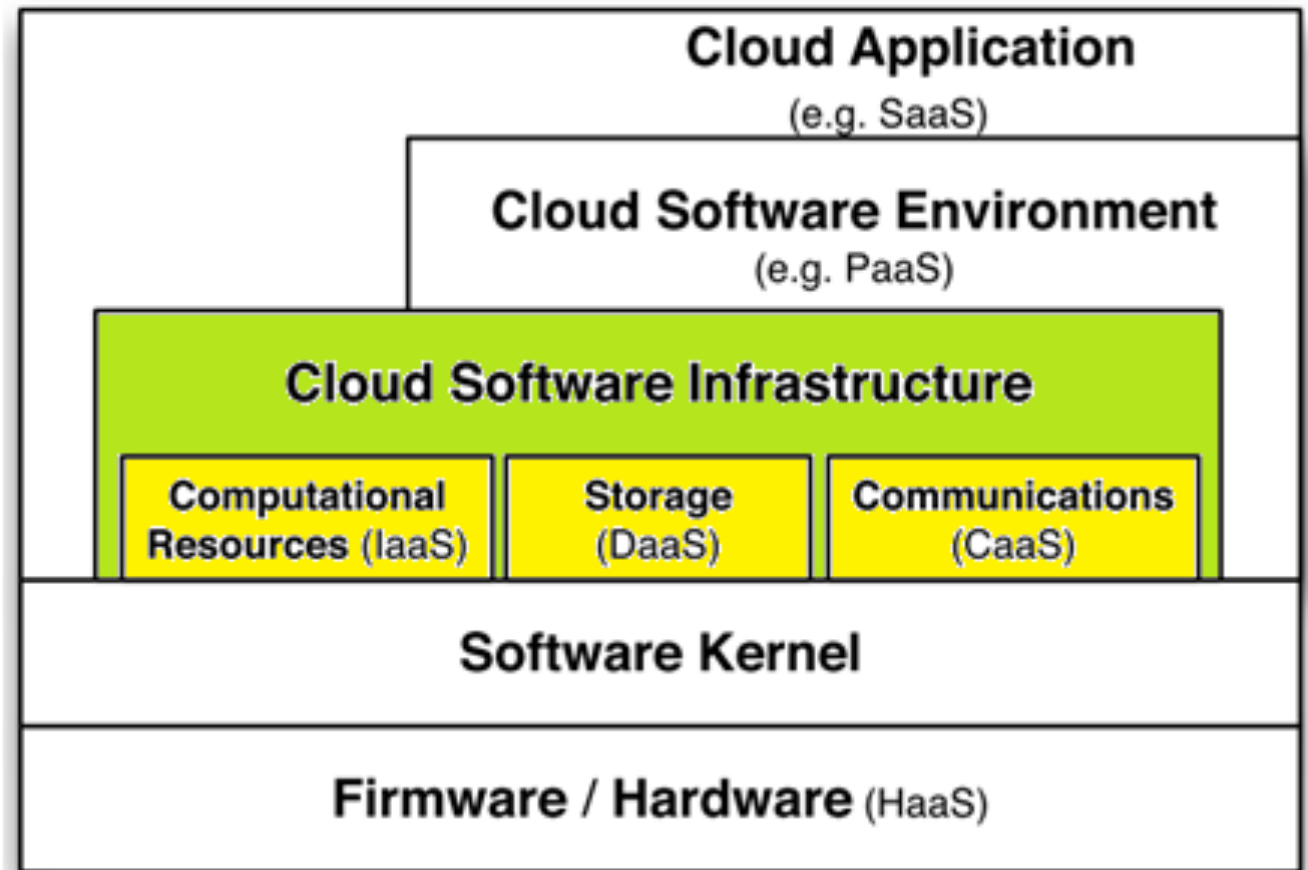
Providers supply developers with a *programming-language-level environment* with a well-defined **API**

- 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

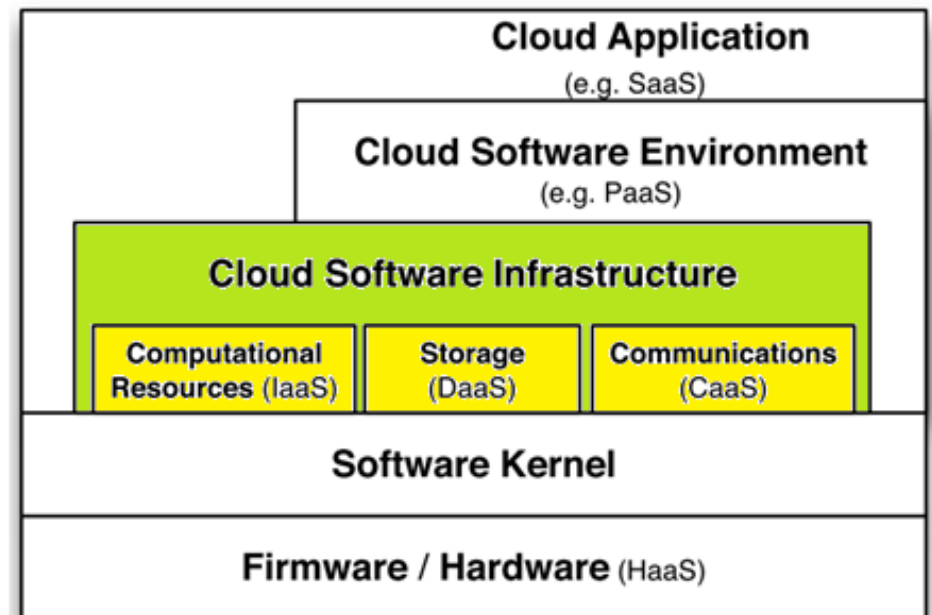
### *Cloud Software Infrastructure Layer*

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

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

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

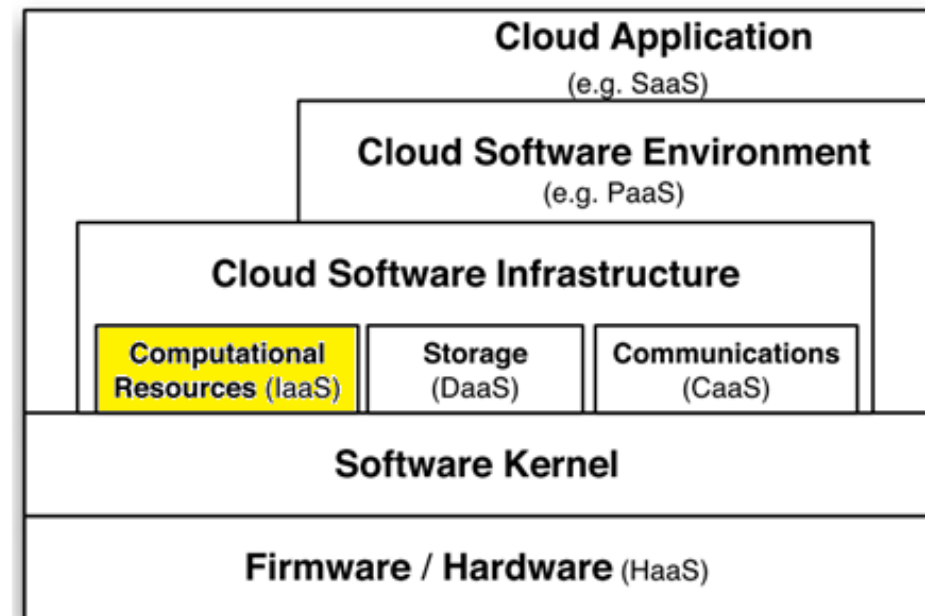
- However, this would:
  - reduce simplicity
  - increase development efforts





## 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**
- **OpenStack**
  - 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

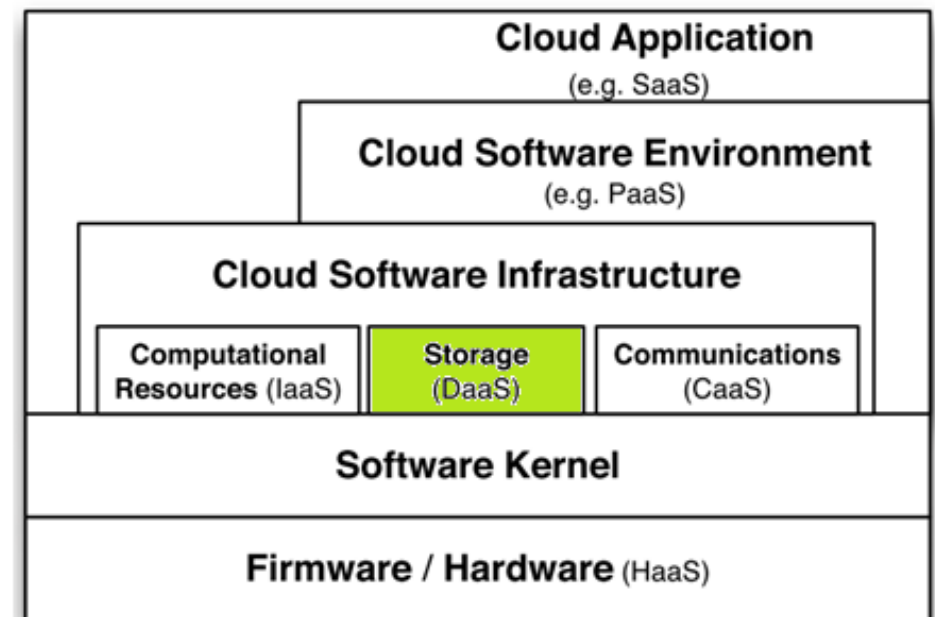
- store their data at remote disks
- access data anytime from any place

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

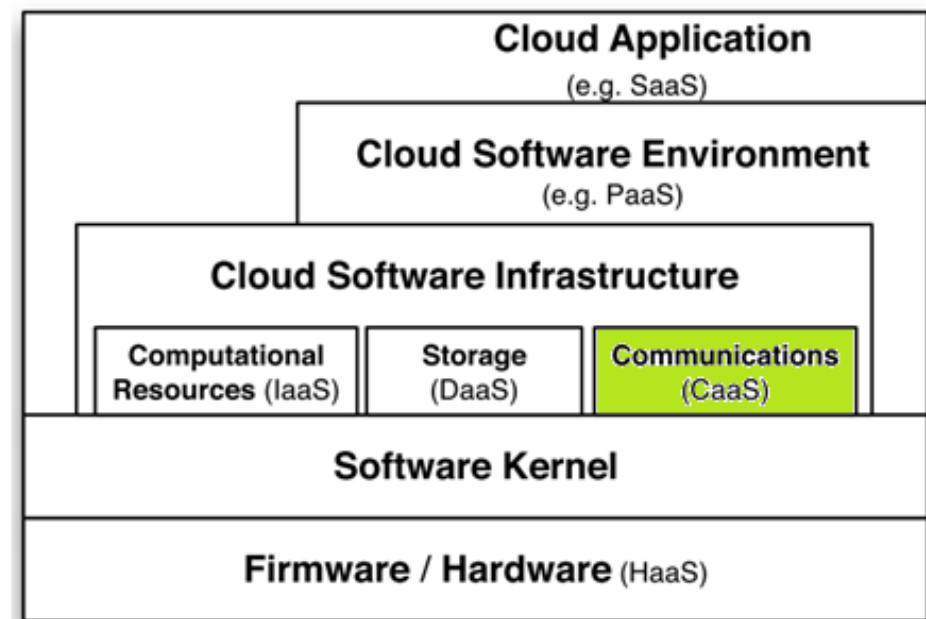




Communications becomes a vital component in guaranteeing QoS

- Communication capability: service oriented, configurable, schedulable, predictable, and reliable
- Network security, dynamic provisioning of virtual overlays for traffic isolation or dedicated bandwidth, guaranteed message delay, communication encryption, and network monitoring

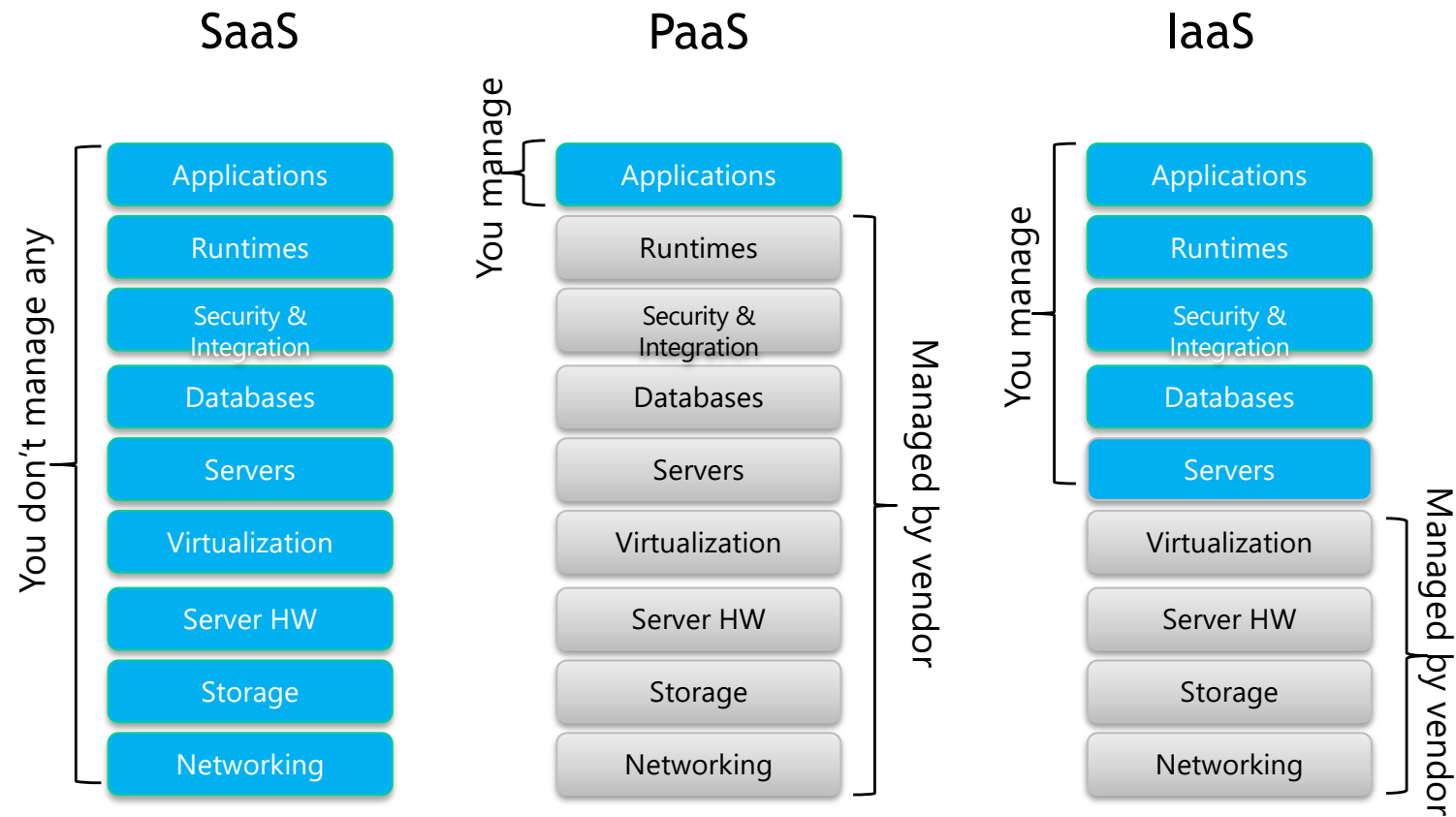
Types of CaaS include Voice over Internet Protocol (VoIP) or internet telephone solutions, and video conferencing services





# SaaS, PaaS, IaaS summary

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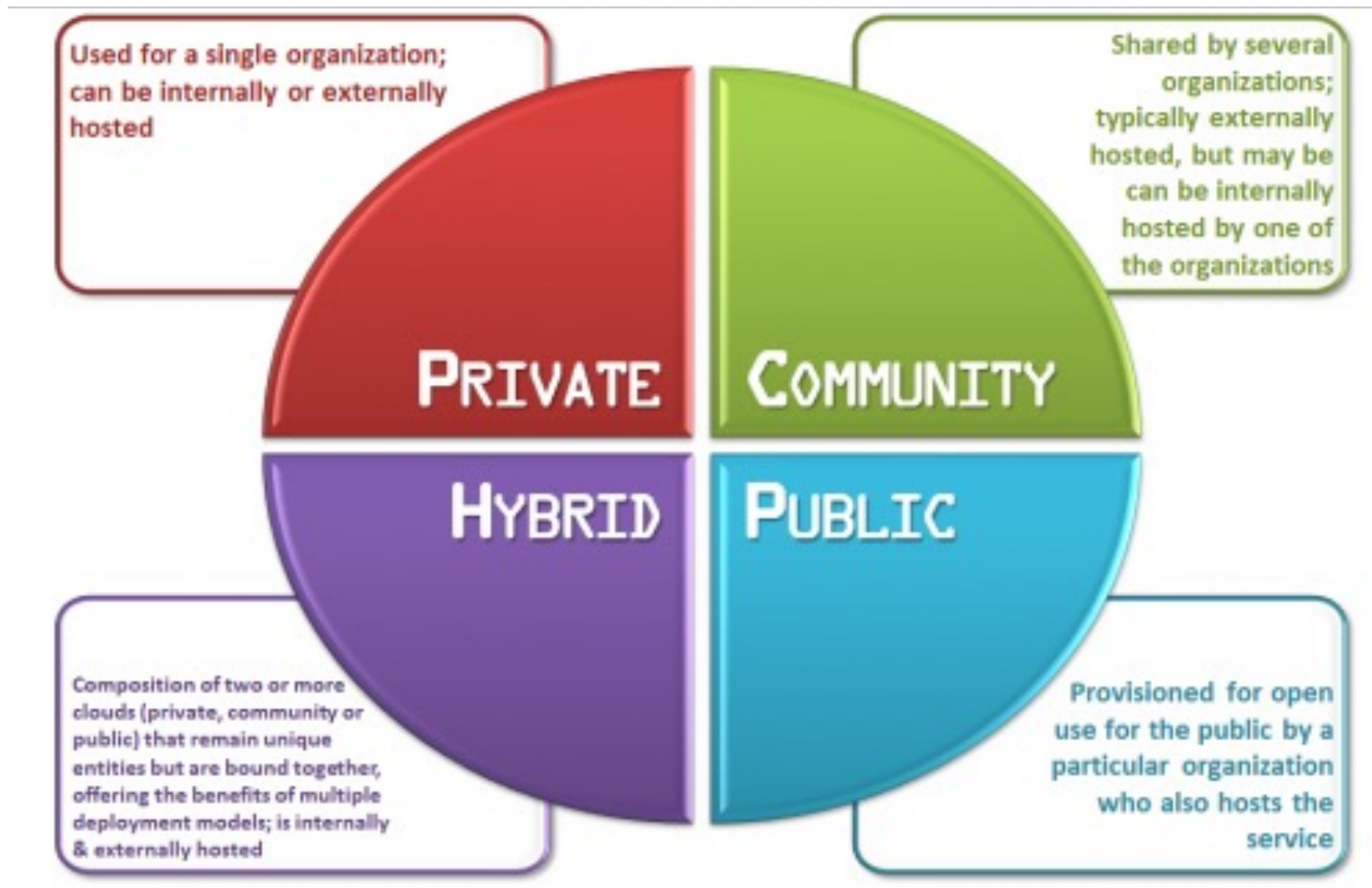


Courtesy of Microsoft



# Types of Clouds

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Large scale infrastructure available on a rental basis

- The definition of Cloud we gave so far

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 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

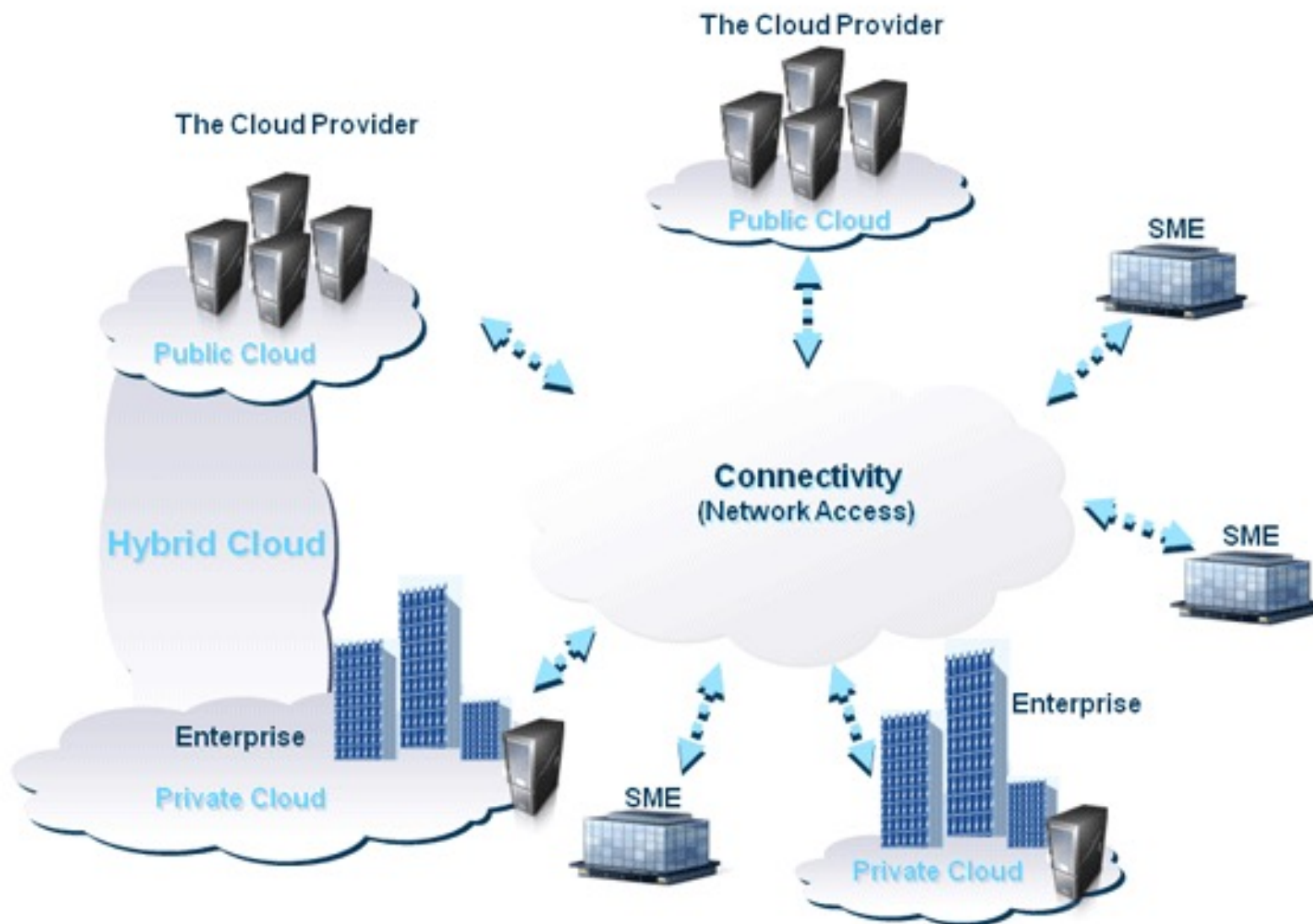
### Common interfaces

- 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



# Types of Cloud

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## 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

Tutorial:

<https://aws.amazon.com/getting-started/launch-a-virtual-machine-B-0/>



# EC2 is an Amazon Web Service

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

- Compute** (circled in red):
  - EC2**: Virtual Servers in the Cloud
  - 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

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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 the "Services" menu, "Edit" button, and user information "Roberto Canonico" and "Oregon".

**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: selecting the AMI

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The screenshot shows the Amazon EC2 Management Console in a Mozilla Firefox browser. The page is titled "Step 1: Choose an Amazon Machine Image (AMI)" and includes a "Cancel and Exit" link. Below the title, there is a brief explanation of AMIs. A "Quick Start" sidebar on the left lists "My AMIs", "AWS Marketplace", and "Community AMIs", with a "Free tier only" filter. The main content area displays four AMI options, each with a logo, name, description, root device type, virtualization type, and a "Select" button. All listed AMIs are marked as "Free tier eligible".

Logo	AMI Name	AMI ID	Architecture	Free tier eligible
Amazon Linux	Amazon Linux AMI 2013.09.1	ami-be1c848e (64-bit) / ami-4c1c847c (32-bit)	64-bit / 32-bit	Yes
Red Hat	Red Hat Enterprise Linux 6.4	ami-b8a63b88 (64-bit) / ami-baa63b8a (32-bit)	64-bit / 32-bit	Yes
SUSE Linux	SUSE Linux Enterprise Server 11	ami-d8b429e8 (64-bit) / ami-9eb429ae (32-bit)	64-bit / 32-bit	Yes
Ubuntu	Ubuntu Server 12.04.3 LTS	ami-6aad335a (64-bit) / ami-68ad3358 (32-bit)	64-bit / 32-bit	Yes



# Amazon EC2: creating an instance

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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 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)

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The screenshot shows the Amazon EC2 Management Console in a Mozilla Firefox browser. The page is titled 'Step 3: Configure Instance Details' and includes a progress bar with steps: 1. Choose AMI, 2. Choose Instance Type, 3. Configure Instance (active), 4. Add Storage, 5. Tag Instance, 6. Configure Security Group, and 7. Review. The main content area contains the following configuration options:

- 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.](#)

Below these options is a section for 'Advanced Details' which is currently collapsed. At the bottom of the page, there are navigation buttons: 'Cancel', 'Previous', 'Review and Launch' (highlighted in blue), and 'Next: Add Storage'. The footer contains copyright information: '© 2008 - 2013, Amazon Web Services, Inc. or its affiliates. All rights reserved.' and links to 'Privacy Policy' and 'Terms of Use', along with a 'Feedback' button.



# Amazon EC2: adding a storage

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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 explains that the instance will be launched with the following storage device settings. It allows attaching additional EBS volumes and instance store volumes, or editing the settings of the root volume. A link to "Learn more about storage options in Amazon EC2" is provided.

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".

The footer contains copyright information: "© 2008 - 2013, Amazon Web Services, Inc. or its affiliates. All rights reserved." and links to "Privacy Policy" and "Terms of Use". A "Feedback" button is also present.



# Amazon EC2: launching the instance(s)

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

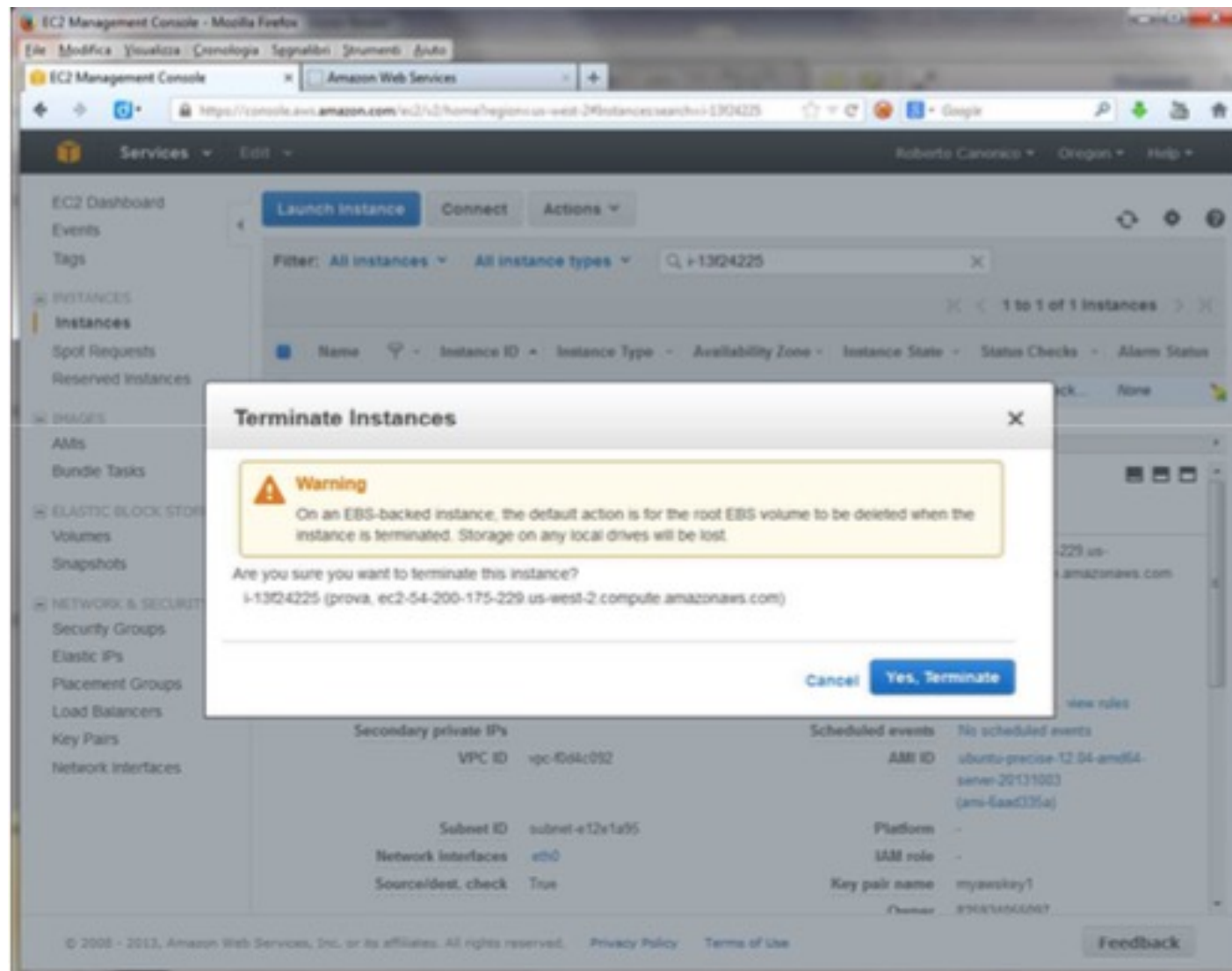
**Instance Details:**

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. <a href="#">view rules</a>
Scheduled events	No scheduled events
AMI ID	ubuntu-precise-12.04-amd64-server-20131003 (ami-6aad335a)
Platform	-
IAM role	-
Key pair name	myawskey1
Owner	825934065097



# Amazon EC2: instance termination

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## 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?





## Disadvantages of Cloud Computing

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



## Fog/Edge Computing

- When it comes to storage and computation of large scales of data, Cloud Computing is the de-facto solution
- With the massive growth in intelligent and mobile devices coupled with technologies like Internet of Things (IoT), V2X Communications, Augmented Reality (AR), the focus has shifted towards
  - gaining real-time responses
  - support for context-awareness
  - mobility
- Due to the delays induced on the WAN and location agnostic provisioning of resources on the cloud, there is a need to bring the features of the cloud closer to the consumer devices
- Nowadays, computing/storage capacity are available at the data sources

