POLITECNICO DI MILANO

Computing Infrastructures





Software Infrastructures: Cloud Computing

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

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

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

Methods:

Reliability and availability of datacenters (definition, fundamental laws, RBDs)

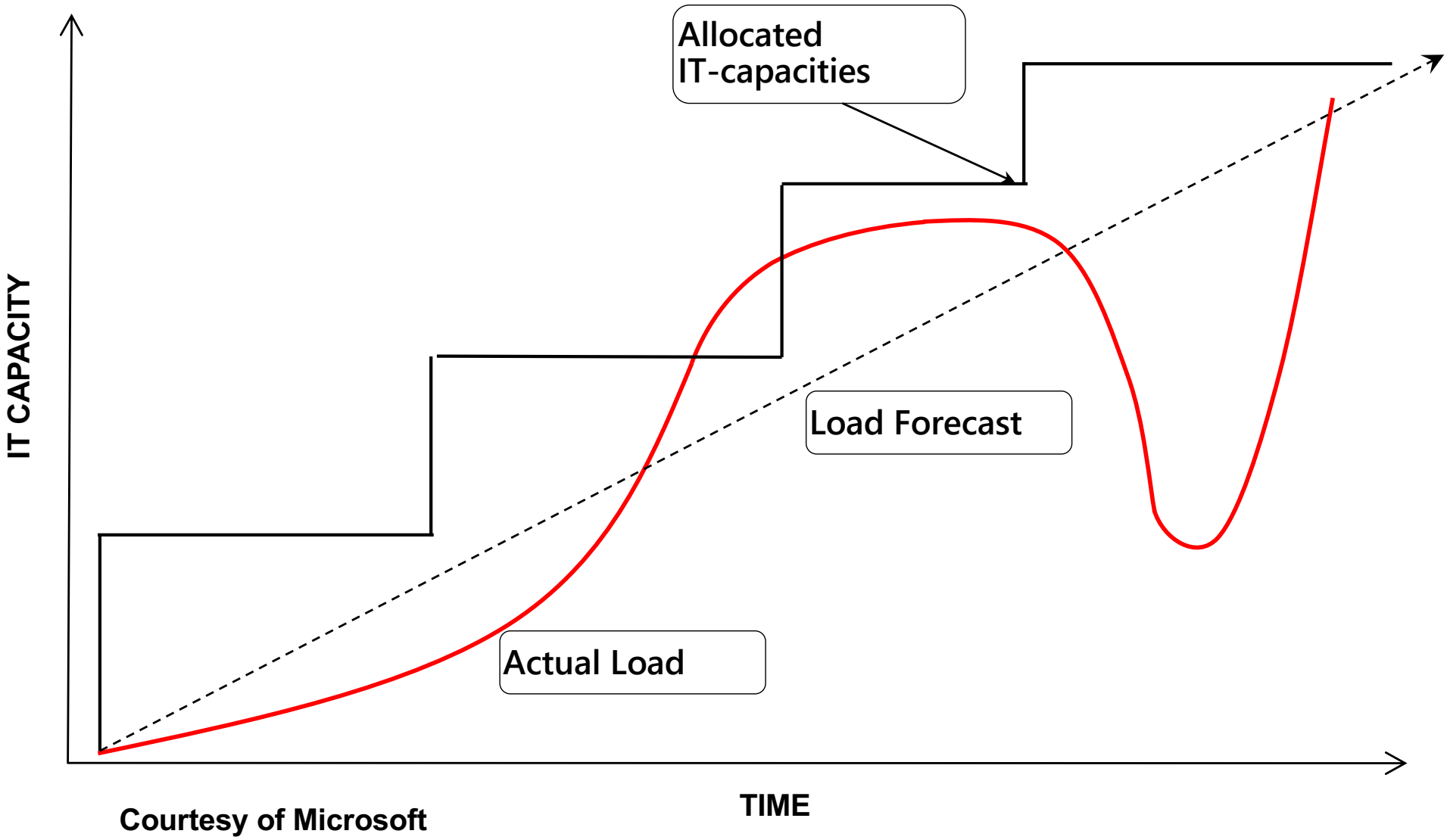
Disk performance (Type, Performance, RAID)

Scalability and performance of datacenters (definitions, fundamental laws, queuing network theory)

What is Cloud Computing?

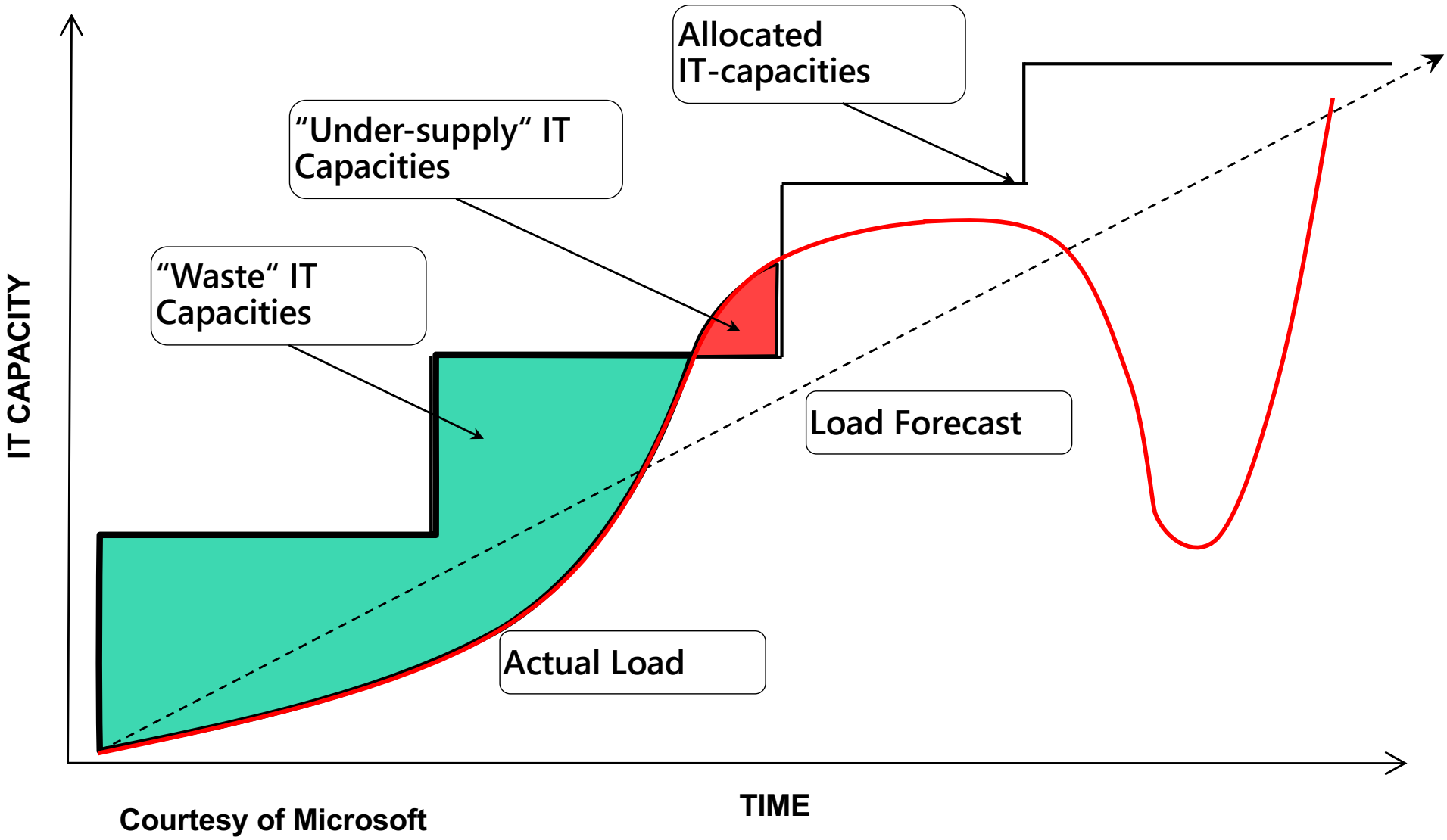
- A coherent, large-scale, publicly accessible collection of computing, storage, and networking resources
- Available via Web service calls through the Internet
- Short- or long-term access on a pay-per-use basis

Over-provisioning - Out of Cloud



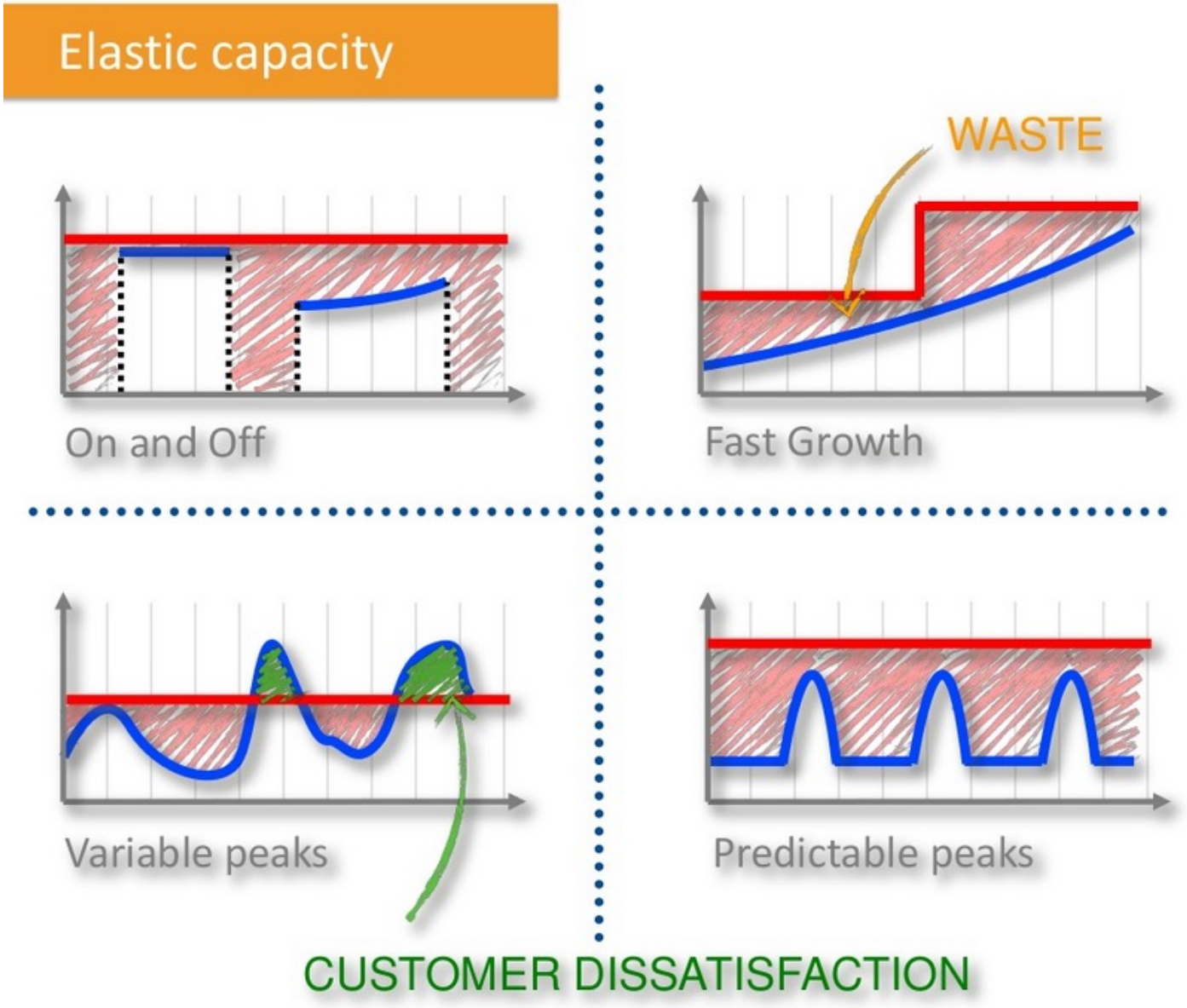
Courtesy of Microsoft

Over-provisioning - Out of Cloud

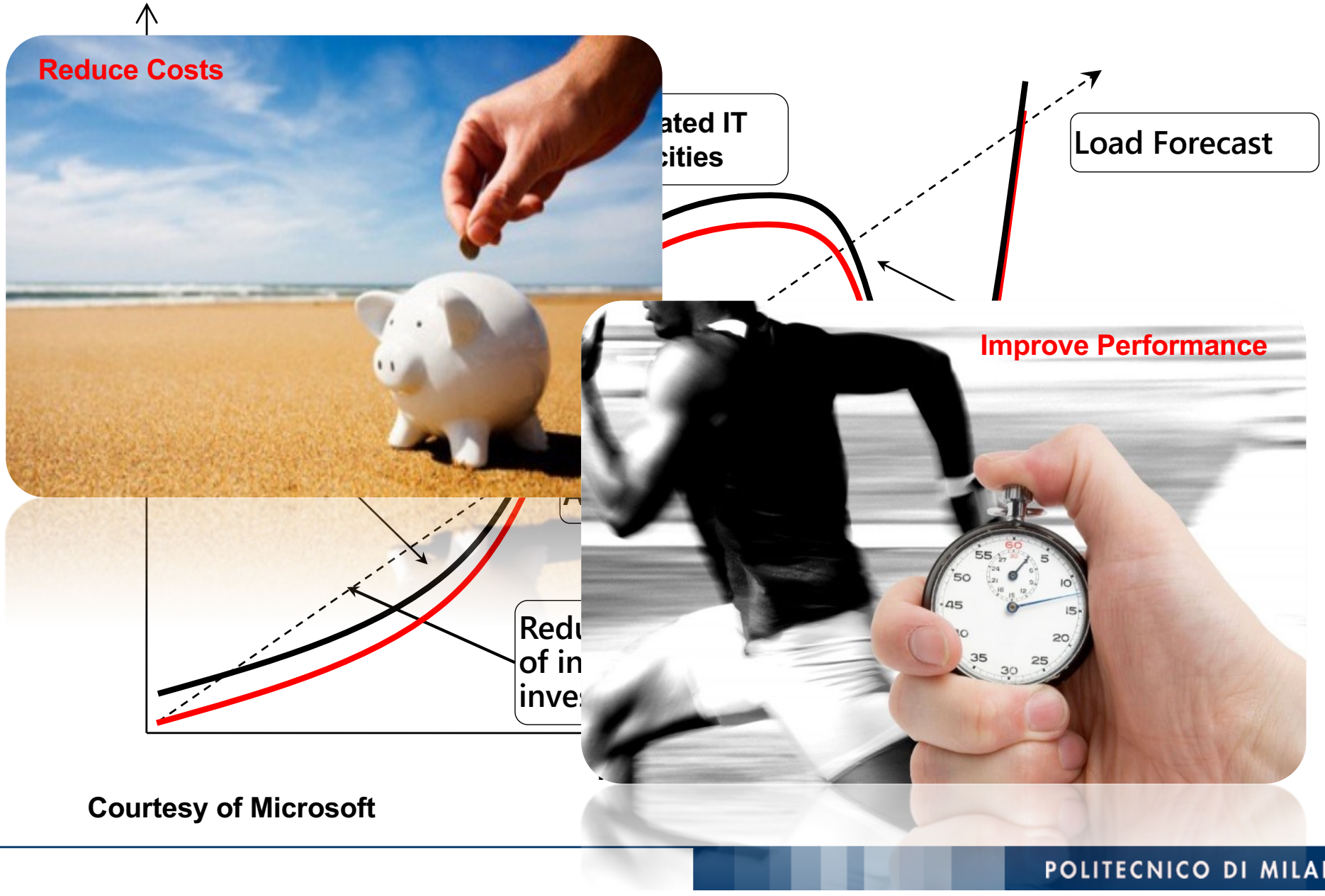


Courtesy of Microsoft

… Over provisioning



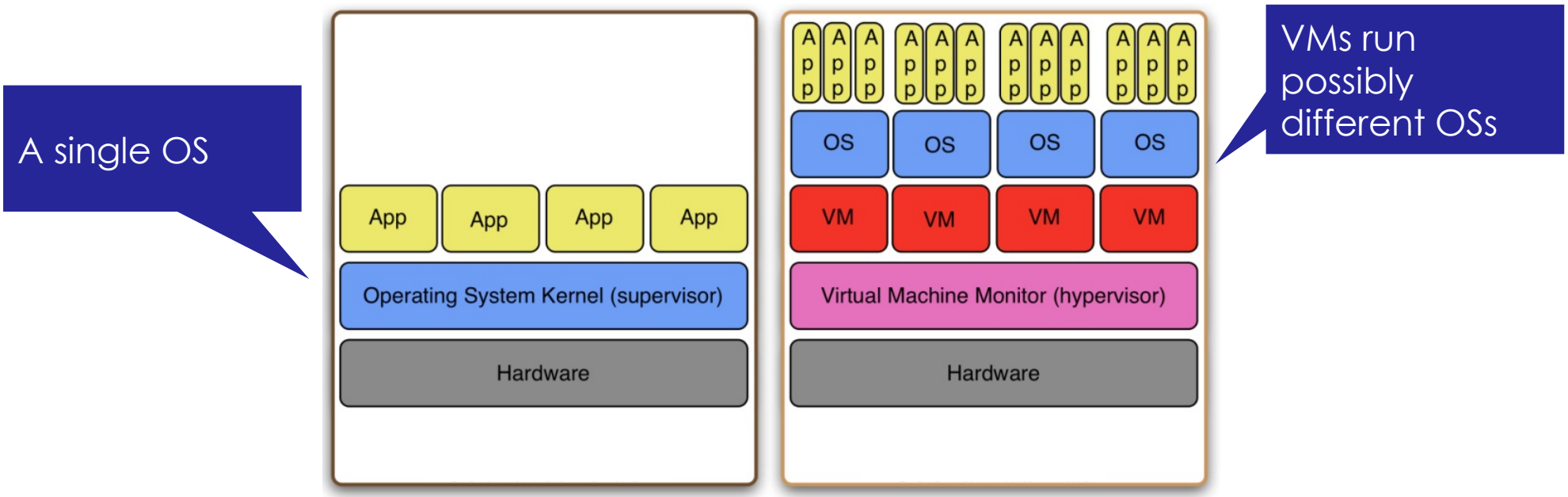
Cloud-provisioning



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 fexibility thanks to pre-built VMs
- OS and applications can be handled as a «*single entity*»

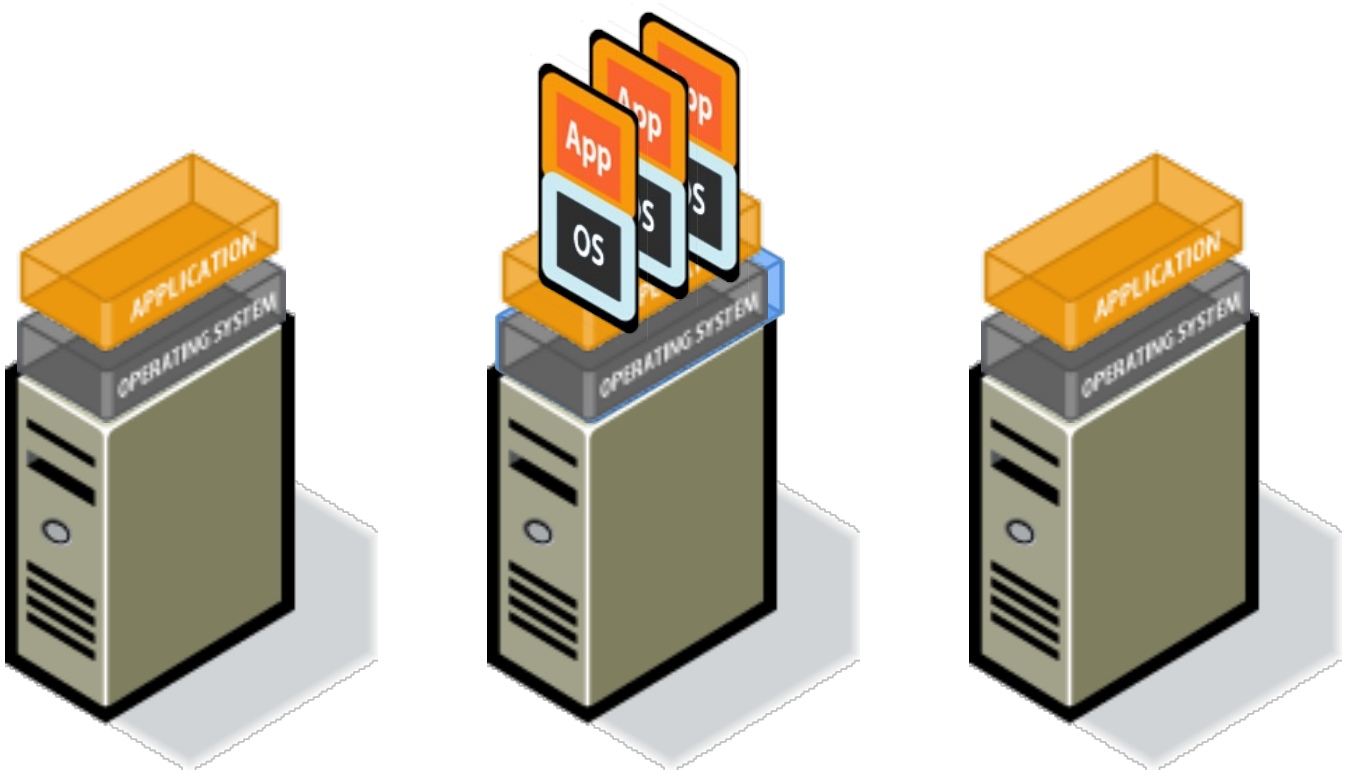
Virtualization Consequences

Impact of Virtualization on the evolution of IT systems:

- Sever consolidation
- Cloud computing

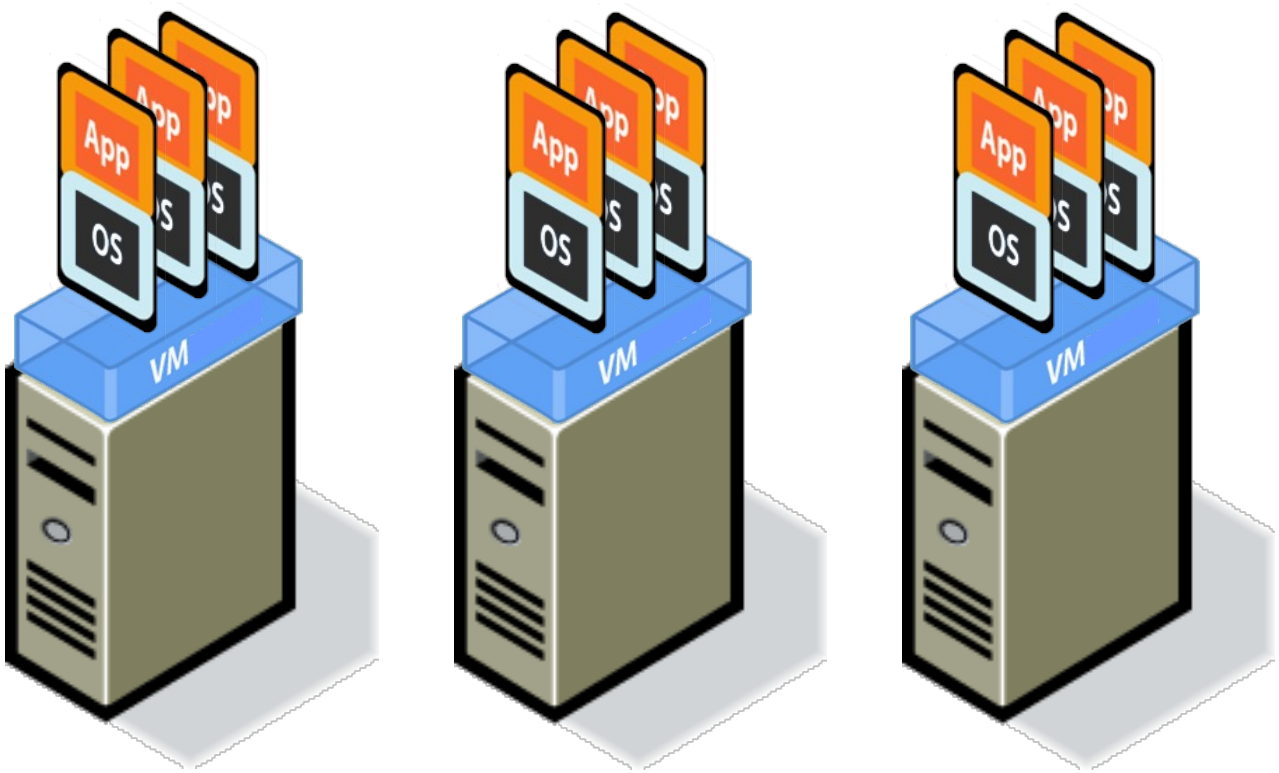
Server Consolidation

Virtualization – Server Consolidation

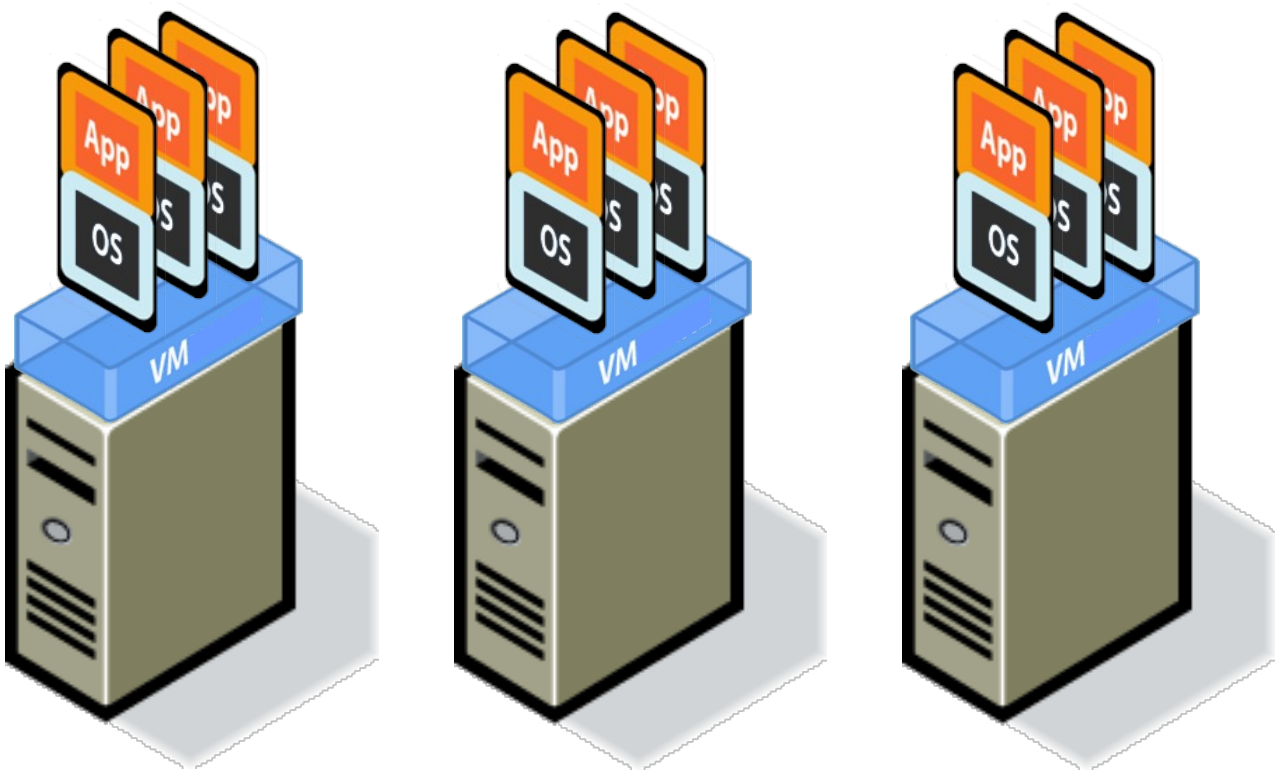


Animation source: VMWare website.

Virtualization

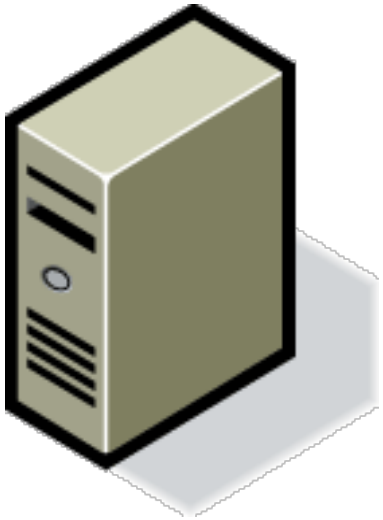


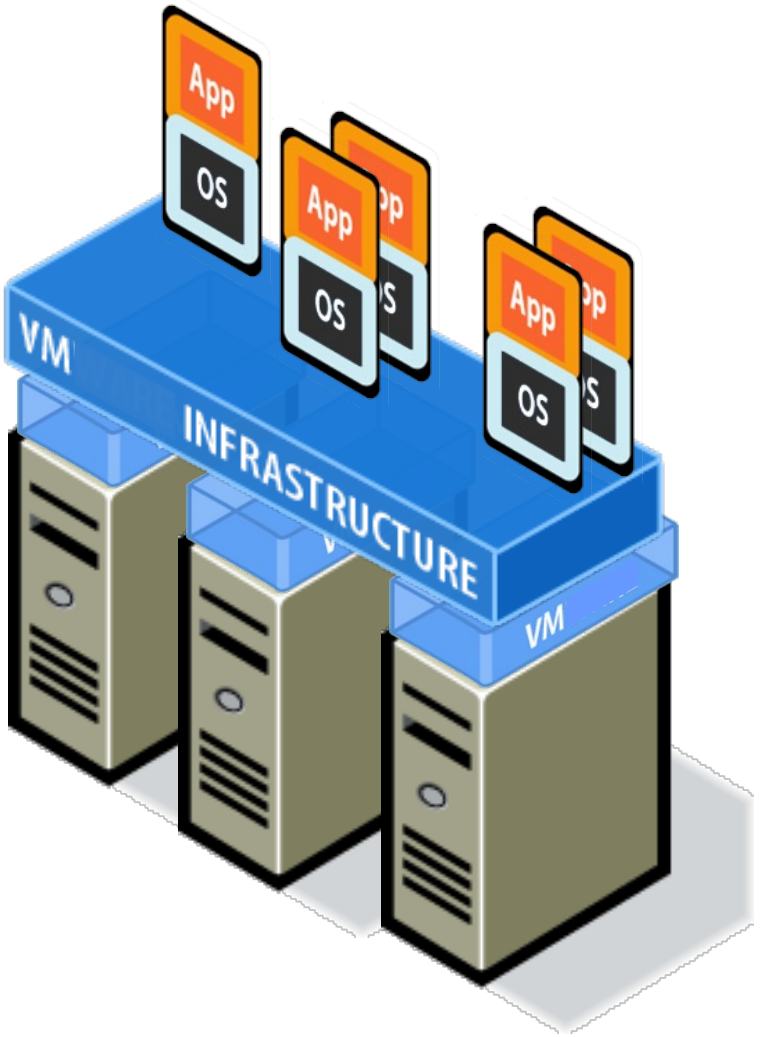
Virtualization



Migration from Physical to Virtual

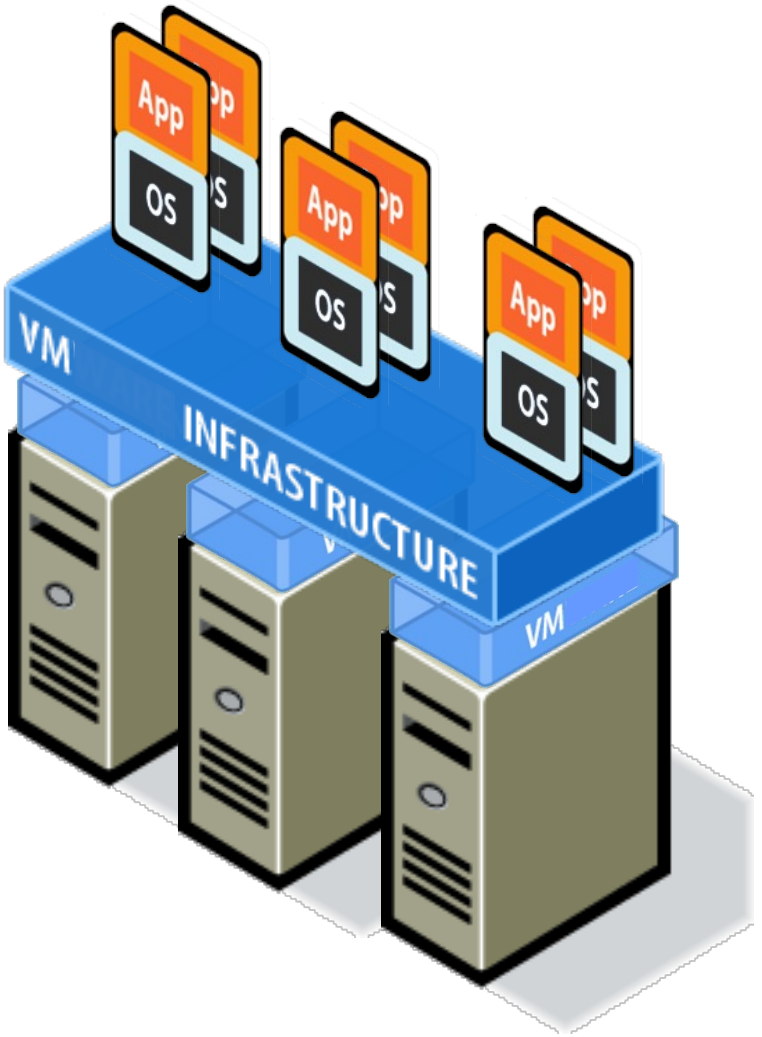
Consolidation Management: migration from physical to virtual machines





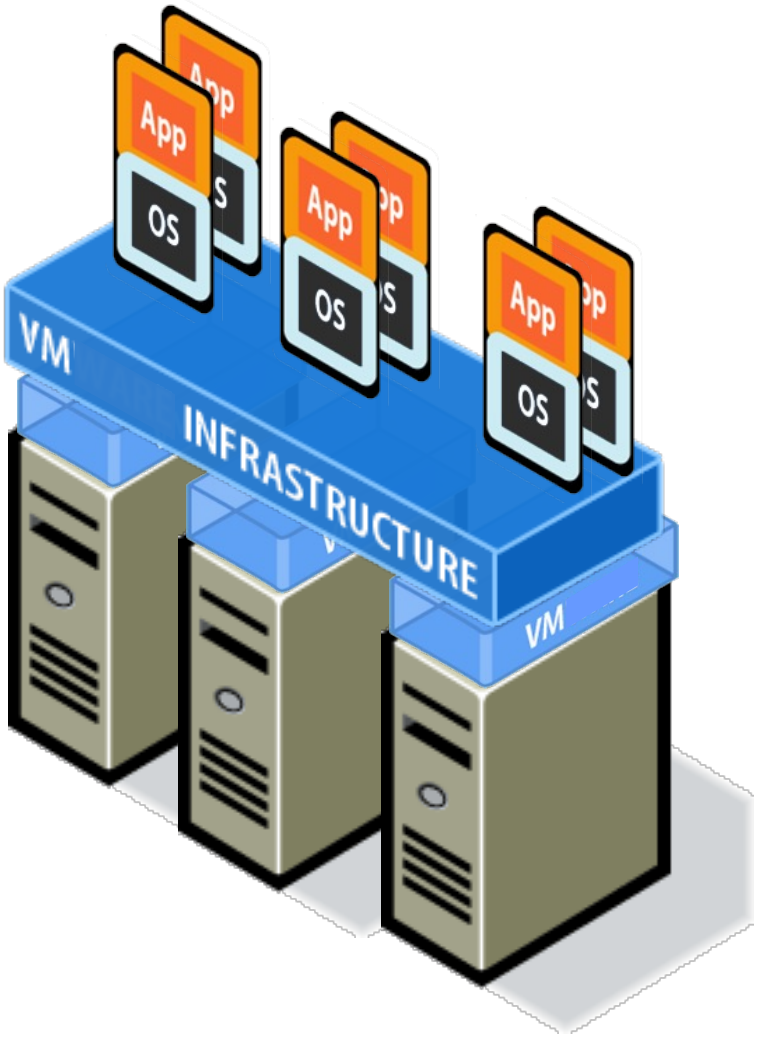
Scalability

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

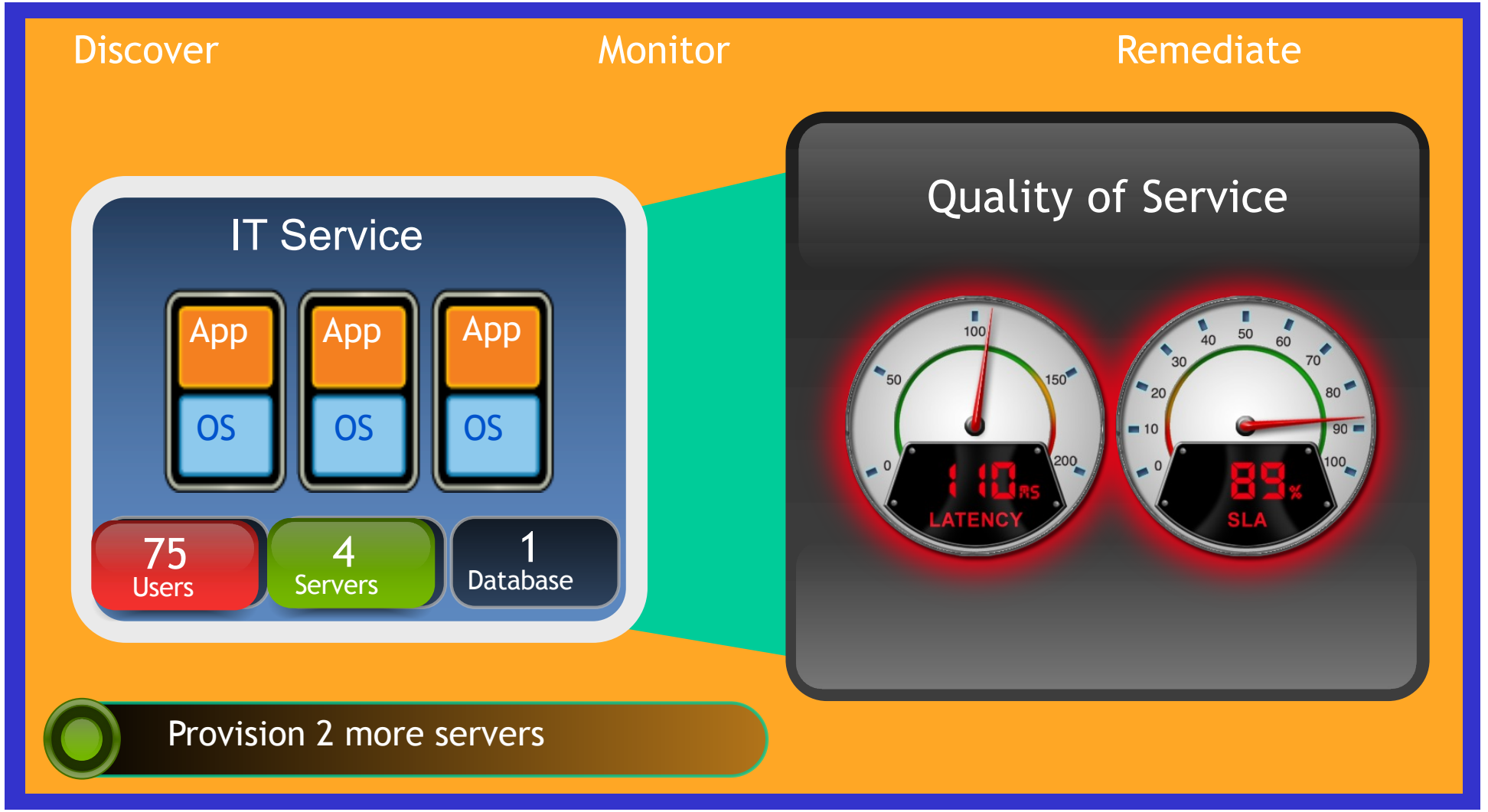


Automatic Scalability

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



Automatic Scalability



High Availability

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: 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

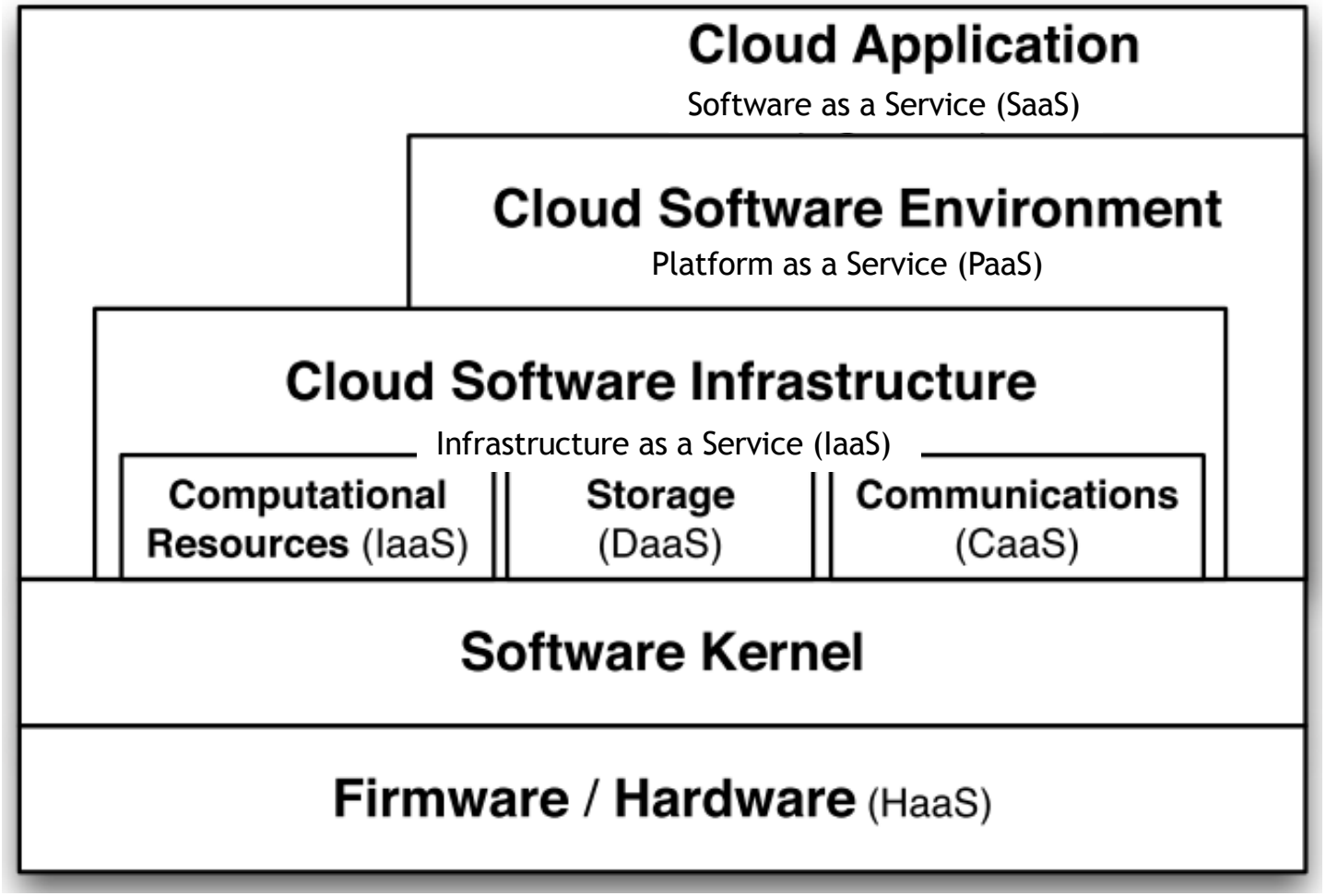
A variety of ‘as-a-Service’ terms to describe services offered in Clouds

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/Function 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

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

- **SaaS – Software-as-a-Service**

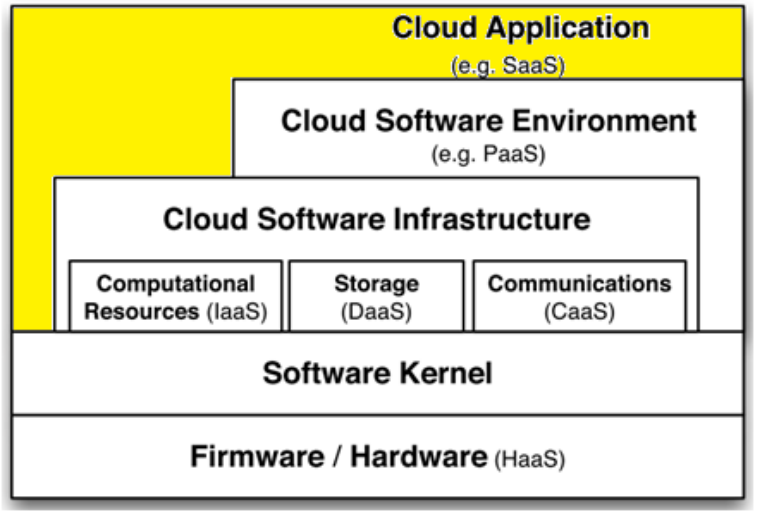
Users access the services provided by this layer through web-portals and are *sometimes* required to pay fees to use them

- Alleviates the burden of software maintenance for both user and cloud application provider
- Permits to use application requiring high computation/memory demand without the need of appropriate local machines

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

Examples:

- Gmail, Webex meeting
- Google Docs and related apps (online office)
- SalesForce.com (CRMaaS)



Cloud Software Environment Layer - PaaS

- **PaaS – Platform-as-a-Service**

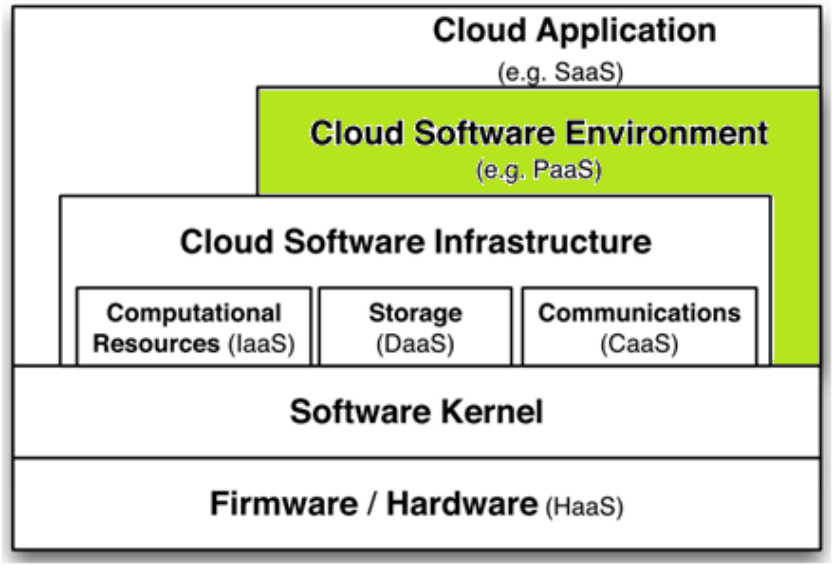
Users are ***application developers*** using cloud to deploy their apps

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
- ***PROBLEM: VENDOR LOCK IN!!***

Examples:

- Amazon SageMaker, AWS AppRunner/,Lambda, Azure App Service/Machine Lerning Machine Learning, Google App Engine/Cloud Run

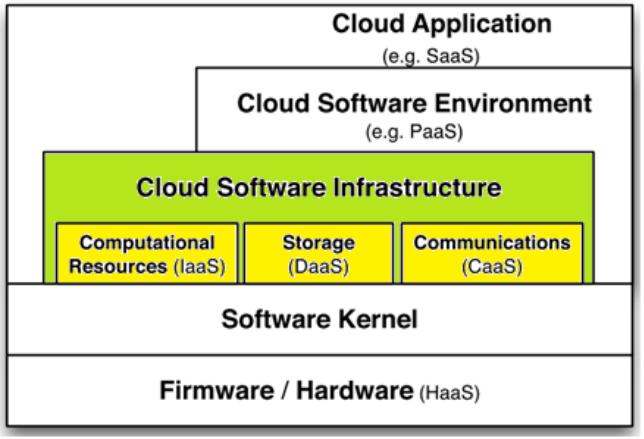


Cloud Software Infrastructure Layer

- Provides resources to the higher-level layers (i.e., Application and Software Environment)
- Allows the user to rent essential IT infrastructure, like servers, storage, and networking, over the internet
- Frees the user from the burden of managing hardware and allows you to scale your resources up or down quickly as your needs change

Cloud Software Infrastructure Layer

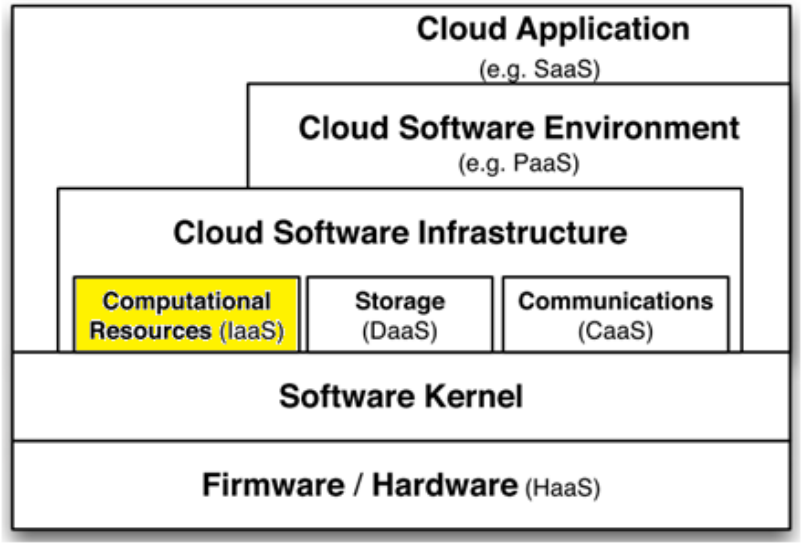
- **IaaS - Infrastructure-as-a-Service**: Computational Resources
- **DaaS - Data-storage-as-a-Service**: Storage
- **CaaS - Communication**: Communications



Infrastructure as a Service (IaaS)

- Provides computational resources in terms of Virtual Machines where you can customize and run your software stack
- Virtual Machines (VM) vs dedicated hardware – Rent vs Buy!
  - VM's benefits:
    - Flexibility given the super-user (root) access to VM for fine granularity settings and customization of installed sw
  - VM's issues:
    - Performance interference and Inability to provide strong guarantees about SLAs in case of competitive price

- Examples of commercial solutions
  - Amazon Elastic Cloud (EC2)
  - Microsoft Azure
  - Google Compute Engine
- Examples of open-source projects
  - Apache CloudStack
  - Open Stack
  - Open Nebula



Data as a Service (DaaS)

Secure and scalable solution for storing your data in the cloud

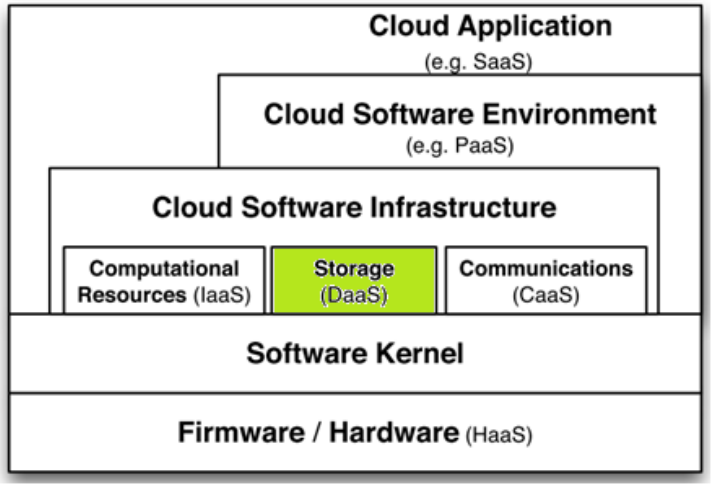
Allows users to

- 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 DBaaS, GoogleStorage, Amazon S3 are examples of DaaS
- CEPH is an open-source solution

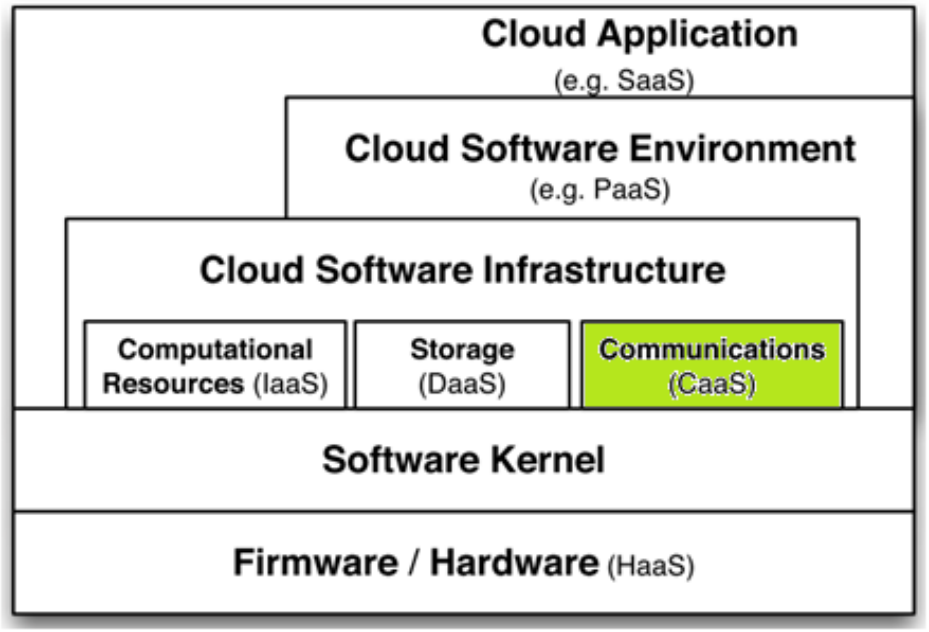


Communications as a Service (CaaS)

Communications becomes a vital component in guaranteeing QoS

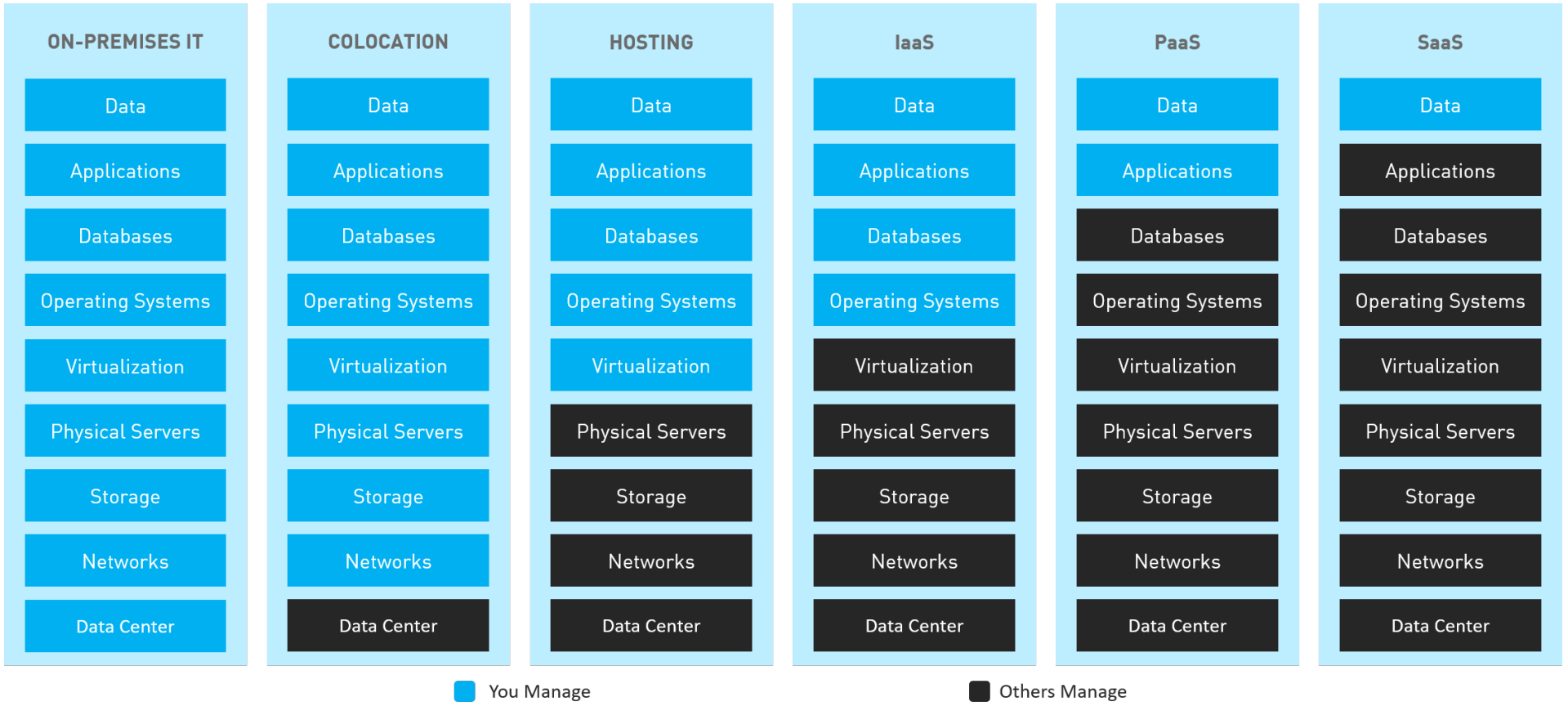
- Communication capability: service oriented, configurable, schedulable, predictable, and reliable
- Network security, dynamic provisioning of virtual overlays for traffic isolation or dedicated bandwidth, guaranteed message delay, communication encryption, and network monitoring

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

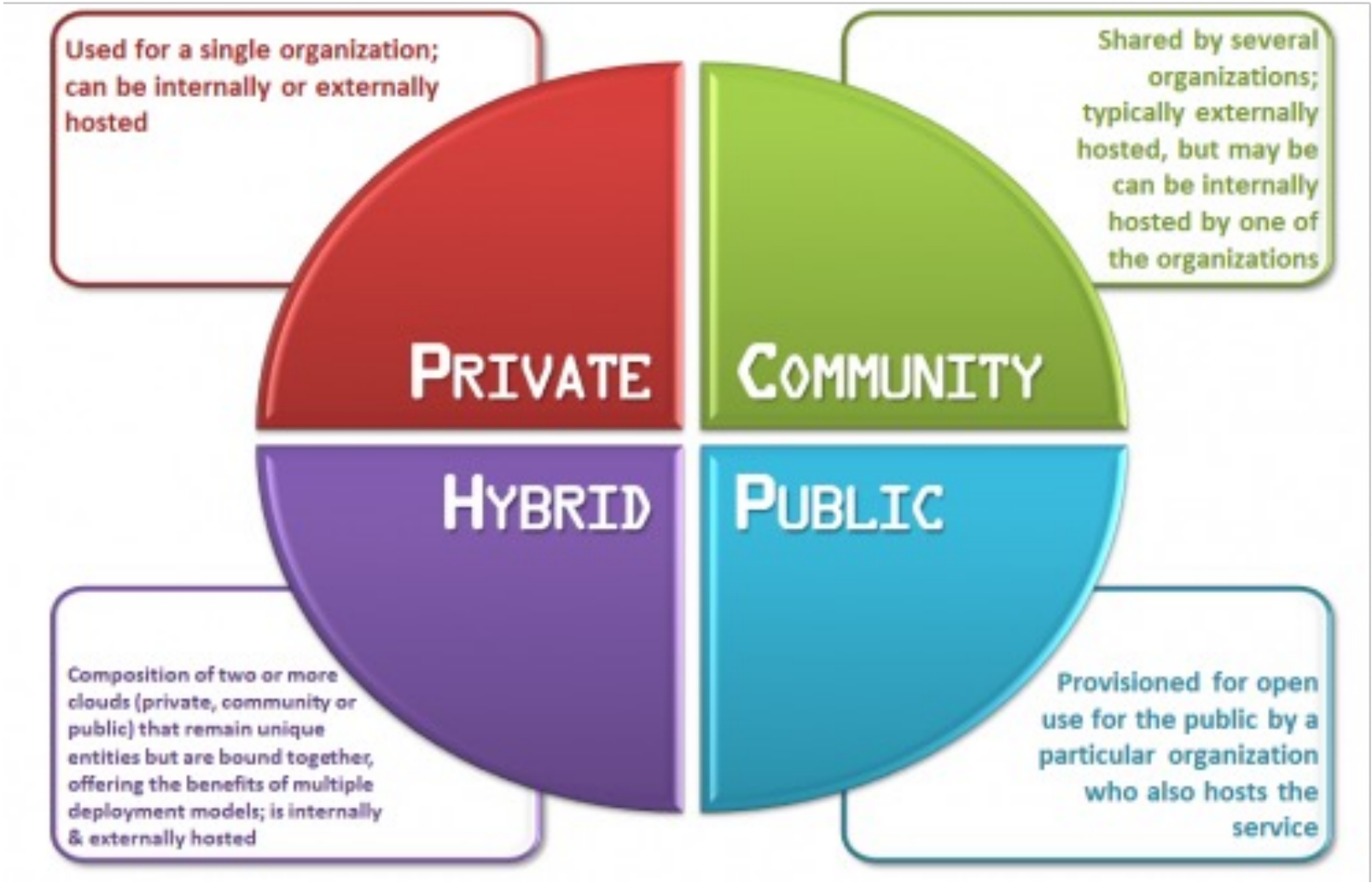


SaaS, PaaS, IaaS summary

Remember from the initial lecture…



Types of Clouds



Public Clouds

Large scale infrastructure available on a rental basis

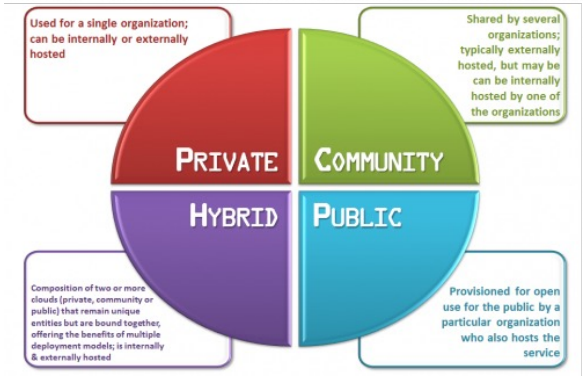
- The definition of Cloud we gave so far

Fully customer self-service

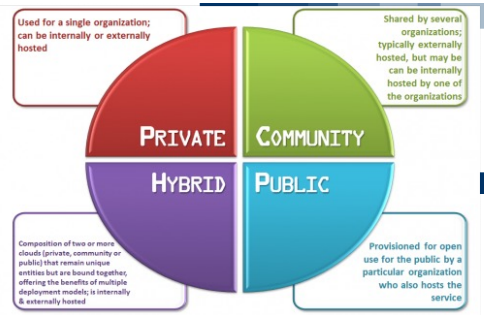
- Service Level Agreements (SLAs) are advertized
- Requests are accepted and resources granted via web services
- Customers access resources remotely via the Internet

Accountability is e-commerce based

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



Private Clouds



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

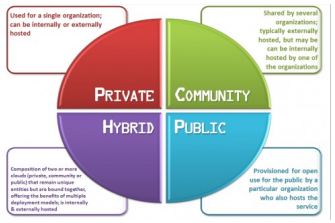
- Combining together several organizations allows economy of scale
- Resources can be shared and used by one organization, while the others are not using them

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



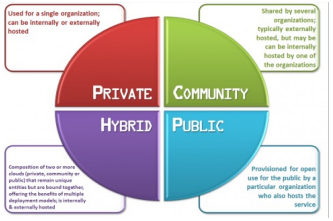
Hybrid Clouds

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



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