An Introduction to Cloud Computing

Stefano Stalio - stefano.stalio@lngs.infn.it

Laboratori Nazionali del Gran Sasso - INFN

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The following definition of Cloud Computing has been developed by the U.S. National Institute of Standards and Technology (NIST):

Definition of Cloud Computing

Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models.

The characteristics of Cloud Computing include:

- **On-demand Self Service**
- **Broad Network Access**
- **Resource Pooling**
- **Rapid Elasticity**
- **Measured Service**.

On-demand self service means that customers (usually organizations) can request and manage their own computing resources. **Broad network access** allows services to be offered over the Internet or private networks. **Pooled resources** means that customers draw from a pool of computing resources, usually in remote data centres. **Services can be scaled** larger or smaller, and **use of a service is measured** and customers are billed accordingly.

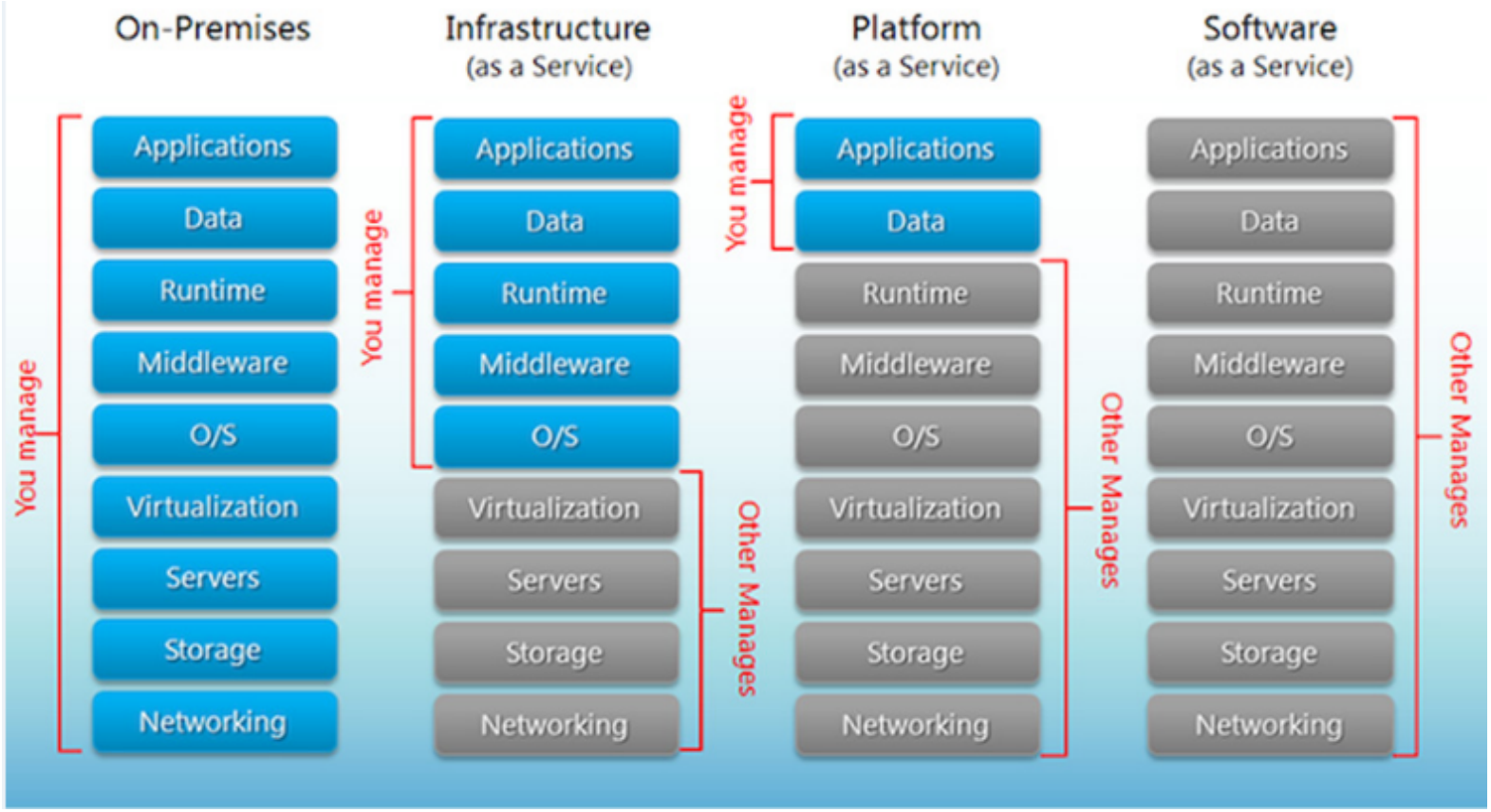
The Cloud Computing service models are:

- **Software as a Service** (SaaS),
- **Platform as a Service** (PaaS),
- **Infrastructure as a Service** (IaaS).

In a **Software as a Service** model, a pre-made application, along with any required software, operating system, hardware, and network are provided.

In **PaaS**, an operating system, hardware, and network are provided, and the customer installs or develops its own software and applications.

The **IaaS** model provides just the hardware and network; the customer installs or develops its own operating systems, software and applications.

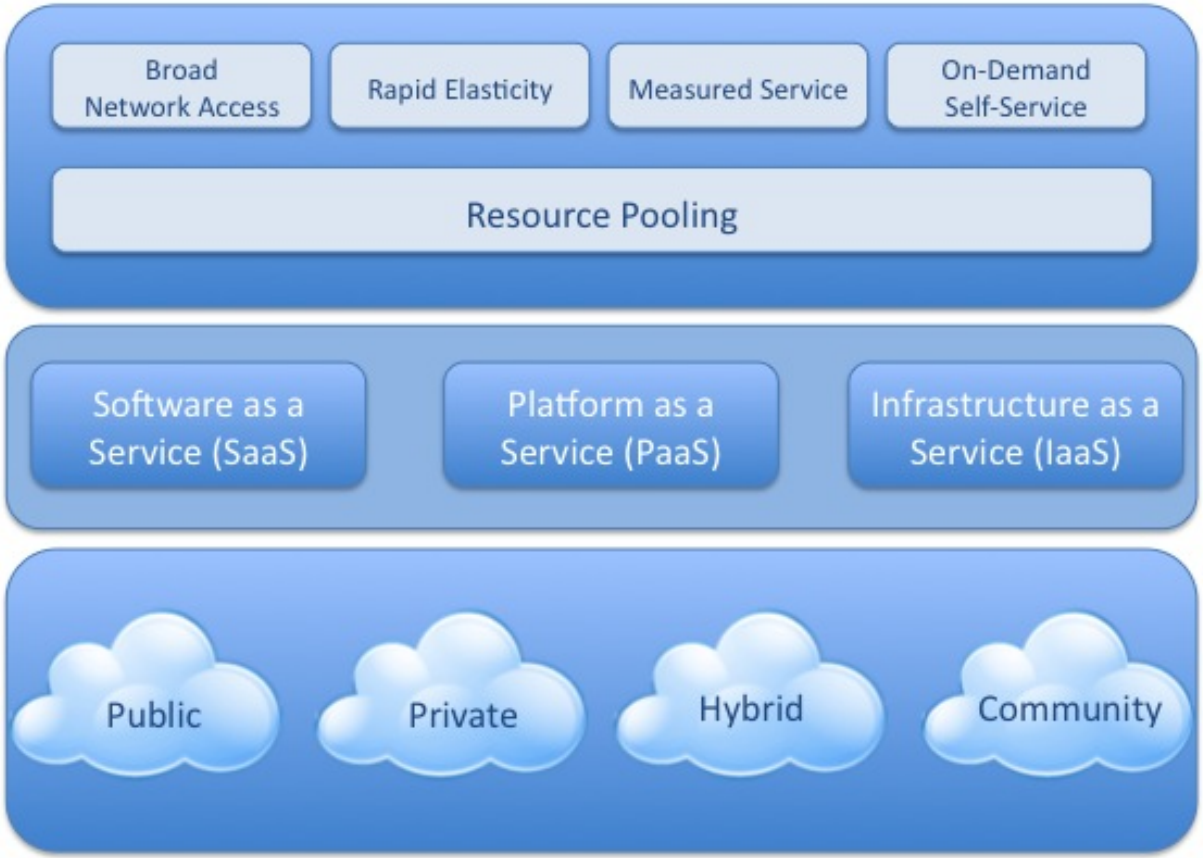

On-Premises
Infrastructure (as a Service)
Platform (as a Service)
Software (as a Service)
Applications
Data
Runtime
Middleware
O/S
Virtualization
Servers
Storage
Networking
You manage
You manage
You manage
Other Manages
Other Manages
Other Manages

Cloud services are typically made available via a **private cloud**, **community cloud**, **public cloud** or **hybrid cloud**.

- Services provided by a **public cloud** are offered over the Internet and are owned and operated by a cloud provider.
- In a **private cloud**, the cloud infrastructure is operated solely for a specific organization, and is managed by the organization or a third party.
- In a **community cloud**, the service is shared by several organizations and made available only to those groups. The infrastructure may be owned and operated by the organizations or by a cloud service provider.
- A **hybrid cloud** is a combination of different methods of resource pooling (for example, combining public and community clouds).

Cloud Computing - Summary

Visual Model Of NIST Working Definition Of Cloud Computing
http://www.csrc.nist.gov/groups/SNS/cloud-computing/index.html



Essential Characteristics

Service Models

Deployment Models

Cloud Computing - Examples

Cloud vs Grid 1/2

The Cloud and the Grid computing models have many similarities, mostly because **they both make remote computing resources available to users that do not own them and do not have to manage them** and they both rely on the availability of broadband network connections.

But they also differ in many aspects:

- As regards **ownership**: a Grid is a collection of computers which is owned by multiple parties in multiple locations and connected together so that users can share the combined power of resources, whereas a Cloud is a collection of computers usually owned by a single party.
- As for **resource distribution**: Cloud Computing is a centralized model whereas Grid Computing is a decentralized model where the computation could occur over many administrative domains.

Cloud vs Grid 2/2

- The Grid was realized by the scientific community with the purpose of coping with its own peculiar computing needs, while the Cloud was thought and realized by powerful IT companies in order to be delivered as a set of services to their clients.
- While Grid services were never able to break the barrier and become widely used outside the scientific community, the Cloud is being used more and more by the scientific community, outside of the traditional audience.
- Simplicity of use is in the Cloud developers mind, while efficiency was the main thought of Grid developers.
- Virtualization techniques, and thus dynamic reallocation of computing resources, are fundamental components of Cloud Computing while they were not mature enough to be adopted by the Grid at the time of its development.

The **INFN IT departments are interested in Cloud Computing technologies**, as this paradigm is seen as the main scenario for scientific computing in the near future, and they are willing to become IaaS service providers for their user and experiments and for third parties.

The INFN Commissione Calcolo e Reti recently formed a **Cloud Working Group** whose members are interested in realizing Cloud services and studying and testing new technologies and solutions related to the Cloud.

The Cloud Working Group many activities are described, in a quite chaotic fashion, at the url http://wiki.infn.it/cn/ccr/cloud/home

INFN Meetings involving the Cloud

- 2012/10/26 - CCR (LNF):
  Round table on Cloud Computing in INFN sites.
  https://agenda.infn.it/conferenceDisplay.py?confId=5455
- 2012/11/29-30 - GARR Workshop on Calcolo e Storage Distribuito (Roma):
  Riflessioni INFN su prospettive per armonizzazione Cloud e Grid.
  http://www.garr.it/workshop-garr-calcolo-e-storage-distribuito
- 2012/12/14 - CCR (Roma):
  Talks about Cloud usage for scientific computing, network services and for technology transfer projects.
  https://agenda.infn.it/conferenceDisplay.py?confId=5625

- 2013/02/06 - CCR (Bologna):
  CCR tutorial day on Cloud Computing.
  https://agenda.infn.it/conferenceDisplay.py?confId=5900
- 2013/05/27-31 - CCR Workshop (Genova): see
  sessions dedicated to Cloud Computing on 5/28 and 5/31.
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The INFN Cloud Working Group - 2/2

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Next meeting

The next **CCR Cloud Working Group** meeting will be on **October 23, 2013** in Bologna.

Cloud and LNGS - 1/3

LNGS adopted host virtualization techniques for the delivery of network services quite early compared to other institutions:

- **2008** The first fully functional virtualized infrastructure for the delivery of highly available network services is realized.
- **2010** A Cloud infrastructure (the name "cloud" was not used yet at the time!) was developed together with a local IT company in order to realize an on-line laboratory for an e-learning course on the high availability of network services.

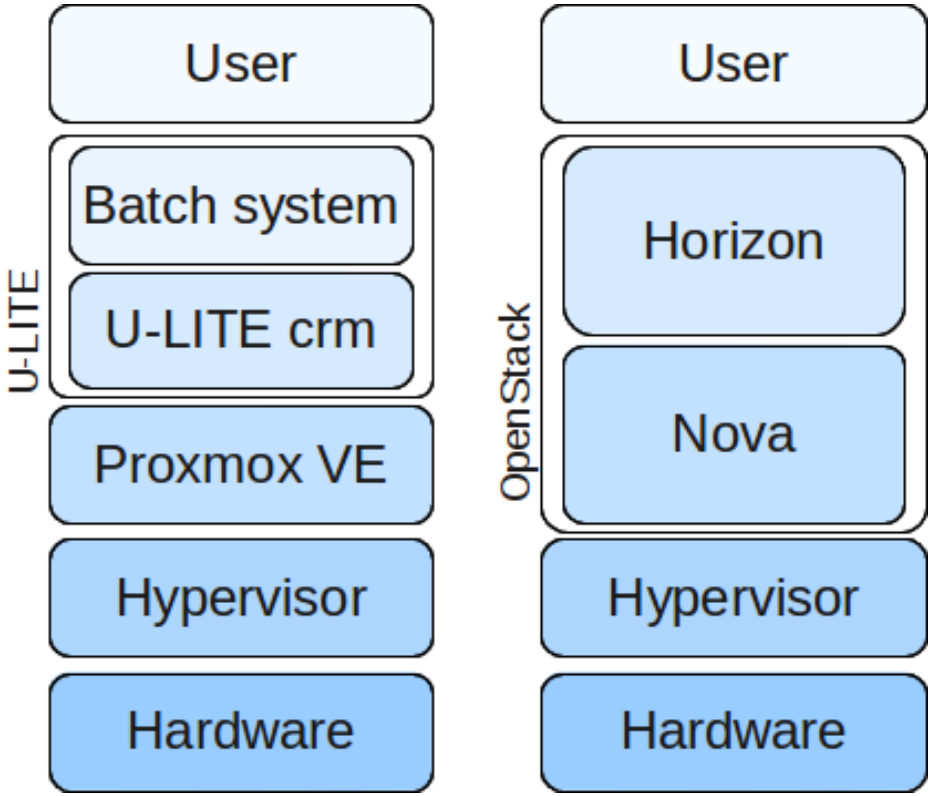
- **2012** A PaaS infrastructure suited for HTC batch job submission is active. This system, mostly developed at LNGS, is known as the **U-LITE Computing Cluster** and has been described on arXiv.org at http://arxiv.org/abs/1212.4658

  The U-LITE Computing Cluster is today **the main computing facility at LNGS** and a mature and reliable computing platform used by most LNGS experiments and by some non-INFN scientific projects.

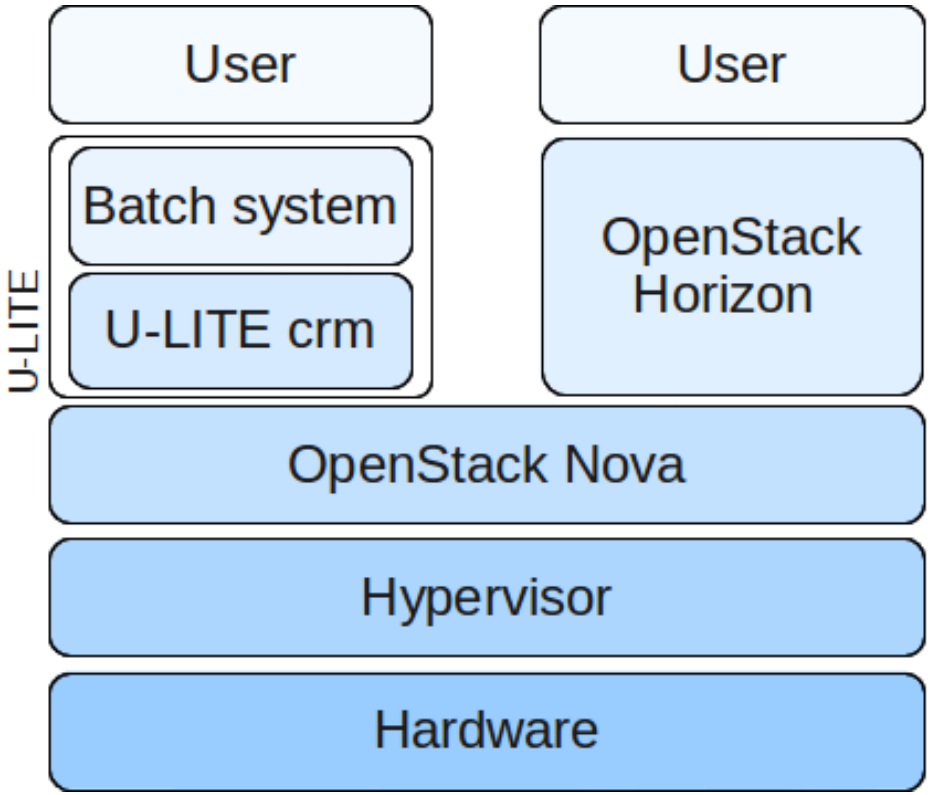
- **2013 Gran Sasso Clouds**, an IaaS Cloud Computing platform, based on the OpenStack (http://www.openstack.org/) open-source software, is available at LNGS.
  It allows experiments and working groups to create, customize and use their own VMs, virtual disks and their network infrastructure.

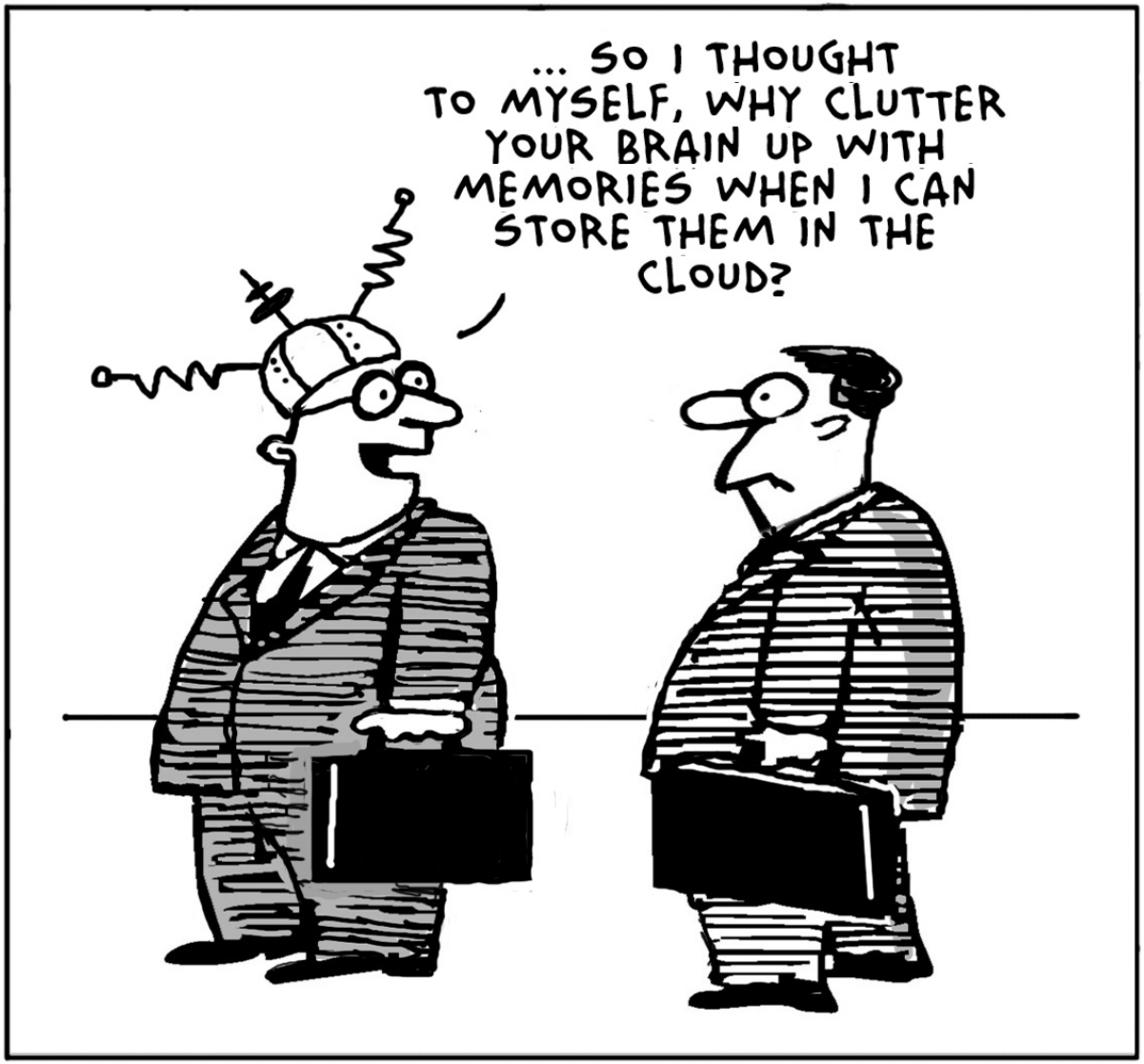
  The OpenStack IaaS Cloud at LNGS will be described in depth in the second part of this seminar.

The **U-LITE Computing Cluster** and **Gran Sasso Clouds** use similar hardware architectures and the same hypervisor (KVM), but they are today distinct entities, with no possibility of resource sharing.



Both systems would benefit if hardware resource sharing was possible and some of the middleware components were common. Such change in the U-LITE Computing Cluster tough is not trivially realized because some architectural aspects must be revisited. **In the todo list!**




... SO I THOUGHT TO MYSELF, WHY CLUTTER YOUR BRAIN UP WITH MEMORIES WHEN I CAN STORE THEM IN THE CLOUD?