OpenNebula.org

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OpenNebula Tutorial

Constantino Vázquez Blanco

Borja Sotomayor

DSA-Research.org

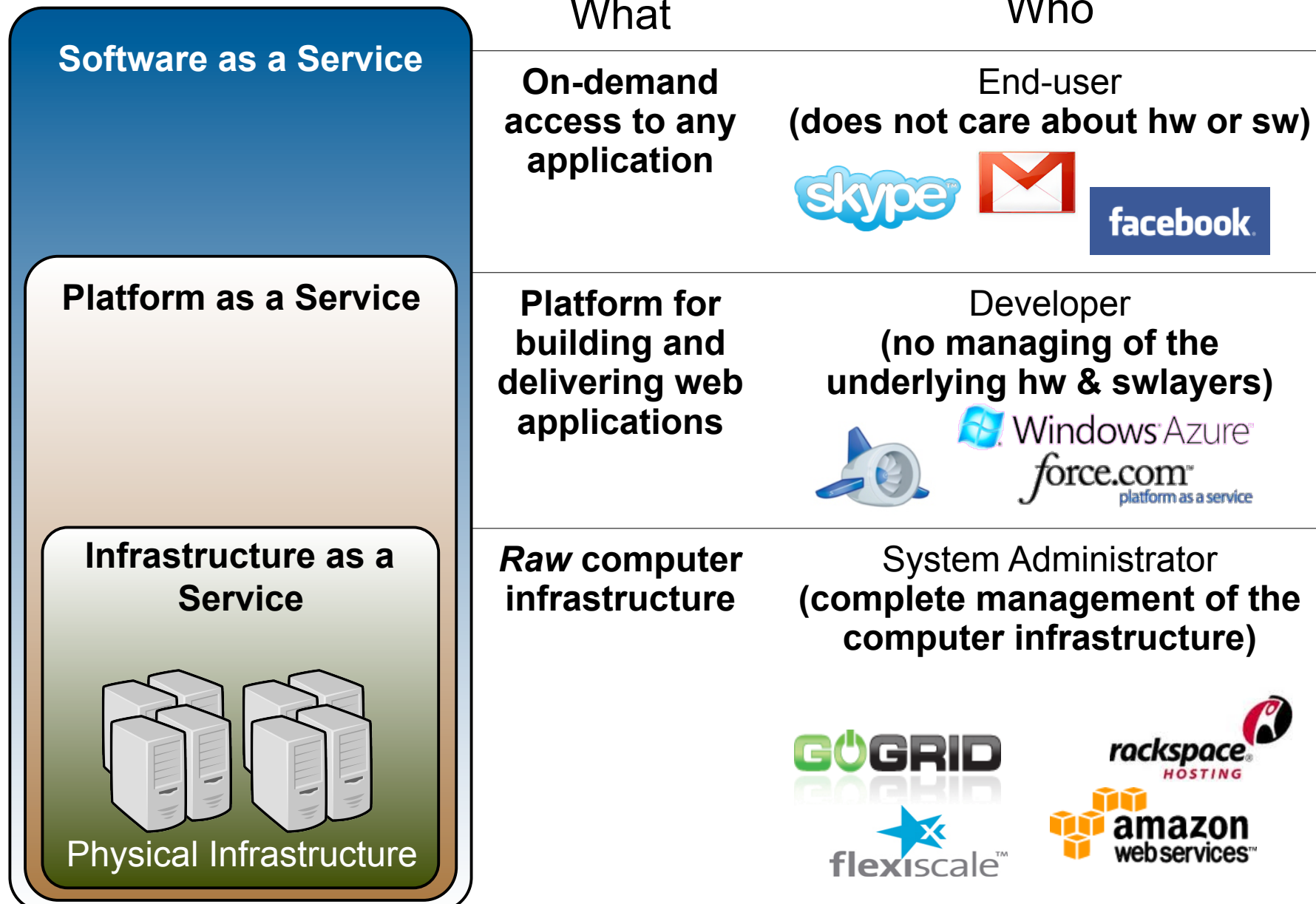Distributed Systems Architecture Research Group
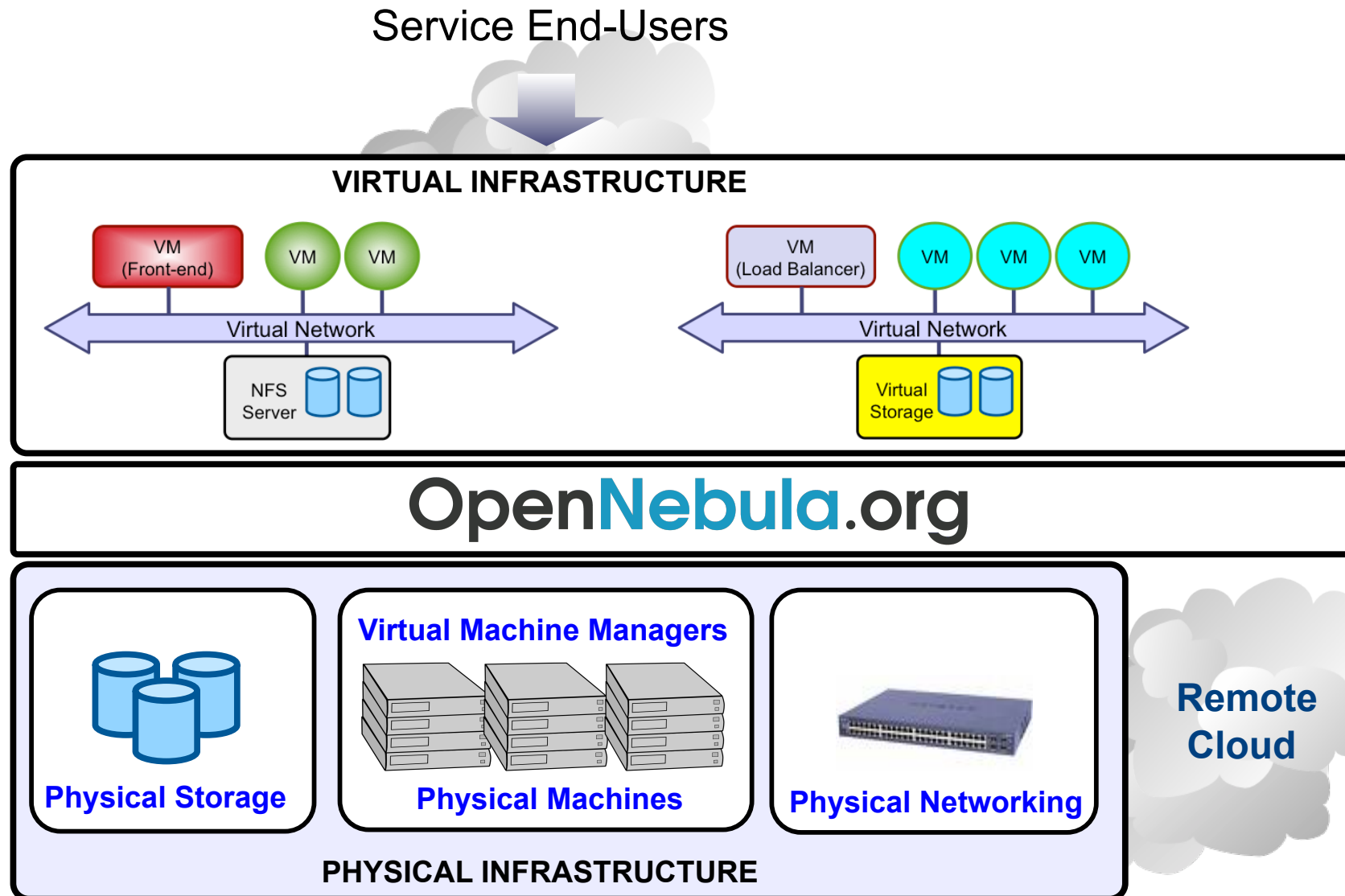Universidad Complutense de Madrid

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- **OpenNebula Overview**

- **Installation and Configuration**

- **Private Cloud: Administration and Basic Usage**

- **Hybrid Cloud: Overview**

- **Public Cloud: Overview**

- **Use Cases**

OpenNebula Overview

A Model for Delivering IT Capabilities

	What	Who
Software as a Service	**On-demand access to any application**	End-user (does not care about hw or sw)
Platform as a Service	**Platform for building and delivering web applications**	Developer (no managing of the underlying hw & sw layers)
Infrastructure as a Service	*Raw* computer infrastructure	System Administrator (complete management of the computer infrastructure)
Physical Infrastructure		

The Data Center is the Computer

Cloud Manager to Orchestrate the Complexity of a Datacenter

Service End-Users

VIRTUAL INFRASTRUCTURE

VM (Front-end)

VM

VM

Virtual Network

NFS Server

VM (Load Balancer)

VM

VM

VM

Virtual Network

Virtual Storage

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Virtual Machine Managers

Physical Storage

Physical Machines

Physical Networking

Remote Cloud

PHYSICAL INFRASTRUCTURE

OpenNebula: *Leading Interoperability and Innovation in Cloud Computing Management*
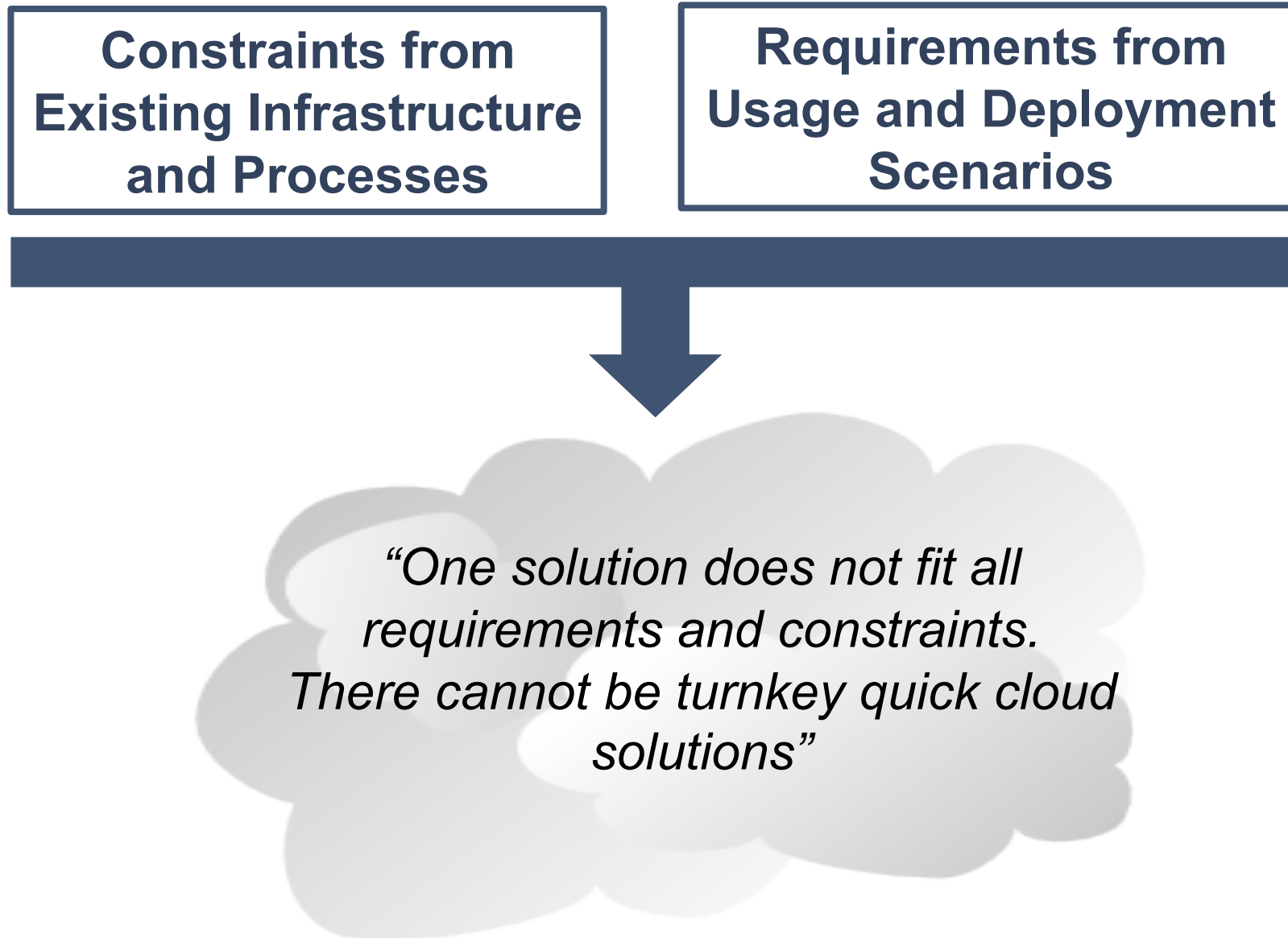
IaaS Cloud Computing

Private Cloud Computing => A "Public Cloud behind the firewall"

- Simplify and optimize internal operations

- Service flexibility and elasticity

- Higher utilization & operational savings

- Security concerns

OpenNebula

Physical Infrastructure

Commercial Cloud
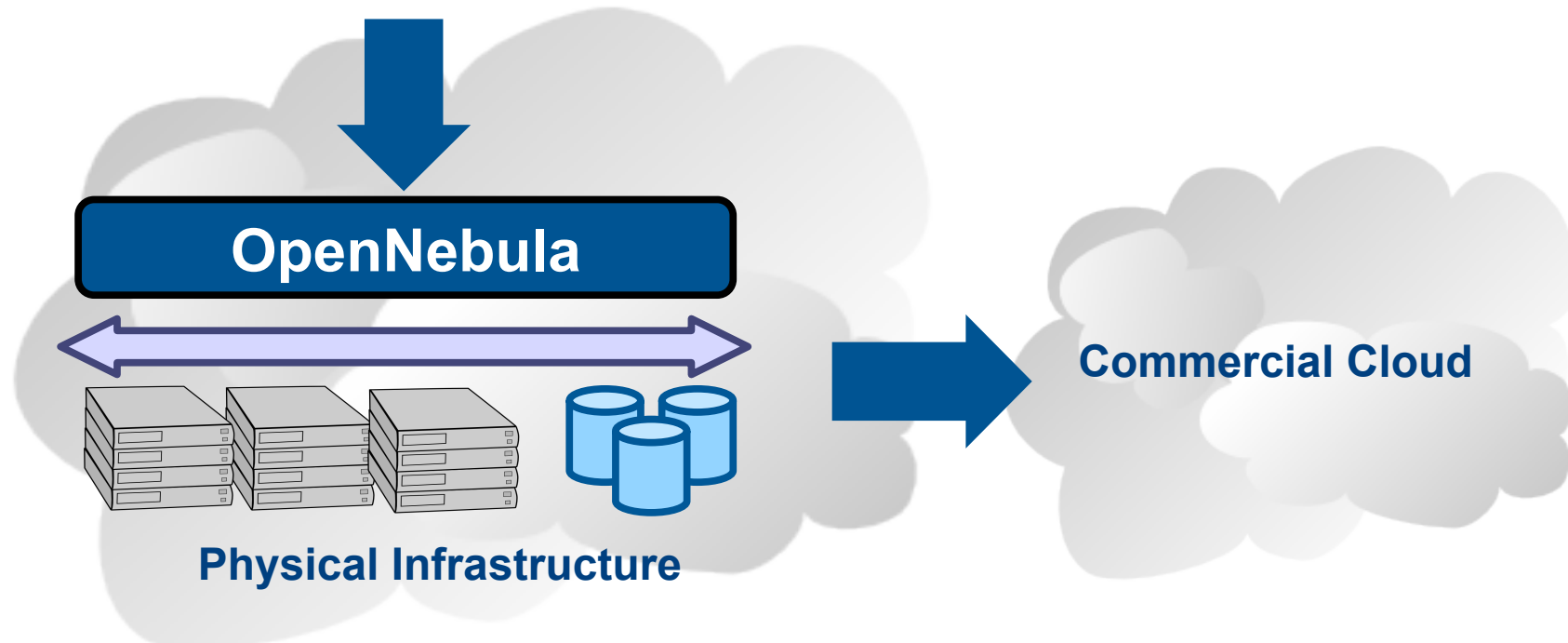
Hybrid Cloud Computing => Utility Computing dream made a reality!

• Supplement the capacity of the Private Cloud

An Evolution of the Data Center

Constraints from Existing Infrastructure and Processes	Requirements from Usage and Deployment Scenarios

"One solution does not fit all requirements and constraints. There cannot be turnkey quick cloud solutions"

> ## Flagship International Projects in Cloud Computing
> Result of many years of research and development in efficient and scalable management of virtual machines on large-scale distributed infrastructures.

> ## Open-source Toolkit
> Open platform for innovation to research the challenges that arise in cloud management, and production-ready tool in both academia and industry

- **Started in 2005, first release in march 2008, and ONE 2.0 just released**

- **Open-source** released under Apache v2.0, packaged for main Linux distributions

- Mailing lists for **best-effort support** and **open development framework**

- Development and roadmap definition **driven by the community and projects**

- Active and engaged **open community and ecosystem**

- > **3,000 downloads/month** (not including code repository and Ubuntu)

- Used in many **production environments**, distributed in **commercial solutions** and availability of **commercial professional support by C12G Labs**

- **Long-term sustainability** ensured by project funding and commercial sponsors

The OpenNebula Toolkit: Why OpenNebula?

OpenNebula.org

Capabilities for Cloud Management
Most advanced open-source toolkit offering unique features to administer the complexity of large-scale distributed infrastructures

Capabilities for Integration
Open, flexible and extensible architecture, interfaces and components that fit into any existing data center

Capabilities for Production Environments
Scalability and performance tested on very large-scale infrastructures consisting of thousands of cores, with the security and fault tolerance levels required in production

Leverage the Vibrant Cloud Ecosystems
Leverage the ecosystems being built around OpenNebula and the most common cloud interfaces, Amazon AWS, OGC OCCI and VMware vCloud
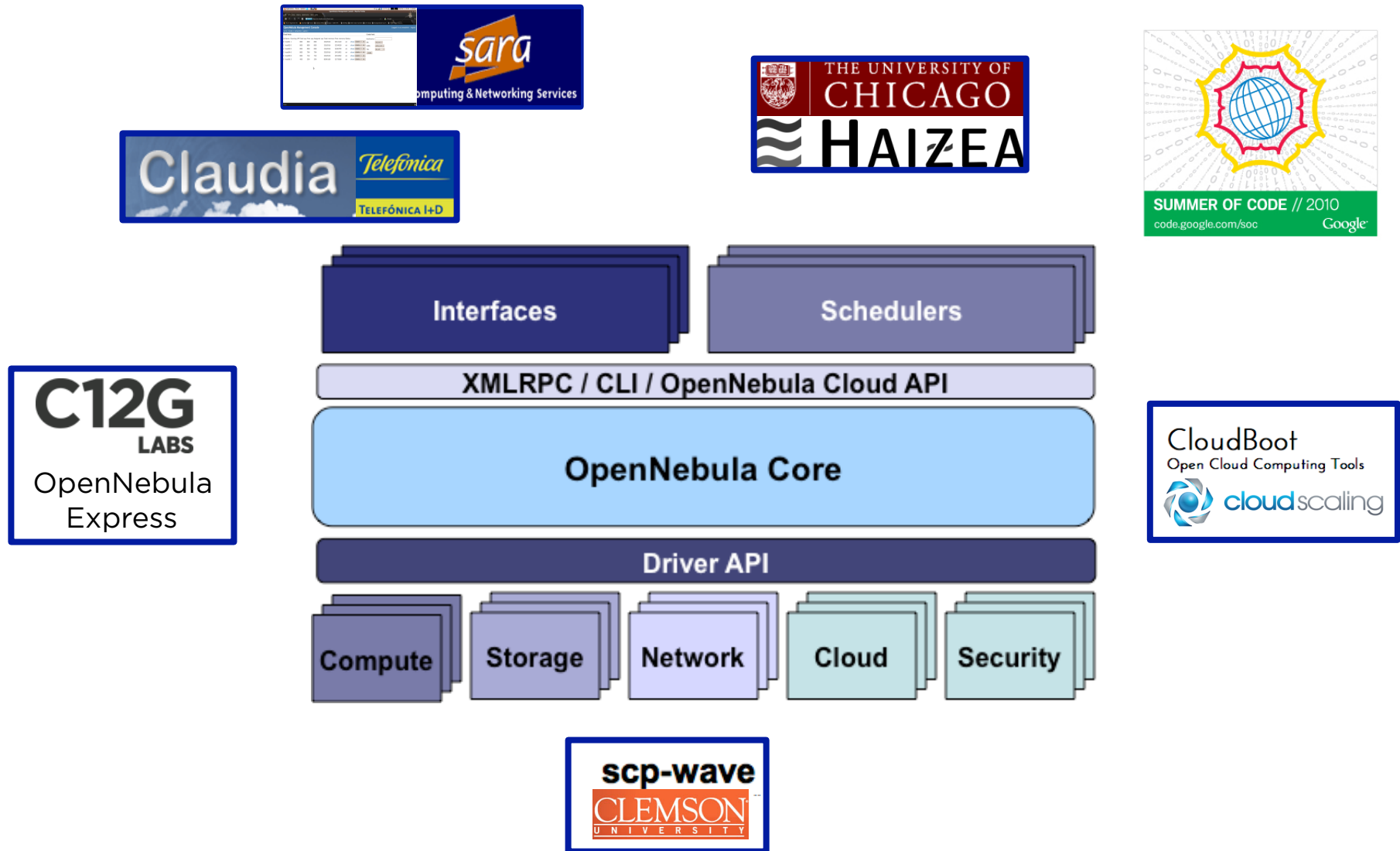
Fully Open Source Cloud Software
OpenNebula is NOT a feature or performance limited edition of an Enterprise version. OpenNebula is truly open, and not open core.

The OpenNebula Toolkit: Flexibility

A Highly Modular Architecture to Fit into any Existing Datacenter

- Cloud Computing is an **evolution of existing data centers**

- One solution can not fit all data-center and user requirements and constraints

- Open, flexible and extensible architecture

- Provide basic components, but allow them to be easily replaceble by others

Interfaces	Schedulers

XMLRPC / CLI / OpenNebula Cloud API

OpenNebula Core

Driver API

Compute	Storage	Network	Cloud	Security
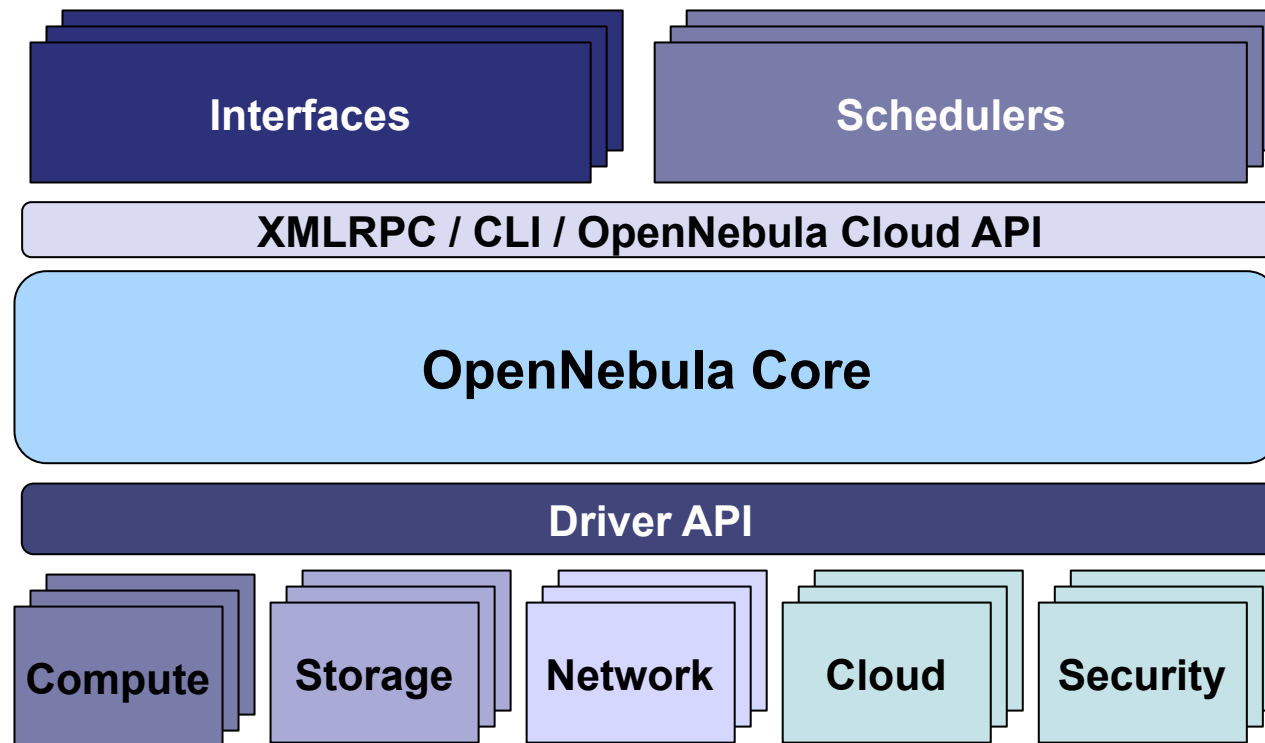
Examples of Components in the Ecosystem

The OpenNebula Toolkit: Interoperability

Openness

- Open architectures
- Open interfaces
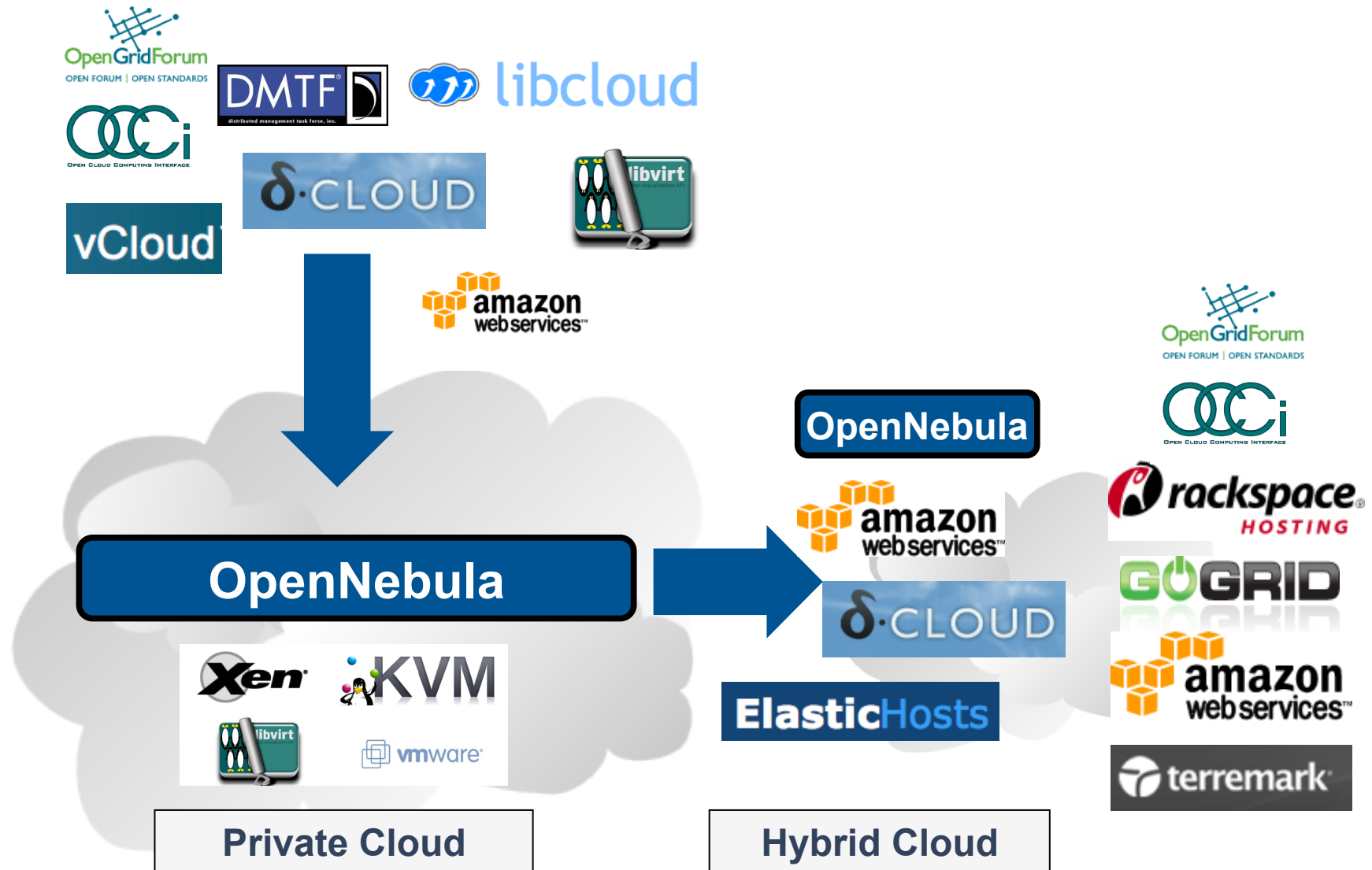- Open code

Adaptability

- Modular architectures

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Standardization

- Use standards
- Implement standards

Portability

- It can be installed in any hardware and software

The OpenNebula Toolkit: Interoperability

Private Cloud

Hybrid Cloud

Installation and Configuration

Planning the Installation

- Executes the OpenNebula Services
- *Usually* acts as a classical cluster front-end

FRONT-END

ONED

Drivers   Images

- Repository of VM images
- Multiple backends (LVM, iSCSI..)

- Modular components to interact with the cluster services
- *Types:* storage, monitoring, virtualization and network

SSH   Images

Hypervisor

CLUSTER NODE 1

SSH   Images

Hypervisor

CLUSTER NODE 2

⚠ The same host can be can be a the front-end and a node

- Provides physical resources to VMs
- *Must have* a hypervisor installed

- $ONE_LOCATION/etc/oned.conf
- General configuration
- Defines the drivers used in the private cloud

- Match-making scheduler (default)
- Placement policies configured per VM

OpenNebula Daemon

Scheduler

VMM drivers

TM drivers

IM drivers

OpenNebula

- $ONE_LOCATION/etc/im_*/im_*.conf
- Defines monitoring probes

- $ONE_LOCATION/etc/vmm_*/vmm_*.conf
- Defaults values for the hypervisor

- $ONE_LOCATION/etc/tm_*/tm_*.conf
- Defines action for generic storage operations

Private Cloud
Administration and Basic Usage

- Add physical **Hosts**

- Create **Users**

- Define VM **Images**

- Define **Virtual Networks**

- Create **Virtual Machine** Templates

- Launch **Virtual Machines**

Hosts

- A Host in OpenNebula

  - Is a resource with capacity (CPU, memory)

  - Is able to run VMs

  - Must be configured as an OpenNebula node

- Host definition

  - **Name** of the physical host

  - **Drivers**

    - **Information**, to extract resource usage

    - **Virtualization,** to interact with the hypervisor

    - **Transfer**, to perform image provision

- From OpenNebula 2.0 onwards – Logic clusters

  - Groups hosts to enforce placement policies

- Hosts are managed with the `onehost` command

Users

- A User in OpenNebula

    - Is an entity that owns resources

- User definition

    - **Name**

    - **Password**

- From OpenNebula 2.0 onwards – Auth module

    - Pluggable architecture

    - Drivers for ssh and ldap

- Users are managed with the `oneuser` command

- An Image in OpenNebula (> 2.0)

  - Is a VM image contained in a Repository

  - Has metadata on how to use the VM image

- Image definition

  - **Name**, of the image

  - **Source**, of the file

  - Can be **persistent** or **public**

- Images are managed with the `oneimage` command

- A Virtual Network in OpenNebula

  - Defines a separated MAC/IP address space to be used by VMs

  - Each virtual network is associated with a physical network through a bridge

  - Virtual Networks can be isolated (at layer 2 level) with ebtables and hooks

- Virtual Network definition

  - **Name**, of the network

  - **Type**

    - **Fixed**, a set of IP/MAC leases

    - **Ranged**, defines a network range

  - **Bridge**, name of the physical bridge in the physical host where the VM should connect its network interface.

- Virtual Networks are managed with the `onevnet` command

- A Virtual Machine in OpenNebula

  - A **capacity** in terms memory and CPU

  - A set of **NICs** attached to one or more virtual networks

  - A set of **disk images**, to be *transferred* to/from the execution host.

  - A **state file** (optional) or recovery file, with the memory image of a running VM plus some hypervisor specific information.

- Virtual Machines are defined in a **VM template** (text file)

- All the files (logs, images, state files...) are stored in `$ONE_LOCATION/var/<VM_ID>`

- Virtual Machines are managed with the `onevm` command

Virtual Machines

```
NAME    = ttylinux
CPU     = 0.1
MEMORY = 64

DISK      = [ image = "base ttylinux" ]

NIC       = [ NETWORK = "One-TD" ]

#This may be useful to debug your VMs (can use also console)

GRAPHICS = [
  type = "vnc",
  listen  = "loclahost",
  port = "5902",
  keymap="es"]
```

- Using a Virtual Network with your VMs

  - Define NICs attached to a given virtual network. The VM will get a NIC with a free MAC in the network and attached to the corresponding bridge

```
#A VM with two interfaces each one in a different vlan
NIC=[NETWORK="One-TD"]
NIC=[NETWORK="One-TD-Invisible"]

#Ask for a specific IP/MAC of the Red vlan
NIC=[NETWORK="One-TD", IP=192.168.$CN.140]
```

  - Prepare the VM to use the IP. Sample scripts to set the IP based on the MAC are provided for several Linux distributions.

IP-MAC address correspondence

IP: 10.0.1.2

MAC: 02:01:0A:00:01:02

          oned.conf   IP Address

Hybrid Cloud Overview

- VMs can be local or remote
- VM connectivity has to be configured, usually VPNs

Virtual Infrastructure

Virtual Network

OpenNebula

Local Physical

Cloud Provider
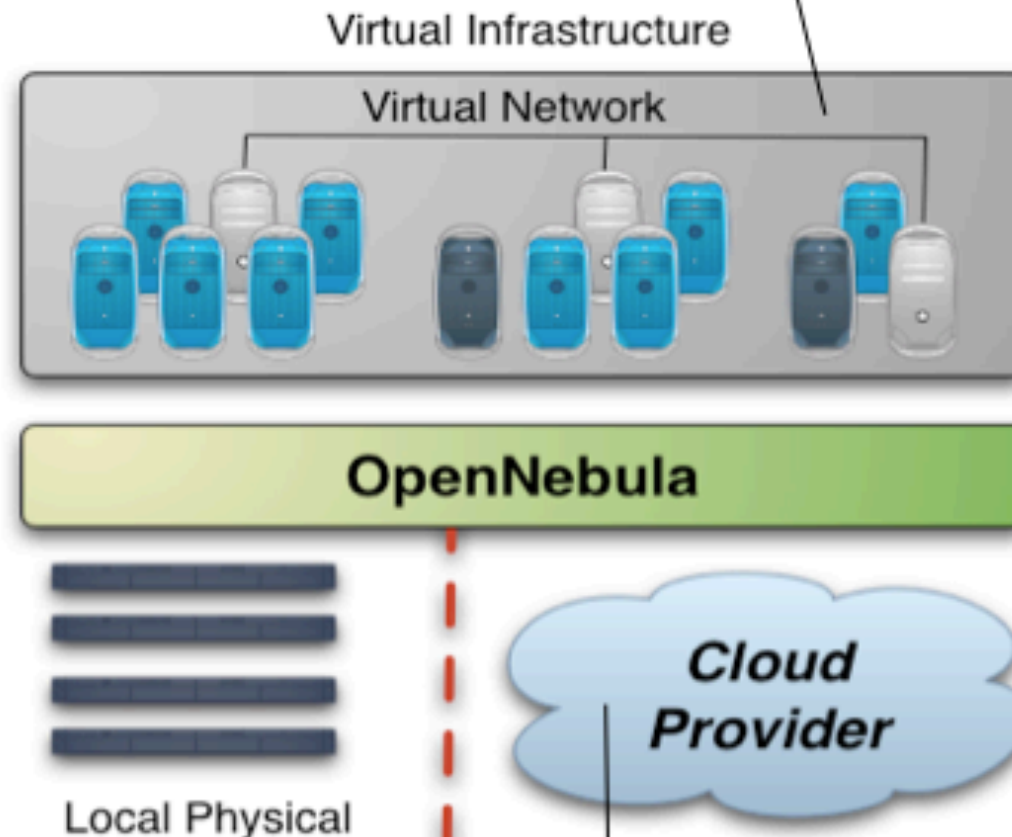
- External Clouds are like any other host
- Placement constraints

```
IM_MAD = [
  name       = "im_ec2",
  executable = "one_im_ec2",
  arguments  = "im_ec2/im_ec2.conf" ]
                # No. of instances of each type

VM_MAD = [
  name       = "vmm_ec2",
  executable = "one_vmm_ec2",
  arguments  = "vmm_ec2/vmm_ec2.conf",
                # Defaults, e.g. keypair
  type       = "xml" ]

TM_MAD = [
    name       = "tm_dummy",
    executable = "one_tm",
    arguments  = "tm_dummy/tm_dummy.conf" ]

    # No actual transfers are made by OpenNebula to EC2
```

- Virtual Machines can be instantiated locally or in EC2

  - The template must provide a description for both instantiation methods.

  - The EC2 counterpart of your VM (`AMI_ID`) must be available for the driver account

  - The EC2 VM template attribute:

```
EC2 = [
  AMI                 = "ami_id for this VM",
  KEYPAIR             = "the keypair to use the instance",
  AUTHORIZED_PORTS    = "ports to access the instance",
  INSTANCETYPE        = "m1.small...",
  ELASTICIP           = "the elastic ip for this instance",
  CLOUD               = "host (EC2 cloud) for this VM"
]
```

Public Cloud
Overview

- You can use multiple interfaces for the Cloud
- Transparent to your setup:
  - Hypervisor
  - Storage Model
  - Hybrid configuration

THIN

Sinatra

CLI

Libvirt

OpenNebula Cloud API

OpenNebula

OpenNebula Cloud

HTTP

ECONE TOOLS

- Client tools uses EC2 libraries
- Potential integration with EC2 tools (EC2_URL problems for example)
- Provided in the OpenNebula distribution
- Includes a simple S3 replacement

- Supports HTTP and HTTPS protocols
- *EC2 authentication* based on OpenNebula credentials
- Public Cloud users need an OpenNebula account

Configuration

```
$ more $ONE_LOCATION/etc/econe.conf
# OpenNebula administrator user, the one_auth contents
USER=oneadmin
PASSWORD=onecloud

# OpenNebula sever contact information
ONE_XMLRPC=http://localhost:2633/RPC2

# Host and port where econe server will run keep FQDNs
SERVER=node-y.opennebula.org
PORT=4567

# Configuration for the image repository
#  IMAGE_DIR will store the Cloud images, check space!
DATABASE=/srv/cloud/one/var/econe.db
IMAGE_DIR=/srv/cloud/public_repo/

# VM types allowed and its template file
VM_TYPE=[NAME=m1.small, TEMPLATE=m1.small.erb]
```

- The **econe-tools** are a subset of the functionality provided by the onevm utility, and resembles the ec2-* cli

- **Image** related commands are:

  - `econe-upload`, place an image in the Cloud repo and returns ID
  - `econe-describe-images`, lists the images
  - `econe-register`, register an image not really needed in 1.4

- **Instance** related commands are:

  - `econe-run-instances`, starts a VM using an image ID
  - `econe-describe-instances`, lists the VMs
  - `econe-terminate-instances`, shutdowns a VM

- User authentication is based in the OpenNebula credentials

  - `AWSAccessKeyId` is OpenNebula's username
  - `AWSSecretAccessKey` is OpenNebula's password

Use Cases

Cloud Case Studies: Enabling your Cloud

Adopt Standards
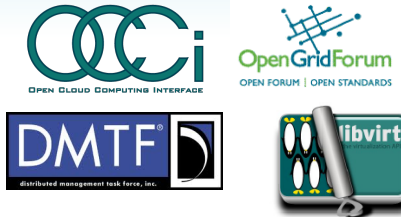
Open Source Community
- Open architecture and interfaces
- Open code abd liberal license
- Open community and ecosystem

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Management Tool

Innovation Tool

OpenNebula: *Leading Interoperability and Innovation in Cloud Co*

Cloud Case Studies: Deployment Models

Model	Definition	Cloud Cases
Private	Infrastructure is owned by a single organization and made available only to the organization	• Optimize and simplify **internal operation** • **SaaS/PaaS** support • IT consolidation within **large organizations** (Goverment Clouds, University Clouds…)
Public	Infrastructure is owned by a single organization and made available to other organizations	• **Commercial cloud providers** • **Science public clouds** by ICT service centers to enable scientific and educational projects to experiment with cloud computing • **Special purpose clouds** with dedicated capabilities (HPC Clouds..)
Hybrid	Infrastructure is a composition of two or more clouds	• **Cloudbursting** to address peak demands • **Cloud Federation** to share infrastructure with partners • **Cloud Aggregation** to provide a larger resource infrastructure

Cloud Case Studies: Computing Provider

Private Cloud to Support Grid Site

- **Goal**: Execution of a virtualized Grid site in D-Grid and EGEE
- **Details**: The D-Grid Resource Center Ruhr (DGRZR) runs an OpenNebula private cloud on 248 blades and 1,984 cores with Xen

Public HPC Cloud

- **Goal**: OpenNebula is used to support the execution of virtual clusters and HPC applications
- **Details**: SARA High Performance Computing Center uses OpenNebula in its new HPC Cloud service

Cloud Case Studies: Computing Provider

- **Goal:** Easier management and new computing models in the batch farm

- **Example of Integration with Existing Infrastructure Environment**

  - **Configuration Management**: Quattor with lifecycle management and "self - notification" in OpenNebula

  - **Network Management**: Adapted to address network infrastructure requirements regarding fixed IP/MAC leases in each box

  - **Storage Management**: New LVM transfer scripts and a very fast parallel scp to push images to all the hosts

Virtual Batch System Scalability

Up to 16,000 VMs on 400 hosts (3,200 cores) running KVM
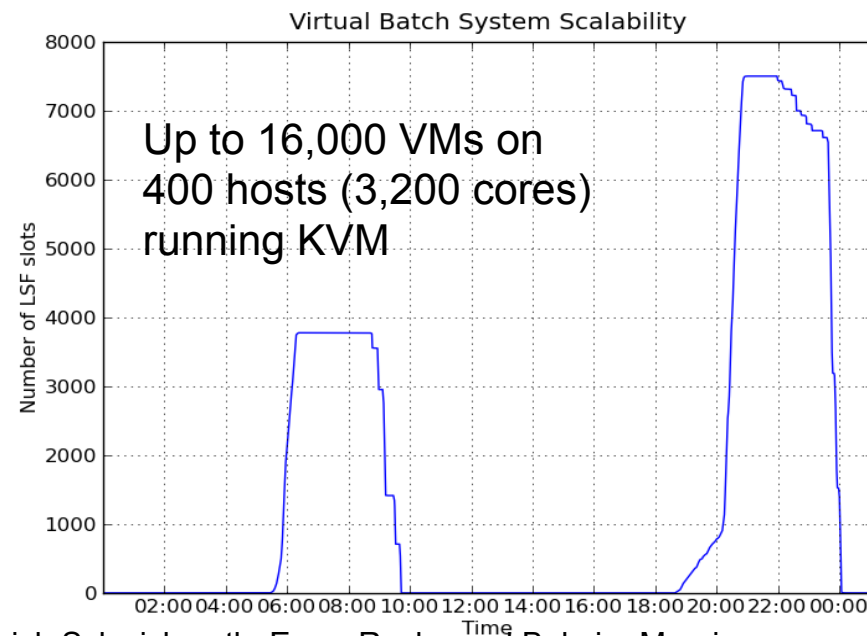
Source: CERN IT-PES/PS Group: Sebastien Goasguen, Ulrich Schwickerath, Ewan Roche and Belmiro Moreira

Cloud Case Studies: Telecom Provider

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- **Goal:** Meet the growing demands for high performance, low cost, high scalability, high reliability of China Mobile IT Infrastructure (computing, storage); and the demands of China Mobile to deliver Internet business and services

- **Details**: 4,096 cores, Xen, Ganglia, and Hadoop
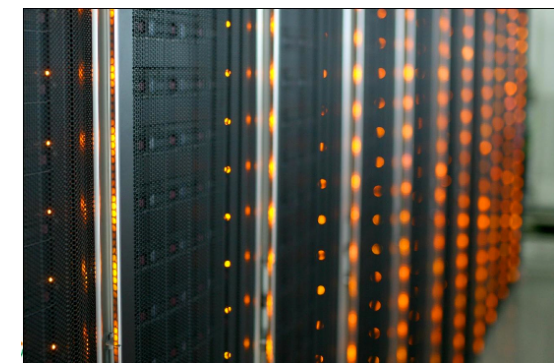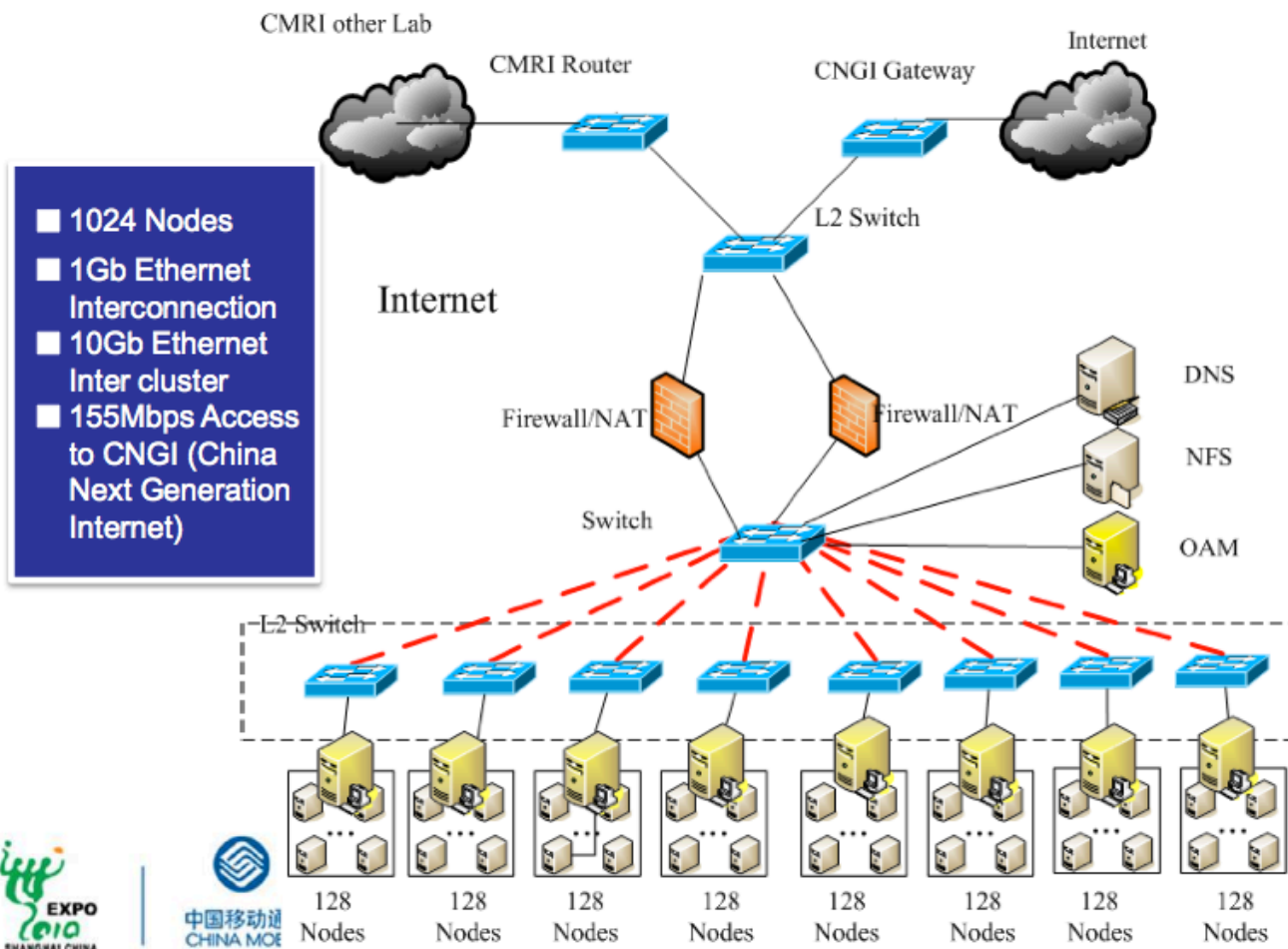
Source: China Mobile's Presentation at OpenCirrus Meeeting

OpenNebula: Leading Interoperability and Innovation in Cloud Computing Management

Cloud Case Studies: Tool for Innovation

RESERVOIR

Agreement 215605 (2008-2011)
Service and Sw Architectures and Infrastructures

Resources and Services Virtualization without Barriers
•Open source technology to enable deployment and management of complex IT services across different administrative domains

IBM

www.reservoir-fp7.eu

Source: RESERVOIR Project
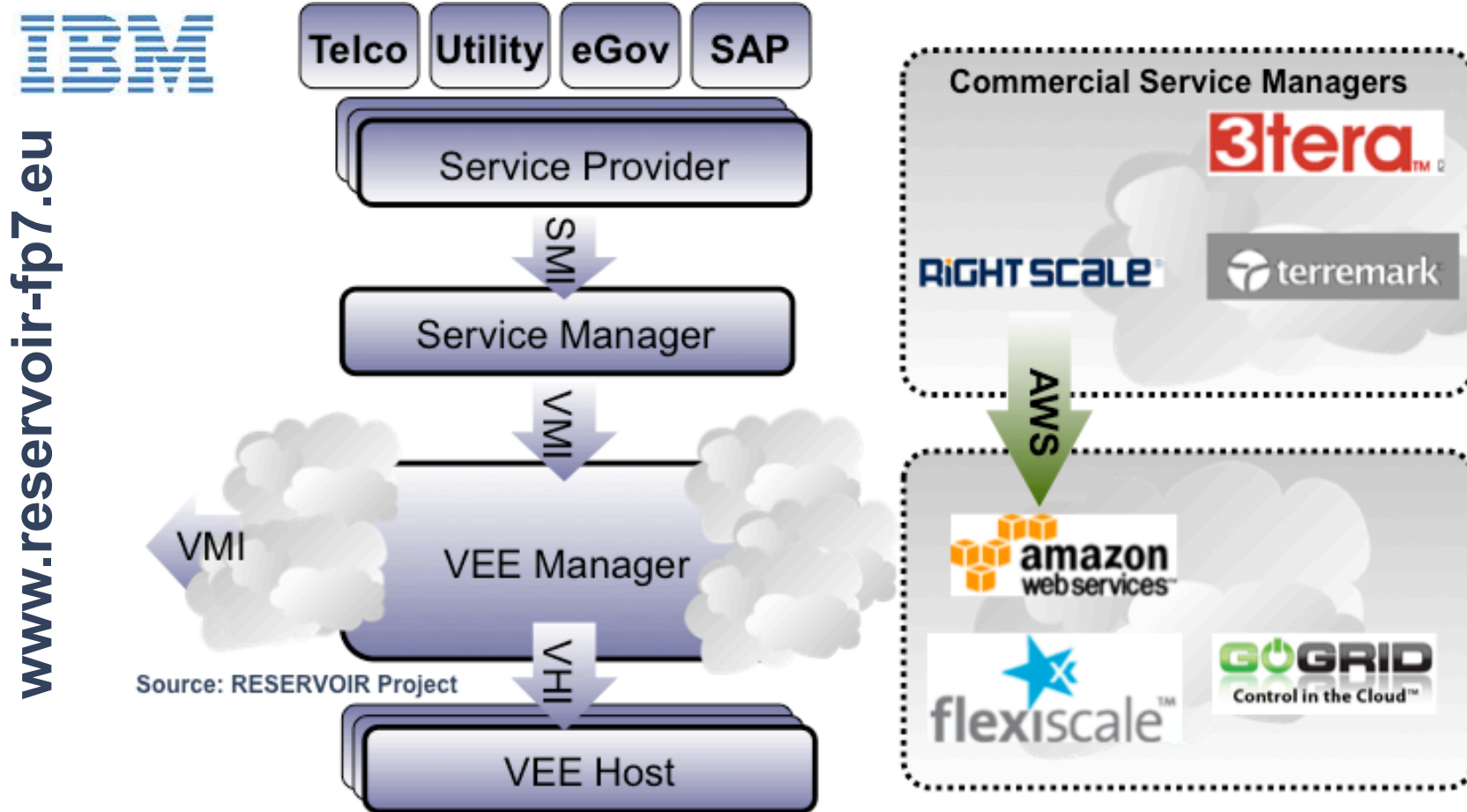
StratusLab

EU grant agreement RI-261552
e-Infrastructure
(2010-2012)

Enhancing Grid Infrastructures with Cloud Computing
•Simplify and optimize its use and operation, providing a more flexible, dynamic computing environment for scientists; and enhance existing computing infrastructures with "IaaS" paradigms

CNrs
dépasser les frontières

www.StratusLab.eu

Source: StratusLab Project

Cloud Case Studies: Tool for Innovation
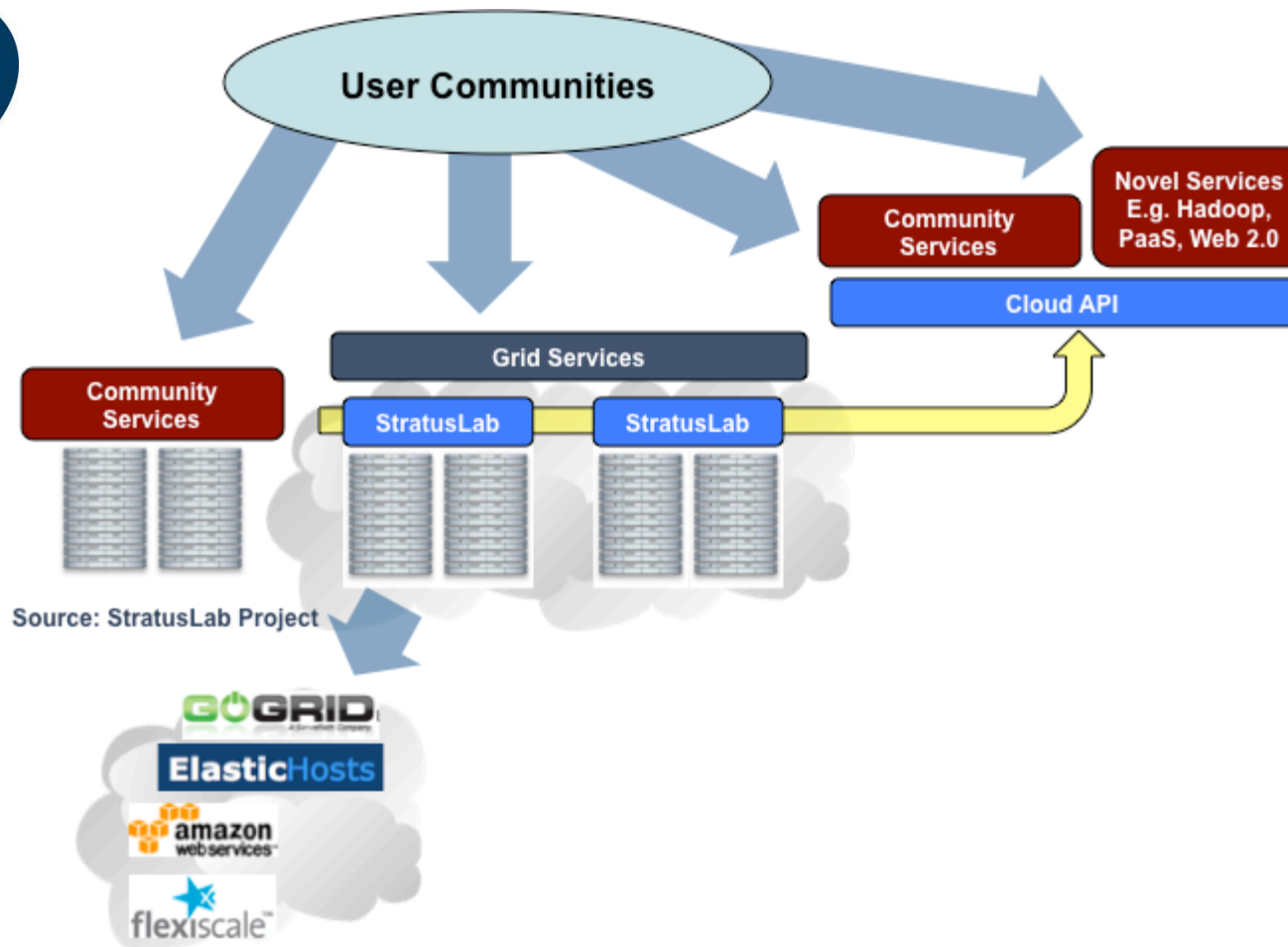
Agreement 257386 (2010-2013)
**New Infrastructure Paradigms
and Experimental Facilities**

Building Service Testbeds on FIRE
•Design, build and operate a multi-site cloud-based facility to support research across applications, services and systems targeting services research community on Future Internet

www.BonFIRE-Project.eu
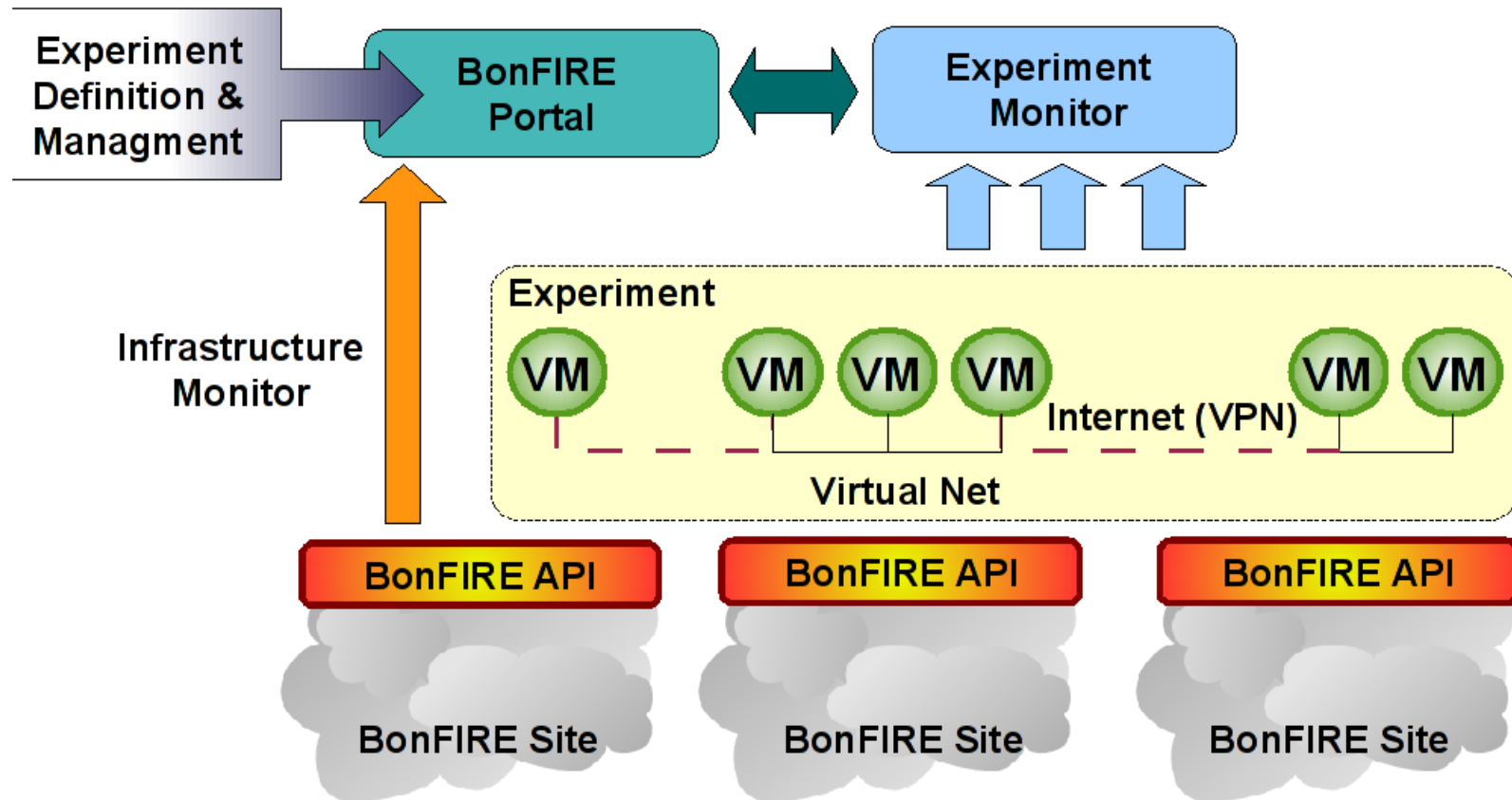
Source: BonFIRE Project

OpenNebula: *Leading Interoperability and Innovation in Cloud Computing Management*

Cloud Case Studies: Tool for Innovation

Agreement 258862 (2010-2013)
Service and Sw Architectures and Infrastructures

Telefónica
Investigación y Desarrollo

4caast.morfeo-project.org

Building the PaaS Cloud of the Future
•Create an advanced PaaS Cloud platform which supports the optimized and elastic hosting of Internet-scale multi-tier applications

Level of abstraction

Software as a Service (SaaS)
- Provision of a) desktop software programs or b) business management applications as a Service

ASP

Platform as a Service (PaaS)
- Provision of a) "containers" where apps can run and b) programming libraries (e.g., HashTable)

Infrastructure as a Service (IaaS)
- Provision of a) virtual machines on which apps can run and/or b) storage space

Solutions for ASP hosting

Cloud applications

+ Utility-like features

Clouds

Source: 4CaaSt Project

Get Involved in the OpenNebula Community!

Use the Technology and Give us Feedback

- Support through several mailing lists
- Report bugs and make feature requests
- Describe your use case in our blog
- Participate in the OpenNebula Technology Days

Spread our Word

- Spread the word about OpenNebula and open source cloud computing

Contribute to the Development

- Open development infrastructure
- Provide patches for bug fixes or enhancements

Contribute to the Quickly Growing Ecosystem

- Submit a new tool or extension to the OpenNebula ecosystem

Sponsor the Community

- Provide funds or resources to support development or to organize workshops or tutorials

Get Involved in the OpenNebula Community!

Sponsors

dsa-research.org

- **European Commission**: RESERVOIR (EU agreement 215605), StratusLab (EU agreement 261552), BonFIRE (EU agreement 257386) and 4CaaSt (EU agreement 258862).
- **Ministry Science & Innovation**: HPCcloud 2010-2012, MICINN TIN2009-07146
- **Community of Madrid**: MEADIANET 2010-2013 CAM S2009/TIC-1468
- **C12G Labs** dedicates an amount of its own engineering resources to support and develop OpenNebula

The OpenNebula Community

- **The OpenNebula Team**: Ignacio M. Llorente, Ruben S. Montero, Tino Vazquez, Javier Fontan, Jaime Melis, Carlos Martín, Rafael Moreno, Daniel Molina, Borja Sotomayor…

- … and many **value community contributors** from several organizations

Your support and contribution are very much appreciated!

More info, downloads, mailing lists at

Research References

- B. Rochwerger, J. Caceres, R.S. Montero, D. Breitgand, E. Elmroth, A. Galis, E. Levy,I.M. Llorente, K. Nagin, Y. Wolfsthal, *"The RESERVOIR Model and Architecture for Open Federated Cloud Computing"*, **IBM Systems Journal**, Vol. 53, No. 4. (2009)
- B. Sotomayor, R. S. Montero, I. M. Llorente and I. Foster, *"Virtual Infrastructure Management in Private and Hybrid Clouds"*, **IEEE Internet Computing**, September/October 2009 (vol. 13 no. 5)