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# Design and Building of IaaS Clouds

Ignacio M. Llorente

[dsa-research.org](http://dsa-research.org)

Distributed Systems Architecture Research Group  
Universidad Complutense de Madrid





# Position in the Cloud Ecosystem

*Design and Building of IaaS Clouds*

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Software as a Service

What

Who

**On-demand access to any application**

**End-user (does not care about hw or sw)**



**facebook**

Platform as a Service

**Platform for building and delivering web applications**

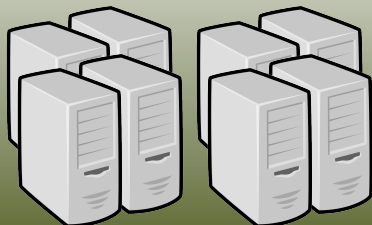
**Developer (no managing of the underlying hw & sw layers)**



**Windows Azure**

**force.com**  
platform as a service

Infrastructure as a Service



Physical Infrastructure

## OpenNebula.org

**Innovative open, flexible and scalable technology to configure your own IT resources into a IaaS cloud**

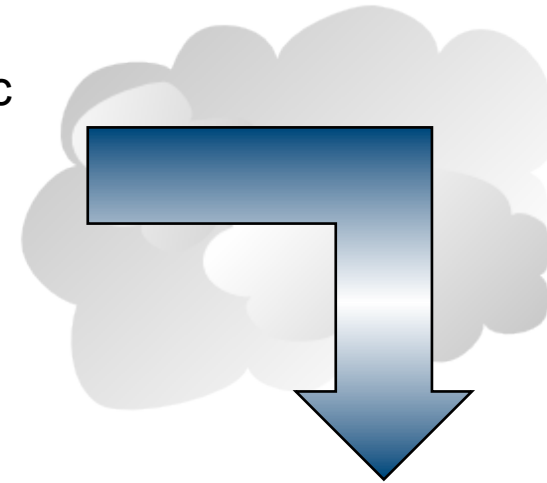
# Transforming your IT Infrastructure into a Cloud

## *Design and Building of IaaS Clouds*

### Commercial Cloud Provider

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- **Flexible and elastic capacity** to meet dynamic demands of service
- **Ubiquitous network access**
- **Pay per use** and on-demand access



### Building your Own Cloud

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- **Optimize and Simplify Internal Operations**
  - **Centralized management** of all servers and services with dynamic resizing of infrastructure and dynamic allocation of capacity
  - **Higher utilization** and **operational saving** of existing resources with server consolidation and removal of application silos
  - **Lower infrastructure expenses** with combination of local and remote Cloud resources
- **Support new IT, scientific, or business Cloud services**

# Deployment Models

## Design and Building of IaaS Clouds

Model	Definition	Examples of Deployment
<b>Private</b>	Infrastructure is owned by a single organization and made available only to the organization	<ul style="list-style-type: none"> <li>• Optimize and simplify <b>internal operation</b></li> <li>• <b>SaaS/PaaS</b> support</li> <li>• IT consolidation within <b>large organizations</b> (Government Clouds, University Clouds...)</li> </ul>
<b>Public</b>	Infrastructure is owned by a single organization and made available to other organizations	<ul style="list-style-type: none"> <li>• <b>Commercial cloud providers</b></li> <li>• <b>Community public clouds</b> by ICT service centers to enable scientific and educational projects to experiment with cloud computing</li> <li>• <b>Special purpose clouds</b> with dedicated capabilities (Science Clouds, HPC Clouds..)</li> <li>• <b>Regional clouds</b> to address regulatory or latency issues</li> </ul>
<b>Hybrid</b>	Infrastructure is a composition of two or more clouds	<ul style="list-style-type: none"> <li>• <b>Cloudbursting</b> to address peak demands</li> <li>• <b>Cloud Federation</b> to share infrastructure with partners</li> <li>• <b>Cloud Aggregation</b> to provide a larger resource infrastructure</li> </ul>



# Contents

*Design and Building of IaaS Clouds*

## **Designing a Cloud Infrastructure**

Addressing challenges from Deployment and Usage Scenarios



## **Building a Cloud Infrastructure**

OpenNebula as Cloud Enabler



## **Experiences and Innovative Projects in Cloud Computing Infrastructures**



RESERVOIR, StratusLab and BonFIRE

# Designing a Cloud: A Design Driven by Requirements


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## Requirements from Usage and Deployment Scenarios

- **Users:** Functionality exposed and workload profile
- **Managers:** Flexible, efficient and scalable management of the Cloud
- **Business:** Hybrid cloud computing and federation
- **Integrators:** Open architecture, interfaces and code



*“One solution does not fit all requirements and constraints, a properly architected solution should fully align with your Cloud strategy”*

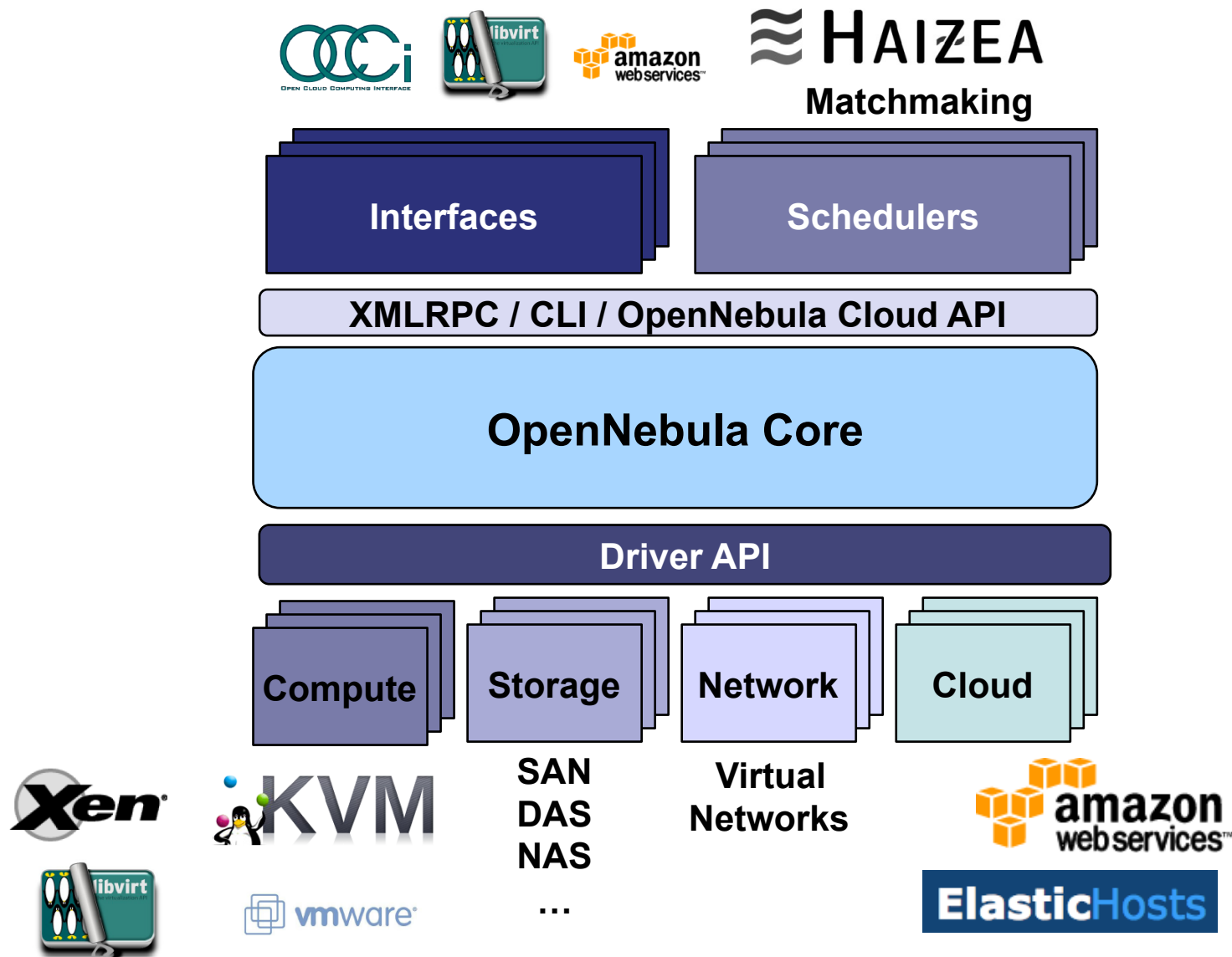


**Constraints from Existing Infrastructure and Processes in the Organization**

# Designing a Cloud: Flexible Cloud Manager

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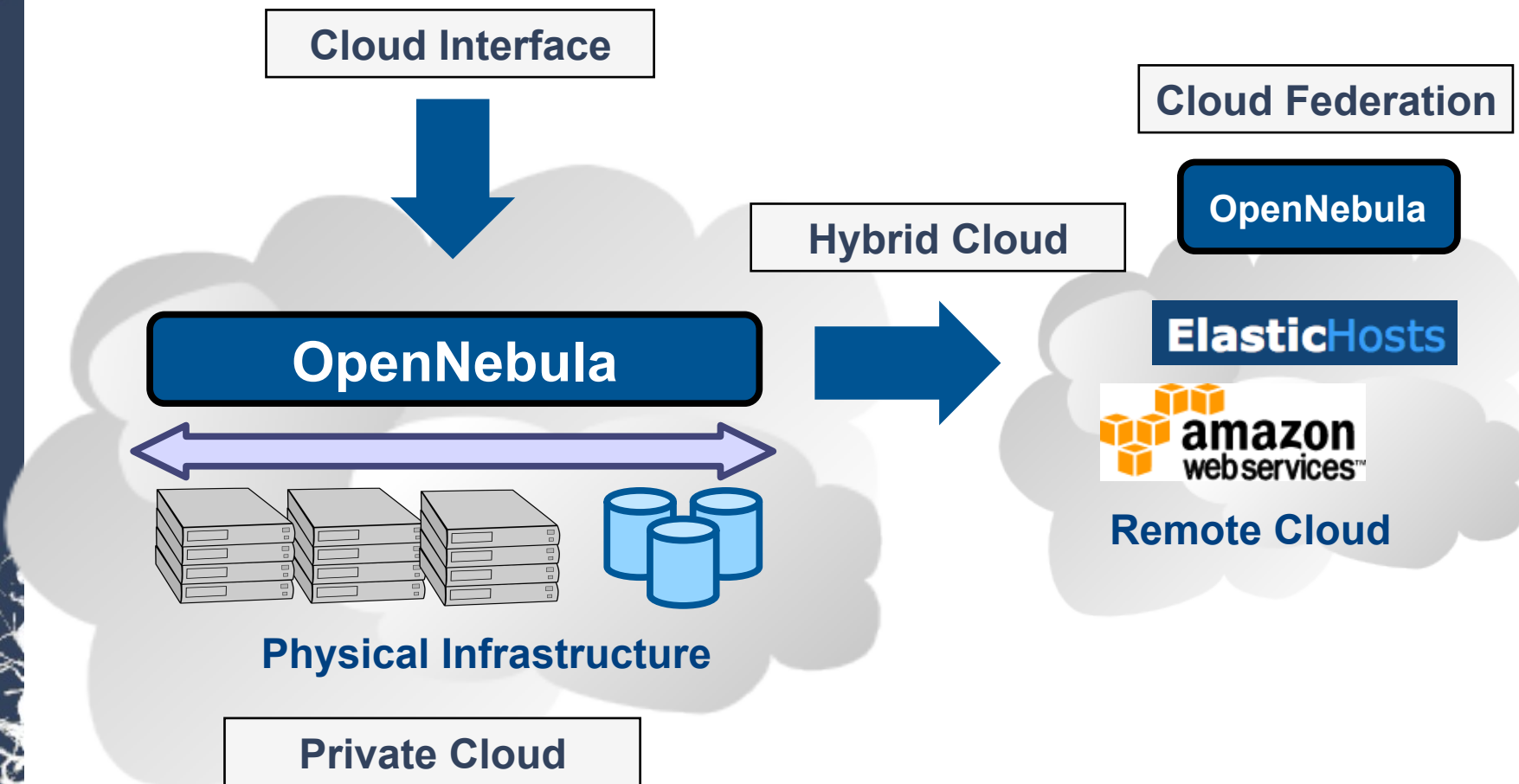
## Cloud Manager as Enabler to Build Your Own Cloud



# Designing a Cloud: Interoperability

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## Interoperation from Different Perspectives





# Building a Cloud: OpenNebula as Cloud Enabler

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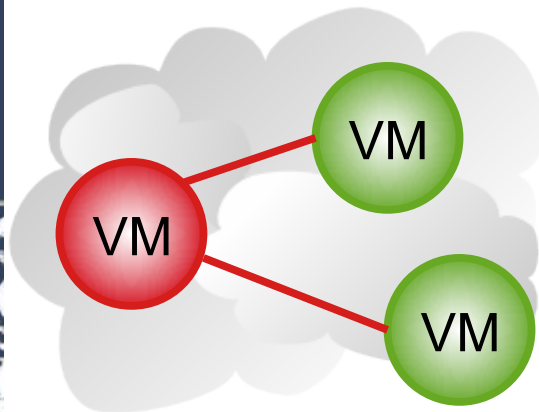
## Innovations

Technology **challenges** in cloud computing management from  
**business use cases**



## Open-source Toolkit

OpenNebula v1.4



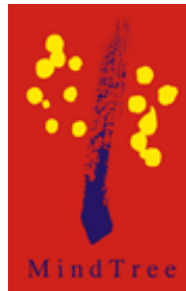
- **Open and flexible tool** to fit into any datacenter and integrate with any ecosystem component
- **Open-source** released under Apache v2.0, and distributed in Ubuntu
- **Most advanced solution** to build private, public, federated and hybrid clouds
- Based on and implements **standards** to avoid vendor lock-in and to enable interoperability
- **Efficient and scalable management** of the cloud



# Building a Cloud: Experiences

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## Different Levels of Use: From Experimental to Production



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# Building a Cloud: Experiences

## *Design and Building of IaaS Clouds*

### Deployment Cases



- A team at Clemson University and CERN has used OpenNebula to deploy thousands of VMs on 400 hosts (3,200 cores) running Xen
- OpenNebula was integrated in internal network and configuration management
- Contributed drivers for using LVM based disk images



- The Dgrid Resource Center Ruhr (DGRZR) has used OpenNebula to manage 248 Blades with a total of 1,984 cores.
- OpenNebula is used to support the execution of a virtualized Grid site in D-Grid and EGEE



- SARA High Performance Computing Center uses OpenNebula in its new HPC Cloud service on 128 cores across 16 servers with KVM
- OpenNebula is used to support the execution of virtual clusters and HPC applications
- Authors of the OpenNebula Management Console



# Building a Cloud: OpenNebula Ecosystem

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## Open Community for Cloud Computing

- **Haizea Lease Manager (University of Chicago):** Advance reservation of capacity and queuing of best effort requests
- **Cloud Management Console (SARA Computing and Networking Services):** Web interface for OpenNebula
- **Virtual Cluster Tool (CRS4 Distributed Computing Group):** Atomic virtual cluster management with versioning and multiple transport protocols.
- **DeltaCloud Driver (DSA-Research@UCM)**
- **RESERVOIR Policy Engine (IBM Haifa/Elsag Datamat):** Policy-driven probabilistic admission control and dynamic placement optimization to satisfy site level management policies
- **VM Consolidation Scheduler (DSA-Research@UCM):** Periodic re-placement of VMs for server consolidation and suspension/resume of physical resources
- **Claudia (Telefonica I+D):** SLA-driven automatic service management
- **Under Development:** SUN Cloud API, vCloud API, VirtualBox plugin, dashboard for infrastructure management, new schedulers, SLA and security framework, Grid service manager, LVM and SAN support,...

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# Building a Cloud: Innovative Projects

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## European Projects on Cloud Computing Infrastructures



EU grant agreement 215605  
**Service and Sw Architectures  
and Infrastructures**  
(2008-2011)

### Resources and Services Virtualization without Barriers

- Open source technology to enable deployment and management of complex IT services across different administrative domains



Proposal in negotiation  
**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.
- Enhance existing computing infrastructures with “IaaS” paradigms



Proposal in negotiation  
**New Infrastructure Paradigms  
and Experimental Facilities**  
(2010-2013)

### 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



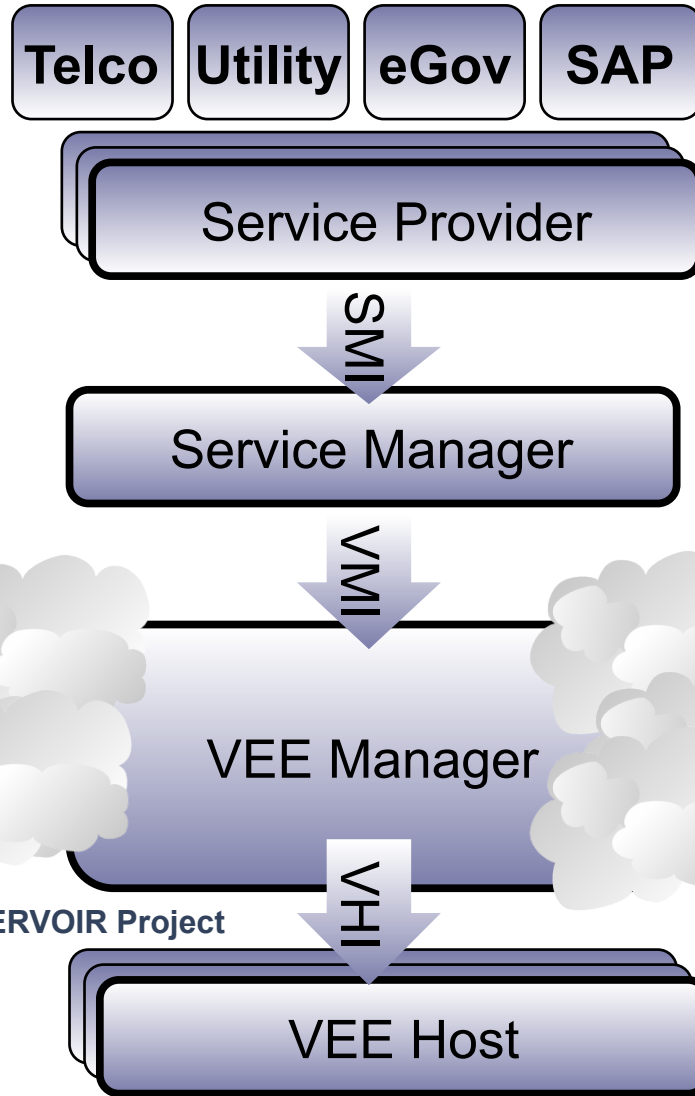
# Innovative Projects: The Enabling Software Artefacts

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[www.reservoir-fp7.eu](http://www.reservoir-fp7.eu)

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Source: RESERVOIR Project



Commercial Infrastructure Provider

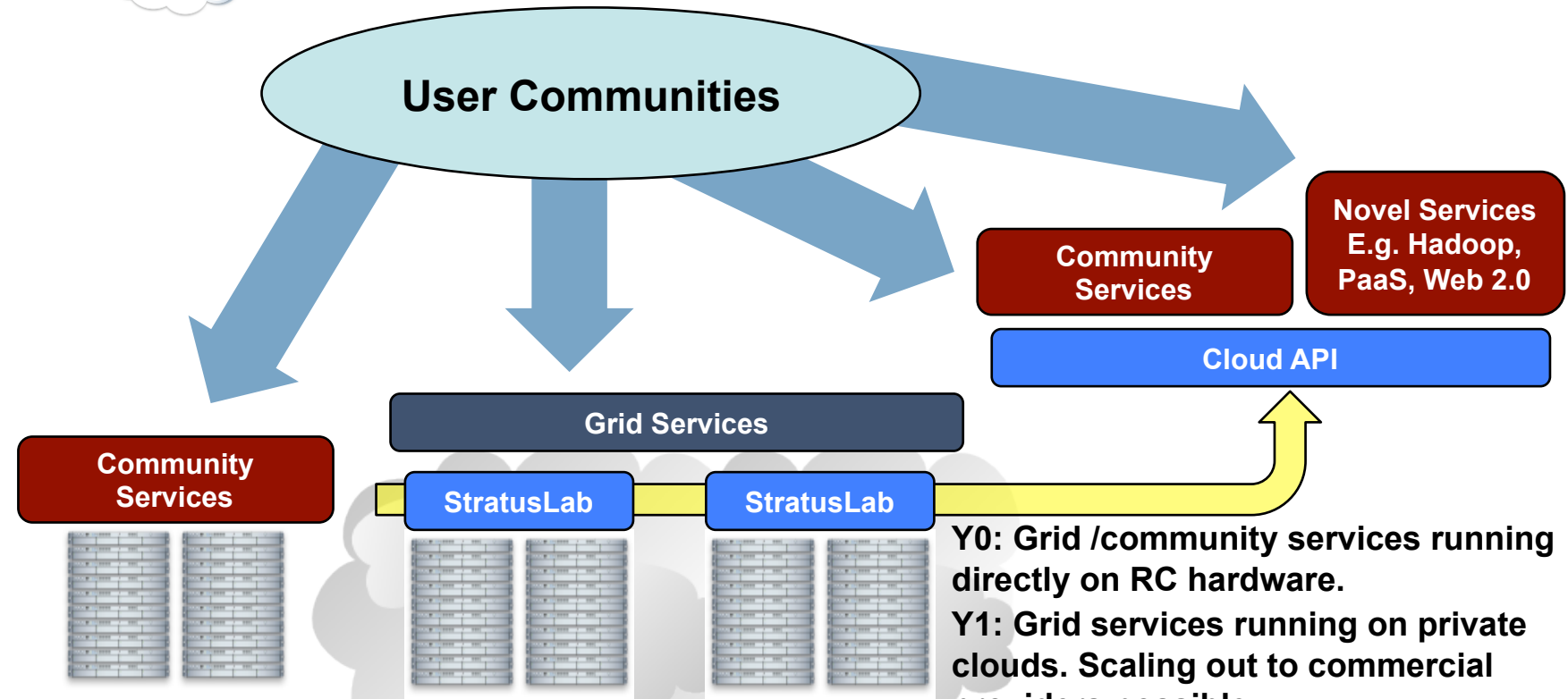


# Innovative Projects: Enhancing Grid with Cloud

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StratusLab [www.stratuslab.org](http://www.stratuslab.org)

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Source: StratusLab Project

**Y0: Grid /community services running directly on RC hardware.**

**Y1: Grid services running on private clouds. Scaling out to commercial providers possible.**

**Y2: Cloud API provided. Virtualized machines available to end users.**

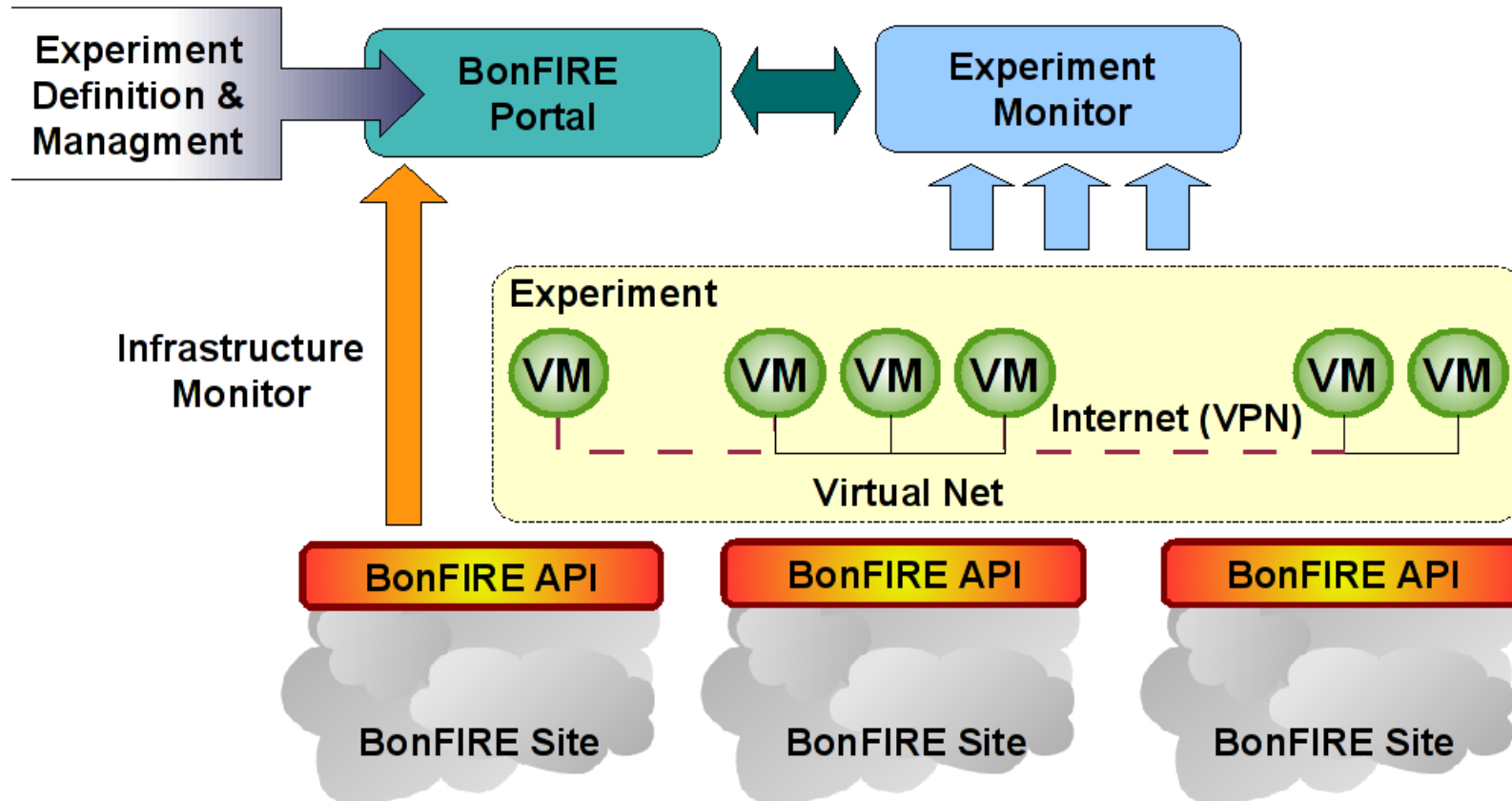
**Y3: Community services run on standard resources via StratusLab cloud API.**

**Y4: Additional community services and novel services built on top of cloud API.**





## Building Service Testbeds on FIRE



Source: BonFIRE Project





# Outlook

*Design and Building of IaaS Clouds*

## About the Short-term Roadmap (2 months): v1.6

Feature	New Function
Scalability, Reliability and High Availability	<ul style="list-style-type: none"><li>• Support for MySQL in the back-end</li><li>• Unit-testing of the core</li><li>• HTTP back-end</li></ul>
Functionality	<ul style="list-style-type: none"><li>• Image repository</li><li>• Support for multiple clusters</li><li>• CLI for accounting and billing support</li></ul>
Cloud Interfaces	<ul style="list-style-type: none"><li>• Improve compatibility with EC2 ecosystem</li></ul>

## About the Medium-term Roadmap

- **Projects** funding OpenNebula
- **Community**

## Funding

- New European Projects ensure the development and maintenance of OpenNebula until end of 2013
- C12G Labs also contributes to the sustainability of the open-source community



# Long-term Sustainability and Commercial Support

Design and Building of IaaS Clouds

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## OpenNebula Enterprise Edition >

The Enterprise-grade Cloud Management Tool to Build your Cloud Solution, Product or Service

C12G  
LABS

The screenshot shows the C12G Labs website. At the top left is the C12G LABS logo. To its right are links for 'partner login' and 'contact us', along with social media icons for Twitter, LinkedIn, and RSS. The main navigation bar includes 'Home', 'Products', 'Services', 'Partners', 'Resources', and 'About Us'. The central banner features the text 'OPENNEBULA ENTERPRISE EDITION >' and 'Your Cloud Management Solution to build a custom Cloud Service, Product or Solution.' Below this is a diagram with three clouds labeled 'Your Solution', 'Your Service', and 'Your Product', all connected to a central cloud labeled 'C12G OpenNebula'. Below the banner are two columns of content: 'About C12G Labs' and 'Answering Questions'. The footer contains 'Top Site Information', 'Contact Us', and 'From Our Blog' sections.

**C12G LABS** partner login | contact us | OPENNEBULA FOR THE ENTERPRISE

Home Products Services Partners Resources About Us

**OPENNEBULA ENTERPRISE EDITION >**  
Your Cloud Management Solution to build a custom Cloud Service, Product or Solution.

Your Solution Your Service Your Product  
C12G OpenNebula

**About C12G Labs**  
C12G Labs provides value-added solutions around the certified and supported Enterprise Edition of the widely-used OpenNebula toolkit for Cloud Computing. Strong partner relationships are the foundation of C12G Labs, providing our customers and partners with an enterprise-grade and flexible cloud management technology that meets the performance, integration and configuration requirements of their infrastructure, processes or use cases to build custom Cloud services, solutions or products.

**Answering Questions**

- Why OpenNebula?
- Why OpenNebula Enterprise?
- Why Being a C12G's Partner?
- What is our Value Proposition?

**Top Site Information**

- Frequently Asked Questions
- White Papers
- Partner Programs
- OpenNebula Community

**Contact Us**

- Partnership: [partners@c12g.com](mailto:partners@c12g.com)
- Contact: [contact@c12g.com](mailto:contact@c12g.com)
- Skype: C12G\_OpenNebula
- USA: +1 650 646 3820
- Europe/UK: +44 20 7193 1748

**From Our Blog**

- OpenNebula Enterprise Edition v1.4 - May 10, 2010
- OpenNebula Cloud Toolkit Goes Commercial - May 5, 2010

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Please send comments to [webmaster](mailto:webmaster)

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# Thanks

## Funding Agencies

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- **European Commission:** RESERVOIR 2008-2011, EU agreement 215605
- **Ministry Science&Innovation:** HPCcloud 2010-2012, MICINN TIN2009-07146
- **Community of Madrid:** MEADIANET 2010-2013 CAM S2009/TIC-1468

## Other Sponsors

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- **C12G Labs** dedicates an amount of its own engineering resources to support and develop OpenNebula

## The OpenNebula Community

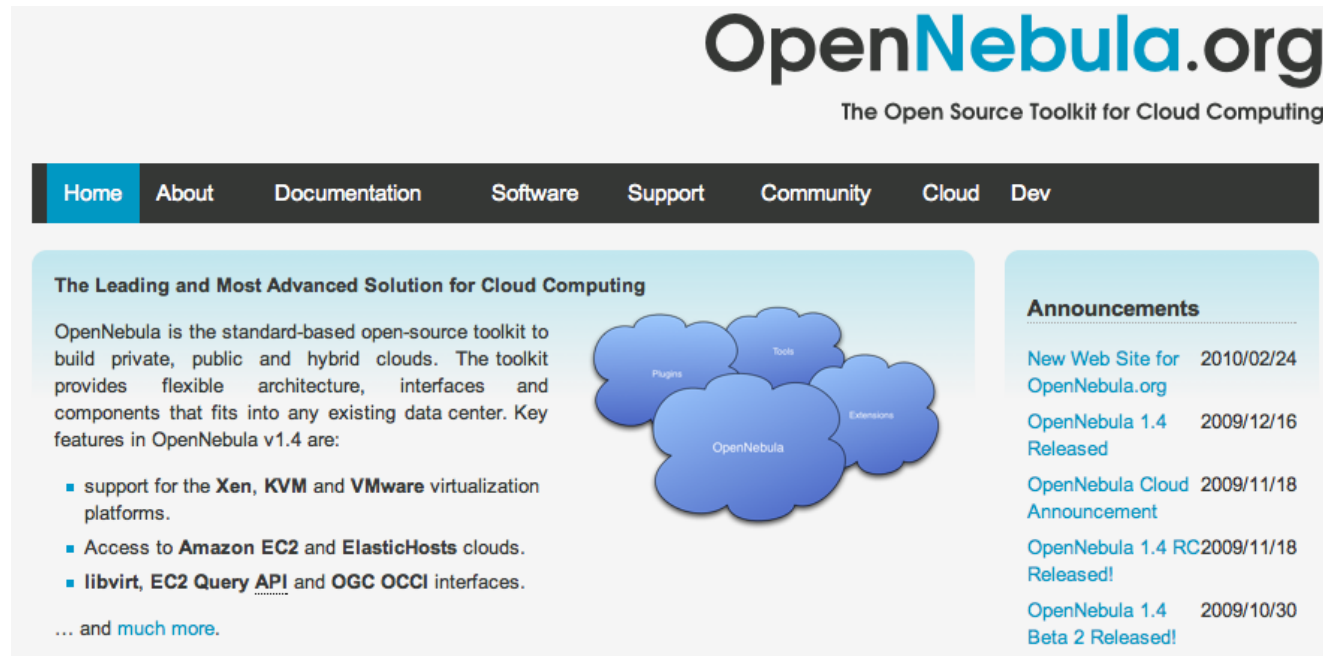
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- **The OpenNebula Team:** Ignacio M. Llorente, Ruben S. Montero, Tino Vazquez, Javier Fontan, Jaime Melis, Carlos Martín, Rafael Moreno, Daniel Molina, Borja Sotomayor...
- ... and many **value community contributors** from several organizations

**Your support and contribution are very much appreciated!**

## More Information

# More info, downloads, mailing lists at



The screenshot shows the OpenNebula.org website. At the top right is the logo "OpenNebula.org" with the tagline "The Open Source Toolkit for Cloud Computing". Below the logo is a navigation menu with links: Home, About, Documentation, Software, Support, Community, Cloud, and Dev. The main content area is divided into two columns. The left column is titled "The Leading and Most Advanced Solution for Cloud Computing" and contains a paragraph describing OpenNebula as a standard-based open-source toolkit for building private, public, and hybrid clouds. It lists key features in OpenNebula v1.4: support for Xen, KVM, and VMware virtualization platforms; access to Amazon EC2 and ElasticHosts clouds; and libvirt, EC2 Query API, and OGC OCCI interfaces. A diagram shows a central cloud labeled "OpenNebula" connected to three other clouds labeled "Plugins", "Tools", and "Extensions". The right column is titled "Announcements" and lists several updates: "New Web Site for OpenNebula.org" (2010/02/24), "OpenNebula 1.4 Released" (2009/12/16), "OpenNebula Cloud Announcement" (2009/11/18), "OpenNebula 1.4 RC2009/11/18 Released!" (2009/11/18), and "OpenNebula 1.4 Beta 2 Released!" (2009/10/30).

## 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)