

15th April 2010
e-InfraNet Workshop
Louvain, Belgium

Cloud Computing from an Institutional Perspective

Ignacio M. Llorente

dsa-research.org

Distributed Systems Architecture Research Group
Universidad Complutense de Madrid





Position in the Cloud Ecosystem

Cloud Computing from an Institutional Perspective

dsa-research.org

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

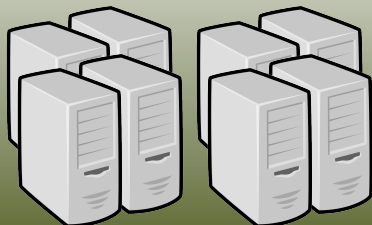
Developer (no managing of the underlying hw & swlayers)



Windows Azure

force.com
platform as a service

Infrastructure as a Service



Physical Infrastructure

OpenNebula.org

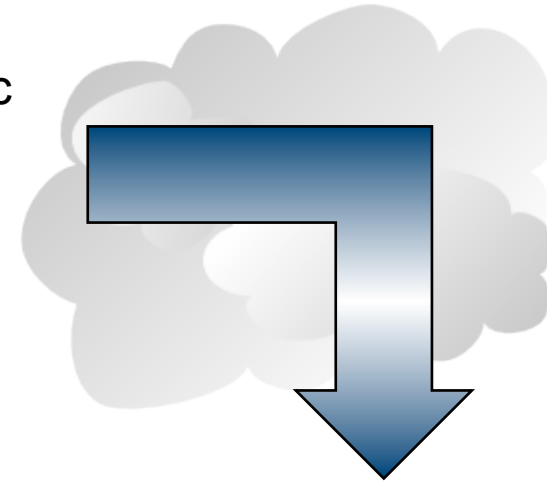
Innovative open, flexible and scalable technology to configure your own IT resources into a IaaS cloud

Transforming your IT Infrastructure into a Cloud

Cloud Computing from an Institutional Perspective

Commercial Cloud Provider

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



Building your Own Cloud

- **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

Cloud Computing from an Institutional Perspective

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



Contents

Cloud Computing from an Institutional Perspective

Designing a Cloud Infrastructure

Addressing challenges from Deployment and Usage Scenarios



Building a Cloud Infrastructure

OpenNebula as Cloud Enabler



Innovative Projects in Cloud Computing Infrastructures

RESERVOIR, StratusLab and BonFIRE




Designing a Cloud: A Design Driven by Requirements

Cloud Computing from an Institutional Perspective

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”

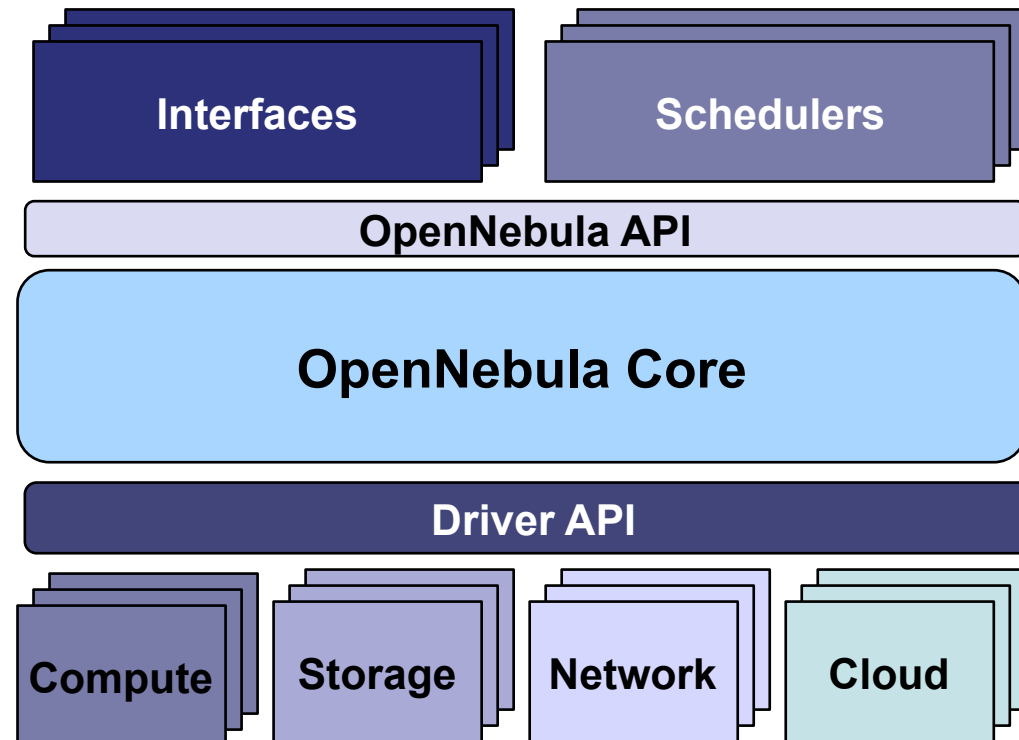
Constraints from Existing Infrastructure and Processes in the Organization

Designing a Cloud: Flexible Cloud Manager

Cloud Computing from an Institutional Perspective

Cloud Manager as Enabler to Build Your Own Cloud

- Management of network, computing, remote cloud and storage capacity
- Management of virtual network, machine and storage life-cycles
- Workload placement and management of VM images
- Management of information, accounting and security
- **Interfacing with any infrastructure service**



Building a Cloud: OpenNebula as Cloud Enabler

Cloud Computing from an Institutional Perspective



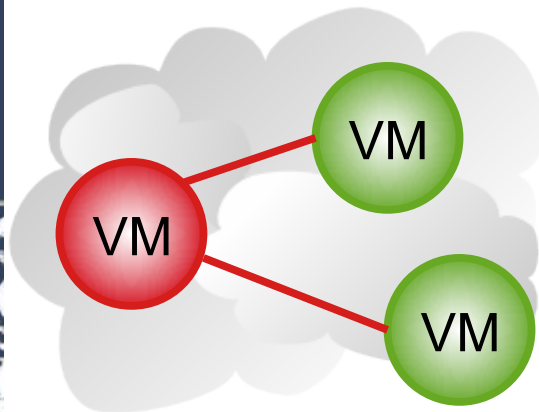
Innovations

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 **standards** avoid vendor lock-in and to enable interoperability
- **Efficient and scalable management** of the cloud



Building a Cloud: OpenNebula Ecosystem

Cloud Computing from an Institutional Perspective

Open Community for Cloud Computing

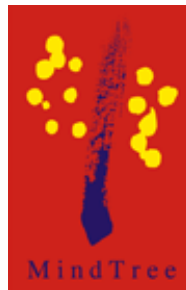
- **Haizea Lease Manager (University of Chicago):** Advance reservation of capacity and queuing of best effort requests
- **Cloud Management Console (SARA Computing and Networking Services):** Web interface for OpenNebula
- **Virtual Cluster Tool (CRS4 Distributed Computing Group):** Atomic virtual cluster 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,...



Building a Cloud: OpenNebula Users

Cloud Computing from an Institutional Perspective

Users (Different Levels of Use: From Experimental to Production)



dsa-research.org

Building a Cloud: Innovative Projects

Cloud Computing from an Institutional Perspective

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



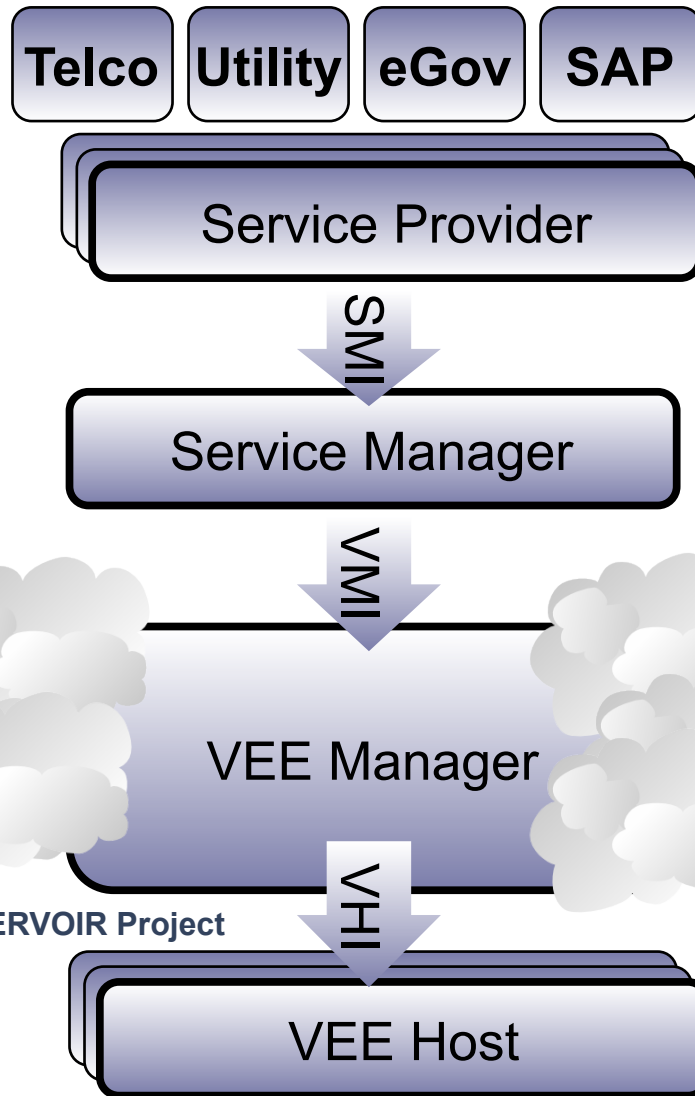
Innovative Projects: The Enabling Software Artefacts

Cloud Computing from an Institutional Perspective



www.reservoir-fp7.eu

dsa-research.org



Source: RESERVOIR Project



Commercial Infrastructure Provider

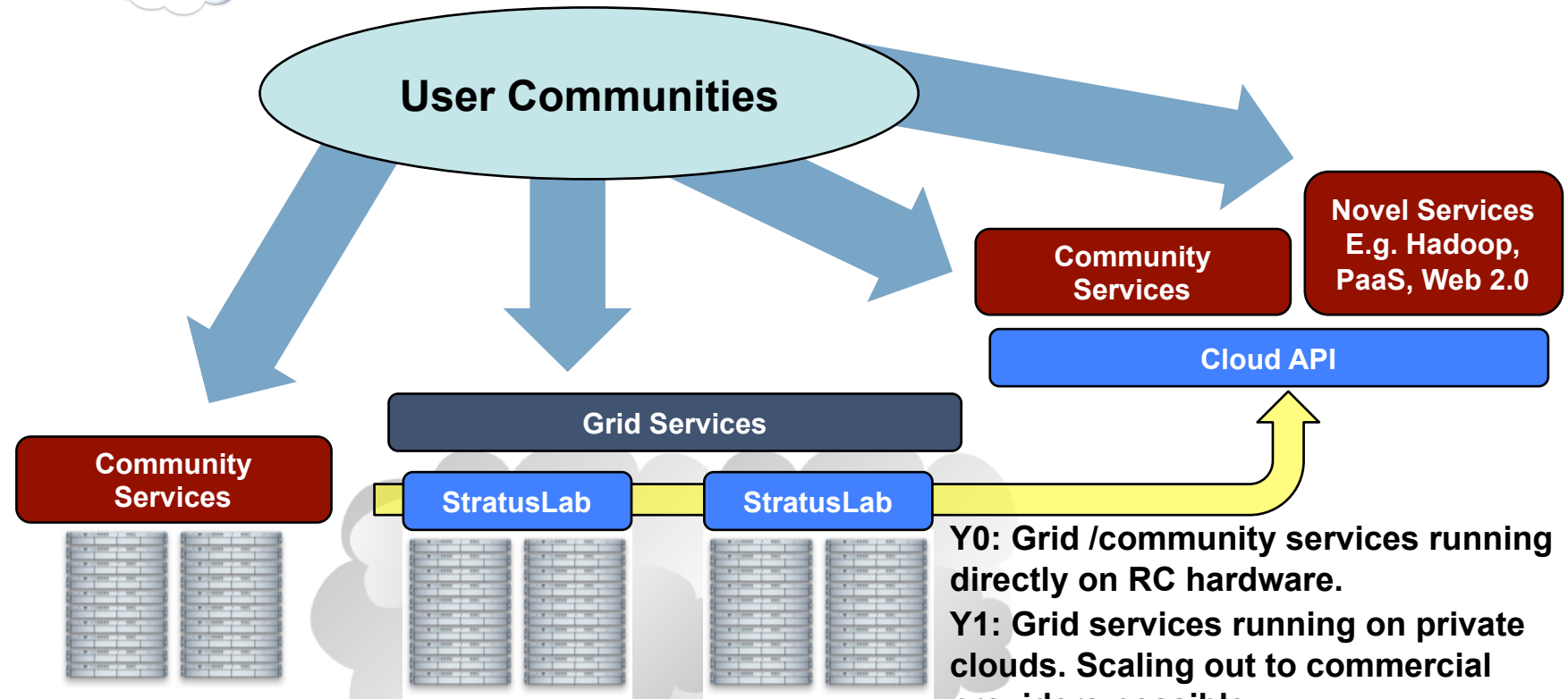


Innovative Projects: Enhancing Grid with Cloud

Cloud Computing from an Institutional Perspective

StratusLab www.stratuslab.org

dsa-research.org



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.

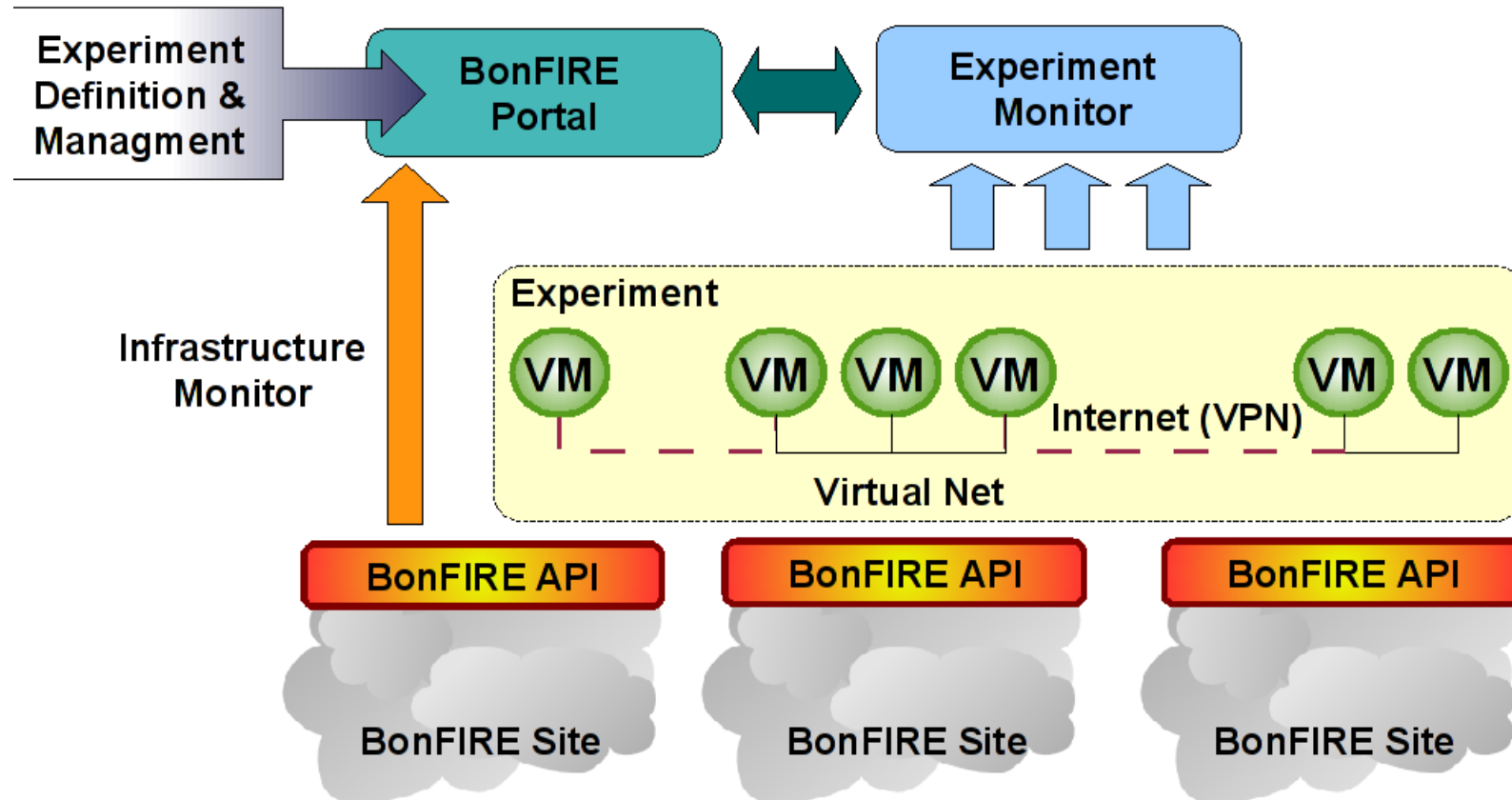
Y3: Community services run on standard resources via StratusLab cloud API.

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





Building Service Testbeds on FIRE



Source: BonFIRE Project



Vision on the Future of Cloud Computing

Cloud Computing from an Institutional Perspective

IT Resources will be the Next Utility

- **Future enterprise datacenters will look like private Clouds** supporting a flexible and agile execution of virtualized services, and combining local with public Cloud-based infrastructure to enable highly scalable hosting environments
- **Growing number of domain specific and regional Cloud providers implementing a utility computing business model** by offering pay per use resources on-demand
- **Public Clouds will be supported by a network of geographically distributed datacenters** for high availability, end-user service proximity, legal and policy issues...
- **Public Clouds will be interconnected to meet fluctuating demands**
- **Grid sites will offer infrastructure cloud-like interfaces** to address the new resource access demands from the community



Vision on the Future of Cloud Computing

Cloud Computing from an Institutional Perspective

Socio-Economic Impact

- **Lower costs for academic and commercial computing centers, and for governments (consolidation)**
- **Energy efficiency and reduction of CO2 emissions**
- **Enhanced commercial participation in European e-Infrastructures**
- **Reduce entry-barriers for SMEs**
- **Raw infrastructure on-demand for research and business in less advanced countries**
- ...



Thanks

Funding Agencies

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

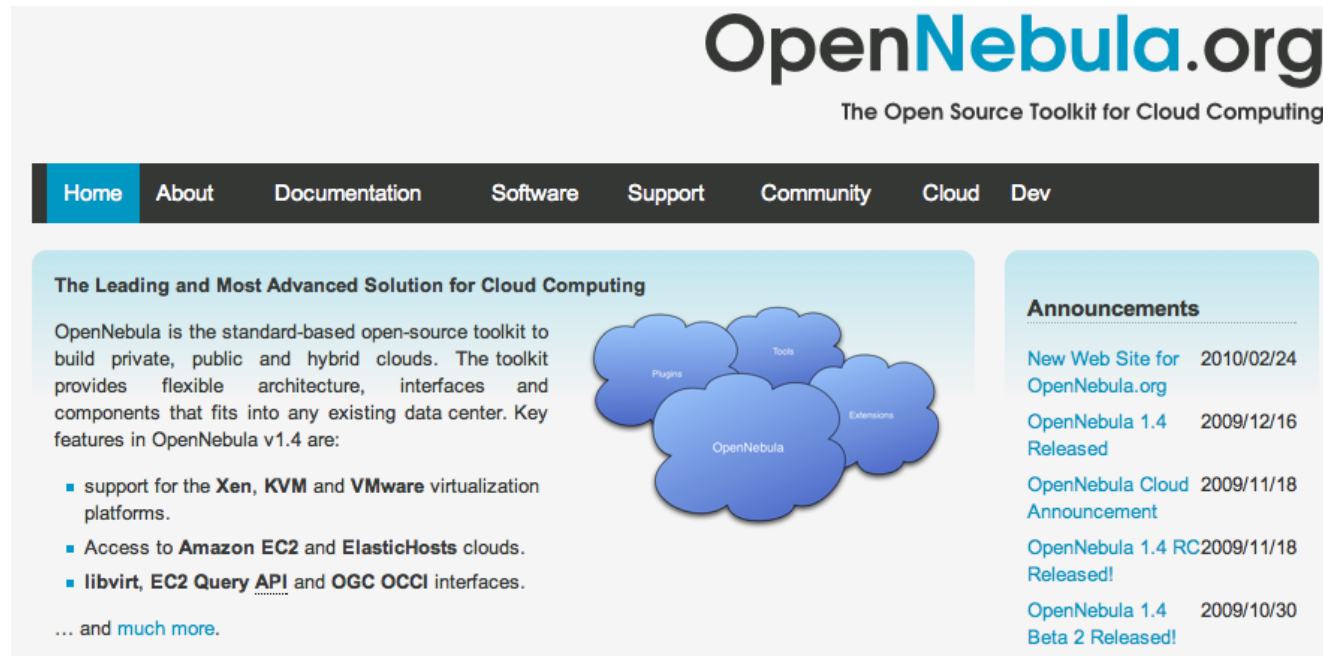
The OpenNebula Community

- **The OpenNebula Team:** Ignacio M. Llorente, Ruben S. Montero, Tino Vazquez, Javier Fontan, Jaime Melis, Carlos Martín, Rafael Moreno, Daniel Molina, and 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. The header features the OpenNebula.org logo and the tagline "The Open Source Toolkit for Cloud Computing". A navigation menu includes links for Home, About, Documentation, Software, Support, Community, Cloud, and Dev. The main content area is divided into two columns. The left column, titled "The Leading and Most Advanced Solution for Cloud Computing", describes OpenNebula as a standard-based open-source toolkit for building private, public, and hybrid clouds. It lists key features in OpenNebula v1.4, including 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 central diagram shows a cloud labeled "OpenNebula" connected to three smaller clouds labeled "Plugins", "Tools", and "Extensions". The right column, titled "Announcements", lists recent 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)