Cloud Computing from an Institutional Perspective

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### Position in the Cloud Ecosystem

**Cloud Computing from an Institutional Perspective**

<table>
<thead>
<tr>
<th>What</th>
<th>Who</th>
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</thead>
<tbody>
<tr>
<td>On-demand access to any application</td>
<td>End-user (does not care about hw or sw)</td>
</tr>
<tr>
<td>Platform for building and delivering web applications</td>
<td>Developer (no managing of the underlying hw &amp; swlayers)</td>
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#### 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

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

<table>
<thead>
<tr>
<th>Model</th>
<th>Definition</th>
<th>Examples of Deployment</th>
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</table>
| **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* (Government Clouds, University Clouds…) |
| **Public** | Infrastructure is owned by a single organization and made available to other organizations | • *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 | • *Cloudbursting* to address peak demands  
• *Cloud Federation* to share infrastructure with partners  
• *Cloud Aggregation* to provide a larger resource infrastructure |
Cloud Computing from an Institutional Perspective

Contents

- Building a Cloud Infrastructure
  - OpenNebula as Cloud Enabler
- Designing a Cloud Infrastructure
  - Addressing challenges from Deployment and Usage Scenarios
- Innovative Projects in Cloud Computing Infrastructures
  - RESERVOIR, StratusLab and BonFIRE
Designing a Cloud: A Design Driven by Requirements

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 architectured 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

- 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

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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 standards avoid vendor lock-in and to enable interoperability
- Efficient and scalable management of the cloud
Building a Cloud: OpenNebula Ecosystem

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

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Users (Different Levels of Use: From Experimental to Production)
Building a Cloud: Innovative Projects

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European Projects on Cloud Computing Infrastructures

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

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

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

Source: RESERVOIR Project
Innovative Projects: Enhancing Grid with Cloud

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StratusLab  www.stratuslab.org

User Communities

Community Services

Grid Services

Cloud API

Novel Services E.g. Hadoop, PaaS, Web 2.0

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.
Innovative Projects: Cloud for Service Experimentation

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Building Service Testbeds on FIRE

Source: BonFIRE Project
Vision on the Future of Cloud Computing

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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

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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 info, downloads, mailing lists at

OpenNebula.org

The Open Source Toolkit for Cloud Computing

Research References


• 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)