Challenges in Hybrid and Federated Cloud Computing

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Acknowledgments

The research leading to these results has received funding from the Ministerio de Ciencia e Innovación of Spain through research grant TIN2009-07146.
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- IaaS Cloud Computing
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- Coupling Levels for Federation
- Common Architectures for Federation
- Challenges for Interoperability and Portability
# IaaS Cloud Computing

**Types of Cloud Services for Provision of IT Capabilities as a Service**

<table>
<thead>
<tr>
<th>What</th>
<th>Who</th>
</tr>
</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></td>
<td><img src="skype.png" alt="skype" /> <img src="gmail.png" alt="gmail" /> <img src="facebook.png" alt="facebook" /></td>
</tr>
<tr>
<td>Platform for building and delivering web applications</td>
<td>Developer (no managing of the underlying hw &amp; swlayers)</td>
</tr>
<tr>
<td><img src="Windows_Azure.png" alt="Windows Azure" /> <img src="force.com.png" alt="force.com" /></td>
<td></td>
</tr>
<tr>
<td>Raw computer infrastructure</td>
<td>System Administrator (complete management of the computer infrastructure)</td>
</tr>
<tr>
<td><img src="cogrid.png" alt="cogrid" /> <img src="rackspace.png" alt="rackspace hosting" /> <img src="flexiscale.png" alt="flexiscale" /> <img src="amazon_web_services.png" alt="amazon web services" /></td>
<td></td>
</tr>
</tbody>
</table>
IaaS Cloud Computing

Provision of Virtualized Resources as a Service

• Management Console
• Simple REST API’s

• Raw infrastructure resources

• Pay-as-you-go & elastic capacity

Manage Instances
OpenNebula Cloud Management

IaaS Cloud Computing Tool for Managing a Data Center's Virtual Infrastructure

Adaptable
● Customizable and Extensible

Proven
● Many Massive Scale Production Deployments

Powerful and Innovative
● Advanced Enterprise-class Functionality

No Lock-in
● Platform Independent and Interoperable

Interoperable
● Popular cloud APIs and standard based

Openness
● Fully open-source
● Apache license

Challenges in Hybrid and Federated Cloud Computing
OpenNebula Cloud Management

Building the Industry Standard Open Source Cloud Computing Tool

OpenNebula.org

- Develop & innovate
- Support the community
- Collaborate

Third party scalability tests: 16000 VMs

Commercial Support

Third party scalability tests: 16000 VMs

European Funding

4,000 downloads/month

TP v1.0 v1.2 v1.4 v2.0 v2.2 V3.0


dsa group doing research...

Ubuntu Debian openSUSE

4,000 downloads/month

European Funding

Challenges in Hybrid and Federated Cloud Computing
OpenNebula Cloud Management

Organizations Building Clouds and Innovative Projects

Organizations Building Clouds for Development, Testing and Production

Projects Building an Open Cloud Ecosystem Around OpenNebula

Challenges in Hybrid and Federated Cloud Computing
## OpenNebula Cloud Management

### Different Models of Deployment

<table>
<thead>
<tr>
<th>Model</th>
<th>Definition</th>
<th>Cloud Cases</th>
</tr>
</thead>
</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 over the Internet | • **Commercial cloud providers**, mostly hosting providers to offer low cost solutions with limited control/configuration and security/reliability good enough  
• **Science public clouds** to enable scientific and educational projects or to experiment with cloud computing |
| Virtual Private | Infrastructure is owned by a single organization and made available to other organization over a dedicated private network | • **Telecom cloud providers** to offer premium solutions with additional control/configuration and security/reliability |
Cloud Federation

Next Step in the Evolution of an Utility

Utility Generation

Utility Distribution

Utility Grid
Cloud Federation

Benefits of Federation

**Scalability**
- Cloudbursting to address peak demands

**Collaboration**
- Sharing of infrastructure between partners

**Multi-site Deployments**
- Infrastructure aggregation across distributed data centers

**Reliability**
- Fault tolerance architectures across sites

**Performance**
- Deployment of services closer to end users

**Cost**
- Dynamic placement to reduce the overall infrastructure cost

**Energy Consumption**
- Minimize energy consumption
Cloud Federation

The Multi-tier Cluster Use Case

Cluster Users

Completely Transparent
- Service interface

Virtual Cluster Flexibility
- Dynamic elasticity rules
- Dynamic provision of cluster configurations

Application Servers

Front-end

Simplify and Optimize Internal Operations
- Dynamic performance partitioning
- Consolidation
- Faster upgrades
- Maintenance
Cloud Federation

The Web Server Use Case

- Scalability
- Performance
- Cost
- Fault tolerance
Coupling Levels for Federation

Different Levels of Control, Monitoring, Cross-site Functionality and Security

- Partner Cloud
- Private Cloud
- Public Cloud
- Company Cloud
Coupling Levels for Federation

Loosely Coupled Federation

Federation with a Cloud without Interoperation Support

<table>
<thead>
<tr>
<th>Control</th>
<th>Basic operations over VMs (start, shutdown, restart...)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Different instance types</td>
</tr>
<tr>
<td>Monitoring &amp; Accounting</td>
<td>Basic virtual resource monitoring (resource consumption...)</td>
</tr>
<tr>
<td>Cross-site</td>
<td>None</td>
</tr>
<tr>
<td>Security</td>
<td>Single account representing the organization</td>
</tr>
</tbody>
</table>
Partially Coupled Federation

Federation with a Cloud with Partial Interoperation Support

<table>
<thead>
<tr>
<th>Control</th>
<th>Monitoring &amp; Accounting</th>
<th>Cross-site</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Advanced operations over VMs (live migration...)</td>
<td>• Advanced virtual resource monitoring (energy consumption, VM placement...)</td>
<td>• Virtual networks</td>
<td>• Framework agreement</td>
</tr>
<tr>
<td>• VM location and affinity constraints</td>
<td></td>
<td>• Virtual storage</td>
<td></td>
</tr>
</tbody>
</table>
Federation with a Cloud with Advanced Interoperation Support

### Coupling Levels for Federation

**Tightly Coupled Federation**

#### Control
- Placement on specific physical resources
- Same instance types

#### Monitoring & Accounting
- Physical resource consumption

#### Cross-site
- Live migration
- High availability

#### Security
- User space sharing
Common Architectures for Cloud Federation

Organization of Multi-site Cloud Environments
Common Architectures for Cloud Federation

Cloudbursting Architecture

<table>
<thead>
<tr>
<th>Cloud Type</th>
<th>Private cloud to scale out with public or virtual private cloud resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aim</td>
<td>Meet peak demands</td>
</tr>
<tr>
<td>Coupling</td>
<td>Loosely and partially coupled</td>
</tr>
</tbody>
</table>
Enhancing Grid Infrastructures with Cloud Computing

Simplify and optimize its use and operation, providing a more flexible, dynamic environment for scientists; and enhance existing computing infrastructures with “IaaS” paradigms.
Common Architectures for Cloud Federation

Cloud Broker Architecture

<table>
<thead>
<tr>
<th>Cloud Type</th>
<th>• User of several public clouds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aim</td>
<td>• Cost, performance and reliability optimization</td>
</tr>
<tr>
<td>Coupling</td>
<td>• Loosely coupled</td>
</tr>
</tbody>
</table>
Common Architectures for Cloud Federation

Cloud Broker Architecture

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

Source: BonFIRE Project
Common Architectures for Cloud Federation

**Aggregated Cloud Architecture**

<table>
<thead>
<tr>
<th>Cloud Type</th>
<th>• Aggregation of different private clouds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aim</td>
<td>• Sharing of resources between partners to meet peak demands</td>
</tr>
<tr>
<td>Coupling</td>
<td>• Partially or tightly coupled</td>
</tr>
</tbody>
</table>
Common Architectures for Cloud Federation

Aggregated Cloud Architecture

Resources and Services Virtualization without Barriers

Open source technology to enable deployment and management of complex IT services across different administrative domains
Common Architectures for Cloud Federation

Multi-tier Cloud Architecture

<table>
<thead>
<tr>
<th>Cloud Type</th>
<th>Aim</th>
<th>Coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Very large corporate clouds (private, public or virtual private) with several instances</td>
<td>• Scalability, isolation or multiple-site support</td>
<td>• Tightly coupled</td>
</tr>
</tbody>
</table>
Common Architectures for Cloud Federation

Multi-tier Cloud Architecture

- User
- oZones Server
  - Portal
  - Cloud API (EC2, OCCI)
  - Global AuthN

OpenNebula Zone

OpenNebula Zone
Common Architectures for Cloud Federation

**Multi-tier Cloud Architecture**

**Advanced Multi-Tenancy within each Zone**

- Typical scenario in large organizations and cloud providers
- On-demand provision of fully-configurable and isolated VDC with full control and capacity to administer its users and resources
Challenges for Interoperability and Portability

Transparent Combination of Local Resources with Cloud Resources with No Changes

1. Management Interfaces for Virtual Workloads

2. Management Interfaces for Data Elements

3. VM Image Description

4. Contextualization

5. Management of Cross-site Networking

6. Common Execution Framework (Instance Type, QoS and Security)
## Challenges for Interoperability and Portability

### Leveraging Existing Standards and Implementing Interoperation

#### Standardization
- Implement standards
- Integrate with standards

#### Which Standard?
- Different *de jure* standards
- Several *de facto* standards

#### Interoperation
- Implement adaptors
- Use transformers
Challenges in Hybrid and Federated Cloud Computing

Implementation of Common APIs and Adaptors

Ecosystem

OpenNebula.org
Questions?

We Will Be Happy to Answer Any Question

CloudPlan.org @imllorente

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