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Challenges in Hybrid and Federated Cloud Computing

Ignacio M. Llorente

DSA-Research.org

Distributed Systems Architecture Research Group

Universidad Complutense de Madrid

Acknowledgments

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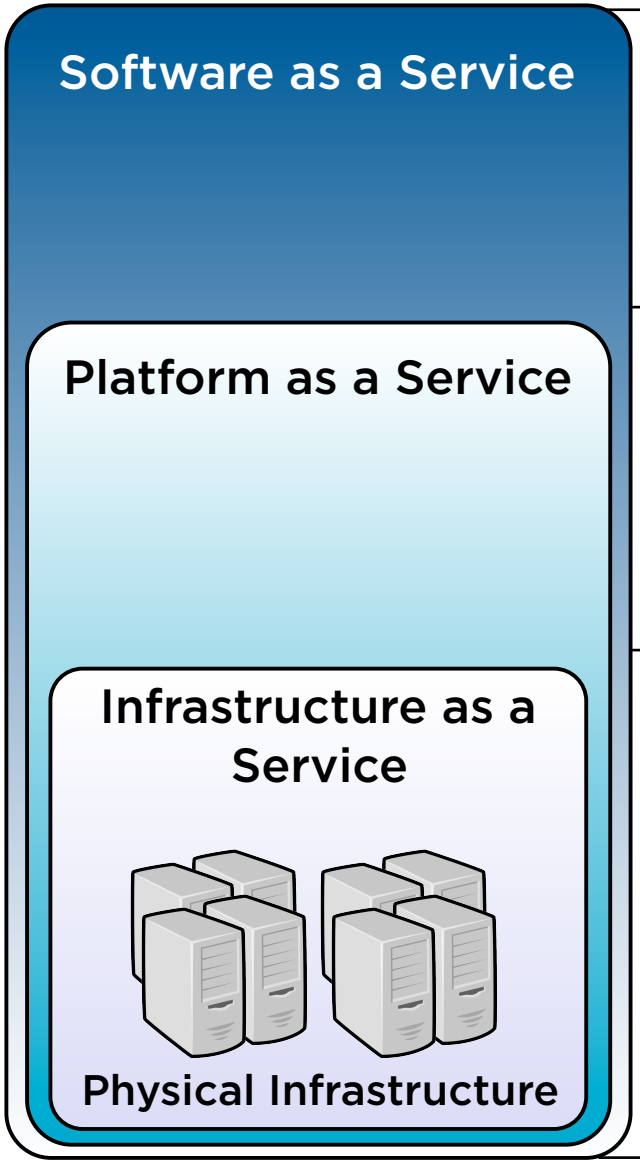
- What is Cloud Computing?
- What is OpenNebula?
- The Future of Cloud Computing
- Levels of Coupling
- Common Architectures for Federation
- Challenges for Interoperability
- Cloud Federation in Grid Infrastructures

What is Cloud Computing?

Provision of IT Capabilities as a Service



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

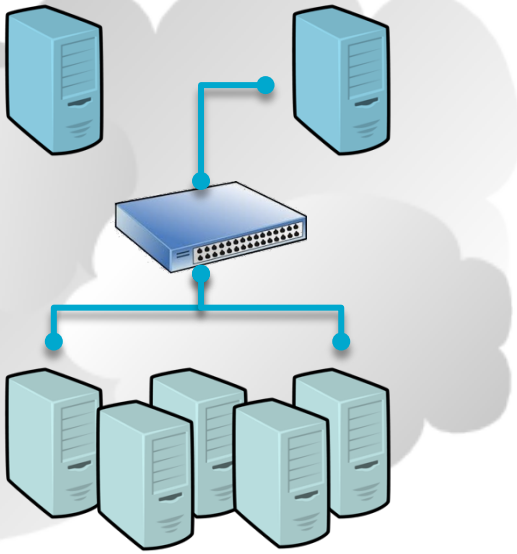
What is Cloud Computing?

Provision of Virtualized Resources as a Service

- Management Console
- Simple **REST** API's

- Raw infrastructure resources

Manage Instances



- Pay-as-you-go & elastic capacity

What is Cloud Computing?

Different Models of Deployment

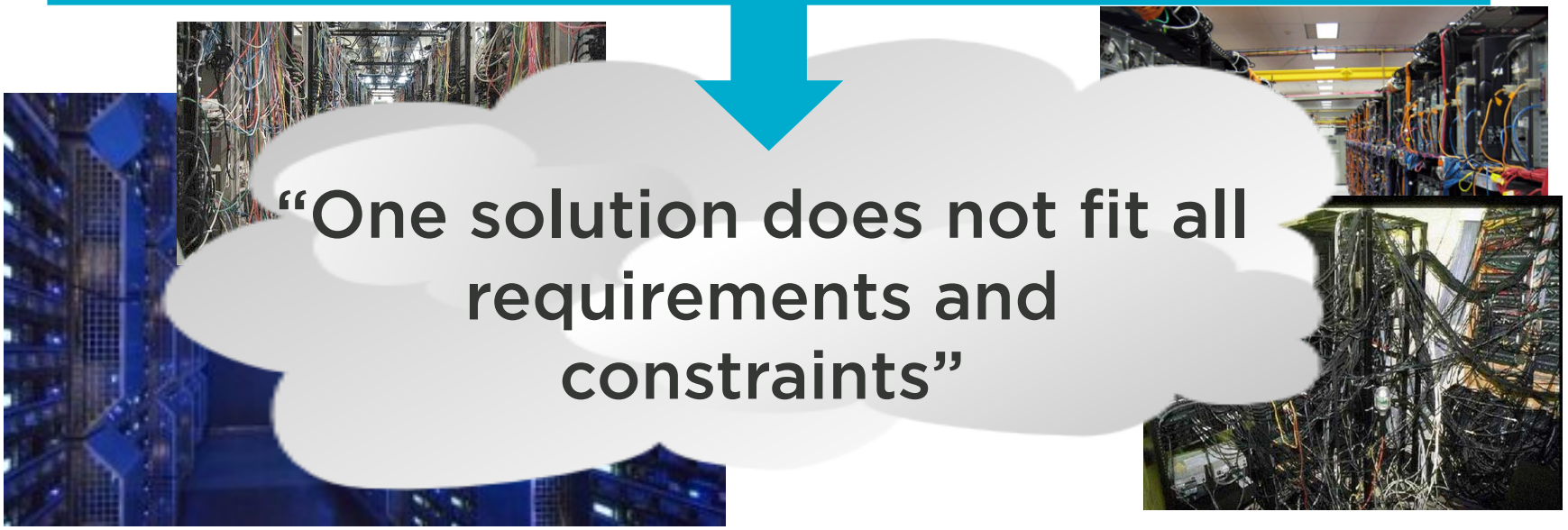
Model	Definition	Cloud Cases
Private	Infrastructure is owned by a single organization and made available only to the organization	• Optimize and simplify **internal operation** • **SaaS**/**PaaS** support • IT consolidation within **large organizations** (**Goverment** Clouds, University Clouds…)
Public	Infrastructure is owned by a single organization and made available to other organizations over the Internet	• Low cost solutions with limited control/ configuration and security/reliability good enough • **Commercial cloud providers,** mostly hosting providers • **Science public clouds** by ICT service centers to enable scientific and educational projects 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	• Premium solutions with additional control/ configuration and security/reliability • **Telecom cloud providers**

What is OpenNebula?

Cloud as an Evolution of the Data Center

Constraints from Existing Infrastructure and Processes

Requirements from Usage and Deployment Scenarios



OpenNebula makes cloud an evolution by leveraging existing IT assets, protecting your existing investments, and avoiding vendor lock-in

What is OpenNebula?

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

Most Advanced and Flexible, Enterprise-grade IaaS Cloud Manager

Adaptable
- Customizable and Extensible

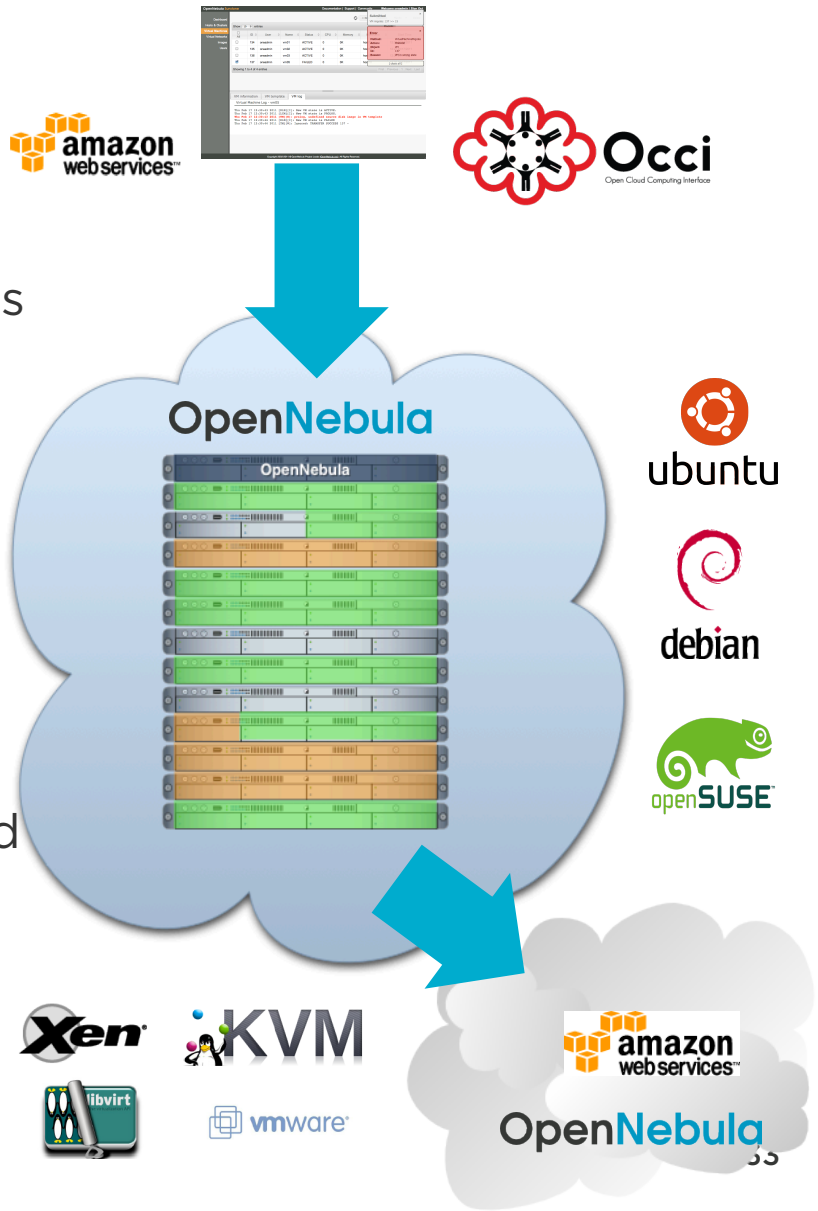
Proven
- Many Massive Scale Production Deployments

Powerful
- Most Advanced Enterprise-class Functionality

No Lock-in
- Platform Independent and Interoperable

Interoperable
- Most popular cloud APIs and standard based

Openness
- Fully open-source
- Apache license



What is OpenNebula?

The Internals of the Cloud

Interfaces & API

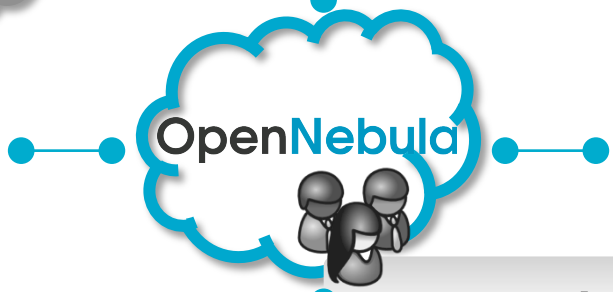
- CLI (local/remote)
- API (java, ruby bindings)
- Sunstone
- Cloud (EC2, OCCI)

VM Networking

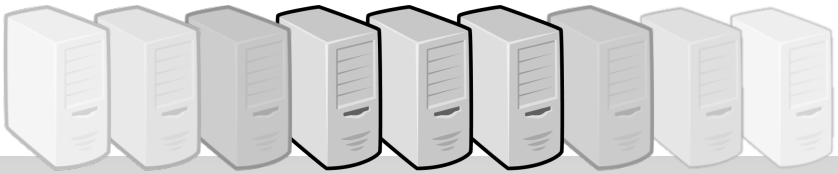
- VLANs
- Firewall hooks
- User defined

Image Repository of VM disks

- ACLs (public + private)
- OS and Data types (persistent)
- Multiple storage backends

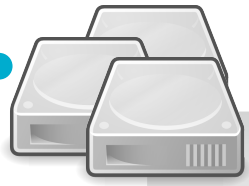


User & Roles



Hosts: Cluster workernodes to run VMs.

- Multiple hypervisors defined per host
- Grouped in logical clusters
- Custom monitoring probes and technologies

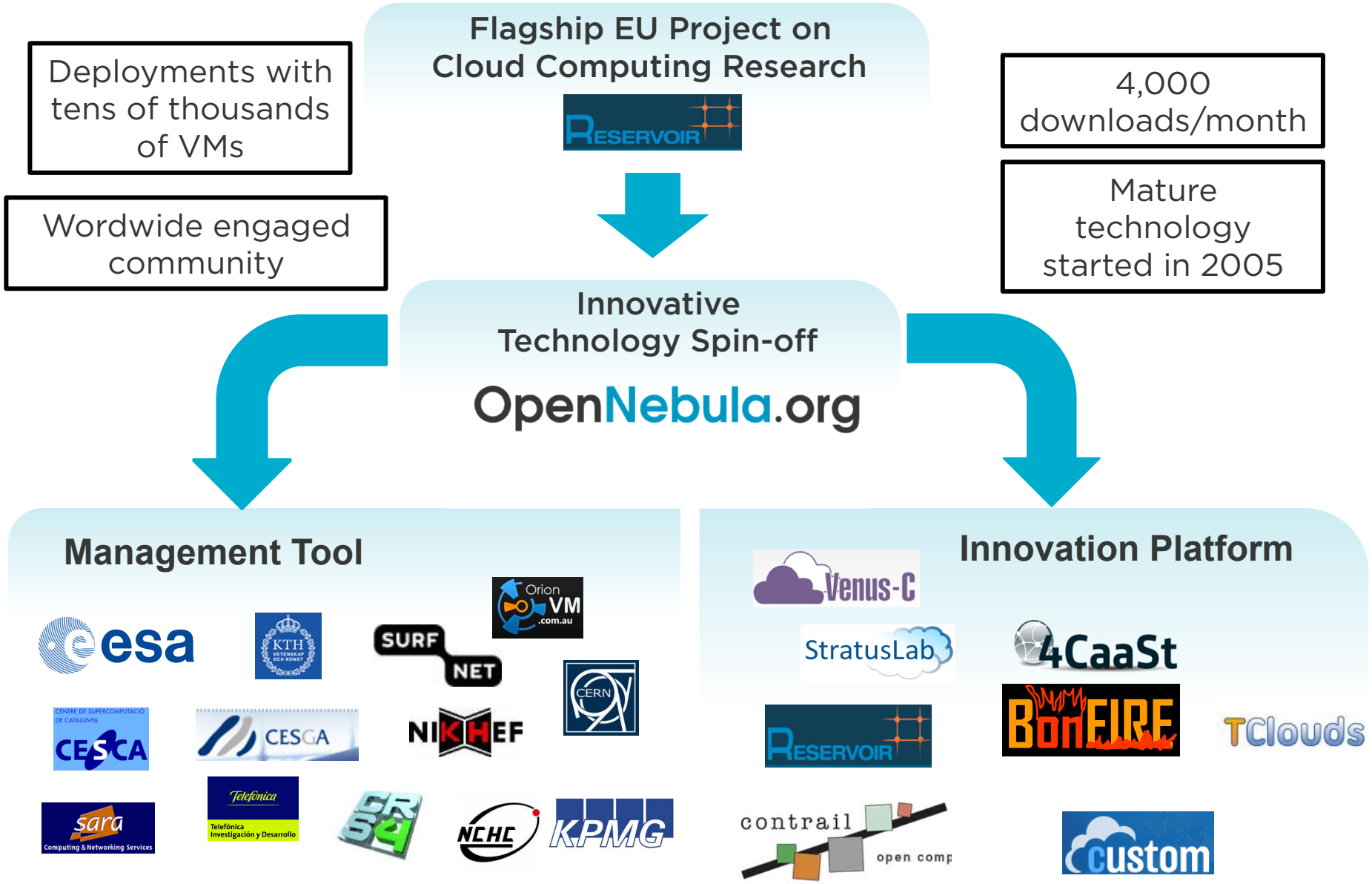


Storage

- NAS
- SAN
- Custom (bittorrent, ssh...)

What is OpenNebula?

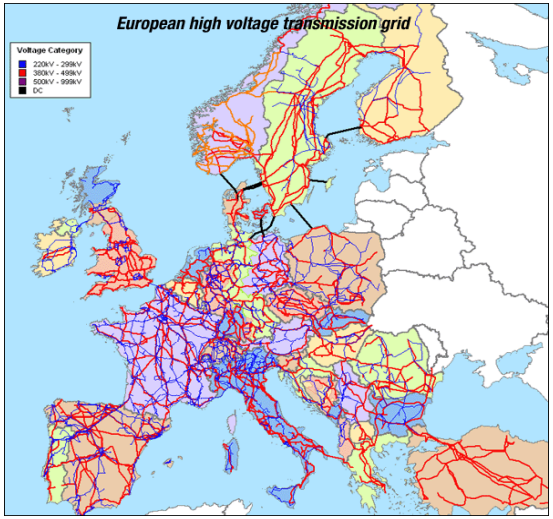
EU Success Story in Cloud Computing Research and Innovation



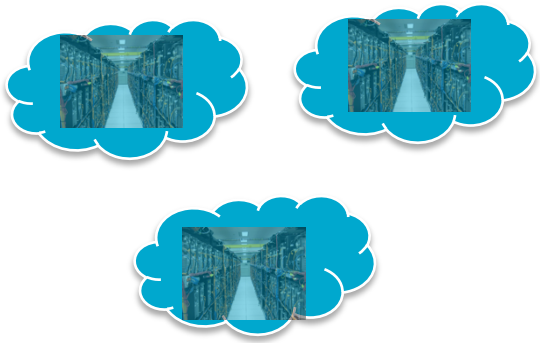
Next Step in the Evolution of an Utility

Utility Generation

Utility Distribution



Utility Grid



Benefits of Federation

Scalability

- Cloudbursting to address peak demands
- Sharing of infrastructure between partners
- Infrastructure aggregation across sites

Reliability

- Fault tolerance architectures across sites

Performance

- Deployment of services closer to end users

Cost

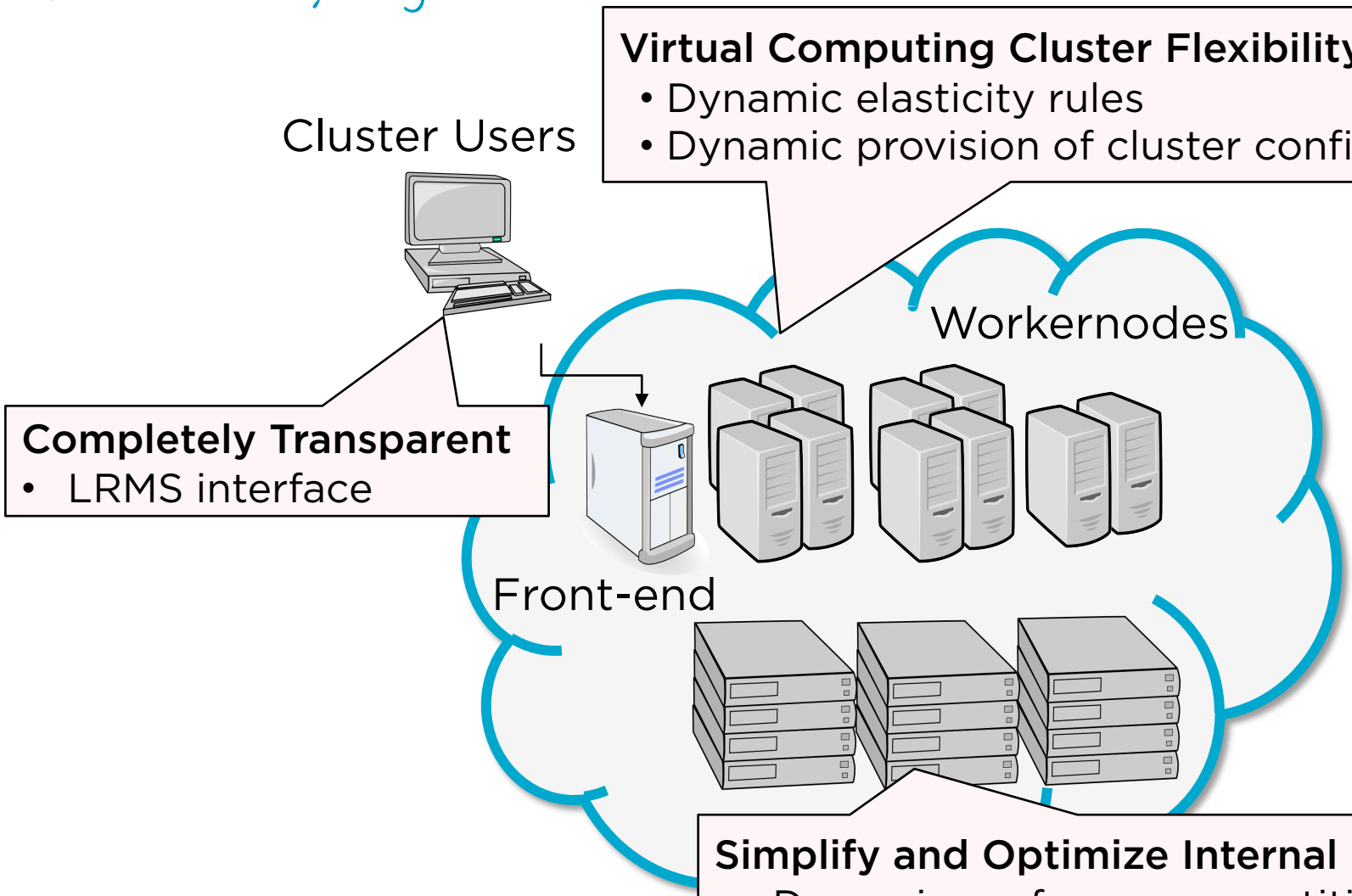
- Dynamic placement to reduce the overall infrastructure cost

Energy Consumption

- Minimize energy consumption

The Cluster Computing Use Case

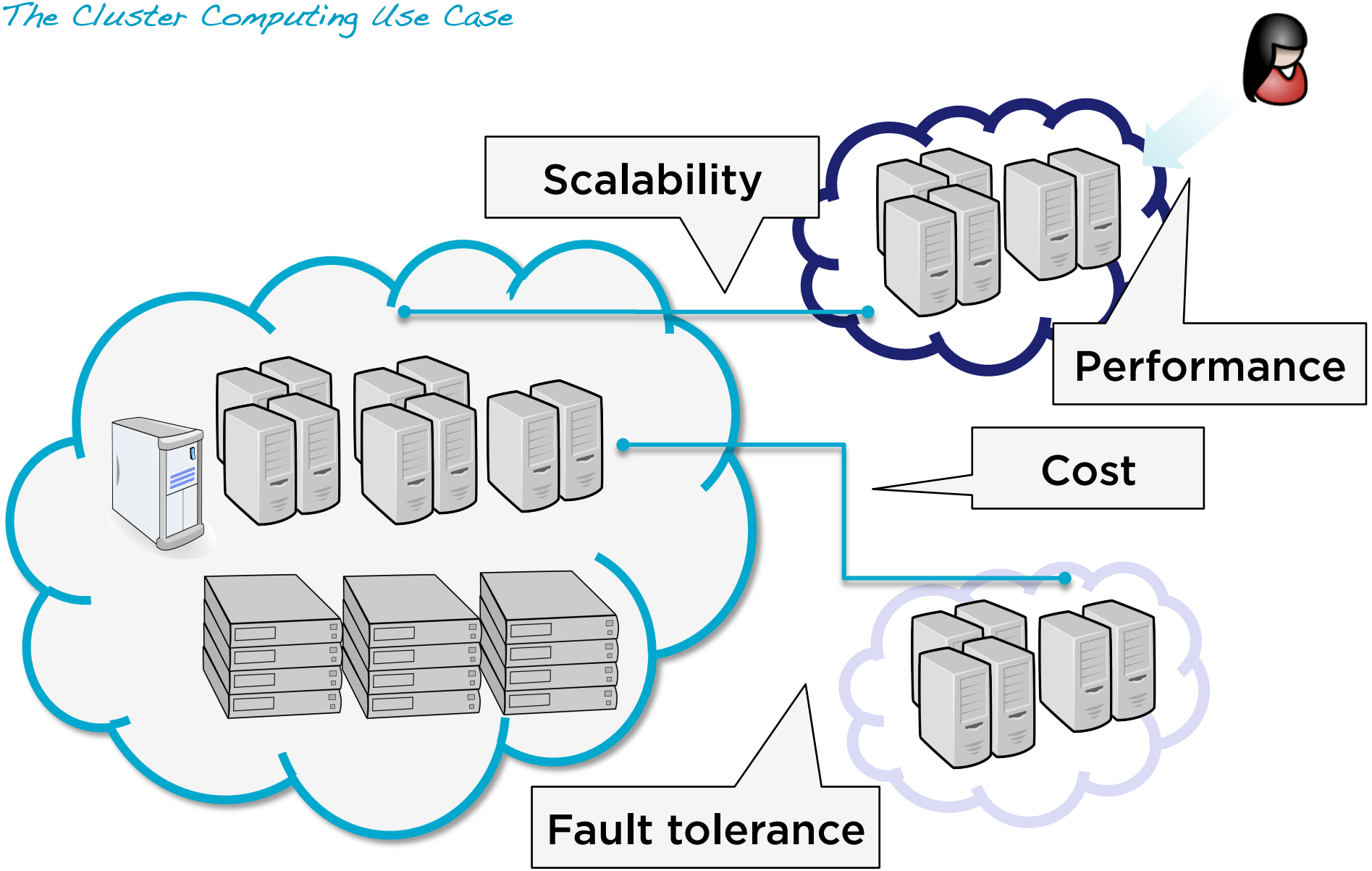
Virtual Computing Cluster Flexibility
- Dynamic elasticity rules
- Dynamic provision of cluster configurations



Completely Transparent
- LRMS interface

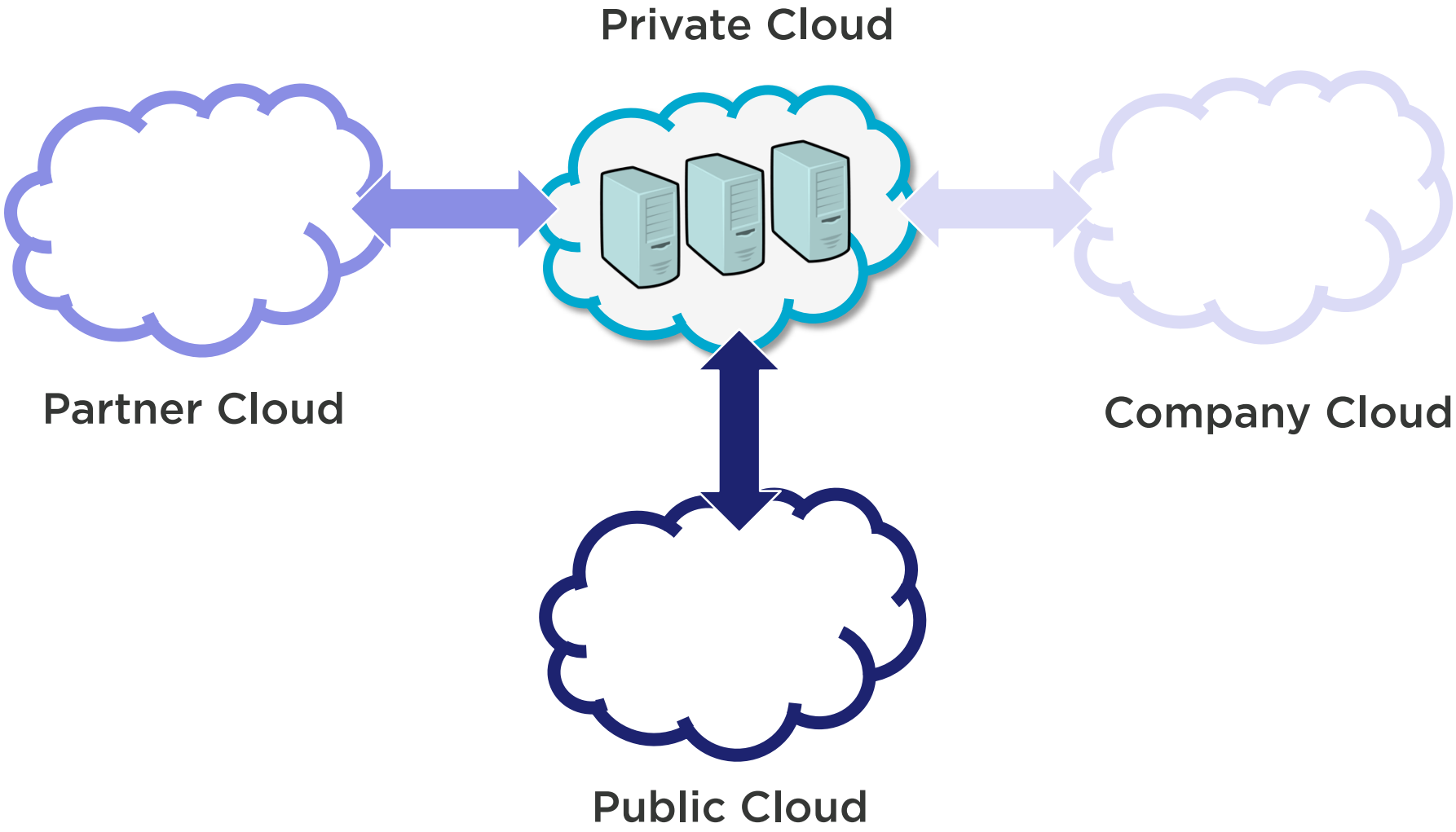
Simplify and Optimize Internal Operations
- Dynamic performance partitioning
- Consolidation
- Faster upgrades
- Maintenance

The Cluster Computing Use Case



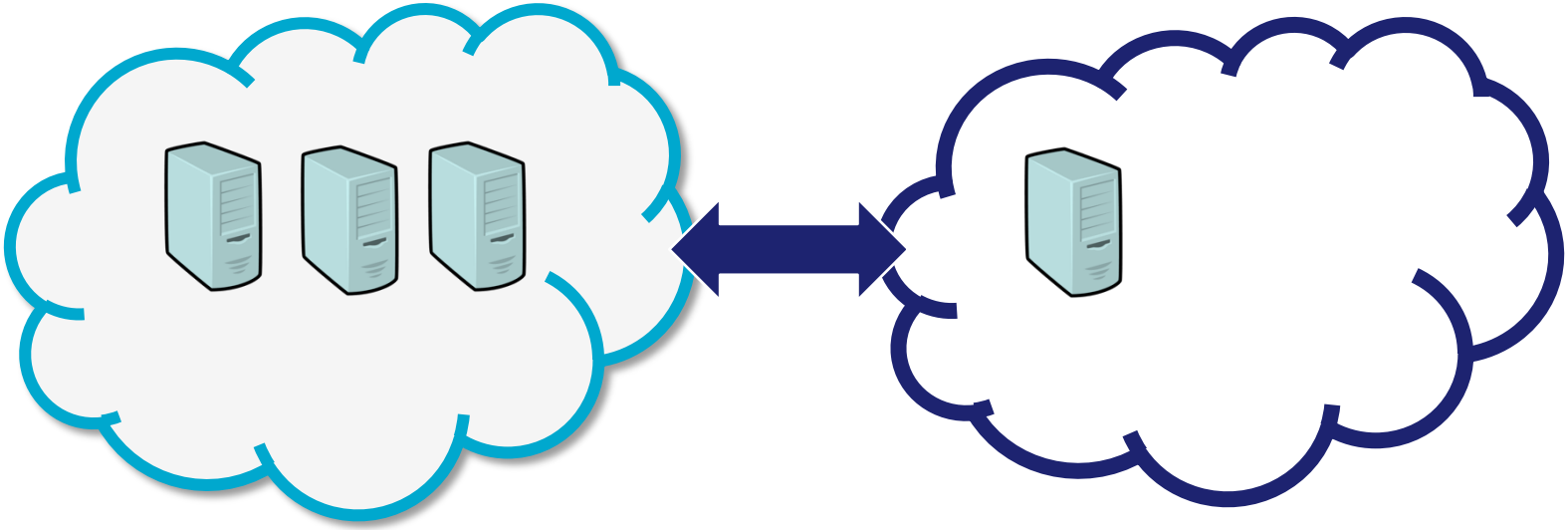
Levels of Coupling

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



Loosely Coupled Federation

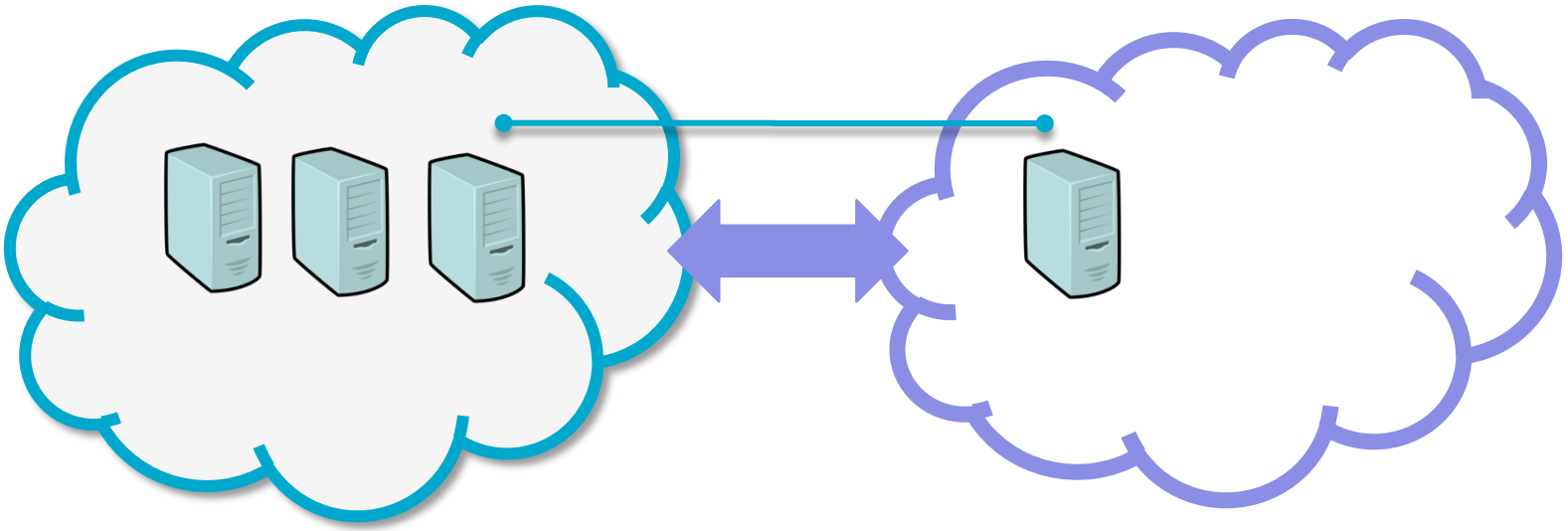
Federation with a Cloud without Interoperation Support



Control	• Basic operations over VMs (start, shutdown, restart...) • Different instance types
Monitoring & Accounting	• Basic virtual resource monitoring (resource consumption...)
Cross-site	• None
Security	• Single account representing the organization

Partially Coupled Federation

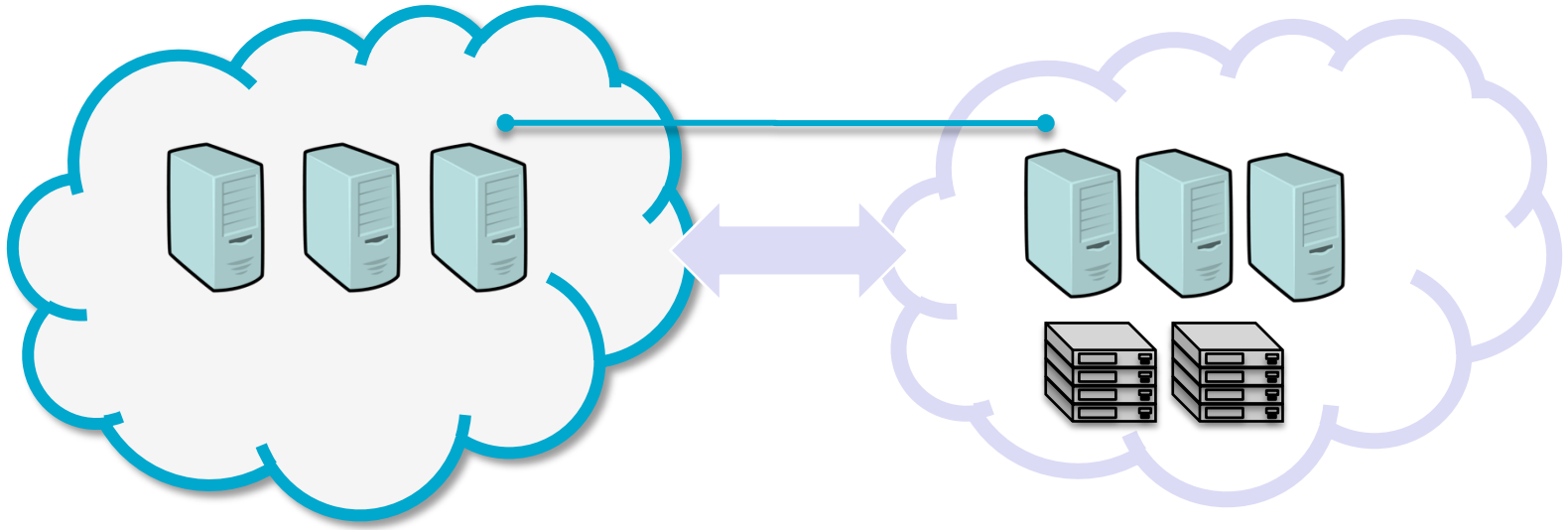
Federation with a Cloud with Partial Interoperation Support



Control	• Advanced operations over VMs (live migration...) • VM location and affinity constraints
Monitoring & Accounting	• Advanced virtual resource monitoring (energy consumption, VM placement...)
Cross-site	• Virtual networks • Virtual storage
Security	• Framework agreement

Tightly Coupled Federation

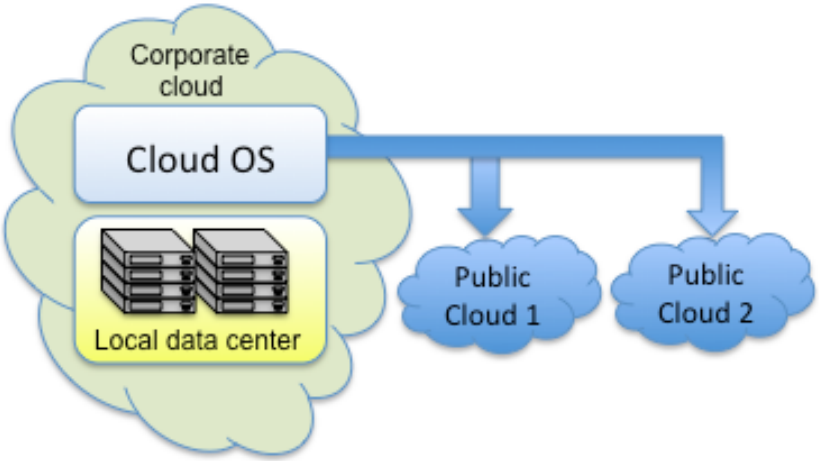
Federation with a Cloud with Advanced Interoperation Support

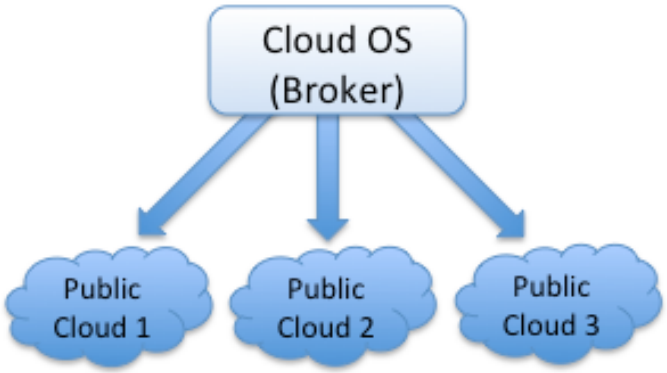


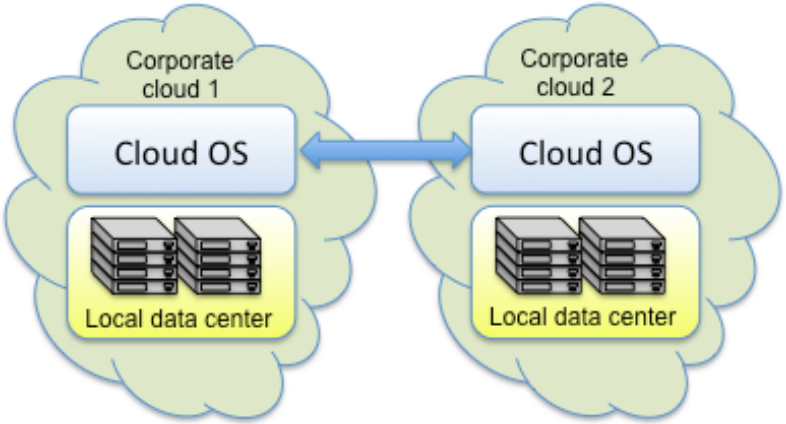
Control	• Placement on specific physical resources • Same instance types
Monitoring & Accounting	• Physical resource consumption
Cross-site	• Live migration • High availability
Security	• User space sharing

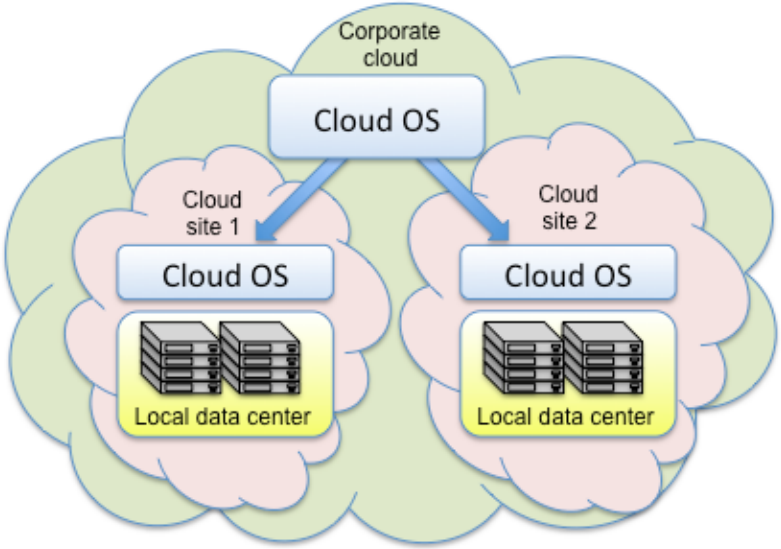
Common Architectures for Cloud Federation

Organization of Multi-site Cloud Environments



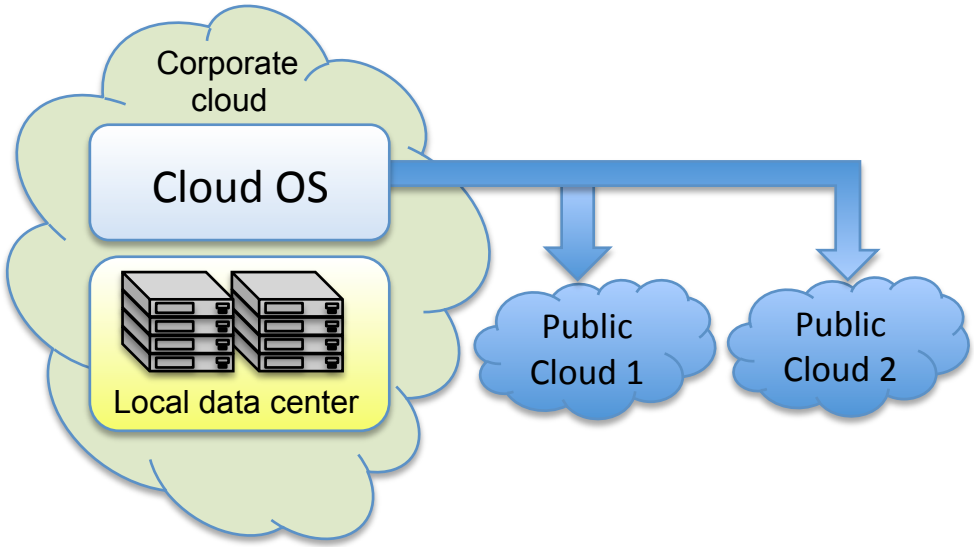






Common Architectures for Cloud Federation

Cloudbursting Architecture



Aim	• Meet peak demands
Cloud Type	• Public cloud by commercial provider • VPC by telecom provider
Coupling	• Loosely and partially coupled

Cloudbursting Architecture

StratusLab

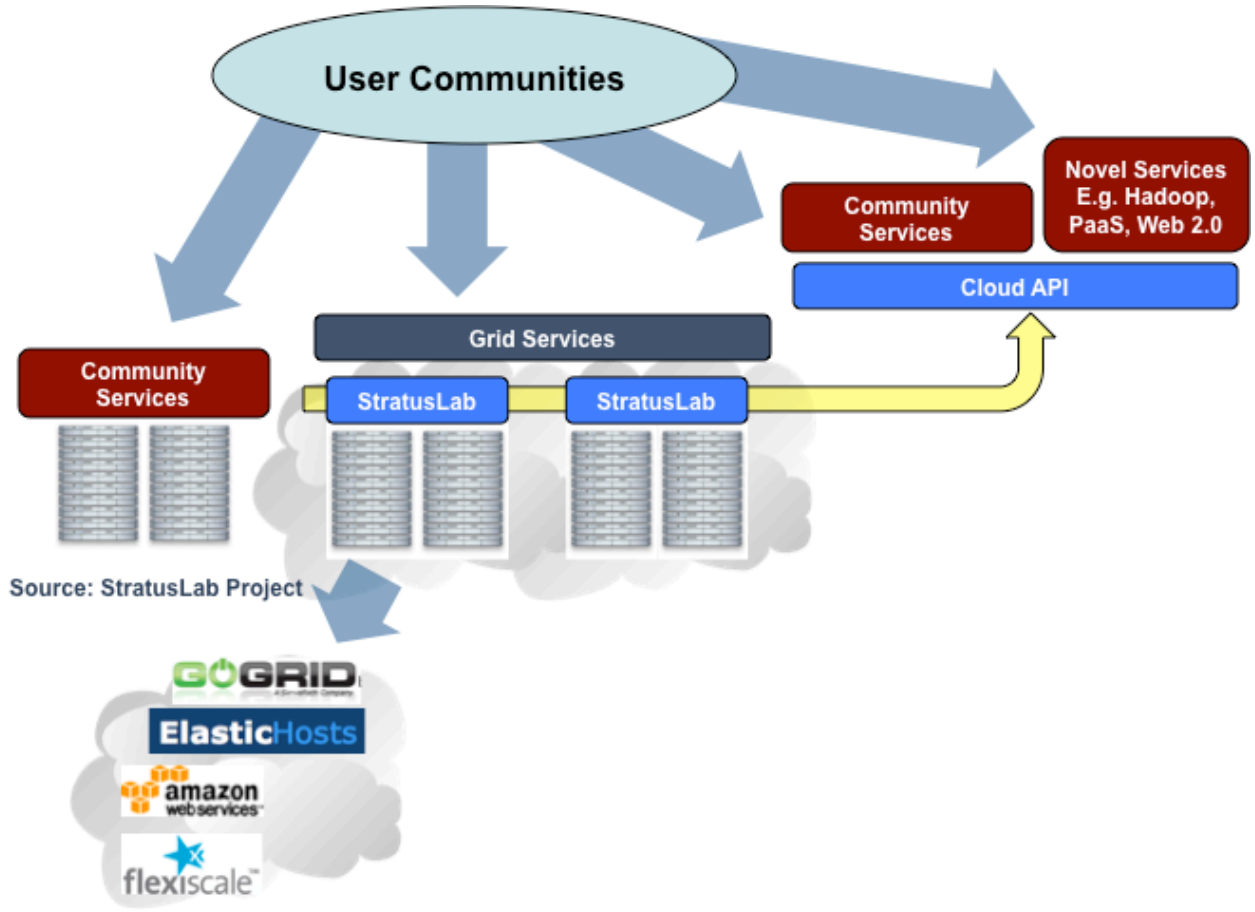
EU grant agreement RI-261552
(2010-2012)
e-Infrastructure

cnrs

www.StratusLab.eu

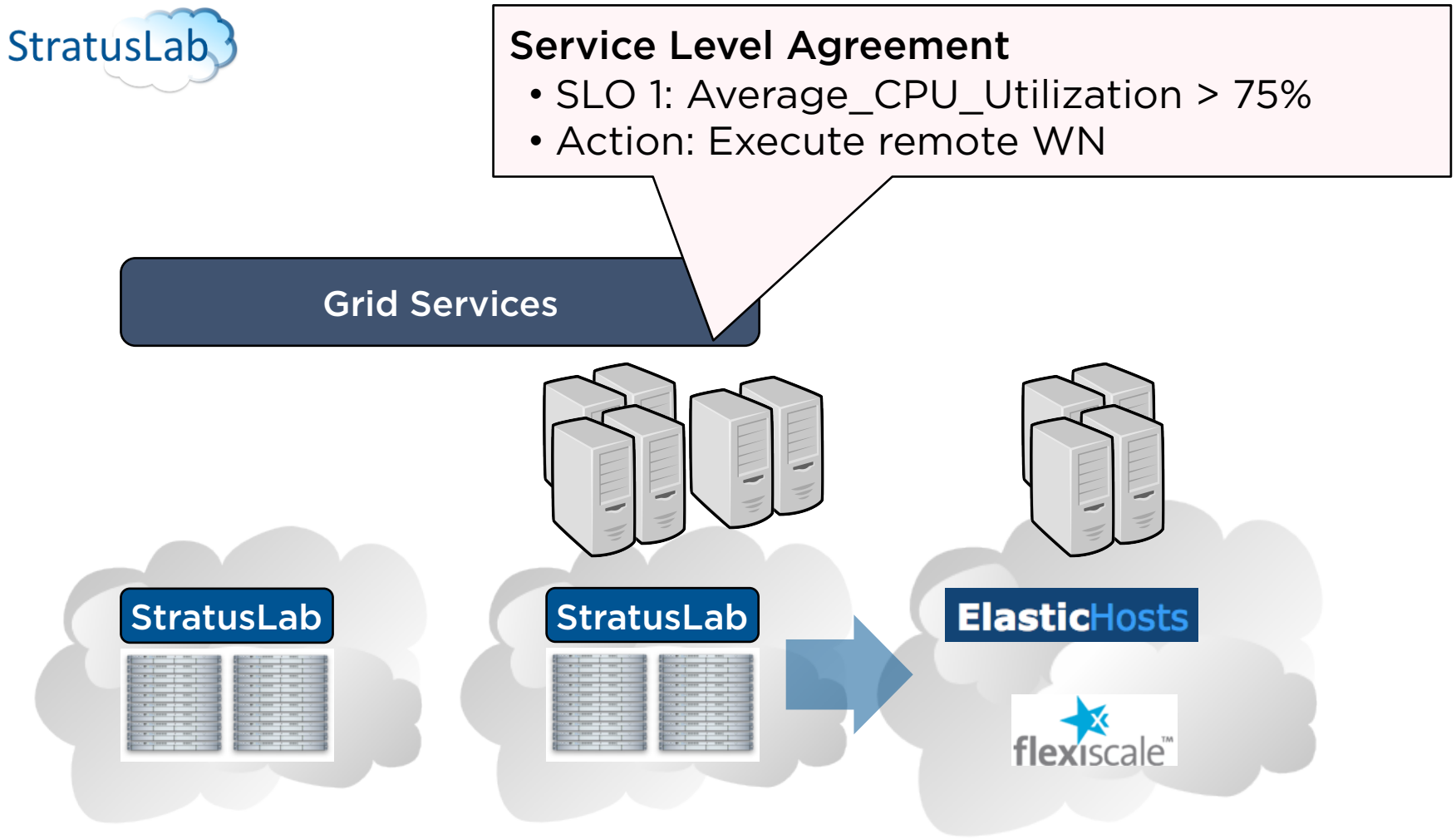
Enhancing Grid Infrastructures with Cloud Computing

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



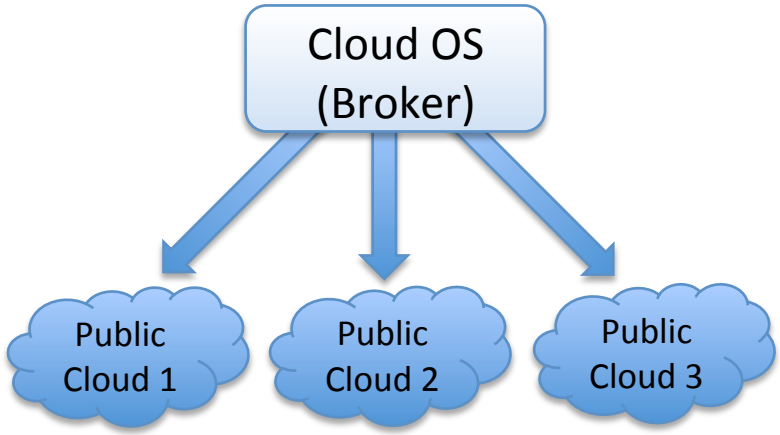
Common Architectures for Cloud Federation

Dynamic Combination of Local with Remote Cloud Resources



Common Architectures for Cloud Federation

Cloud Broker Architecture



Aim	• Cost, performance and reliability optimization
Cloud Type	• Public clouds by commercial provider
Coupling	• Loosely coupled

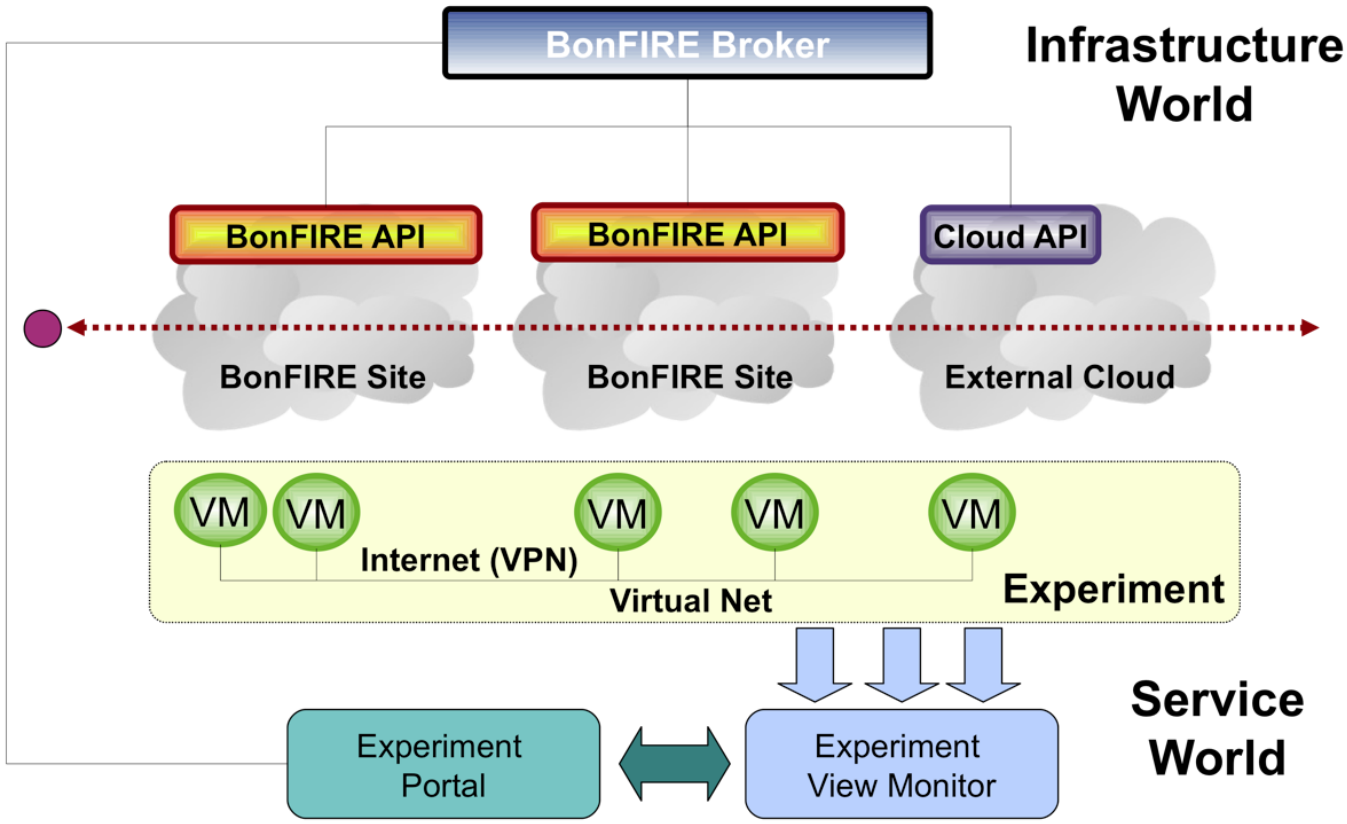
Cloud Broker Architecture

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

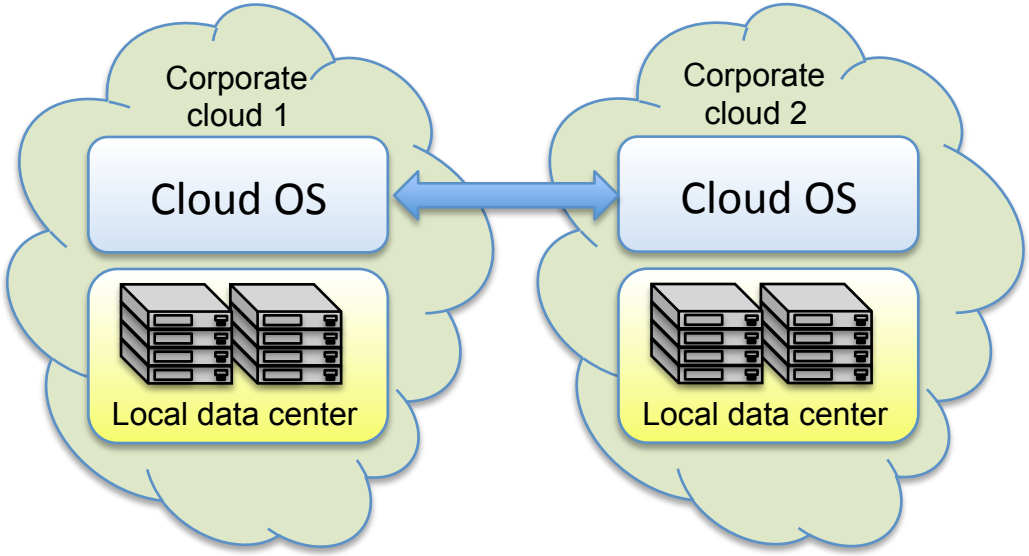
www.BonFIRE-Project.eu



Source: BonFIRE Project

Common Architectures for Cloud Federation

Aggregated Cloud Architecture



Aim	• Sharing of resources to meet peak demands
Cloud Type	• Partner or company clouds
Coupling	• Partially or tightly coupled

Aggregated Cloud Architecture

RESERVOIR

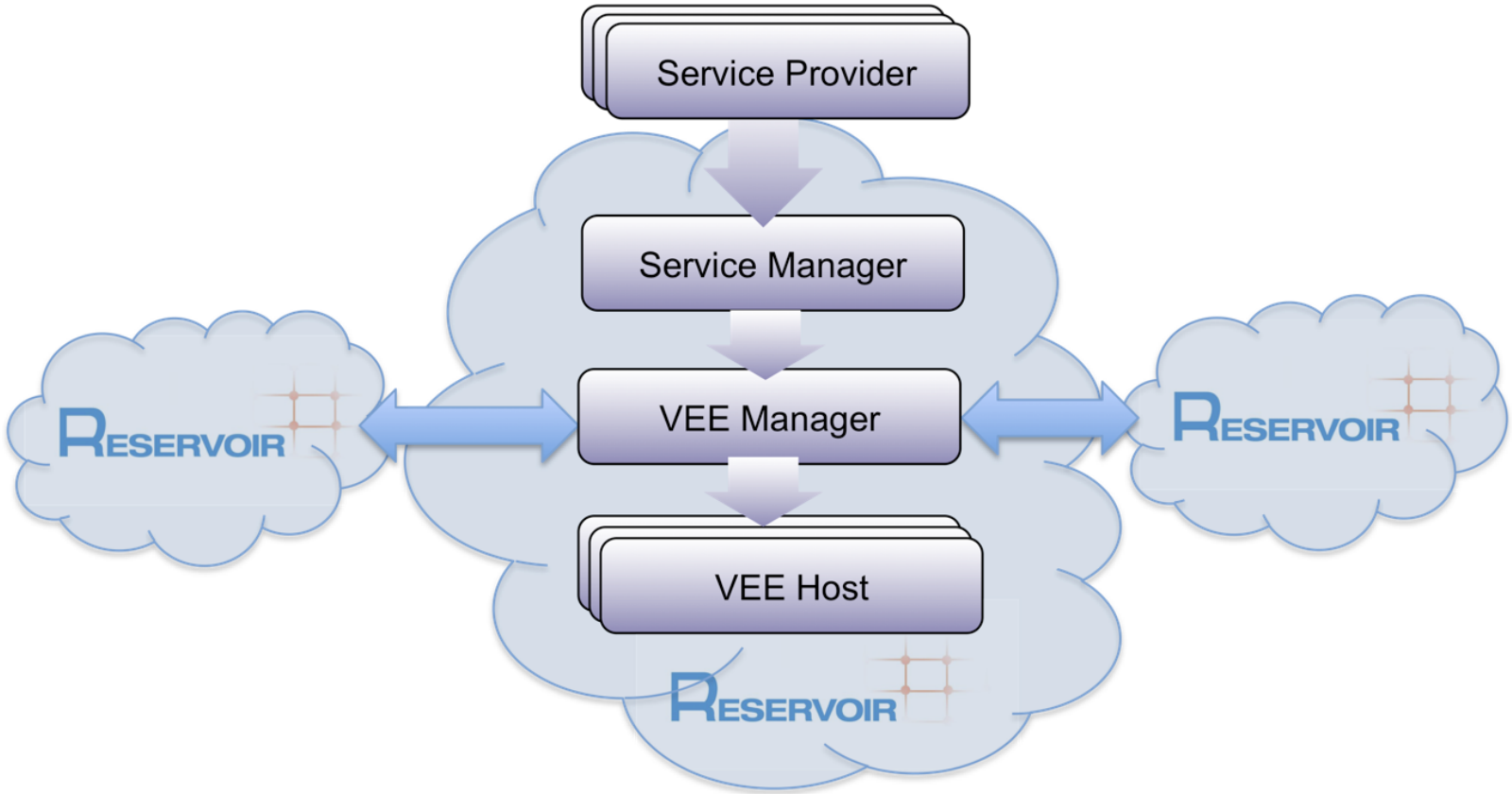
Agreement 215605 (2008-2011)
Service and Sw Architectures and Infrastructures

Resources and Services Virtualization without Barriers

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

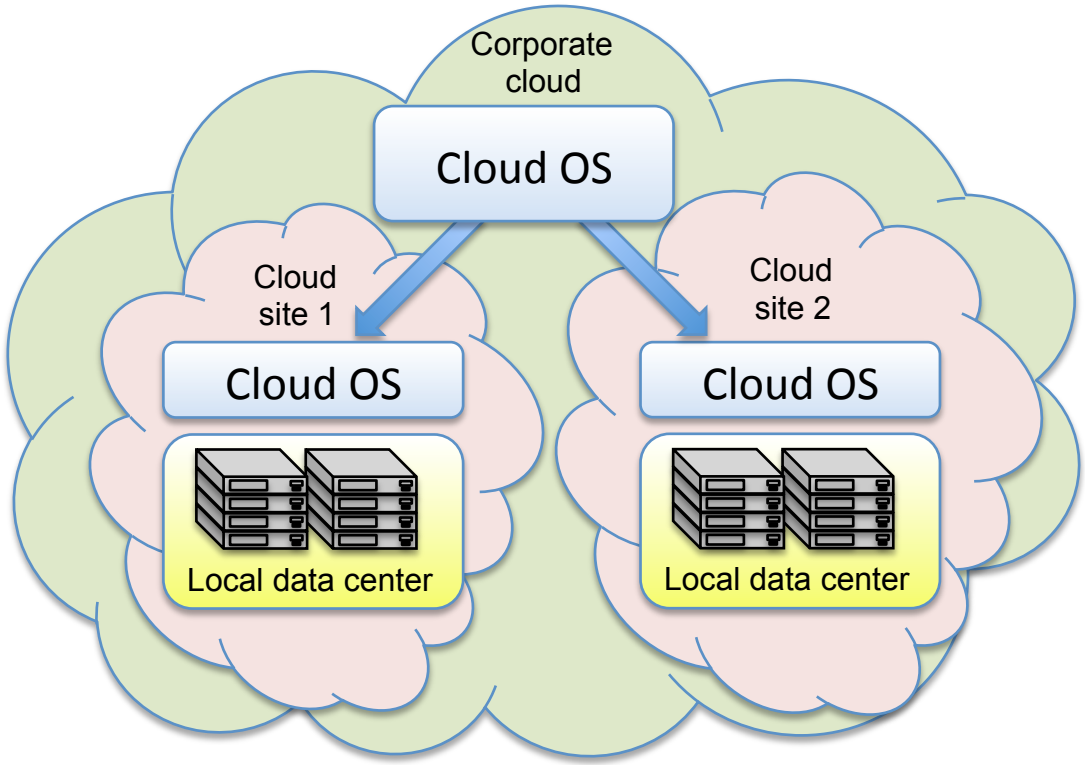
IBM

www.reservoir-fp7.eu



Common Architectures for Cloud Federation

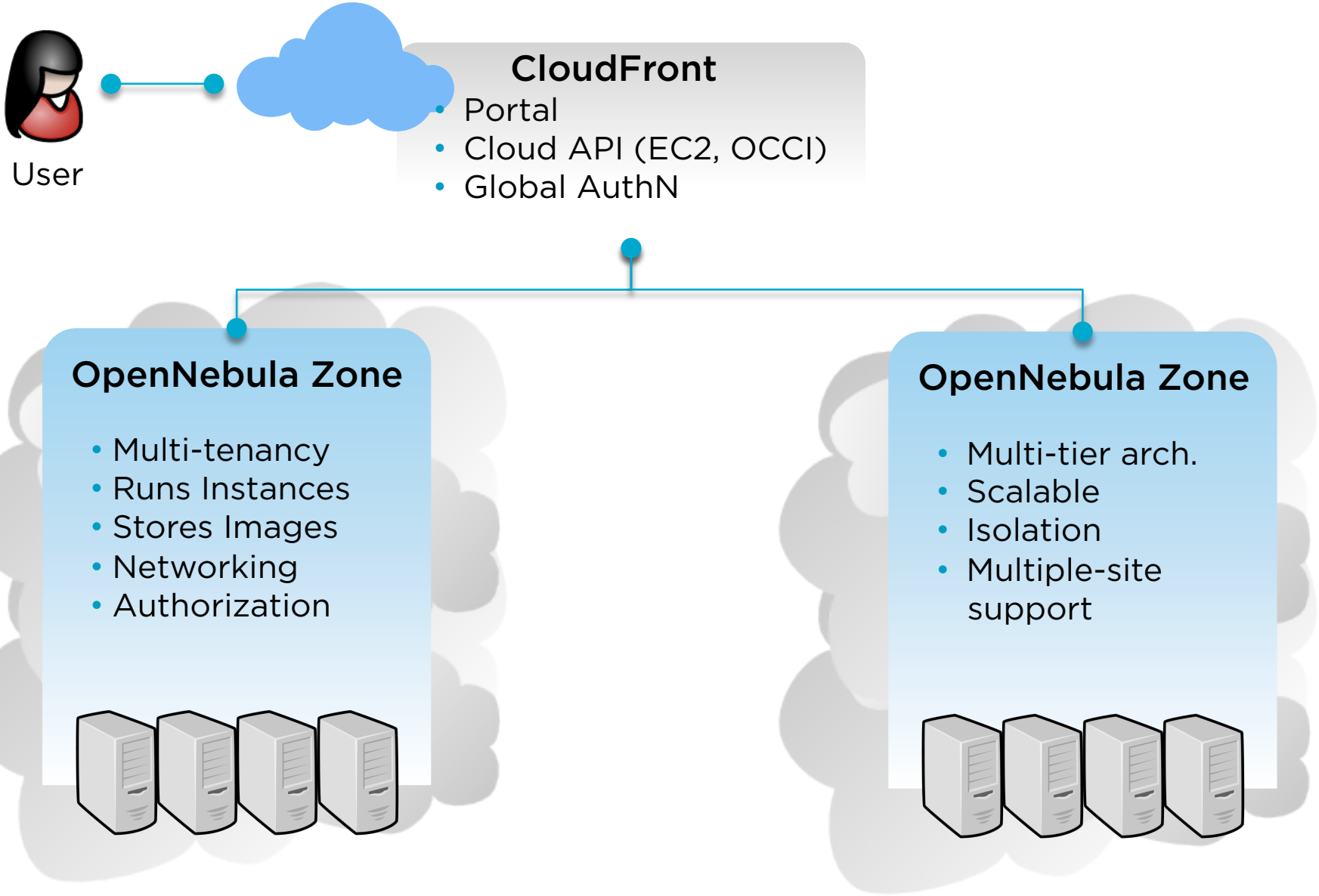
Multi-tier Cloud Architecture



Aim	• Very large scale or geographically distributed data centers
Cloud Type	• Company clouds
Coupling	• Tightly coupled

Common Architectures for Cloud Federation

Multi-tier Cloud Architecture



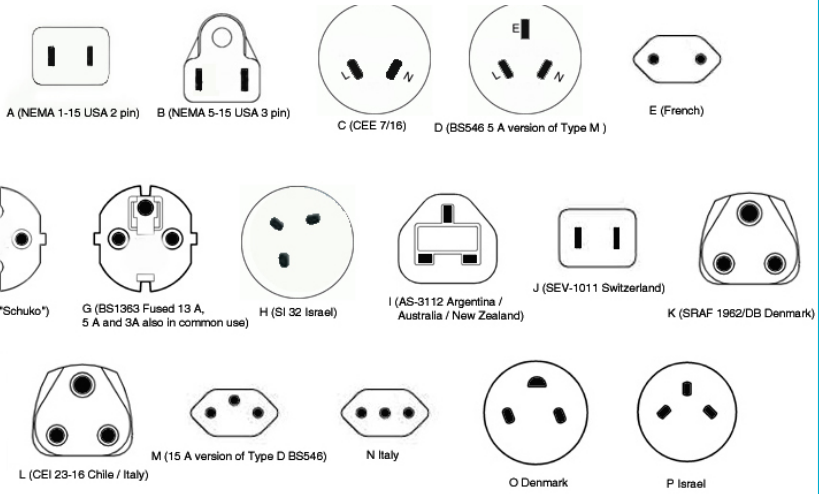
Leveraging Existing Standards and Implementing Interoperation

Standardization

- Implement standards
- Integrate with standards


Which Standard?

- Different *de jure* standards
- Several *de facto* standards



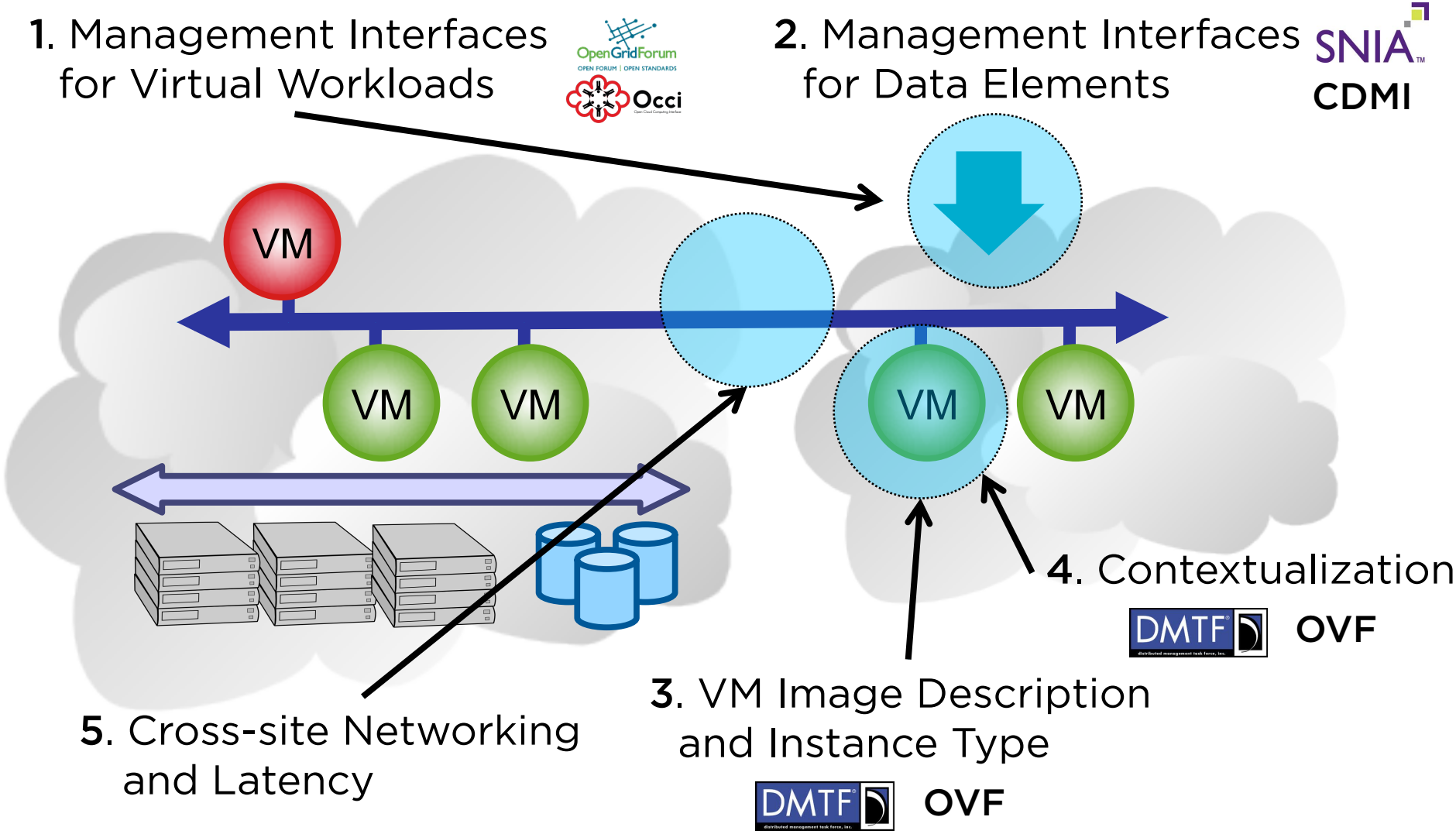
Interoperation

- Implement adaptors
- Use transformers


Challenges for Interoperability

I Want to Combine My Private Cloud with a Remote Cloud without Changes

Transparent Combination of Local Resources with Cloud Resources



Cloud Federation in Grid Infrastructures

StratusLab

Grid and Cloud as Complementary Computing Models

Grids

Usage

- Job Processing
- Big Batch System
- File Sharing Services

Achievements

- Federation of Resources
- VO Concept

But…

- User experience
- Complexity

Clouds

Usage

- Raw infrastructure
- Elasticity & Pay-per-use
- Simple Web Interface

Achievements

- Agile Infrastructures
- IT is another Utility

But…

- Interoperability
- Federation

Resource Sharing

Scientific Applications

Uniform Security

Resource Management

Customize Environments

Flexibility & Simplicity

Cloud Federation in Grid Infrastructures

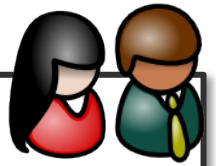
StratusLab

The StratusLab Vision

- Batch Job Processing
- Custom Execution Environments
- Grid Service Integration

2

- Industry Applications
- Other WMS (pilots)
- Complete Services (cluster)



Acc

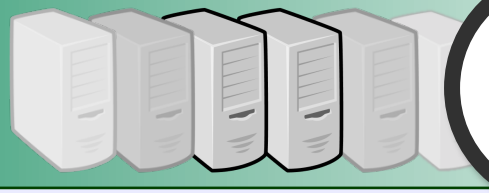
Grid Middleware

IaaS Interface

Service

LRMS (LSF, PBS…)

StratusLab Toolkit



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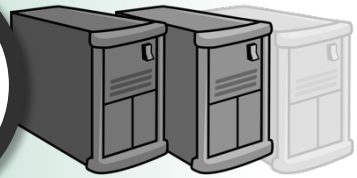


Virtual CE, WN…

Other (web, mail...)

Raw machines

Provision

3

Grid Sites

External Providers

StratusLab

The StratusLab Architecture

Grid Services

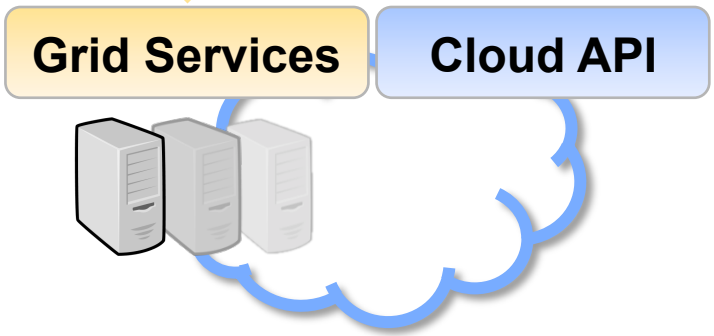
- Federation facilities
- Security
- Grid specific services

MarketPlace

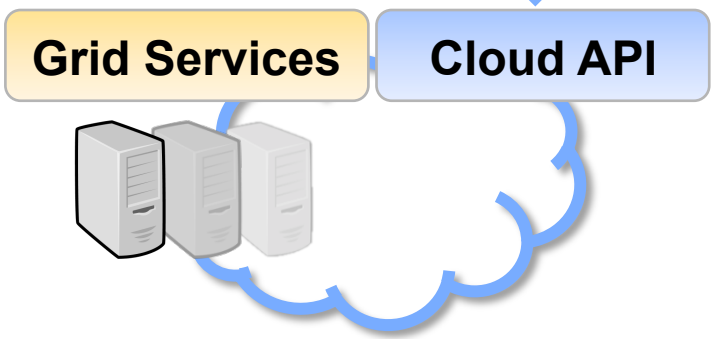
- Sharing existing VM images
- Registry of metadata
- Image are kept elsewhere
- Supports trust

Appliance Repo

- Storage VM images
- Distributed
- Multi-protocol



Cloud/Grid Site



Cloud/Grid Site

Questions?

We Will Be Happy to Answer Any Question

CloudPlan.org

@imllorente

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