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Challenges in Hybrid and Federated Cloud Computing

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Acknowledgments







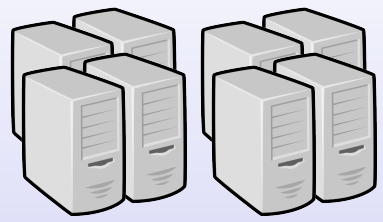






The research leading to these results has received funding from the European Union's Seventh Framework Programme ([FP7/2007-2013]) under grant agreement n° **261552** (StratusLab Project)

Challenges in Hybrid and Federated Cloud Computing

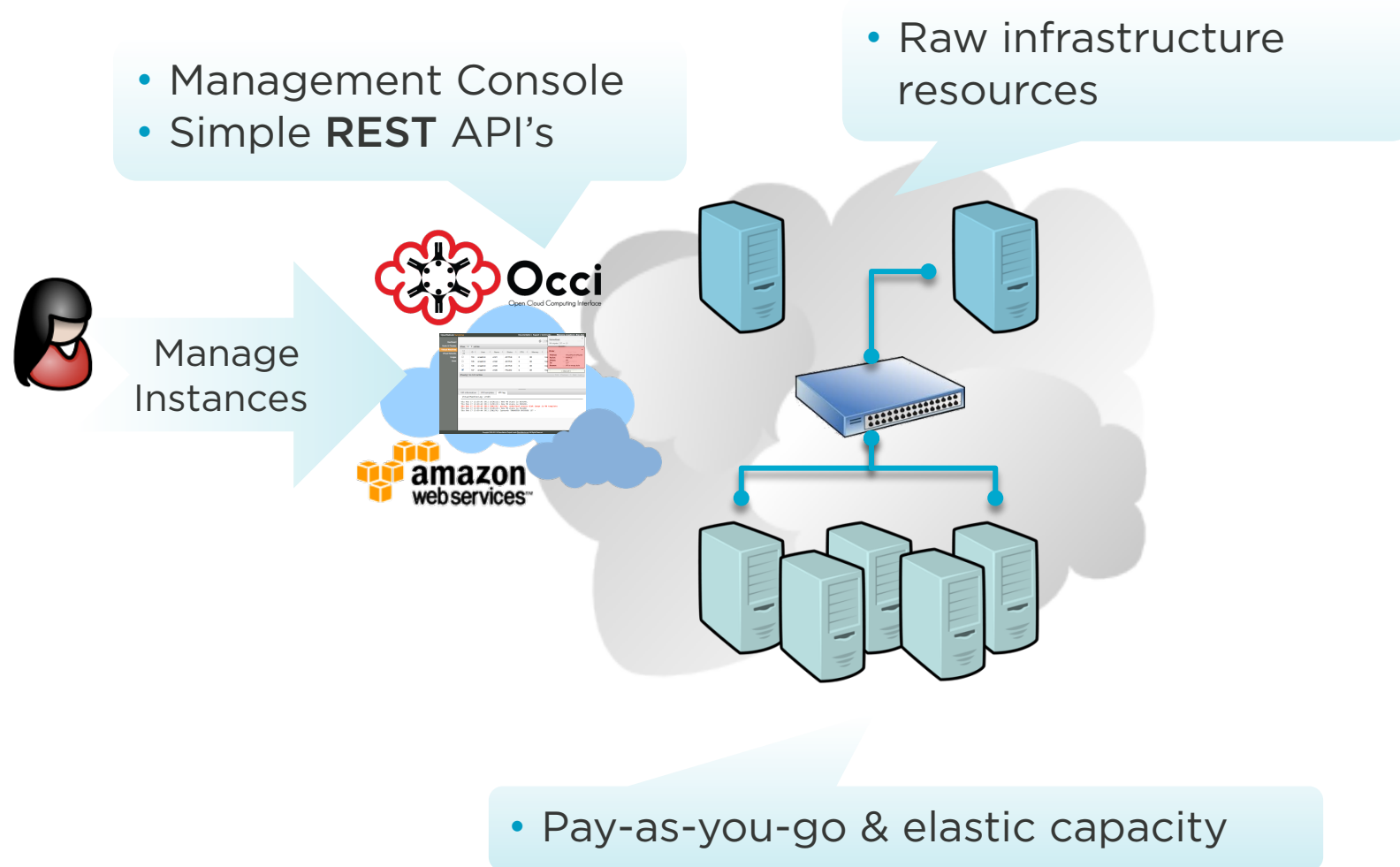
- What is Cloud Computing?
- What is OpenNebula?
- The Future of Cloud Computing
- Levels of Coupling
- Common Architectures for Federation
- Challenges for Interoperability
- Cloud Federation in Grid Infrastructures

Provision of IT Capabilities as a Service

	What	Who
<div style="background-color: #0056b3; color: white; padding: 10px; border-radius: 15px; text-align: center;"> <h2>Software as a Service</h2> </div>	<p>On-demand access to any application</p>	<p>End-user (does not care about hw or sw)</p> <div style="display: flex; justify-content: space-around; align-items: center;">    </div>
<div style="background-color: #add8e6; padding: 10px; border-radius: 15px; text-align: center;"> <h2>Platform as a Service</h2> </div>	<p>Platform for building and delivering web applications</p>	<p>Developer (no managing of the underlying hw & sw layers)</p> <div style="display: flex; justify-content: space-around; align-items: center;">  <div style="text-align: center;">  <p>Windows Azure</p>  <p>force.com™ platform as a service</p> </div> </div>
<div style="background-color: #e6f2ff; padding: 10px; border-radius: 15px; text-align: center;"> <h2>Infrastructure as a Service</h2> <div style="display: flex; justify-content: center; align-items: center; margin: 10px 0;">  </div> <p>Physical Infrastructure</p> </div>	<p>Raw computer infrastructure</p>	<p>System Administrator (complete management of the computer infrastructure)</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 20px;"> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> </div>

What is Cloud Computing?

Provision of Virtualized Resources as a Service



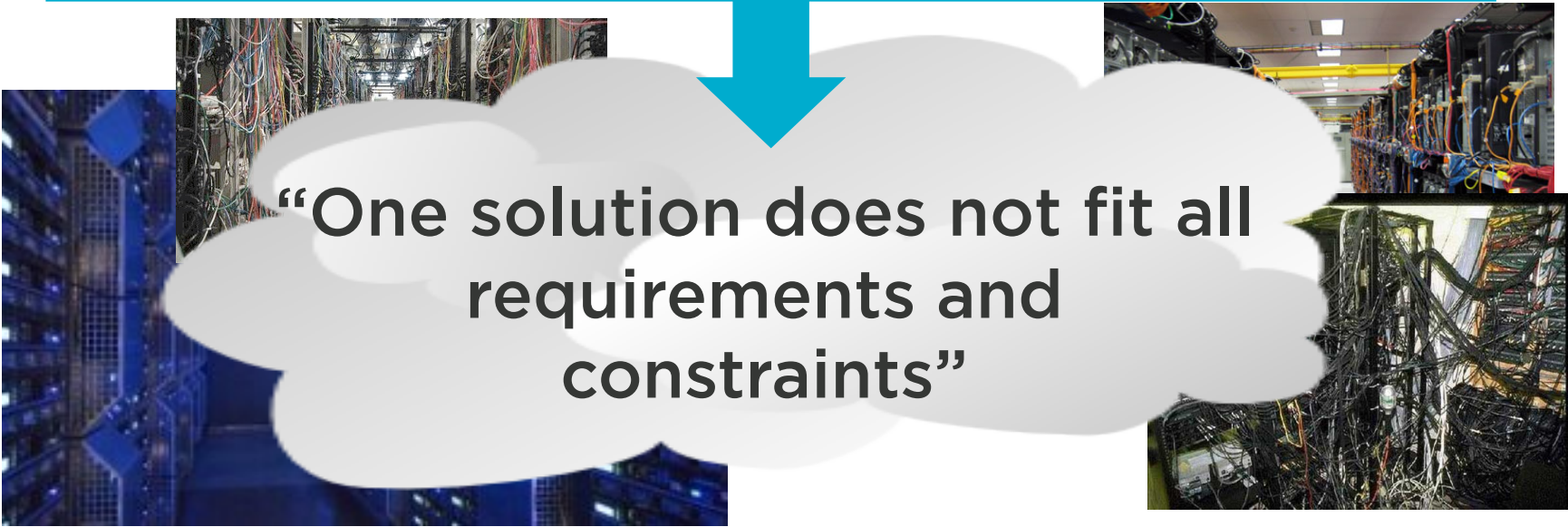
Different Models of Deployment

Model	Definition	Cloud Cases
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 over the Internet	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• Premium solutions with additional control/configuration and security/reliability• Telecom cloud providers

Cloud as an Evolution of the Data Center

Constraints from Existing Infrastructure and Processes

Requirements from Usage and Deployment Scenarios



“One solution does not fit all requirements and constraints”

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

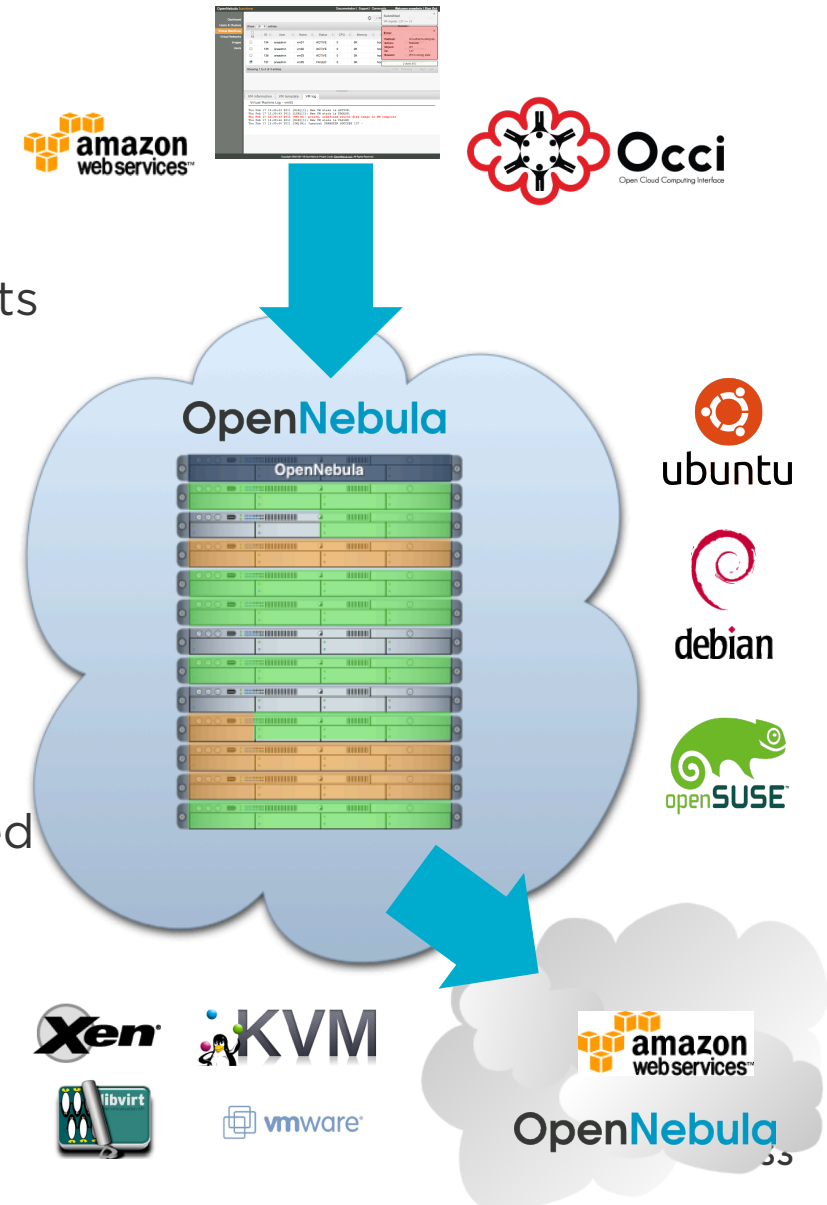
Interoperable

- Most popular cloud APIs and standard based

Openness

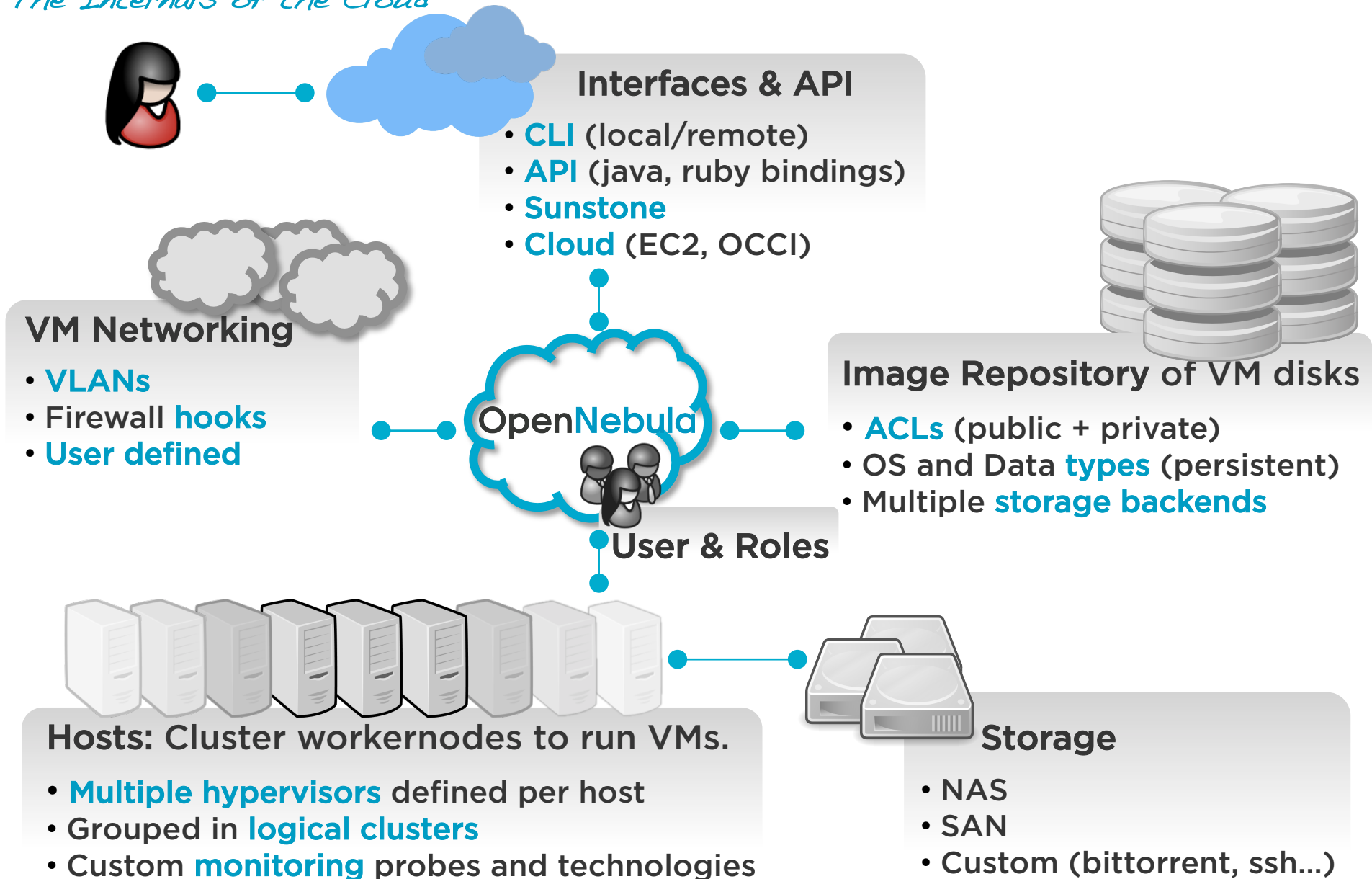
- Fully open-source
- Apache license

Challenges in Hybrid and Federated Cloud Computing



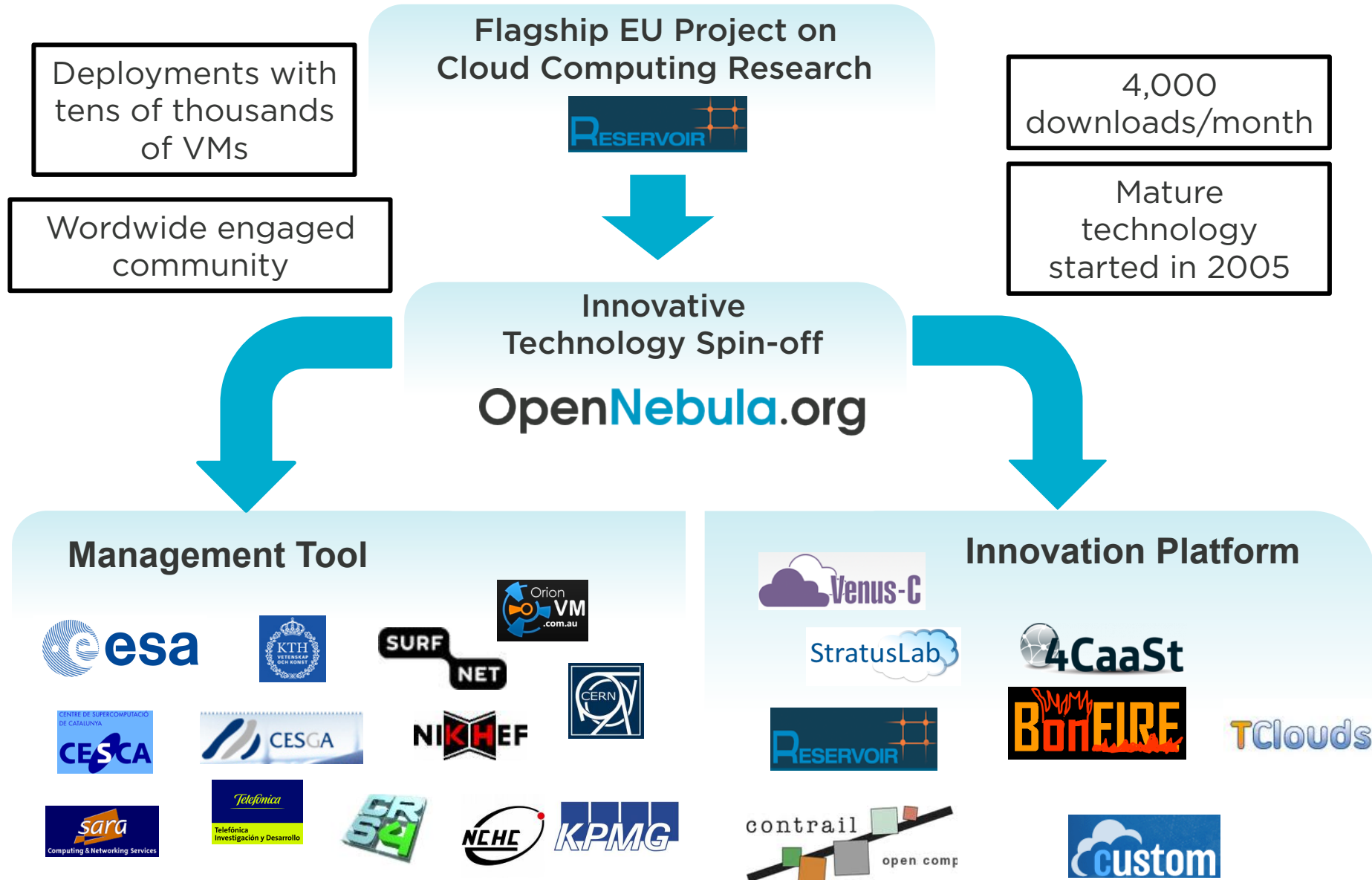
What is OpenNebula?

The Internals of the Cloud



What is OpenNebula?

EU Success Story in Cloud Computing Research and Innovation



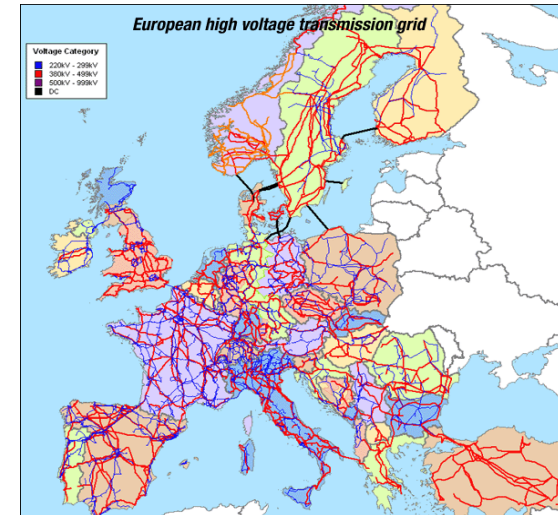
Next Step in the Evolution of an Utility



**Utility
Generation**



**Utility
Distribution**



Utility Grid



Benefits of Federation

Scalability

- Cloudbursting to address peak demands

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

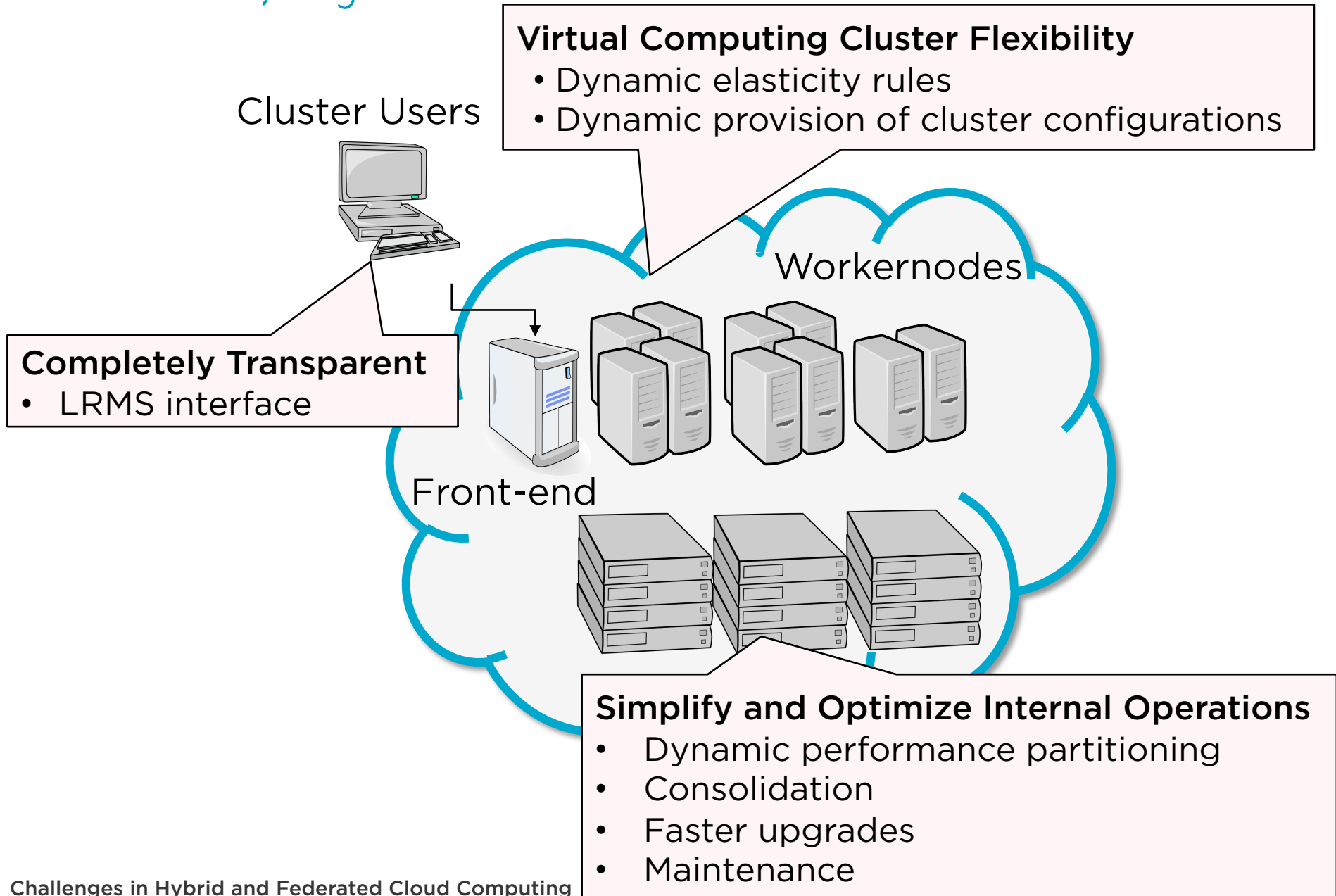
Cost

- Dynamic placement to reduce the overall infrastructure cost

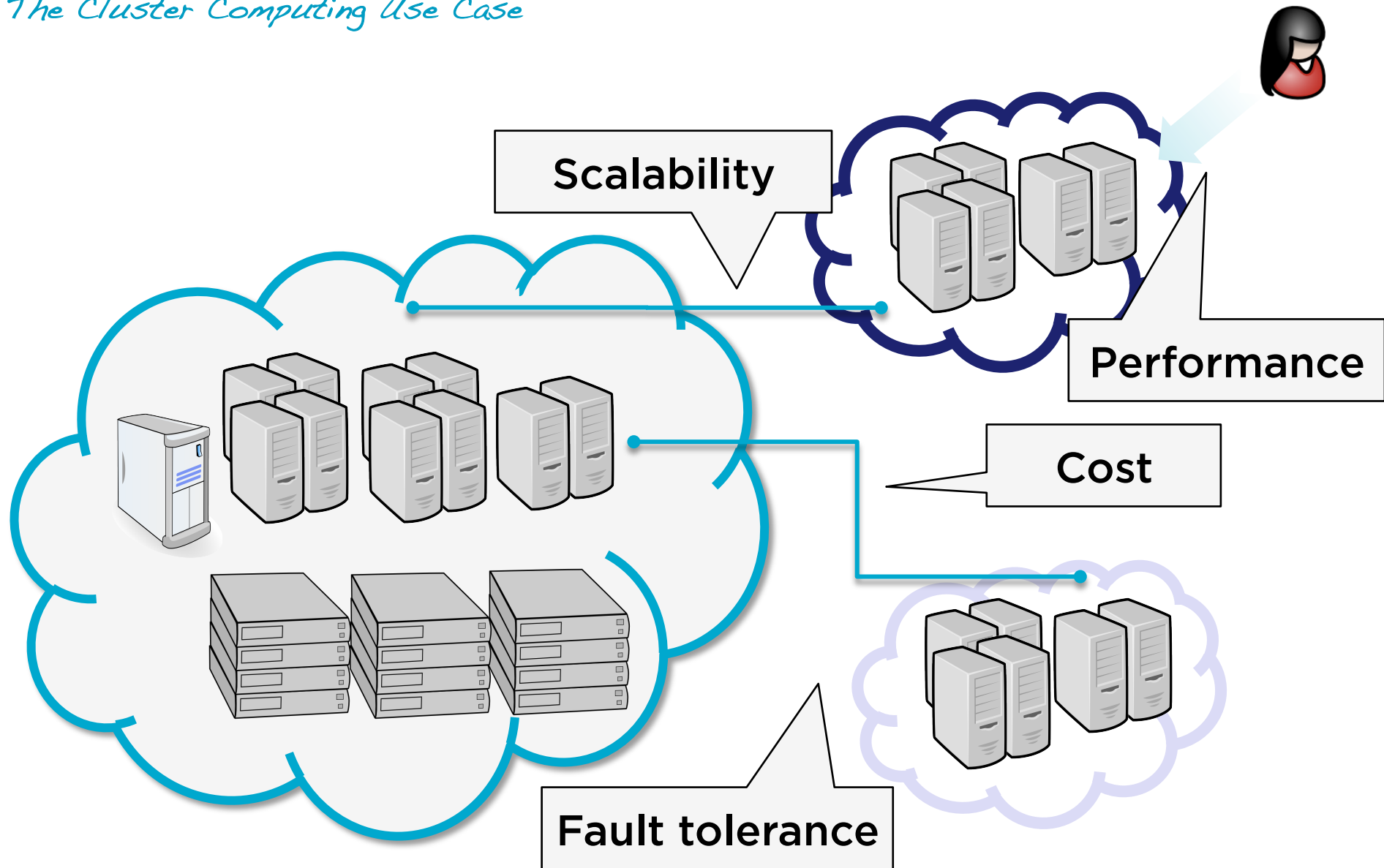
Energy Consumption

- Minimize energy consumption

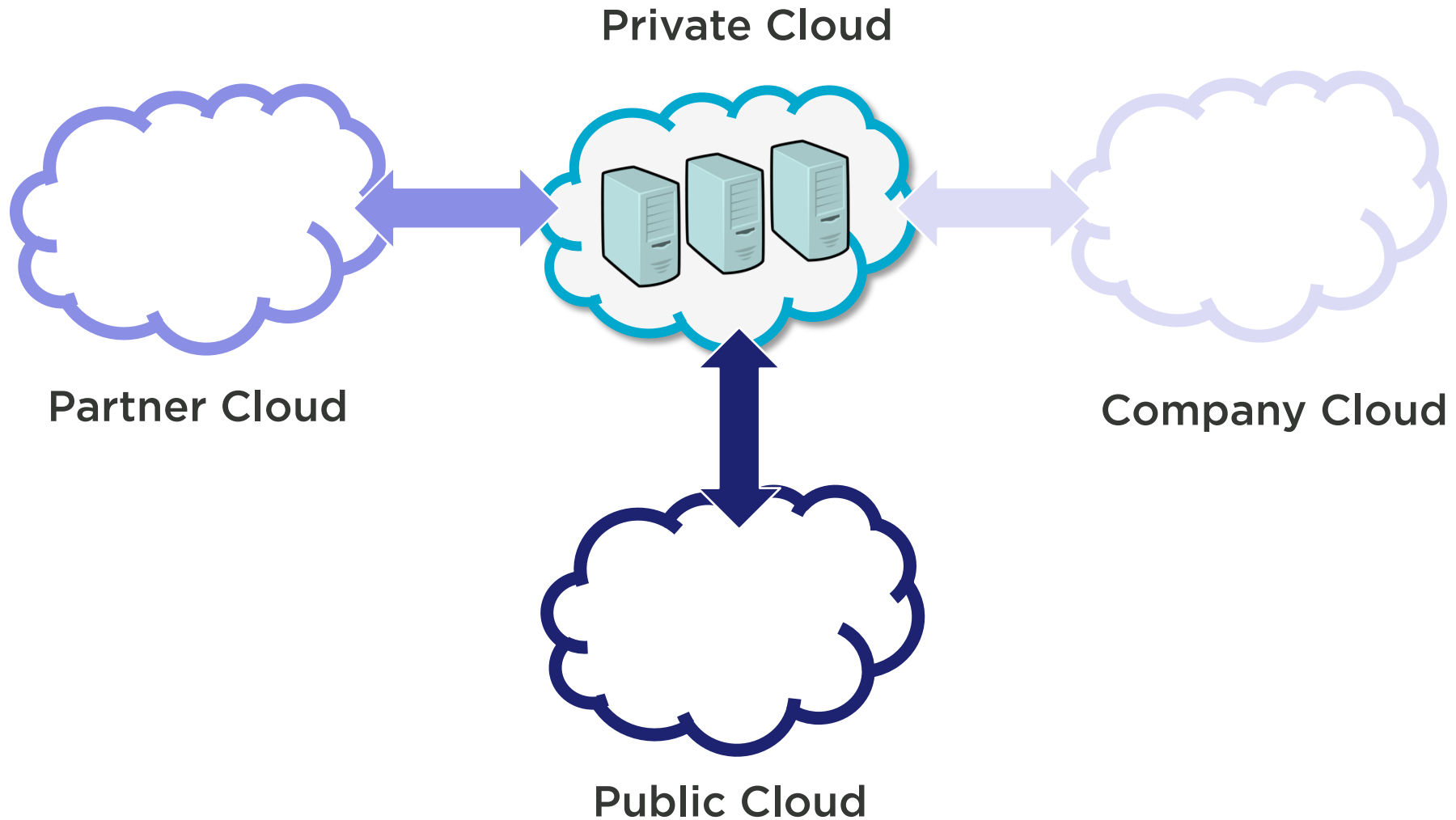
The Cluster Computing Use Case



The Cluster Computing Use Case

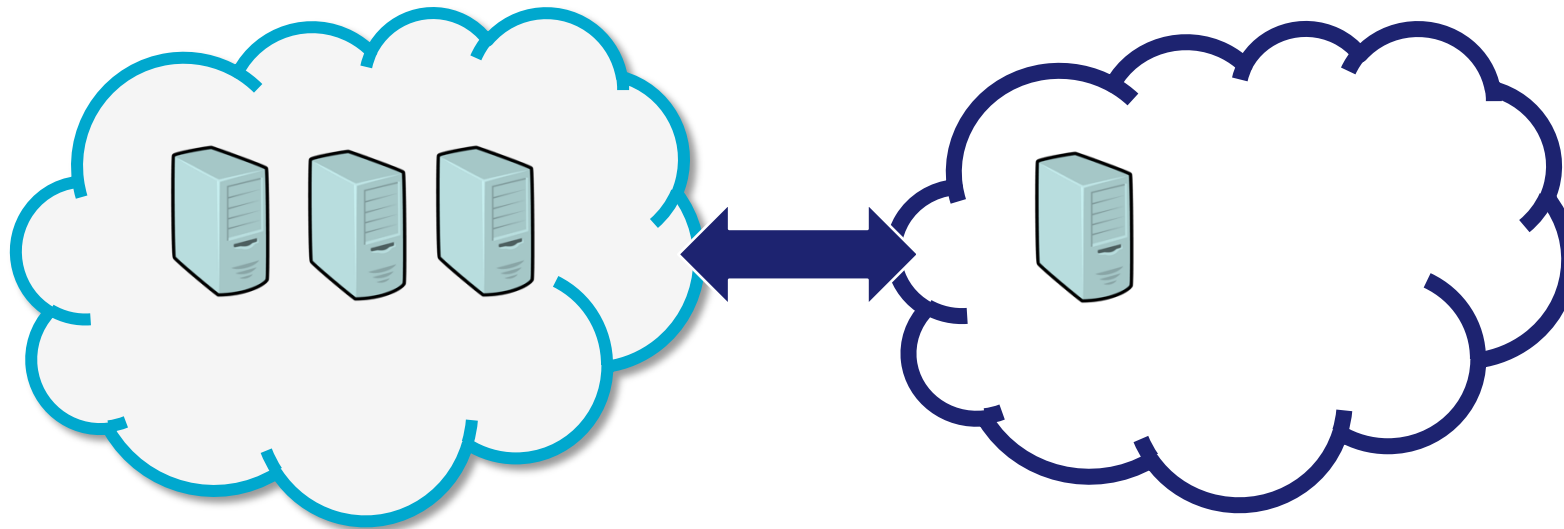


Different Levels of Control, Monitoring, Cross-site Functionality and Security



Loosely Coupled Federation

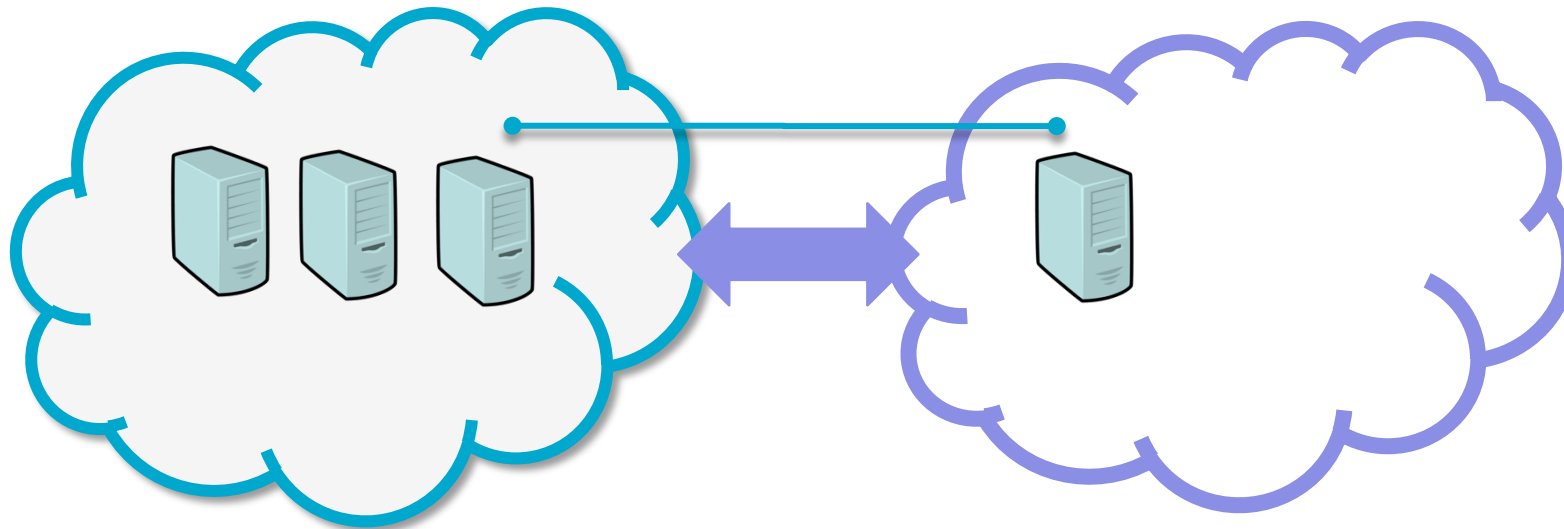
Federation with a Cloud without Interoperation Support



Control	<ul style="list-style-type: none">• Basic operations over VMs (start, shutdown, restart...)• Different instance types
Monitoring & Accounting	<ul style="list-style-type: none">• Basic virtual resource monitoring (resource consumption...)
Cross-site	<ul style="list-style-type: none">• None
Security	<ul style="list-style-type: none">• Single account representing the organization

Partially Coupled Federation

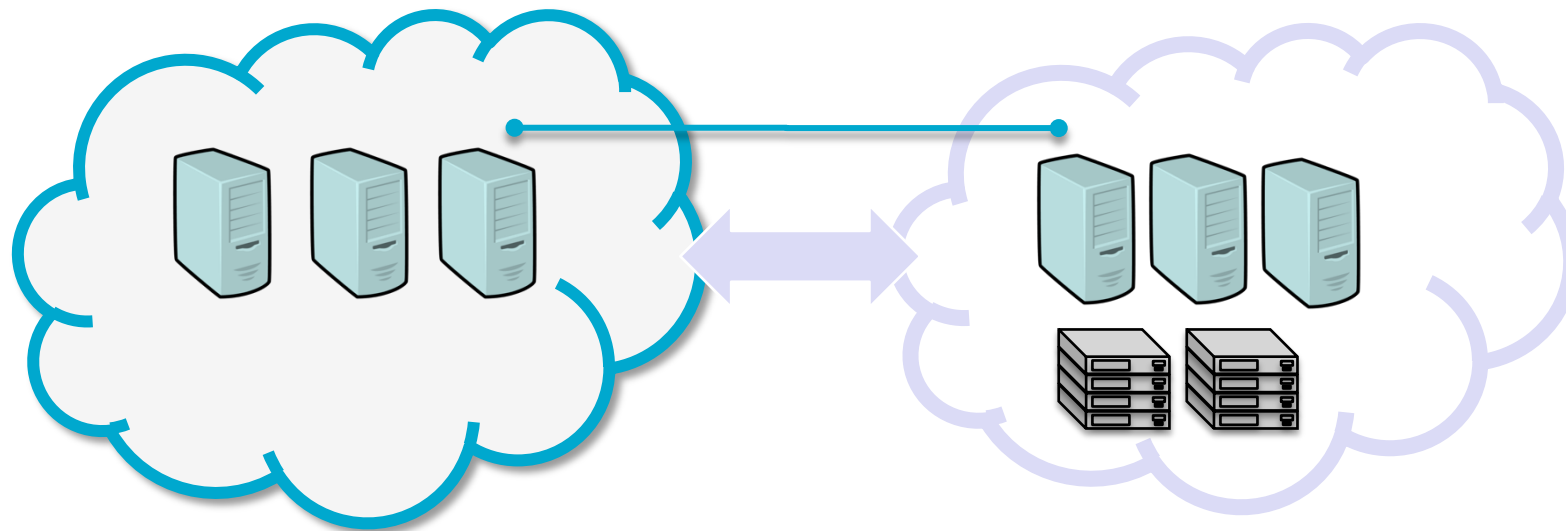
Federation with a Cloud with Partial Interoperation Support



Control	<ul style="list-style-type: none">• Advanced operations over VMs (live migration...)• VM location and affinity constraints
Monitoring & Accounting	<ul style="list-style-type: none">• Advanced virtual resource monitoring (energy consumption, VM placement...)
Cross-site	<ul style="list-style-type: none">• Virtual networks• Virtual storage
Security	<ul style="list-style-type: none">• Framework agreement

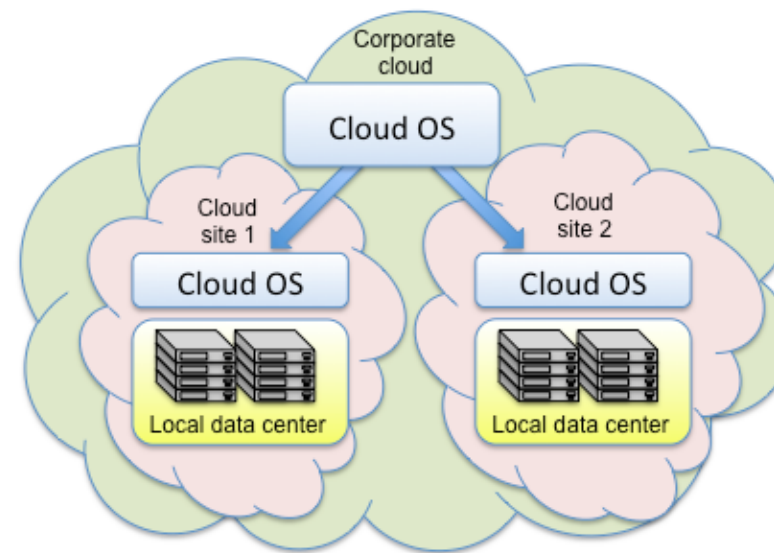
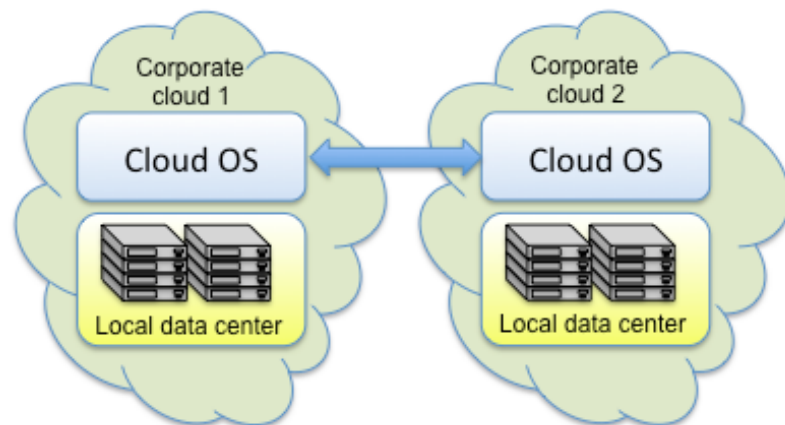
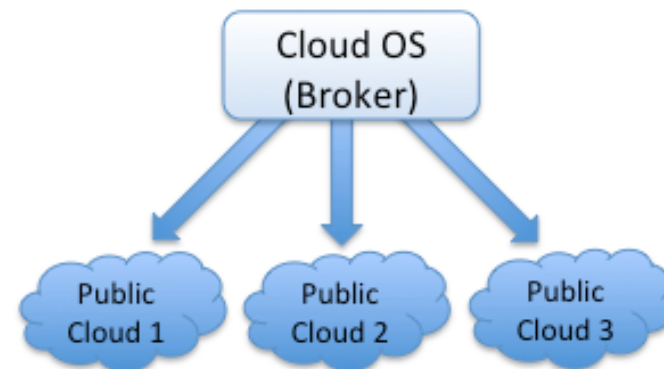
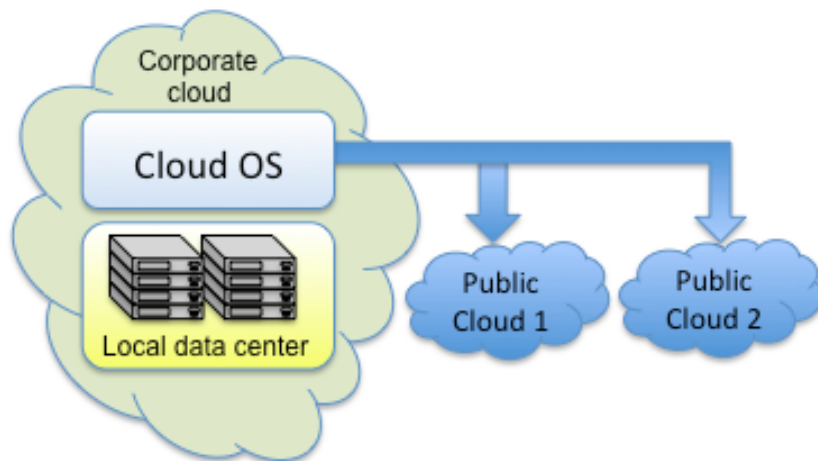
Tightly Coupled Federation

Federation with a Cloud with Advanced Interoperation Support

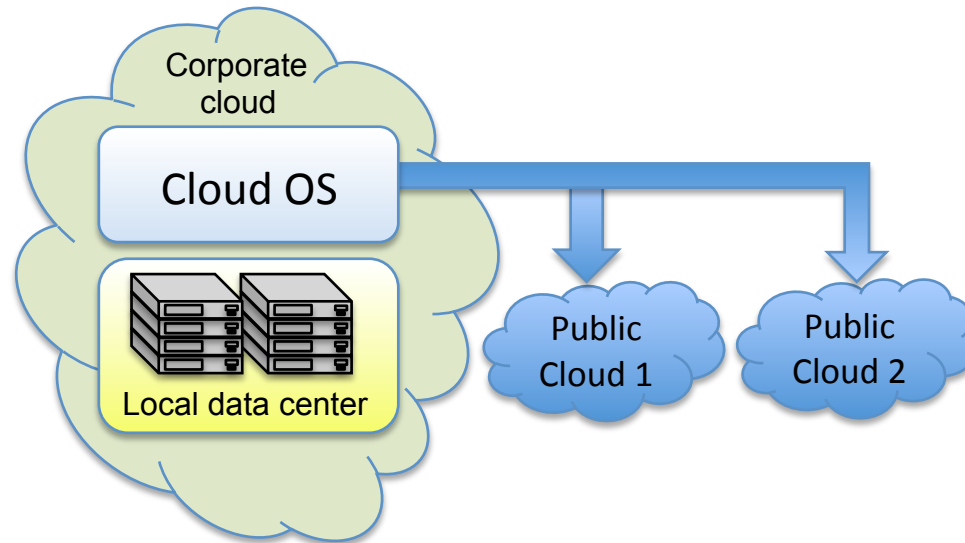


Control	<ul style="list-style-type: none">• Placement on specific physical resources• Same instance types
Monitoring & Accounting	<ul style="list-style-type: none">• Physical resource consumption
Cross-site	<ul style="list-style-type: none">• Live migration• High availability
Security	<ul style="list-style-type: none">• User space sharing

Organization of Multi-site Cloud Environments



Cloudbursting Architecture



Aim	<ul style="list-style-type: none">• Meet peak demands
Cloud Type	<ul style="list-style-type: none">• Public cloud by commercial provider• VPC by telecom provider
Coupling	<ul style="list-style-type: none">• Loosely and partially coupled

Cloudbursting Architecture



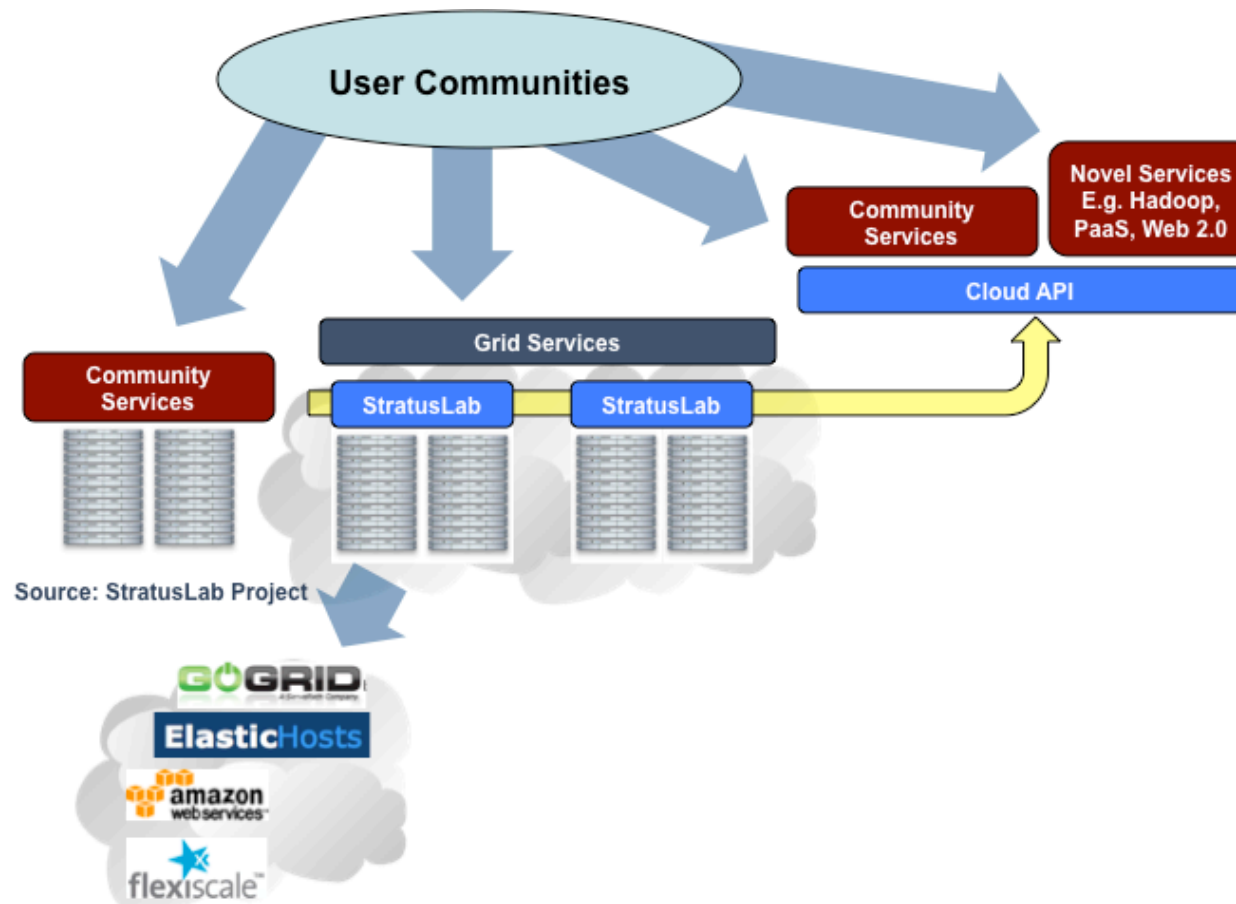
EU grant agreement RI-261552
(2010-2012)
e-Infrastructure



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



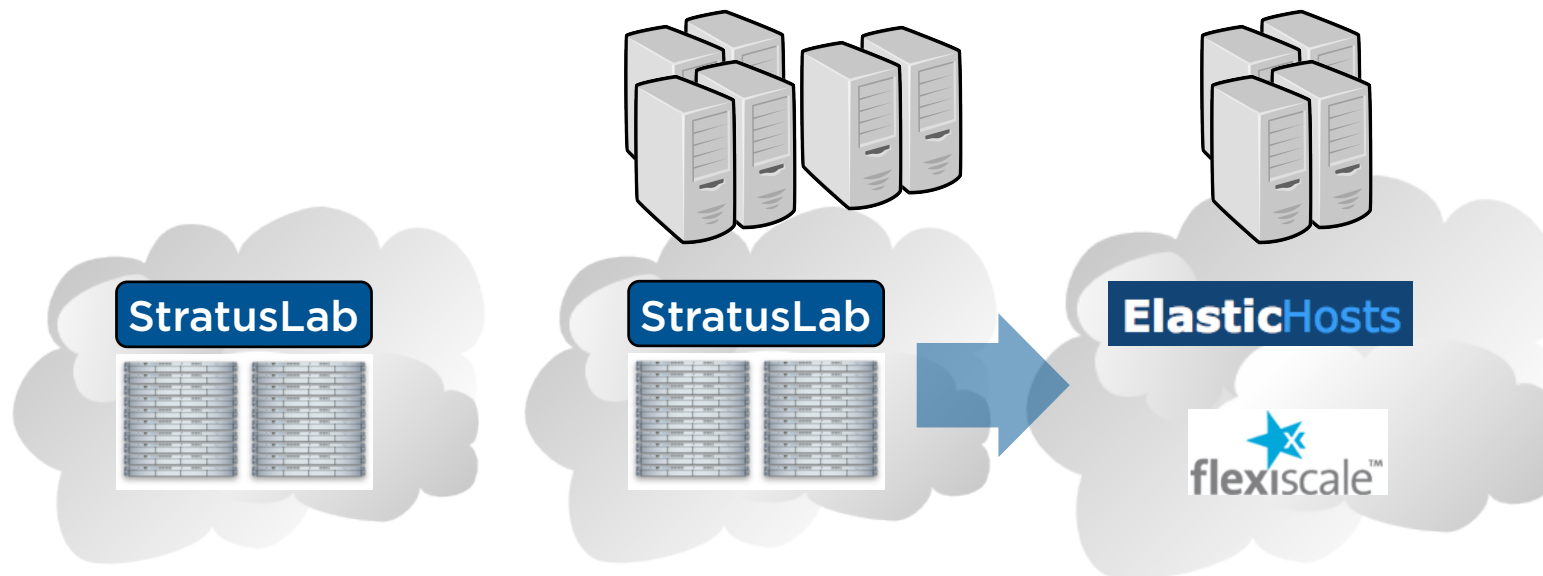
Dynamic Combination of Local with Remote Cloud Resources

StratusLab

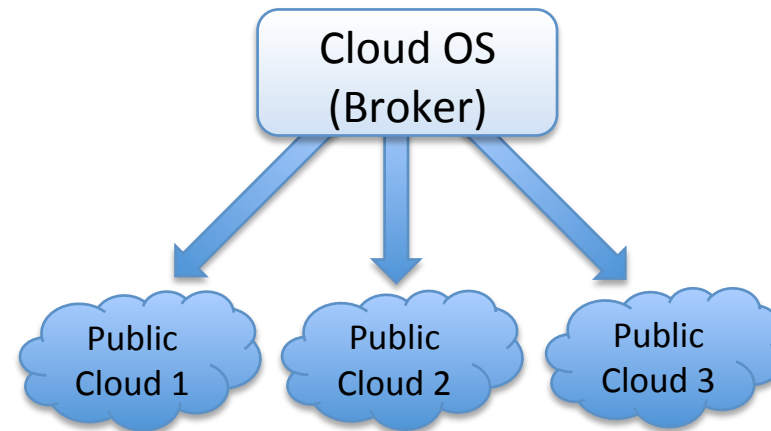
Service Level Agreement

- SLO 1: Average_CPU_Utilization > 75%
- Action: Execute remote WN

Grid Services



Cloud Broker Architecture



Aim	<ul style="list-style-type: none">• Cost, performance and reliability optimization
Cloud Type	<ul style="list-style-type: none">• Public clouds by commercial provider
Coupling	<ul style="list-style-type: none">• Loosely coupled

Cloud Broker Architecture



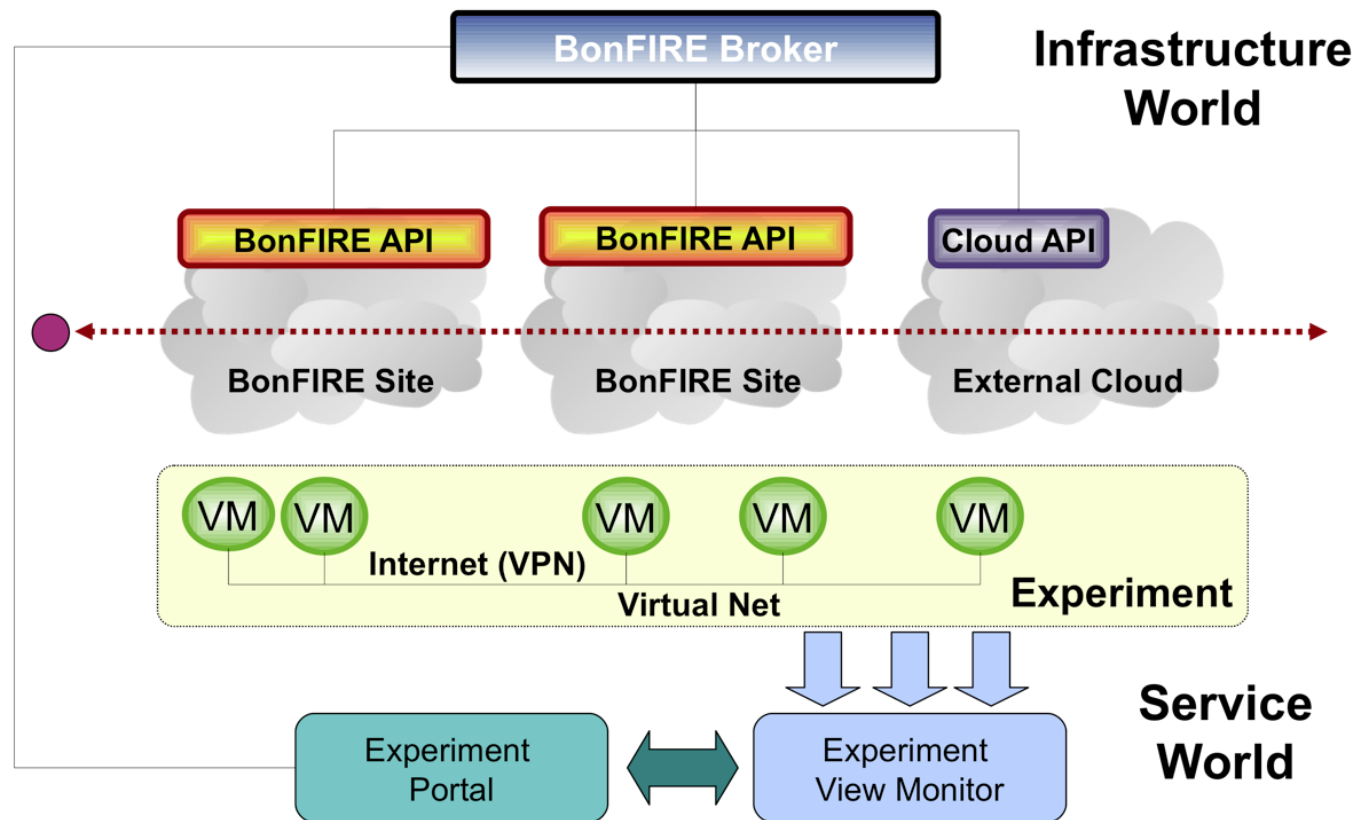
Agreement 257386 (2010-2013)
New Infrastructure Paradigms
and Experimental Facilities

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

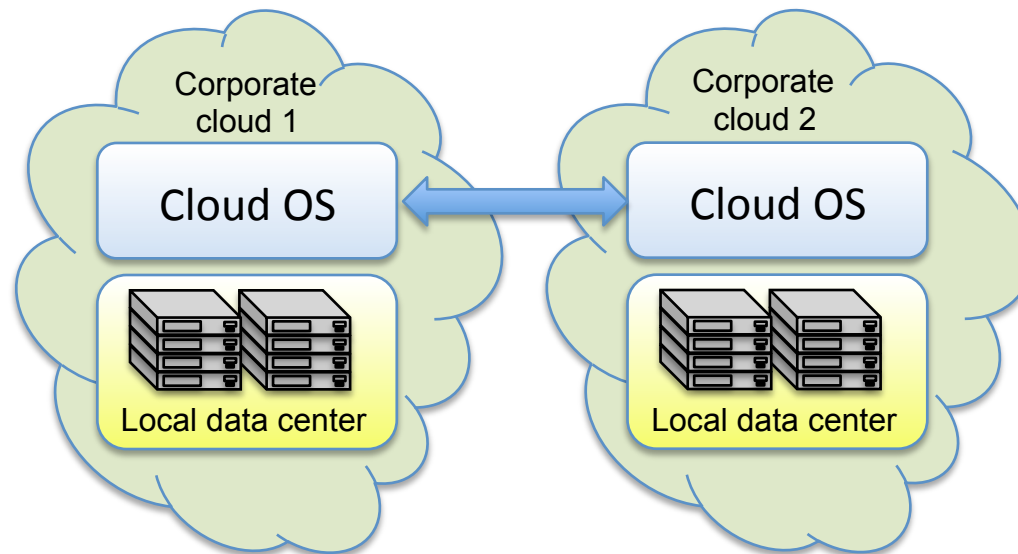


www.BonFIRE-Project.eu



Source: BonFIRE Project

Aggregated Cloud Architecture



Aim	<ul style="list-style-type: none">• Sharing of resources to meet peak demands
Cloud Type	<ul style="list-style-type: none">• Partner or company clouds
Coupling	<ul style="list-style-type: none">• Partially or tightly coupled

Aggregated Cloud Architecture



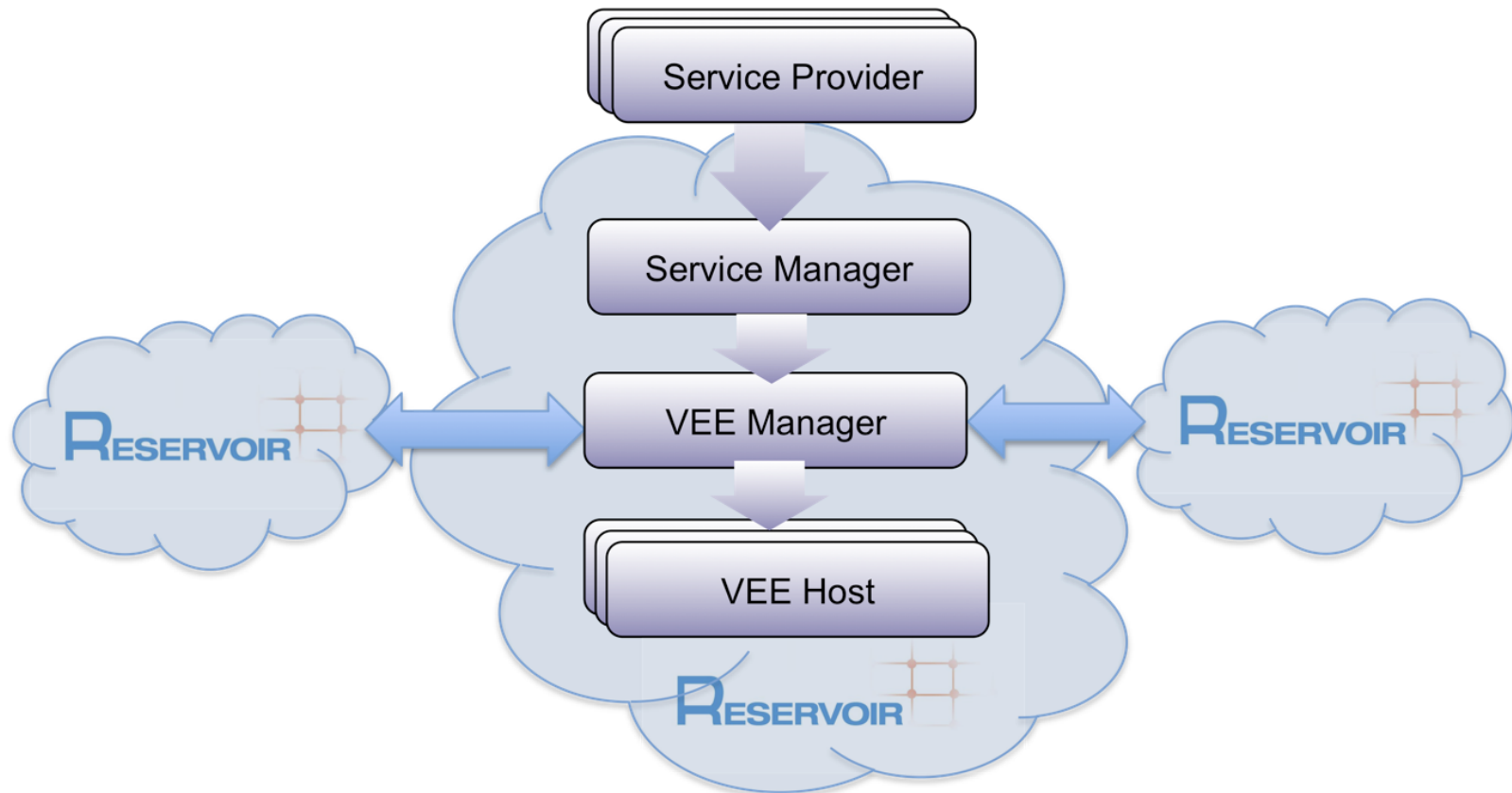
Agreement 215605 (2008-2011)
Service and Sw Architectures and
Infrastructures

Resources and Services Virtualization without Barriers

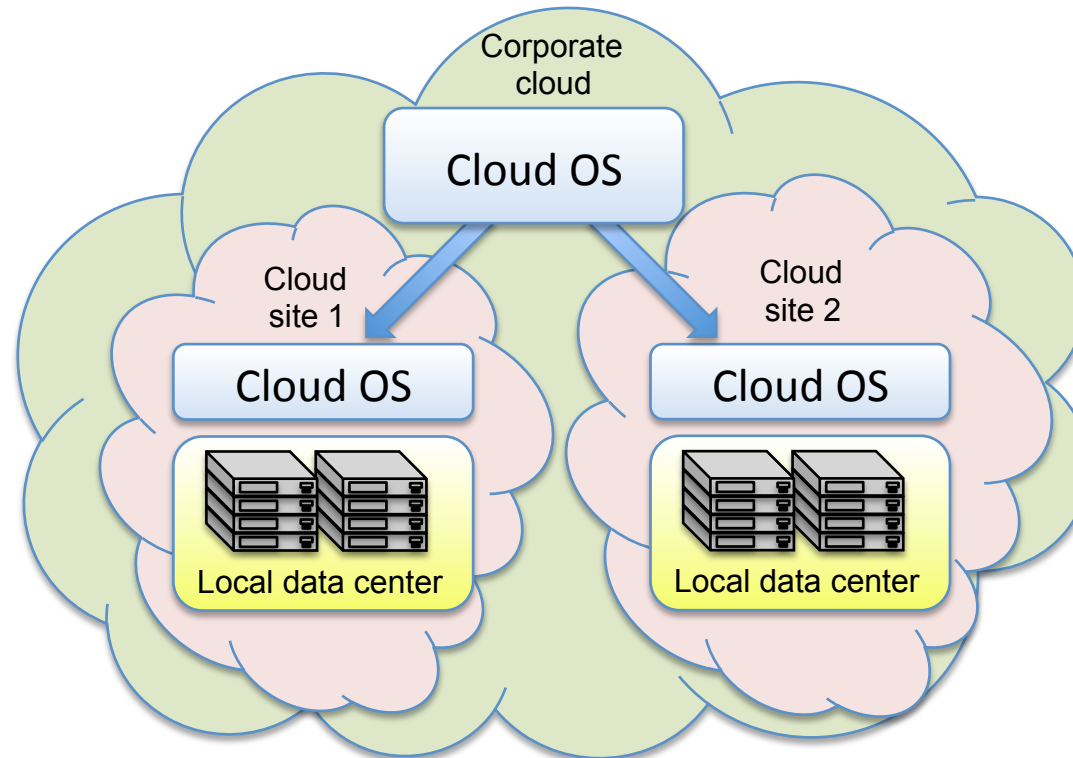
Open source technology to enable deployment and management of complex IT services across different administrative domains



www.reservoir-fp7.eu

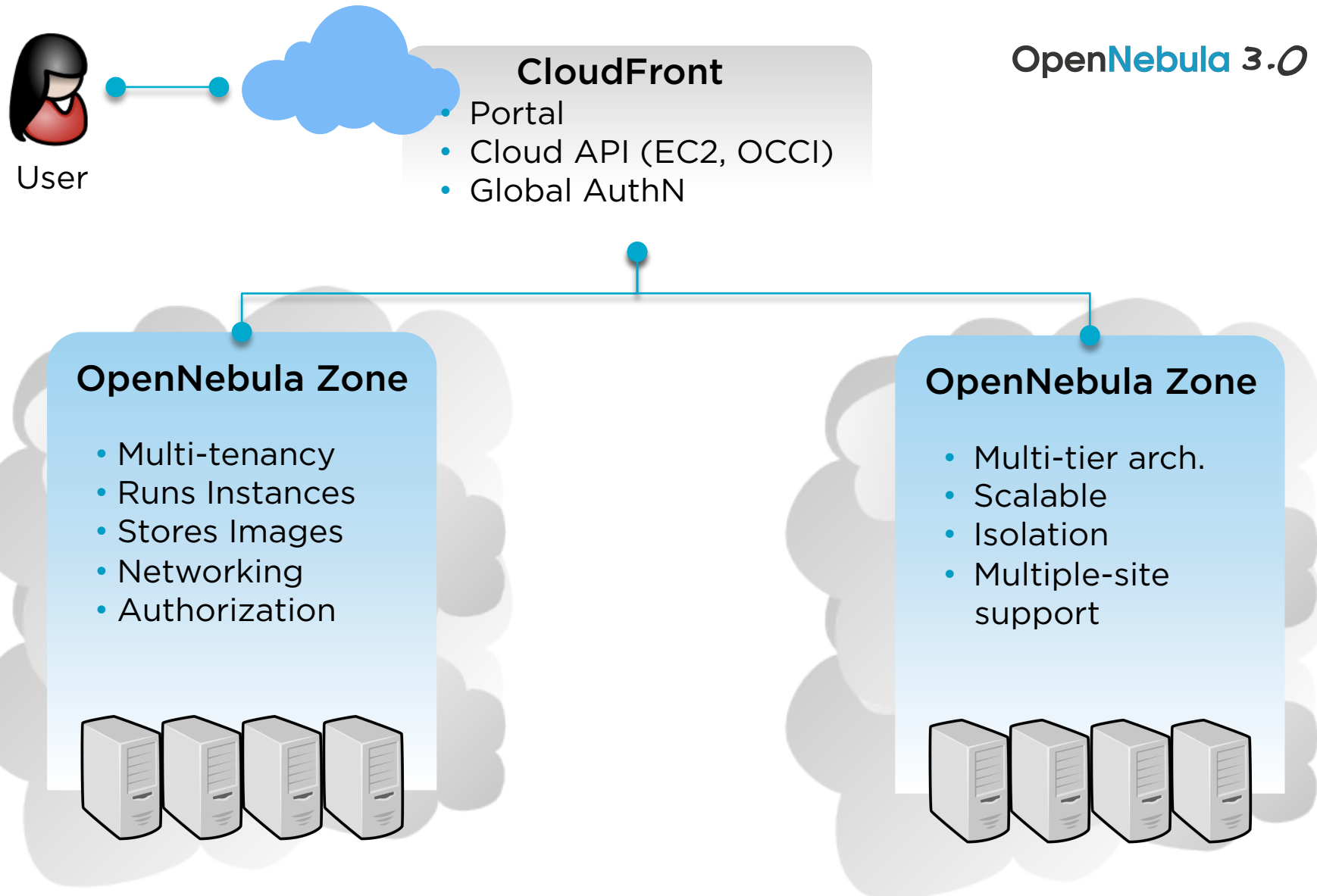


Multi-tier Cloud Architecture



Aim	<ul style="list-style-type: none">• Very large scale or geographically distributed data centers
Cloud Type	<ul style="list-style-type: none">• Company clouds
Coupling	<ul style="list-style-type: none">• Tightly coupled

Multi-tier Cloud Architecture



Leveraging Existing Standards and Implementing Interoperation

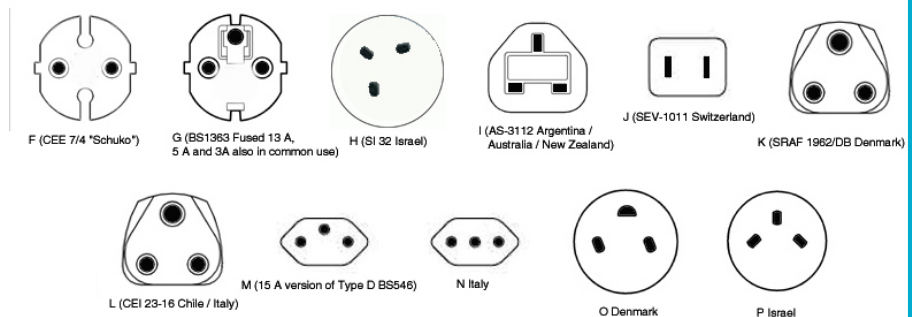
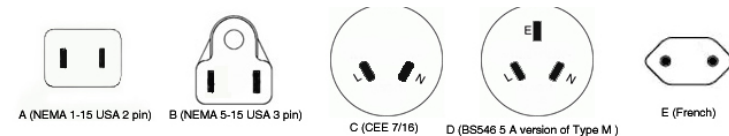
Standardization

- Implement standards
- Integrate with standards



Which Standard?

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



Interoperation

- Implement adaptors
- Use transformers



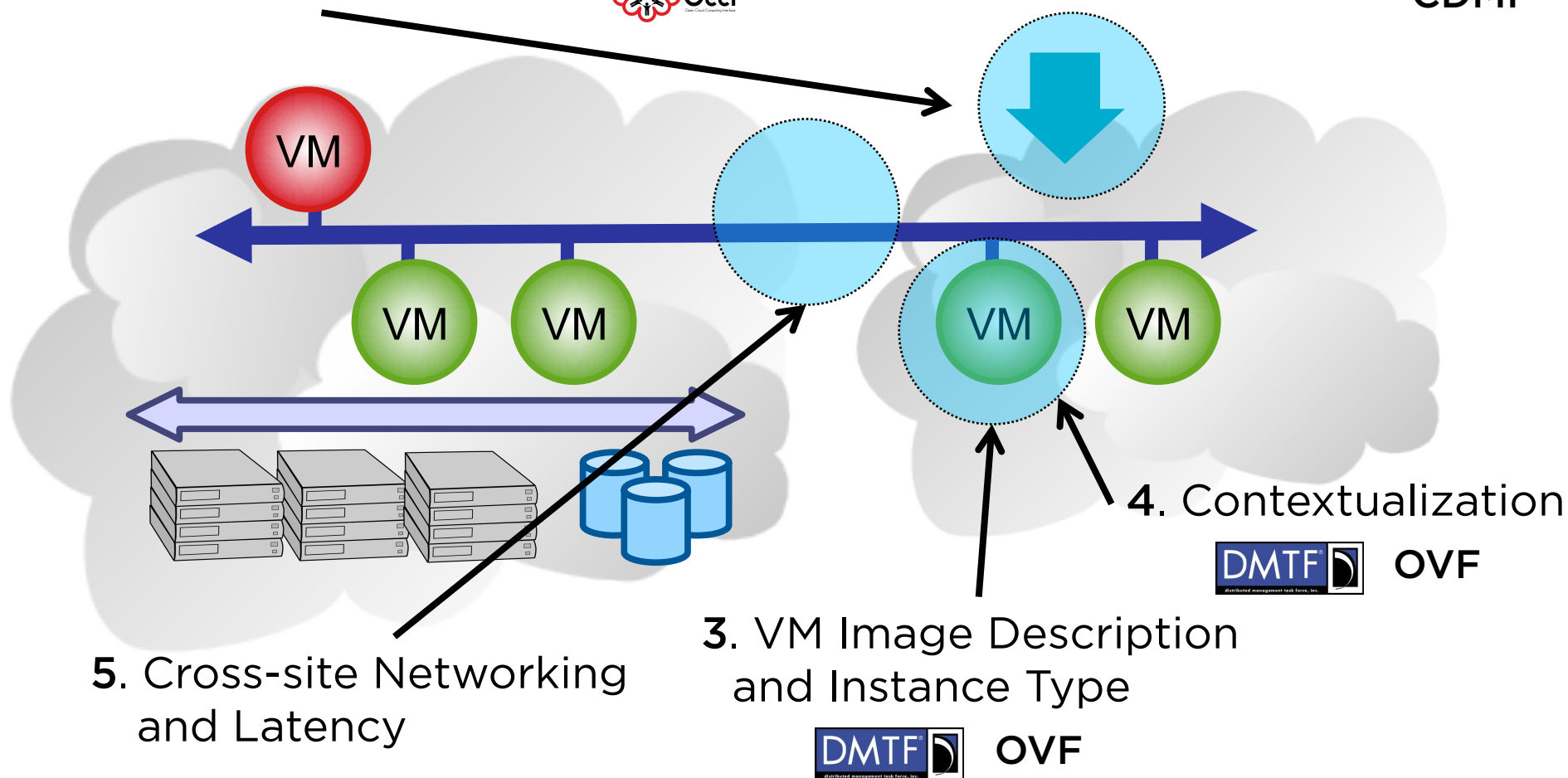
I Want to Combine My Private Cloud with a Remote Cloud without Changes

Transparent Combination of Local Resources with Cloud Resources

1. Management Interfaces for Virtual Workloads



2. Management Interfaces for Data Elements



Grid and Cloud as Complementary Computing Models

Usage

- Job Processing
- Big Batch System
- File Sharing Services

Achievements

- Federation of Resources
- VO Concept

But...

- User experience
- Complexity

Grids

Usage

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

Achievements

- Agile Infrastructures
- IT is another Utility

But...

- Interoperability
- Federation

Clouds

Resource Sharing

Scientific Applications

Uniform Security

Resource Management

Customize Environments

Flexibility & Simplicity

StratusLab



The StratusLab Vision



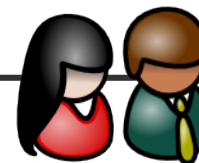
- Batch Job Processing
- Custom Execution Environments
- Grid Service Integration

Access

Grid Middleware

2

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



IaaS Interface

Service

LRMS (LSF, PBS...)



Virtual CE, WN...

1



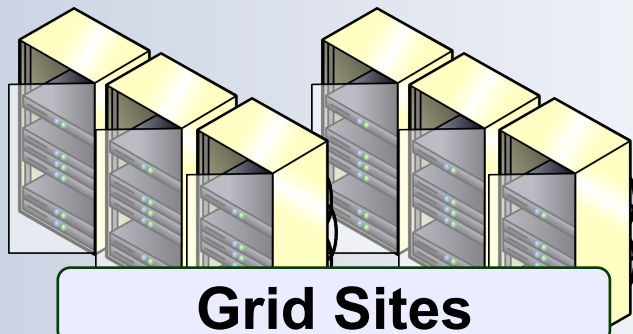
Other (web, mail...)

StratusLab Toolkit



Raw machines

Provision



Grid Sites

3



External Providers

The StratusLab Architecture

Grid Services

- Federation facilities
- Security
- Grid specific services



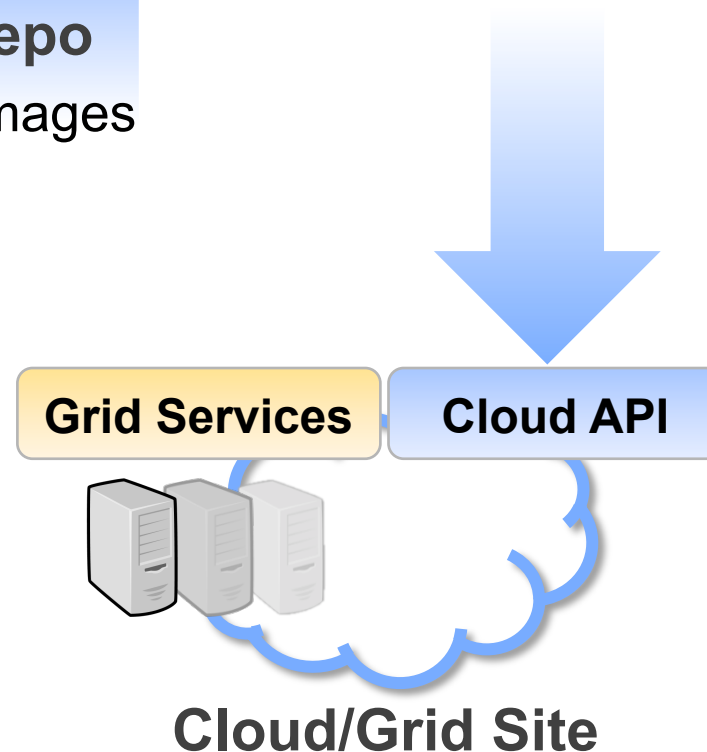
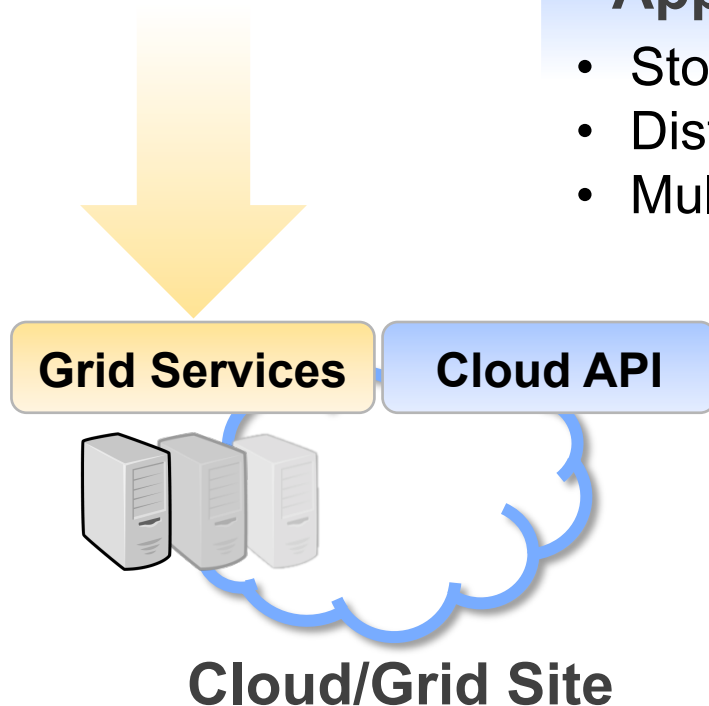
MarketPlace

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



Appliance Repo

- Storage VM images
- Distributed
- Multi-protocol



Questions?

We Will Be Happy to Answer Any Question

 CloudPlan.org

 [@imllorente](https://twitter.com/imllorente)



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