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Building Clouds with OpenNebula: A Grid Computing Perspective

Ruben S.Montero

dsa-research.org

Distributed Systems Architecture Research Group
Universidad Complutense de Madrid



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- Provide an overview of Cloud Computing
- Describe how Clouds can help Grids
- Experiences using Clouds and Grids
- Hands on: Using a OpenNebula Cloud



Cloud Computing in a Nutshell

Software as a Service

What
On-demand access to any application

Who
End-user
(does not care about hw or sw)



facebook

Platform as a Service

What
Platform for building and delivering web applications

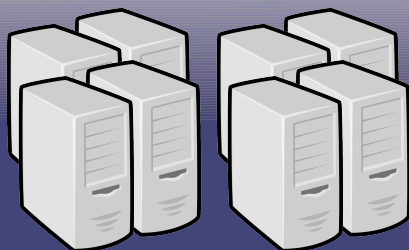
Who
Developer
(no managing of the underlying hw & sw layers)



Windows Azure

force.com
platform as a service

Infrastructure as a Service



Physical Infrastructure

What
Delivery of a *raw* computer infrastructure

Who
System Administrator
(complete management of the computer infrastructure)

GO GRID

flexiscale™

amazon
web services™

The Public IaaS Cloud

- **Simple Web Interface**
- **Raw *Infrastructure* Resources**
 - Total control of the resources
 - Capacity leased in the form of Vms
 - Complete Service-HW decoupling
- **Pay-as-you-go (On-demand access)**
 - A single user can not get all the resources
 - Multi-tenancy
- **Elastic & “*infinite*” Capacity**

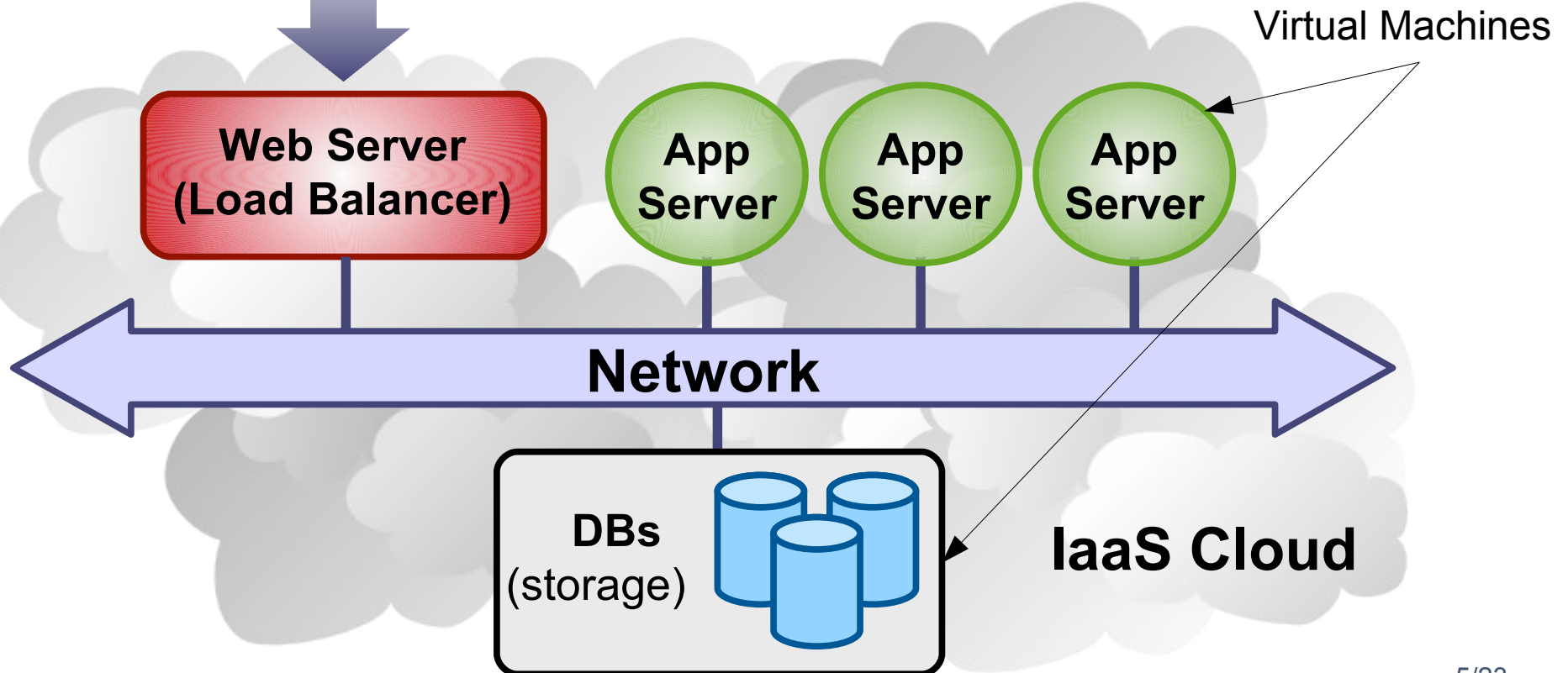
Using a Public IaaS Cloud



Service End-Users

Total control of service layout

- Resources allocated
- Software Stack
- Type & Number of components
- Service Elasticity



The Private IaaS Cloud

A “Public Cloud behind the firewall”

- Security concerns
- Flexible management (consolidation, adaptation, provisioning...)

VMs are great!!... (*the BUT's*)

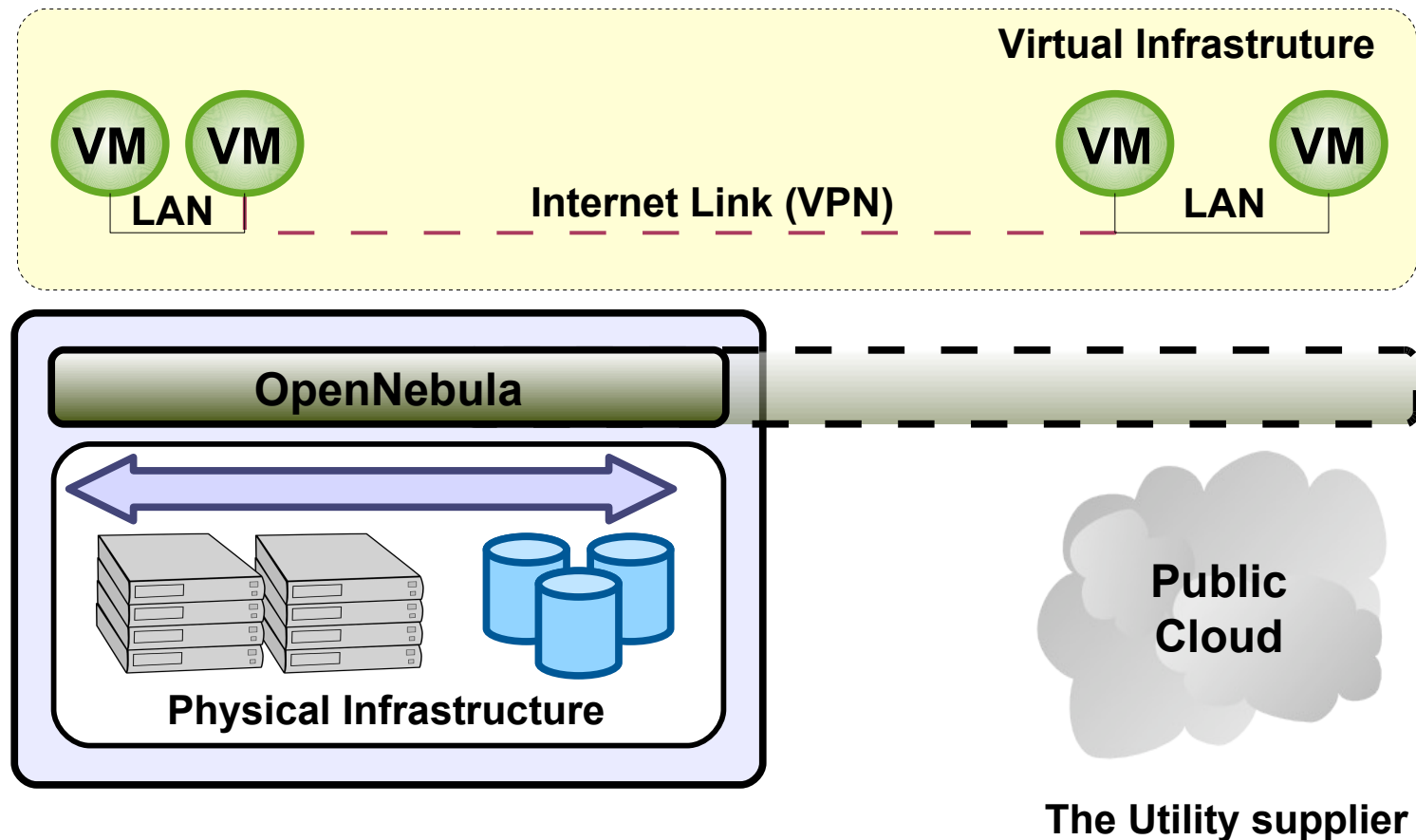
- Where did/do I put my VM? (*scheduling & monitoring*)
- How do I provision a new cluster node? (*clone & context*)
- What MAC addresses are available? (*networking*)

Cloud Management Layer (e.g. OpenNebula)

- Provides a *uniform view* of the physical resource pool
- *Life-cycle management* and monitoring of VM
- *Integrates* Image, Network and Virtualization

The Hybrid IaaS Cloud

- Supplement the capacity of the local infrastructure
- Transparent access to the resulting hybrid cloud
- Utility Computing dream made a reality!



What is OpenNebula?

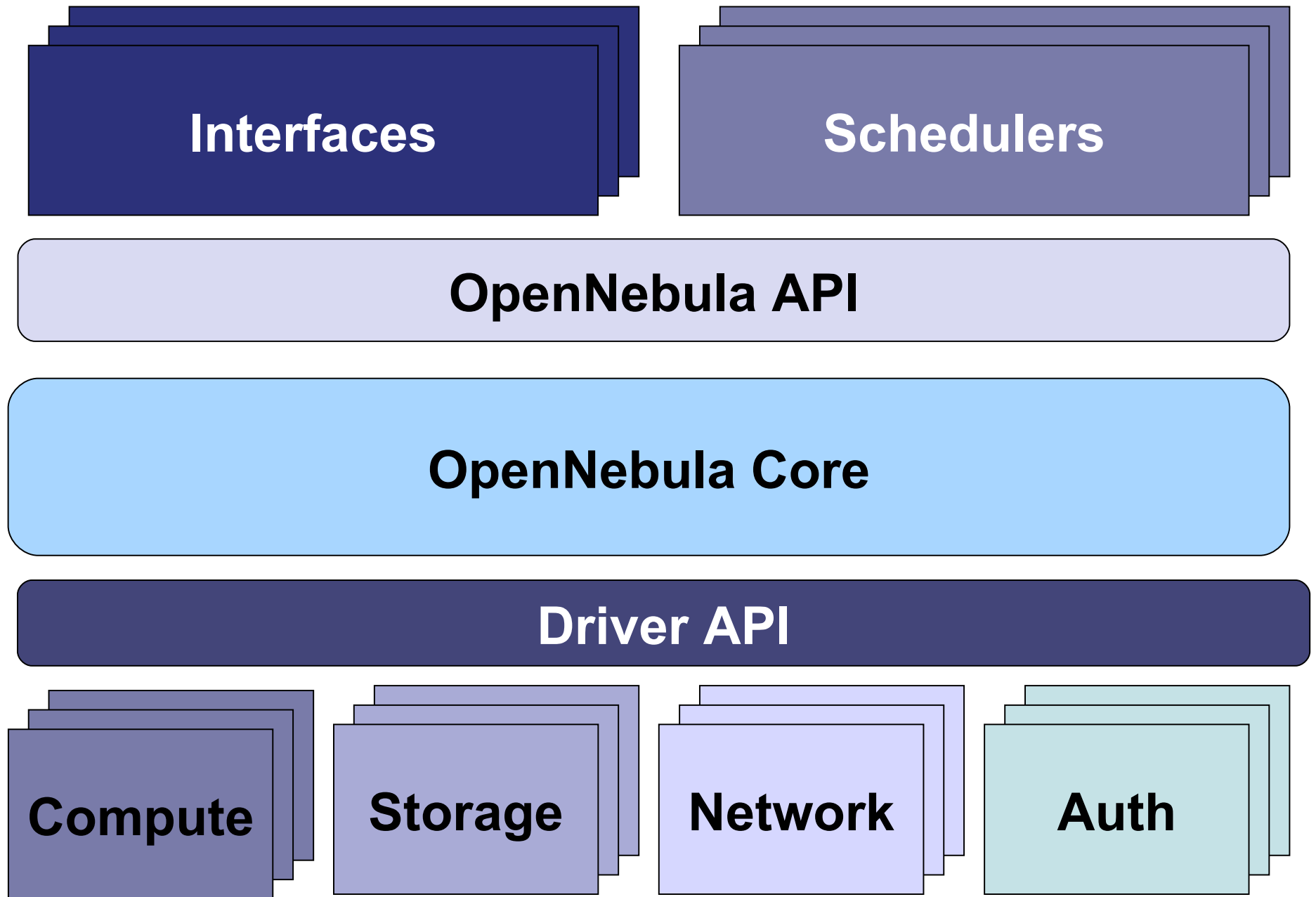


OpenNebula is a standard-based open-source toolkit to build private, public and hybrid clouds

Design Philosophy

- One solution can not fit all data-center and user requirements and constraints
- Open, Flexible and extensible architecture that allows multiple components to be orchestrated
- Provide basic components, but allow them to be easily replaceable by others

What is OpenNebula?



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Current Grid Infrastructures...

- High degree of heterogeneity (software & hardware)
- High operational costs
- Isolate and partition resources contributed to the Grid
- Specific environment requirements for different Vos
- Users simply do not feel like adopting our execution models (*pilot jobs...*)

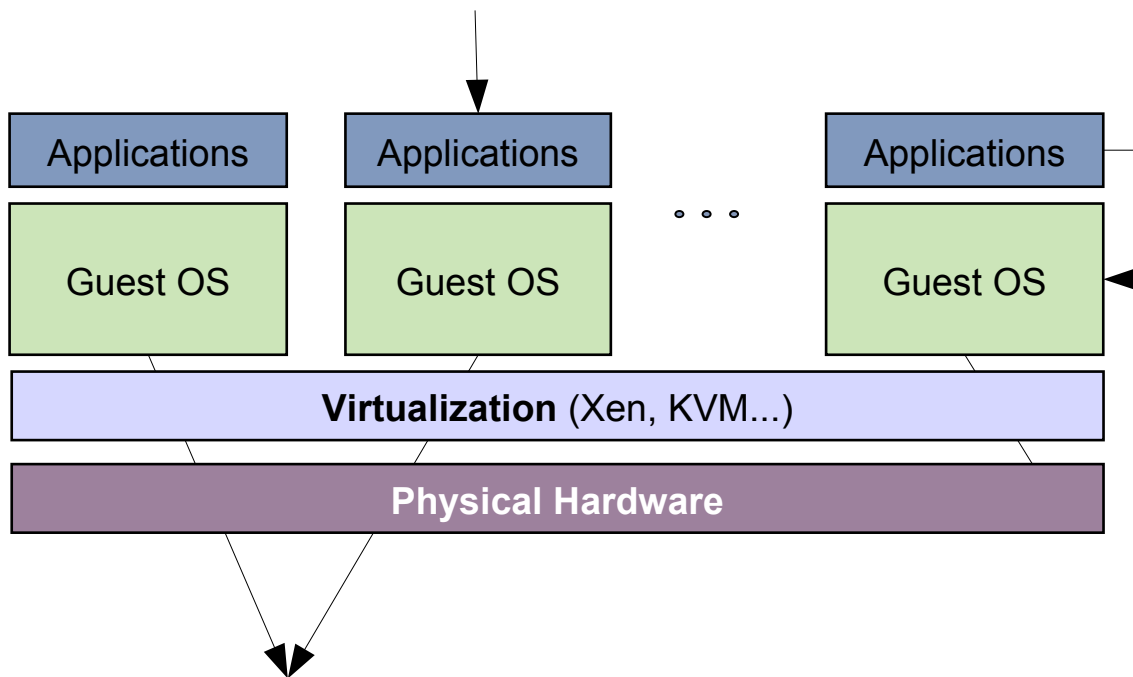


Grids are difficult to maintain, operate and use

Grids, Clouds... and Virtual Machines

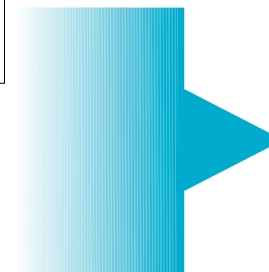
- A VM is an isolated runtime environment (guest OS and apps)
- Hypervisors: Full Virtualized, para-virtualization, HW Virtualization

Execution of legacy applications



Domains are **isolated**

Natural way to deal with the **heterogeneity**

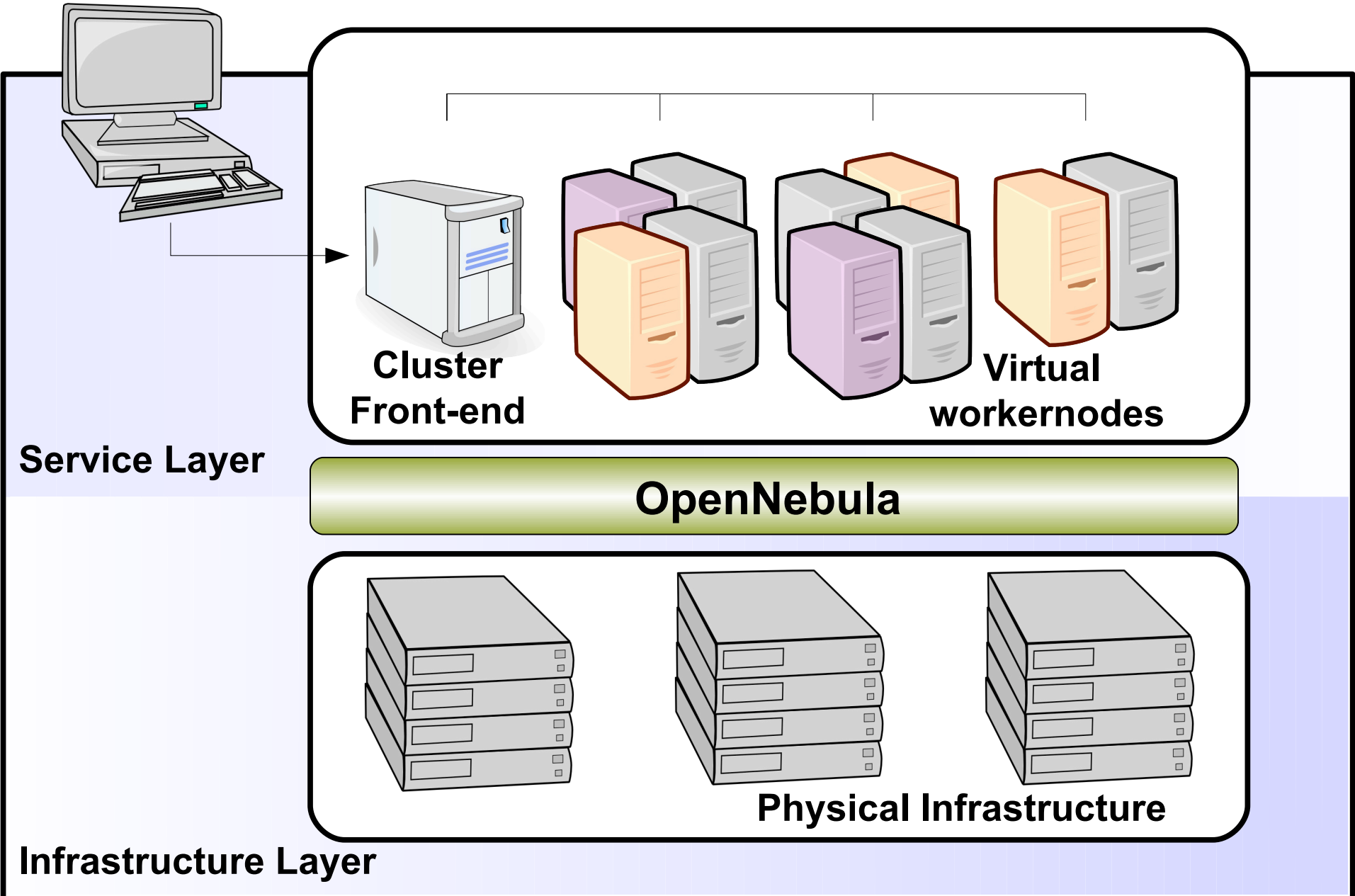


Application / HW decoupling

VMs can be provided with a **Cloud-like model!**

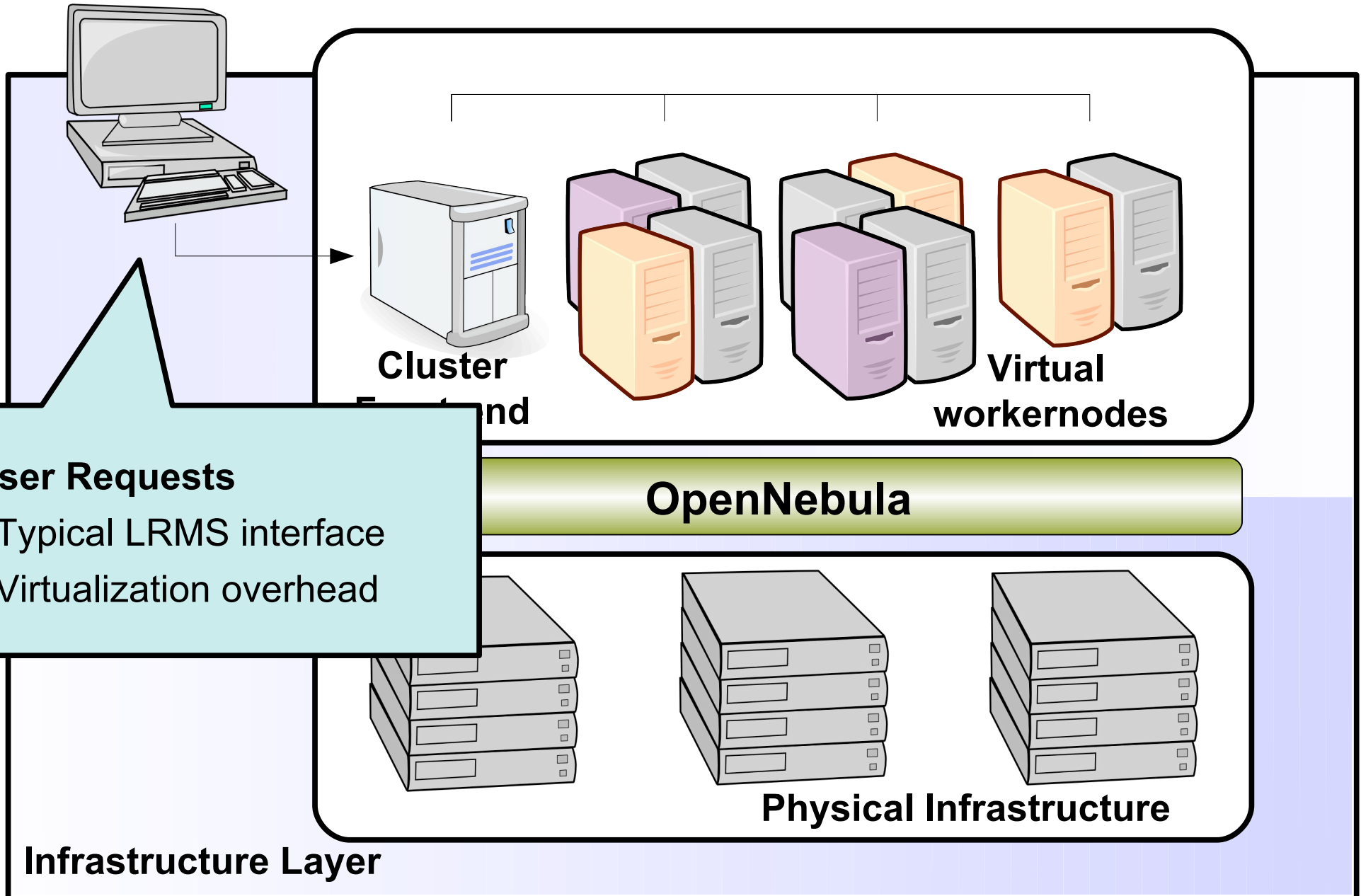
Grids, Clouds... and Virtual Machines

Cluster users



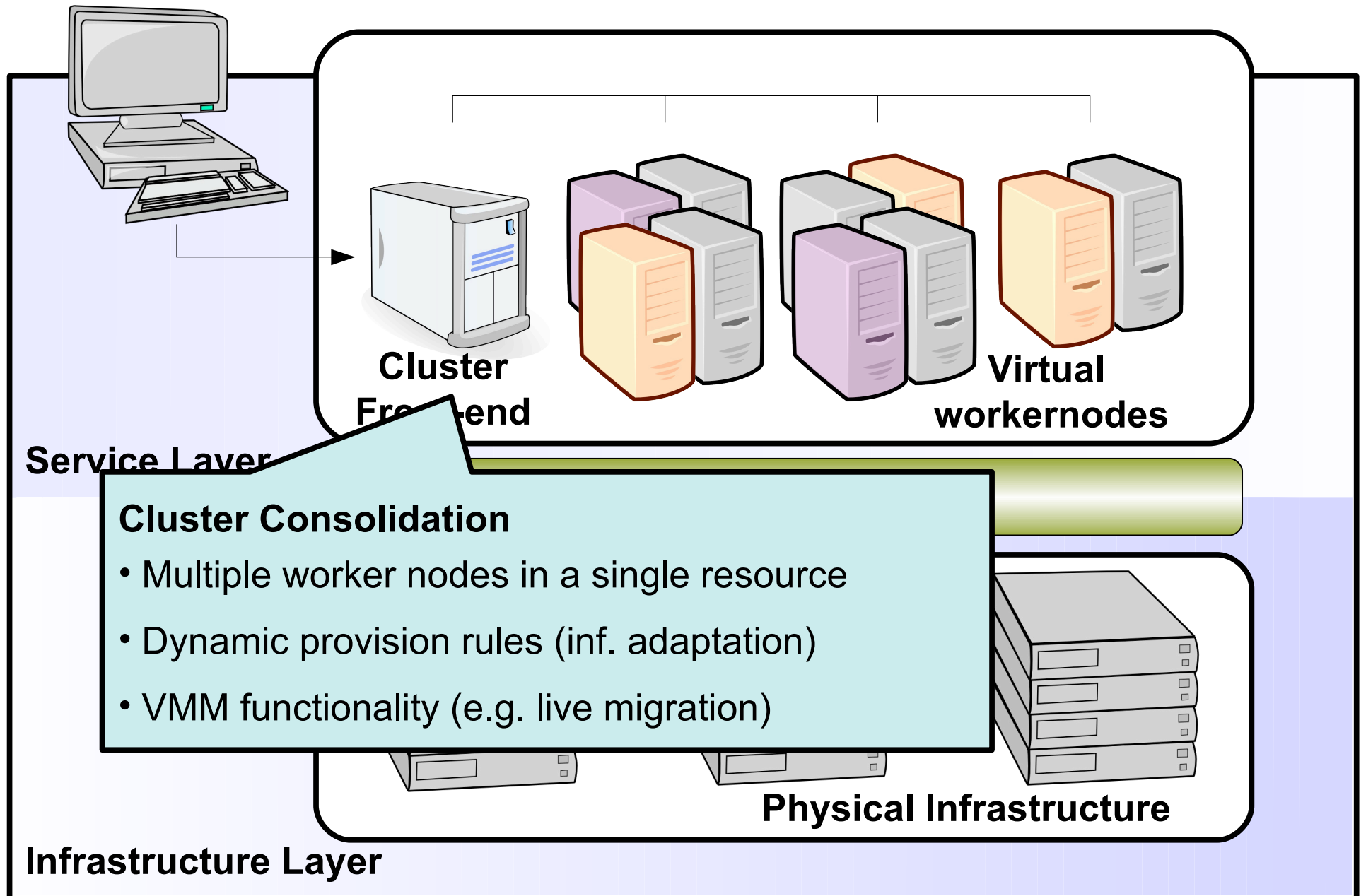
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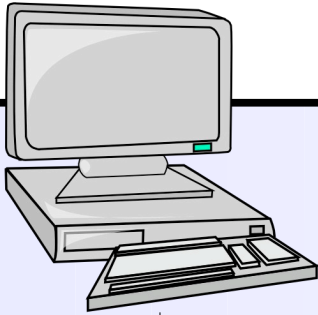
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Grids, Clouds... and Virtual Machines

Cluster users



Cluster Partitioning

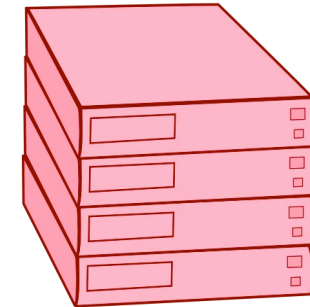
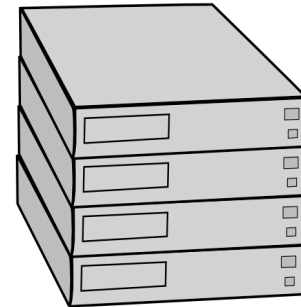
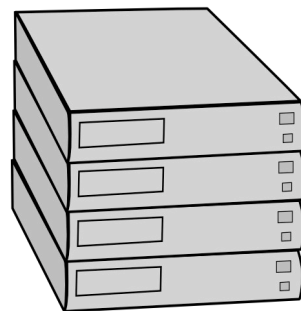
- Performance partitioning (dedicated nodes)
- Isolate cluster workload
- Dedicated HA partitions

Cluster Front-end

Virtual workernodes

Service Layer

OpenNebula



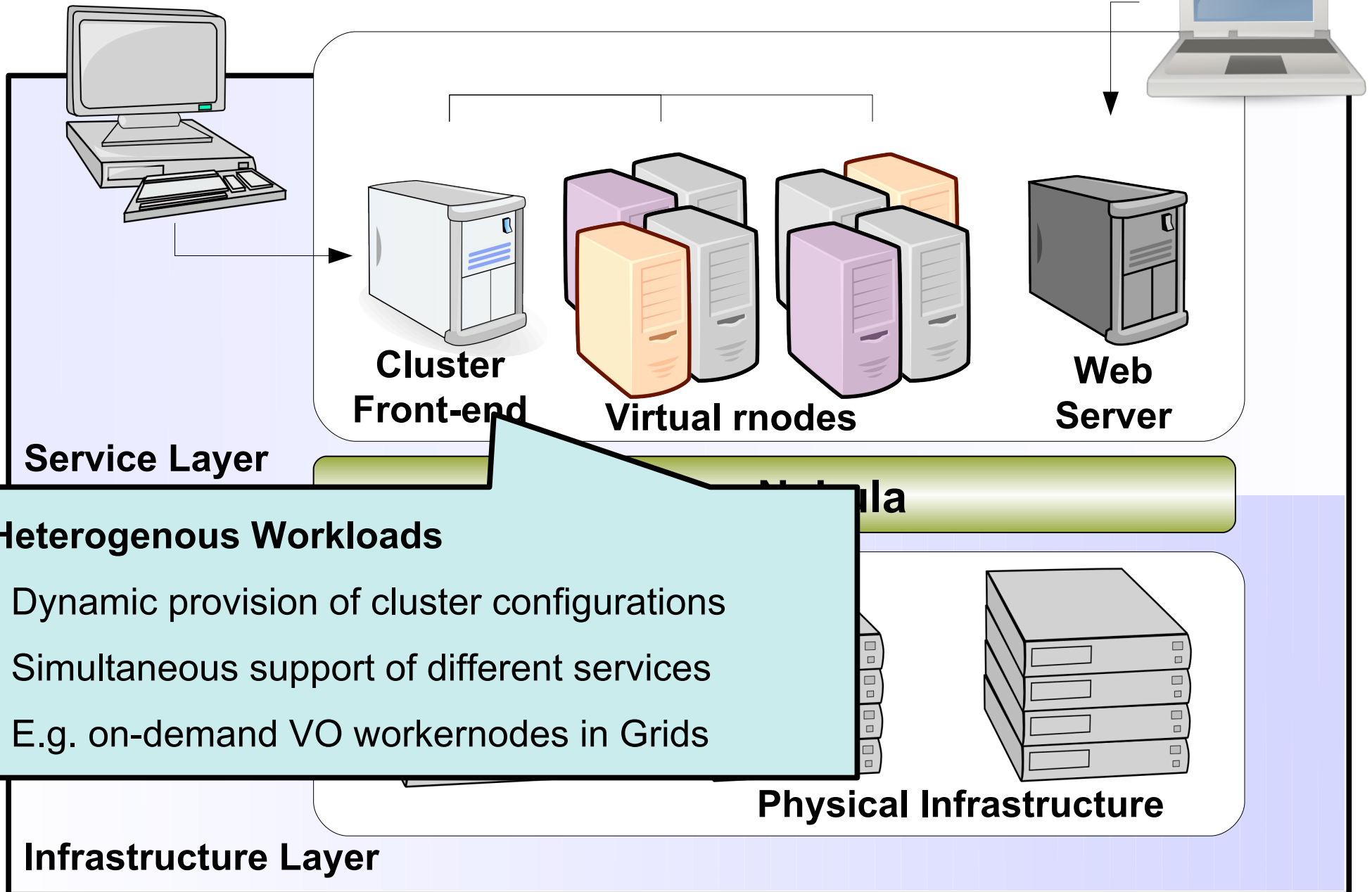
Physical Infrastructure

Infrastructure Layer

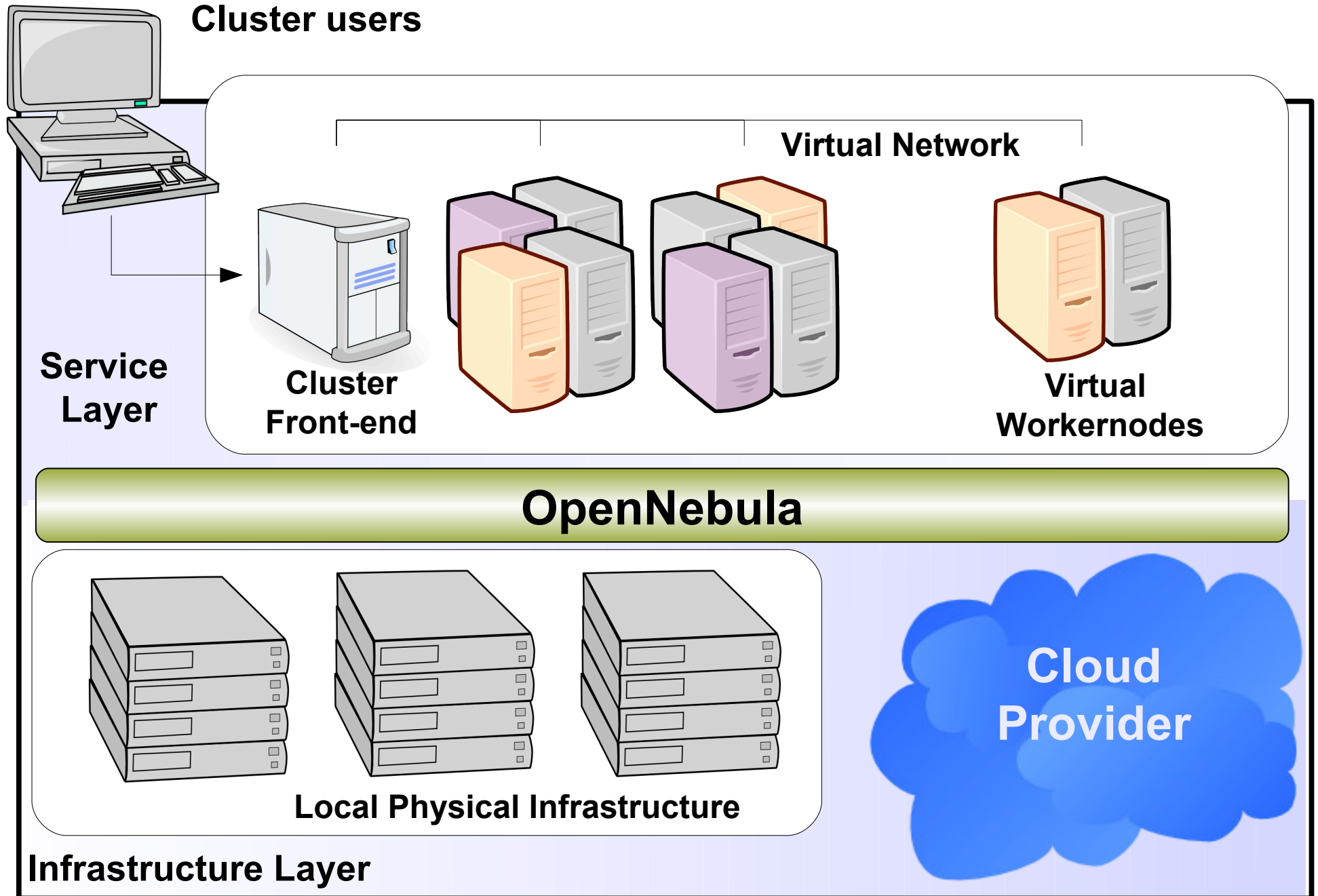
Grids, Clouds... and Virtual Machines

Cluster users

HTTP clients



Grids, Clouds... and Virtual Machines



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- **Experiences using Clouds and Grids**
- Hands on: Using a OpenNebula Cloud

Grids, Clouds... and Virtual Machines

- Use VMs as basic building block for Grid Services
- Current Trends:

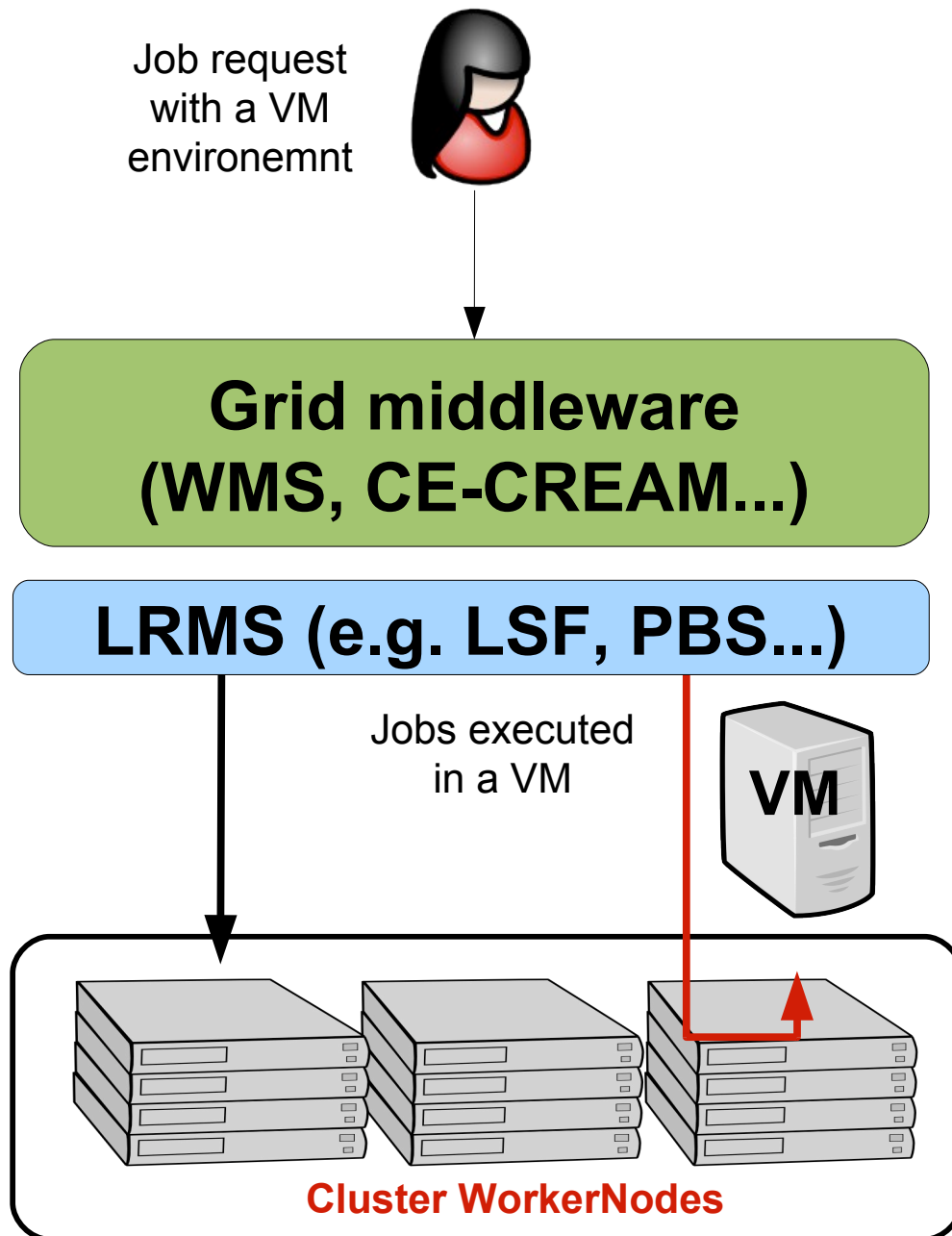
- VMs as Job Container
- VMs as Grid execution service component

- Deal with heterogeneity
- Simplify & Improve site management
- Give VOs control over the worker-node SW

- IaaS interfaces for a Grid Site

- Attract business users
- Support novel execution models

VM as a Job Container



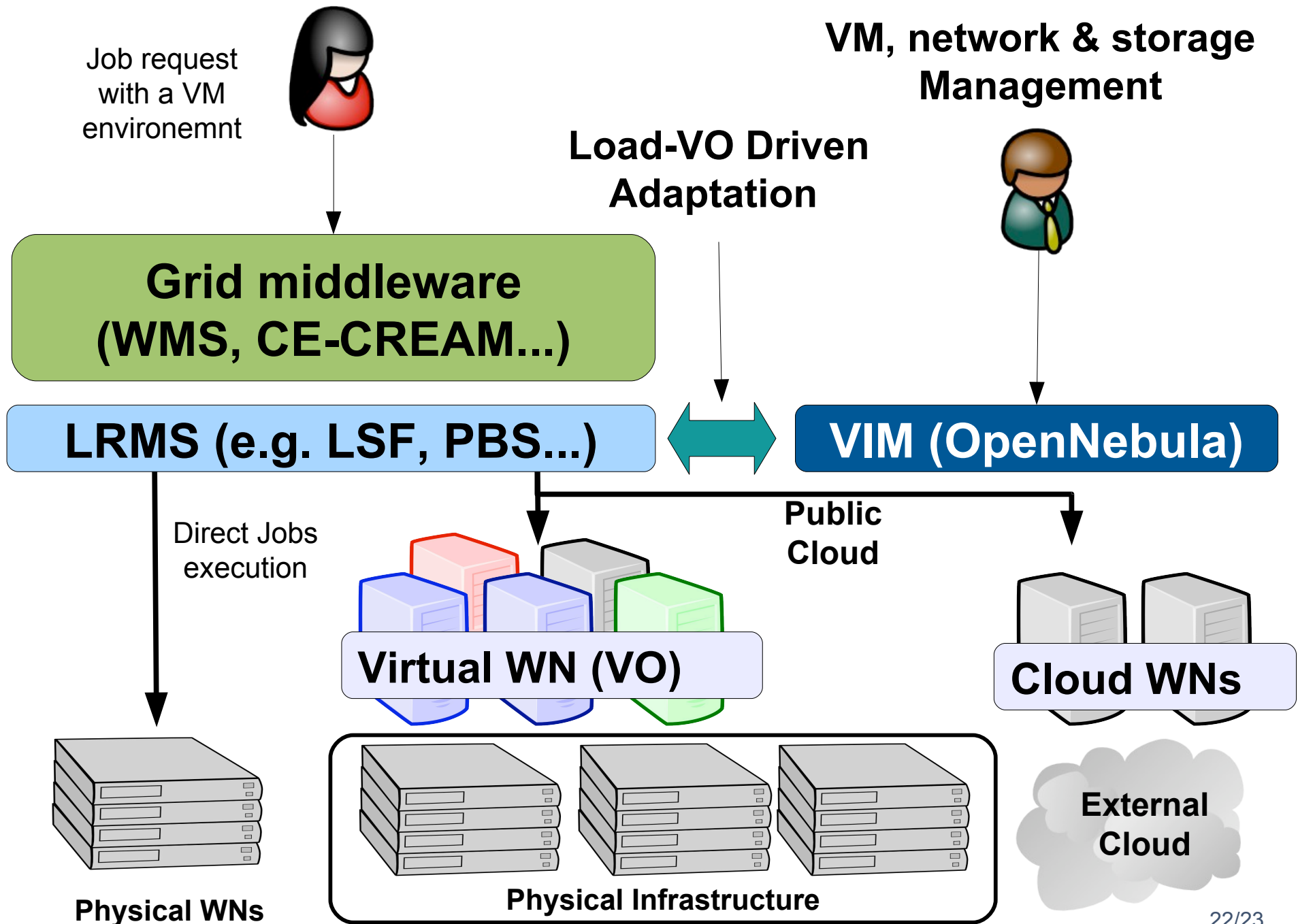
Features

- Single LRMS-based
- Integrated with Grid MW

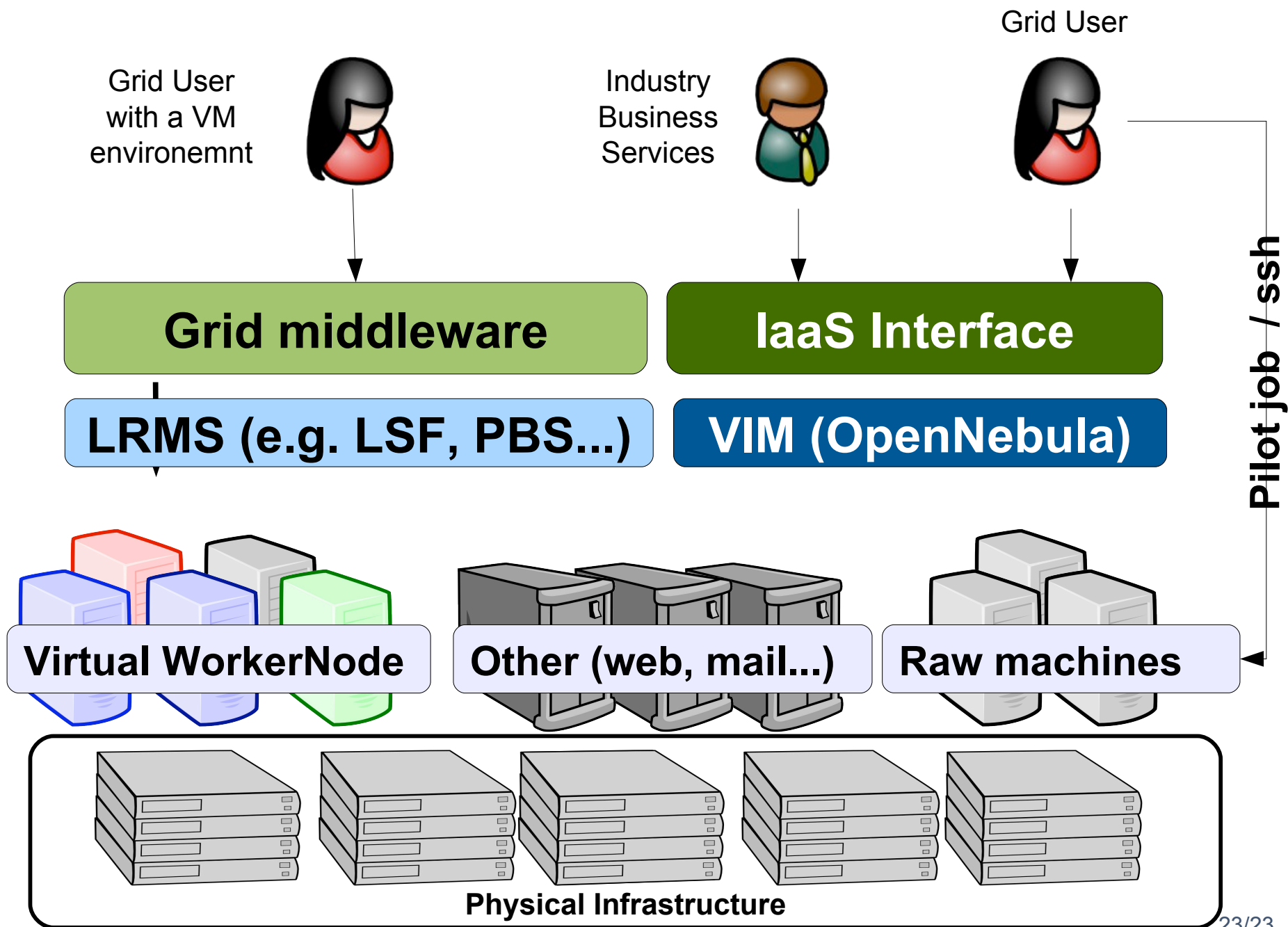
Drawbacks

- Jobs and VMs are different
- Need to integrate other resources (network, storage...)
- Do not decouple totally infrastructure from the Grid services
- Can not leverage VM features (e.g. Migration...)
- Focused on Job execution

VM as Grid Service Component



IaaS Interface for a Site



OpenNebula in the Grid Arena

- A team at Clemson University and CERN has used OpenNebula to deploy ~ 10,000 VMs on 500 physical hosts running Xen.
- These VMs are used to run batch jobs (submitted via WLG-CE and managed by LSF)
- Used XMLRPC API to add autonomic functionality, and to integrate with CERN's Quattor (<http://www.quattor.org/>)
- Created, and contributed, drivers for using LVM-based disk images.



OpenNebula in the Grid Arena

- The D-Grid Resource Center Ruhr (DGRZR) has used OpenNebula to manage 247 Blades with a total of 1,972 cores.



- Entire D-Grid software stack is run on VMs. Worker nodes currently managed with OpenNebula, frontend nodes to follow shortly

- The BiG Grid Virtual Machine Working Group (in NIKHEF) did an evaluation of several cloud solutions, and recommended using OpenNebula for managing worker node VMs in BiG Grid.



OpenNebula in the Grid Arena

- SARA is the Dutch National HighPerformance Computing and e-Science Support Center, and the Dutch supernode in the international Science Grid.
- They offer an HPC cloud that uses OpenNebula. Starting with 128 cores across 16 physical machines running KVM.
- Users use a management console developed at SARA to request a new VM (several templates are provided for them)



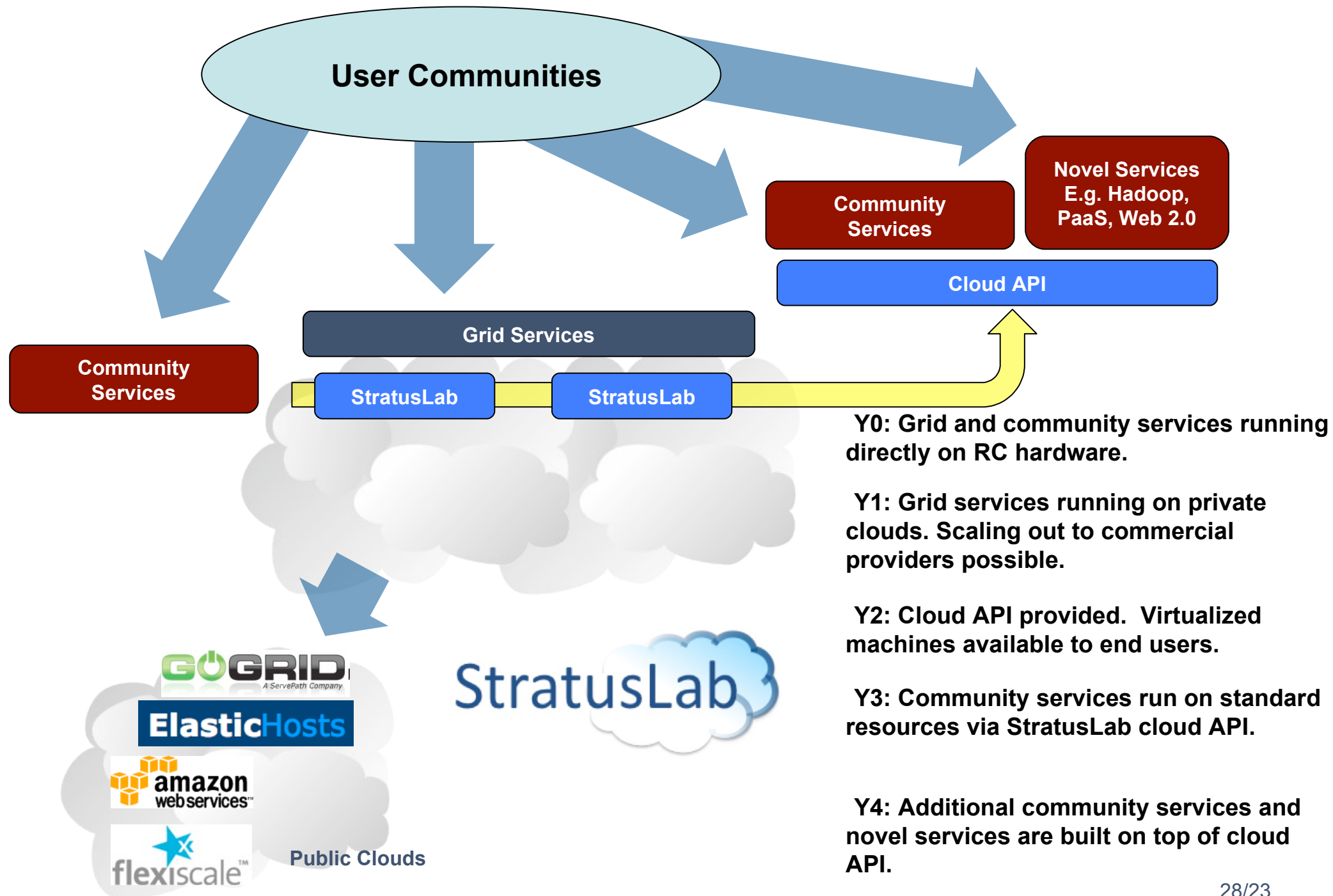
Vision

- Grid and cloud embody **complementary computing models** that will coexist and cooperate in existing and future e-infrastructures

Aim

- To produce the **StratusLab Toolkit** open source cloud distribution, bringing **cloud/virtualization innovation to existing Grid infrastructures.**
- **Service Centred Project** driven to support production infrastructures

The StratusLab Project



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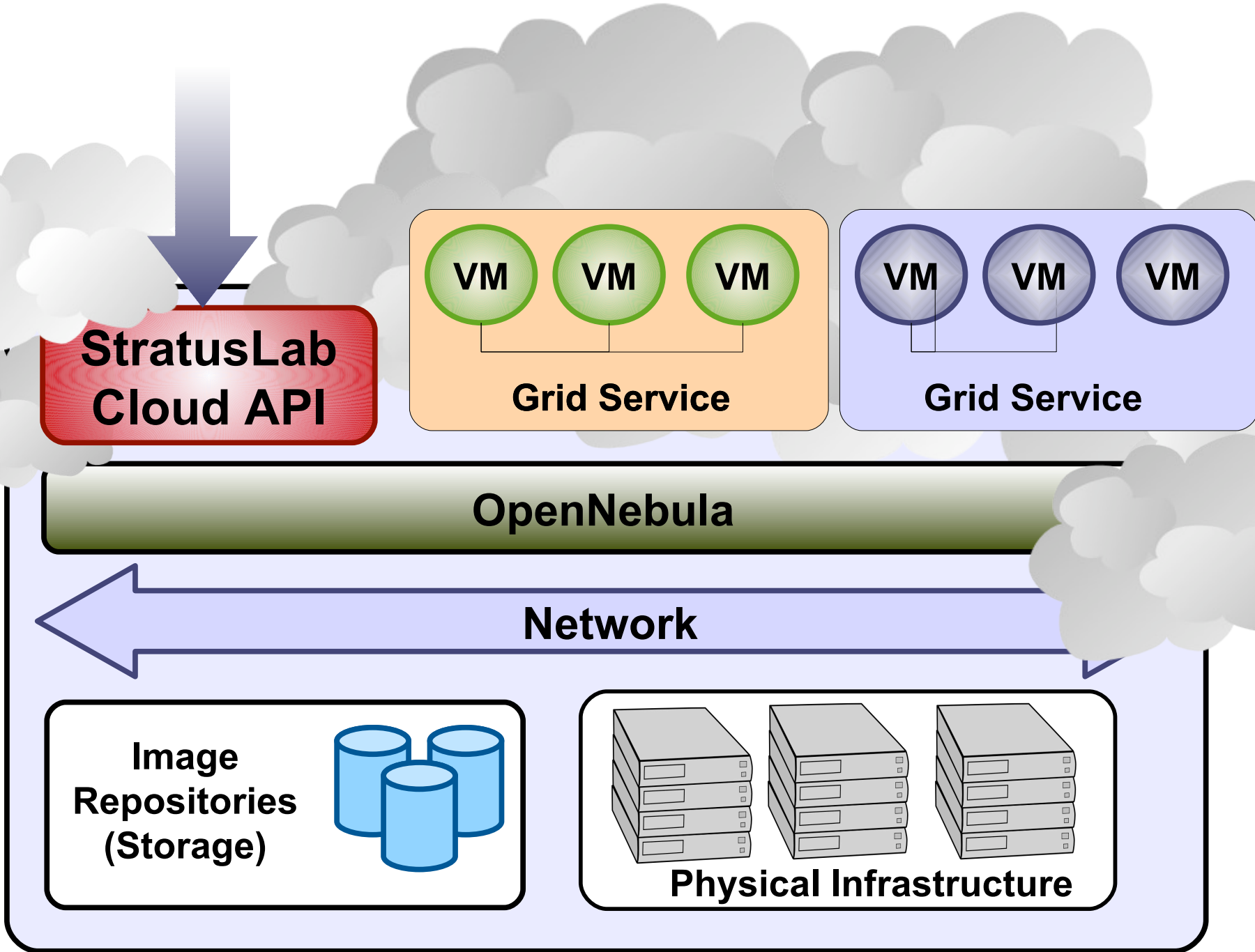
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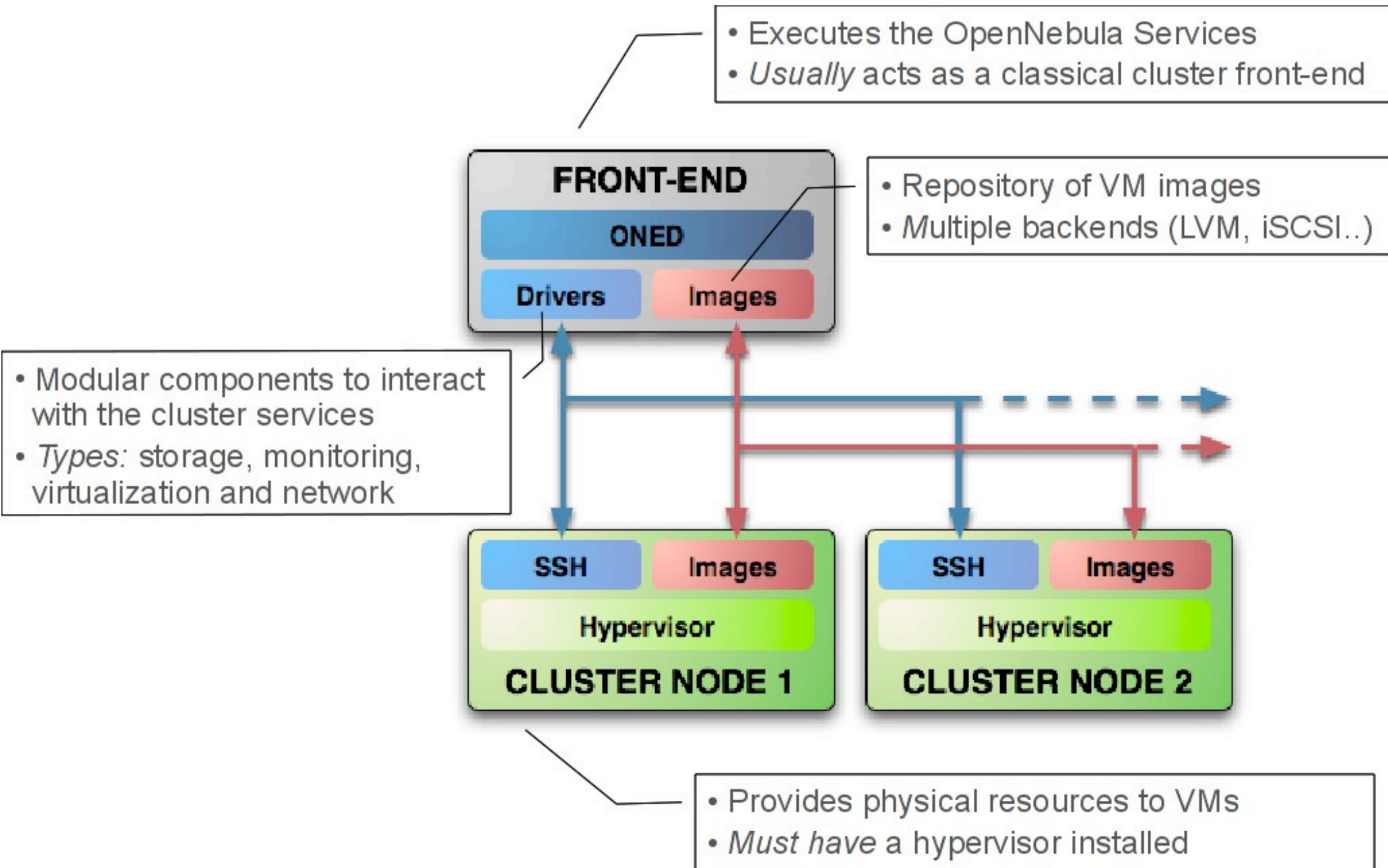


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The Anatomy of an OpenNebula Cloud



Overview of Main Components



Using Virtual Networks and Hosts

- Define VM NICs attached to a given virtual network. The VM will get a NIC with a free MAC in the network

```
#A VM with two interfaces each one in a different vlan
```

```
NIC=[NETWORK="Blue LAN"]
```

```
NIC=[NETWORK="Red LAN"]
```

```
#Ask for a specific IP/MAC of the Red vlan
```

```
NIC=[NETWORK="Red LAN", IP=192.168.0.3]
```

- Prepare the VM to use the IP. Sample scripts to set the IP based on the MAC are provided.

IP-MAC address correspondence

IP:

10. 0. 1. 2
↓ ↓ ↓ ↓

MAC: 02: 01: 0A: 00: 01: 02

oned.conf

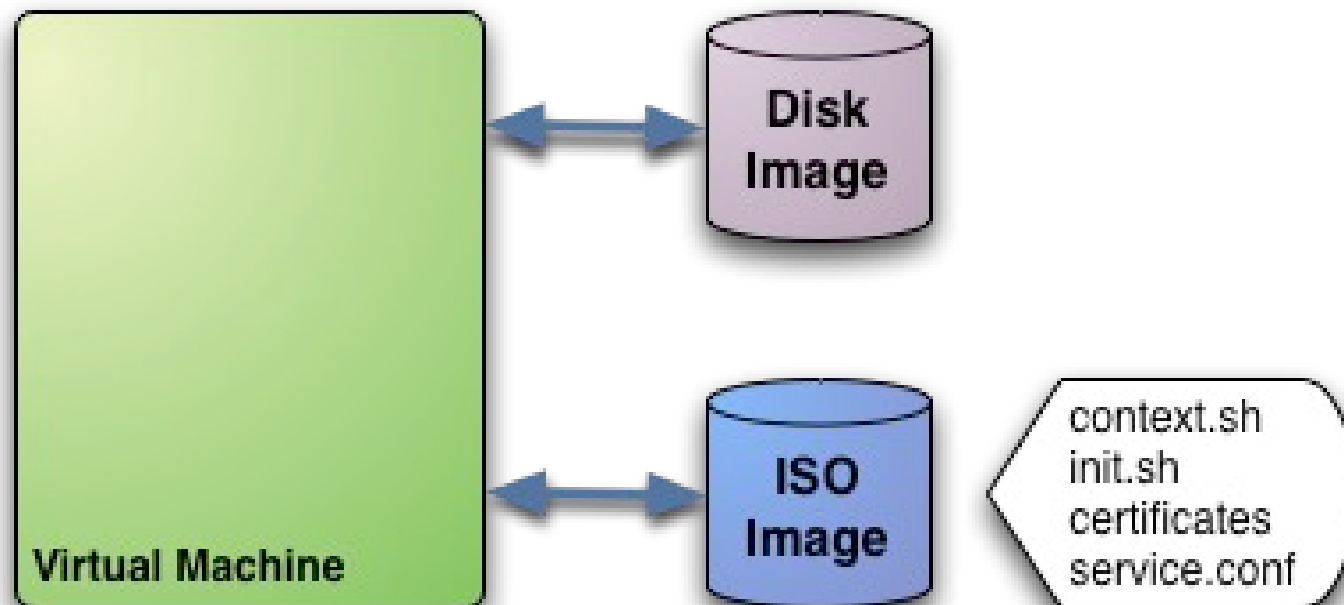
IP Address

Defining a Virtual Machine

- A capacity in terms memory and CPU
 - A set of NICs attached to one or more virtual networks
 - A set of disk images, to be “*transferred*” to/from the execution host.
 - A state file (optional) or recovery file, with the memory image of a running VM plus some hypervisor specific information.
-
- Virtual Machines are defined in a VM template
 - Each VM has an unique ID in OpenNebula the VM_ID

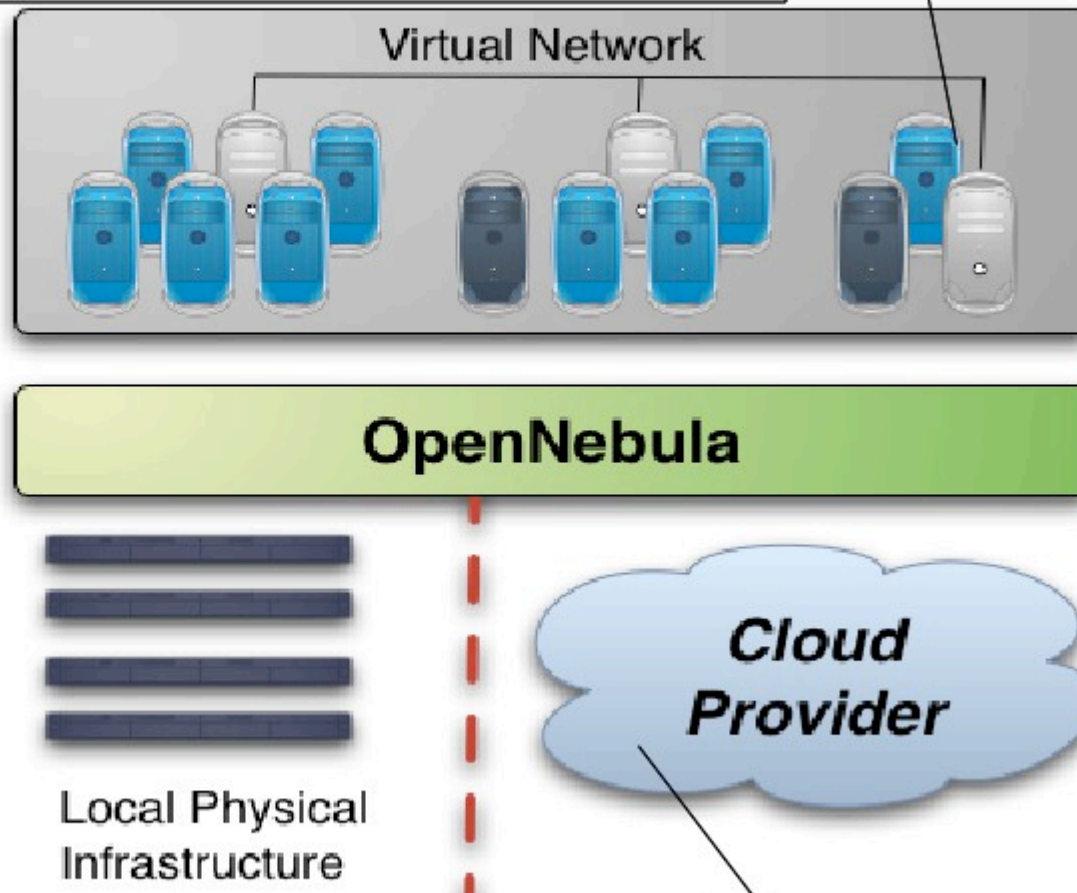
Context for Virtual Machines

- Custom data to be passed to the VM at boot time
- **Boot Process**
 - Mount an iso image with context data
 - Use context.sh to look for variables
 - Access any file to setup VM services (e.g. ssh keys...)



Hybrid Cloud Computing

- VMs can be local or remote
- VM connectivity has to be configured, usually VPNs



- External Clouds are like any other host
- Placement constraints

Using the EC2 Cloud with OpenNebula

- Several accounts or zones can be configured
- The capacity allocated in EC2 can be limited
- VMs must be prepared to be instantiated locally or in the EC2
- The template must provide a description for both instantiation methods.
- The EC2 counterpart of your VM (`AMI_ID`) must be available for the driver account

```
EC2 = [  
  AMI           = "ami_id for this VM",  
  KEYPAIR       = "the keypair to use the instance",  
  AUTHORIZED_PORTS = "ports to access the instance",  
  INSTANCETYPE  = "m1.small...",  
  ELASTICIP     = "the elastic ip for this instance",  
  CLOUD         = "EC2 cloud to use"  
]
```

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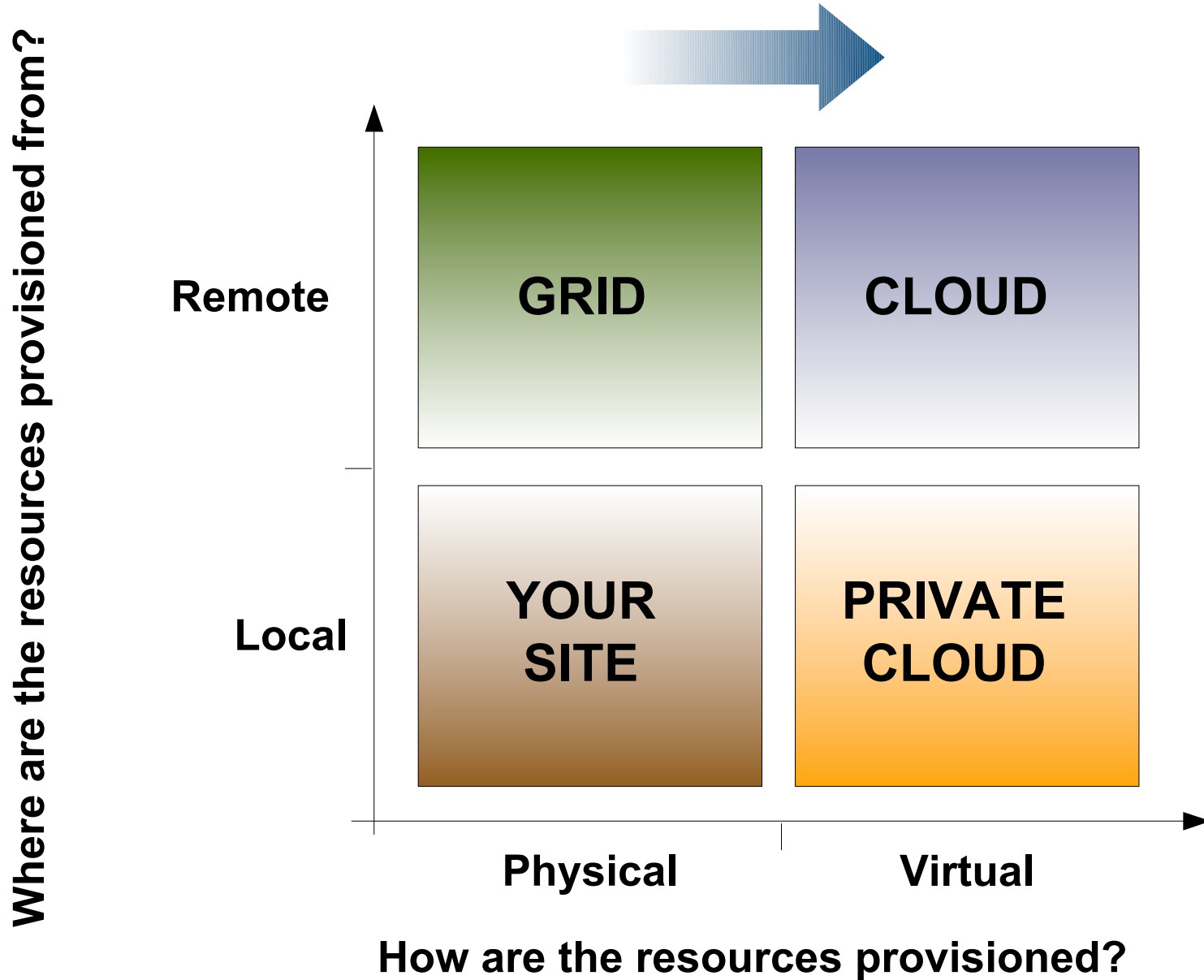
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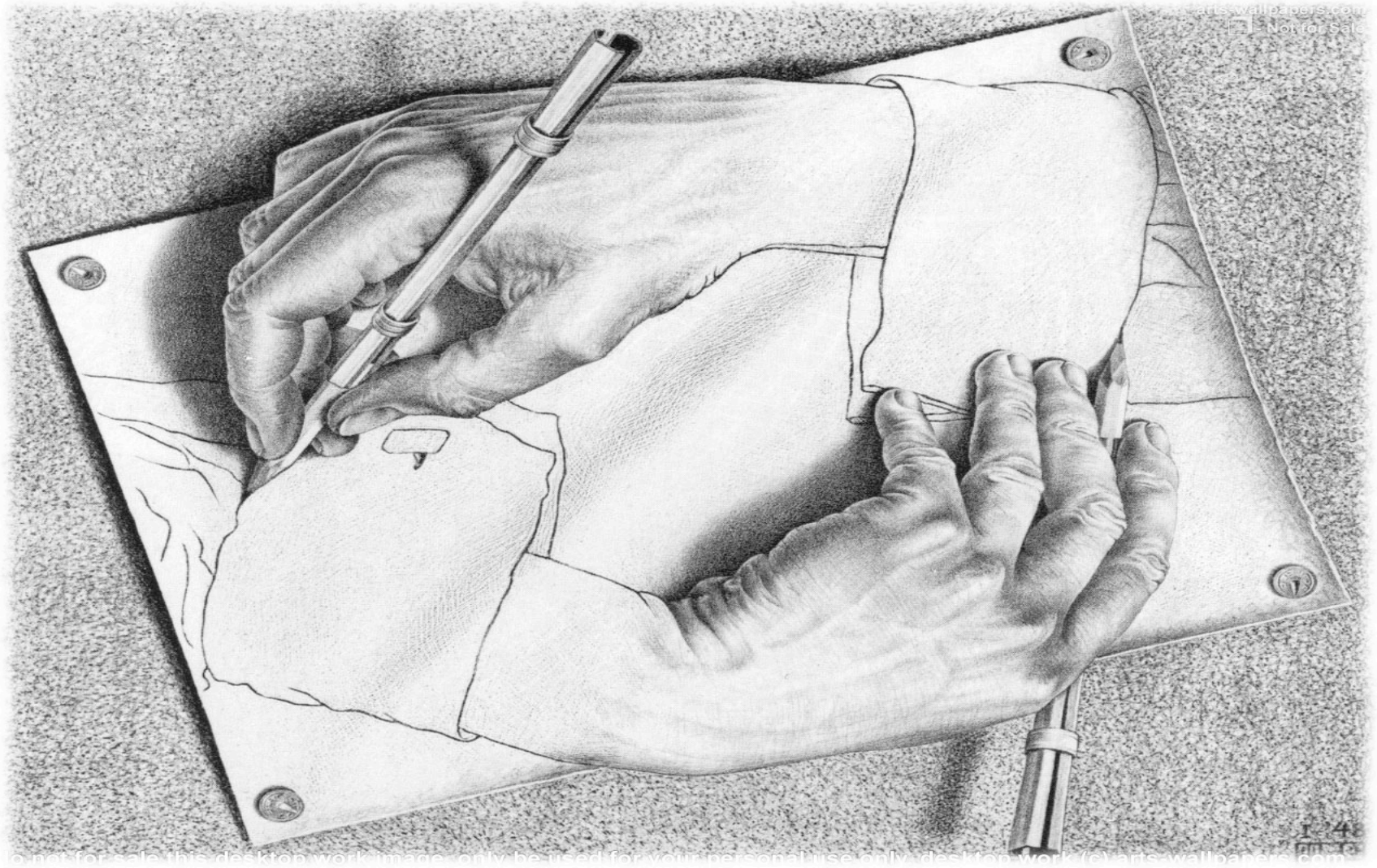


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Resource Provisioning Models



THANK YOU FOR YOUR ATTENTION



QUESTIONS?