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Integrating multiple scientific computing needs via a Private Cloud Infrastructure

Stefano Bagnasco
Dario Berzano
Stefano Lusso
Sara Vallero

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INFN
Istituto Nazionale
di Fisica Nucleare

SIGIL · VNIVERS · AVGVSTAE · TAVRINORVM

The INFN Torino Computing Centre

STORAGE RESOURCES

- 552 SATA/SAS 7.2K disks (1-3 TB each) → 1060 TB (gross) total

COMPUTATIONAL RESOURCES

- 28 physical nodes: 16GB RAM, 8 job-slots each
- 38 Intel/AMD hypervisors (KVM virtualizer): 64GB RAM, 16 job-slots each

SERVICES RESOURCES

- 43 servers, the newest with:
  - 2 Intel 6-core processors / 48GB RAM
  - 2 SAS 10K mirrored disks

LOCAL AREA NETWORK

- 140 1Gbps + 22 10Gbps links

WIDE AREA NETWORK

- 1Gbps (soon 10Gbps)

Stakeholders

PROVISIONED

- WLCG Tier2
  (primarily for ALICE)
- PANDA computing
- Belle-2 computing
- Virtual Analysis Facility for ALICE
  (interactive analysis based on PoD)
- Medical Image Processing
  (local research group)
- Theory (local research group)
- Virtual farm on-demand

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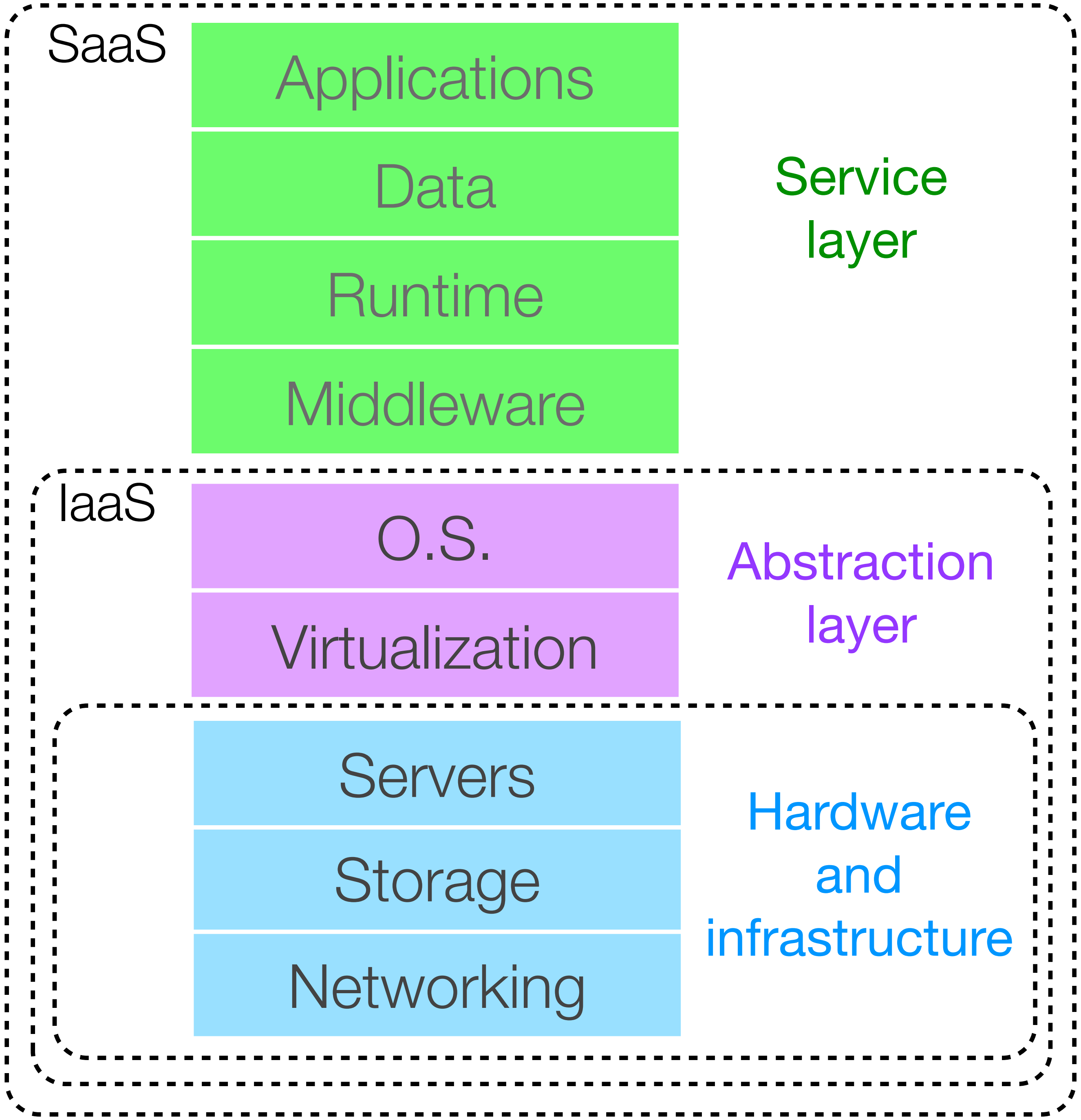
COMING SOON...

- BESIII grid Tier2
  (test infrastructure ready)
- WLCG grid “Tier3” for CMS

Software/Infrastructure as a Service (SaaS/IaaS)

Resources/applications rapidly increasing → manpower is not!

Consolidate available resources to achieve scalability and economies of scale.



SaaS

- Applications
- Data
- Runtime
- Middleware

Service layer

IaaS

- O.S.
- Virtualization

Abstraction layer

- Servers
- Storage
- Networking

Hardware and infrastructure

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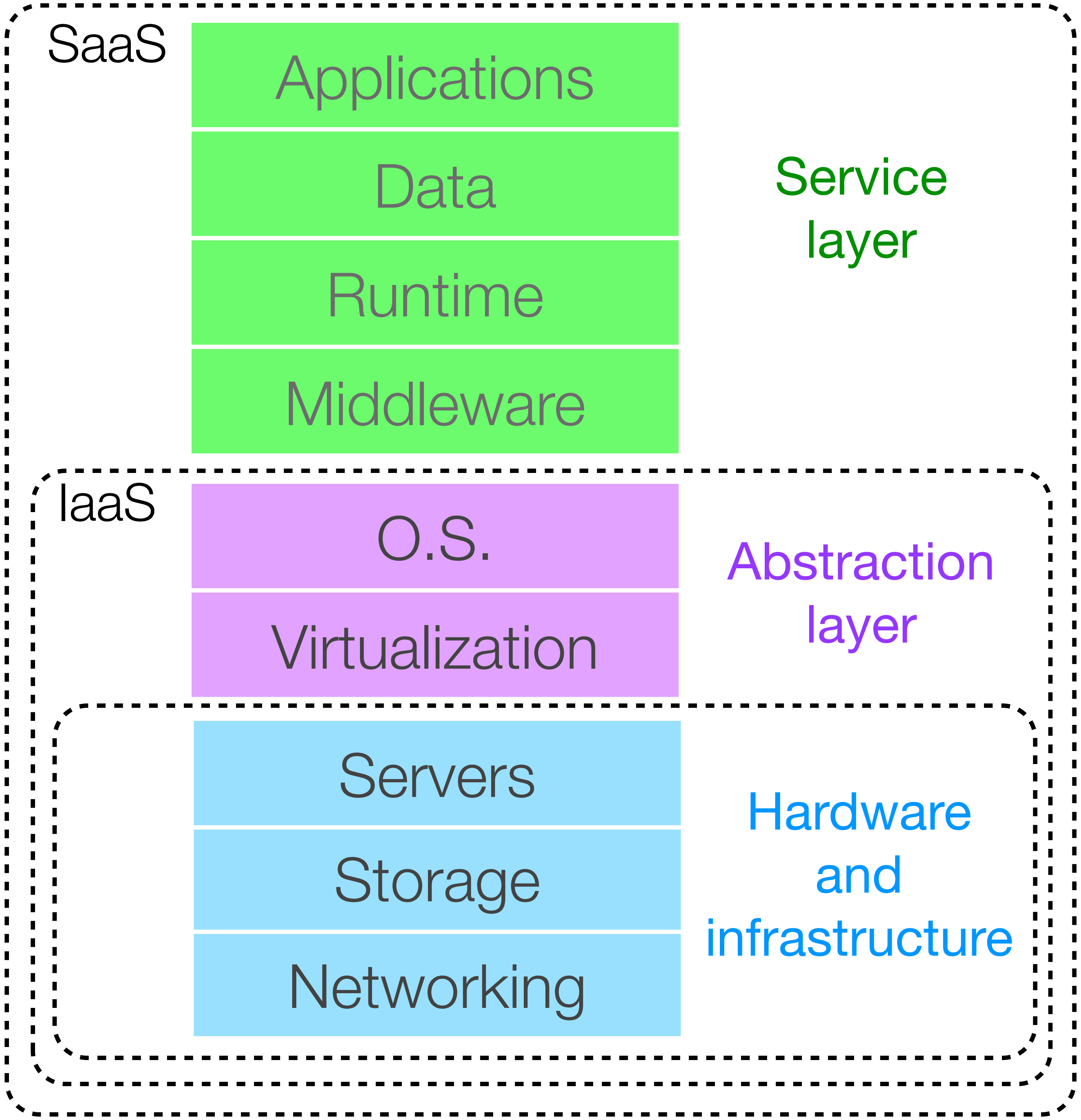
Separate APPLICATION and INFRASTRUCTURE management.

Data-centers become providers of:

- computing resources and storage
- higher-level services



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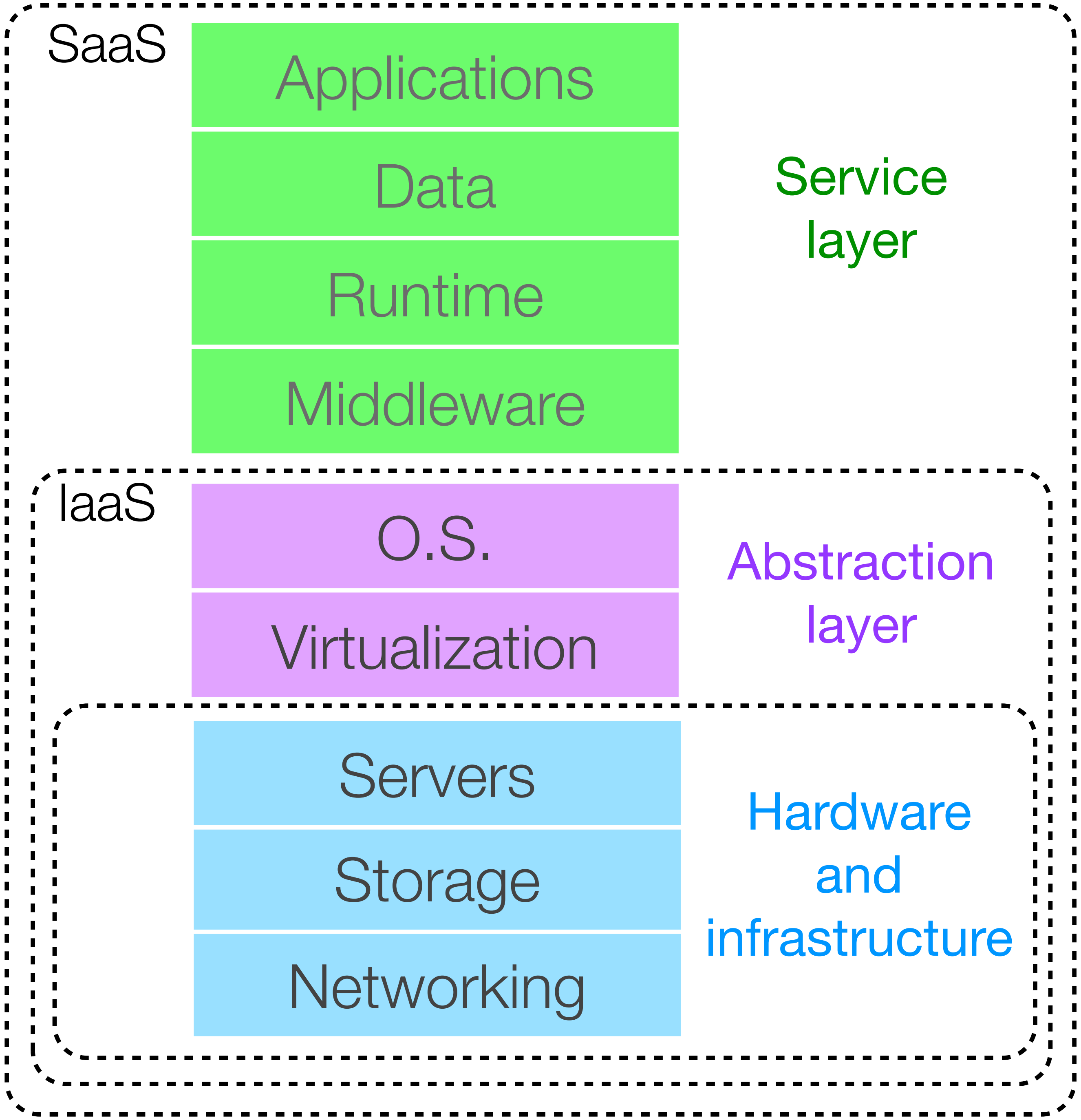
→ the underlying paradigm
(cloud computing) is transparent
to the consumer



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A Private Cloud

Cloud-computing is a resources management strategy which allows:

- on-demand network access to configurable resources
- pooling of resources to serve multiple consumers using a multi-tenant model
- elastic provisioning or releasing of capabilities to scale with demand

... these goals are naturally achieved with virtualization.

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PROOF as a Service on the Cloud
D. Berzano - Tuesday 4:51 PM

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Towards an **hybrid** cloud:

INFN and Italian HTC community are moving towards a national cloud infrastructure

→ R&D ongoing to develop the technical tools to expose the infrastructure to standard interfaces

Our philosophy

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KEEP IT SIMPLE

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- use stable and widely-used tools:
  - **OpenNebula** cloud controller
  - **GlusterFS** distrib. filesystem
  - **OpenWRT** for network management

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BE USER-ORIENTED

- agile development cycle
- provide resources asap
- add functionalities when needed

The ingredients

OpenNebula as
cloud management toolkit:

- open source
- wide user community
- fits our use-cases
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- light-weight Linux distribution for embedded systems
- tools for network configuration and management

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GlusterFS as filesystem:

- mimics RAID functionalities at FS level (aggregates *bricks* on different machines)
- easy to set-up in basic configuration
- easy management (on-line addition/removal/replacement of bricks)
- flexible to cater different needs with a single tool
- proven robustness
- horizontal scalability:
  - peer-to-peer synchronizations
  - data access directly form host node

Two clusters of VMs

SERVICES-CLASS VMs

- provide critical services
- in/out-bound connectivity
- public and private IP
- live migration
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- resiliency-optimized FS for shared system disks (RAID1)
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- private IP only
- high storage I/O performance

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WORKERS-CLASS VMs

- computational work-force (e.g. grid worker nodes)
- private IP only
- high storage I/O performance

- lower-class hardware
- cached image repository
- performance-optimized file system
- currently 35 hosts

Multipurpose storage: use cases

SHARED FS FOR SERVICES-CLASS INSTANCES

- replicated on two servers for redundancy
- replica is synchronous
- self-healing enabled
- little I/O
- low performance required

VM IMAGE REPOSITORY

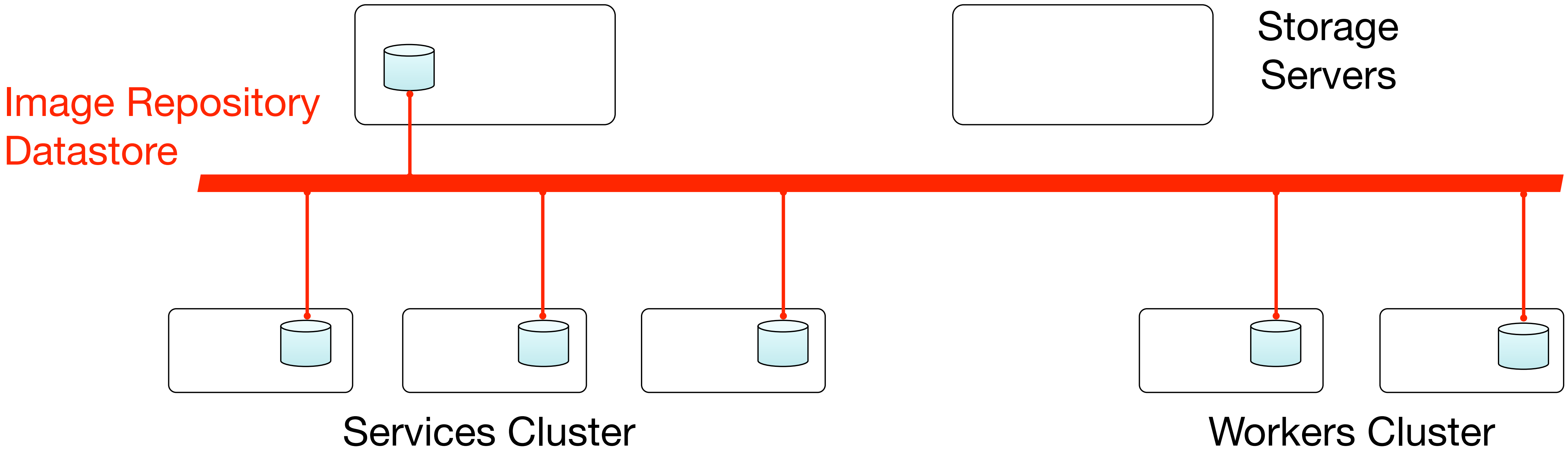
- images in raw or qcow2 format
- locally cached on workers cluster

DATA STORAGE

- pool of aggregated disks (50 TB)
- very high throughput towards many concurrent clients

Multipurpose storage: set-up

2 Storage Servers with 10 Gbps links provide their Fibre Channel SAN LUNs to build bricks through GlusterFS



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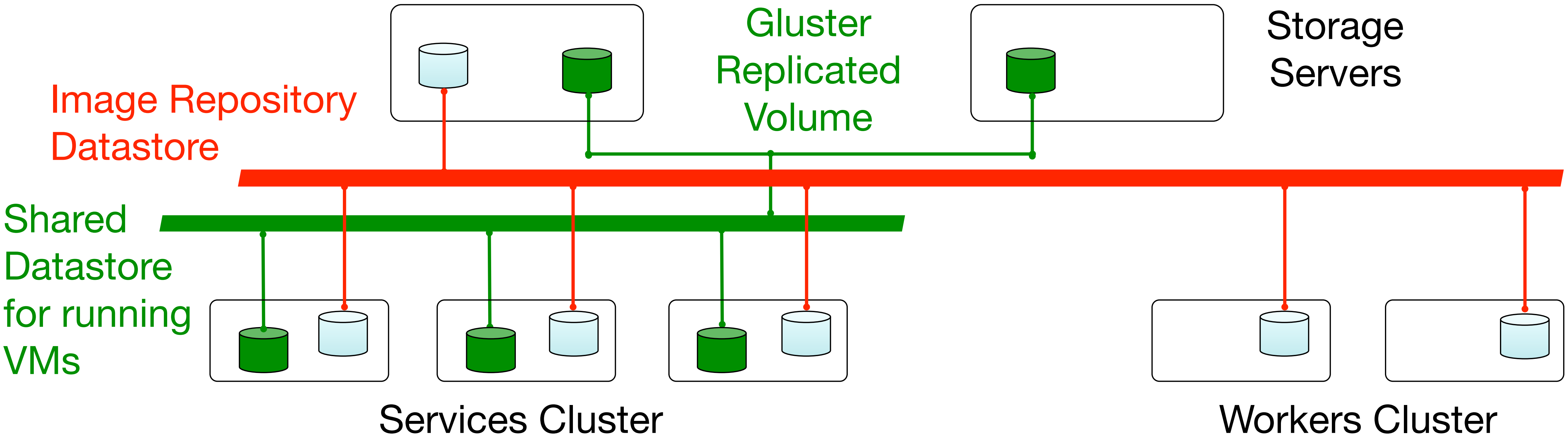
SERVICES FS for running instances:
shared among Service Cluster hosts to allow for live-migration


Gluster Replicated Volume
Storage Servers
Image Repository Datastore
Shared Datastore for running VMs
Services Cluster
Workers Cluster

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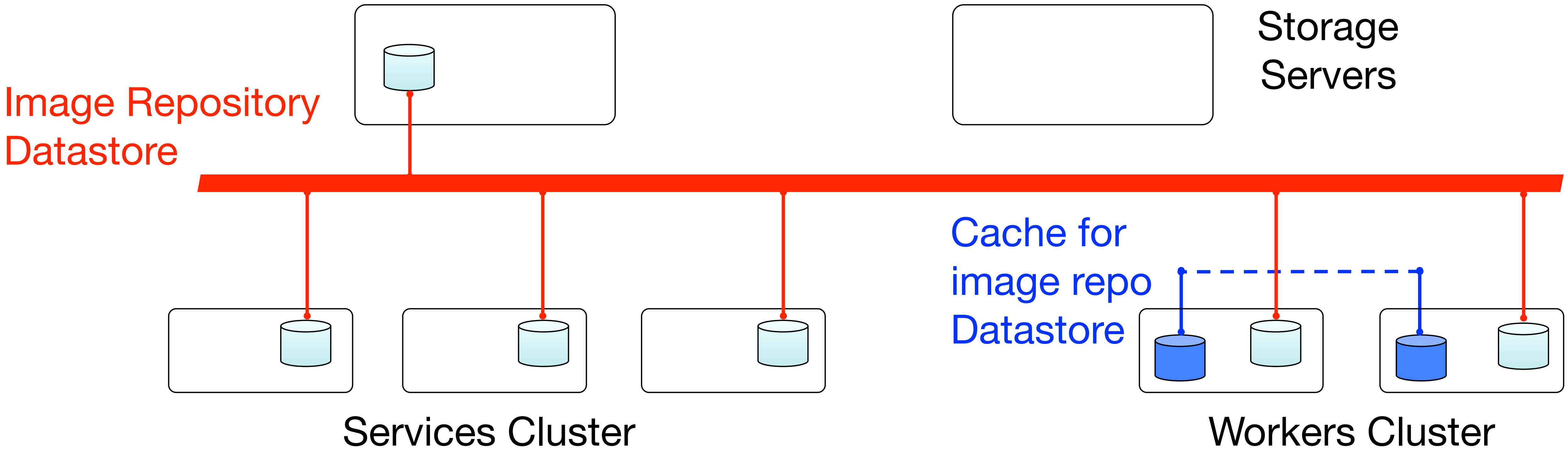
WORKERS FS for running instances:

- local to hypervisors to increase I/O throughput
- images repo locally cached to reduce start-up time
- custom torrent-like tool (scp Wave + rsync) to synchronize local copies



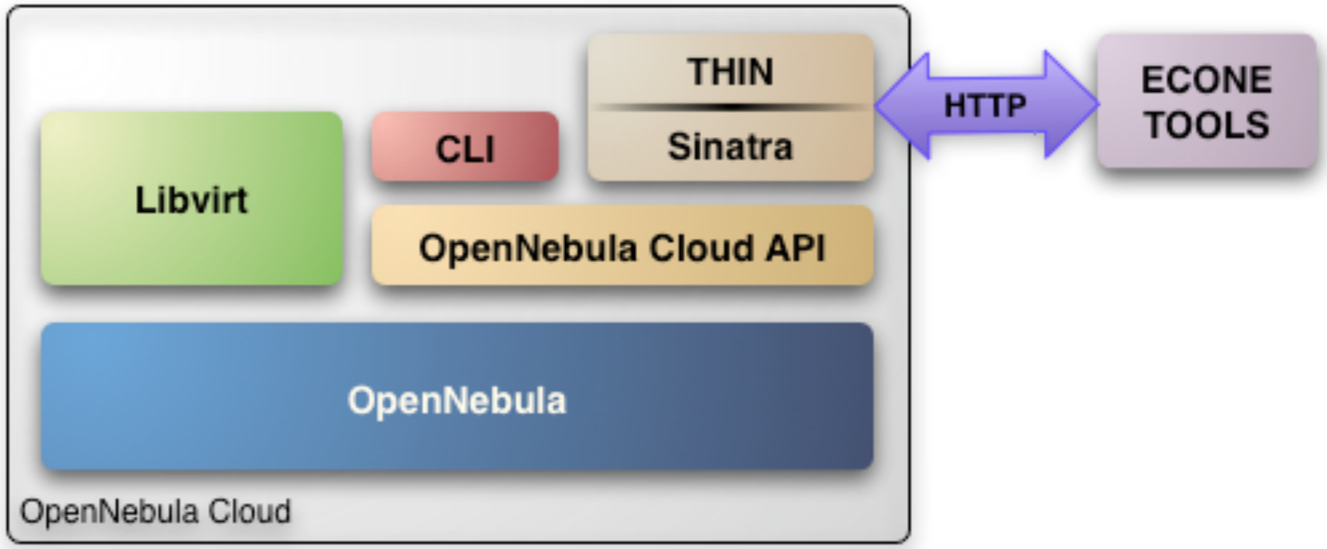
Stay mainstream...

- independently from the complexity of the infrastructure, our Cloud exposes a standard interface (EC2)
- support contextualization via a widely used tool (CloudInit)

Exposing a standard Cloud interface

EC2 QUERY

- OpenNebula web service to manage VMs through *Amazon EC2 API*
- can be used alongside the native OpenNebula client
- implemented upon the OpenNebula Cloud API (OCA)
- Sinatra as light web framework
- includes basic tools to use the query service (econe-tools)



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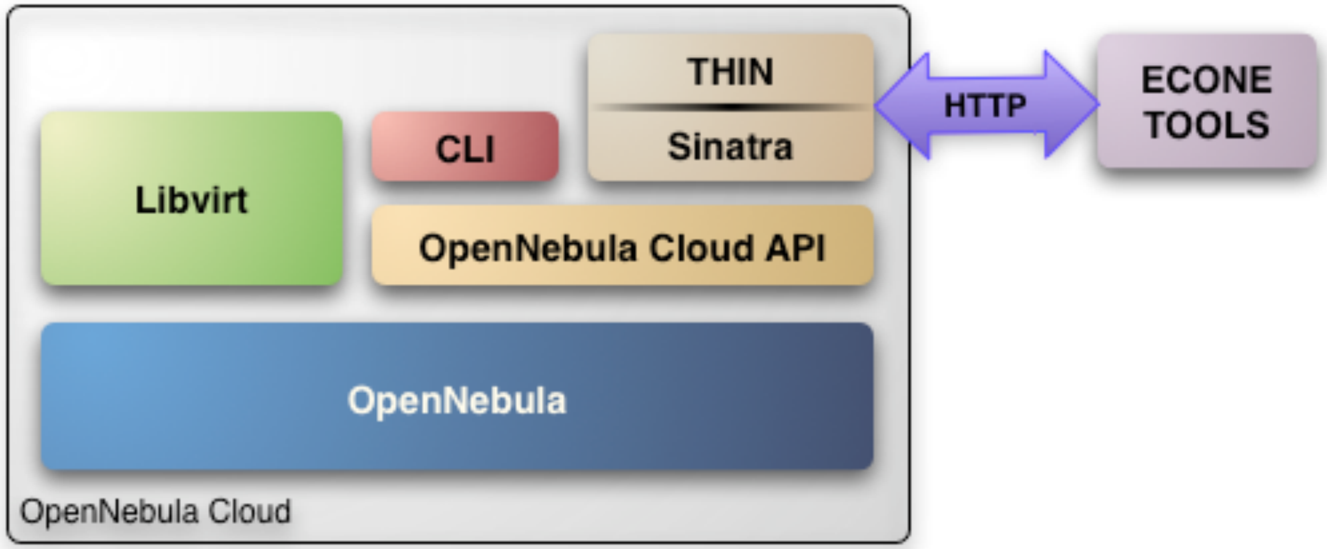

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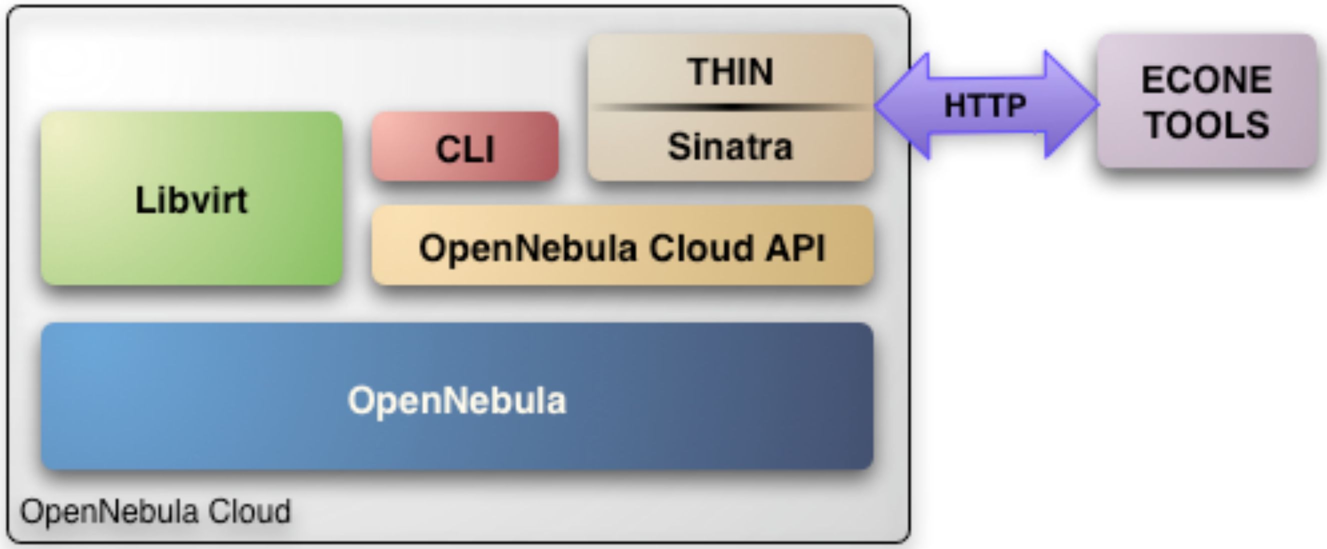

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EUCA-TOOLS

- native Eucalyptus command-line tools (open-source) http://goo.gl/qiSmXb
- interact with AWS-compatible web services
- more functionalities than econe-tools (e.g. pass user-data as file)

CloudInit

Docs:
http://goo.gl/jNebHc
http://goo.gl/UVbDZb

Source code:
http://goo.gl/hU1G8v

WHAT?

- Ubuntu package to handle early initialization of a cloud instance
- default on Ubuntu images on EC2
- available for multiple Linux distros
- Python source code
- boto library to fetch configuration data
- datasources:
  - meta-data (from the cloud stack): hostname, ssh keys, ephemeral mount-points etc...
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- modular and customizable: custom modules and *part-handlers*
- several configuration formats: cloud-config (yaml), shell scripts, include urls, gzip or MIME archives...

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CloudInit and OpenNebula

- since version 0.7.3 OpenNebula context disk supported as data-source
- not many examples yet
- small change applied to enable usage of user-data *file* with euca-tools

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- script to embed all the information (part-handlers, configuration, keys...) in a single MIME archive
- instance VM with euca-tools passing the MIME archive
- user-data are securely shipped to the instance via the OpenNebula context disk

Example: work in progress...

At the moment part of the configuration data are taken from an http server (not directly embedded in the MIME)

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Configure your instance:

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#multiple-config
# vim: syntax=yaml

# Configure local file-system
localfs:
   parts:
      # below percent of VG
      cvmfs: 17
      cvmfs-mount: /var/lib/cvmfs
      home: 58
      tmp: 8
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      swap: 100

# Configure CVMFS
cvmfs:
  install: true
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  local:
    repositories: alice.cern.ch...
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Run a script to produce the MIME archive:

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From nobody Tue Oct  8 16:11:36 2013
Content-Type: multipart/mixed;
boundary="===============181078353...
MIME-Version: 1.0

--===============1810783535439179425...
Content-Type: text/x-include-url; charset="us-
ascii"
Content-Transfer-Encoding: 7bit
Content-Disposition: attachment;
filename="include_modules.txt"

#include
http:srm-dom0.to.infn.it/test/cc_localfs.py
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Instance your VM *à la EC2:*

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euca-run-instances ami-000070 \
                         -t m1.large \
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↓

Check the logs:

- each part-handler produces a detailed log-file
- a final script checks the logs for errors
- summary log with a list of failed handlers

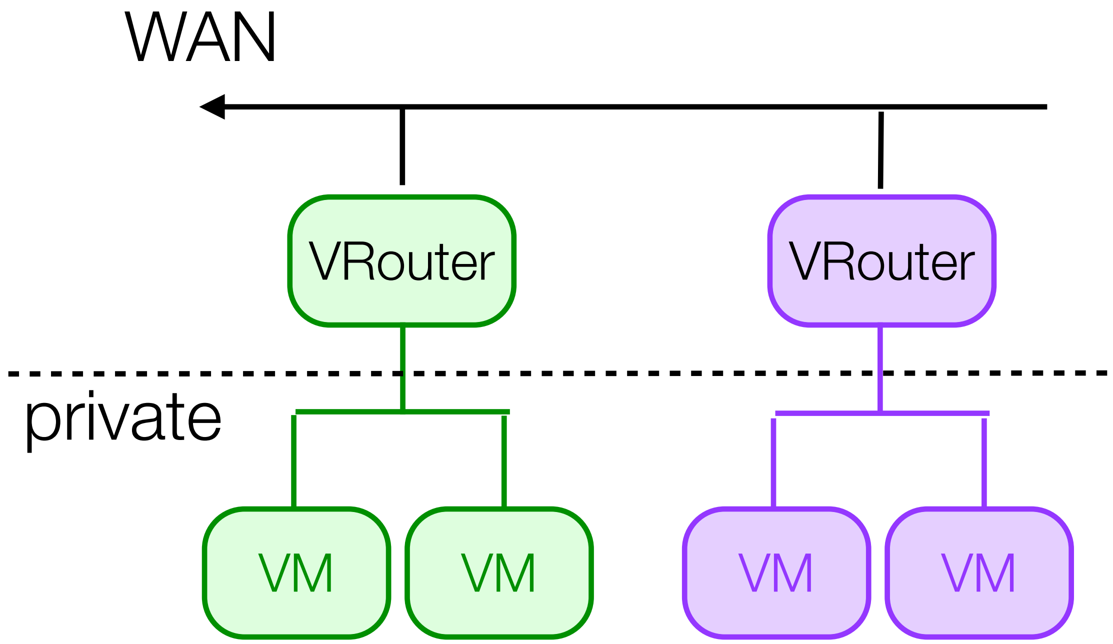
→ **next**: shut-down the instance in case of failures

Be user-oriented...

- private networks
- private farms

Networking: VRouter and Elastic IPs

Provide users with fully featured class-C private networks.



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Network isolation (level 2):

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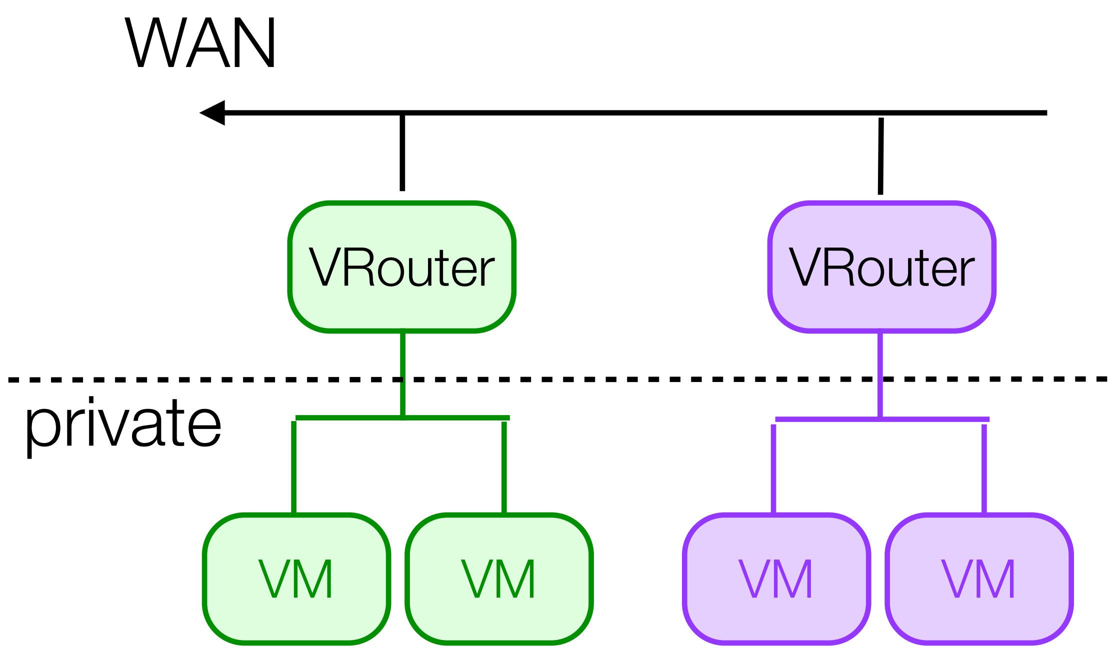
- each network is isolated with ebtables rules on the hypervisor bridge (OpenNebula V-net driver)



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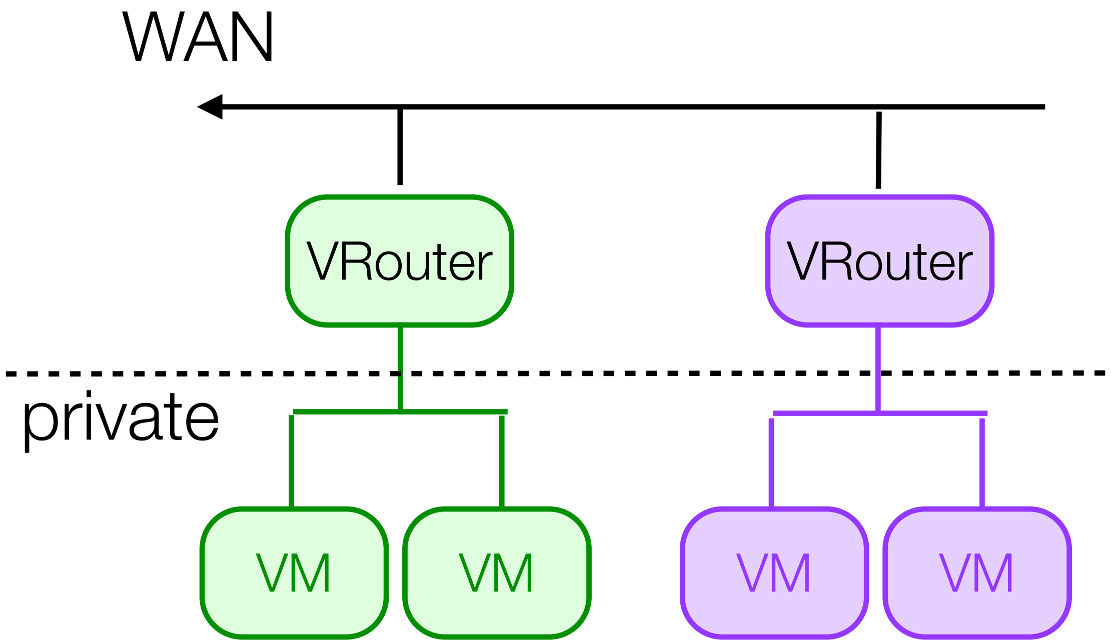
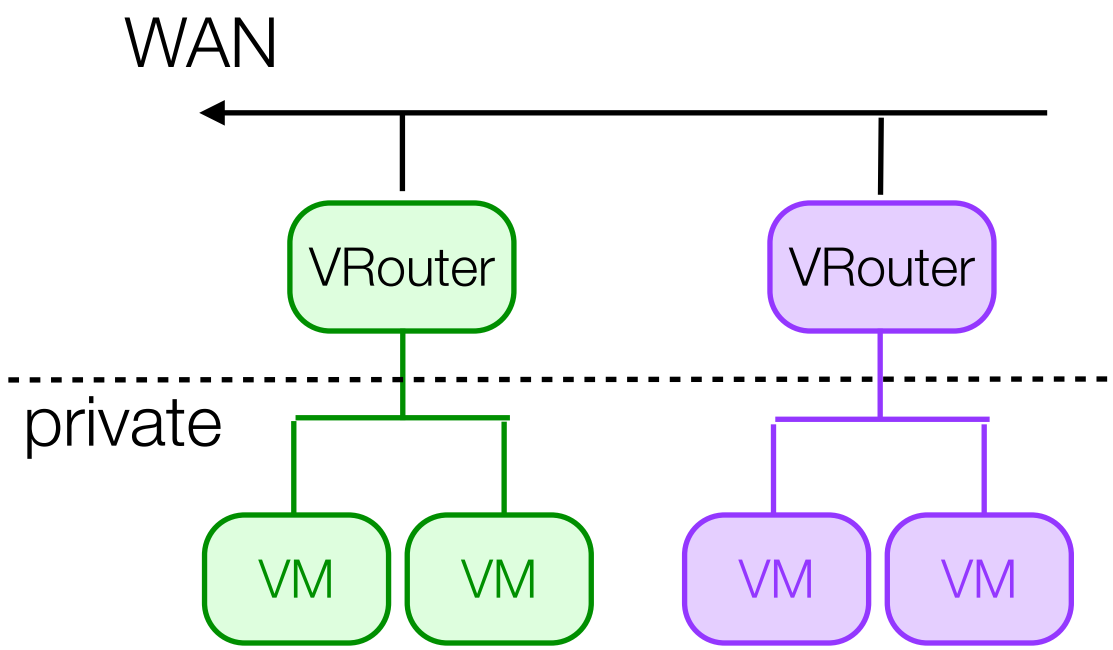
Virtual Routers (level 3):

- private and public IP
- light-weight OpenWRT VM (1CPU, 150 MB)
- DHCP, DNS, NAT functionalities
- Firewalling / port-forwarding
- configuration possible via HTTPS or SSH



Networking: VRouter and Elastic IPs

Provide users with fully featured class-C private networks.



Network isolation (level 2):

- each user is assigned a Virtual Network
- each network is isolated with ebtables rules on the hypervisor bridge (OpenNebula V-net driver)

Virtual Routers (level 3):

- private and public IP
- light-weight OpenWRT VM (1CPU, 150 MB)
- DHCP, DNS, NAT functionalities
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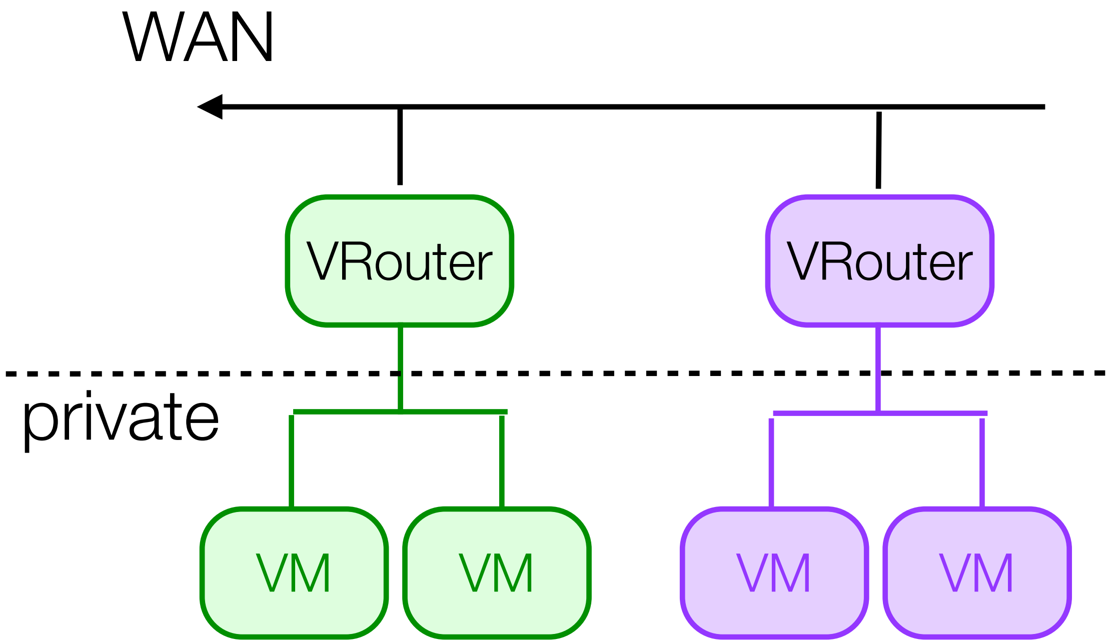

ELASTIC IPs

The VRouter allows to use EC2-compatible APIs (euca-tools) to

→ bind DINAMICALLY a public IP to one of the private VM instances

A model for Virtual Farm provisioning

Wiki: http://goo.gl/Lj5l01

Automated creation of a sandboxed environment within our Private Cloud:

- creation of new OpenNebula user
- creation of isolated Virtual Network
- configuration and instantiation of dedicated VRouter
- 1 elastic public IP assigned
- restrictive quota on the amount of resources
- use only a subset of images with *public* permissions
- configuration simplified through the definition of Amazon-like flavors
- flavors mapped onto OpenNebula templates

Flavor	**CPUs**	**RAM**	**Ephemeral disk**
m1.small	1	512 MB	-
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State of the art:

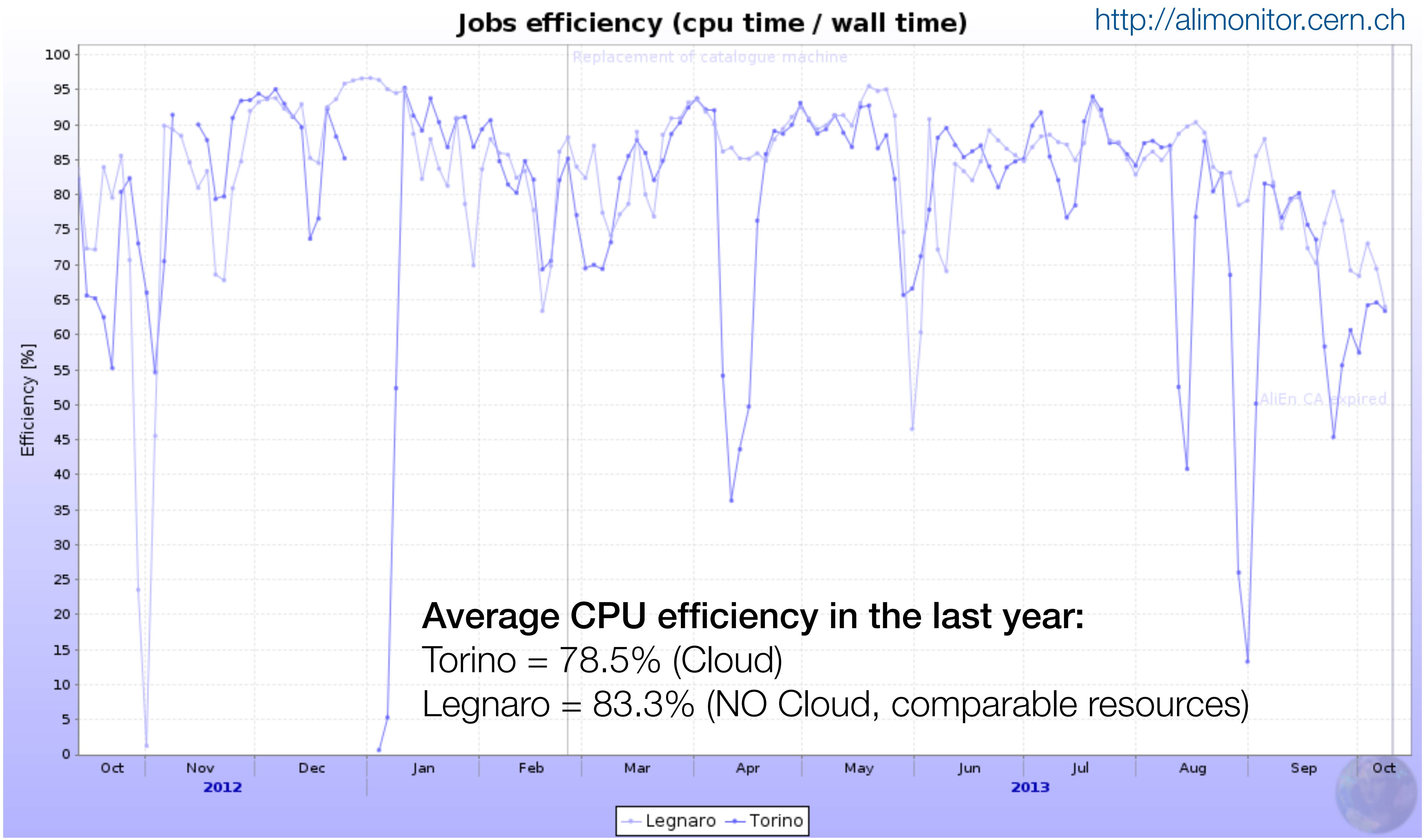
- ready to be tried out by users
- access and control from within the INFN Torino network
- access tools (euca-tools) available on public login hosts

Conclusions and Outlook

- Cloud infrastructure in production for nearly 2 years
- until now IaaS paradigm allowed us to reduce the management effort
- infrastructure now ready for dynamic use cases and self-service provisioning
- coordination with other INFN Cloud development activities
- any new hardware will be included in the Cloud infrastructure and transparently given back to users as virtual resources
- Work in progress: automated reallocation of resources

Back-up

ALICE Tier2 CPU efficiency



http://alimonitor.cern.ch

Average CPU efficiency in the last year:

Torino = 78.5% (Cloud)

Legnaro = 83.3% (NO Cloud, comparable resources)