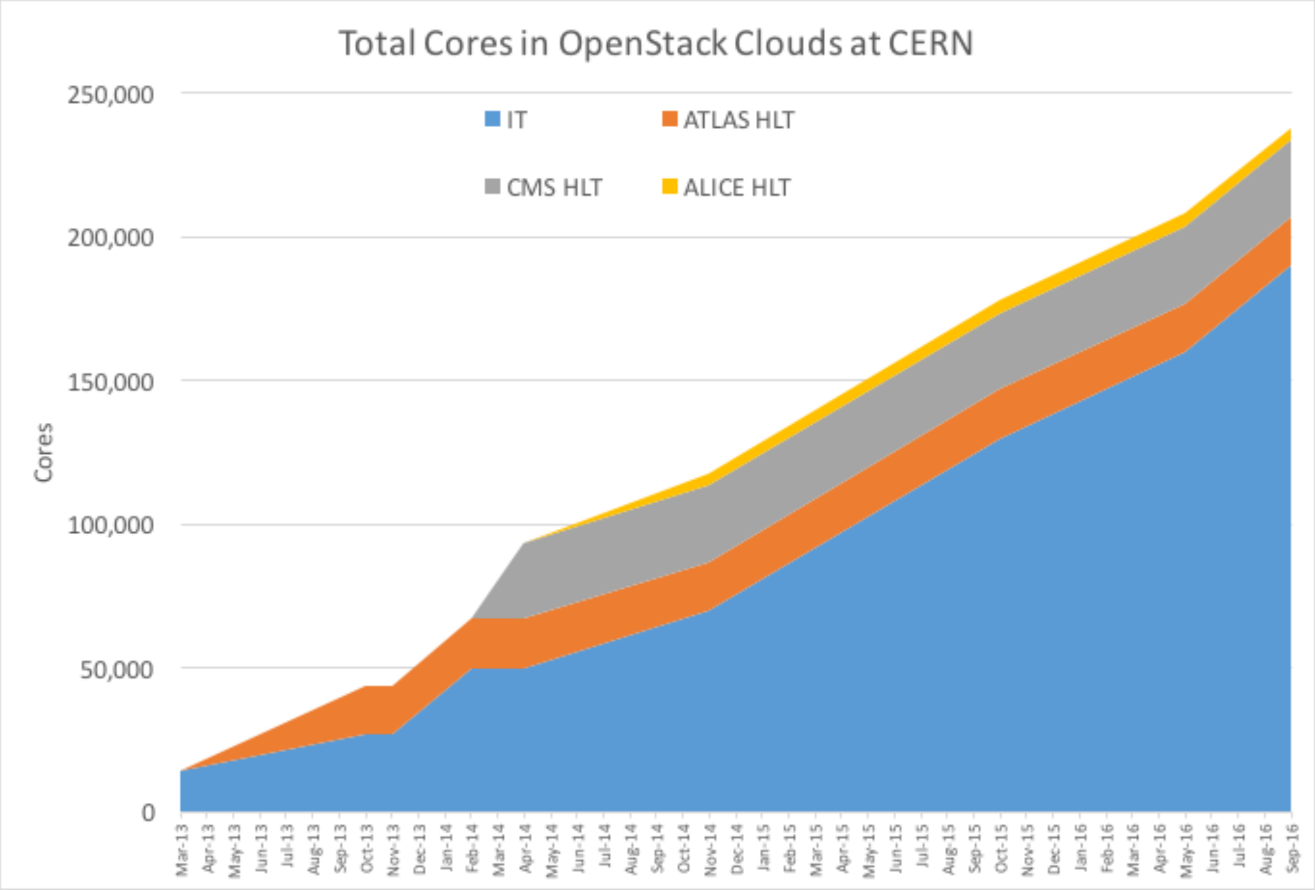
CERN Experience

D. Giordano / CERN-IT

WLCG Workshop
8-9 October 2016

OpenStack Clouds at CERN



In production:

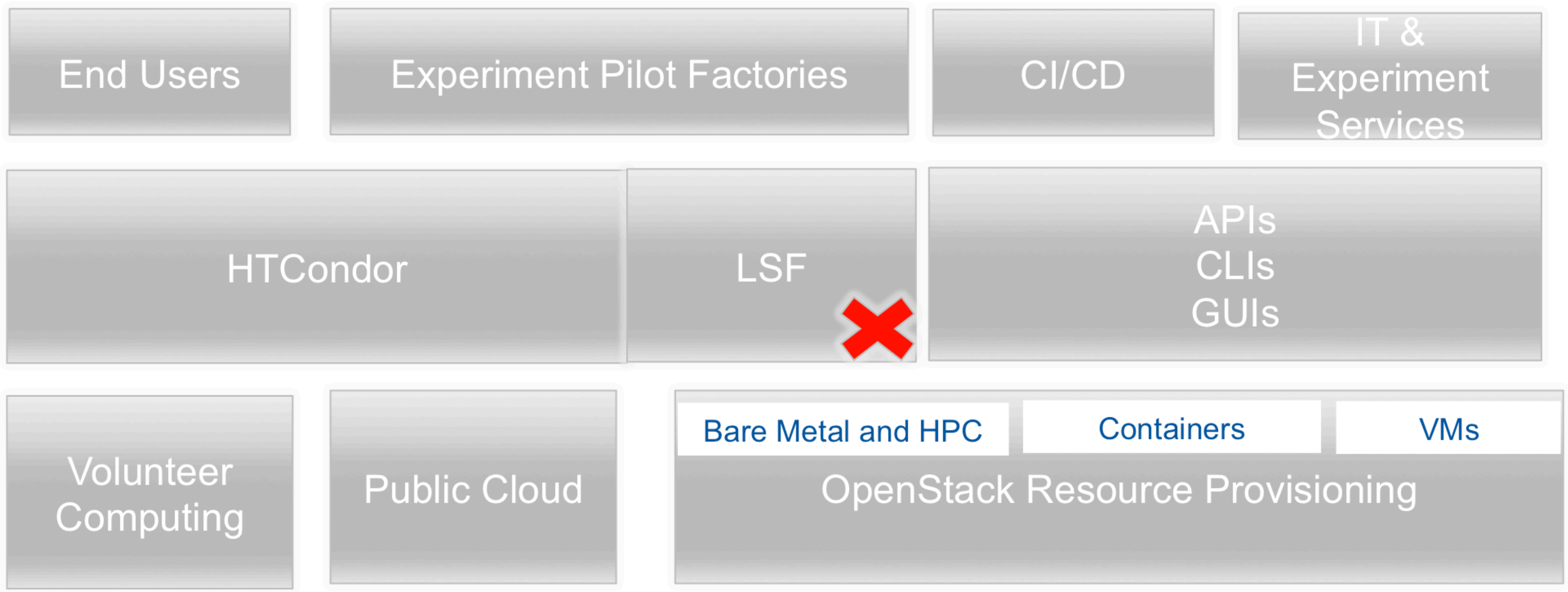
- □ 4 clouds
- □ >230K cores
- □ >8,000 hypervisors

90% of CERN's compute resources are now delivered on top of OpenStack

A further 42K cores to be installed in next few months

Tier-0 Compute Services 2017

- Universal resource provisioning layer for bare metal, containers and VMs
- HTCondor as the single end user interface with LSF retirement by LS2
- Continue investing in automation and other communities for scaling with fixed staff
- Self service for end users within the policies and allocations



End Users

Experiment Pilot Factories

CI/CD

IT & Experiment Services

HTCondor

LSF ✖

APIs
CLIs
GUIs

Volunteer Computing

Public Cloud

Bare Metal and HPC

Containers

VMs

OpenStack Resource Provisioning

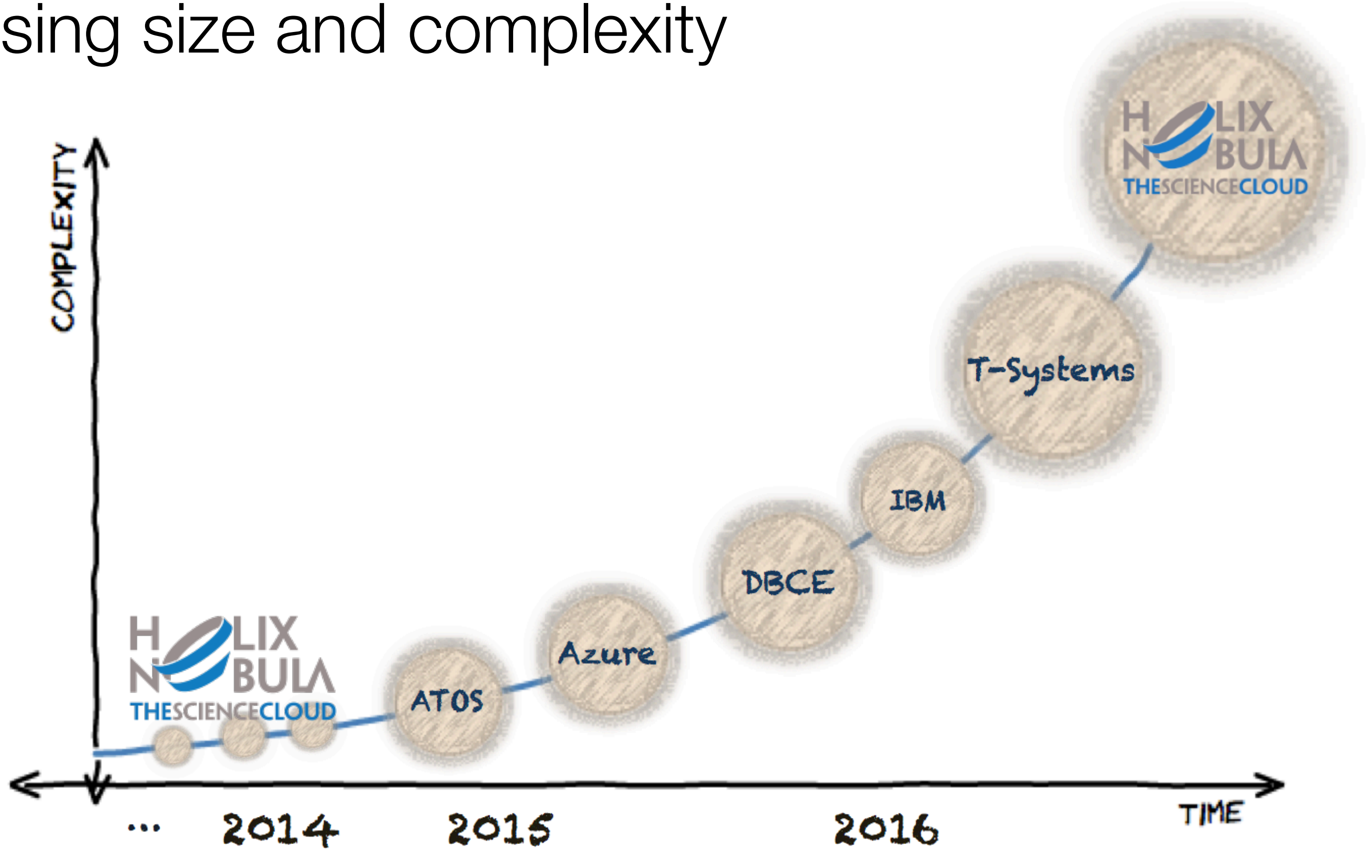
courtesy of T. Bell

Evaluation of
Public Cloud Service Providers (CSP)

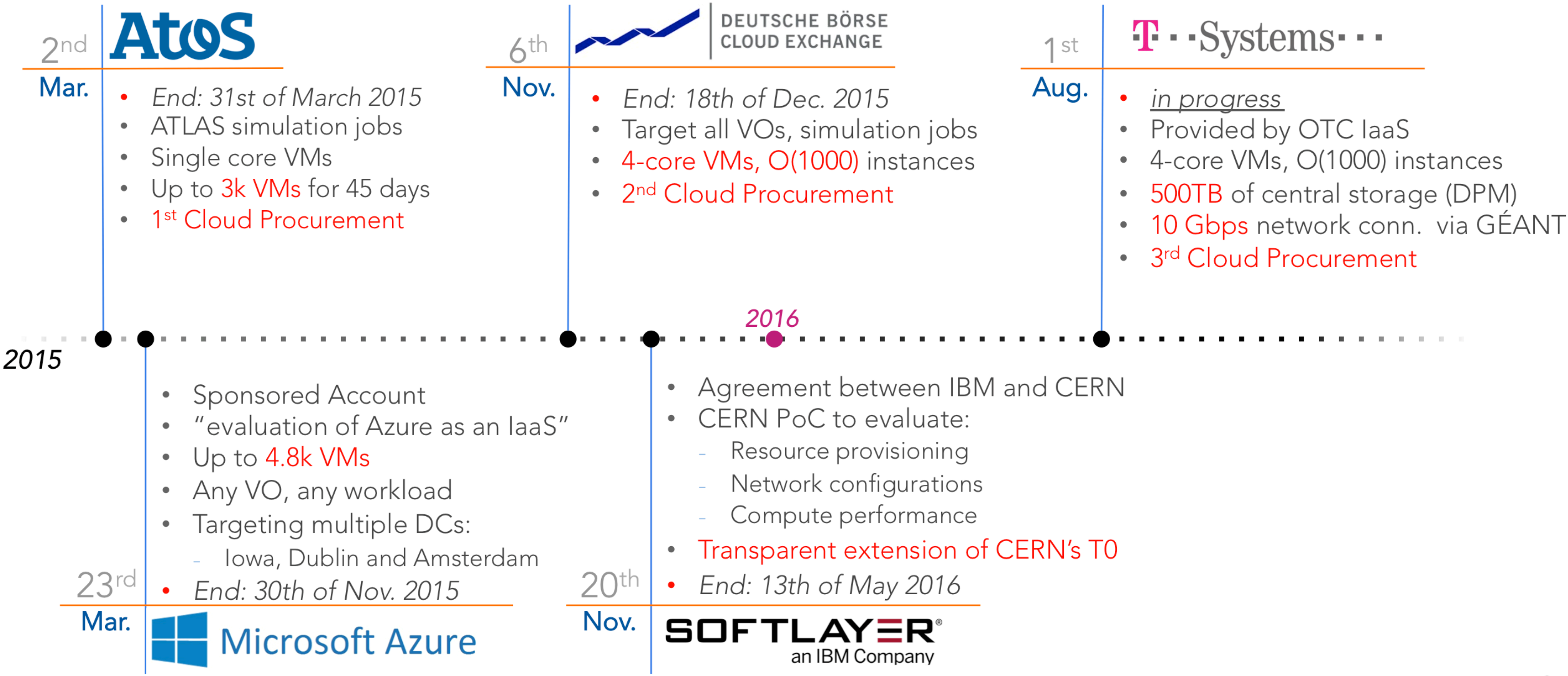
Roadmap

Started in 2011 with the EC funded project Helix-Nebula

Since 2015, series of short CERN procurement projects of increasing size and complexity



In a nutshell



2015

2nd Mar. — Atos
- *End: 31st of March 2015*
- ATLAS simulation jobs
- Single core VMs
- Up to 3k VMs for 45 days
- 1st Cloud Procurement

23rd Mar. — Microsoft Azure
- Sponsored Account
- "evaluation of Azure as an IaaS"
- Up to 4.8k VMs
- Any VO, any workload
- Targeting multiple DCs:
  - Iowa, Dublin and Amsterdam
- *End: 30th of Nov. 2015*

6th Nov. — DEUTSCHE BÖRSE CLOUD EXCHANGE
- *End: 18th of Dec. 2015*
- Target all VOs, simulation jobs
- 4-core VMs, O(1000) instances
- 2nd Cloud Procurement

20th Nov. — SOFTLAYER an IBM Company
- Agreement between IBM and CERN
- CERN PoC to evaluate:
  - Resource provisioning
  - Network configurations
  - Compute performance
- Transparent extension of CERN's T0
- *End: 13th of May 2016*

2016

1st Aug. — T-Systems
- *in progress*
- Provided by OTC IaaS
- 4-core VMs, O(1000) instances
- 500TB of central storage (DPM)
- 10 Gbps network conn. via GÉANT
- 3rd Cloud Procurement

[see CHEP o-26]

Some Lessons learned

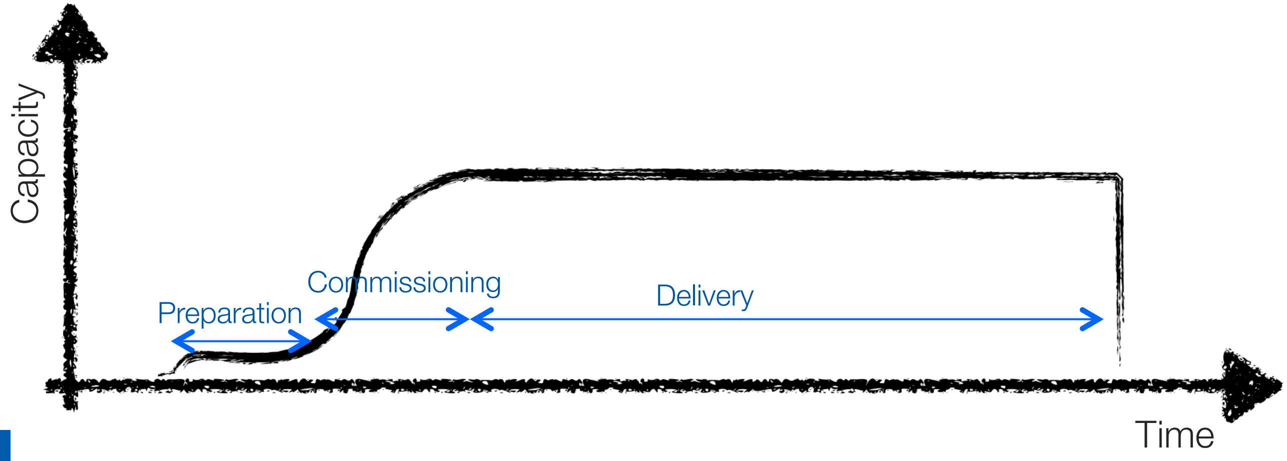
Cloud Brokerage not as effective as publicized

Overhead in managing several, small public CSP

Client-side accounting, monitoring and benchmarking are crucial

Cannot avoid preparation and commissioning phases

- Ramp-up speed is often connected to the maturity and stability of the CSP



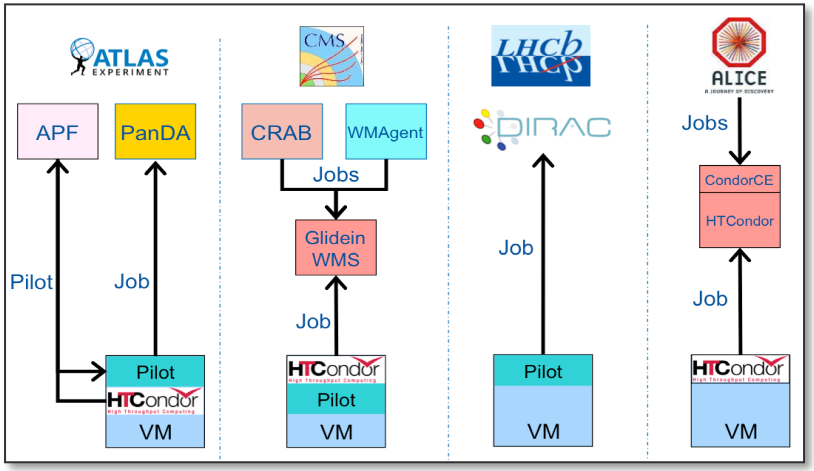
Provisioning, Monitoring, Exploitation

Transparent Extension of CERN Resources

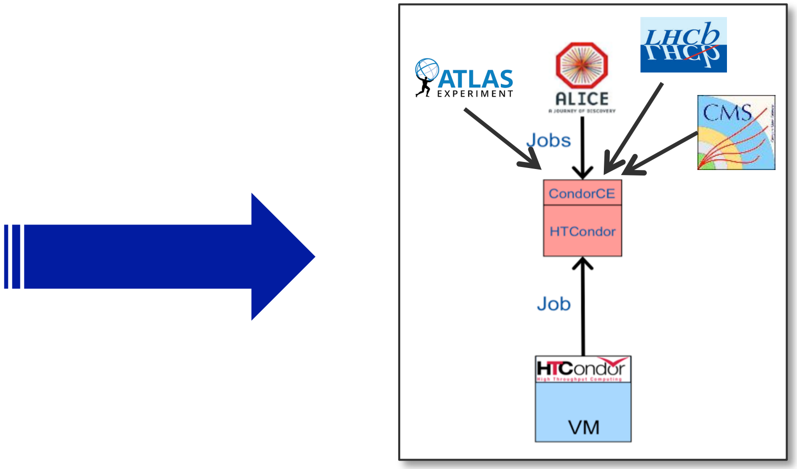
Consolidate the strategies adopted in the past cloud activities

- Manage and exploit external resources using same toolset and entry points as CERN on premises resources
  - *Puppet* configuration
  - **HTCondor** for scheduling and match-making
  - Infrastructure **monitoring** *[see CHEP p-22]*
- Adopted ***Terraform*** for VM lifecycle management (N.B.: looking for long VM lifetime)
  - Open source toolkit, supports several cloud providers

2015 approaches



Now



Provisioning tools:

Vcycle; custom scripts for HNX-SlipStream, Azure RM

Terraform

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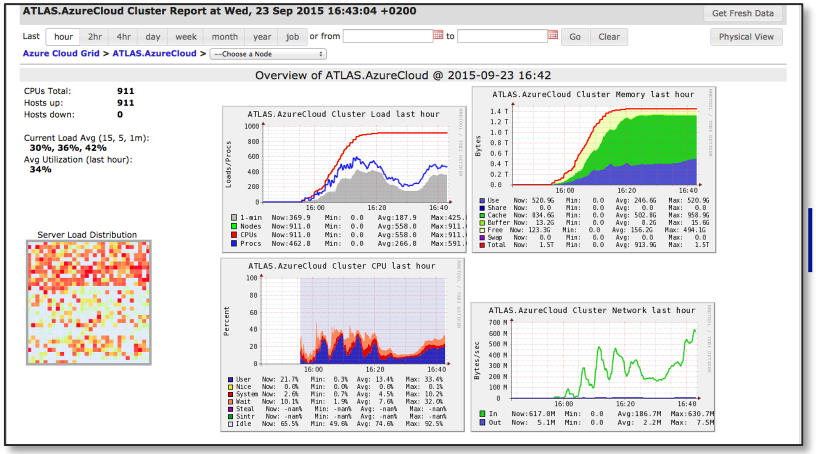
2015 approaches



ATLAS.AzureCloud Cluster Report at Wed, 23 Sep 2015 16:43:04 +0200

Last: hour | 2hr | 4hr | day | week | month | year | job — or from ___ to ___ Go Clear

Azure Cloud Grid > ATLAS.AzureCloud > --Choose a Node

Overview of ATLAS.AzureCloud @ 2015-09-23 16:42

CPUs Total: **911**
Hosts up: **911**
Hosts down: **0**

Current Load Avg (15, 5, 1m):
30%, 36%, 42%
Avg Utilization (last hour):
34%

Server Load Distribution

ATLAS.AzureCloud Cluster Load last hour

```
1-min   Now:369.9   Min:  0.0   Avg:187.9   Max:425.
Nodes   Now:911.0   Min:  0.0   Avg:558.0   Max:911.
CPUs    Now:911.0   Min:  0.0   Avg:558.0   Max:911.
Procs   Now:462.8   Min:  0.0   Avg:266.8   Max:591.
```

ATLAS.AzureCloud Cluster Memory last hour

```
Use    Now: 520.9G   Min:   0.0   Avg: 246.6G   Max: 520.9G
Share  Now:   0.0    Min:   0.0   Avg:   0.0    Max:   0.0
Cache  Now: 834.6G   Min:   0.0   Avg: 502.8G   Max: 958.9G
Buffer Now:  13.2G   Min:   0.0   Avg:   8.2G   Max:  15.6G
Free  Now: 123.3G   Min:   0.0   Avg: 156.2G   Max: 494.1G
Swap   Now:   0.0    Min:   0.0   Avg:   0.0    Max:   0.0
Total  Now:   1.5T   Min:   0.0   Avg: 913.9G   Max:   1.5T
```

ATLAS.AzureCloud Cluster CPU last hour

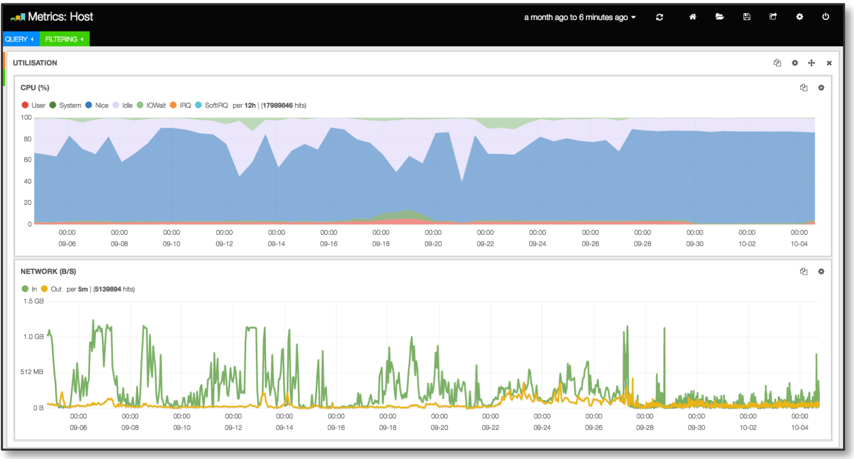
```
User   Now: 21.7%   Min:  0.3%   Avg: 13.4%   Max: 33.4%
Nice   Now:  0.0%   Min:  0.0%   Avg:  0.0%   Max:  0.1%
System Now:  2.6%   Min:  0.7%   Avg:  4.5%   Max: 10.2%
Wait   Now: 10.1%   Min:  1.9%   Avg:  7.6%   Max: 32.0%
Steal   Now: -nan%   Min: -nan%   Avg: -nan%   Max: -nan%
Sintr   Now: -nan%   Min: -nan%   Avg: -nan%   Max: -nan%
Idle   Now: 65.5%   Min: 49.6%   Avg: 74.6%   Max: 92.5%
```

ATLAS.AzureCloud Cluster Network last hour

```
In    Now:617.0M   Min:   0.0   Avg:186.7M   Max:630.7M
Out   Now:  5.1M   Min:   0.0   Avg:  2.2M   Max:  7.5M
```

Monitoring:
Ganglia

Now



Metrics: Host

a month ago to 6 minutes ago

UTILISATION

CPU (%)

● User ● System ● Nice ● Idle ● IOWait ● IRQ ● SoftIRQ per **12h** | (**17989846** hits)

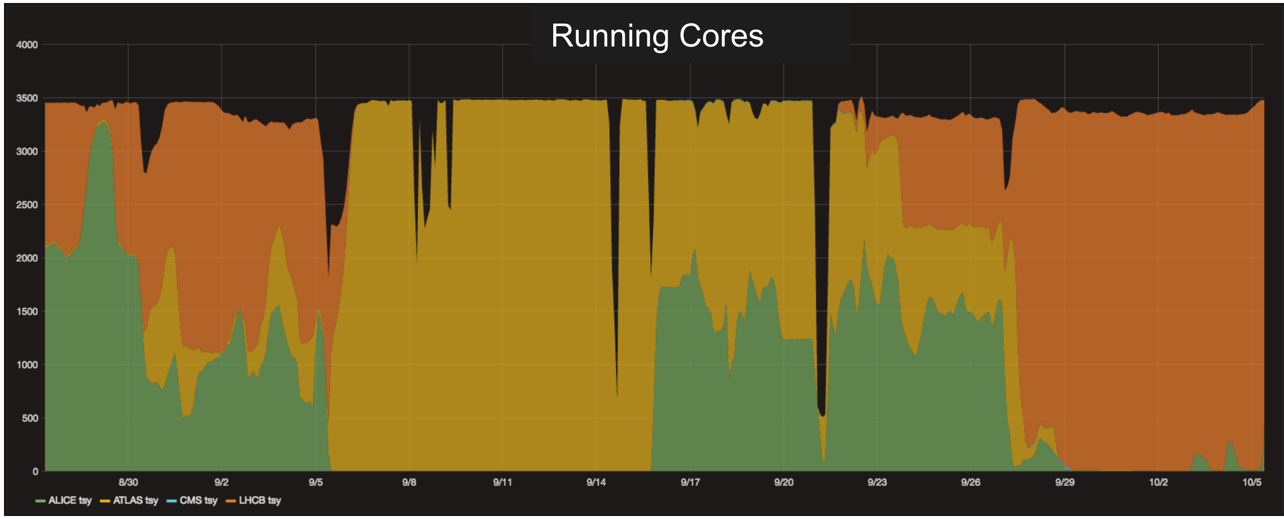
NETWORK (B/S)

● In ● Out per **5m** | (**5139894** hits)

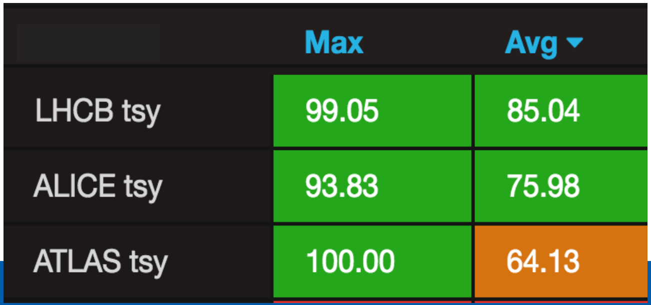
AI Monitoring

Recent activity: T-Systems

- Batch resources fully loaded
  - shared among VOs

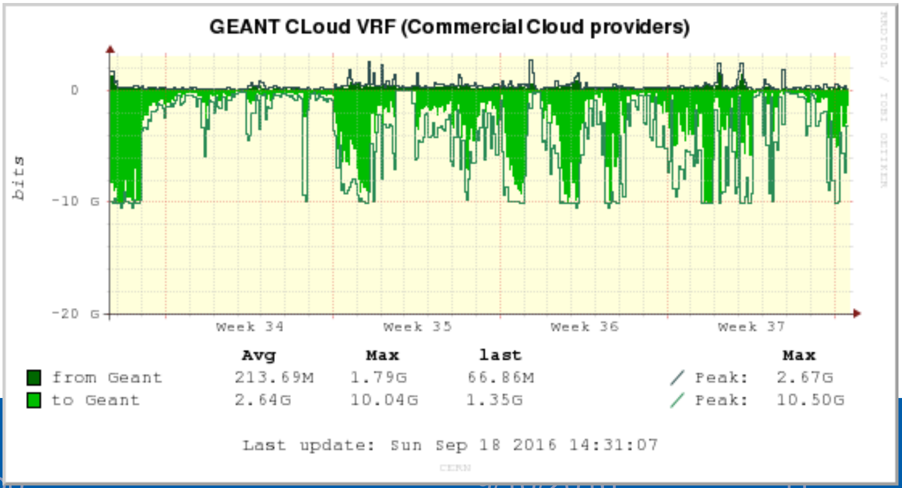


- Mixture of “CPU-intensive” and “network-intensive” tasks
  - MC workloads tend to dominate: easier to manage?



	Max	Avg
LHCB tsy	99.05	85.04
ALICE tsy	93.83	75.98
ATLAS tsy	100.00	64.13

- WAN largely used
  - Sometimes even saturated



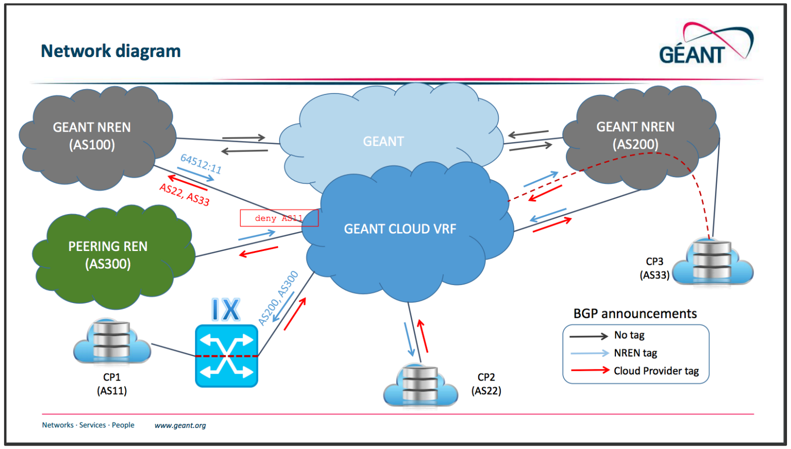
Network Connectivity

WAN connectivity over GÉANT network

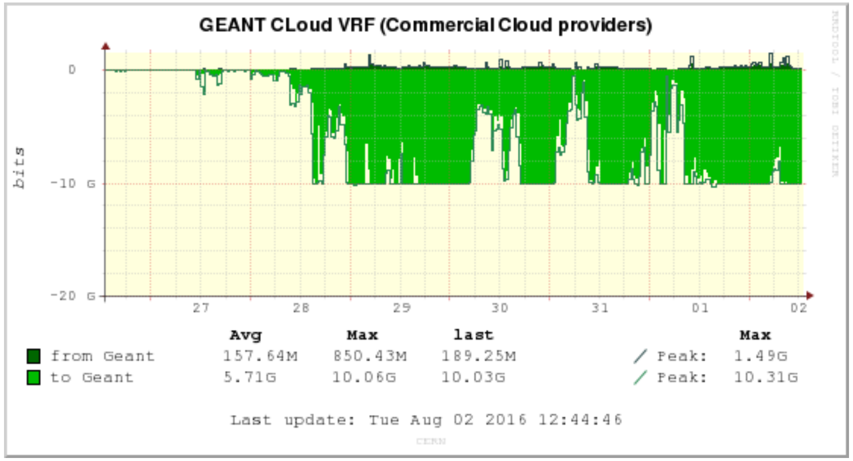
Requirement for CSP since the first procurement (early ’15)

GÉANT Cloud VRF is currently connecting CERN and T-Systems (via DFN)

- 10 Gbps of total reserved peak bandwidth available
- The VRF is configured to only allow traffic between CSPs and NRENs; no CSP-CSP traffic is allowed



source V. Capone: GÉANT approach to Cloud R&E traffic



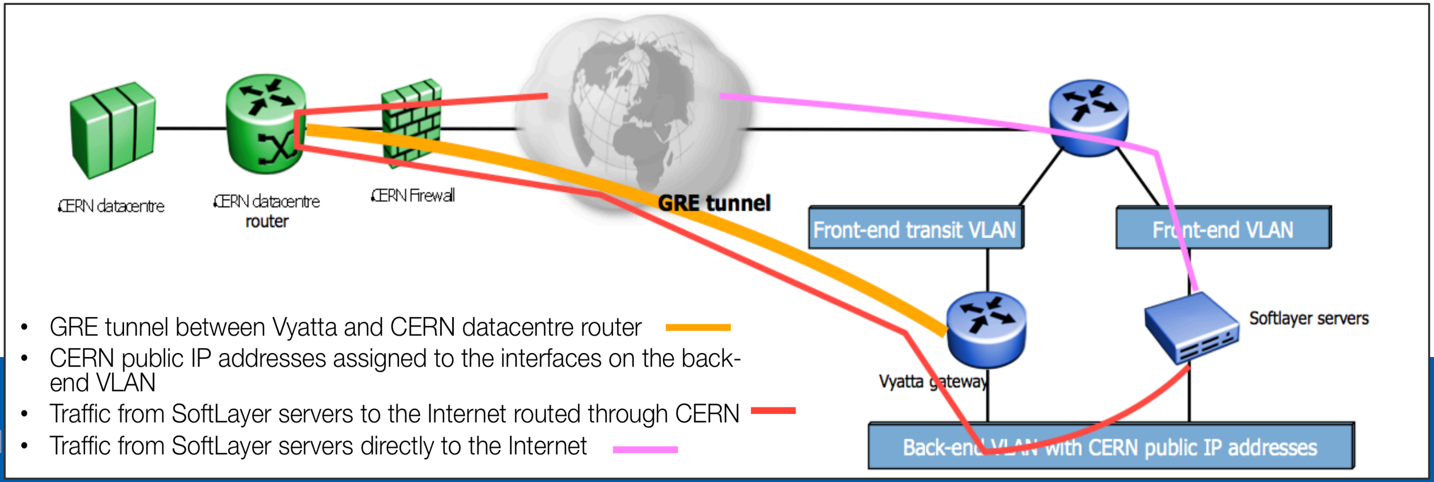
VPN Evaluation

Performed during the IBM-SoftLayer activity over GÉANT

- Established connectivity @ Amsterdam in co-located PoP
- Performance measured using **perfSONAR** (throughput, latency, loss, routing)

VPN evaluation outcome

- Performance: not necessary the best option for maximum throughput
- Management: overhead due to additional configuration
- Security: VPN implies full access to CERN from outside
  - On the contrary w/o VPN going through the CERN firewall. No access to full CERN from outside. Only ports open and to be secured are for Puppet CA.


CERN datacentre
CERN datacentre router
CERN Firewall
GRE tunnel
Front-end transit VLAN
Front-end VLAN
Softlayer servers
Vyatta gateway
Back-end VLAN with CERN public IP addresses
GRE tunnel between Vyatta and CERN datacentre router
CERN public IP addresses assigned to the interfaces on the back-end VLAN
Traffic from SoftLayer servers to the Internet routed through CERN
Traffic from SoftLayer servers directly to the Internet

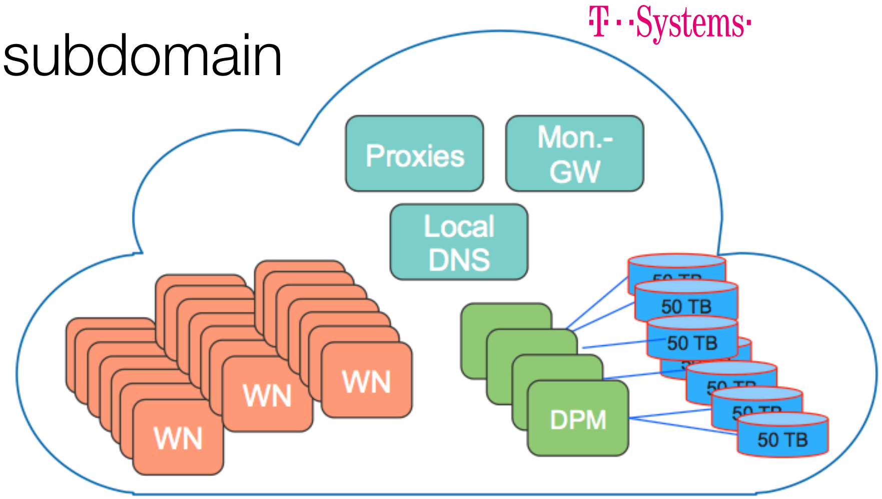
Cloud Storage

Cloud Storage in addition to Compute

Opportunity to study requirements and performance of "data-intensive" workloads, i.e. more than MC simulation

500 TB of Central Storage included in the last contract, awarded to T-Systems

- Block storage, managed via **DPM** (Tier-2 like model)
- Nodes registered in tsy.cern.ch subdomain
- Local DNS service needed for performance reasons with 1:1 NAT



Storage Vs Network
“Block” vs “Object” Storage

Two open questions

1. Is storage (mainly a cache) needed in public cloud?
   - Or is it better to buy more WAN bandwidth?
   - Different requirements from the VOs:
     - Disk-less resources (LHCb)
     - Cache for Minimum Bias (ATLAS and initially CMS the before pre-mixed PU approach)
     - Tier-2 like storage for Analysis (ALICE)

2. Status of adoption of Object Storage in WLCG workloads
   - CSPs prefer to leverage Object Storage
     - More scalable, reliable and cost effective than block storage

Procurement Actions

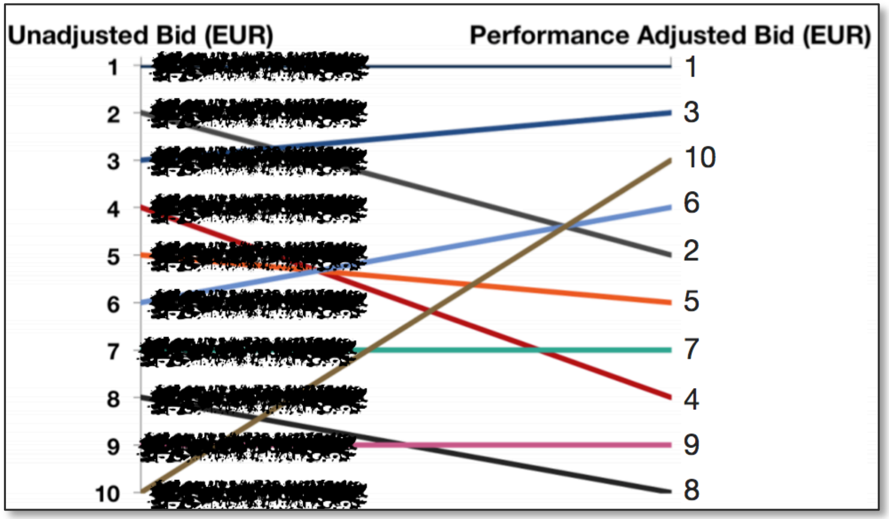
CERN Procurements

Procurement rules apply

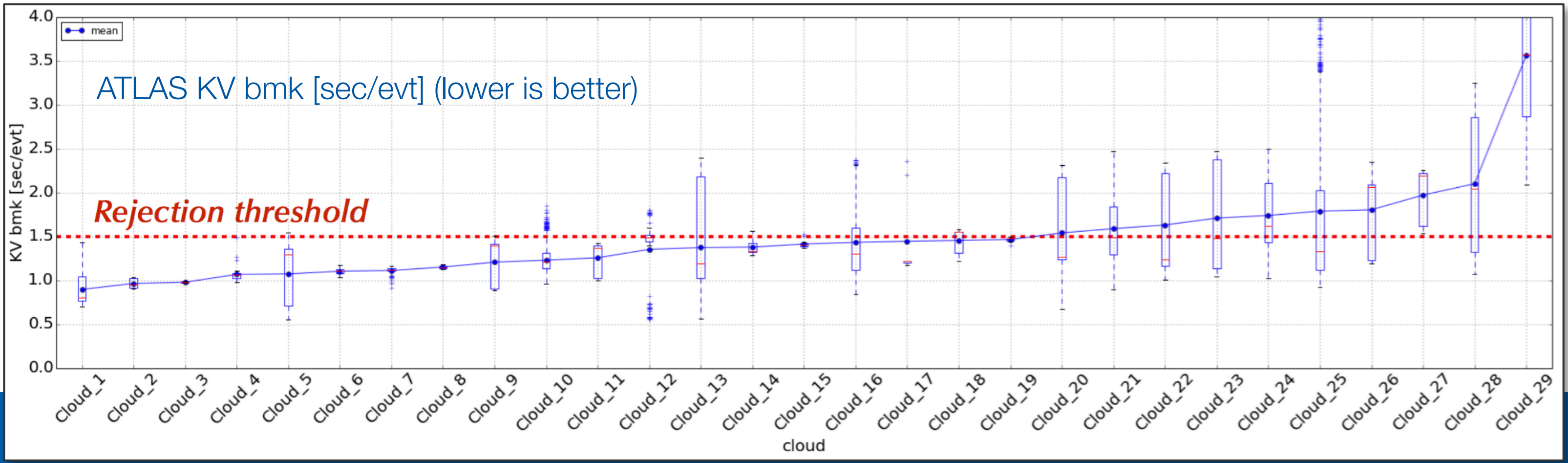
- No credit card to buy cloud services
- Request for Tender with upfront detailed Technical Specifications
- Award to the lowest compliant bid

Compare quality & cost

- Requiring firms to execute benchmarks during the tender procedure
- Adopt CPU benchmarks representative of the experiments' workloads *[see CHEP p-28]*



Ranking changes significantly when price is adjusted for expected performance (1 is cheapest)



ATLAS KV bmk [sec/evt] (lower is better)

Rejection threshold

Cost Evaluation

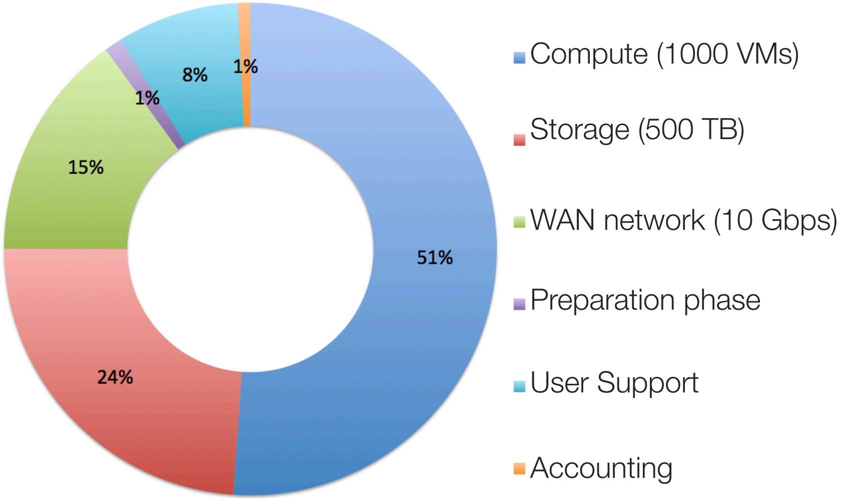
Main focus on the procurement process and features of cloud deployments: functionality, stability, maintainability, …

- Prefer duration (several weeks) to high peak capacity

Side effect: economy of scale not reached

- Shown by the large cost spread per CSP and per service (compute, storage, network, etc)

Cost breakdown of the median Bids for 90 days



Median Price for compute

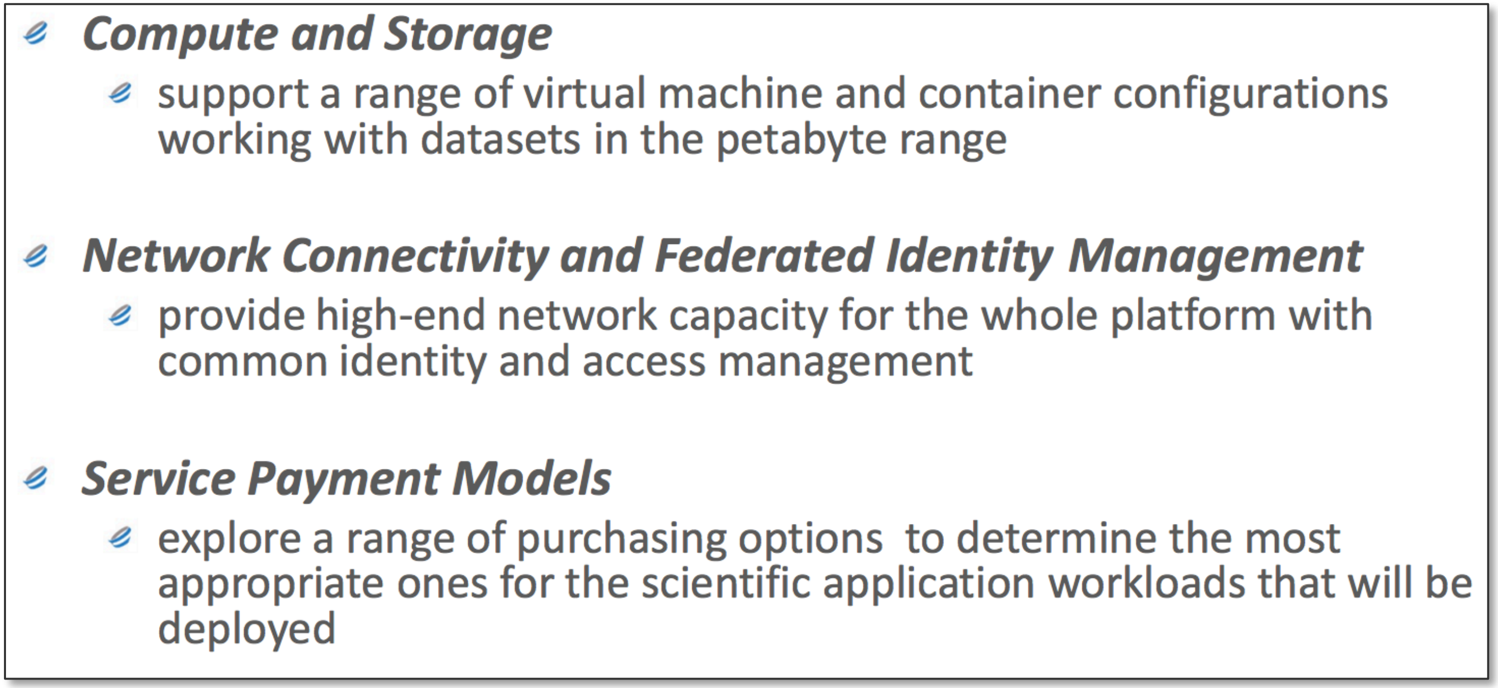
- 0.02 CHF/core/hour
- Including RAM (2 GB/core) and Disk (25 GB/core)

Storage (500 TB) represents 24% of the cost

- If not needed can invest more in network

HNSciCloud Pre-Commercial Procurement

- 5.3 MEur procurement of R&D services *[see CHEP o-397,o-399, p-401]*
- Build a Hybrid Cloud platform for the European research community
  - Combining services at IaaS to be integrated with in-house resources
- HNSciCloud challenges, triggering some of the next questions:



- ***Compute and Storage***
  - support a range of virtual machine and container configurations working with datasets in the petabyte range
- ***Network Connectivity and Federated Identity Management***
  - provide high-end network capacity for the whole platform with common identity and access management
- ***Service Payment Models***
  - explore a range of purchasing options to determine the most appropriate ones for the scientific application workloads that will be deployed

www.cern.ch

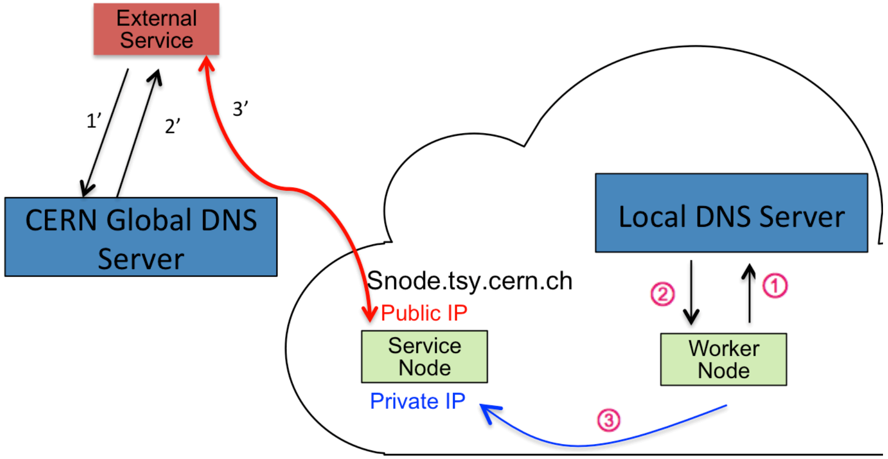
DNS setup

VMs are generated with private IP addresses

- Public Elastic IP bound to the VM via 1:1 NAT
- VMs assigned to CERN subdomain tsy.cern.ch

NAT

- Different behavior for internal/external clients
- Requires cloud-local DNS



DNS reverse lookups

- Grid clients need this for both public and private IPs
- T-Systems, as authoritative entity for reverse DNS, has implemented the Global DNS reverse function for the CERN-OTC service nodes