Cloud Computing for on-Demand Resource Provisioning

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Objectives

- Show the benefits of the **separation of resource provisioning from job execution management** for HPC, cluster and grid computing
- Introduce **OpenNEbula** as the Engine for on-demand resource provisioning
- Present **Cloud Computing** as a paradigm for the on-demand provision of virtualized resources as a service
- Describe **Grid as the interoperability technology** for the federation of clouds
- Introduce the **RESERVOIR project** as the infrastructure technology to support the setup and deployment of services and resources on-demand across administrative domains
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   1.1. The Engine for the Virtual Infrastructure
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   2.1. Access to Cloud Systems
   2.2. Federation of Cloud Systems
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3. Conclusions
1. Local on-Demand Resource Provisioning

1.1. The Engine for the Virtual Infrastructure

The OpenNEbula Virtual Infrastructure Engine

- OpenNEbula creates a *distributed virtualization layer*
  - Extend the benefits of VM Monitors from one to multiple resources
  - Decouple the VM (service) from the physical location
  - Transform a distributed physical infrastructure into a **flexible and elastic virtual infrastructure**, which adapts to the changing demands of the VM (service) workloads

Any service, not only cluster working nodes
1. Local on-Demand Resource Provisioning

1.2. Virtualization of Cluster and HPC Systems

Separation of Resource Provisioning from Job Management

- New virtualization layer **between the service and the infrastructure layers**
- **Seamless integration** with the existing middleware stacks.
- **Completely transparent** to the computing service and so end users

![Diagram of SGE Frontend, Virtualized SGE nodes, and OpenNebula with VMMs]
1. Local on-Demand Resource Provisioning

1.3. Benefits

- SGE Frontend
- Dedicated SGE nodes
- Virtualized SGE nodes
- OpenNebula
- User Requests
  - SGE interface
  - Virtualization overhead
- Cluster Nodes
1. Local on-Demand Resource Provisioning

1.3. Benefits

Cluster Consolidation

- Heuristics for dynamic capacity provision leveraging VMM functionality (e.g. live migration)
- Reduce space, administration effort, power and cooling requirements or support the shutdown of systems without interfering workload
1. Local on-Demand Resource Provisioning

1.3. Benefits

Cluster Partitioning
- Dynamic partition of the infrastructure
- Isolate workloads (several computing clusters)
- Dedicated HA partitions

SGE Frontend

Virtualized SGE nodes

Dedicated SGE nodes

Cluster Nodes

OpenNebula

VMM

VMM

VMM
1. Local on-Demand Resource Provisioning

1.3. Benefits

Support of Heterogeneous Workloads

- Custom worker-node configurations (queues)
- Dynamic provision of cluster configurations
- Example: on-demand VO worker nodes in Grids

OpenNebula

Virtualized SGE nodes

Dedicated SGE nodes

Cluster Nodes
1. Local on-Demand Resource Provisioning

1.3. Benefits

On-demand resource provisioning

SGE Frontend

Dedicated SGE nodes

Virtualized SGE nodes

Cluster Nodes

OpenNebula

Virtualized Web server

VIRTUAL INFRASTRUCTURE
3. Conclusions

1.3. Benefits

Benefits for Existing Grid Infrastructures (EGEE, TeraGrid…)

- The **virtualization of the local infrastructure** supports a virtualized alternative to contribute resources to a Grid infrastructure
  - Simpler deployment and operation of new middleware distributions
  - Lower operational costs
  - Easy provision of resources to more than one infrastructure or VO
  - Easy support for VO-specific worker nodes
  - Performance partitioning between local and grid clusters

=> Solve many obstacles for Grid adoption
1. Local on-Demand Resource Provisioning

1.4. Related Work

Integration of Job Execution Managers with Virtualization

- VMs to Provide pre-Created Software Environments for Jobs
  - Extensions of job execution managers to create per-job basis VMs so as to provide a pre-defined environment for job execution
  - Those approaches still manage jobs
  - The VMs are bounded to a given PM and only exist during job execution
  - Condor, SGE, MOAB, Globus GridWay…

- Job Execution Managers for the Management of VMs
  - Job execution managers enhanced to allow submission of VMs
  - Those approaches manage VMs as jobs
  - Condor, “pilot” backend in Globus VWS…
1. Local on-Demand Resource Provisioning

1.4. Related Work

Differences between Job and VM Management

• Differences between VMs and Jobs as basic Management Entities
  • **VM structure**: Images with fixed and variable parts for migration…
  • **VM life-cycle**: Fixed and transient states for contextualization, live migration…
  • **VM duration**: Long time periods (“forever”)
  • **VM groups (services)**: Deploy ordering, affinity, rollback management…
  • **VM elasticity**: Changing of capacity requirements and number of VMs

• Different Metrics in the Allocation of Physical Resources
  • **Capacity provisioning**: Probability of SLA violation for a given cost of provisioning including support for server consolidation, partitioning…
  • **HPC scheduling**: Turnaround time, wait time, throughput…
Other Tools for VM Management

• VMware DRS, Platform Orchestrator, IBM Director, Novell ZENworks, Enomalism, Xenoserver…

• Advantages:
  • Open-source (Apache license v2.0)
  • Open and flexible architecture to integrate new virtualization technologies
  • Support for the definition of any scheduling policy (consolidation, workload balance, affinity, SLA…)
  • LRM-like CLI and API for the integration of third-party tools
2. Remote on-Demand Resource Provisioning

2.1. Access to Cloud Systems

What is Cloud Computing?

- Provision of virtualized resources as a service

**VM Management Interfaces**
- Submission
- Control
- Monitoring

Infrastructure Cloud Computing Solutions

- **Commercial Cloud**: Amazon EC2
- **Scientific Cloud**: Nimbus (University of Chicago)
- **Open-source Technologies**
  - Globus VWS (Globus interfaces)
  - Eucalyptus (Interfaces compatible with Amazon EC2)
  - OpenNEbula (Engine for the Virtual Infrastructure)
2. Remote on-Demand Resource Provisioning

2.1. Access to Cloud Systems

On-demand Access to Cloud Resources

- Supplement local resources with cloud resources to **satisfy peak or fluctuating demands**

![Diagram of on-demand resource provisioning]

- Dedicated SGE nodes
- Virtualized SGE nodes
- Cluster Nodes
- OpenNebula
- VMMs
Grid and Cloud are Complementary

- Grid interfaces and protocols enable the interoperability between the clouds or infrastructure providers.
- Grid as technology for federation of administrative domains *(not as infrastructure for job computing)*.
- Grid infrastructures for computing are one of the service use cases that could run on top of the cloud.
2. Remote on-Demand Resource Provisioning

2.3. RESERVOIR Project

Who?

• IBM (coordinator), Sun, SAP, ED, TID, UCM, UNIME, UMEA, UCL, USI, CETIC, Thales and OGF-Europe

• 17-million and 3-year project partially funded by the European Commission (NESSI Strategic Project)

What?

• The Next Generation Infrastructure for Service Delivery, where resources and services can be transparently and dynamically managed, provisioned and relocated like utilities – virtually “without borders”

How?

• Integration of virtualization technologies with grid computing driven by new techniques for business service management
2. Remote on-Demand Resource Provisioning

2.3. RESERVOIR Project

A Project Driven by Business Use Cases

- **Scenario 1: SAP business application (SAP)**
  - Business application oriented use cases and the opportunities to execute them on a flexible infrastructure.

- **Scenario 2: Telco application (TID)**
  - Hosting web sites that deals with massive access (e.g., the Olympics games)

- **Scenario 3: Utility computing (Sun)**
  - Deploy arbitrary operating system and application stacks on remote resources

- **Scenario 4: eGov application (Thales)**
  - Automatic adjustment of resources and domains cooperation
2. Remote on-Demand Resource Provisioning

2.3. RESERVOIR Project

The Architecture, main Components and Interfaces

- **Monitor service and enforce SLA compliance by managing number and capacity of service components (VEEs)**
- **Organize the placement of VEEs to meet optimization policies and constraints**
- **Support advanced new functionality for performance and relocation optimization**

![Diagram](image)

**Service Provider**

**Service Manager System (SMS)**

**VEE Management System (VEEMS)**

**Reservoir Infrastructure Provider (RIP)**

**VEE Host (VEEH) (e.g., Hypervisor, VJSC Host)**

**SLA**

**SDD**

**SMI**

**VMI**
2. Remote on-Demand Resource Provisioning

2.3. RESERVOIR Project

The VEE Manager (OpenNEbula based)

- **Generic and independent** of the underlying virtualization technology
- **Open source** and based on standards (Grid & Virtualization OGF WG)
- **Automatic provision** of VEEs to meet pre-defined infrastructure site policies for SLA commitment
- **VEE groups** (forming a single service) with affinity rules, deployment ordering rules, rollback policies, elasticity management…
- Access to remote grid sites, supporting **on-demand access and federation of data-centers** (GT4 Interfaces are being evaluated)
3. Conclusions

- Show the benefits of the separation of resource provisioning from job execution management for HPC, cluster and grid computing.
- Introduce OpenNEbula as the Engine for the local Virtual Infrastructure.
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THANK YOU FOR YOUR ATTENTION!!!
More info, downloads, mailing lists at www.OpenNEbula.org

OpenNEbula is partially funded by the “RESERVOIR– Resources and Services Virtualization without Barriers” project
EU grant agreement 215605

www.reservoir-fp7.eu/

Acknowledgements

• Javier Fontan  • Tino Vazquez
• Luis Gonzalez  • Rafael Moreno
• Rubén S. Montero