Clouds, Grids & Virtual Machines

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Objectives

- Brief Overview of Clouds
- The IaaS approach for Infrastructure Provisioning
- Management of Virtual Infrastructures
- IaaS for the dynamic provisioning of virtual clusters in Grids
- Grids & Clouds: Trends and Opportunities
- OpenNebula Tutorial
### Cloud Computing in a Nutshell

<table>
<thead>
<tr>
<th>What</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-demand access to any application</td>
<td>End-user (does not care about hw or sw)</td>
</tr>
<tr>
<td>Platform for building and delivering web applications</td>
<td>Developer (no managing of the underlying hw &amp; sw layers)</td>
</tr>
<tr>
<td>Delivery of a raw computer infrastructure</td>
<td>System Administrator (complete management of the computer infrastructure)</td>
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**Software as a Service**
- Skype
- Gmail
- Facebook

**Platform as a Service**
- Windows Azure
- Force.com

**Infrastructure as a Service**
- GoGrid
- Flexiscale
- Amazon Web Services
The IaaS Clouds: A Four-Point Checklist

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

NOTE: This applies to any IaaS Cloud (private, public...
Service Deployment using IaaS

Total control of service layout
- Software Stack
- Type & Number of components
- Service Elasticity
- Placement Constraints

Service End-Users

Web Server (Load Balancer)  
App Server  
App Server  
App Server

Network

DBs (storage)
The Anatomy of an IaaS Cloud

Cloud API (web) -> VMs (Virtual Infrastructure Manager) -> Service (Network) -> Image Repositories (Storage) -> Physical Infrastructure (web)
Virtual Infrastructure Manager

- VMs are great!!...but something more is needed
  - 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**)
- Provides a *uniform view* of the resource pool
- **Life-cycle management** and monitoring of VM
- The VIM **integrates** Image, Network and Virtualization
Virtual Infrastructure Manager: Image Management

- VM Images Sources:
  - Master images in local repositories
  - Appliance supplier
  - Creation on the fly
- Clones have to be contextualized (Context VBD)
Virtual Infrastructure Manager: Networking

- VMs interconnected through **one or more** networks
  - Isolated, layer 2 LANs
  - Virtual networks are dynamically created
  - Medium size networks (x.x.x.x/20) with limited public IPs
- **TCP/IP services** are not responsibility of the VM Manager
### Virtual Infrastructure Manager: Life-cycle

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resource Selection:</strong></td>
<td>Where do I place the VM?</td>
</tr>
<tr>
<td></td>
<td>- Capacity planning (consolidation)</td>
</tr>
<tr>
<td></td>
<td>- Placement requirements (e.g. affinity)</td>
</tr>
<tr>
<td></td>
<td>- Placement Heuristics (e.g. Green IT, AR...)</td>
</tr>
<tr>
<td><strong>Resource Preparation:</strong></td>
<td>What do I need for the VM?</td>
</tr>
<tr>
<td></td>
<td>- Network preparation</td>
</tr>
<tr>
<td></td>
<td>- Image cloning &amp; contextualization</td>
</tr>
<tr>
<td><strong>VM Creation:</strong></td>
<td>How do I start a VM?</td>
</tr>
<tr>
<td></td>
<td>- Interface with different hypervisors</td>
</tr>
<tr>
<td><strong>VM Monitoring:</strong></td>
<td>How is the VM doing?</td>
</tr>
<tr>
<td><strong>VM Migration:</strong></td>
<td>Is there a better resource for the VM?</td>
</tr>
<tr>
<td></td>
<td>- Adjust placement to better fit to the infrastructure target</td>
</tr>
<tr>
<td><strong>VM Termination:</strong></td>
<td>Do I need to save any VM image?</td>
</tr>
</tbody>
</table>
Virtual Infrastructure Manager: OpenNebula

www.OpenNebula.org

- Flexible & Open Design
  - Third-party components
  - Easily adapted & extended
- Management of Virtual Services
  - Image, Network & Context
- Integrated with cloud providers
- Open Source – Apache2
- Included in Ubuntu 9.04 (server)
Some Limitations of Current Grids

- 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 & Virtual Machines

Cluster users

Service Layer

Virtual Network

Virtual Workernodes (WN)

Virtual Infrastructure Manager

Physical Infrastructure
Grids & Virtual Machines

Cluster users

Virtual Network

Cluster Front-end

Virtual WNs

User Requests
- “used-to” LRMS interface
- Virtualization overhead

OpenNebula (VIM)

Physical Infrastructure
Cluster Consolidation
- Multiple clusters in a single cluster
- Dynamic provision rules
- Leverage VMM functionality
Clusters & Virtual Machines

Cluster users

Service Layer

OpenNebula (VIM)

Infrastructure Layer

Cluster Partitioning
- Performance partitioning
- Isolate cluster workload
- Dedicated HA partitions

Physical Infr.  Dedicated WN
Grids & Virtual Machines

Cluster users

Service Layer

Virtual WNs

Heterogenous Workloads
- Dynamic provision of cluster configurations
- Simultaneous support of different services
- E.g. on-demand VO workernodes in Grids

Infrastructure Layer

Physical Infrastructure

Web Server

HTTP clients

Cluster Front-end

OpenNebula (VIM)
A Complete Grid Middleware Stack

- **Applications**
  - Unmodified Applications (Grid or local)
  - Interfaces preserved (qsub, DRMAA..)

- **Grid Middleware Layer**
  - Meta-schedulers (GridWay, Condor/G...)
  - gLite, UNICORE, Globus...
  - Cluster Frontend (SGE...)

- **Computing Service Layer**
  - WNs register to different queues
  - Multiple VO-specific clusters

- **Infrastructure Layer**
  - OpenNebula (VIM)
  - Infrastructure consolidation
  - Infrastructure partitioning
  - Infrastructure adaptation
A Complete Grid Middleware Stack

Meta-schedulers (GridWay, Condor/G…)

- Unmodified Applications (Grid or local)
- Interfaces preserved (qsub, DRMAA..)

Applications

- Virtual resources are exposed by GM
- Dynamic scheduling
- Fault detection & recovery

Grid Middleware Layer

- WNs register to different queues
- Multiple VO-specific clusters

Computing Service Layer

- Infrastructure consolidation
- Infrastructure partitioning
- Infrastructure adaptation

Infrastructure Layer

Grid/Cluster as a Service!!!
Grids, Clouds and Virtual Machines

OpenNebula (Virtual Infrastructure Manager)

Cluster users

Virtual Workernodes

Virtual Network

Service Layer

Cluster Front-end

Local Physical Infrastructure

Infrastructure Layer

Cloud Provider
Tutorial: Hybrid Deployment of a Virtual Cluster

Amazon EC2

Worker Node

Worker Node

OpenVPN Tunnels

Internet Connection

OpenVPN Server

SGE Front-End

Physical Host

Local private network

Bridge

Worker Node

Worker Node

Bridge

Worker Node

Worker Node

Bridge

Worker Node

Worker Node

Physical Host

Physical Host

Physical Host
Grids & Clouds: Trends

How are the resources provisioned?

Where are the resources provisioned from?

- Remote
- Local

- Physical
- Virtual

- GRID
- CLOUD
- YOUR SITE
- PRIVATE CLOUD
• Virtualization, cloud, and grid are complementary technologies and will coexist and cooperate at different levels of abstraction

• Virtualization can solve many obstacles for Grid adoption

• Virtualization and cloud do NOT require any modification within service layers (end-user perspective)

• Separation between service and infrastructure layers will allow the application of the utility model to scientific computing in any form (HPC MPI)

• Share Hardware not Services (LRMS)!!!
More info, downloads, mailing lists at www.OpenNebula.org

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www.reservoir-fp7.eu/

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THANK YOU FOR YOUR ATTENTION

QUESTIONS?