Karlsruhe Institute of Technology

Steinbuch Centre for Computing

GridKa School 2011
Cloud Computing Workshop

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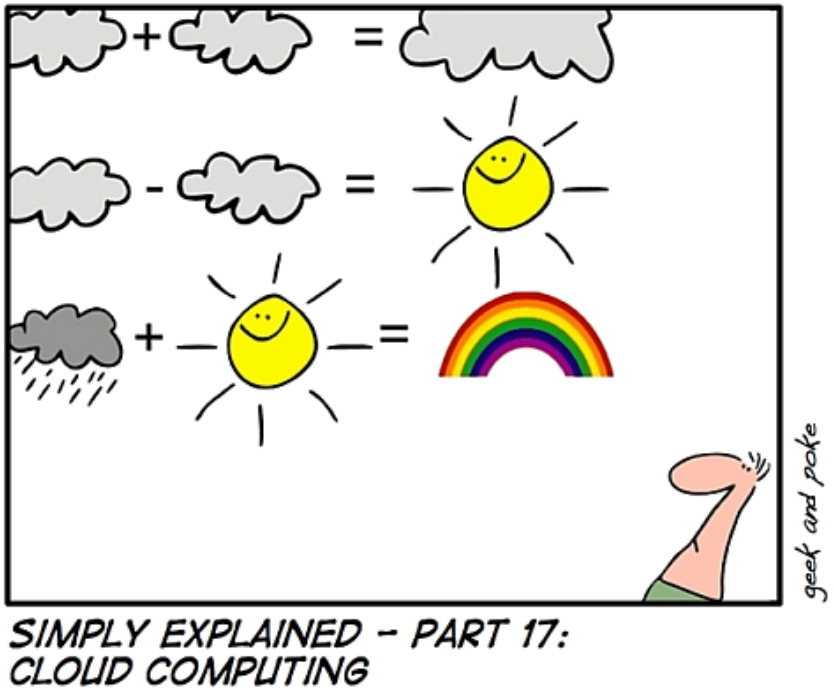
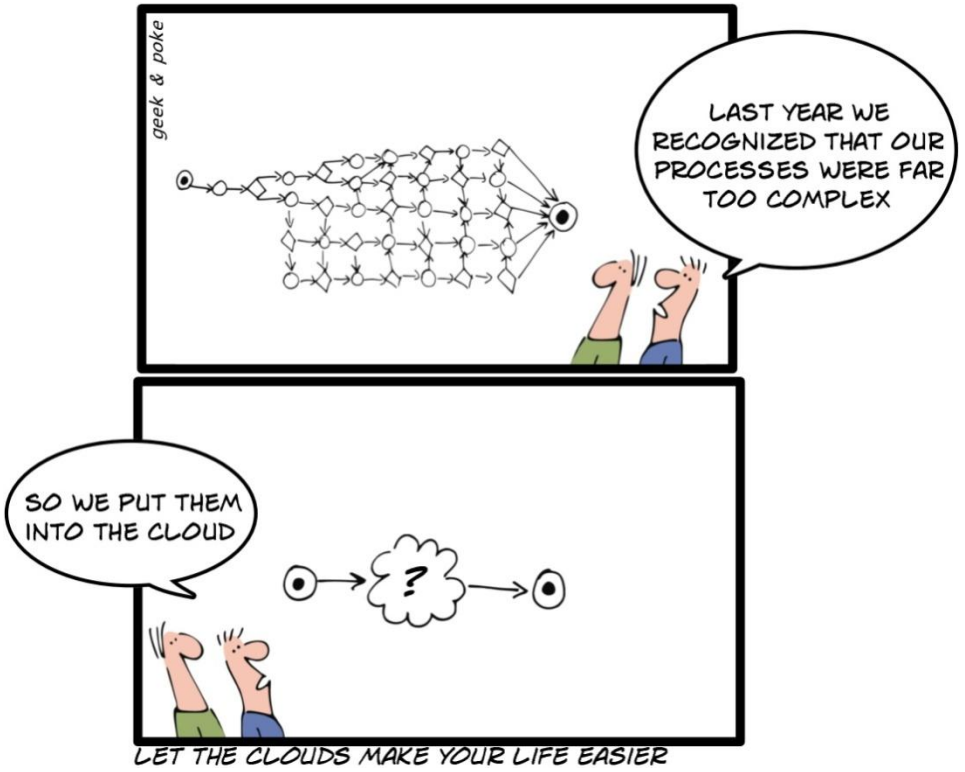
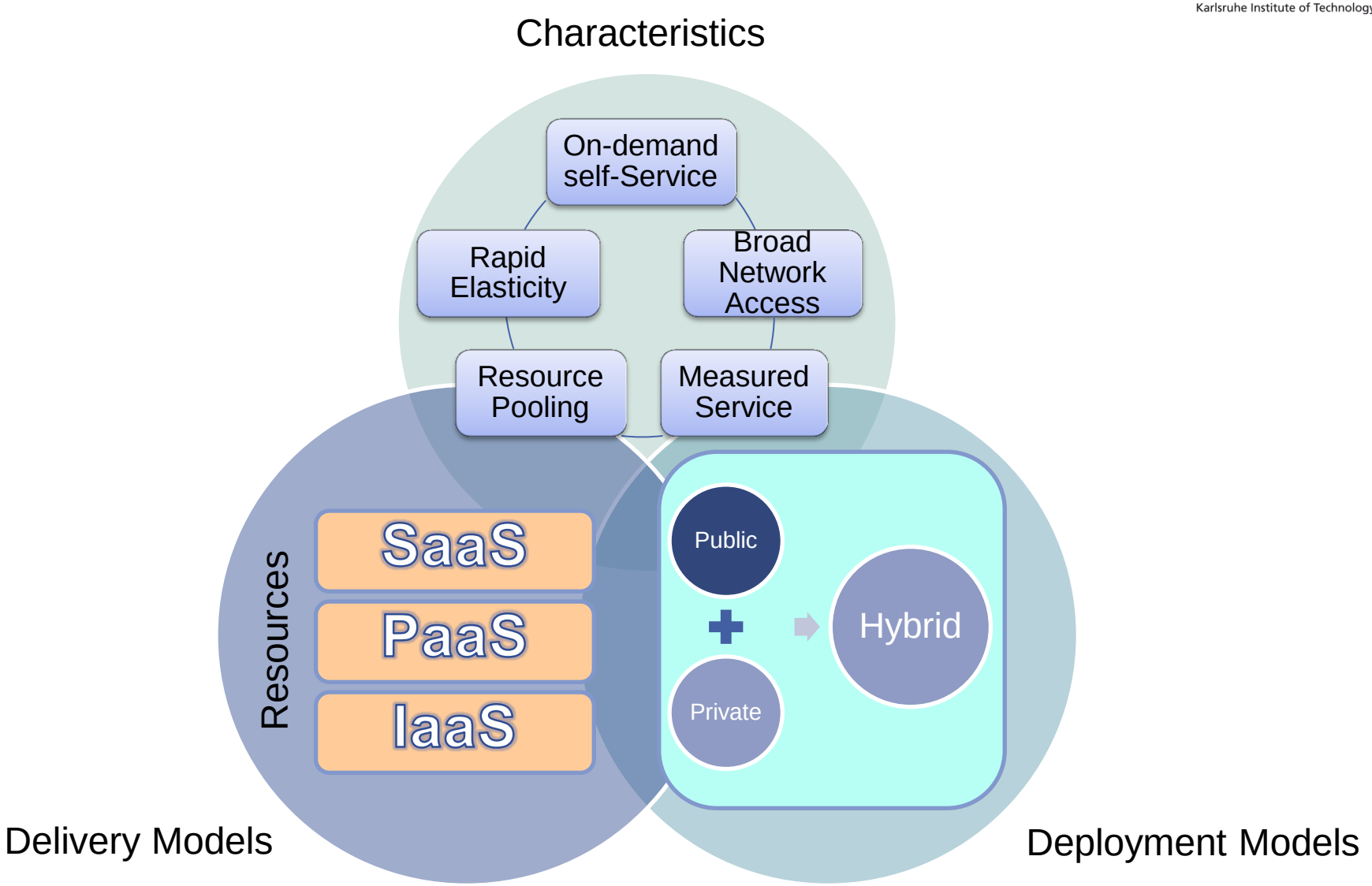




What's behind all this??

Cloud Computing



Toward an Architectural Style for Cloud Computing: Five essential characteristics

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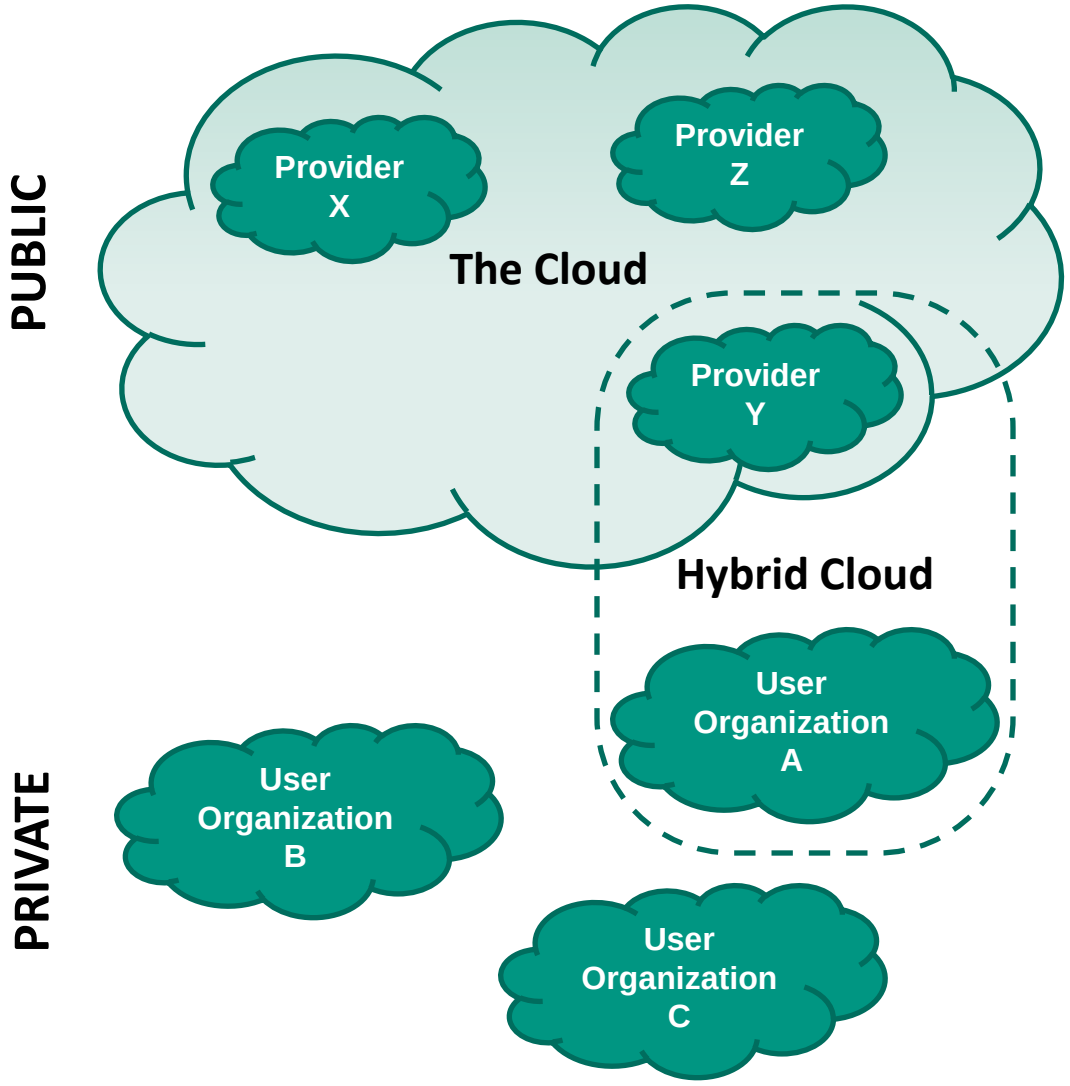
1. Rapid Elasticity: the ability to scale resources both up and down as needed. To the consumer, the cloud appears to be infinite.
2. Measured Service: In a measured service, aspects of the cloud service are controlled and monitored by the cloud provider. This is crucial for billing, access control, resource optimization, capacity planning and other tasks.
3. On-Demand Self-Service: The on-demand and self-service aspects of cloud computing mean that a consumer can use cloud services as needed without any human interaction with the cloud provider.
4. Broad Network Access: the cloud provider's capabilities are available over the network and can be accessed through standard mechanisms.
5. Resource Pooling: Resource pooling allows a cloud provider to serve its consumers via a multi-tenant model. Physical and virtual resources are assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided.

[NIST]

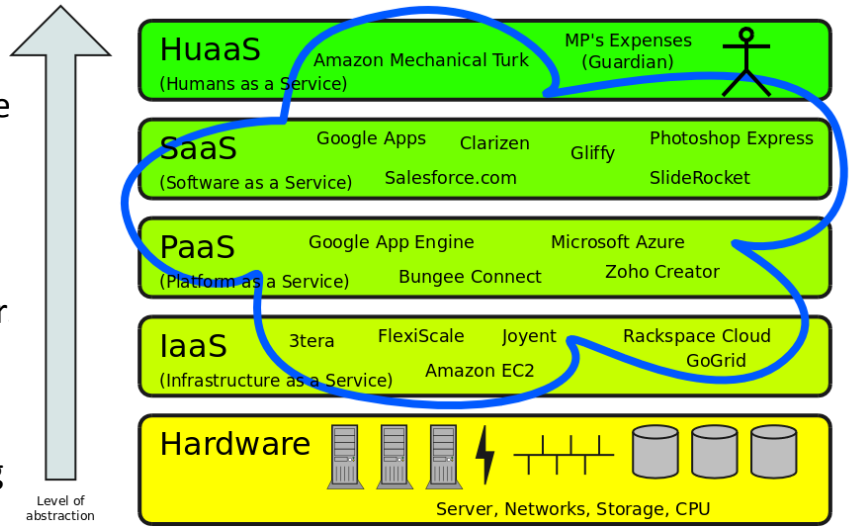
Concept of Cloud Computing – Organisatorical Types



- **Public Cloud**
  - Providers have commercial interests
  - Users have no costs concerning purchase, operation and maintenance of own hardware
  - Critical situation concerning data privacy and security of sensible information
  - Fear for a Lock-in situation!
- **Private Cloud**
  - Providers and users are from the same organization
  - No security or privacy issues
  - Similar operation costs like a non Cloud-based architecture
  - Lock-in situation cannot happen
  - Compatible with the popular public cloud services (in a perfect world!)
- **Hybrid Cloud**
  - Services of private and public clouds are combined to process load peaks or outsource data copies

Everything as a Service (XaaS)

- **1. Layer: Infrastructure as a Service (IaaS)**
  - Users run virtual server instances with optional operations system configurations (restricted by the providers)
  - Administrative user rights
  - Own firewall rules
  - No direct contact to physical hardware for the user
- **2. Layer: Platform as a Service (PaaS)**
  - Scalable running environment and (sometimes) development environment for 1 or 2 programming languages
  - No administrative effort concerning the operation environment
  - More restriction then in IaaS
- **3. Layer: Software as a Service (SaaS)**
  - Applications a run by a provider
  - No need for a local installation at the users site
  - Users do not need to take care about installation, security updates, …
  - Users need to trust the provider concerning the process of their data in the cloud (e.g. E-Mail accounts)



- **4. Layer: Human as a Service (HaaS)**
  - Principle of crowd sourcing
  - Human creativity becomes available as a resource in the cloud
  - Interesting for tasks which are difficult to automate by computers (e.g.: translation, image recognition)

Overview of some Private Cloud IaaS Frameworks

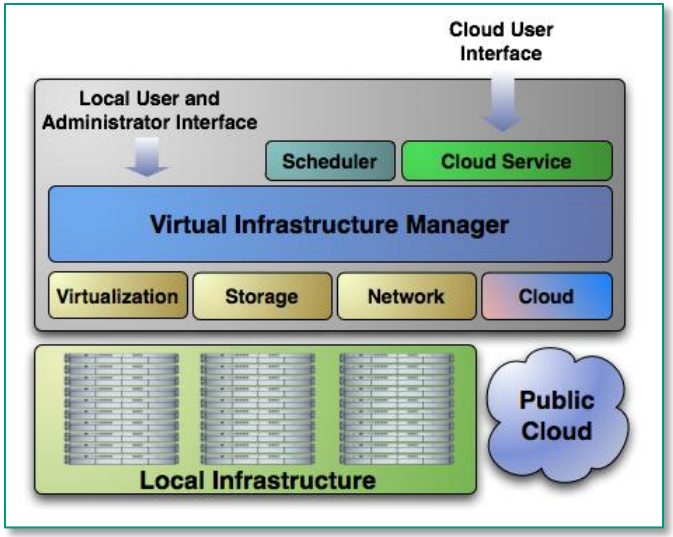
- Lots of Private Cloud IaaS solutions available at first sight
  - All of them are Open Source!
- Already used in science projects
  - CERN uses a Cloud Environment with OpenNebula with the goal to manage up to 45,000 Virtual Machine instances (Bittorrent for VM demployment)

Cloud.com CloudStack	http://cloud.com	*no storage*; XEN; KVM, Vmware; EC2 compatible
OpenStack	http://www.openstack.org/	Storage (Swift); XEN, KVM; EC2, S3 compatible
OpenNebula	http://www.opennebula.org	*no storage*; Xen, KVM, VMware; EC2 compatible
Nimbus	http://www.nimbusproject.org	Storage (Cumulus); XEN, KVM; EC2, S3 compatible
Eucalyptus	http://open.eucalyptus.com	Storage (Walrus); VMware, Xen, KVM; EC2, S3 compatible

OpenNebula – Introduction

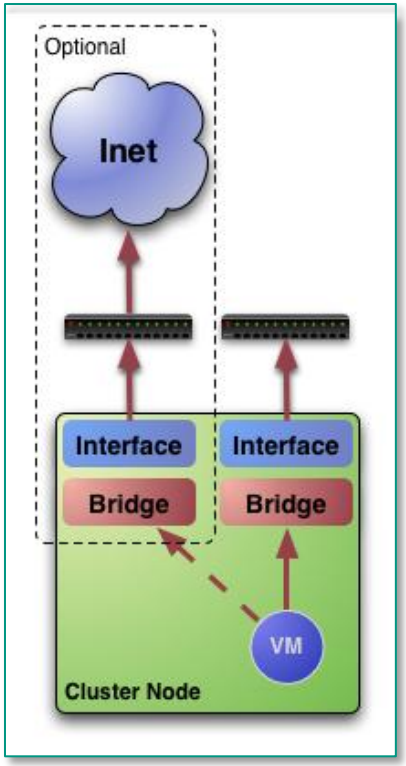
- OpenNebula is an open-source toolkit to easily build any type of cloud: **private**, **public** and **hybrid**.
- OpenNebula supports **KVM, Xen and VMware**
- OpenNebula has been designed to be integrated with any networking and storage solution and so to fit into any existing data center.

- Only a small part of the EC2 API implemented since OpenNebula 2.0
  - describe images
  - describe, run, reboot und terminate instances
- Trivial architecture
  - Easy to implement additional features
  - Easy to debug because of central log data
- Nodes can be grouped, Important for HPCaaS and network latency (e.g. MPI)
- No storage service included



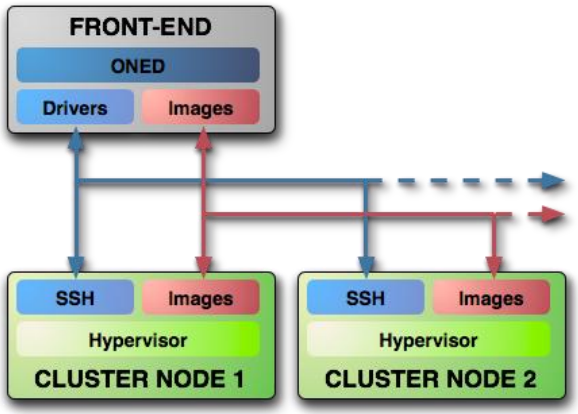
OpenNebula – Structure Notes

- Installation:
  - Documentation available for Ubuntu, CentOS, Debian, OpenSUSE, MacOS, …
    see: http://opennebula.org/documentation:documentation
- Structure:
  - Separation in Front-End and Cluster Nodes
  - Communication based on SSH (password-less login via SSH keys), XML-RPC protocol and Ruby scripts
  - Front-End uses the **libvirt library** to control the Hypervisor on the Cluster Nodes via SSH
  - To provide one or more physical networks for the VMs, the cluster nodes have to be set up with Ethernet Bridges
- Two operation methods for VM Deployment:
  - via SSH
    - Images are copied via SSH to the Cluster Node partitions
  - on a Shared File System
    - Live Migration is possible
    - FS should be performant enough to manage high I/O -> SAN mount

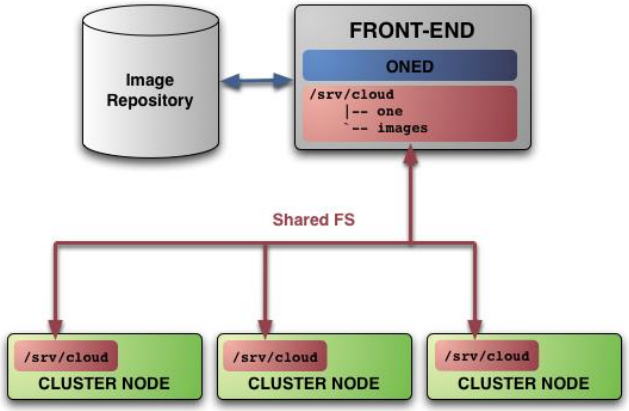


OpenNebula – Private Cloud Tutorial Instance

- 6x Dell Blades - Dual Intel Xeon Quad Core 2,66 GHz / 16 GB Ram:
  1 Front-End + 5 Cluster Nodes (40 Cores)
- Connection: 1 Gigabit Ethernet
- **Image Deployment via SSH**
- Based on Ubuntu 11.04/11.10 Server
- Virtualization Technology: **KVM** Hypervisor
- Version: **OpenNebula 3.0 Beta1**
- Installation can be found under `/srv/cloud/one` on the front-end



Deployment via SSH



Shared File System

1 Exploring the Private Cloud

- **Hands on…** explore the Cloud with some basic OpenNebula commands:

Node Management: **onehost <list top show create delete enable disable …>**
Check out how many cluster nodes are available with **onehost list**.
Explore the details of one cluster node with **onehost show *host_id***

Network Management: **onevnet <list show create delete …>**
Check out which virtual networks are available with **onevnet list**.
Explore the details of one virtual network with **onevnet show *vnet_id***

Machine Management: **onevm <create delete migrate supend resume …>**
Check out how many virtual machines are running with **onevm list** or **onevm top**.
Explore the details of one virtual machine with **onevm show *vm_id***

Management: **oneimage <list show ...>**
Check out how many images are available with **oneimage list**
Explore the details of one image with **oneimage show image_*id***

User Management: **oneuser <create delete list …>**
Only available for the cloud admin to create and delete cloud users.

Group Management: **onegroup <create delete list …>**
Only available for the cloud admin to create and delete cloud groups.

Template Management: **onetemplate <create delete list …>**
With this command you will define your VM templates for the next exercises.

2 Virtual Networks I

- A Virtual Network in OpenNebula
  - Defines a MAC/IP address space to be used by VMs
  - Each Virtual Network is associated with a physical network through a bridge
- Virtual Network definition
  - **Name** of the Network
  - **Type**
    - **Fixed**, a set of IP/MAC leases
    - **Ranged**, defines a network range
  - **Bridge**, name of the physical bridge in the physical host where the VM should connect its network interface

```
# Ranged VNET template file
NAME                = "Red LAN"
TYPE                = RANGED
BRIDGE              = eth0
NETWORK_SIZE        = C
NETWORK_ADDRESS     = 192.168.169.0
```

```
# Fixed VNET template file
NAME                = "Blue LAN"
TYPE                = FIXED
BRIDGE              = br0
LEASES              = [IP=192.168.170.11]
LEASES              = [IP=192.168.170.12]
LEASES              = [IP=192.168.170.13]
```

- **Hands on…** create your own fixed Virtual Network with two IPs.

Virtual Networks II

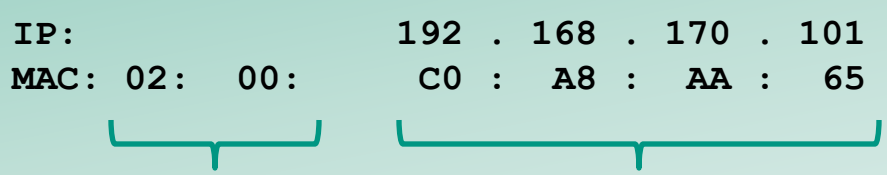
- How to use a Virtual Network with your VMs
  - Define NICs attached to a given virtual network. The VM will get a NIC with a free MAC address in the network and attached to the corresponding bridge

```
#A VM with two interfaces each one in a different vlan
NIC      = [NETWORK_ID = X]
NIC      = [NETWORK_ID = Y]

#Ask for a specific IP/MAC
NIC      = [NETWORK_ID = X, IP = 192.168.0.11]
```

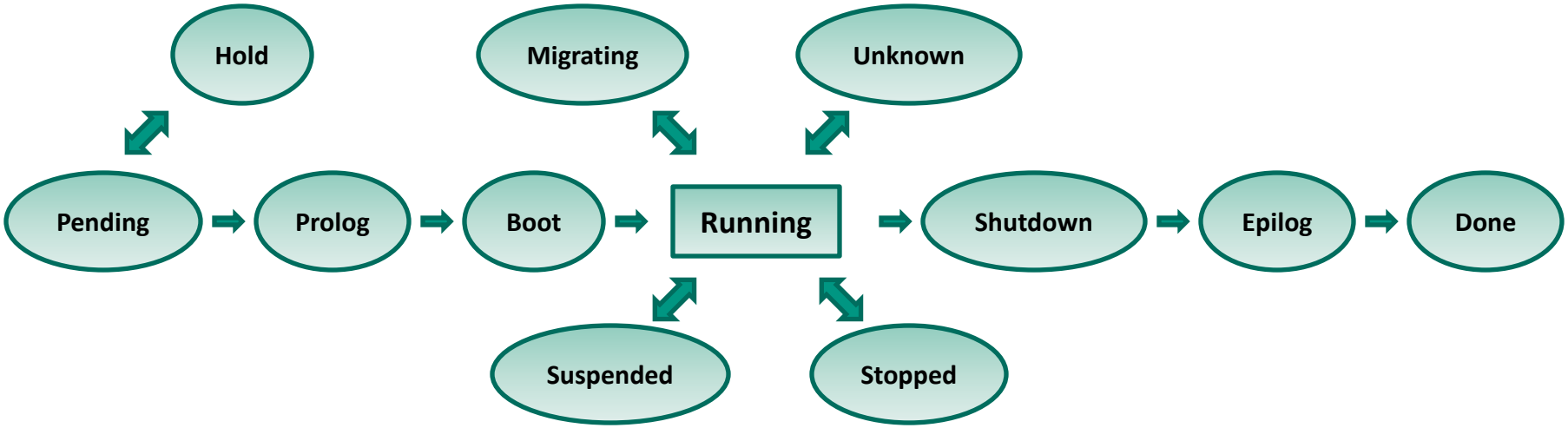
  - Prepare the VM to use the IP. Sample scripts to set the IP based on the MAC are provided for several Linux distributions.

IP-MAC address correspondence



Virtual Machines I

- Preparing a VM to be used with OpenNebula
  - You can use any VM prepared for the target hypervisor
  - Prepare master images: Install once and deploy many;
  - Do not put private information (e.g. ssh keys) in the master images, instead use **CONTEXT** (see later)
  - Pass arbitrary data to a master image using **CONTEXT**
- Virtual Machine Life-cycle:



Virtual Machines II

- Virtual Machines are defined in a VM template file
- Each VM has an unique ID in OpenNebula, the **VM_ID**
- All log files are stored in `/srv/cloud/one/var/<VM_ID>` on the head node (after life)
- The images will be copied via a SSH connect to the cluster nodes

- A Virtual Machine template in OpenNebula consists of
  - a **capacity** section in terms of name, 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
  - …

Virtual Machine Definition File 3.0 (VM template) I

```
#-------------------------------------------------------------
# Capacity Section
#-------------------------------------------------------------
NAME      = "name that the VM will get for description purposes"
CPU       = "percentage of CPU divided by 100 required for the Virtual Machine"
MEMORY    = "amount of requested MEM"
VCPU      = "number of virtual cpus"


#-------------------------------------------------------------
# OS and boot options
OS        = [
          arch                = "CPU architecture to virtualization"
          kernel              = "path to os kernel",
          initrd              = "path to initrd image",
          kernel_cmd          = "kernel command line",
          root                = "device to be mounted as root",
          bootloader          = "path to the boot loader exec",
          boot                = "device to boot from" ]


#-------------------------------------------------------------
# Features of the hypervisor
FEATURES  = [
          pae       = "yes|no",
          acpi      = "yes|no" ]
```

Virtual Machine Definition File 3.0 (VM template) II

```
#-------------------------------------------------------------
# VM Disks
DISK      = [
          image_id  = "id of the image managed by ONE"
          type      = "image|floppy|disk|cdrom|swap|fs|block",
          source    = "path to disk image file|physical dev",
          format    = "type for fs disks",
          size      = "size_in_GB",
          target    = "device to map disk",
          bus       = "ide|scsi|virtio|xen",
          readonly  = "yes|no",
          clone     = "yes|no",
          save      = "yes|no" ]


#-------------------------------------------------------------
# Network Interface
NIC       = [
          network_id          = "id of the virtual network managed by ONE",
          target              = "device name to map if",
          ip                  = "ip address",
          bridge              = "name of bridge to bind if",
          mac                 = "HW address",
          script              = "path to script to bring up if",
          model               = "NIC model" ]
```

Virtual Machine Definition File 3.0 (VM template) III

```
#-------------------------------------------------------
# I/O Interfaces
INPUT     = [
          type      = "mouse|tablet",
          bus       = "usb|ps2|xen" ]
GRAPHICS  = [
          type      = "vnc|sdl",
          listen    = "IP to listen on",
          port      = "port for VNC server",
          passwd    = "password for VNC server",
          keymap    = "keyboard configuraiton locale to use in the VNC display" ]
#-------------------------------------------------------
# RAW Hypervisor attributes
RAW       = [
          type      = "xen|kvm",
          data      = "raw domain configuration" ]
#-------------------------------------------------------
# CONTEXT Section used for Customization of VMs
CONTEXT   = [ ... ]           # see later
#-------------------------------------------------------
# Placement Section
REQUIREMENTS        = "Boolean expression that rules out provisioning hosts form list"
RANK                = "Attribute which will be used to sort the suitable hosts for VM"
```

Complete reference and examples for all sections:
http://www.opennebula.org/documentation:rel3.0:template

3 Submitting & Management of VMs

- **Hands on…** define a minimal VM template and create your first VM:

```
#-------------------------------------------------------------
# VM template for the ttylinux image
NAME      =         my_test_vm                    # define a name for your VM
MEMORY    =         128
DISK      = [       IMAGE_ID   =  X,
                    BUS        = ide    ]        # enter the image ID of ttylinux
NIC       = [       NETWORK_ID =  Y     ]        # enter the id of your created vnet
OS        = [       ARCH       = x86_64,
                    BOOT       = hd     ]
```

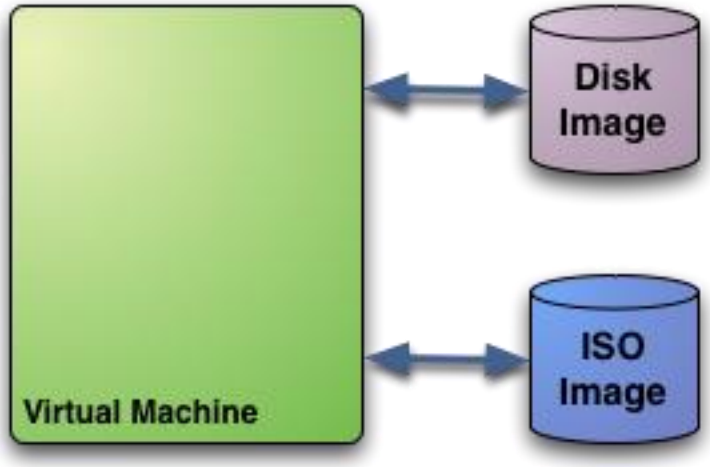
- Submit your VM template: **onetemplate create *vm_template_file***
- Instantiate one VM instance: **onetemplate instantiate *vm_template_id***
- Monitor the status for your VM: **onevm list**
- Get detailed information, (e.g. IP): **onevm show *VM_ID***
- Try to perform some VM operation: **onevm <migrate|suspend|resume|delete|…>**
- Try to login (User: “root", PW: “password"): **ssh root@*VM_IP***
- Take a look to the script file "**/etc/rc.d/init.d/vmcontexttty**" within the VM, which is part of the boot procedure and try to understand how the network will be configured
- Optional: Modify the template:
  create - on the fly – another empty **DISK**, e.g.: **`TYPE=fs, FORMAT=ext2, SIZE=100, TARGET=hdb`**
  and try to mount it within the VM

4 Customization of VMs

ONE provides a method to modify created VMs. The master image **ubuntu** is already preconfigured to support the CONTEXT Block:

- The ISO Image will be mounted under **/mnt/context**
- The **init.sh** script will be executed with root privileges
- Afterwards the ISO Image will be un-mounted

```
# VM template
...
CONTEXT = [
  FILES   = "/path/init.sh /path/id_rsa.pub",
  TARGET  = "hdc",
  HOST    = "myHostname",
  EDITOR  = „nano"
… ]
```



context.sh
id_rsa.pub
init.sh

```
#context.sh (created by ONE)
HOST       = "myHostname"
EDITOR     = „nano"
…
```

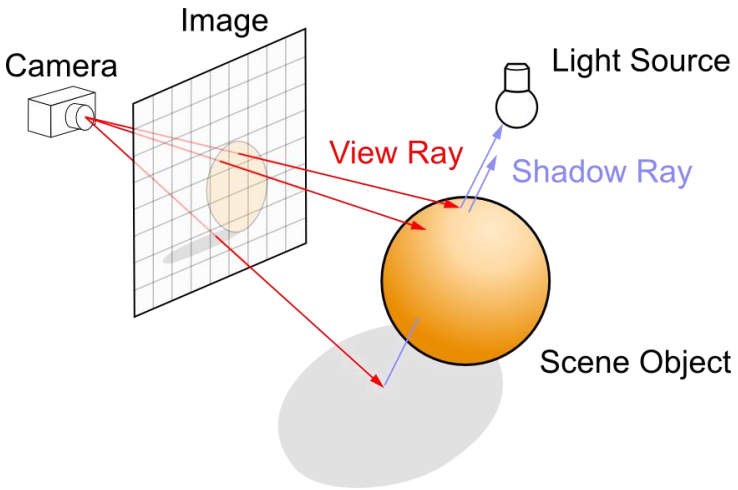
```
#init.sh
. /mnt/context/context.sh

hostname $HOST
apt-get install $EDITOR
cat /mnt/context/id_rsa.pub >> \
    /root/.ssh/authorized_keys
```

- **Hands on…** define a VM template for the **Ubuntu** Image and try to use the CONTEXT Block (see Handout).

5 Performing some Rendering Jobs

- high quality pictures can be rendered using ray tracing
- the rendering can be done in parallel
  - regions of a picture
  - singe frames of an animation
- POV-Ray is open source

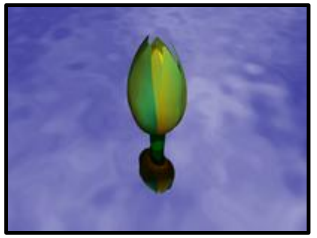


- **Hands on…** define a new CONTEXT section for the Ubuntu Image to perform a rendering job. Divide the complete rendering procedure of the pictures in 2 parts:
  - First VM: 0..49
  - Second VM: 50..99

  See handout!!

ray.pov

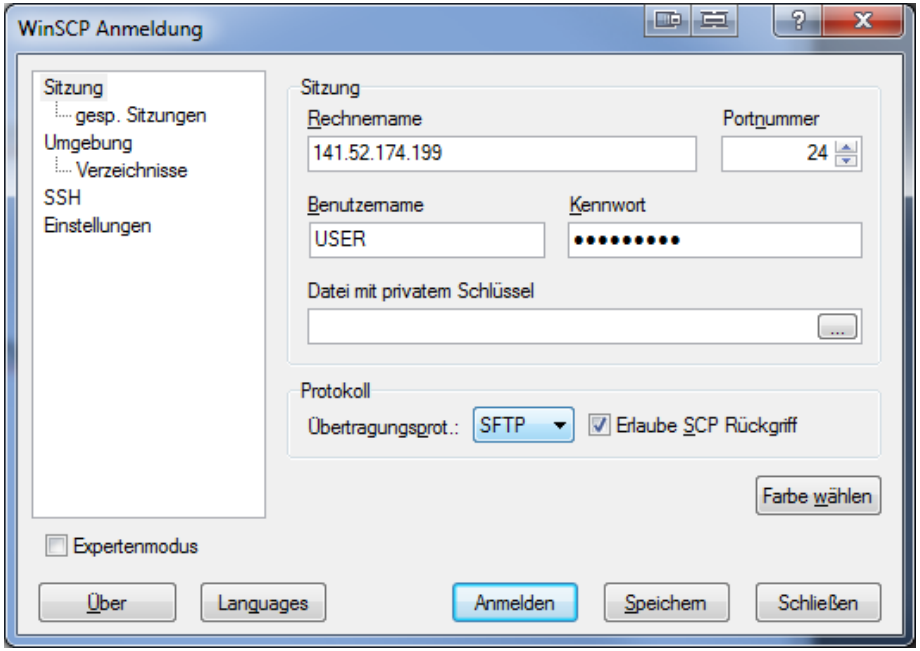
vortex.pov



flower.pov

How to copy the results from the headnode

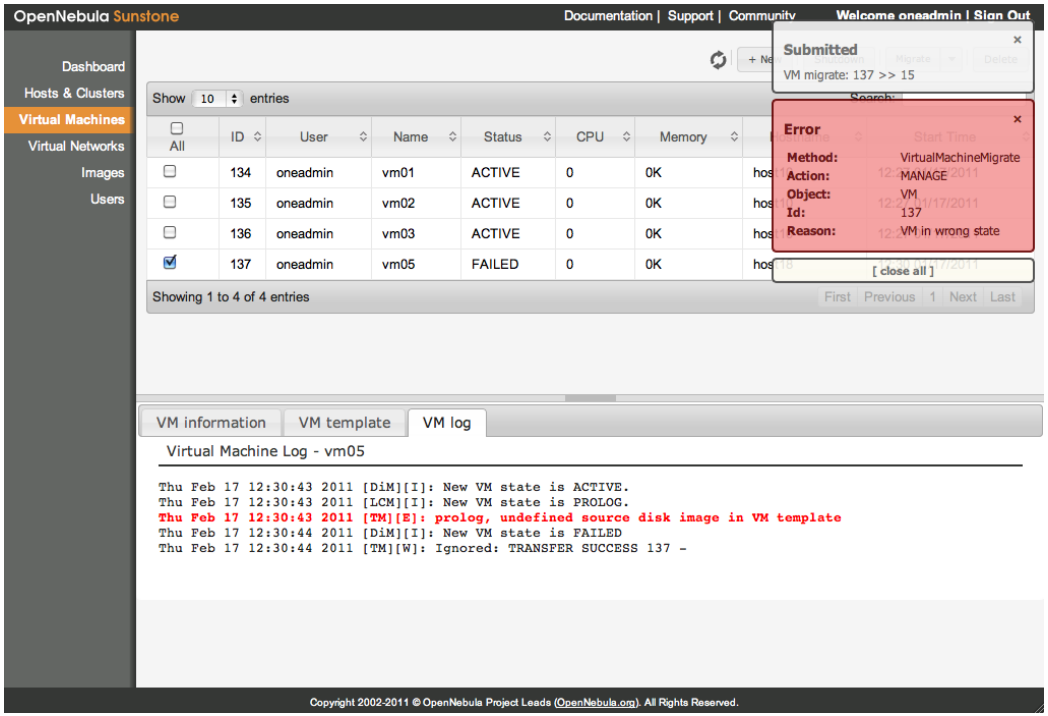
- Linux:
  - scp –P 24 USER@141.52.174.199:~/render/results/movie.avi .
- Windows:
  - Download WinSCP from http://winscp.net and install it
  - The Remote address is 141.52.174.199
  - Port number is 24
  - Protocol is SFTP with SCP fallback
    - or SCP directly
  - Navigate to ~/render/results
  - Copy the file movie.avi to your PC



OpenNebula Sunstone

- Browser GUI available
- Open your browser an go to:

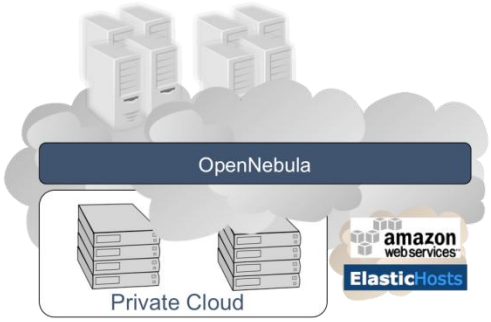
http://141.52.174.199:2222

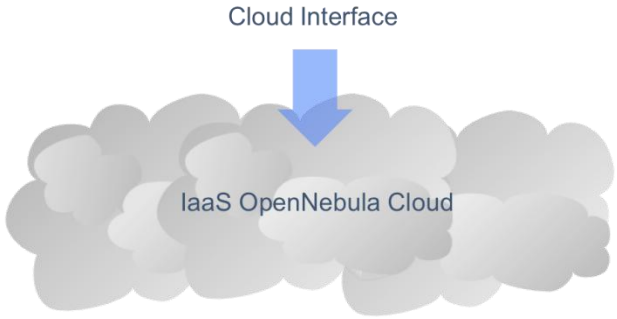


- Provides the full functionality of ONE
- Still some bugs concerning the consistency with the CLI commands
- Future releases will provide VNC connections to the VMs

Further Feature

- Hybrid Cloud:
  - Provides the possibility to control AWS / ElasticHosts resources with the same basic ONE commands
  - Creates a simple abstraction layer over the EC2-API-Tools
  - However there is no simple way to deploy own images to AWS / ElasticHosts





- Public Cloud:
  - Extension of a Private Cloud to expose RESTful Cloud interfaces
  - Can be added to you Private or Hybrid Cloud if you want to provide partners or external users with acces to your infrastructure

- EC2 Compatible Management:
  - Since ONE 2.0 there is the possibility to control ONE resources via EC2 compatible GUI tools, like
    - HybridFox / ElasticFox (Firefox Plug-Ins)
    - KOALA (PaaS Browser Service- http://koalacloud.appspot.com/)

Thank You!

- Links:
  - OpenNebula Website: http://opennebula.org/