Xen Virtualization and the Art of Virtual Clusters

SDSC

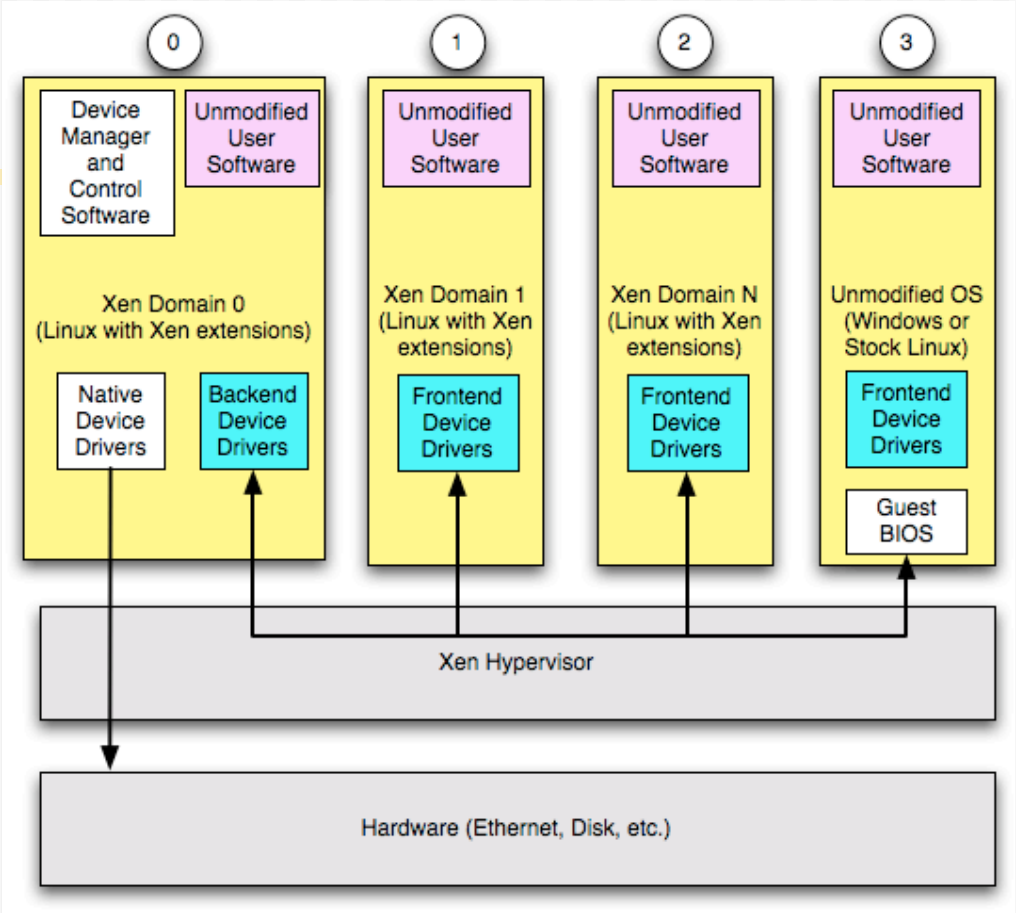
What We'll Cover

- Overview of Xen
- Installing a virtual cluster in Rocks
- Extra Xen roll commands
- "Lights Out" VM frontend install

What is Xen

- Xen is “virtual machine monitor” (VMM) used to control VMs
- Xen VMM is called the “hypervisor”
- Xen VMs are called “guests”

What is Xen



- Guests' traps and exceptions are passed to and handled by hypervisor

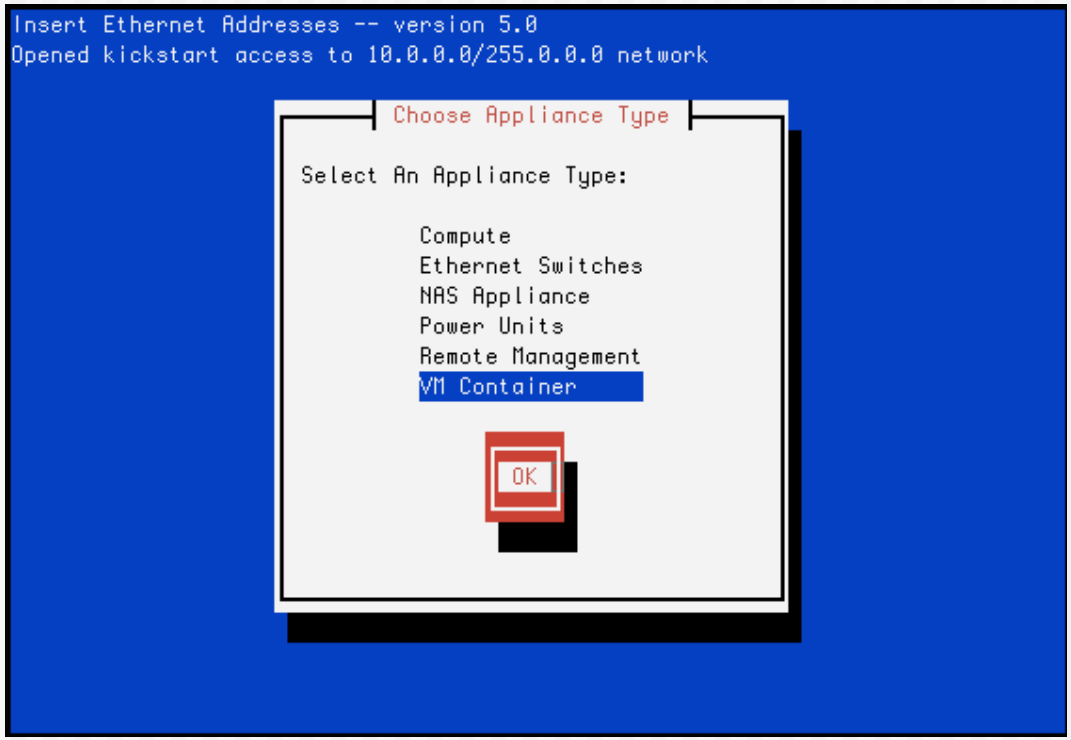
Xen in Rocks 5.2

Step 0

- You must install a Rocks 5.2 frontend with the Xen Roll

Step 0.5

- Optionally install at least one cluster node as a “VM Container”

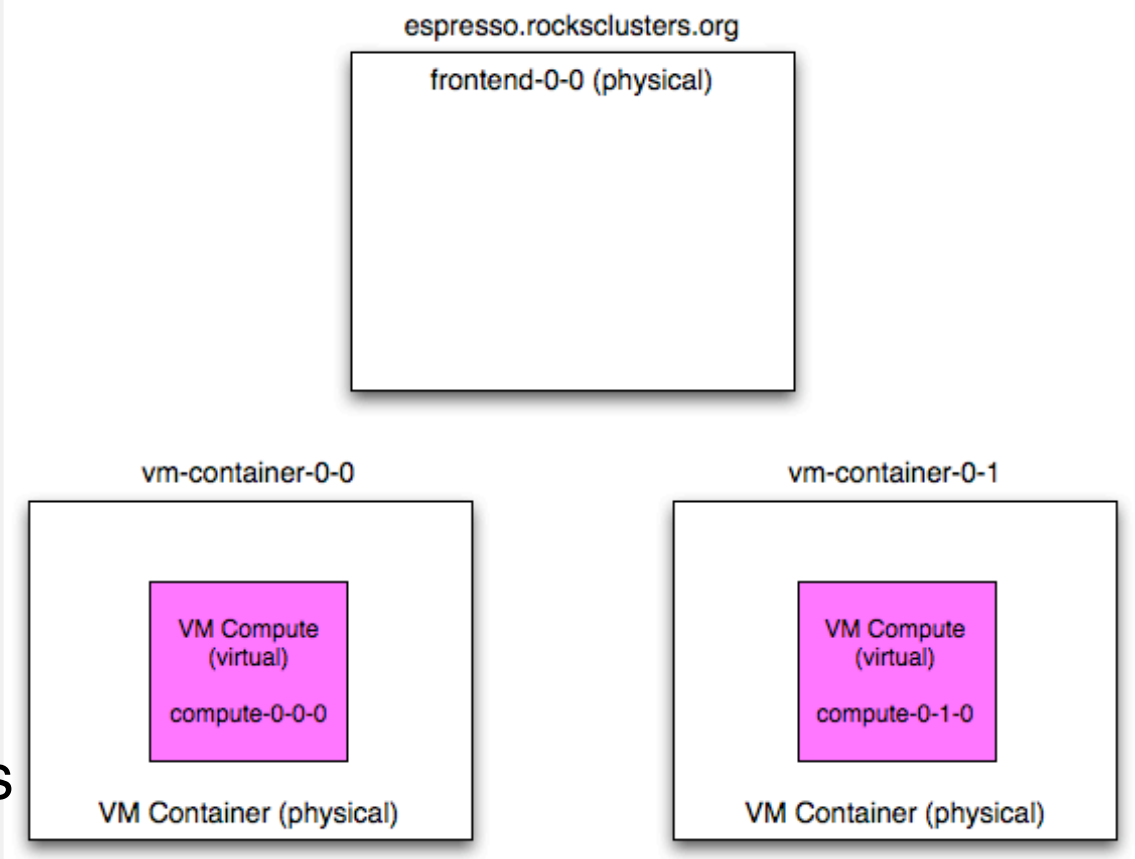


Supported Configurations

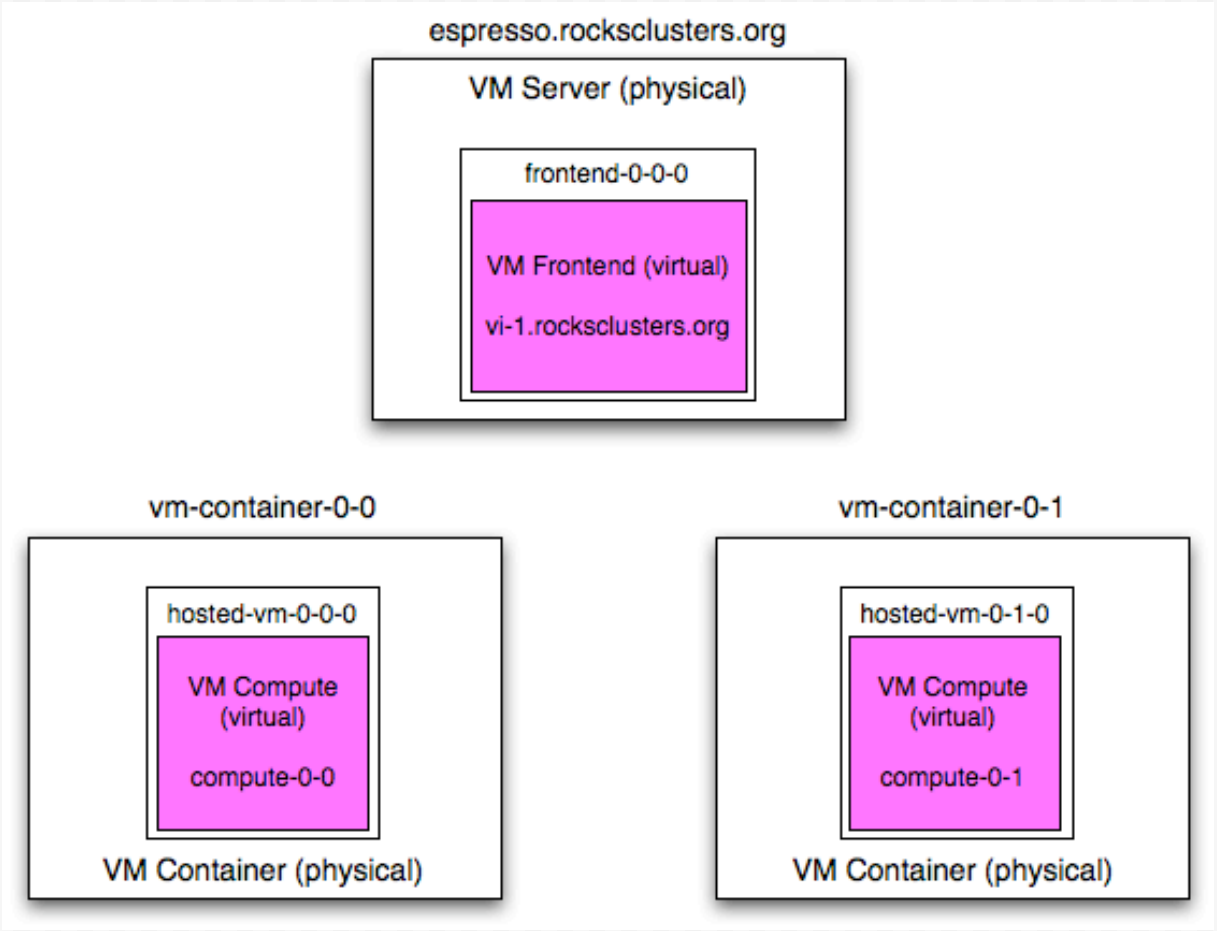
- Physical frontend with virtual compute nodes
- Virtual frontend with virtual compute nodes
  - Note: A virtual frontend with physical compute nodes is doable, but it requires an understanding of VLANs

Physical Frontend and Virtual Computes

- All node names with a white background are physical machines
- All node names with purple backgrounds are virtual
- This was the only configuration that Rocks v5.0 supported

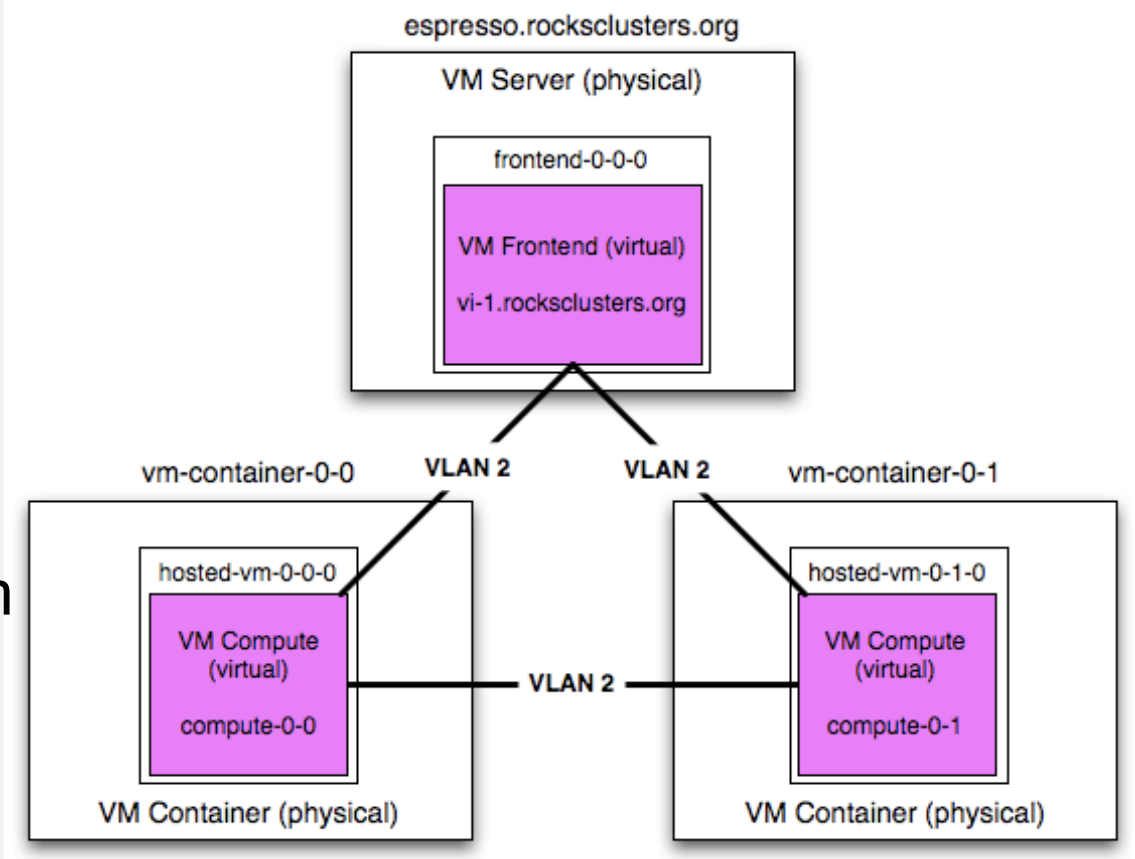


Virtual Frontend and Virtual Computes



Virtual Frontend and Virtual Computes

- Network traffic for VM frontend and VM computes are isolated with a VLAN
- Processes running on the physical machines don't see the traffic from the virtual cluster



Key VM Functions

- “add cluster”
  - Add a new VM cluster
- “start host vm”
  - Boot a VM
- “set host boot”
  - Set a VM to install or boot its OS

Adding a Cluster

- "rocks add cluster" command

```
# rocks add cluster {FQDN of frontend} \
  {IP of frontend} {number of computes}
```

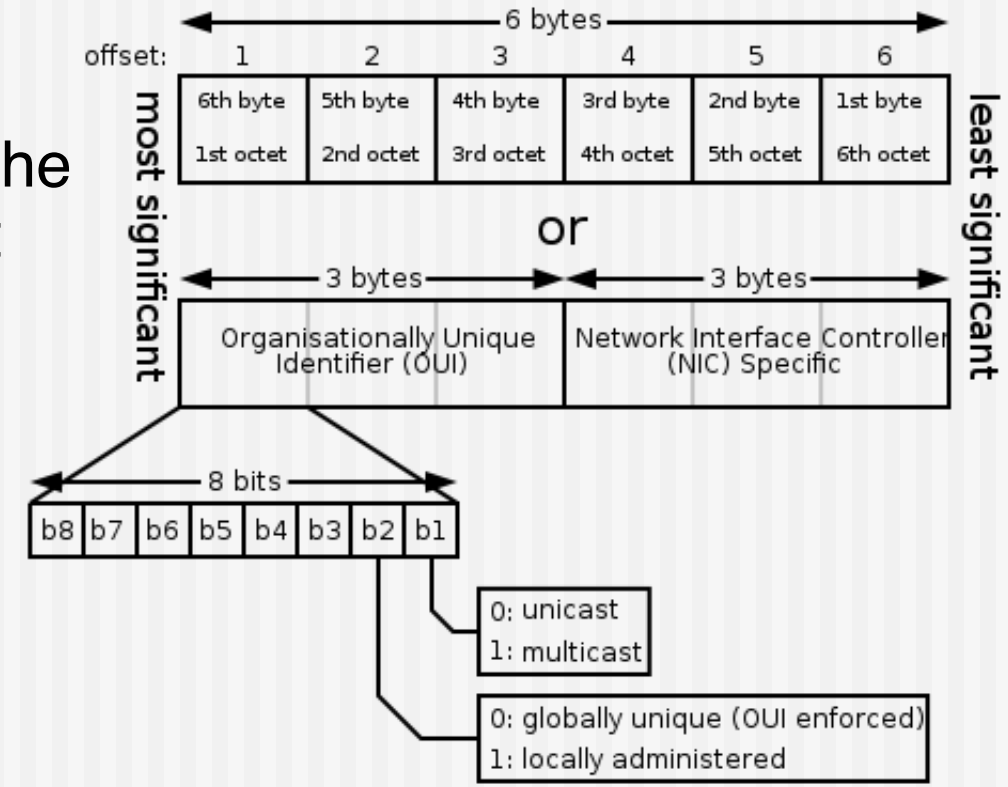
- What this does:
  - Creates a frontend VM on the physical frontend (frontend-0-0-0)
  - Creates virtual compute nodes on VM containers (in round robin order)
  - Creates a unique VLAN for this cluster and plumbs the VMs to it
    - Adds a new unique VLAN to the physical machines on-the-fly

More on What the Command Does

- Adds an entry to the vm_nodes table
  - Keep track of which physical host houses the VM
- Adds an entry to the vm_disks tables
  - Allocates disk space for the VM
    - Uses the Xen “file” virtual block device
    - Puts the file on the largest partition of the physical host
- Allocates unique MAC addresses for each VM
  - MAC prefix is based on the frontend’s public IP

MAC Address Prefix

- MAC prefix is based on the frontend's public IP
  - Take the public IP, toss the first octet, then reverse it
    - Most unique part of IP address is the MAC's first octet
- Also set the "locally administered" bit and clear the "multicast" bit



Adding a Cluster

- Example

```
# rocks add cluster vi-1.rocksclusters.org \
  137.110.119.118 2
```

- Output:

```
created frontend VM named: frontend-0-0-0
        created compute VM named: hosted-vm-0-0-0
        created compute VM named: hosted-vm-0-1-0
```

Adding a Cluster

```
# rocks list cluster
FRONTEND                    CLIENT NODES     TYPE
bayou.rocksclusters.org:    ---------------- physical
:                           vm-container-0-0 physical
:                           vm-container-0-1 physical
vi-1.rocksclusters.org:     ---------------- VM
:                           hosted-vm-0-0-0  VM
:                           hosted-vm-0-1-0  VM
```

‘rocks add cluster’ Extra Flags

- [container-hosts=string]
  - A list of VM container hosts that will be used to hold the VM compute nodes.
- [cpus-per-compute=string]
  - The number of CPUs to allocate to each VM compute node. The default is 1.
- [disk-per-compute=string]
  - The size of the disk (in gigabytes) to allocate to each VM compute node. The default is 36.
- [disk-per-frontend=string]
  - The size of the disk (in gigabytes) to allocate to the VM frontend node. The default is 36.
- [mem-per-compute=string]
  - The amount of memory (in megabytes) to allocate to each VM compute node. The default is 1024.
- [vlan=string]
  - The VLAN ID to assign to this cluster. All network communication between the nodes of the virtual cluster will be encapsulated within this VLAN. The default is the next free VLAN ID.

Install the Frontend VM

- "rocks start host vm" command

```
# rocks start host vm frontend-0-0-0
```

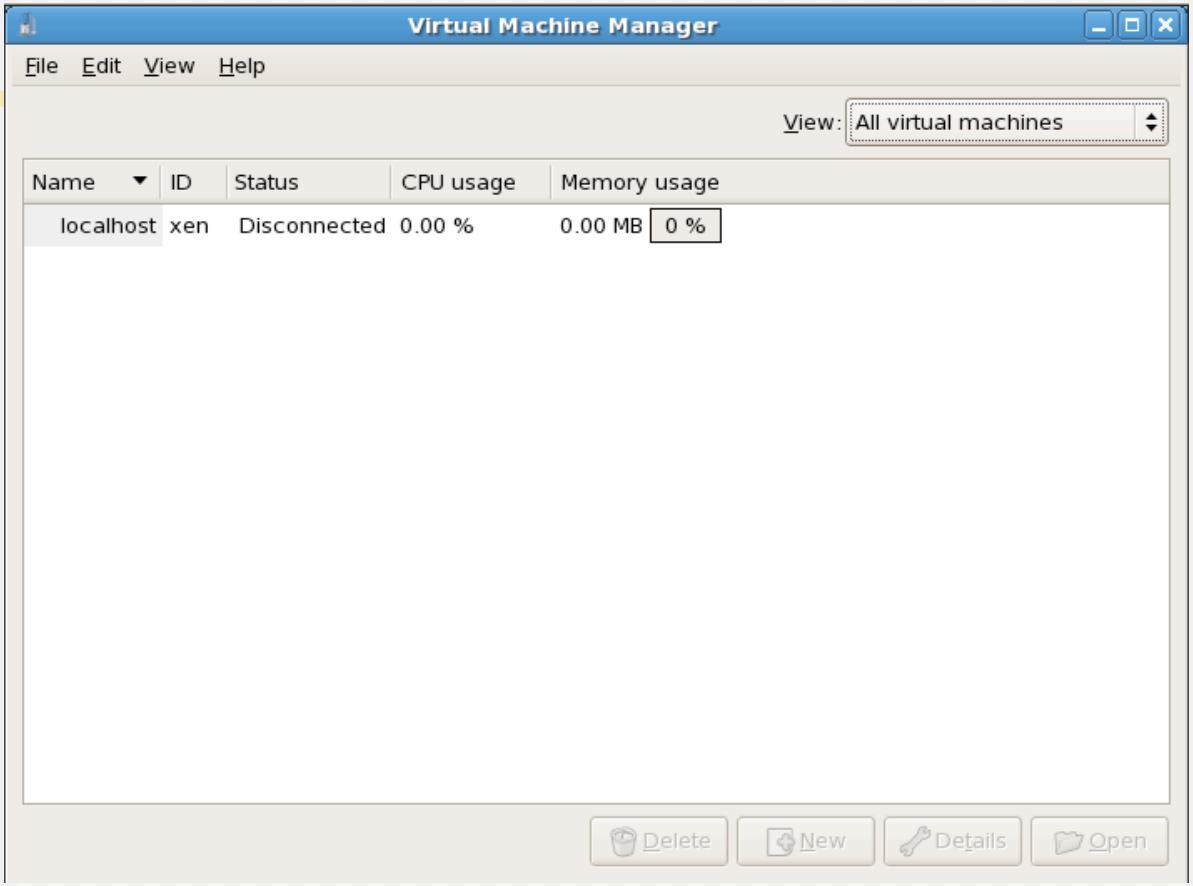
- This starts a standard Rocks installation on the VM

Install the Frontend VM

- To input data at user screens, need to bring up the console for the VM frontend

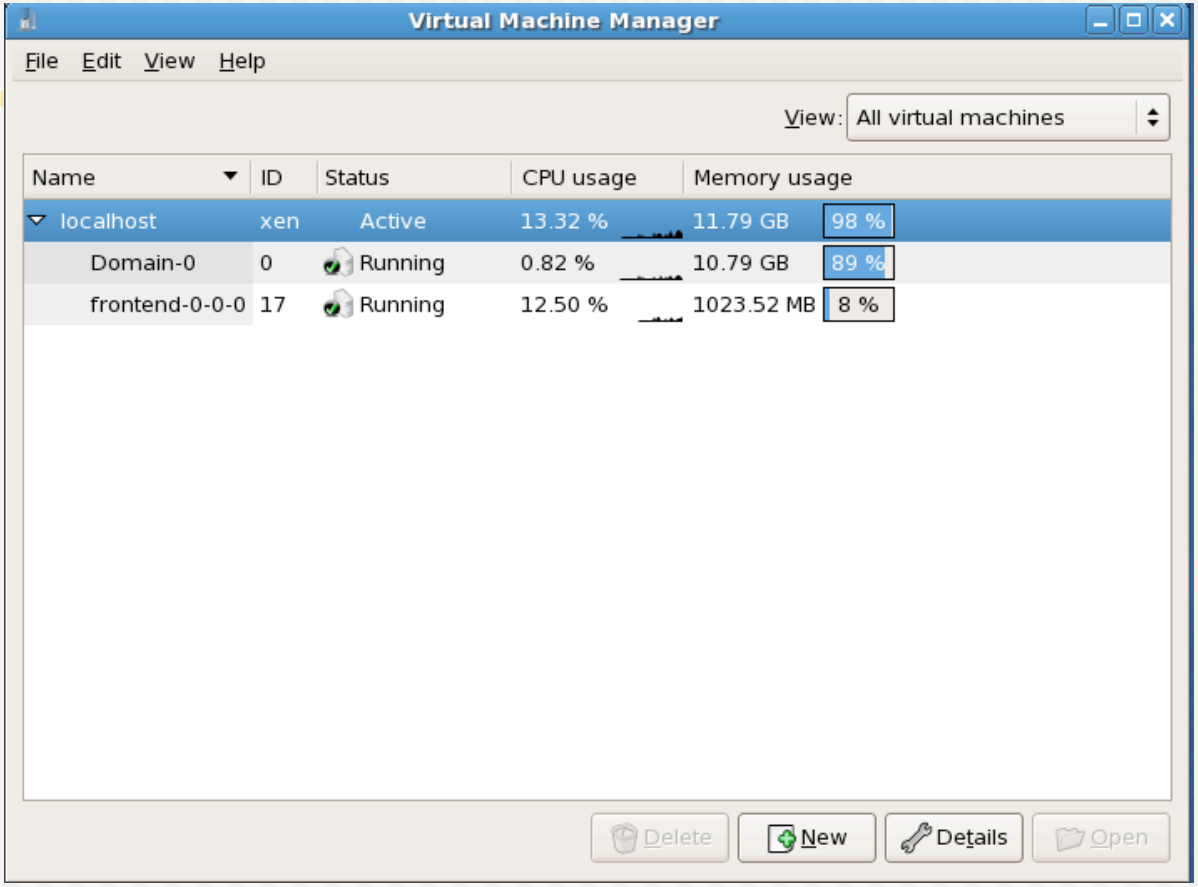
```
# virt-manager
```

Virt-manager



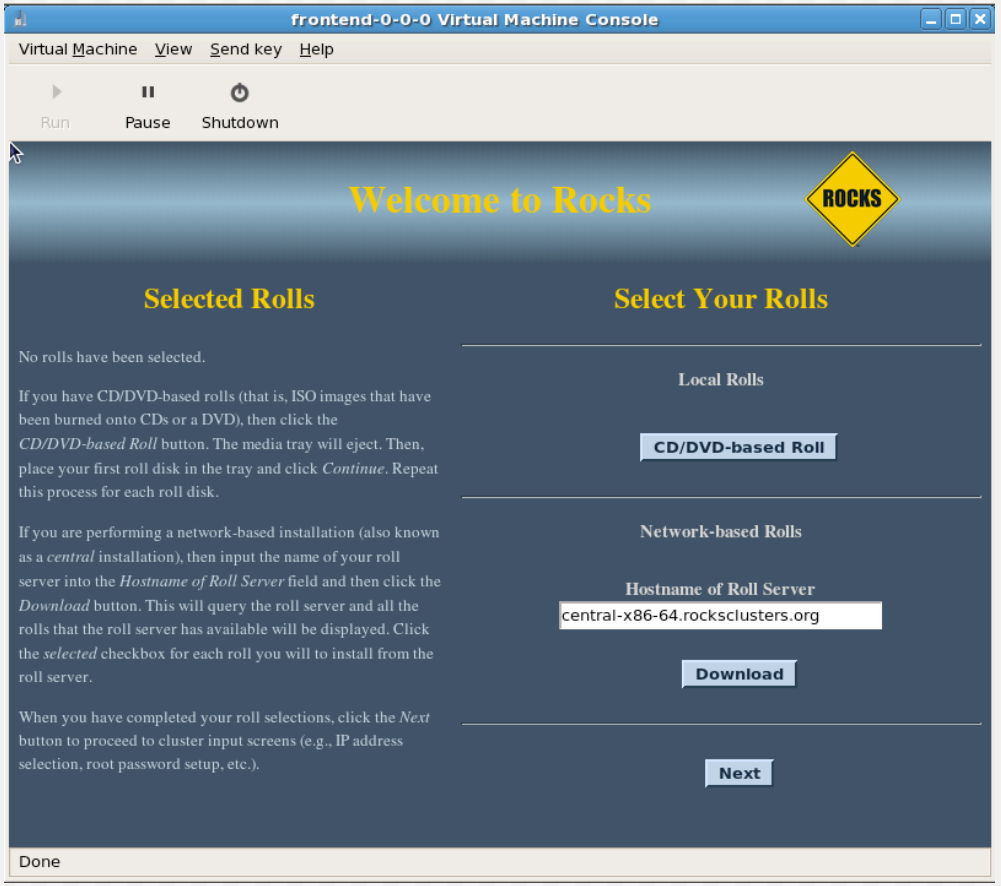
- Double click on ‘localhost’

Virt-manager



- Double click on ‘frontend-0-0-0’ to bring up the console

Virt-manager



Install the Frontend VM

- Input the data
  - Hint: use the FQDN of the physical frontend for the “Hostname of the Roll Server”
- The frontend will install, then reboot
- X will start and you’ll see the graphical login screen
  - Just like a physical frontend!

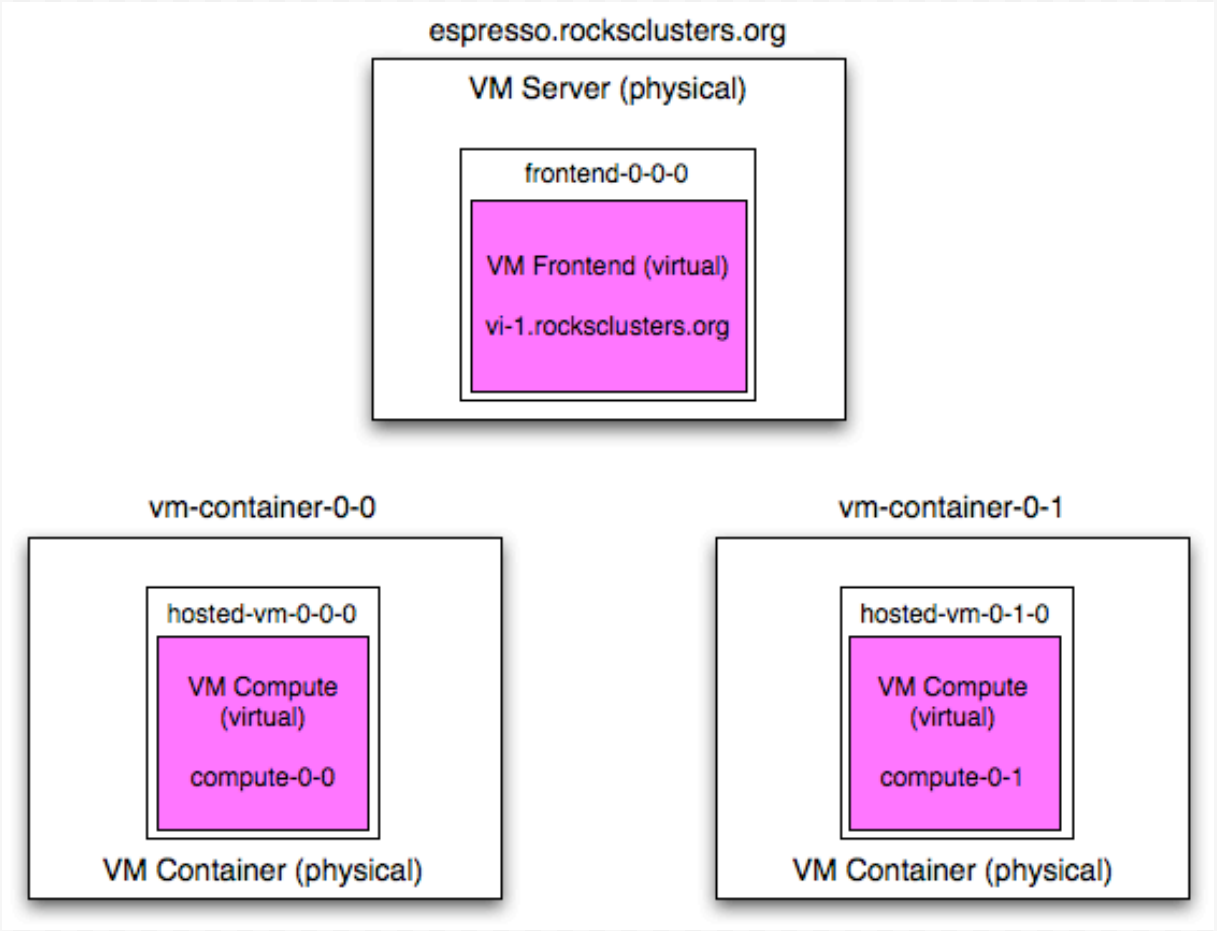
Install VM Compute Nodes

- Login to the VM frontend
  - Run ‘insert-ethers’
- On the physical frontend, execute:

```
# rocks start host vm hosted-vm-0-0-0
```

- The software configuration comes from the VM frontend
- The “power control” comes from the physical frontend

Virtual Frontend and Virtual Computes



Get Status

- Use ‘rocks list cluster status=y’
- On the physical frontend:

```
# rocks list cluster status=y
FRONTEND                    CLIENT NODES     TYPE      STATUS
bayou.rocksclusters.org:    ---------------- physical  -------
:                           vm-container-0-0 physical  -------
:                           vm-container-0-1 physical  -------
vi-1.rocksclusters.org:     ---------------- VM        active
:                           hosted-vm-0-0-0  VM        active
:                           hosted-vm-0-1-0  VM        nostate
```

Other Rocks Xen Commands

list

- List info about all configured VMs

```
# rocks list host vm status=y
VM-HOST           SLICE MEM   CPUS MAC                HOST             STATUS
frontend-0-0-0:   0     1024  1    72:77:6e:80:00:00 bayou            active
frontend-0-0-0:   ----- ----- ---- 72:77:6e:80:00:01 ---------------- -------
hosted-vm-0-0-0: 0     1024  1    72:77:6e:80:00:02 vm-container-0-0 active
hosted-vm-0-1-0: 0     1024  1    72:77:6e:80:00:03 vm-container-0-1 nostate
```

set

- Change VM parameters

```
# rocks set host vm {host} [disk=string] [disksize=string] \
  [mem=string] [physnode=string] [slice=string] \
  [virt-type=string]
```

- Example, allocate 4 GB of memory to a VM:

```
# rocks set host vm hosted-vm-0-0-0 mem=4096
```

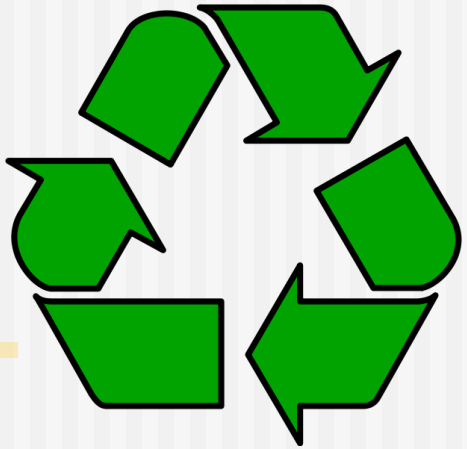
pause/resume

- Execute the “pause” and “resume Xen commands on a VM

```
# rocks pause host vm hosted-vm-0-0-0
# rocks resume host vm hosted-vm-0-0-0
```

- “pause” holds the VM in memory, but the hypervisor doesn’t schedule the VM
  - Like hitting a breakpoint

save/restore



- Execute the “save” and “restore” Xen commands on a VM

```
# rocks save host vm hosted-vm-0-0-0
# rocks restore host vm hosted-vm-0-0-0
```

- What’s the difference between “pause” and “save”?
  - “pause” keeps the VM in memory
  - “save” writes VM state to a file and releases memory and CPU

stop

- Destroy a VM

```
# rocks stop host vm hosted-vm-0-0-0
```

- This is equivalent to pulling the power cord on a physical machine

move

- Move a VM from one physical node to another

```
# rocks move host vm hosted-vm-0-0-0 vm-container-1-0
```

- This operation will take some time
  - It “saves” the current VM
  - Copies the VMs disk file to the new VM container
    - If your diskfile is 36 GB, it will move 36 GB across the network
  - Then “restores” the VM

Other “Internal” Commands

- “dump”
  - Used on the restore roll to capture VM configuration
- “report”
  - Called by “rocks start host vm” to create Xen VM configuration files
- “remove”
  - Called by “rocks remove host” to remove the VM specific info for a host

Lights Out Virtual Frontend Install

What is “Lights Out”?

- Install a frontend without filling out any user screens
- Accomplish this with “attributes” and by assigning rolls to a VM frontend

Attributes

- Assign values to variables in the graph
- An evolution of the <var> tags and the app_globals table
- Previous syntax:

```
ServerName <var name="Kickstart_PublicHostname"/>
```

- New syntax:

```
ServerName &Kickstart_PublicHostname;
```

Attributes

- Attributes can be set at 4 levels:
  - Globally
    - ‘rocks set attr’
  - By appliance type
    - ‘rocks set appliance attr’
  - By OS (linux or sunos)
    - ‘rocks set os attr’
  - By host
    - ‘rocks set host attr’

Attributes

```
# rocks list host attr tile-0-0
HOST      ATTR                          VALUE                          SOURCE
tile-0-0: Info_CertificateCountry       US                             G
tile-0-0: Info_CertificateLocality      San Diego                      G
tile-0-0: Info_CertificateOrganization  CalIT2                         G
tile-0-0: Kickstart_DistroDir           /export/rocks                  G
tile-0-0: Kickstart_PrivateAddress      10.1.1.1                       G
tile-0-0: Kickstart_PrivateBroadcast    10.1.255.255                   G
tile-0-0: Kickstart_PrivateDNSDomain    local                          G
tile-0-0: Kickstart_PrivateDNSServers   10.1.1.1                       G
tile-0-0: Kickstart_PrivateGateway      10.1.1.1                       G
tile-0-0: Kickstart_PublicDNSServers    132.239.0.252                  G
tile-0-0: Kickstart_PublicGateway       137.110.119.1                  G
tile-0-0: Kickstart_PublicHostname      vizagra.rocksclusters.org      G
tile-0-0: Kickstart_PublicKickstartHost central.rocksclusters.org      G
tile-0-0: Kickstart_PublicNTPHost       pool.ntp.org                   G
tile-0-0: Kickstart_PublicNetmask       255.255.255.0                  G
tile-0-0: Kickstart_PublicNetmaskCIDR   24                             G
tile-0-0: Kickstart_PublicNetwork       137.110.119.0                  G
tile-0-0: Kickstart_Timezone            America/Los_Angeles            G
tile-0-0: Server_Partitioning           force-default-root-disk-only   G
tile-0-0: arch                          x86_64                         H
tile-0-0: hostname                      tile-0-0                       I
tile-0-0: rack                          0                              I
tile-0-0: rank                          0                              I
tile-0-0: rocks_version                 5.2                            G
tile-0-0: HideBezels                    false                          G
tile-0-0: HttpConf                      /etc/httpd/conf                O
tile-0-0: HttpConfigDirExt              /etc/httpd/conf.d              O
tile-0-0: HttpRoot                      /var/www/html                  O
```

Setting Host Attributes

```
# rocks set host attr vi-1 Kickstart_PrivateHostname vi-1

# rocks set host attr vi-1 Kickstart_PublicAddress \
    137.110.119.118

# rocks set host attr vi-1 Kickstart_PublicHostname \
    vi-1.rocksclusters.org

# rocks set host attr vi-1 Kickstart_PublicKickstartHost \
    bayou.rocksclusters.org
```

Assign Rolls to the VM Frontend

```
# rocks set host roll vi-1 os 5.2 x86_64
# rocks set host roll vi-1 base 5.2 x86_64
# rocks set host roll vi-1 kernel 5.2 x86_64


# rocks list host roll vi-1
HOST              NAME   VERSION ARCH   OS
frontend-0-0-0: os     5.2     x86_64 linux
frontend-0-0-0: base   5.2     x86_64 linux
frontend-0-0-0: kernel 5.2     x86_64 linux
```

Assign Rolls to VM Frontend

```
# rocks report host roll vi-1
<rolls>
<roll
        name="os"
        version="5.2"
        arch="x86_64"
        url="http://bayou.rocksclusters.org/install/rolls/"
        diskid=""
/>
<roll
        name="base"
        version="5.2"
        arch="x86_64"
        url="http://bayou.rocksclusters.org/install/rolls/"
        diskid=""
/>
<roll
        name="kernel"
        version="5.2"
        arch="x86_64"
        url="http://bayou.rocksclusters.org/install/rolls/"
        diskid=""
/>
</rolls>
```

Start the VM

```
# rocks start host vm vi-1
```

- This will automatically install the VM frontend
  - Internals:
    - This creates the files /tmp/site.attrs and /tmp/rolls.xml in the installing node
    - If these two files exist, then the user input screens will be skipped
- When the installation completes, the VM frontend will reboot
  - If you connect to the VM console with ‘virt-manager’, you’ll see that X is up at the login screen

Error Conditions

- When the VM frontend is trying to get its kickstart file: “Could not get file”
  - Try opening up firewall
  - By default, http/https is open on public network to hosts in the same subnet
    - E.g., if host is 137.110.119.118/24, then any host on the subnet 137.110.119.0 can access the web server over the public interface

Xen in Rocks Futures

Futures

- Support fully-virtualized VMs
  - Can run any OS in a VM container

Supporting Different Architectures for VMs

Support both i386 and x86_64 VMs

- On a x86_64 physical cluster, can support both 32-bit and 64-bit VMs
- Need to:
  - Get i386 Rocks ISOs
  - Create new distro
  - Add i386 version of ‘rocks-boot’ to the frontend
  - Add bootactions to the database

Adding rocks-boot

```
# cd /export/rocks/install
# rpm -i -force rocks-dist/i386/RedHat/RPMS/rocks-boot-xen-5.2-1.i386.rpm
```

- This adds the files:
  - /boot/kickstart/xen/vmlinuz-5.2-i386
  - /boot/kickstart/xen/initrd-xen.iso.gz-5.2-i386

Add bootactions

```
# rocks add bootaction action="install vm i386" \
        kernel="file:///boot/kickstart/xen/vmlinuz-5.2-i386" \
        ramdisk="file:///boot/kickstart/xen/initrd-xen.iso.gz-5.2-i386" \
        args="ks ramdisk_size=1500000 lang= devfs=nomount kssendmac \
              selinux=0 noipv6"

# rocks add bootaction action="install vm frontend i386" \
        kernel="file:///boot/kickstart/xen/vmlinuz-5.2-i386" \
        ramdisk="file:///boot/kickstart/xen/initrd-xen.iso.gz-5.2-i386" \
        args="ramdisk_size=150000 lang= devfs=nomount pxe kssendmac \
              selinux=0 noipv6 \
              ks=http://bayou.rocksclusters.org/install/sbin/kickstart.cgi \
              ksdevice=eth1 build"
```

- Change ‘bayou.rocksclusters.org’ to your physical frontend

Assign bootactions to i386 VMs

```
# rocks set host installaction frontend—0-0-0 \
      action="install vm frontend i386"

# rocks set host installaction hosted-vm—0-0-0 \
      action="install vm i386"
```