Virtual Machines in Condor

Condor Project
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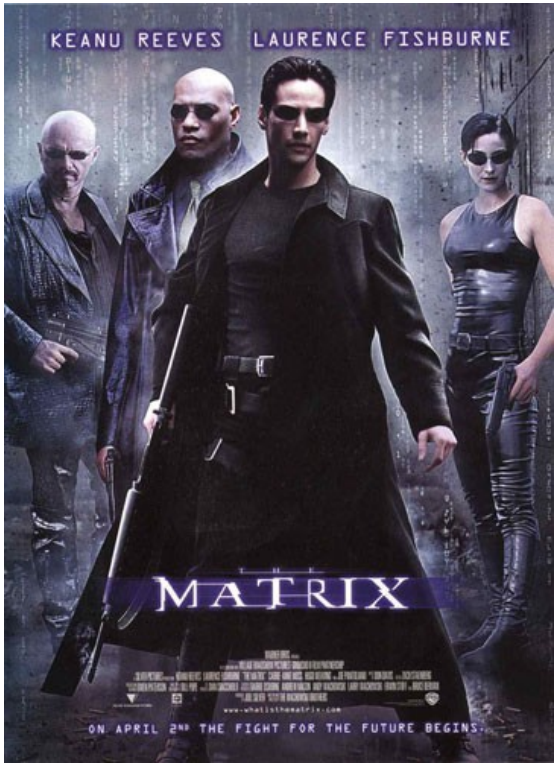
Virtual Machines

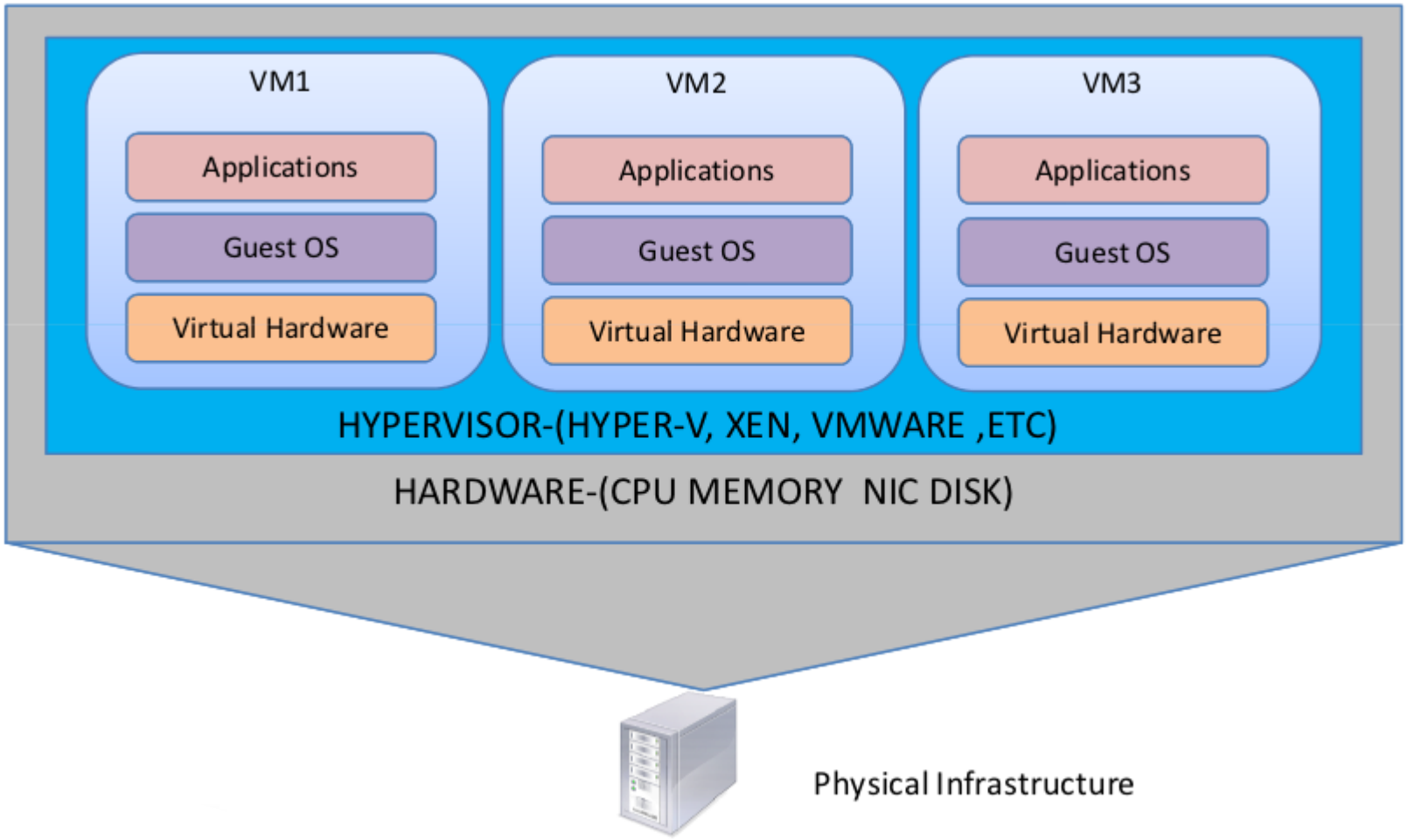
- Simulated hardware
- Software in the VM thinks it's running on a normal machine
- Efficient use of hardware resources
- Distributed architectures are inherently complex:
  - Resources scattered all around the globe and are heterogeneous
  - Distributed administration: no centralized control
  - Efficient resource management is essential in those architectures in order to achieve high performance



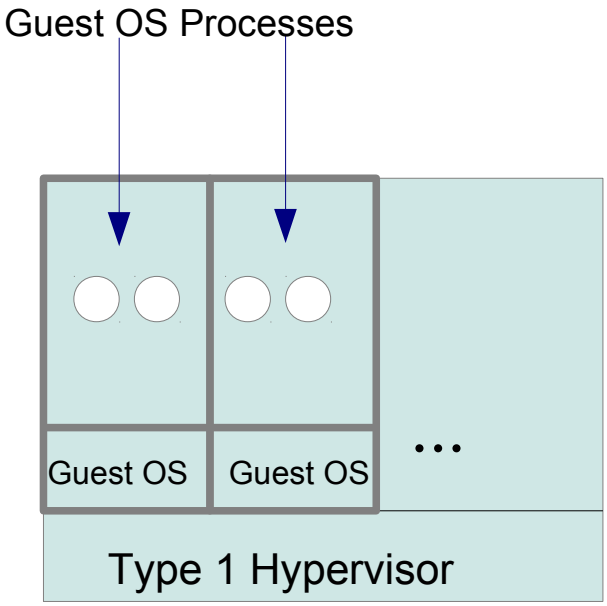
Virtualization concept

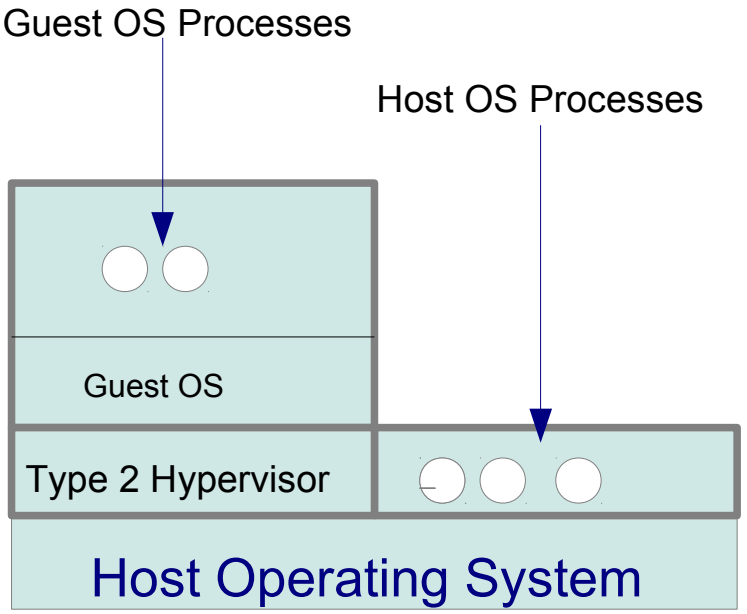
- Virtualization is a framework or methodology of dividing the resources of a computer into multiple execution environments, by applying one or more concepts or technologies such as hardware and software partitioning, time-sharing, partial or complete machine simulation, emulation, quality of service, and many others.
- Virtualized resources enable a more efficient resource management
- Each instance of such execution is called a Virtual Machine(VM)

Virtualization concept



Virtualization concept





Type 1 Hypervisor

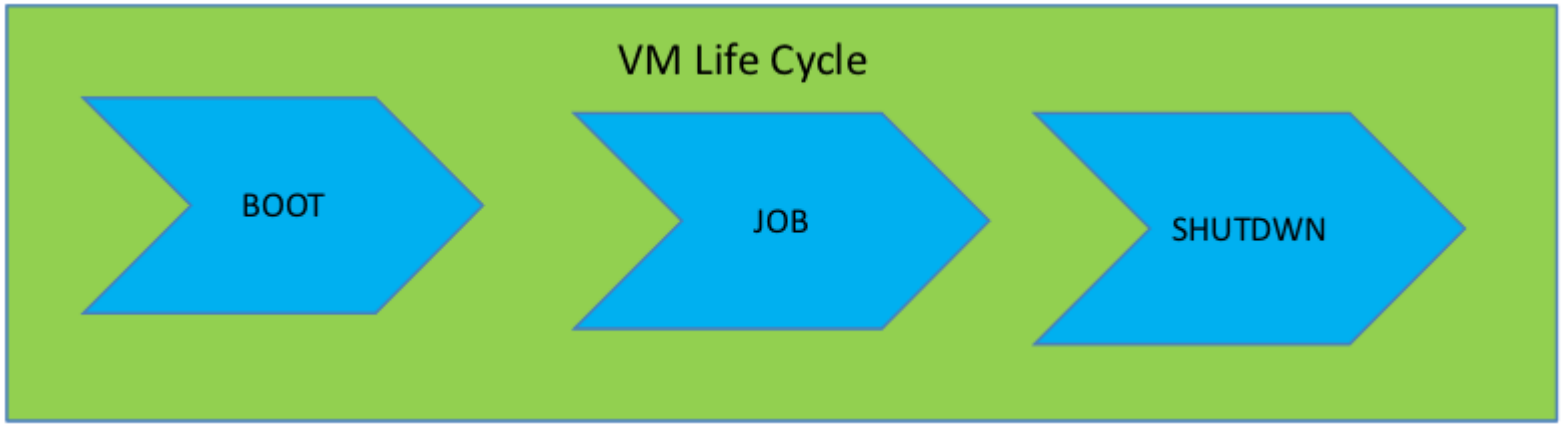
Type 2 Hypervisor

Virtualization concept

- Few advantages of Virtual Machines
  - Hardened security
  - Platform isolation
  - Easy reconfiguration
  - Better Reliability, Availability and Serviceability

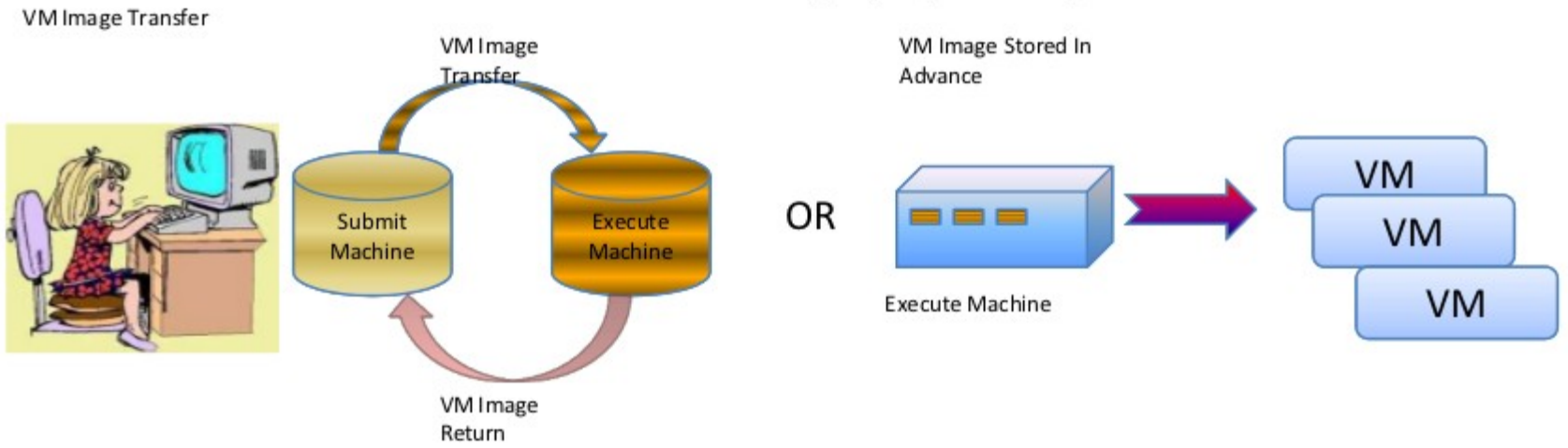
Virtualization concept

- Virtual Machine Life Cycle
  - Boot Up of the VM
  - Running Job on VM
  - Completion Job and Shutdown of the VM

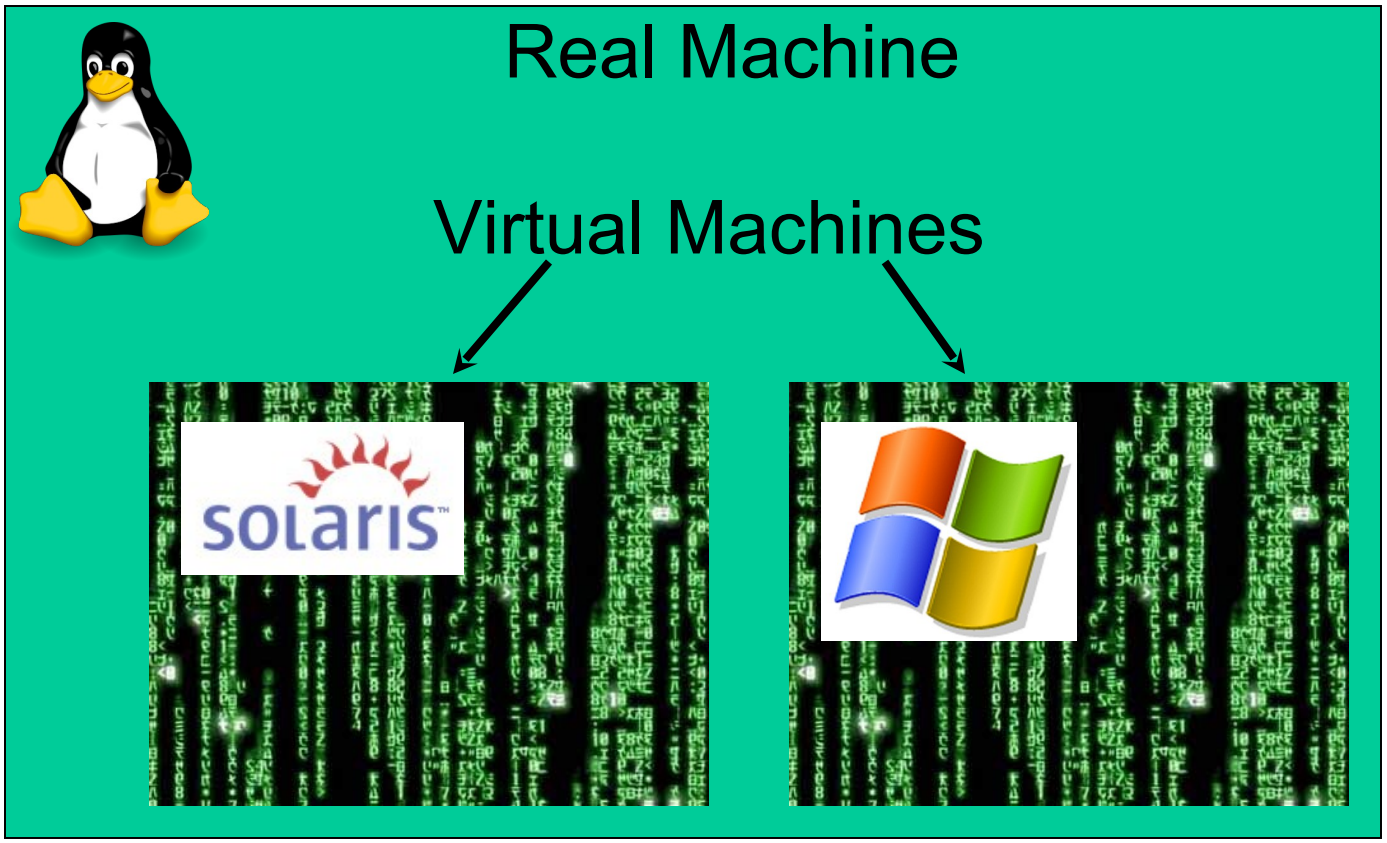


Virtualization concept

- Virtual Machine Job
  - Starting Boot Up of the VM
  - Running VM On
  - Completion Shutdown of the VM
  - Result Modified VM image (Optional)



Virtual Machines



Benefits of Virtual Machines

- Job sandboxing
- Checkpoint and migration
- Jobs with elevated privileges
- Platform independence

Job Sandboxing

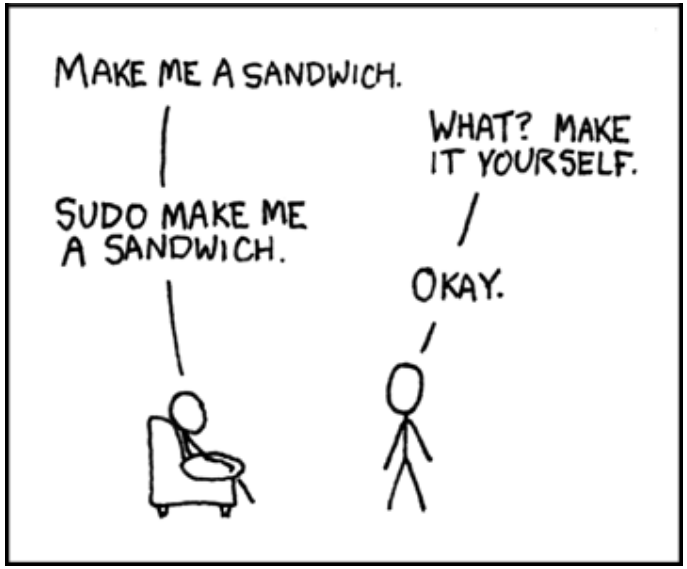
- Protect machines from jobs
  - Both accidental and malicious damage
- Machine owners more willing to run unfamiliar jobs

Checkpoint and Migration

- State of entire VM (OS and all) is recorded
- VM can be checkpointed for…
  - Failure recovery
  - Migration to other machines

Jobs with Elevated Privileges

- Run as root or administrator user
- Alter OS installation
- Useful for automated testing of software like Condor



Platform Independence

- Jobs can run on more machines
- Machines can run more jobs
- Linux jobs on Windows machines
  - And vice versa

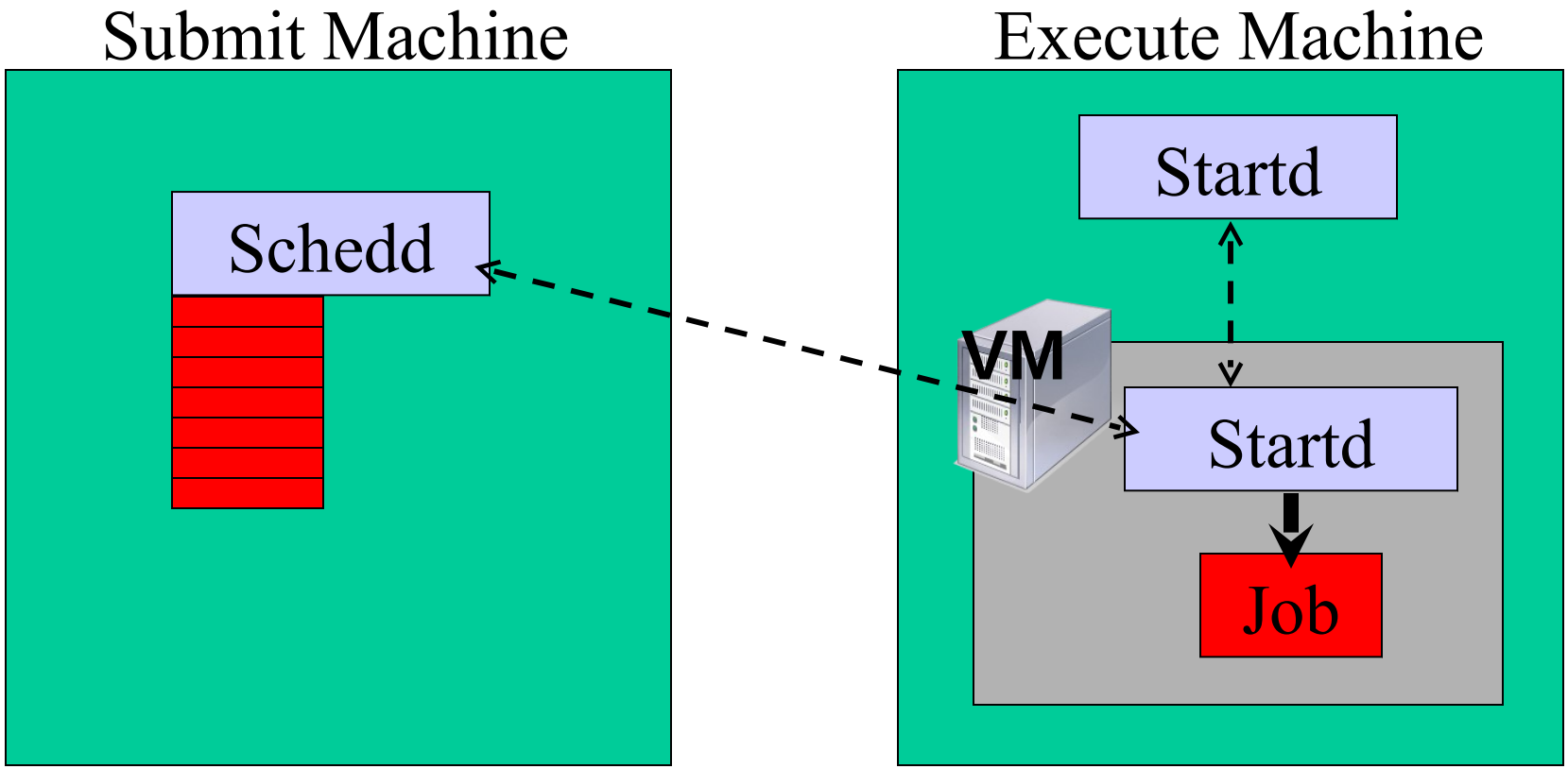
VM Image Provided By…

- Machine Owner
  - Condor runs inside a VM
  - VM becomes a node in your Condor pool
- Job Owner
  - VM universe
  - Condor runs a user-provided VM image

Condor in a VM

- Run Condor in a VM
- VM joins your pool
- VM acts like any other node
- Condor in VM can gather information from host machine
  - E.g. load average, keyboard idle time

Condor in a VM



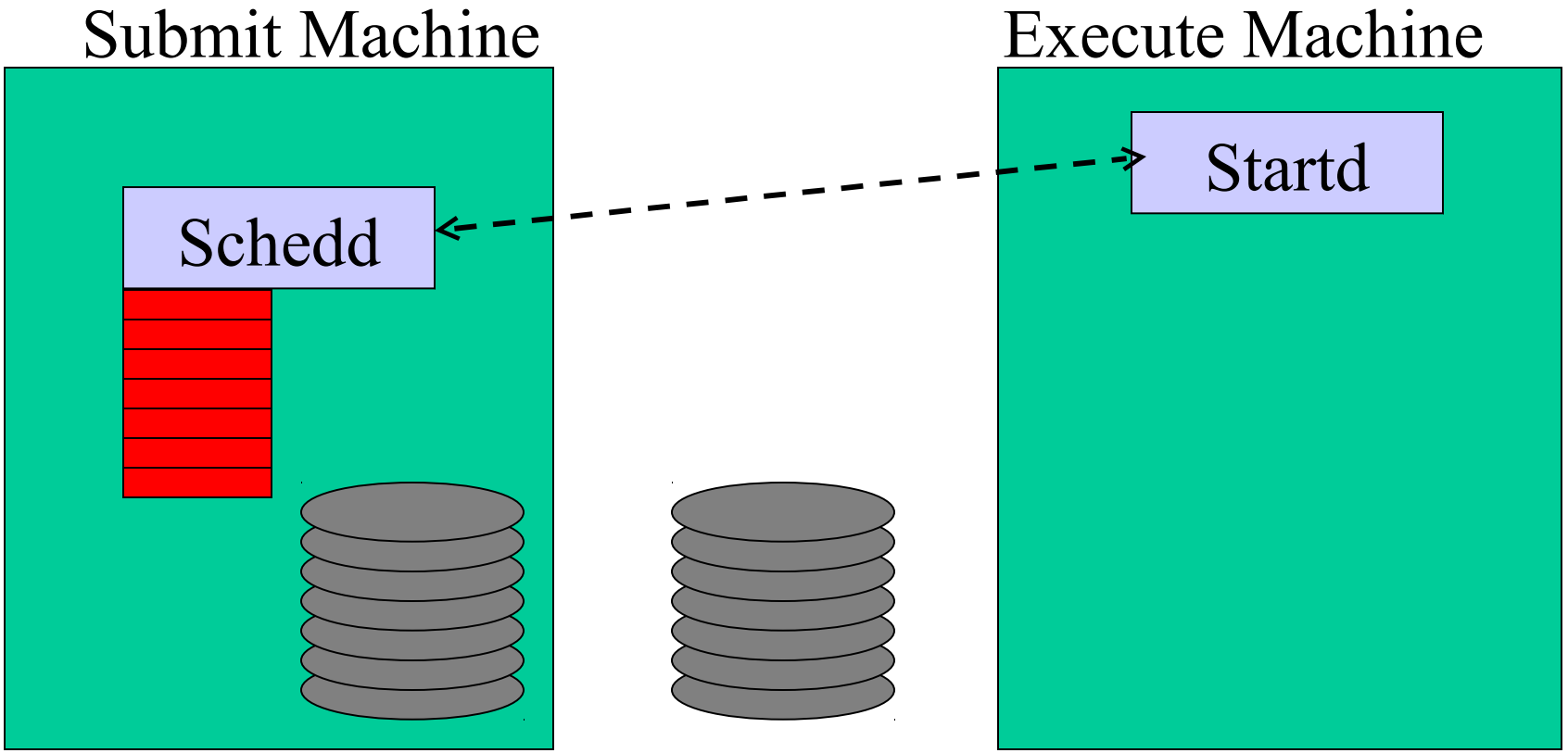
Config Settings

- Host config file
  - `VMP_VM_LIST = vm1.bar.edu, vm2.bar.edu`
  - `HOSTALLOW_WRITE = $(HOSTALLOW_WRITE), \`
    `$(VMP_VM_LSIT)`
- VM config file
  - `VMP_HOST_MACHINE = foo.bar.edu`
  - `START = (KeyboardIdle > 150) && \`
    `(HOST_KeyboardIdle > 150)`

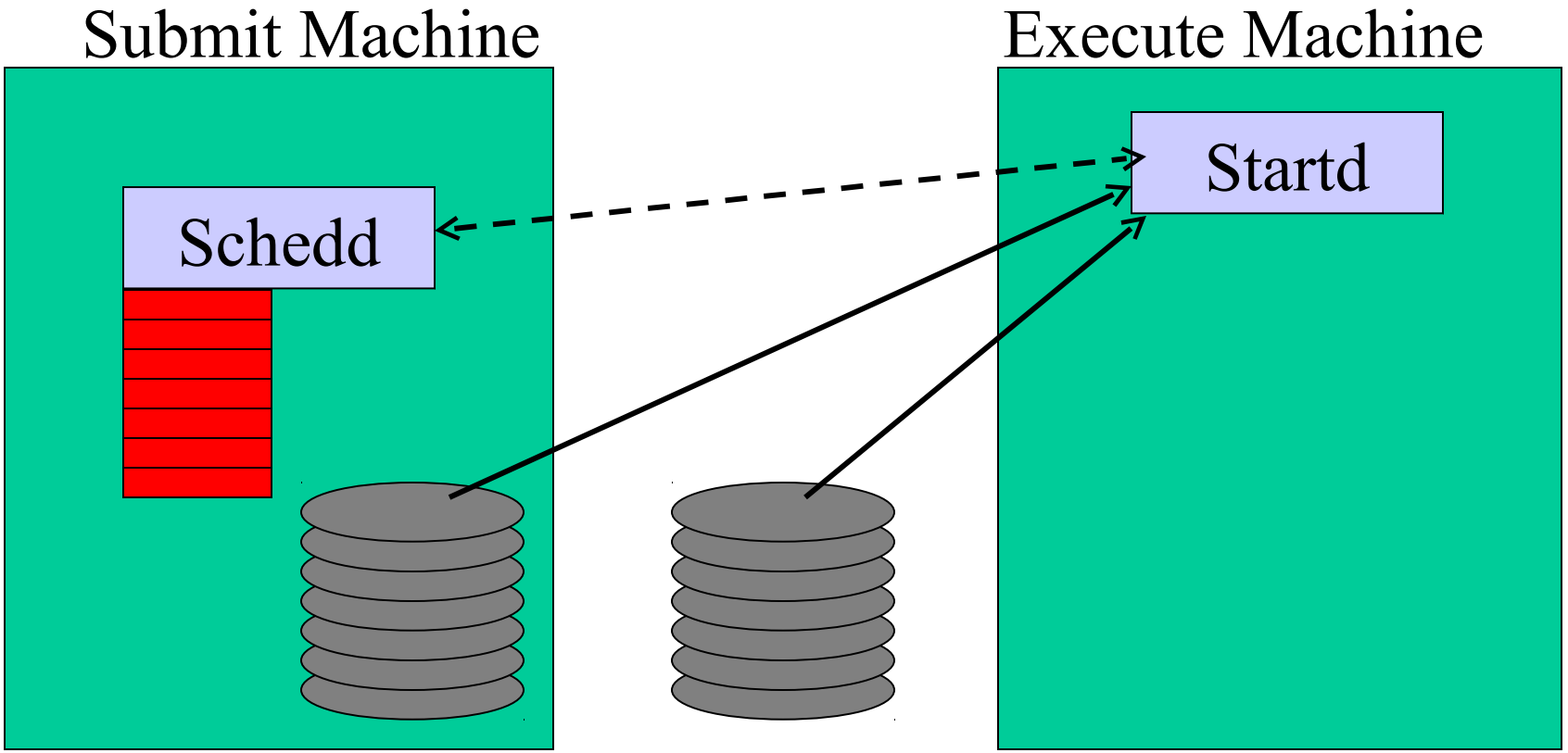
VM Universe

- The VM image is the job
- Job output is the modified VM image
- VMWare, KVM and Xen are supported
- VM GAHP
  - Daemon used to condor_starter to interact with VM software

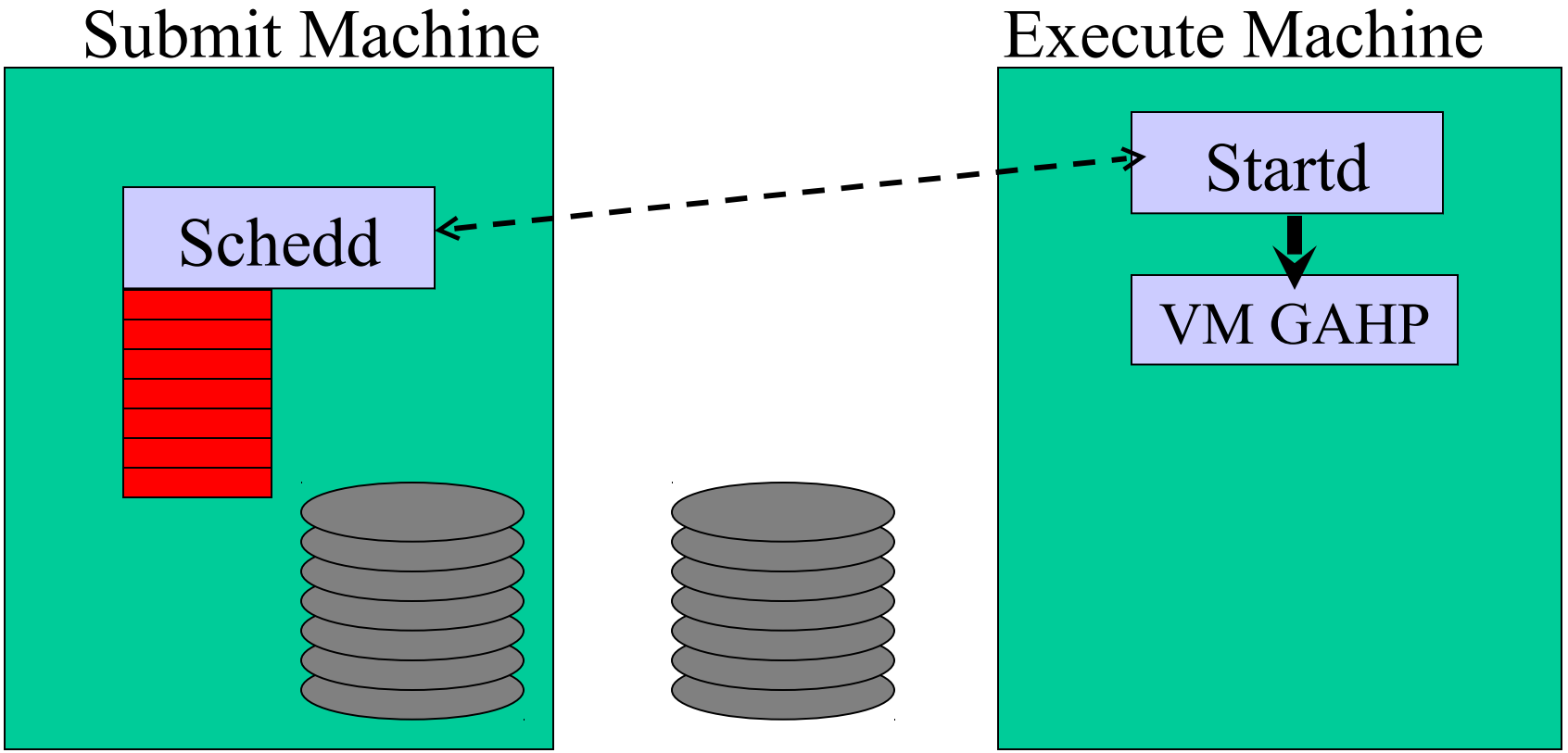
VM Universe Example



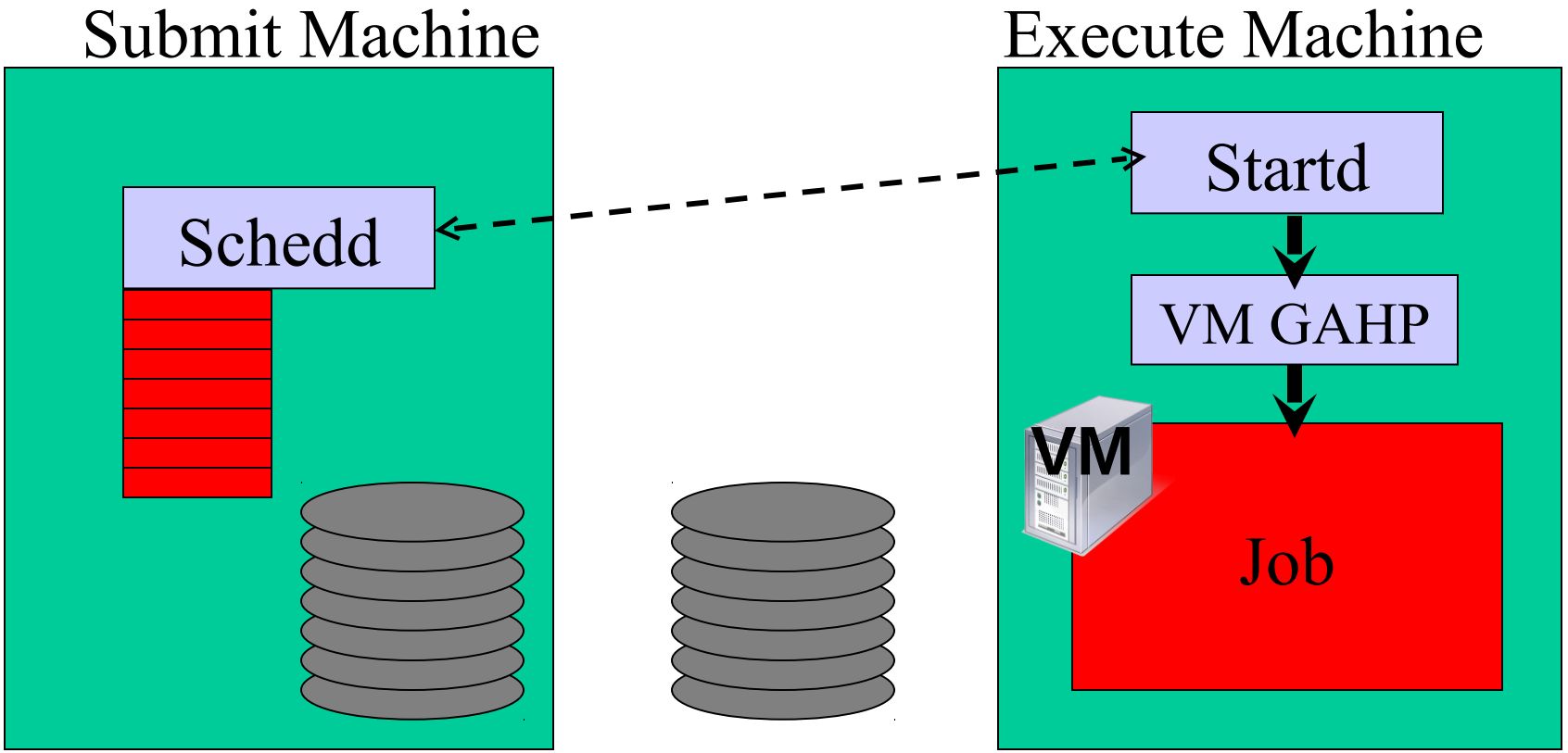
VM Universe Example



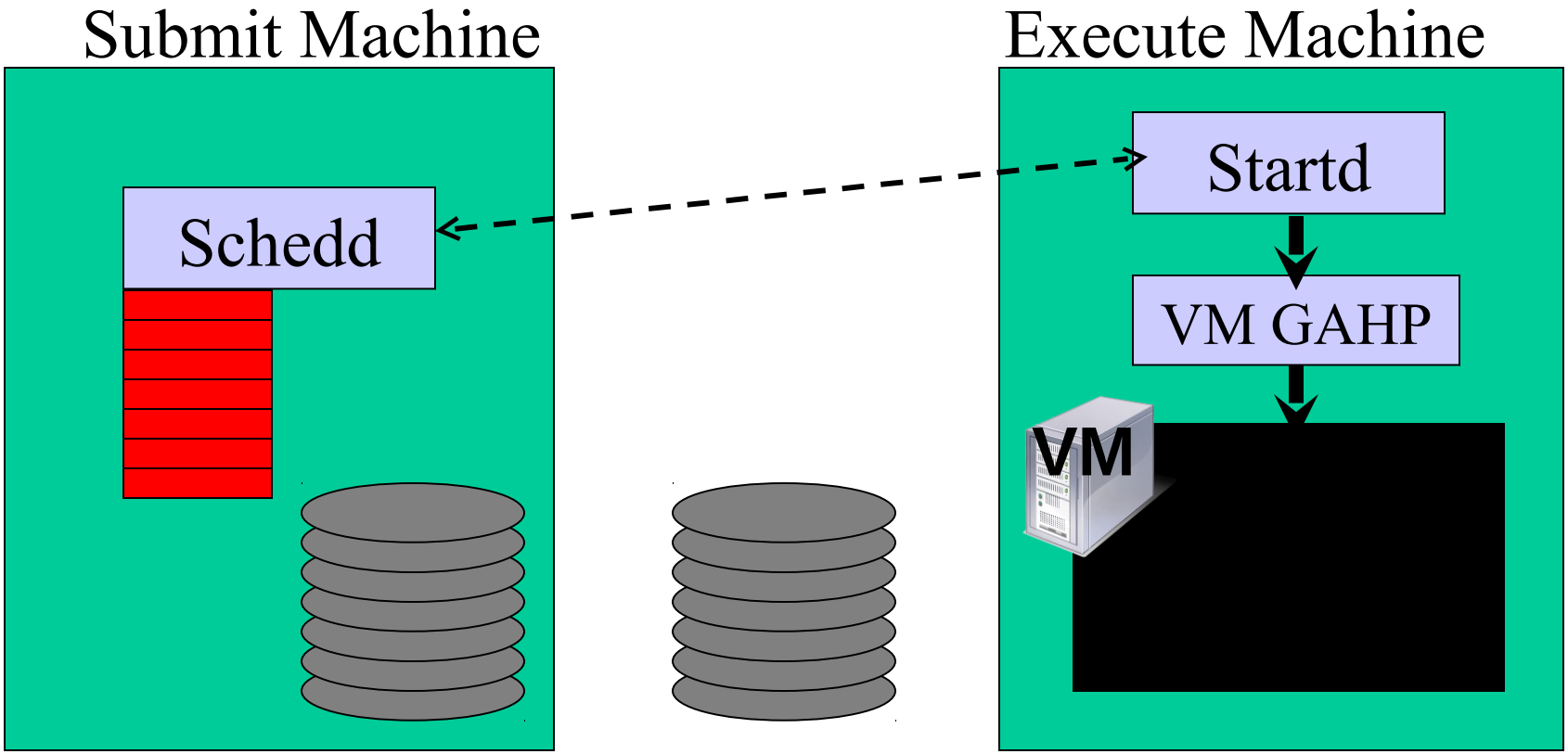
VM Universe Example



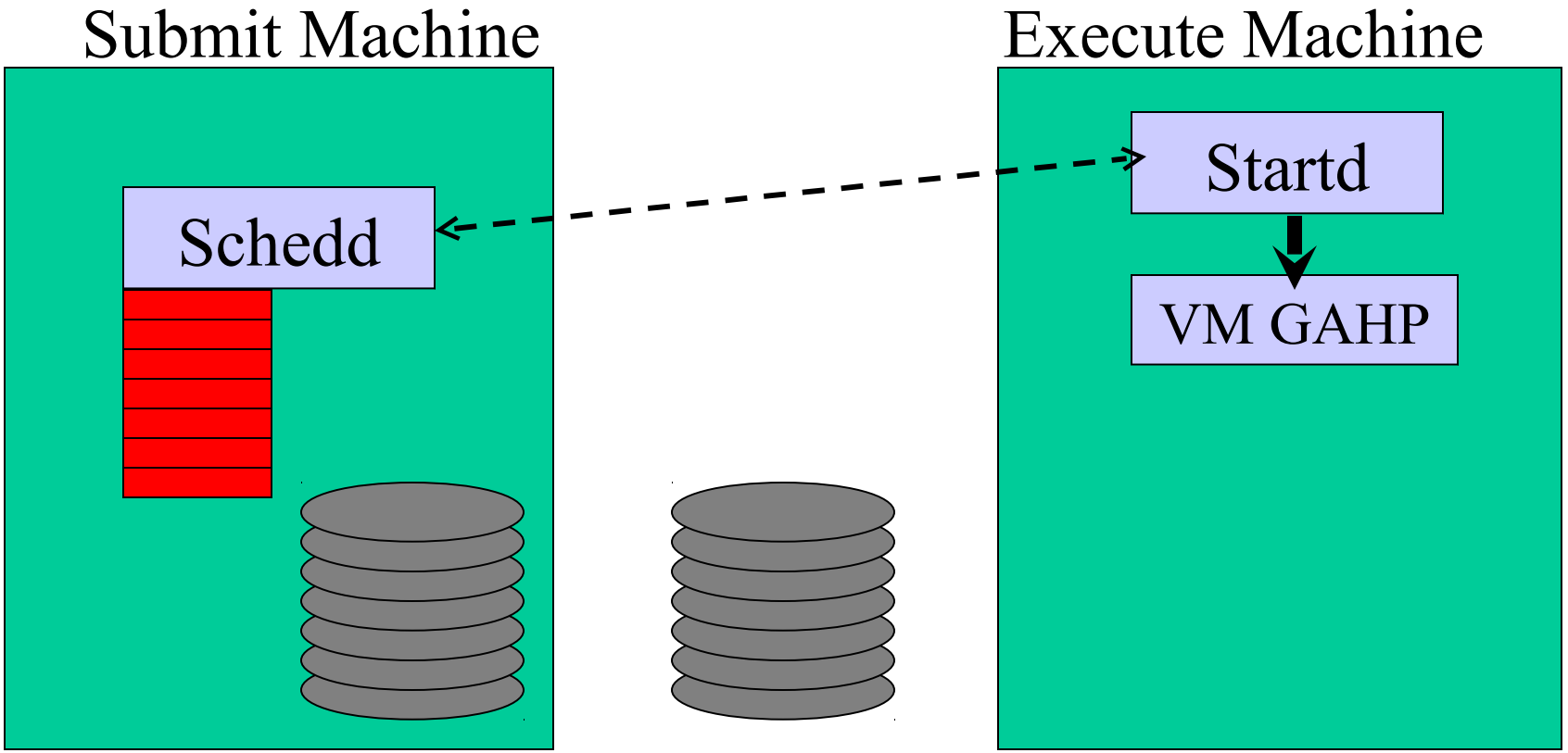
VM Universe Example



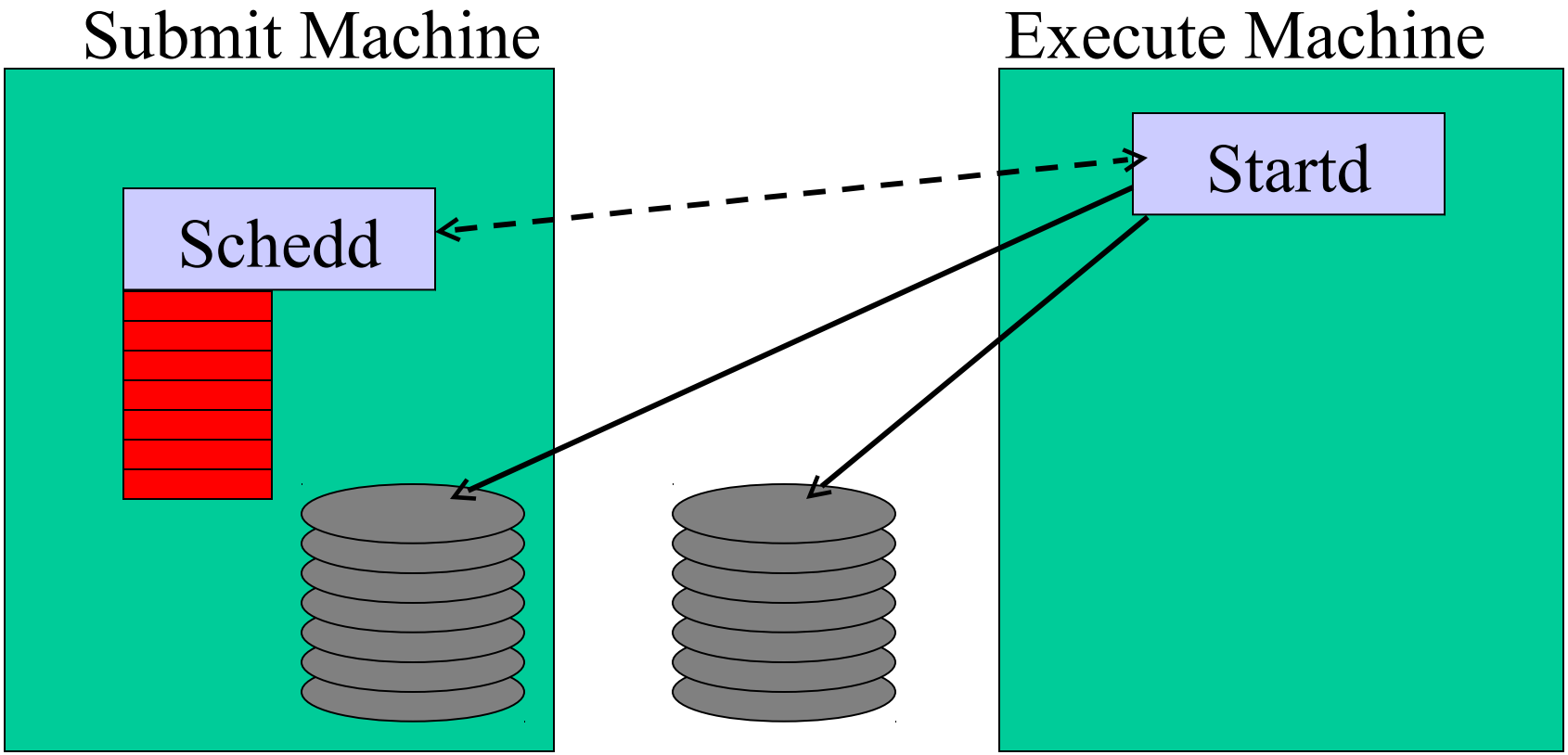
VM Universe Example



VM Universe Example



VM Universe Example



Condor Config File

- VM_TYPE = <xen|kvm|vmware>
  - Indicate what VM software you have
  - This enables VM capabilities
- VM_MEMORY = 256
  - Max memory all VMs can use
- VM_MAX_NUMBER = 2
  - Max simultaneous VMs

Condor Config File

- VM_NETWORKING = TRUE
  - Can the VM access the network?
- VM_NETWORKING_TYPE = nat, bridge
  - Ways the VM access the network
- VM_NETWORKING_DEFAULT_TYPE = nat
  - Default network access type
- VM_SOFT_SUSPEND = True
  - Suspend VM in memory or write to disk?

Config File for VMWare

- VMWARE_NETWORKING_TYPE = \
  <nat|bridged>
  - Networking type to appear in .vmx file
- VMWARE_LOCAL_SETTINGS_FILE = \
  /path/to/file
  - Extra attributes to insert in .vmx file

Config File for Xen/KVM

- LIBVIRT_XML_SCRIPT = \
  $(LIBEXEC)/libvirt_simple_script.awk
  - Optional callout to write libvirt XML description
- VM_BRIDGE_SCRIPT = \
  vif-bridge bridge=xenbr0
  - Script to set up networking
- XEN_BOOTLOADER = /usr/bin/pygrub
  - Xen only, when kernel included in disk image

Machine ClassAd

```
HasVM = True
VM_AvailNum = 2
VM_Memory = 256
VM_Networking = True
VM_Networking_Types = "nat,bridge"
VM_GAHP_VERSION =
   "$VMGahpVersion..."
VM_Type = "vmware"
```

Build a Submit File

- universe = vm
- executable = MyJob1
  - Executable only used for naming in condor_q display
- vm_type = *<vmware|kvm|xen>*

Build a Submit File

- vm_memory = 256
  - Units are megabytes

Build a Submit File

- vm_networking = *<True/False>*
  - Does VM require a network interface?
  - Some machines may not provide one
- vm_networking_type = *<nat/bridge>*
  - Does VM require a specific type of network interface?
  - Some machines may not provide both types

Build a Submit File

- vm_no_output_vm = \
  <True/False>
  - Should modified VM image be returned to user?
  - Some VM jobs may send results over the network

Build a Submit File

- vm_cdrom_files = a.txt, b.txt
  - Files are mounted in VM as a CD-ROM image
  - Allows you to use a VM image for many different jobs
  - You can replace the list of files with a single ISO image

Build a Submit File

- vm_should_transfer_cdrom_files = \
  <True/False>
  - If True, files for CD-ROM image are transferred from submit machine to execute machine
  - If False, files are read from a shared filesystem on execute machine

Build a Submit File

- vm_checkpoint = *<True/False>*
  - If True, Condor will checkpoint VM periodically and on eviction from execute machine
  - Checkpoints stored on submit machine

VMWare Parameters

- vmware_dir = *<path>*
  - Directory containing the VMWare VM image to be run

VMWare Parameters

- vmware_snapshot_disk = \
  <True/False>
  - A snapshot disk records only the changes from the original VM image
  - Saves network bandwidth and disk space on submit machine

VMWare Parameters

- vmware_should_transfer_files = \
  <True|False>
  - If True, files in vmware_dir are transferred from submit machine to execute machine
  - If False, files are read from a shared file system on execute machine

Xen/KVM Parameters

- xen_disk = file1:dev1:perm1,\
  file2:dev2:perm2
- kvm_disk = file1:dev1:perm1,\
  file2:dev2:perm2
  - The VM image is a list of disk image files, along with the devices they should be mapped to in the VM and the permissions they should have
  - The image files can be whole disks or disk partitions

Xen Parameters

- xen_kernel = included
  - The kernel is in the disk image file
- xen_kernel = */path/to/kernel*
  - Use the indicated kernel

Xen Parameters

- xen_kernel_params = *<params>*
  - Append <params> to Xen kernel command line
- xen_root = *<device>*
  - Indicates root disk when kernel not included in disk image
- xen_initrd = *<path>*
  - Path to ramdisk image to be used

Xen/KVM Parameters

- xen_cdrom_device = *<device>*
- kvm_cdrom_device = *<device>*
  - **When using** vm_cdrom_files**, you must specify what device the CD-ROM image will be mapped to**

Xen/KVM Parameters

- xen_transfer_files = file1, file2
- kvm_transfer_files = file1, file2
  - Xen-related files to be transferred from the submit machine to the execute machine
  - Any VM image files not listed are assumed to accessible on the execute machine

Checkpointing and Networking

- VM's MAC and IP address are saved across checkpoint and restart
- Network connections may be lost
  - If NAT networking is used and job changes machines
  - If job is idle for too long before restart
- VMWare provides a tool to maintain DHCP leases across checkpoint and restart

VM Checkpointing vs. Standard Universe

- No relinking
- Works with more types of jobs
  - Multiple processes and threads
  - Networking (but migration problematic)
- No Remote IO
  - Must specify input files

Creating a VM Image

- Configure OS to…
  - Run your application on boot-up
  - Shut down when your application exits
- Input files can be read from CD-ROM image
  - Input files can include application binary

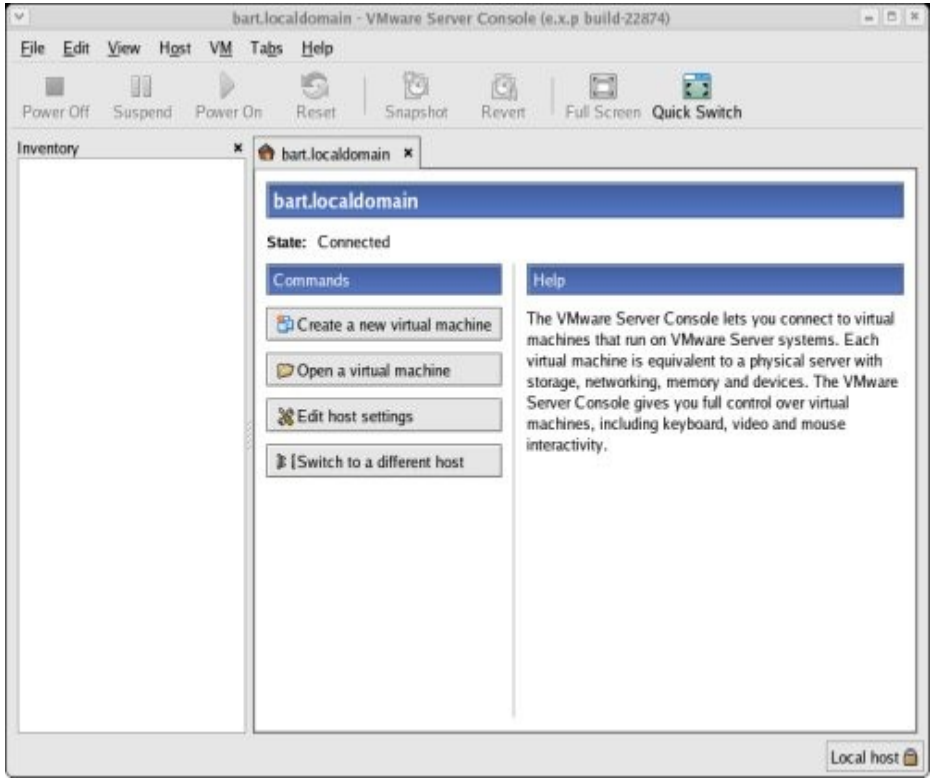
Running in the VM

- Sample boot script on linux
  - /etc/rc.d/rc3.d/S90myjob:

```
#!/bin/sh
su – joe ~/myjob 123 >~/output
shutdown –h now
```

How to Create VM images

- VMware Server
  - Using VMware Server Console

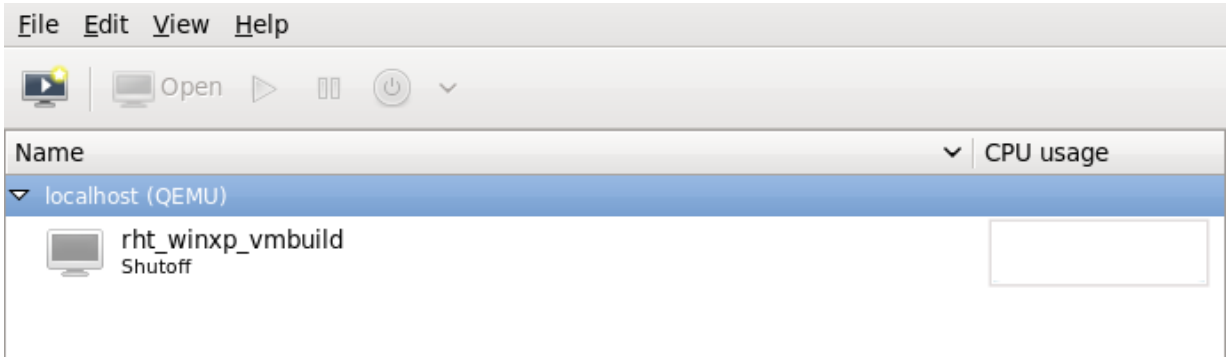


How to Create VM images

- VMware Server
  - Can download pre-created VMs from http://www.vmware.com/appliances/
  - Many Linux distributions: Ubuntu, Fedora, Red Hat Enterprise, openSUSE, CentOS

How to Create VM images

- Xen and KVM
  - Several Linux distributions have GUI or command line tool to create a VM image
    - On Fedora Core, virt-install and virt-manager
    - On OpenSuse, through YaST
  - Can create a VM from scratch by using dd, mke2fs, and mount –o loop



Small VM Images

- Damn Small Linux
  - www.damnsmalllinux.org
  - As small as 6MB
- LitePC
  - www.litepc.com
  - Windows 2000 in 150MB
  - Windows 9x in 40MB

Thank You

- Any questions?
- Several VM-related talks on Wednesday
- Discussion: Virtual Machines and Condor
  - Friday, 11:30-12:15