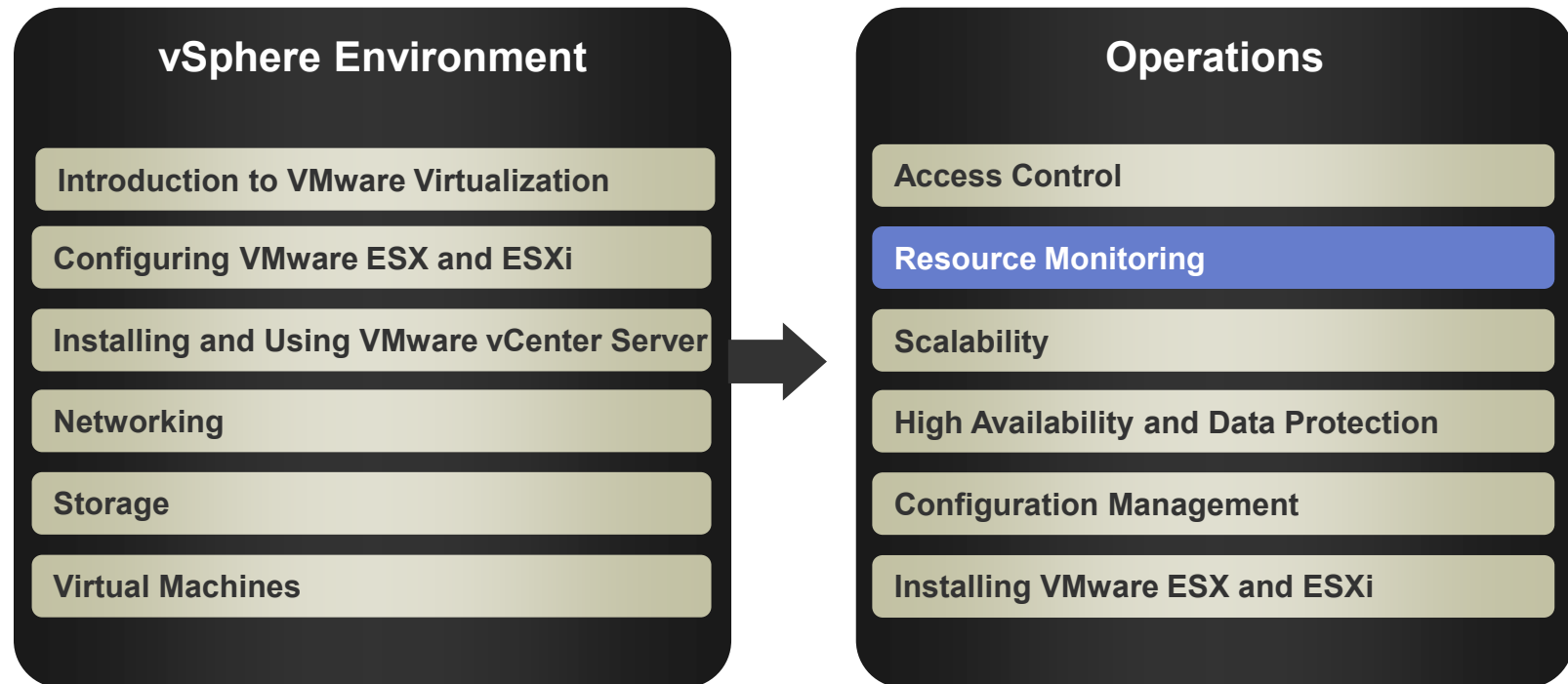




# Resource Monitoring

## Module 9

## You Are Here



## Importance

- Although the VMkernel works proactively to avoid resource contention, maximizing performance requires both analysis and ongoing monitoring.

## Module Lessons

**Lesson 1: Virtual CPU and Memory Concepts**

**Lesson 2: Monitoring Resource Usage**

**Lesson 3: Using Alarms**

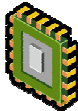
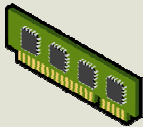

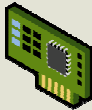


# Lesson 1: Virtual CPU and Memory Concepts

## Lesson Objectives

- Understand the different methods used by the VMkernel for optimizing CPU and memory usage

## Systems for Optimizing VM Resource Use

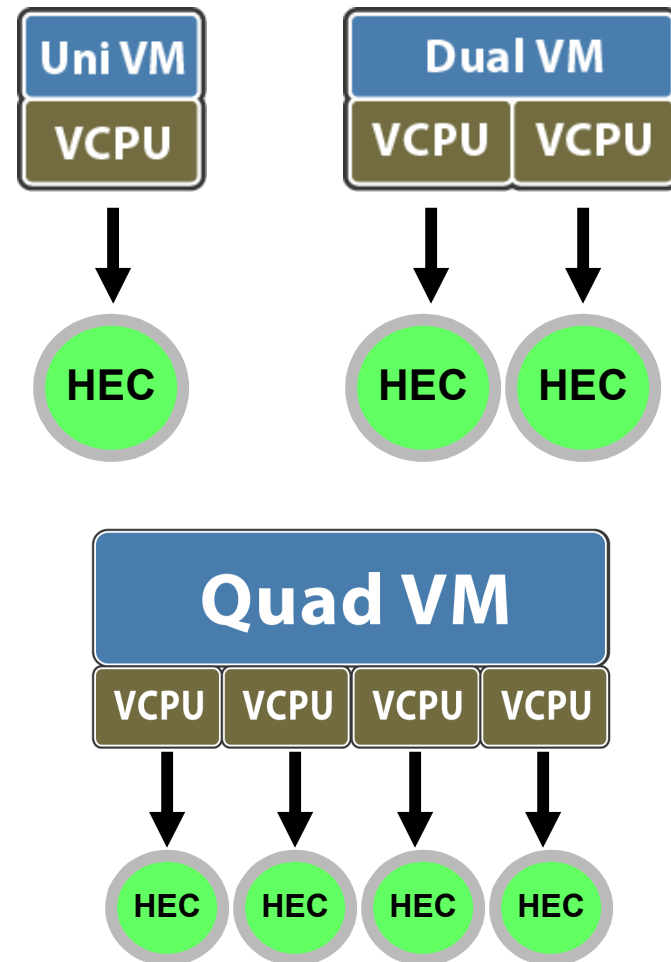
	<i>Automatically managed by VMkernel</i>	<i>Configured by virtual machine owner</i>	<i>Adjustable by administrator</i>
CPU cycles 	<ul style="list-style-type: none"> <li>• Hyperthreading</li> <li>• Load balancing</li> </ul>	<ul style="list-style-type: none"> <li>• Virtual SMP</li> </ul>	<ul style="list-style-type: none"> <li>• Limit</li> <li>• Reservation</li> <li>• Share allocation</li> </ul>
RAM 	<ul style="list-style-type: none"> <li>• Transparent page sharing</li> <li>• <code>vmmemctl</code></li> <li>• Use of VMkernel swap files for VMs</li> </ul>	<ul style="list-style-type: none"> <li>• Available memory</li> </ul>	<ul style="list-style-type: none"> <li>• Limit</li> <li>• Reservation</li> <li>• Share allocation</li> </ul>
Disk bandwidth 		<ul style="list-style-type: none"> <li>• Virtual machine file location</li> </ul>	<ul style="list-style-type: none"> <li>• Multipathing</li> </ul>
Network bandwidth 		<ul style="list-style-type: none"> <li>• Virtual switch with teamed NICs</li> </ul>	<ul style="list-style-type: none"> <li>• Traffic shaping</li> </ul>

## Virtual CPUs

A virtual machine can have up to eight virtual CPUs (VCPUs).

When a VCPU must be scheduled, the VMkernel maps a VCPU to a hardware execution context (HEC).

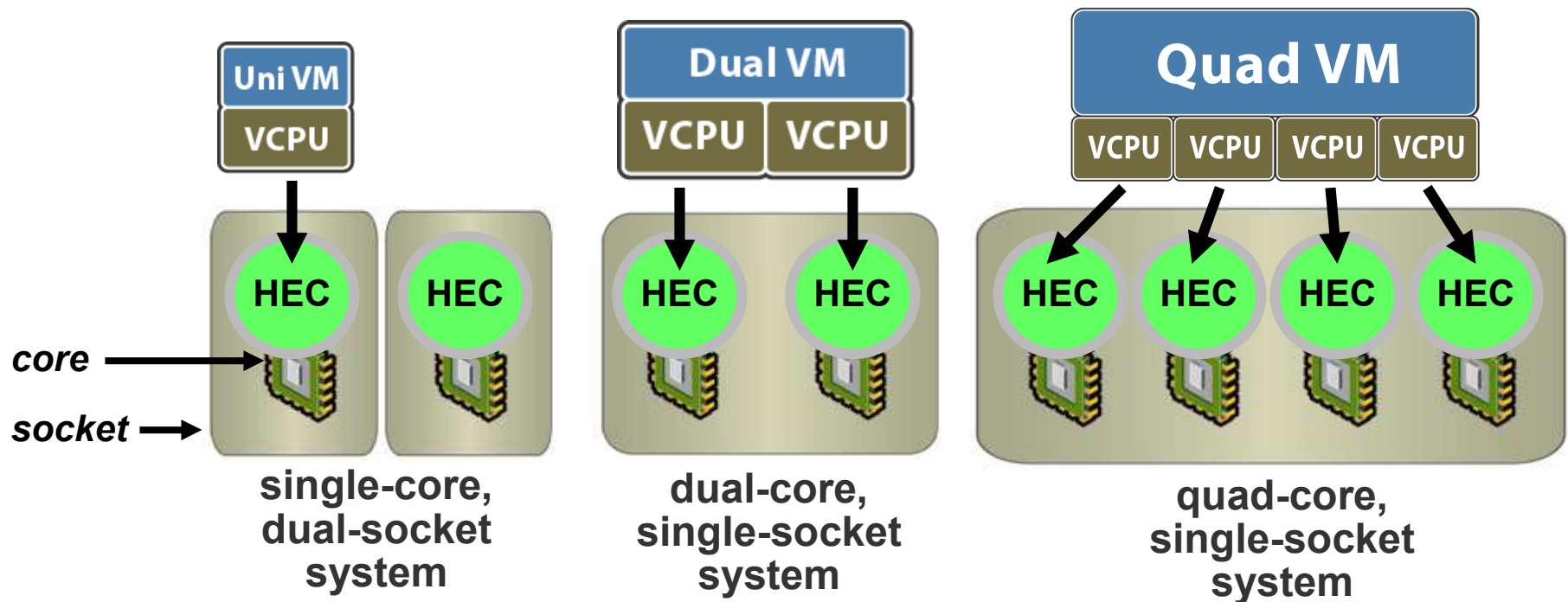
A hardware execution context is a processor's capability to schedule one thread of execution.





## Hardware Execution Contexts

Different systems provide different numbers of hardware execution contexts.

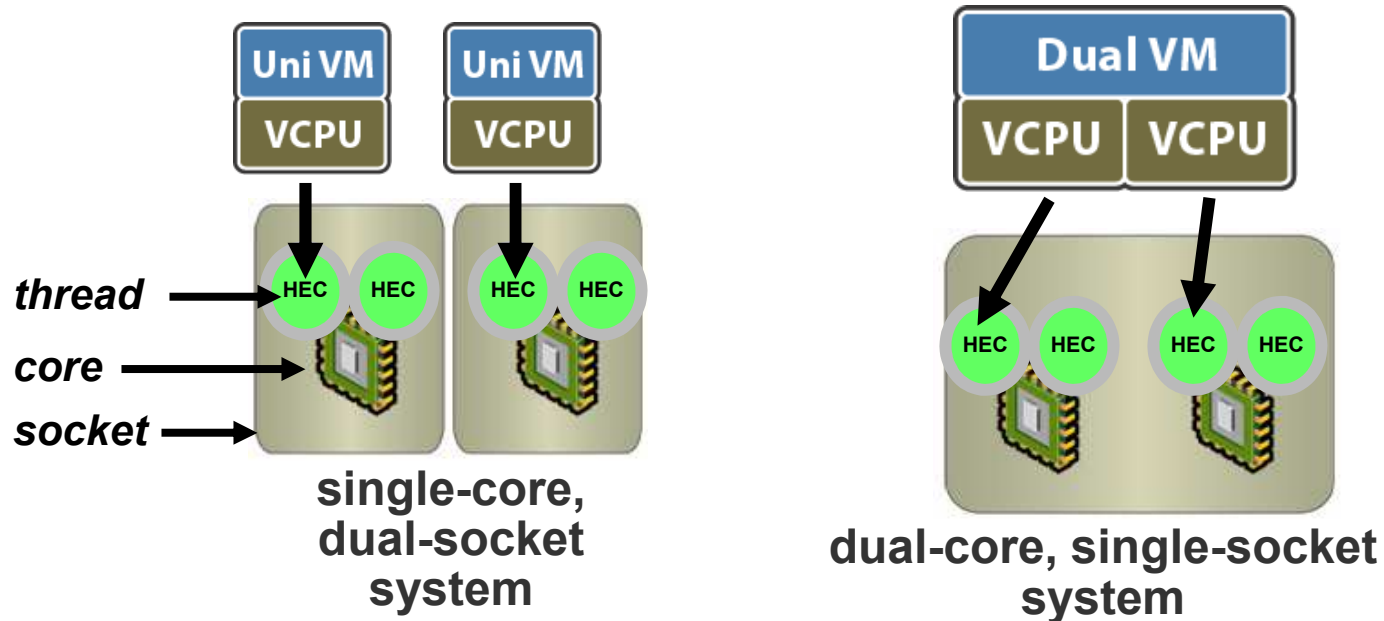


*(Hyperthreading Not Enabled)*

## Hyperthreading

Enables a core to execute two threads, or sets of instructions, at the same time

Provides more hardware execution contexts for VCPUs to be scheduled

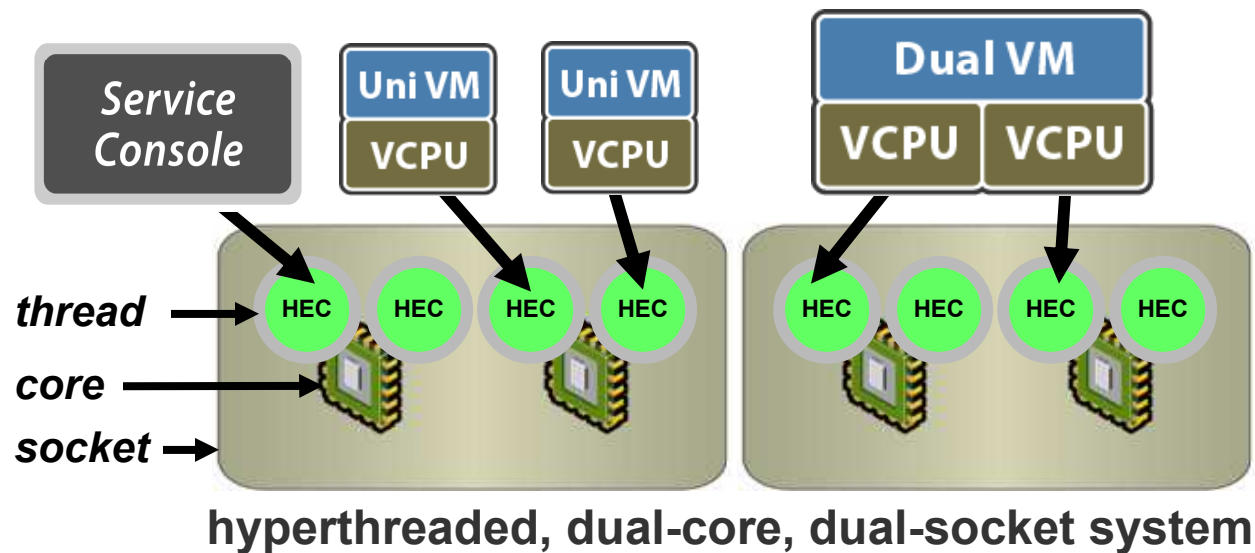


## VMkernel CPU Load Balancing

The VMkernel dynamically schedules virtual machines and the service console.

(VMware ESX™ only) The service console always runs on the first hardware execution context.

The VMkernel avoids scheduling multiple VCPUs on HECs in the same core.



## Memory Virtualization Overview

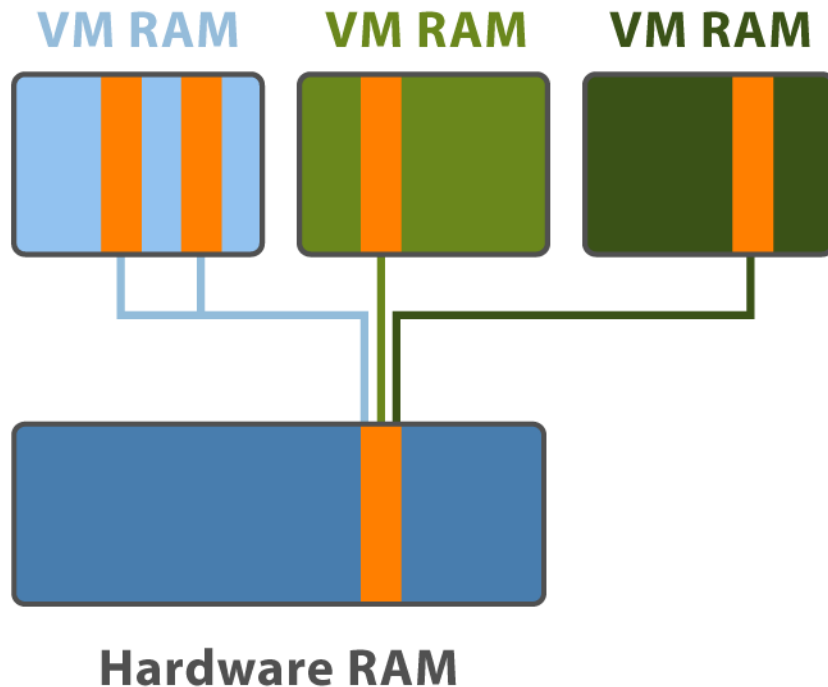
### **The VMkernel manages a machine's entire memory.**

- On ESX and ESXi hosts, part of this memory is for the VMkernel.
- On ESX hosts only, part of this memory is for the service console.
- The rest is available for use by virtual machines.
  - Each virtual machine can reserve some amount of physical memory.
  - Each virtual machine also incurs some amount of overhead.

### **Virtual machines can use more memory than the physical machine has available.**

- This is called memory overcommitment.

## Transparent Memory Page Sharing



The VMkernel detects identical pages in virtual machines' memory and maps them to the same underlying physical page.

- > No changes to guest operating system required

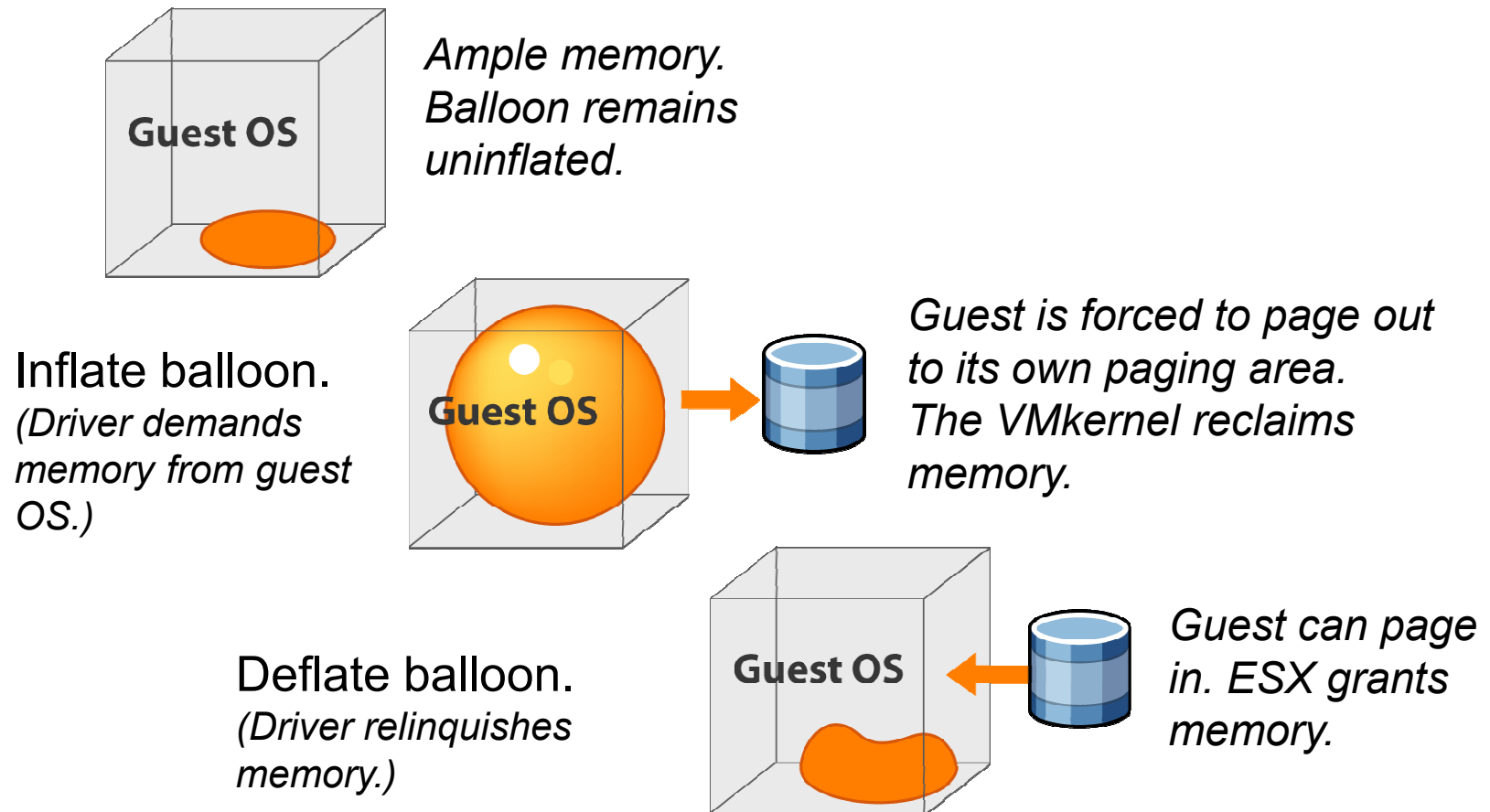
The VMkernel treats the shared pages as copy-on-write.

- > Read-only when shared
- > Private copies after write

Page sharing is always active, unless administratively disabled.

## vmmemctl: Balloon-Driver Mechanism

Deallocate memory from selected virtual machines when RAM is scarce.



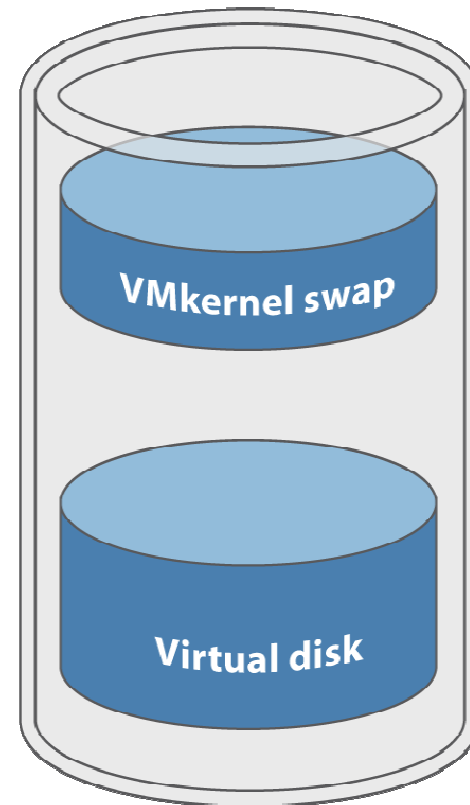
## VMkernel Swap

**Each powered-on virtual machine needs its own VMkernel swap file.**

- Created when the VM is powered on, deleted when the VM is powered off
- Default location: same VMware vStorage VMFS volume as virtual machine's boot disk
- Size equal to the difference between the memory guaranteed to it, if any, and the maximum it can use
- Allows the VMkernel to swap out the virtual machine entirely if memory is scarce

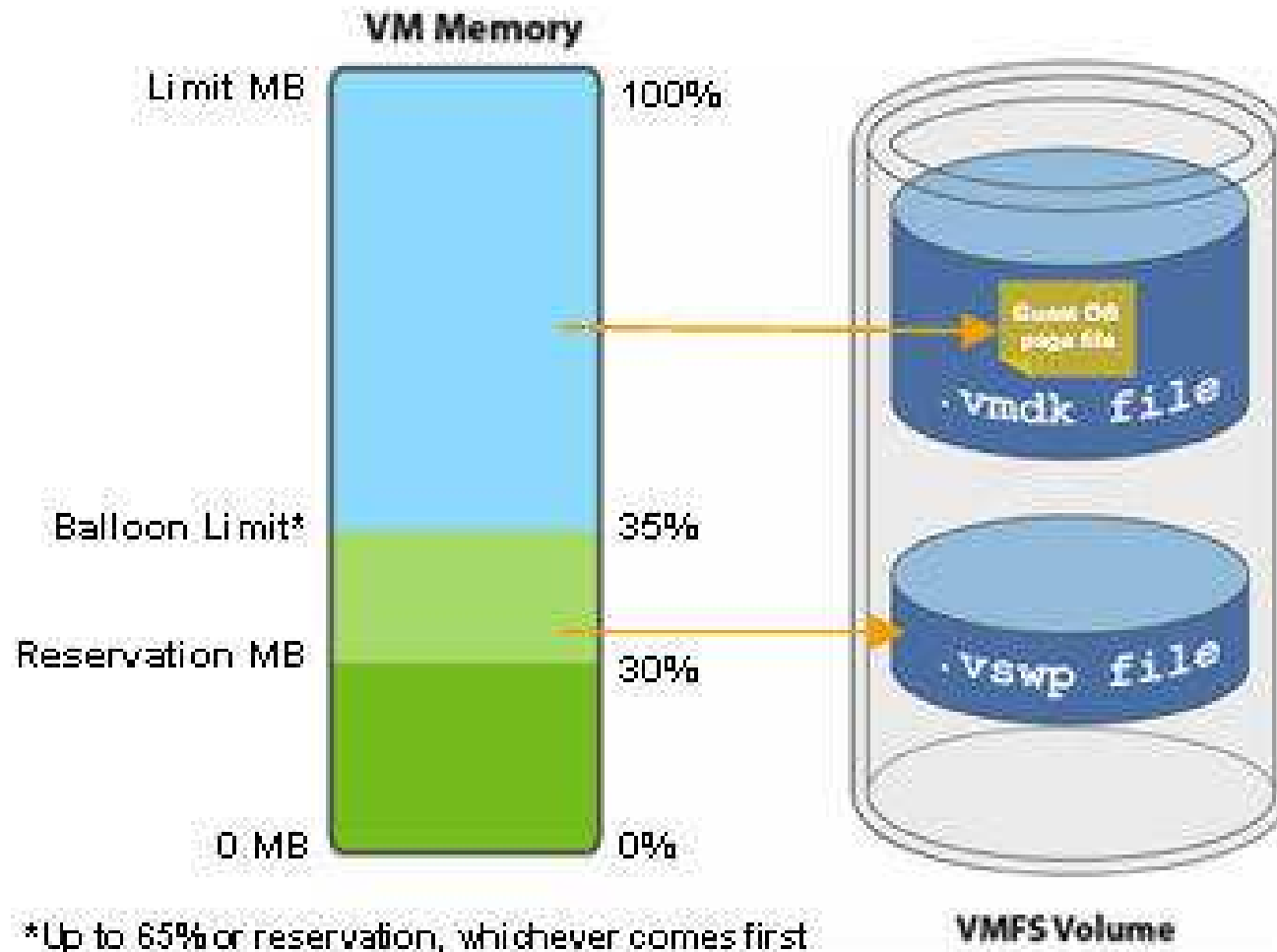
**Use of VMkernel swap is a last resort.**

- Performance will be noticeably slow.



**VMFS volume**

# Ballooning vs. VMkernel Swapping





## Lesson Summary

- The VMkernel uses hyperthreading and load balancing to manage CPU allocated across virtual machines.
- The VMkernel uses transparent page sharing, the balloon driver mechanism, and VMkernel swap files to manage memory allocation across virtual machines.



# Lesson 2: Monitoring Resource Usage

## Lesson Objectives

- Monitor a virtual machine's resource usage
  - CPU
  - Memory
  - Disk
  - Network bandwidth

## Performance-Tuning Methodology

### Assess performance.

- Use appropriate monitoring tools.
- Record a numerical benchmark before changes.

### Identify the limiting resource.

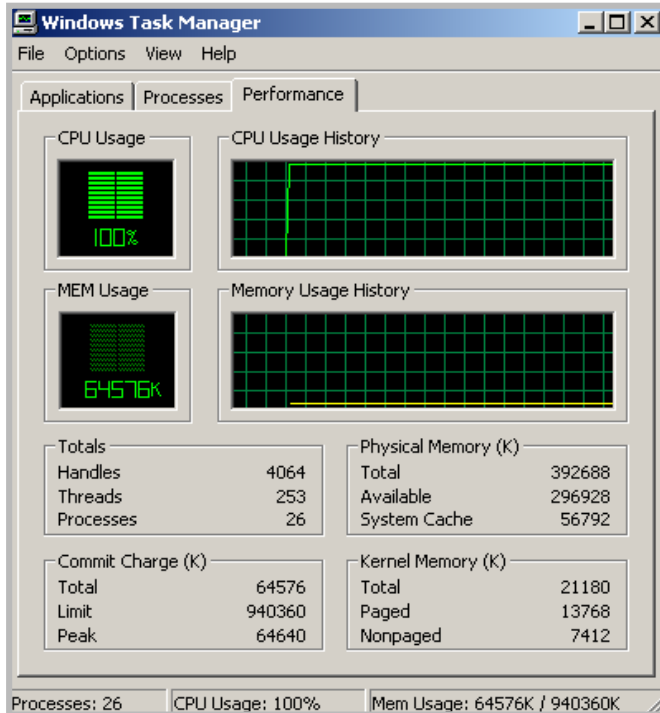
### Make more resource available.

- Allocate more.
- Reduce competition.
- Log your changes!

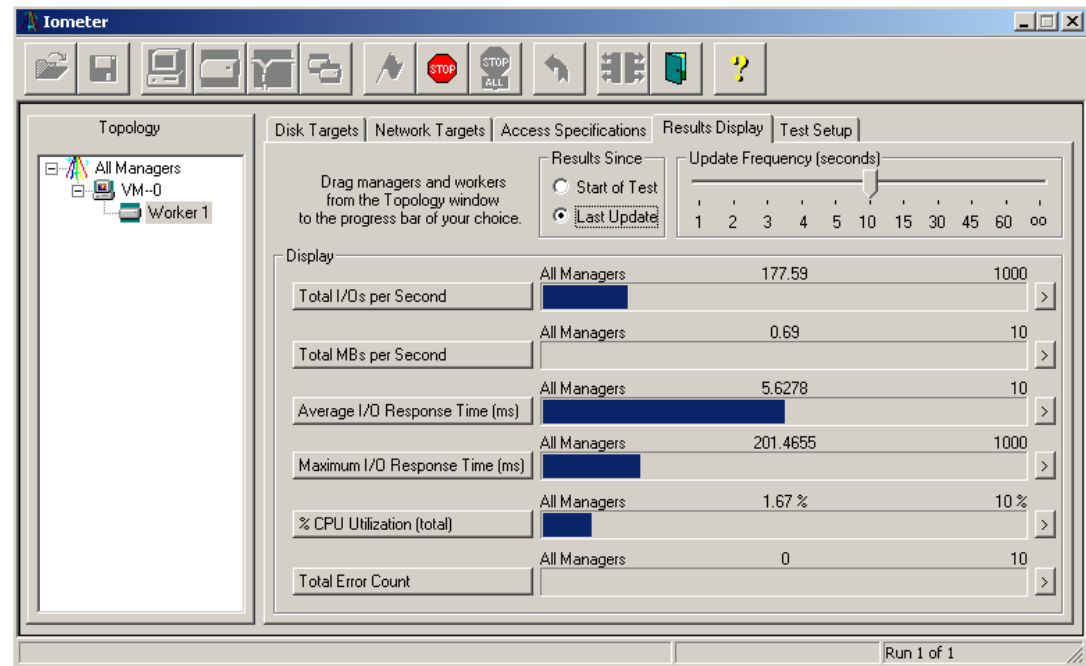
### Benchmark again.

*Do not make casual  
changes to production  
systems!*

# Guest Operating System Monitoring Tools



*Task Manager*



*Iometer*

## Using Perfmon to Monitor VM Resources

VMware Tools' Perfmon DLL provides VM processor and memory object to access host statistics inside a virtual machine.

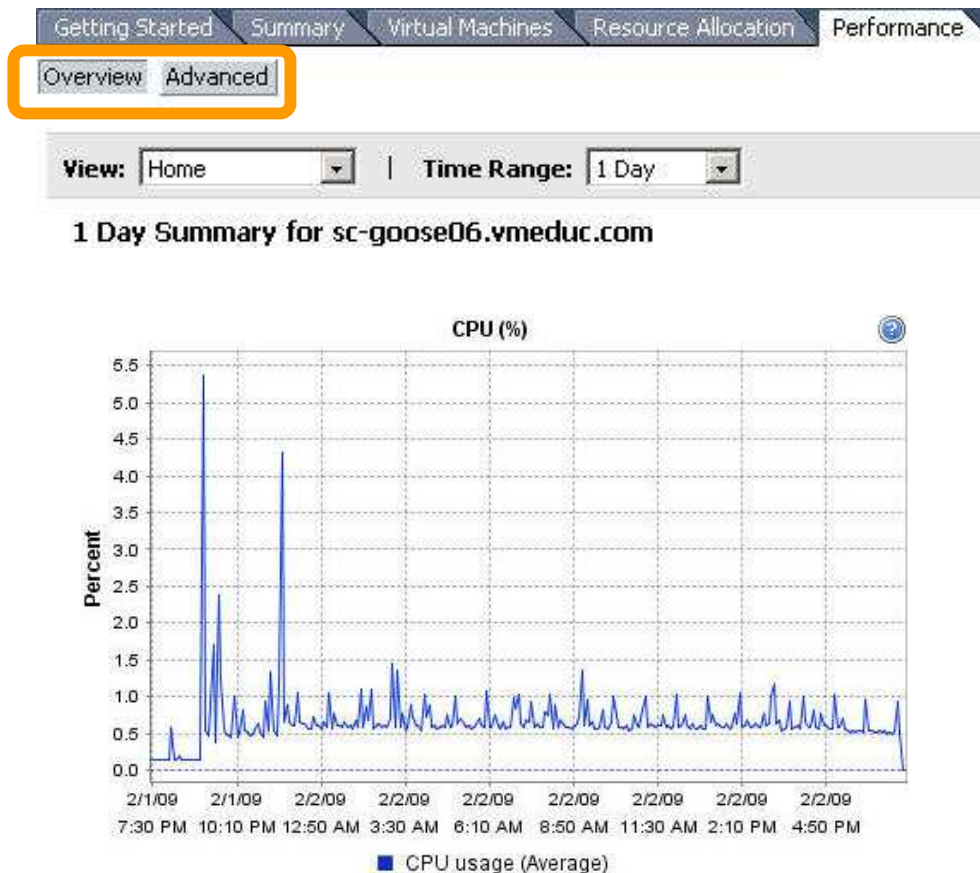
The image shows a Windows Performance Monitor window with two 'Add Counters' dialog boxes overlaid. The background window displays a graph and a table of performance data. The table has columns for Color, Scale, and Counter. The 'Add Counters' dialog boxes are for the computer \\APPSVR02. The left dialog box shows 'VM Memory' selected as the Performance object, with a list of memory-related counters. The right dialog box shows 'VM Processor' selected as the Performance object, with a list of processor-related counters. Both dialog boxes have 'Add' and 'Explain' buttons.

Color	Scale	Counter
Blue	1.000	Pages/s
Green	100...	Avg. Dis
Red	1.000	% Proce
Yellow	0.10...	Memory
Magenta	0.10...	Memory
Cyan	0.01...	Memory
Black	0.01...	Memory
Black	0.10...	Memory

# vCenter Server Performance Charts

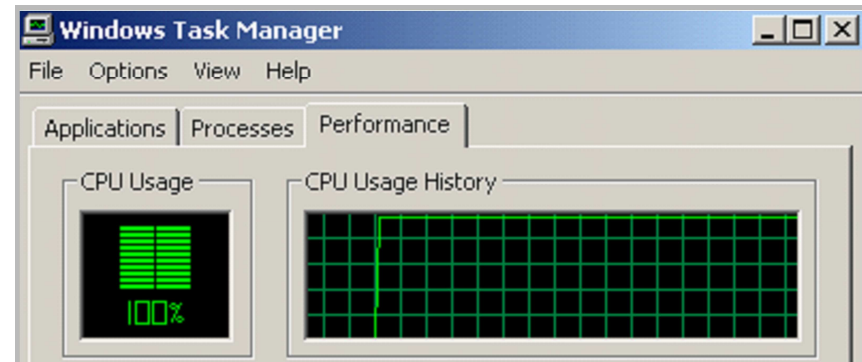
The Performance tab displays two kinds of charts for hosts and virtual machines:

- > Overview charts
  - Display the most common metrics for an object
- > Advanced charts
  - Display data counters not shown in the Overview charts

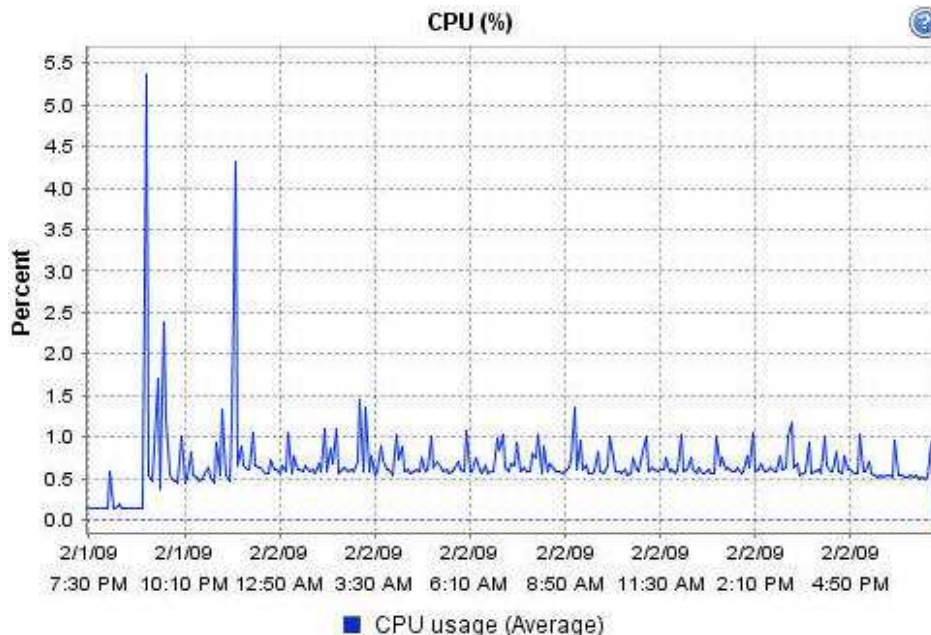


## Interpreting Data from the Tools

**VMware vCenter™ Server monitoring tools and guest operating system monitoring tools provide different points of view.**



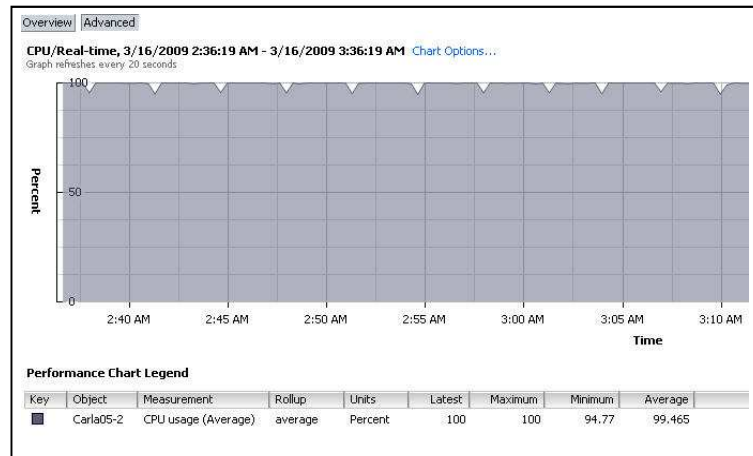
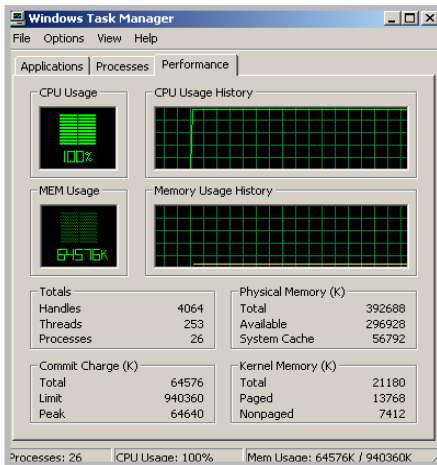
Task Manager in guest operating system



CPU Usage chart for host



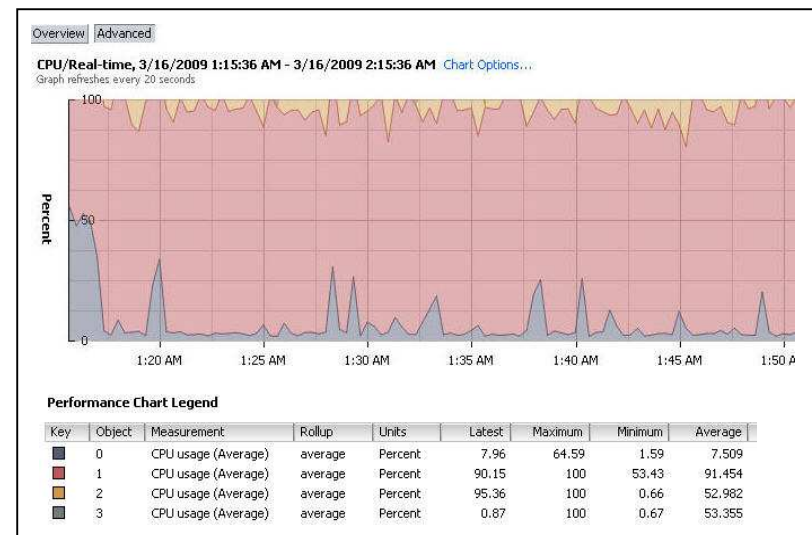
# Is the Virtual Machine CPU-Constrained?



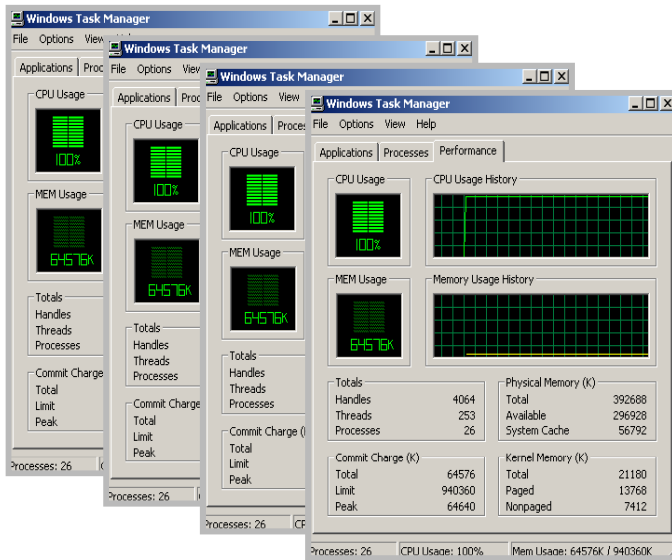
**Check the virtual machine's CPU utilization.**

**If CPU utilization is continuously high, then the virtual machine is constrained by CPU.**

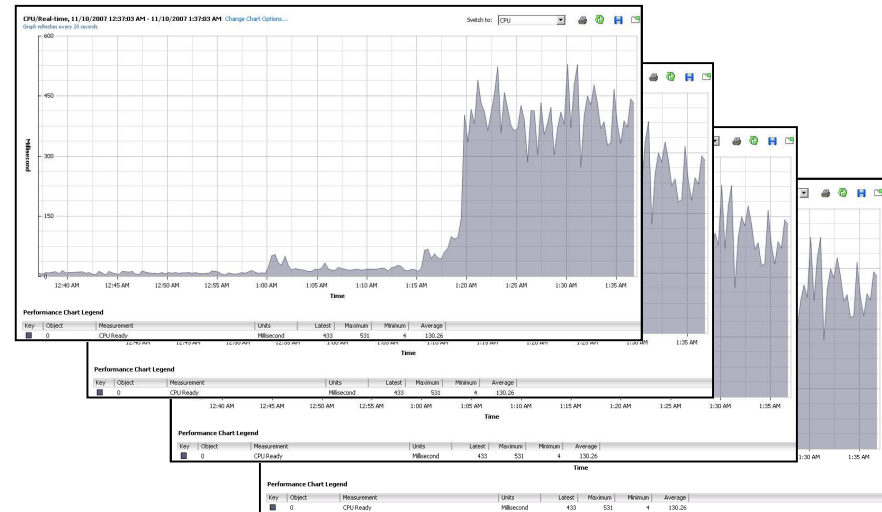
**However, the host might have enough CPU for other virtual machines to run.**



# Are Virtual Machines CPU-Constrained?



**Task Manager of several OSES**

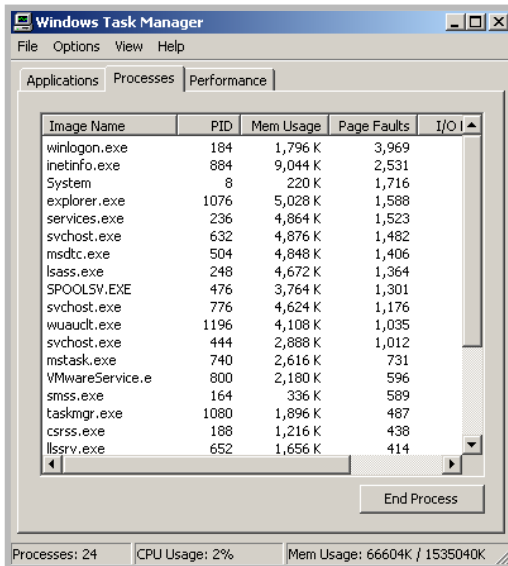


**CPU Ready graph of several VMs**

**Multiple virtual machines are constrained by CPU if:**

- There is high CPU utilization in the guest operating system.
- There are relatively high CPU ready values for the virtual machines.

# Is a Virtual Machine Memory-Constrained?

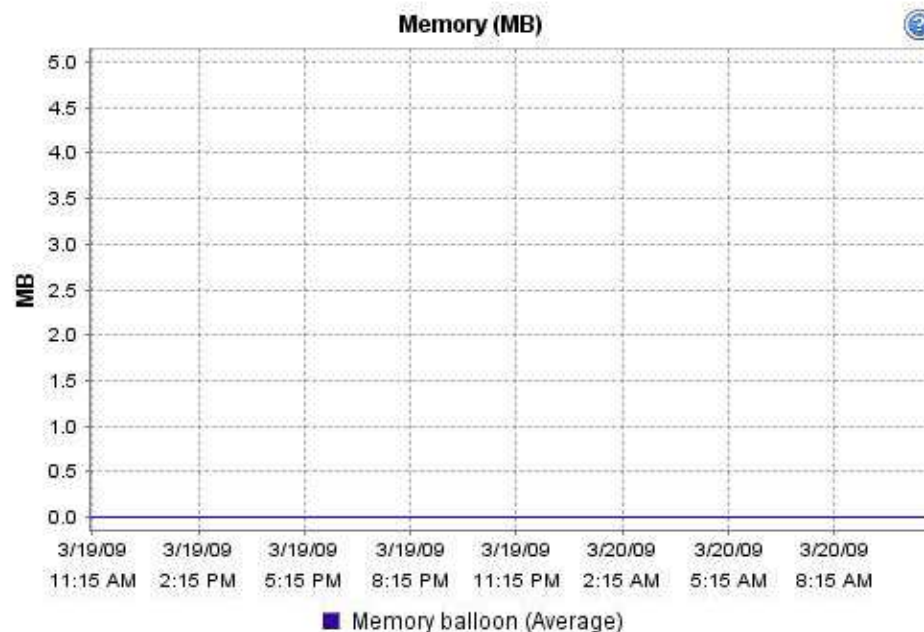


Windows Task Manager Performance tab showing process memory usage. The table below is a transcription of the data shown in the screenshot.

Image Name	PID	Mem Usage	Page Faults	I/O
winlogon.exe	184	1,796 K	3,969	
inetinfo.exe	884	9,044 K	2,531	
System	8	220 K	1,716	
explorer.exe	1076	5,028 K	1,588	
services.exe	236	4,864 K	1,523	
svchost.exe	632	4,876 K	1,482	
msdtc.exe	504	4,848 K	1,406	
lsass.exe	248	4,672 K	1,364	
SPOOLSV.EXE	476	3,764 K	1,301	
svchost.exe	776	4,624 K	1,176	
wuauclt.exe	1196	4,108 K	1,035	
svchost.exe	444	2,888 K	1,012	
mstask.exe	740	2,616 K	731	
VMwareService.e	800	2,180 K	596	
smss.exe	164	336 K	589	
taskmgr.exe	1080	1,896 K	487	
csrss.exe	188	1,216 K	438	
lsrv.exe	652	1,656 K	414	

Processes: 24 CPU Usage: 2% Mem Usage: 66604K / 1535040K

**Task Manager inside VM**

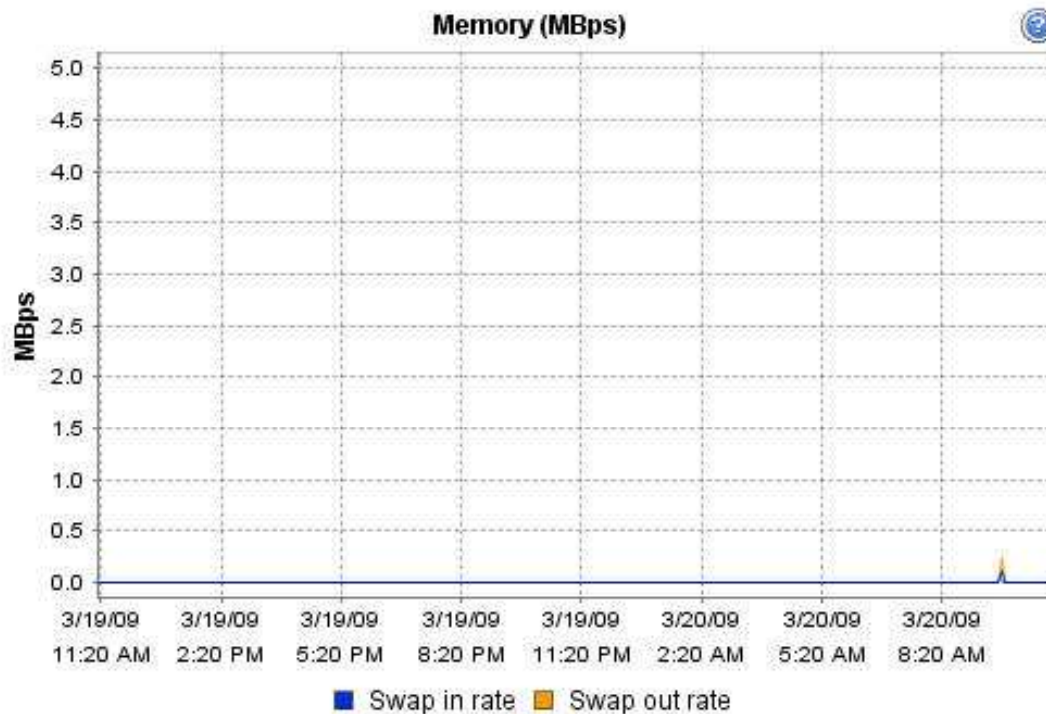


**VM  
ballooning  
activity**

## Check the virtual machine's ballooning activity:

- If ballooning activity is high, this might not be a problem if all virtual machines have sufficient memory.
- If ballooning activity is high and the guest operating system is swapping, then the virtual machine is constrained for memory.

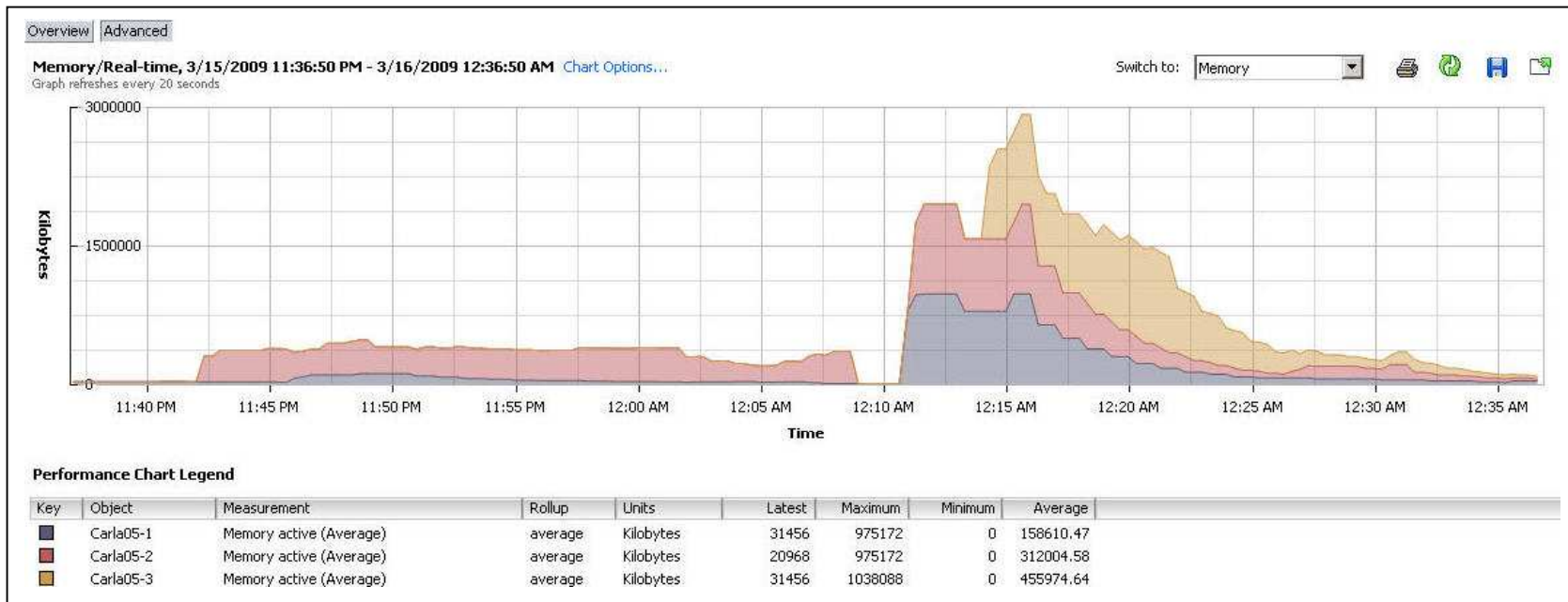
## Is the Host Memory-Constrained?



**Host  
swap-ins/swap-outs**

**If the virtual machines are being swapped in and out, then the host memory is probably overcommitted.**

# Monitoring Active Memory of a Virtual Machine



## Monitor for increases in active memory on the host:

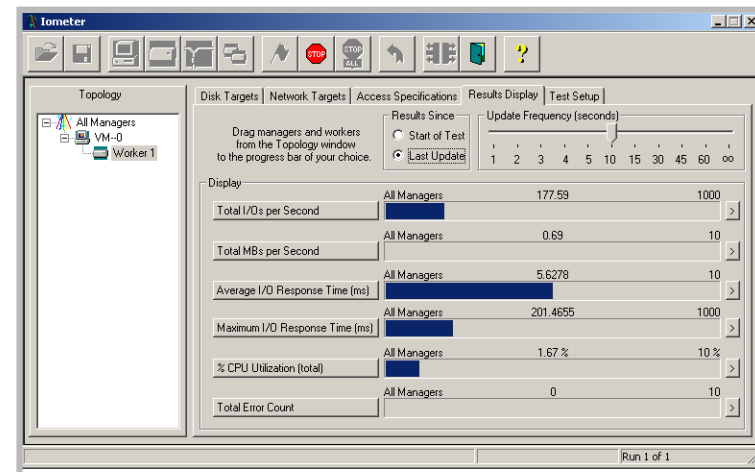
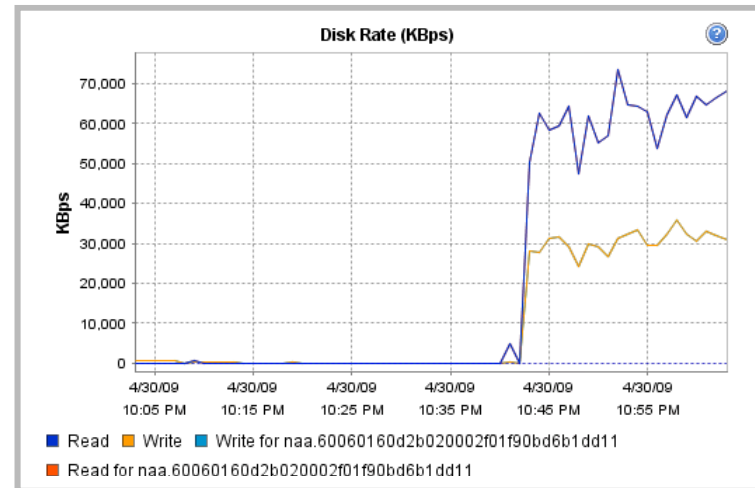
- Host active memory refers to active physical memory used by virtual machines and the VMkernel.
- If amount of active memory is high, this could lead to virtual machines that are memory-constrained.

## Are Virtual Machines Disk-Constrained?

**Disk-intensive applications can saturate the storage or the path.**

**If you suspect that a virtual machine is constrained by disk access:**

- Measure the effective bandwidth between virtual machine and the storage.
- Measure the resource consumption using performance graphs.



## Monitoring Disk Latency

**To determine disk performance problems, monitor two disk latency data counters:**

- Kernel disk command latency
  - The average time spent in the VMkernel per SCSI command
  - High numbers (greater than 2–3ms) represent either an overworked array or an overworked host.
  
- Physical device command latency
  - The average time the physical device takes to complete a SCSI command
  - High numbers (greater than 15–20ms) represent a slow or overworked array.

# Are Virtual Machines Network-Constrained?

**Network-intensive applications often bottleneck on path segments outside the ESX host.**

- Example: WAN links between server and client

**If you suspect that a virtual machine is constrained by the network:**

- Confirm that VMware Tools is installed.
  - Enhanced network drivers are available.
- Measure the effective bandwidth between the virtual machine and its peer system.



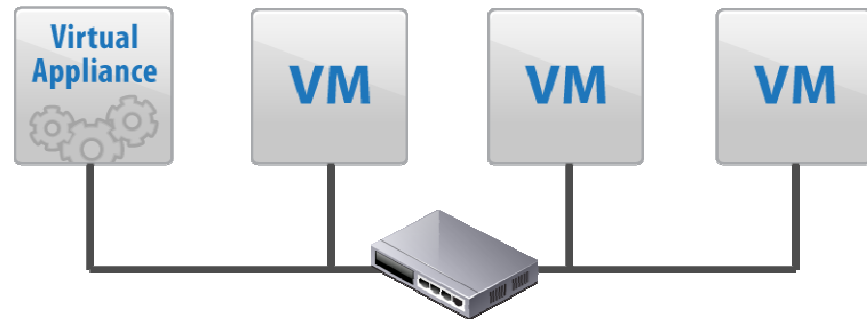


## Application Performance Management: AppSpeed

**A virtual appliance  
for proactive  
application  
performance  
management**

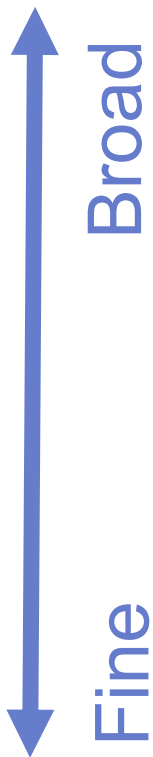
**Provides visibility  
into the performance  
of multitier  
applications running  
in virtual machines**

VMWARE  
vCENTER APPSPEED



## Improving Virtual Machine Performance

Methods for improving virtual machine performance:



**Use a VMware Distributed Resource Scheduler cluster.**

**Use storage multipathing.**

**Use NIC teaming.**

**Modify resource pool's CPU and memory limits and reservations.**

**Modify virtual machine's CPU and memory and reservations.**

**Use network traffic shaping.**

## Lab 15

**In this lab, you will see how CPU workload is reflected by system-monitoring tools.**

1. Monitor CPU utilization using vCenter Server.
2. Run a CPU-intensive application.
3. Undo changes made to your virtual machines for this lab.

## Lesson Summary

- VMware Tool's Perfmon DLL provides a way to get CPU and memory statistics inside a Windows virtual machine.
- Use the Performance tab for real-time graphs showing a virtual machine's resource usage.
- Virtual machine performance can be improved by using shares and reservations, balancing the load with DRS, and storage and network multipathing.



# Lesson 3: Using Alarms

## Lesson Objectives

- Create alarms with condition-based triggers
- Create alarms with event-based triggers
- View and acknowledge triggered alarms

## What Is an Alarm?



































**An alarm is a notification that occurs in response to selected events or conditions that occur with an object in the inventory.**

**Default alarms exist for various inventory objects.**

- Many default alarms for hosts and virtual machines

**You can create custom alarms for a wide range of inventory objects.**

- Virtual machines, hosts, clusters, datacenters, datastores, networks, distributed switches, and distributed port groups

Name
 Status of other host hardware objects
 Virtual machine total disk latency
 Host memory status
 Virtual machine Fault Tolerance seco...
 Host storage status
 Host processor status
 Host error
 Host cpu usage
 Virtual machine Fault Tolerance state ...
 Host hardware voltage
 Virtual machine error
 License error
 Host memory usage
 Host hardware fan status
 Host connection failure
 Cluster high availability error
 Host service console swapout rate
 License inventory monitoring
 Host hardware power status
 Cannot connect to network
 Virtual machine high availability error
 Host service console swapin rate
 Datastore usage on disk
 Host hardware temperature status
 Host hardware system board status
 Cannot connect to storage
 Exit standby error
 Virtual machine cpu usage
 No compatible host for secondary virt...
 Host battery status
 Migration error
 Virtual machine memory usage
 Host connection and power state
 Timed out starting secondary virtual ...

*Default  
Alarms  
(partial list)*

## Creating an Alarm

Right-click inventory object, then choose Alarm > Add Alarm.

**Alarm Settings**

General | Triggers | Reporting | Actions

Alarm name: New Alarm

Description:

Alarm Type

Monitor: Virtual Machines

Monitor for specific conditions or state, for example, CPU usage, power state

Monitor for specific events occurring on this object, for example, VM powered On

⚠ Changing these options will clear current trigger list.

Enable this alarm

### Alarm support for:

- Virtual machines
- Hosts
- Clusters
- Datacenters
- Datastores
- Networks
- Distributed switches
- Distributed port groups



## Alarm Triggers

**An alarm is comprised of a trigger. There are two types:**

- Condition, or state, trigger – Monitors the current condition or state; for example:
  - A virtual machine's current snapshot is above 2GB in size.
  - A host is using 90 percent of its total memory.
  - A datastore has been disconnected from all hosts.
- Event – Monitors events; for example:
  - The health of a host's hardware has changed.
  - There are insufficient licenses in the datacenter.
  - A distributed virtual port group has been reconfigured.

# Configuring Condition Triggers

## Condition triggers for a virtual machine

**Alarm Settings**

General | **Triggers** | Reporting | Actions

Trigger Type	Condition	Warning	Condition Length	Alert	Condition Length
VM CPU Usage (%)	Is above	75	for 5 min	90	for 5 min
VM Heartbeat	Is equal to	None		No Heartbeat	

Trigger if any of the conditions are satisfied  
 Trigger if all of the conditions are satisfied

Add

# Configuring Event Triggers

## Event trigger for a host

The image shows two overlapping windows from the VMware vSphere interface. The background window is titled "Alarm Settings" and has tabs for "General", "Triggers", "Reporting", and "Actions". The "Triggers" tab is active, showing a table of event triggers. The foreground window is titled "Trigger Conditions" and is used to define the conditions for a specific event trigger.

**Alarm Settings - Triggers Tab**

The alarm will trigger if any of the specified events occur.

Event	Status	Conditions
Hardware Health Changed	Alert	<a href="#">Advanced...</a>

**Trigger Conditions Dialog**

Event Arguments

All the entered conditions should be satisfied for the trigger to fire.

Argument	Operator	Value
Data center name	equal to	Training

Add

## Configuring Reporting Options

Use the Reporting pane to avoid needless re-alarms.

**Alarm Settings**

General | Triggers | Reporting | Actions

Range

Repeat triggered alarm when condition exceeds this range:

20 percent (above or below limit)

Frequency

Repeat triggered alarm every:

10 minutes

**Avoid small fluctuations.**

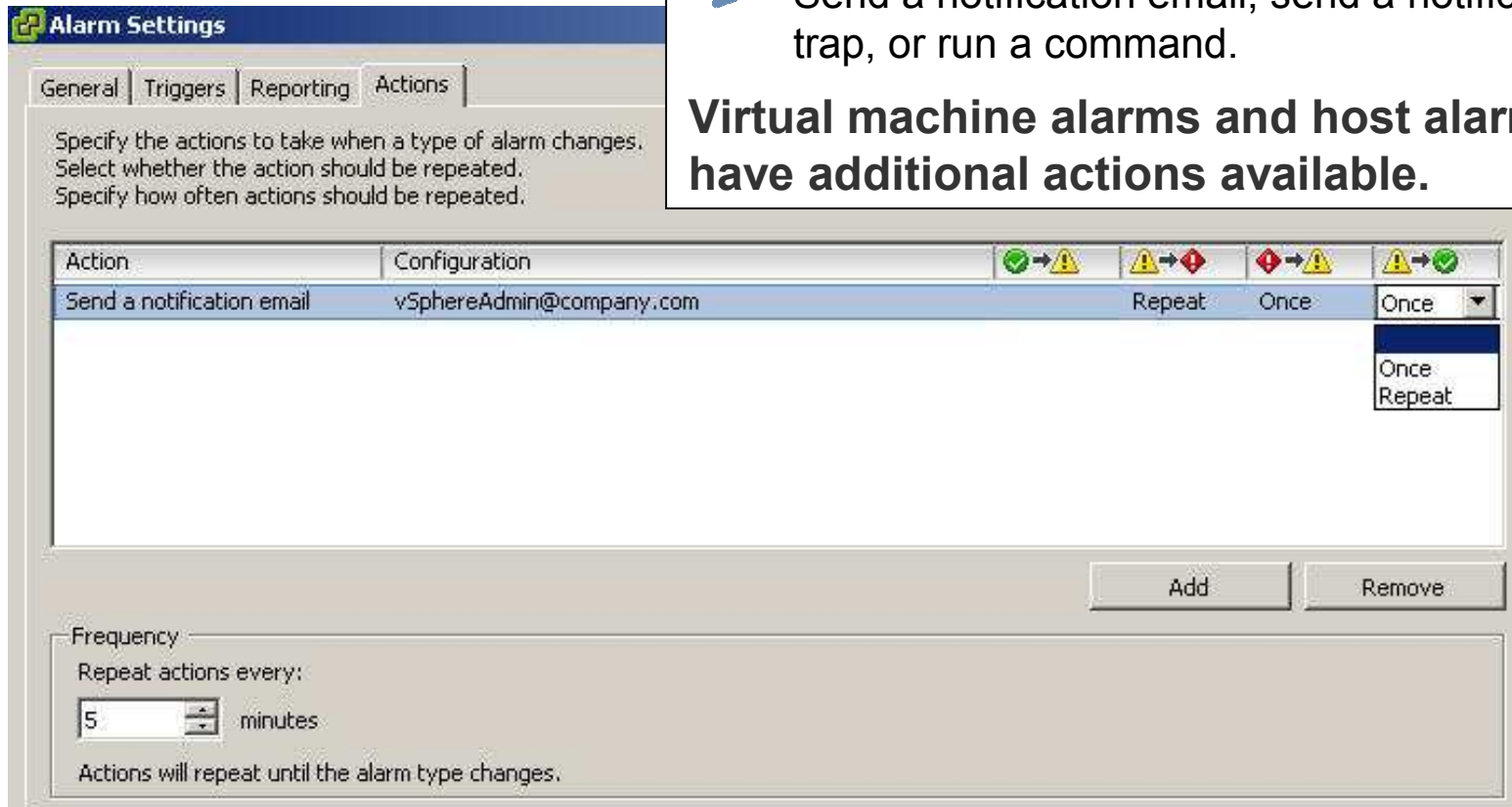
**Avoid repeats.**

# Configuring Actions

**Every alarm type has the following actions:**

- > Send a notification email, send a notification trap, or run a command.

**Virtual machine alarms and host alarms have additional actions available.**



**Alarm Settings**

General | Triggers | Reporting | **Actions**

Specify the actions to take when a type of alarm changes. Select whether the action should be repeated. Specify how often actions should be repeated.

Action	Configuration	Repeat
Send a notification email	vSphereAdmin@company.com	Once

Add Remove

Frequency

Repeat actions every:

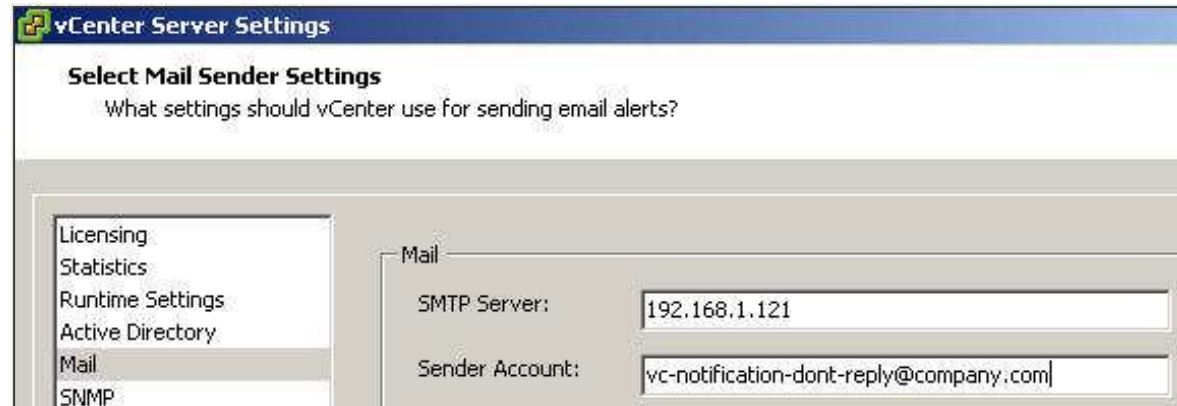
5 minutes

Actions will repeat until the alarm type changes.

## Configuring vCenter Server Notifications

In the menu bar, choose Administration > vCenter Server Settings.

Click Mail to set SMTP parameters.



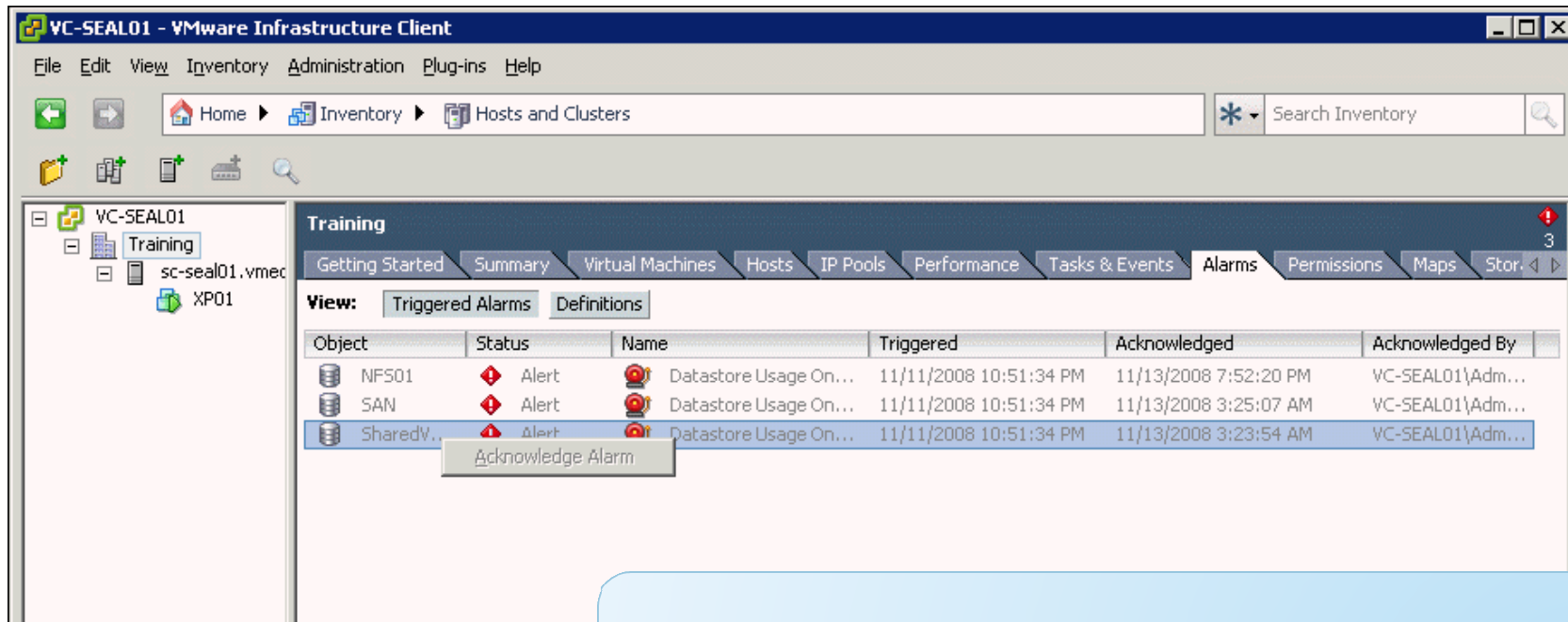
The screenshot shows the 'vCenter Server Settings' window with the 'Mail' tab selected. The title is 'Select Mail Sender Settings' with the subtitle 'What settings should vCenter use for sending email alerts?'. On the left is a navigation pane with 'Mail' highlighted. The main area contains two input fields: 'SMTP Server' with the value '192.168.1.121' and 'Sender Account' with the value 'vc-notification-dont-reply@company.com'.

Click SNMP to specify trap destinations.



The screenshot shows the 'vCenter Server Settings' window with the 'SNMP' tab selected. The title is 'Select SNMP Settings' with the subtitle 'Where will SNMP alerts be received?'. On the left is a navigation pane with 'SNMP' highlighted. The main area contains 'SNMP Receivers' settings. The 'Primary Receiver' is configured with 'Receiver URL' '192.168.1.121' and 'Community String' 'behappy'. There are also checkboxes for 'Enable Receiver 2' and 'Enable Receiver 3', which are currently unchecked.

# Viewing and Acknowledging Triggered Alarms



The screenshot shows the VMware Infrastructure Client interface. The left pane displays a tree view with 'VC-SEAL01' expanded to show 'Training' and 'XP01'. The main pane is titled 'Training' and has tabs for 'Getting Started', 'Summary', 'Virtual Machines', 'Hosts', 'IP Pools', 'Performance', 'Tasks & Events', 'Alarms', 'Permissions', 'Maps', and 'Storage'. The 'Alarms' tab is active, showing a table of triggered alarms. A context menu is open over the 'SharedV...' row, with 'Acknowledge Alarm' selected.

Object	Status	Name	Triggered	Acknowledged	Acknowledged By
NFS01	Alert	Datastore Usage On...	11/11/2008 10:51:34 PM	11/13/2008 7:52:20 PM	VC-SEAL01\Adm...
SAN	Alert	Datastore Usage On...	11/11/2008 10:51:34 PM	11/13/2008 3:25:07 AM	VC-SEAL01\Adm...
SharedV...	Alert	Datastore Usage On...	11/11/2008 10:51:34 PM	11/13/2008 3:23:54 AM	VC-SEAL01\Adm...

The Acknowledgement Alarm feature is used to track when triggered alarms are addressed.

## Lab 16

**In this lab, you will demonstrate the vCenter Server alarm feature.**

1. Create a virtual machine alarm.
2. Trigger the virtual machine alarm, then acknowledge it.
3. Disable the alarms.



## Lesson Summary

- Condition-based alarms monitor the current condition or state of virtual machines, hosts, and datastores.
- Event-based alarms monitor events that occur in response to operations occurring with an inventory object.
- The Acknowledgement Alarm feature is used to track when triggered alarms have been addressed.

## Key Points

- The VMkernel has built-in mechanisms (such as CPU load balancing and transparent page sharing) for managing the CPU and memory allocation on an ESX/ESXi host.
- The Performance tab allows you to monitor a host or virtual machine's performance in real time or over a period of time.
- Monitor your vCenter Server inventory using alarms, which notify you when selected events or conditions have occurred.