



Monitoring ESXi host memory utilization with the policy VI-VMwareVCHostMemUtilMonitor

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The Virtualization Infrastructure SPI provides the policy VI-VMwareVCHostMemUtilMonitor for the monitoring of memory utilization of ESXi hosts. The alerting logic of this policy is very different from what is intuitively expected. This paper describes the metrics, parameters and logic of the policy and provides guidelines for testing the policy.



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How to read this paper?

If the intention is only to implement and test the policy, it is recommended to read the sections:

- Policy parameters
- Before testing the policy
- Testing the policy using exaggerated threshold parameter values

To understand the logic of the policy, it is best to read the whole paper.

Concepts of VMware host memory management in very short

Ballooning and host swapping are two techniques used by ESXi hosts to reclaim memory from virtual machines when falling short of memory.

Ballooning

Memory ballooning is implemented by the process `vmmemctl` that runs on virtual machines where VMware Tools is installed. From the virtual machine's OS point of view, `vmmemctl` is just another process that can allocate and de-allocate memory for its own use. But this process actually cooperates with the host's `vmkernel`. It allocates the amount of reclaimed memory within the virtual machine as non-pageable memory. It indicates the location of the memory to the host's `vmkernel` and then keeps this memory allocated but untouched. The host's `vmkernel` knows that this memory will remain untouched and will safely repurpose it for something else.

As the memory pressure on a host increases, the `vmmemctl` processes of the virtual machines will allocate more memory for the host to repurpose. From the virtual machines perspective, it looks like the memory usage of the process inflates like a balloon. The advantage of this technique is that the virtual machine's OS is given the possibility to reorganize its memory and decide for itself which memory pages may need to be paged out or which processes may need to be swapped out.

Host memory swap

Host memory swap comes into the picture when the host kernel is not able to reclaim sufficient memory through memory ballooning. The host kernel will pick memory pages of virtual machines that it writes into the virtual machine swap file (this is not the virtual machine's OS swap space) to free the underlying physical memory page.

This is a more aggressive technique as the host kernel cannot really determine what will be the performance penalty for picking one or another virtual memory page. This can lead to severe performance issues experienced by the virtual machines.

Metrics consumed by the policy

For each monitored ESXi host, the policy VI-VMwareVCHostMemUtilMonitor uses below metrics collected by the OAVA (Operations Agent Virtual Appliance) to determine if an alert message should be sent.



Metric name	Scope	VMware closest equivalent	Description
MemPhysUtil	Host	mem.usage	Percentage of physical host memory consumed by the virtual machines, the VMkernel and vSphere services (unit: percentage)
MemPhys	Host		Amount of host physical memory (unit: MB)
MemActive	VM	mem.active	Amount of memory that is actively used, as estimated by VMkernel based on recently touched memory pages (unit: MB)
MemSwapUtil	VM	mem.swapped / (non-reserved VM memory) x 100%	Amount of guest physical memory swapped out to the virtual machine's swap file by the VMkernel. Expressed in percentage of non-reserved VM memory.
MemBalloonUtil	VM	mem.vmmemctl / (configured VM memory) x 100%	Amount of guest physical memory that is currently reclaimed from the virtual machine through ballooning. Expressed in percentage of configured VM memory.

The policy also uses below additional metrics to enhance the alert messages. These metrics do not participate in the alerting logic.

Metric name	Scope	VMware equivalent	Description
SystemHostName	Host		Fully qualified domain name of the host
MemOverallHealth	Host	mem.state	VMware counter that determines the swapping and ballooning behavior for memory reclamation based on free host memory
SystemHostName	VM		Fully qualified domain name of the virtual machine

Policy parameters

Below table lists the parameters that can be tuned for this policy.

Name	Default value	Type	Description
HostMemUtilCriticalThreshold	65535	%	These parameters <u>do not directly participate in the alerting logic</u>. If and only if the alerting logic has determined that an alert message should be sent based on total active memory usage, will the host memory utilization be compared to these parameters to determine the severity of the alert message, A value above 100 disables this particular severity. The warning threshold should not be disabled. Threshold values must have increasing values from warning to critical. It is a common mistake to lower just these parameters for testing the policy, but this will not produce the expected results.
HostMemUtilMajorThreshold	95	%	
HostMemUtilMinorThreshold	90	%	
HostMemUtilWarningThreshold	85	%	
VMMemSwapUtilThreshold	20	%	If the amount of VM memory of a particular VM that the ESXi host has swapped out is above or equal to this threshold, the VM is considered potentially under memory pressure.
VMMemBalloonUtilThreshold	10	%	If the amount of VM memory of a particular VM that is reclaimed by ballooning is above or equal to this threshold, the VM is considered potentially under memory pressure.
HighMemSwapUtilVMCountPercentThreshold	70	%	An alert will be sent if the percentage of VMs that are considered potentially under memory pressure due to host swapping is above or equal to this threshold.
HighMemBalloonUtilVMCountPercentThreshold	70	%	An alert will be sent if the percentage of VMs that are considered potentially under memory pressure due to ballooning is above or equal to this hreshold.



MemOverCommitmentThreshold	10	%	Amount of memory over-commitment considered safe, expressed in percentage of host physical memory. A value of 10 indicates that the host can safely handle an amount of total active memory equal to 110% of the host physical memory.
BalloonUtilAndSwapUtilCheck	false	Boolean	Defines which alerting logic to use. If true, the alerting logic is based entirely on host swap and ballooning activity. If false, the alerting logic also considers the total amount of active memory. For details on the alerting logic, read the sections Alerting Criteria and Alerting Logic below.
MessageGroup	Virtualization	String	Message group configured in the alert messages
MessageApplication	VMware	String	Application configured in the alert message
Debug	0	Integer	A value of 1 will result in debug messages sent to the console. A value of 2 will result in debug messages written to the file /var/opt/OV/log/Infraspi.txt

Alerting criteria

In this section, we will describe the various alerting criteria used by the policy VI-VMwareVCHostMemUtilMonitor. Depending on the setting of the parameter BalloonUtilAndSwapUtilCheck, the policy will consider the first two or all of the three below criteria to decide if an alert needs to be sent. The logic of this decision will be described in the next section.

First criterion: host memory swap

In one sentence, the first criterion is satisfied when the percentage of VMs running on the ESXi host that are subject to memory pressure due to host swap activity is greater or equal to the threshold parameter HighMemSwapUtilVMCountPercentThreshold.

Practically, the policy scans through the VMs that are currently running on the ESXi host. For each VM, it looks at the metric MemSwapUtil to determine how much of this VM's memory has been swapped out by the ESXi host. Whenever this amount is greater or equal to the threshold parameter VMMemSwapUtilThreshold, the VM is added to the list VM_Swap_Util_List.

Next, the policy calculates the percentage of VMs currently running on the host that were added to the list VM_Swap_Util_List. The first criterion is satisfied when this percentage is greater or equal to HighMemSwapUtilVMCountPercentThreshold.

Note that this criterion automatically evaluates to 'not satisfied' if no VM is running on the host, or if the only VM running on the host is the OAVA node.

Second criterion: memory ballooning

In one sentence, the second criterion is satisfied when the percentage of VMs running on the ESXi host that are subject to memory pressure due to ballooning is greater or equal to the threshold parameter HighMemBalloonUtilVMCountPercentThreshold.

Practically, the policy scans through the VMs that are currently running on the ESXi host. For each VM, it looks at the metric MemBalloonUtil to determine how much of this VM's memory has been reclaimed through ballooning. Whenever this amount is greater or equal to the threshold parameter VMMemBalloonUtilThreshold, the VM is added to the list VM_Balloon_Util_List.

Next, the policy calculates the percentage of VMs currently running on the host that were added to the list VM_Balloon_Util_List. The second criterion is satisfied when this percentage is greater or equal to HighMemBalloonUtilVMCountPercentThreshold.

Note that this criterion automatically evaluates to 'not satisfied' if no VM is running on the host, or if the only VM running on the host is the OAVA node.

Third criterion: total active memory

In one sentence, the third criterion is satisfied when the total amount of active memory of all VMs that are currently running on the ESXi host is greater or equal to the amount of active memory that the ESXi can safely handle.

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Practically, the policy scans through the VMs that are currently running on the ESXi host. For each VM, it looks at the metric MemActive to determine how much of this VM's memory is active. This metric is summed up for all VMs in the variable Total_Mem_Active.

Next, the policy looks at the metric HostMem and the parameter MemOverCommitmentThreshold to calculate the amount of active memory that the ESXi is able to safely handle:

$$\text{Max_Total_Mem_Active} = \text{HostMem} \times (1 + \text{MemOverCommitmentThreshold}/100)$$

The third criterion is satisfied if:

$$\text{Total_Mem_Active} > \text{Max_Total_Mem_Active}$$

Alerting logic

The policy repeats the alerting logic separately for each monitored ESXi host. The exact alerting logic depends on the parameter BalloonUtilAndSwapUtilCheck as described below.

When parameter BalloonUtilAndSwapUtilCheck = true

The policy will alert if any of the first or second criterion is satisfied. The alert message will always come with severity Major and will show following text:

```
Memory Pressure may increase on the Host ... due to high swap or balloon
utilizations of the VM's.
```

The message text also contains the list of VMs built during verification of the first criterion, if this criterion was satisfied. Similarly it contains the list of VMs built during verification of the second criterion, if this criterion was satisfied.

When parameter BalloonUtilAndSwapUtilCheck = false

The policy will alert if the third criterion is satisfied and any of the first or second criterion is satisfied. The severity of the message is determined as follows:

```
if HostMemUtil >= HostMemUtilCriticalThreshold set severity Critical
elseif HostMemUtil >= HostMemUtilMajorThreshold set severity Major
elseif HostMemUtil >= HostMemUtilMinorThreshold set severity Minor
elseif HostMemUtil >= HostMemUtilWarningThreshold set severity Warning
```

Note that the threshold parameter HostMemUtilWarningThreshold must be defined with the lowest threshold value of these four threshold parameters for consistent behavior of the policy.

The alert message text is like:

```
High Memory Pressure has been detected on ESX/i host ...
%Memory utilization = ...
Host Memory Health = ...
Performance of the host may be affected if this behaviour continues.
```

The message text also contains the list of VMs built during verification of the first criterion, if this criterion was satisfied. Similarly it contains the list of VMs built during verification of the second criterion, if this criterion was satisfied.



Before testing the policy

Before testing the policy, make sure to understand the **source level filters** configured in VISPI policies. This feature can dramatically improve the performance of VISPI policies, but it also introduces new challenges that, if not mastered, will lead to missing performance alerts from the VISPI policies, and thereby failing to run conclusive tests of this policy. The recommendation is to remove numerical source level filters as described in the Support Note "What you must know about source level filters in VISPI policies for VMware monitoring through the OAVA" at:

- [Software Support Online \(KM01512443\)](#)
- [Operations Manager for Unix Support Customer Forum](#)
- [Operations Manager for Windows Support Customer Forum](#)
- [HP Connections](#) (HP internal)

Testing the policy using exaggerated threshold parameter values

To successfully test this policy, one needs to lower the threshold parameters to values that will allow the alerting criteria to be satisfied. Note also that the policy will only alert for hosts that run at least one VM other than the OAVA node.

Testing the policy with BalloonUtilAndSwapUtilCheck = true

Below exaggerated parameter values should enable to produce alerts most of the time when BalloonUtilAndSwapUtilCheck = true.

Name	Test value	Units	Description
VMMemSwapUtilThreshold	0	%	If the amount of VM memory of a particular VM that the ESXi host has swapped out is above or equal to this threshold, the VM is considered potentially under memory pressure.
VMMemBalloonUtilThreshold	0	%	If the amount of VM memory of a particular VM that is reclaimed by ballooning is above or equal to this threshold, the VM is considered potentially under memory pressure.
HighMemSwapUtilVMCountPercentThreshold	0	%	An alert will be sent if the percentage of VMs that are considered potentially under memory pressure due to host swapping is above or equal to this threshold.
HighMemBalloonUtilVMCountPercentThreshold	0	%	An alert will be sent if the percentage of VMs that are considered potentially under memory pressure due to ballooning is above or equal to this hreshold.
BalloonUtilAndSwapUtilCheck	true	Boolean	Defines which alerting logic to use. If true, the alerting logic is based entirely on host swap and ballooning activity. If false, the alerting logic also considers the total amount of active memory. For details on the alerting logic, read the sections Alerting Criteria and Alerting Logic above.

Testing the policy with BalloonUtilAndSwapUtilCheck = false

Below exaggerated parameter values should enable to produce alerts most of the time when BalloonUtilAndSwapUtilCheck = false.

Name	Test value	Units	Description
HostMemUtilCriticalThreshold	65535	%	These parameters do not directly participate in the alerting logic. If and only if the alerting logic has determined that an alert message should be sent based on total active memory usage, will the host memory utilization be compared to these parameters to determine the severity of the alert message, A value above 100 disables this particular severity. The warning threshold should not be disabled. Threshold values must have increasing values from warning to critical. It is a common mistake to lower just these parameters for testing the policy, but this will not produce the expected results.
HostMemUtilMajorThreshold	50	%	
HostMemUtilMinorThreshold	20	%	
HostMemUtilWarningThreshold	1	%	

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VMMemSwapUtilThreshold	0	%	If the amount of VM memory of a particular VM that the ESXi host has swapped out is above or equal to this threshold, the VM is considered potentially under memory pressure.
VMMemBalloonUtilThreshold	0	%	If the amount of VM memory of a particular VM that is reclaimed by ballooning is above or equal to this threshold, the VM is considered potentially under memory pressure.
HighMemSwapUtilVMCountPercentThreshold	0	%	An alert will be sent if the percentage of VMs that are considered potentially under memory pressure due to host swapping is above or equal to this threshold.
HighMemBalloonUtilVMCountPercentThreshold	0	%	An alert will be sent if the percentage of VMs that are considered potentially under memory pressure due to ballooning is above or equal to this threshold.
MemOverCommitmentThreshold	-99	%	Amount of memory over-commitment considered safe, expressed in percentage of host physical memory. A value of 10 indicates that the host can safely handle an amount of total active memory equal to 110% of the host physical memory.
BalloonUtilAndSwapUtilCheck	false	Boolean	Defines which alerting logic to use. If true, the alerting logic is based entirely on host swap and ballooning activity. If false, the alerting logic also considers the total amount of active memory. For details on the alerting logic, read the sections Alerting Criteria and Alerting Logic above.

Testing the policy with controlled threshold parameter values

For more controlled testing of the policy, one can select a host and choose the threshold parameter values so that they are just too high to satisfy the alerting criteria. With these values, the policy should produce an alert within 10 minutes after adding additional memory load on the host, for instance by starting a few additional VMs.

Testing the policy with BalloonUtilAndSwapUtilCheck = true

Below command will provide the current values of relevant metrics for a particular host (esxhost4.gale2.net in this example).

```
# cd /opt/ov/support
# ./easyoa.pl -dn Infrastructure -c Node -m MemSwapUtil,MemBalloonUtil \
-f SystemRole=GUEST,SystemState=on,SystemHostHostName=esxhost4.gale2.net
```

If this command shows for instance that 25% of the VMs have a value of MemSwapUtil greater or equal to 10%, the first criterion described in the Alerting Criteria section above will be satisfied for any values of parameters HighMemSwapUtilVMCountPercentThreshold and VMMemSwapUtilThreshold respectively lower or equal to 25% and 10%.

Similarly, if this command shows for instance that 20% of the nodes have a value of MemBalloonUtil greater or equal to 5%, the second criterion described in the Alerting Criteria section above will be satisfied for any values of parameters HighMemBalloonUtilVMCountPercentThreshold and VMMemBalloonUtilThreshold respectively lower or equal to 20% and 5%.

Testing the policy with BalloonUtilAndSwapUtilCheck = false

First it is necessary to choose parameter values for VMMemSwapUtilThreshold, HighMemSwapUtilVMCountPercentThreshold, VMMemBalloonUtilThreshold and HighMemBalloonUtilVMCountPercentThreshold as described in the testing case where BalloonUtilAndSwapUtilCheck = true.

Next, below command will list the amount of active memory (MemActive) for each VM running on the host (esxhost4.gale2.net in this example).

```
# cd /opt/ov/support
# ./easyoa.pl -dn Infrastructure -c Node -m MemActive \
-f SystemRole=GUEST,SystemState=on,SystemHostHostName=esxhost4.gale2.net
```



Note the filter "`SystemHostHostName=esxhost4.gale2.net`". The variable `SystemHostHostName` contains the hostname of the host on which a virtual machine runs. It is not a typo.

The sum of all the values of `MemActive` provides the total amount of active memory on the host. Next, below command will provide the amount of physical memory (`MemPhys`) and percentage of physical memory in use (`MemPhysUtil`) on the host.

```
# cd /opt/ov/support
# ./easyoa.pl -dn Infrastructure -c Node -m MemPhys,MemPhysUtil \
              -f SystemHostName=esxhost4.gale2.net
```

The value of the parameter `MemOverCommitmentThreshold` should be chosen to satisfy this criterion:

$$\text{Total amount of active memory} > \text{MemPhys} \times (1 + \text{MemOverCommitmentThreshold}/100)$$

Reformulated, this gives:

$$\text{MemOverCommitmentThreshold} < (\text{Total amount of active memory}) / \text{MemPhys} \times 100 - 100$$

Note that this often results in a negative number.

Finally, the parameter `HostMemUtilWarningThreshold` should be set to a value lower or equal to `MemPhysUtil`.

Learn more at

Manuals: <http://support.openview.hp.com/selfsolve/manuals>

Forum: <http://h30499.www3.hp.com/t5/Systems-Management-OpenView-OP/ct-p/sws-OMC>