vSphere Monitoring and Performance

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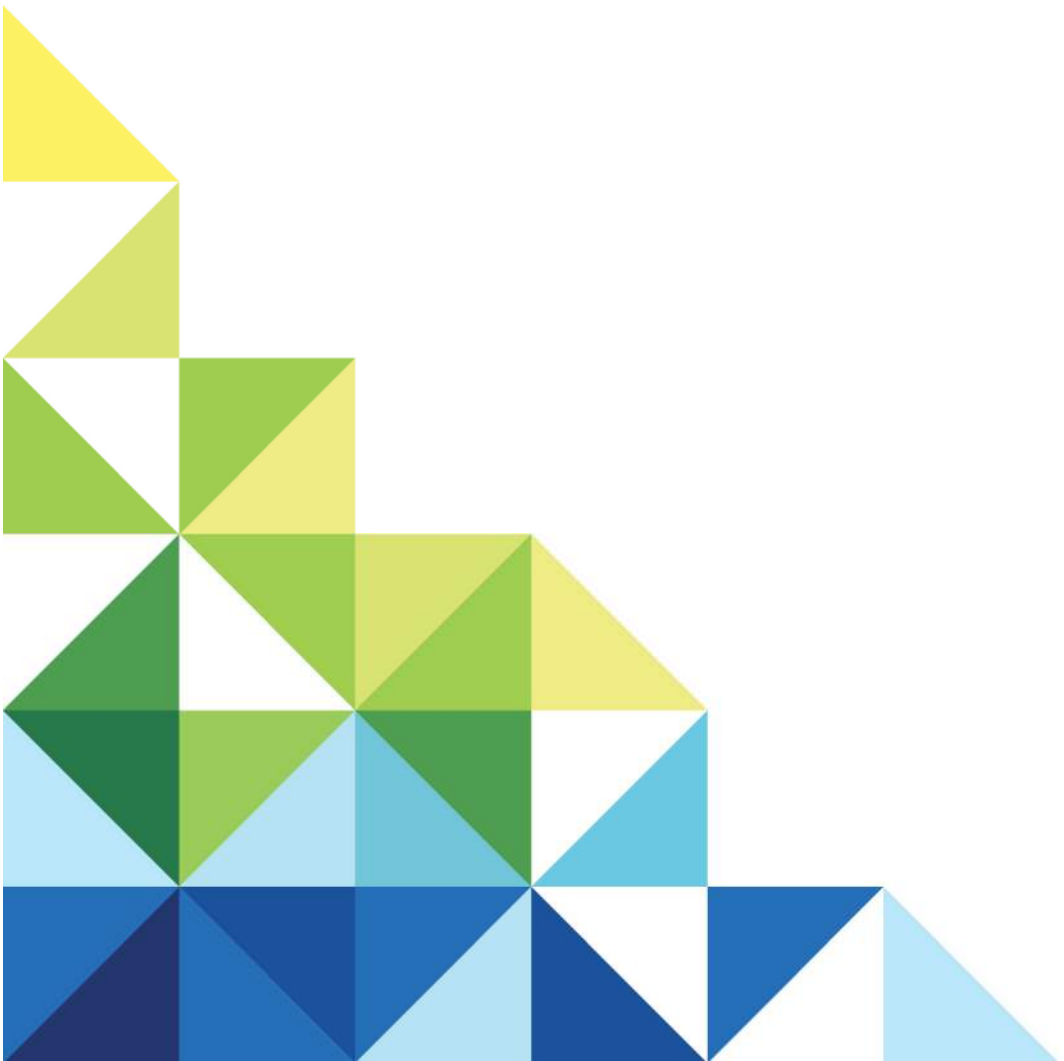

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About vSphere Monitoring and Performance

VMware provides several tools to help you monitor your virtual environment and to locate the source of potential issues and current problems.

Performance Charts	Allow you to see performance data on a variety of system resources including CPU, Memory, Storage, and so on.
Performance Monitoring Command-line Utilities	Allow you to access detailed information on system performance through the command line.
Host Health	Allows you to quickly identify which hosts are healthy and which are experiencing problems.
Events, Alerts, and Alarms	Allow you to configure alerts and alarms and to specify the actions the system should take when they are triggered.
System Log Files	System logs contain additional information about activities in your vSphere environment.

Intended Audience

The content in this section is intended for vSphere administrators who perform the following tasks:

- Monitor the health and performance of physical hardware backings for the virtual environment.
- Monitor the health and performance of virtual devices in the virtual environment.
- Troubleshoot problems in the system.
- Configure alarms.
- Configure SNMP messages.

Virtual machine administrators also might find the section on Chapter 2 Monitoring Guest Operating System Performance helpful.

vSphere Web Client and vSphere Client

Instructions in this guide reflect the vSphere Client (an HTML5-based GUI). You can also use the instructions to perform the tasks by using the vSphere Web Client (a Flex-based GUI).

Tasks for which the workflow differs significantly between the vSphere Client and the vSphere Web Client have duplicate procedures that provide steps according to the respective client interface. The procedures that relate to the vSphere Web Client, contain vSphere Web Client in the title.

Note In vSphere 6.7 Update 1, almost all of the vSphere Web Client functionality is implemented in the vSphere Client. For an up-to-date list of any remaining unsupported functionality, see Functionality Updates for the vSphere Client.

Monitoring Inventory Objects with Performance Charts

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The vSphere statistics subsystem collects data on the resource usage of inventory objects. Data on a wide range of metrics is collected at frequent intervals, processed, and archived in the vCenter Server database. You can access statistical information through command-line monitoring utilities or by viewing performance charts in the vSphere Web Client.

Counters and Metric Groups

vCenter Server systems and hosts use data counters to query for statistics. A data counter is a unit of information relevant to a given inventory object or device. Each counter collects data for a different statistic in a metric group. For example, the disk metric group includes separate data counters to collect data for disk read rate, disk write rate, and disk usage. Statistics for each counter are rolled up after a specified collection interval. Each data counter consists of several attributes that are used to determine the statistical value collected.

For a complete list and description of performance metrics, see the *vSphere API Reference*.

Note Counters that are introduced in later versions might not contain data from hosts of earlier versions. For details, see the VMware Knowledge Base.

Collection Levels and Collection Intervals

Collection levels determine the number of counters for which data is gathered during each collection interval. Collection intervals determine the time period during which statistics are aggregated, calculated, rolled up, and archived in the vCenter Server database. Together, the collection interval and collection level determine how much statistical data is collected and stored in your vCenter Server database.

Data Availability

Real-time data appears in the performance charts only for hosts and virtual machines that are powered on. Historical data appears for all supported inventory objects, but might be unavailable during certain circumstances.

This chapter includes the following topics:

Performance Chart Types

Performance metrics are displayed in different types of charts, depending on the metric type and object.

Table 1-1. Performance Chart Types

Chart Type	Description
Line chart	Displays metrics for a single inventory object. The data for each performance counter is plotted on a separate line in the chart. For example, a network chart for a host can contain two lines: one showing the number of packets received, and one showing the number of packets transmitted.
Bar chart	Displays storage metrics for datastores in a selected data center. Each datastore is represented as a bar in the chart. Each bar displays metrics based on the file type: virtual disks, snapshots, swap files, and other files.
Pie chart	Displays storage metrics for a single object, based on the file types, or virtual machines. For example, a pie chart for a datastore can display the amount of storage space occupied by the virtual machines taking up the largest space.
Stacked chart	Displays metrics for the child objects that have the highest statistical values. All other objects are aggregated, and the sum value is displayed with the term **Other**. For example, a host's stacked CPU usage chart displays CPU usage metrics for the 10 virtual machines on the host that are consuming the most CPU. The **Other** amount contains the total CPU usage of the remaining virtual machines. The metrics for the host itself are displayed in separate line charts. Stacked charts are useful in comparing the resource allocation and usage across multiple hosts or virtual machines. By default, the 10 child objects with the highest data counter values are displayed.

Data Counters

Each data counter includes several attributes that are used to determine the statistical value collected. See the *vSphere API Reference* for a complete list and description of supported counters.

Table 1-2. Data Counter Attributes

Attribute	Description
Unit of Measurement	Standard in which the statistic quantity is measured. ■ Kilobytes (KB) – 1024 bytes ■ Kilobytes per second (KBps) – 1024 bytes per second ■ Kilobits (kb) – 1000 bits ■ Kilobits per second (kbps) – 1000 bits per second ■ Megabytes (MB) ■ Megabytes per second (MBps) ■ Megabits (Mb), megabits per second (Mbps) ■ Megahertz (MHz) ■ Microseconds (µs) ■ Milliseconds (ms) ■ Number (#) ■ Percent (%) ■ Seconds (s)
Description	Text description of the data counter.
Statistics Type	Measurement used during the statistics interval. Related to the unit of measurement. ■ Rate – Value over the current statistics interval ■ Delta – Change from previous statistics interval. ■ Absolute – Absolute value (independent of the statistics interval).
Rollup Type	Calculation method used during the statistics interval to roll up data. Determines the type of statistical values that are returned for the counter. ■ Average – Data collected during the interval is aggregated and averaged. ■ Minimum – The minimum value is rolled up. ■ Maximum – The maximum value is rolled up. The Minimum and Maximum values are collected and displayed only in statistics level 4. Minimum and maximum rollup types are used to capture peaks in data during the interval. For real-time data, the value is the current minimum or current maximum. For historical data, the value is the average minimum or average maximum. For example, the following information for the CPU usage chart shows that the average is collected at statistics level 1. The minimum and maximum values are collected at statistics level 4. ■ Counter: usage ■ Unit: Percentage (%) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4) ■ Summation – Data collected is summed. The measurement displayed in the chart represents the sum of data collected during the interval. ■ Latest – Data collected during the interval is a set value. The value displayed in the performance charts represents the current value.
Collection level	Number of data counters used to collect statistics. Collection levels range from 1 to 4, with 4 having the most counters. **Note** Be careful when you set a higher collection level, as the process requires significant increase of resource usage. For more information, see Data Collection Levels .

Metric Groups in vSphere

The performance data collection subsystem for vSphere collects performance data on various inventory items and their devices. Data counters define individual performance metrics. Performance metrics are organized into logical groups based on the object or object device. Statistics for one or more metrics can be displayed in a chart.

Table 1-3. Metric Groups

Metric group	Description
Cluster Services	Performance statistics for clusters configured by using vSphere Distributed Resource Scheduler, vSphere High Availability, or both.
CPU	CPU utilization per host, virtual machine, resource pool, or compute resource.
Datastore	Statistics for datastore utilization.
Disk	Disk utilization per host, virtual machine, or datastore. Disk metrics include I/O performance, such as latency and read/write speeds, and utilization metrics for storage as a finite resource.
Memory	Memory utilization per host, virtual machine, resource pool, or compute resource. The value obtained is one of the following: ■ For virtual machines, memory refers to the guest physical memory. Guest physical memory is the amount of physical memory presented as a virtual-hardware component to the virtual machine, at creation time, and made available when the virtual machine is running. ■ For hosts, memory refers to the machine memory. Machine memory is the RAM that is installed on the hardware that comprises the host.
Network	Network utilization for both physical and virtual network interface controllers (NICs) and other network devices. The virtual switches that support connectivity among all components, such as hosts, virtual machines, VMkernel.
Power	Energy usage statistics per host.
Storage Adapter	Data traffic statistics per host bus adapter (HBA).
Storage Path	Data traffic statistics per path.
System	Overall system availability, such as the system heartbeat and uptime. These counters are available directly from hosts and from vCenter Server.
Virtual Disk	Disk utilization and disk performance metrics for virtual machines.
Virtual Flash	Virtual flash counters.
Virtual Machine Operations	Virtual machine power and provisioning operations in a cluster or data center.
vSphere Replication	Statistics for the virtual machine replication performed by VMware vCenter Site Recovery Manager.

Data Collection Intervals

Collection intervals determine the duration for which statistics are aggregated, calculated, rolled up, and archived. Together, the collection interval and collection level determine how much statistical data is gathered and stored in your vCenter Server database.

Table 1-4. Collection Intervals

Collection Interval/ Archive Length	Collection Frequency	Default Behavior
1 Day	5 Minutes	Real-time statistics are rolled up to create one data point every 5 minutes. The result is 12 data points every hour and 288 data points every day. After 30 minutes, the six data points collected are aggregated and rolled up as a data point for the 1-Week time range. You can change the interval duration and archive length of the 1-Day collection interval by configuring the statistics settings.
1 Week	30 Minutes	1-Day statistics are rolled up to create one data point every 30 minutes. The result is 48 data points every day and 336 data points every week. Every 2 hours, the 12 data points collected are aggregated and rolled up as a data point for the 1-Month time range. You cannot change the default settings of the 1-Week collection interval.
1 Month	2 Hours	1-Week statistics are rolled up to create one data point every 2 hours. The result is 12 data points every day and 360 data points every month (assuming a 30-day month). After 24 hours, the 12 data points collected are aggregated and rolled up as a data point for the **1-Year** time range. You cannot change the default settings of the 1-Month collection interval.
1 Year	1 Day	1-Month statistics are rolled up to create one data point every day. The result is 365 data points each year. You can change the archive length of the 1-Year collection interval by configuring the statistics settings.

Note If you change the duration of data collection intervals you might need to allocate more storage resources.

Data Collection Levels

Each collection interval has a default collection level that determines the amount of data gathered and which counters are available for display in the charts. Collection levels are also referred to as statistics levels.

Table 1-5. Statistics Levels

Level	Metrics	Best Practice
Level 1	■ Cluster Services (VMware Distributed Resource Scheduler) – all metrics ■ CPU – cpuentitlement, totalmhz, usage (average), usagemhz ■ Disk – capacity, maxTotalLatency, provisioned, unshared, usage (average), used ■ Memory – consumed, mementitlement, overhead, swapinRate, swapoutRate, swapused, totalmb, usage (average), vmmemctl (balloon) ■ Network – usage (average), IPv6 ■ System – heartbeat, uptime ■ Virtual Machine Operations – numChangeDS, numChangeHost, numChangeHostDS	Use for long-term performance monitoring when device statistics are not required. Level 1 is the default Collection Level for all Collection Intervals.
Level 2	■ Level 1 metrics ■ CPU – idle, reservedCapacity ■ Disk – All metrics, excluding numberRead and numberWrite. ■ Memory – All metrics, excluding memUsed and maximum and minimum rollup values. ■ Virtual Machine Operations – All metrics	Use for long-term performance monitoring when device statistics are not required but you want to monitor more than the basic statistics.
Level 3	■ Level 1 and Level 2 metrics ■ Metrics for all counters, excluding minimum and maximum rollup values. ■ Device metrics	Use for short-term performance monitoring after encountering problems or when device statistics are required. Because of the large quantity of troubleshooting data retrieved and recorded, use level 3 for the shortest time period (Day or Week collection interval).
Level 4	All metrics supported by the vCenter Server, including minimum and maximum rollup values.	Use for short-term performance monitoring after encountering problems or when device statistics are required. Because of the large quantity of troubleshooting data retrieved and recorded, use level 4 for the shortest amount of time.

Note When you increase the collection level, the storage and system requirements might change. You might need to allocate more system resources to avoid a decrease in the performance.

View Performance Charts

The vCenter Server statistics settings, the type of object selected, and the features that are enabled on the selected object determine the amount of information displayed in charts. Charts are organized into views. You can select a view to see related data together on one screen. You can also specify the time range, or data collection interval. The duration extends from the selected time range to the present time.

Overview charts display multiple data sets in one panel to evaluate different resource statistics, display thumbnail charts for child objects. It also displays charts for a parent and a child object. Advanced charts display more information than overview charts, are configurable, and can be printed or exported. You can export data in the PNG, JPEG, or CSV formats. See View Advanced Performance Charts.

Procedure

1 Select a valid inventory object in the vSphere Web Client.

   Overview and advanced performance charts are available for datacenter, cluster, host, resource pool, vApp, and virtual machine objects. Overview charts are also available for datastores and datastore clusters. Performance charts are not available for network objects.

2 Click the **Monitor** tab, and click **Performance**.

3 Select a view.

   Available views depend on the type of object. For views that might contain many charts in a large environment, the vSphere Web Client displays the charts distributed on multiple pages. You can use the arrow buttons to navigate between pages.

4 Select a predefined or custom time range.

Performance Charts Options Available Under the View Menu

The performance chart options that you can access under the **View** menu vary depending on the type of inventory object you select.

For example, the **Virtual Machines** view is available when you view host performance charts only if there are virtual machines on the selected host. Likewise, the **Fault Tolerance** view for virtual machine performance charts is available only when that feature is enabled for the selected virtual machine.

Table 1-6. Performance Chart Views by Inventory Object

Object	View List Items
Data center	■ **Storage** - space utilization charts for datastores in the data center, including space by file type and storage space used by each datastore in the data center. ■ **Clusters** - thumbnail CPU and memory charts for each cluster, and stacked charts for total CPU and memory usage in the data center. This view is the default.

Datastore and datastore cluster	■ **Space** - space utilization charts for the datastore:
	  ■ space utilization by file type
	  ■ space utilization by virtual machine
	  ■ space usage
	■ **Performance** - performance charts for the datastore or datastore cluster and for virtual machine disks on the resource.
	Note The Performance view for datastores is only available when all hosts that are connected to the datastores are ESX/ESXi 4.1 or greater. The Performance view for datastore clusters is only available when the Storage DRS is enabled.

Table 1-6. Performance Chart Views by Inventory Object (continued)

Object	View List Items
Cluster	■ **Home** - CPU and memory charts for the cluster. ■ **Resource Pools & Virtual Machines** - thumbnail charts for resource pools and virtual machines, and stacked charts for total CPU and memory usage in the cluster. ■ **Hosts** - thumbnail charts for each host in the cluster, and stacked charts for total CPU, memory, disk usage, and network usage.
Host	■ **Home** - CPU, memory, disk, and network charts for the host. ■ **Virtual Machines** - thumbnail charts for virtual machines, and stacked charts for total CPU usage and total memory usage on the host.
Resource Pool and vApps	■ **Home** - CPU and memory charts for the resource pool. ■ **Resource Pools & Virtual Machines** - thumbnail charts for resource pools, and virtual machines and stacked charts for CPU and memory usage in the resource pool or vApp.
Virtual Machine	■ **Storage** - space utilization charts for the virtual machine: space by file type, space by datastore, and total gigabytes. ■ **Fault Tolerance** - CPU and memory charts that display comparative metrics for the fault-tolerant primary and secondary virtual machines. ■ **Home** - CPU, memory, network, host (thumbnail charts), and disk usage charts for the virtual machine.

Overview Performance Charts

The overview performance charts display the most common metrics for an object in the inventory. Use these charts to monitor and troubleshoot performance problems.

The metrics provided in Overview performance charts are a subset of those collected for hosts and the vCenter Server. For a complete list of all metrics collected by hosts and the vCenter Server, see the *vSphere API Reference*.

Clusters

The cluster charts contain information about CPU, disk, memory, and network usage for clusters. The help topic for each chart contains information about the data counters displayed in that chart. The collection level set for vCenter Server determines the available counters.

CPU (MHz)

The CPU (MHz) chart displays CPU usage for the cluster.

Cluster Counters

This chart is located in the Home view of the Cluster **Performance** tab.

Table 1-7. Data Counters

Chart Label	Description
Usage	Sum of the average CPU usage values, in Megahertz, of all virtual machines in the cluster. ■ Counter: usagemhz ■ Stats Type: Rate ■ Unit: Megahertz (MHz) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)
Total	Total amount of CPU resources available in the cluster. The maximum value is equal to the number of cores multiplied by the frequency of the processors. For example, a cluster has two hosts, each of which has four CPUs that are 3 GHz each, and one virtual machine that has two virtual CPUs. VM totalmhz = 2 vCPUs * 3000 MHz = 6000 MHz Host totalmhz = 4 CPUs * 3000 MHz = 12000 MHz Cluster totalmhz = 2 x 4 * 3000 MHz = 24000 MHz ■ Counter: totalmhz ■ Stats Type: Rate ■ Unit: Megahertz (MHz) ■ Rollup Type: Summation ■ Collection Level: 1

Chart Analysis

A short spike in CPU usage indicates that you are making the best use of cluster resources. However, if the value is constantly high, the CPU demanded is likely greater than the CPU capacity available. A high CPU usage value can lead to increased ready time and processor queuing of the virtual machines on the hosts in the cluster.

If performance is impacted, consider taking the following actions.

Table 1-8. CPU Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on each virtual machine.
2	If the cluster is not a DRS cluster, enable DRS. To enable DRS, perform the following tasks: 1 Select the cluster, and click the **Configure** tab. 2 Under **Services**, click **vSphere DRS**. 3 click **Edit.** An Edit Cluster Settings dialog box opens. 4 Click **Turn ON vSphere DRS**, and click **OK.**
3	If the cluster is a DRS cluster: ■ Increase the number of hosts, and migrate one or more virtual machines to the new host. ■ Check the aggressiveness threshold. If the value is low, increase the threshold. This might help avoid hot spots in the cluster.
4	Migrate one or more virtual machines to a new host.
5	Upgrade the physical CPUs or cores on each host in the cluster if necessary.

Table 1-8. CPU Performance Enhancement Advice (continued)

#	Resolution
6	Enable CPU-saving features, such as TCP Segmentation Offload.
7	Replace software I/O with the dedicated hardware, such as iSCSI HBAs or TCP Segmentation Offload NICs.

CPU Usage

The cluster CPU Usage charts monitor the CPU utilization of the hosts, resource pools, and virtual machines in the cluster. This chart displays the 10 child objects in the cluster with the most CPU usage.

This chart is located in the Resource Pools and Virtual Machines view of the Cluster **Performance** tab.

Table 1-9. Data Counters

Chart Label	Description
<host>, <resource pool>, or <virtual machine>	Amount of CPU actively used by the host, resource pool, or virtual machine in the cluster. ■ Counter: usagemhz ■ Stats Type: Rate ■ Unit: MegaHertz (MHz) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

A short spike in CPU usage indicates that you are making the best use of cluster resources. However, if the value is constantly high, the CPU demanded is likely greater than the CPU capacity available. A high CPU usage value can lead to increased ready time and processor queuing of the virtual machines on the hosts in the cluster.

If performance is impacted, consider taking the following actions.

Table 1-10. CPU Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on each virtual machine.
2	If the cluster is not a DRS cluster, enable DRS. To enable DRS, perform the following tasks: 1 Select the cluster, and click the **Configure** tab. 2 Under **Services**, click **vSphere DRS**. 3 click **Edit.** An Edit Cluster Settings dialog box opens. 4 Click **Turn ON vSphere DRS**, and click **OK.**
3	If the cluster is a DRS cluster: ■ Increase the number of hosts, and migrate one or more virtual machines to the new host. ■ Check the aggressiveness threshold. If the value is low, increase the threshold. This might help avoid hot spots in the cluster.
4	Migrate one or more virtual machines to a new host.
5	Upgrade the physical CPUs or cores on each host in the cluster if necessary.

Table 1-10. CPU Performance Enhancement Advice (continued)

#	Resolution
6	Enable CPU-saving features, such as TCP Segmentation Offload.
7	Replace software I/O with the dedicated hardware, such as iSCSI HBAs or TCP Segmentation Offload NICs.

Disk (KBps)

The Disk (KBps) chart displays the disk I/O of the 10 hosts in the cluster with the most disk usage.

This chart is located in the Hosts view of the cluster **Performance** tab.

Table 1-11. Data Counters

Chart Label	Description
host_name	Average data I/O rate across all hosts in the cluster. ■ Counter: usage ■ Stats Type: Rate ■ Unit: Kilobytes per second (KBps) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

Use the disk charts to monitor average disk loads and to determine trends in disk usage. For example, you might notice a performance degradation with applications that frequently read from and write to the hard disk. If you see a spike in the number of disk read or write requests, check whether any such applications were running then.

The best ways to determine if your vSphere environment is experiencing disk problems is to monitor the disk latency data counters. You can use the advanced performance charts to view these statistics.

- The kernelLatency data counter measures the average amount of time, in milliseconds, that the VMkernel spends processing each SCSI command. For best performance, the value must be 0 -1 milliseconds. If the value is greater than 4 ms, the virtual machines on the host are trying to send more throughput to the storage system than the configuration supports. Check the CPU usage, and increase the queue depth.
- The deviceLatency data counter measures the average amount of time, in milliseconds, to complete a SCSI command from the physical device. Depending on your hardware, a number greater than 15 ms indicates probable problems with the storage array. Move the active VMDK to a volume with more spindles or add disks to the LUN.
- The queueLatency data counter measures the average amount of time taken per SCSI command in the VMkernel queue. This value must always be zero. If not, the workload is too high and the array cannot process the data fast enough.

If the disk latency values are high, or if you notice other problems with disk I/O performance, consider taking the following actions.

Table 1-12. Disk I/O Performance Enhancement Advice

#	Resolution
1	Increase the virtual machine memory. It allows more operating system caching, which reduces I/O activity. Note: It might require you to increase the host memory. Increasing memory might reduce the need to store data because databases can utilize the system memory to cache data and avoid disk access. To verify that virtual machines have adequate memory, check swap statistics in the guest operating system. Increase the guest memory, but not to an extent that leads to excessive host memory swapping. Install VMware Tools so that memory ballooning can occur.
2	Defragment the file systems on all guests.
3	Disable antivirus on-demand scans on the VMDK and VMEM files.
4	Use the vendor's array tools to determine the array performance statistics. When too many servers simultaneously access common elements on an array, the disks might have trouble keeping up. To increase throughput, consider array-side improvements.
5	Use Storage vMotion to migrate I/O-intensive virtual machines across multiple hosts.
6	Balance the disk load across all physical resources available. Spread heavily used storage across LUNs that are accessed by different adapters. Use separate queues for each adapter to improve disk efficiency.
7	Configure the HBAs and RAID controllers for optimal use. Verify that the queue depths and cache settings on the RAID controllers are adequate. If not, increase the number of outstanding disk requests for the virtual machine by adjusting the `Disk.SchedNumReqOutstanding` parameter. For more information, see *vSphere Storage*.
8	For resource-intensive virtual machines, separate the virtual machine's physical disk drive from the drive with the system page file. It alleviates disk spindle contention during periods of high use.
9	On systems with sizable RAM, disable memory trimming by adding the line `MemTrimRate=0` to the virtual machine's VMX file.
10	If the combined disk I/O is higher than a single HBA capacity, use multipathing or multiple links.
11	For ESXi hosts, create virtual disks as preallocated. When you create a virtual disk for a guest operating system, select **Allocate all disk space now**. The performance degradation associated with reassigning additional disk space does not occur, and the disk is less likely to become fragmented.
12	Use the most current host hardware.

Memory (MB)

The Memory (MB) chart displays consumed memory for the cluster. The chart appears only at collection level 1.

This chart is located in the Home view of the cluster **Performance** tab.

Table 1-13. Data Counters

Chart Label	Description
Consumed	Amount of host machine memory used by all powered on virtual machines in the cluster. A cluster's consumed memory consists of virtual machine consumed memory and overhead memory. It does not include host-specific overhead memory, such as memory used by the service console or VMkernel. ■ Counter: consumed ■ Stats Type: Absolute ■ Unit: Megabytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)
Total	Total amount of machine memory of all hosts in the cluster that is available for virtual machine memory (physical memory for use by the Guest OS) and virtual machine overhead memory. Memory Total = Aggregate host machine memory - (VMkernel memory + Service Console memory + other service memory) **Note** The totalmb data counter is the same as the effectivemem data counter, which is supported only for backward compatibility. ■ Counter: totalmb ■ Stats Type: Absolute ■ Unit: Megabytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

Memory usage is not an indicator of performance problems. Memory can be high if a host is swapping or ballooning, which can result in virtual machine guest swapping. In such cases, check for other problems, such as CPU over-commitment or storage latencies.

If you have constantly high memory usage in a cluster, resource pool, or vApp, consider taking the following actions.

Table 1-14. Memory Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on each virtual machine.
2	Verify that the balloon driver is enabled. The balloon driver is installed with VMware Tools and is critical to performance. The VMkernel regularly reclaims unused virtual machine memory by ballooning and swapping. Generally, it does not impact virtual machine performance.
3	If the balloon value is high, check the resource shares, reservations, and limits for the virtual machines and resource pools on the hosts. Verify that the host's settings are adequate and not lower than those set for the virtual machine. If free memory is available on the hosts and the virtual machines are experiencing high swap or balloon memory, the virtual machine (or resource pool, if it belongs to one) has reached its resource limit. Check the maximum resource limit set on that host.

Table 1-14. Memory Performance Enhancement Advice (continued)

#	Resolution
4	If the cluster is not a DRS cluster, enable DRS. To enable DRS, perform the following tasks: 1 Select the cluster, and click the **Configure** tab. 2 Under **Services**, click **vSphere DRS**. 3 click **Edit**. An Edit Cluster Settings dialog box opens. 4 Click **Turn ON vSphere DRS**, and click **OK**.
5	If the cluster is a DRS cluster: ■ Increase the number of hosts, and migrate one or more virtual machines to the new host. ■ Check the aggressiveness threshold. If the value is low, increase the threshold. It might help avoid hot spots in the cluster.
6	Add more physical memory to one or more hosts.

Memory (MB)

The Memory (MB) chart displays memory data counters for clusters. The chart appears at all collection levels except level 1.

Description

This chart is located in the **Home** view of the cluster **Performance** tab.

Note These data counter definitions are for hosts. At the cluster level, the values are collected and totaled. The counter values in the chart represent the aggregate amounts of the host data. The counters that appear in the chart depend on the collection level set for your vCenter Server.

Table 1-15. Data Counters

Chart Label	Description
Active	Sum of the active guest physical memory of all powered on virtual machines on the host, plus memory used by basic VMkernel applications. Active memory is estimated by the VMkernel. ■ Counter: active ■ Stats Type: Absolute ■ Unit: Megabytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 2 (4)
Balloon	Sum of the guest physical memory reclaimed by the balloon driver for all powered on virtual machines on the host. ■ Counter: vmmemctl ■ Stats Type: Absolute ■ Unit: Megabytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Table 1-15. Data Counters (continued)

Chart Label	Description
Consumed	Amount of machine memory used on the host. Consumed memory includes virtual machine memory, service console memory, and VMkernel memory. consumed memory = total host memory - free host memory ■ Counter: consumed ■ Stats Type: Absolute ■ Unit: Megabytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)
Granted	Sum of the guest physical memory granted for all powered on virtual machines. Granted memory is mapped to the host's machine memory. Granted memory for a host includes the shared memory of each virtual machine on the host. ■ Counter: granted ■ Stats Type: Absolute ■ Unit: Megabytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 2 (4)
Swap Used	Sum of the memory swapped by all powered on virtual machines on the host. ■ Counter: swapused ■ Stats Type: Absolute ■ Unit: Megabytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 2 (4)
Total	Aggregate total memory available to the cluster. ■ Counter: totalmb ■ Stats Type: Absolute ■ Unit: Megabytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

To ensure best performance, the host memory must be large enough to accommodate the active memory of the virtual machines. The active memory can be smaller than the virtual machine memory size. It allows you to over-provision memory, but still ensures that the virtual machine active memory is smaller than the host memory.

Transient high-usage values usually do not cause performance degradation. For example, memory usage can be high when several virtual machines are started at the same time or when a spike occurs in virtual machine workload. However, a consistently high memory usage value (94% or greater) indicates that the host is probably lacking the memory required to meet the demand. If the active memory size is the same as the granted memory size, the demand for memory is greater than the memory resources available. If the active memory is consistently low, the memory size might be too large.

If the memory usage value is high, and the host has high ballooning or swapping, check the amount of free physical memory on the host. A free memory value of 6% or less indicates that the host cannot handle the demand for memory. It leads to memory reclamation, which might degrade performance.

If the host has enough free memory, check the resource shares, reservation, and limit settings of the virtual machines and resource pools on the host. Verify that the host settings are adequate and not lower than those set for the virtual machines.

If the host has little free memory available, or if you notice a degradation in performance, consider taking the following actions.

Table 1-16. Memory Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on each virtual machine. The balloon driver is installed with VMware Tools and is critical to performance.
2	Verify that the balloon driver is enabled. The VMkernel regularly reclaims unused virtual machine memory by ballooning and swapping. Generally, it does not impact virtual machine performance.
3	Reduce the memory space on the virtual machine, and correct the cache size if it is too large. This frees up memory for other virtual machines.
4	If the memory reservation of the virtual machine is set to a value much higher than its active memory, decrease the reservation setting so that the VMkernel can reclaim the idle memory for other virtual machines on the host.
5	Migrate one or more virtual machines to a host in a DRS cluster.
6	Add physical memory to the host.

Memory Consumed

The Memory Consumed chart displays memory usage for the 10 child objects in the cluster with the most consumed memory.

For resource pools and virtual machines in a cluster, this chart is located in the **Resource Pools & Virtual Machines** view of the cluster **Performance** tab. For hosts in a cluster, this chart is located in the **Hosts** view of the cluster **Performance** tab.

Table 1-17. Data Counters

Chart Label	Description
resource_pool, *virtual_machine*, or *host*	Amount of machine memory used by all resource pools and virtual machines in the cluster or by all hosts in the cluster, depending on the cluster view. Consumed memory includes virtual machine memory, service console memory, and VMkernel memory. consumed memory = total host memory - free host memory ■ Counter: consumed ■ Stats Type: Absolute ■ Unit: MegaBytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

Memory usage is not an indicator of performance problems. Memory can be high if a host is swapping or ballooning, which can result in virtual machine guest swapping. In such cases, check for other problems, such as CPU over-commitment or storage latencies.

If you have constantly high memory usage in a cluster, resource pool, or vApp, consider taking the following actions.

Table 1-18. Memory Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on each virtual machine.
2	Verify that the balloon driver is enabled. The balloon driver is installed with VMware Tools and is critical to performance. The VMkernel regularly reclaims unused virtual machine memory by ballooning and swapping. Generally, it does not impact virtual machine performance.
3	If the balloon value is high, check the resource shares, reservations, and limits for the virtual machines and resource pools on the hosts. Verify that the host's settings are adequate and not lower than those set for the virtual machine. If free memory is available on the hosts and the virtual machines are experiencing high swap or balloon memory, the virtual machine (or resource pool, if it belongs to one) has reached its resource limit. Check the maximum resource limit set on that host.
4	If the cluster is not a DRS cluster, enable DRS. To enable DRS, perform the following tasks: 1 Select the cluster, and click the **Configure** tab. 2 Under **Services**, click **vSphere DRS**. 3 click **Edit**. An Edit Cluster Settings dialog box opens. 4 Click **Turn ON vSphere DRS**, and click **OK.**
5	If the cluster is a DRS cluster: ■ Increase the number of hosts, and migrate one or more virtual machines to the new host. ■ Check the aggressiveness threshold. If the value is low, increase the threshold. It might help avoid hot spots in the cluster.
6	Add more physical memory to one or more hosts.

Network (Mbps)

The Network (Mbps) chart displays network speed for the 10 hosts in the cluster with the most network usage.

This chart is located in the **Hosts** view of the Cluster **Performance** tab.

Table 1-19. Data Counters

Chart Label	Description
<host>	Average rate at which data is transmitted and received across all NIC instances on the host. ■ Counter: usage ■ Stats Type: Rate ■ Unit: Megabits per second (Mbps) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

Network performance depends on the application workload and network configuration. Dropped network packets indicate a bottleneck in the network. To determine whether packets are being dropped, use `esxtop` or the advanced performance charts to examine the `droppedTx` and `droppedRx` network counter values.

If packets are being dropped, adjust the virtual machine shares. If packets are not being dropped, check the size of the network packets and the data receive and transfer rates. In general, the larger the network packets, the faster the network speed. When the packet size is large, fewer packets are transferred, which reduces the amount of CPU required to process the data. When network packets are small, more packets are transferred but the network speed is slower because more CPU is required to process the data.

Note In some instances, large packets might result in a high network latency. To check the network latency, use the VMware AppSpeed performance monitoring application or a third-party application.

If packets are not being dropped and the data receive rate is slow, the host is probably lacking the CPU resources required to handle the load. Check the number of virtual machines assigned to each physical NIC. If necessary, perform load balancing by moving virtual machines to different vSwitches or by adding more NICs to the host. You can also move virtual machines to another host or increase the host CPU or virtual machine CPU.

If you experience network-related performance problems, also consider taking the following actions.

Table 1-20. Networking Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on each virtual machine.
2	If possible, use vmxnet3 NIC drivers, which are available with VMware Tools. They are optimized for high performance.
3	If virtual machines running on the same host communicate with each other, connect them to the same vSwitch to avoid transferring packets over the physical network.
4	Assign each physical NIC to a port group and a vSwitch.
5	Use separate physical NICs to handle the different traffic streams, such as network packets generated by virtual machines, iSCSI protocols, vMotion tasks.
6	Ensure that the physical NIC capacity is large enough to handle the network traffic on that vSwitch. If the capacity is not enough, consider using a high-bandwidth physical NIC (10 Gbps). Alternatively, consider moving some virtual machines to a vSwitch with a lighter load or to a new vSwitch.
7	If packets are being dropped at the vSwitch port, increase the virtual network driver ring buffers where applicable.
8	Verify that the reported speed and duplex settings for the physical NIC match the hardware expectations and that the hardware is configured to run at its maximum capability. For example, verify that NICs with 1 Gbps are not reset to 100 Mbps because they are connected to an older switch.
9	Verify that all NICs are running in full duplex mode. Hardware connectivity problems might result in a NIC resetting itself to a lower speed or half duplex mode.
10	Use vNICs that are TCP Segmentation Offload (TSO)-capable, and verify that TSO-Jumbo Frames are enabled where possible.

Data centers

The data center charts contain information about CPU, disk, memory, and storage usage for data centers. The help topic for each chart contains information about the data counters displayed in that chart. The counters available are determined by the collection level set for vCenter Server.

CPU (MHz)

The CPU (MHz) chart displays CPU usage for the 10 clusters in the data center with the most CPU usage.

This chart is located in the Clusters view of the Datacenters **Performance** tab.

Table 1-21. Data Counters

Chart Label	Description
<cluster>	Amount of CPU currently in use by the cluster. The active CPU usage is approximately equal to the ratio of the used CPU cycles to the available CPU cycles. The maximum possible value is the frequency of the processors multiplied by the number of cores. For example, a two-way SMP virtual machine using 4000MHz on a host that has four 2GHz processors is using 50% of the CPU (4000 ÷ 4 × 2000) = 0.5). ■ Counter: usagemhz ■ Stats Type: Rate ■ Unit: MegaHertz (MHz) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

A short spike in CPU usage indicates that you are making the best use of cluster resources. However, if the value is constantly high, the CPU demanded is likely greater than the CPU capacity available. A high CPU usage value can lead to increased ready time and processor queuing of the virtual machines on the hosts in the cluster.

If performance is impacted, consider taking the following actions.

Table 1-22. CPU Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on each virtual machine.
2	If the cluster is not a DRS cluster, enable DRS. To enable DRS, perform the following tasks: 1 Select the cluster, and click the **Configure** tab. 2 Under **Services**, click **vSphere DRS**. 3 click **Edit.** An Edit Cluster Settings dialog box opens. 4 Click **Turn ON vSphere DRS**, and click **OK.**
3	If the cluster is a DRS cluster: ■ Increase the number of hosts, and migrate one or more virtual machines to the new host. ■ Check the aggressiveness threshold. If the value is low, increase the threshold. This might help avoid hot spots in the cluster.

Table 1-22. CPU Performance Enhancement Advice (continued)

#	Resolution
4	Migrate one or more virtual machines to a new host.
5	Upgrade the physical CPUs or cores on each host in the cluster if necessary.
6	Enable CPU-saving features, such as TCP Segmentation Offload.
7	Replace software I/O with the dedicated hardware, such as iSCSI HBAs or TCP Segmentation Offload NICs.

Memory (MB)

The Memory (MB) chart displays the average amount of consumed memory for the 10 clusters in the data center with the most consumed memory.

This chart is located in the **Clusters** view of the Datacenters **Performance** tab.

Table 1-23. Data Counters

Chart Label	Description
<cluster>	Amount of host machine memory used by all powered on virtual machines in the cluster. ■ Counter: consumed ■ Stats Type: Absolute ■ Unit: MegaBytes (MB) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

A cluster's consumed memory consists of virtual machine consumed memory and overhead memory. It does not include host-specific overhead memory, such as memory used by the service console or VMkernel.

If you experience problems with cluster memory usage, use the thumbnail cluster charts to examine memory usage for each cluster and increase memory resources if needed.

If the cluster is a DRS cluster, check the aggressiveness threshold. If the value is low, increase the threshold. Increasing the threshold might help avoid hot spots in the cluster.

Space used by Datastore in GB

The Space used by Datastore in GB chart displays the 10 datastores in the data center with the most used disk space.

This chart is located in the **Storage** view of the Datacenter **Performance** tab.

Table 1-24. Data Counters

Chart Label	Description
<datastore>	Amount of used storage space on the 10 datastores with the most used space. ■ Counter: used ■ Stats Type: Absolute ■ Unit: GigaBytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1

Chart Analysis

The datastore is at full capacity when the used space is equal to the capacity. Allocated space can be larger than datastore capacity, for example, when you have snapshots and thin-provisioned disks. If possible, you can provision more space to the datastore, or you can add disks to the datastore or use shared datastores.

If snapshot files are consuming high datastore space, consider consolidating them to the virtual disk when they are no longer needed. Consolidating the snapshots deletes the redo log files and removes the snapshots from the vSphere Web Client user interface. For information about consolidating the data center, see the vSphere documentation.

Space Utilization By File Type

The Space Utilization By File Type chart displays datastore space usage for virtual disks, swap files, snapshot files, and other virtual machine files.

Note This chart does not show historical statistics. It only shows the most recently available data, which may be up to 30 minutes late, depending on when the last statistics rollup occurred. In addition, statistics are not collected across all datastores at one time. They are collected asynchronously.

The Space Utilization by File Type chart is located in the **Storage** view of the data center **Performance** tab.

Datastore Counters

Table 1-25. Data Counters

File Type	Description
Virtual Disks	Amount of disk space used by virtual disk files. Virtual disk files store the contents of the virtual machine's hard disk drive. It includes information that you write to a virtual machine's hard disk, such as the operating system, program files, and data files. The files have the extension `.vmdk` and appear as a physical disk drive to a guest operating system. **Note** Delta disks, which also have an extension `.vmdk`, are not included in this file type. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1 (4)
Swap Files	Amount of disk space used by swap files. Swap files back up the virtual machine's physical memory. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1 (4)
Snapshots	Amount of disk space used by virtual machine snapshot files. Snapshot files store information about virtual machine snapshots. They include snapshot state files and delta disk files. A snapshot state file stores the running state of the virtual machine at the time of the snapshot. It has the extension `.vmsn`. A delta disk file stores the updates made by the virtual machine to the virtual disks after a snapshot is taken. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1 (4)
Other VM Files	Amount of disk space used by all other virtual machine files, such as configuration files and log files. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1 (4)
Other	Amount of disk space used by all other non-virtual machine files, such as documentation files and backup files.
Free Space	Amount of disk space not currently in use.
Total Space	Amount of disk space available to the datastore. It defines the datastore capacity. The chart displays the information for datastores but not for data centers. total space = virtual disk space + swap file space + snapshot space + other VM file space + other space + free space

Chart Analysis

The datastore is at full capacity when the used space is equal to the capacity. Allocated space can be larger than datastore capacity, for example, when you have snapshots and thin-provisioned disks. If possible, you can provision more space to the datastore, or you can add disks to the datastore or use shared datastores.

If snapshot files are consuming high datastore space, consider consolidating them to the virtual disk when they are no longer needed. Consolidating the snapshots deletes the redo log files and removes the snapshots from the vSphere Web Client user interface. For information about consolidating the data center, see the vSphere documentation.

Datastores and Datastore Clusters

The datastore charts contain information about disk usage for datastores or the datastores that are part of a cluster. The help topic for each chart contains information about the data counters displayed in that chart. The counters available are determined by the collection level set for vCenter Server.

Space in GB

The Space in GB chart displays space usage data counters for datastores.

This chart is located in the **Space** view of the datastore or datastore cluster **Performance** tab.

Table 1-26. Data Counters

Chart Label	Description
Allocated	Amount of physical space provisioned by an administrator for the datastore. It is the storage size up to which files on the datastore can grow. Allocated space is not always in use. ■ Counter: provisioned ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1
Used	Amount of physical datastore space in use. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1
Capacity	Maximum capacity of the datastore. capacity = virtual machine file space + non-virtual machine file space + free space **Note** Storage data is collected and updated in the overview charts every 30 minutes. Therefore, if you refresh the datastore, the capacity value might only be updated in the datastore **Summary** tab, and not in the overview charts. ■ Counter: capacity ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1

Chart Analysis

The datastore is at full capacity when the used space is equal to the capacity. Allocated space can be larger than datastore capacity, for example, when you have snapshots and thin-provisioned disks. If possible, you can provision more space to the datastore, or you can add disks to the datastore or use shared datastores.

If snapshot files are consuming high datastore space, consider consolidating them to the virtual disk when they are no longer needed. Consolidating the snapshots deletes the redo log files and removes the snapshots from the vSphere Web Client user interface. For information about consolidating the data center, see the vSphere documentation.

Space Utilization By File Type

The Space Utilization by File Type chart displays space used by virtual disks, swap files, snapshot files, and other virtual machine files on the datastore or the datastore cluster.

Note This chart does not show historical statistics. It only shows the most recently available data, which may be up to 30 minutes late, depending on when the last statistics rollup occurred. In addition, statistics are not collected across all datastores at one time. They are collected asynchronously.

The Space Utilization by File Type chart is located in the **Storage** view of the datastore **Performance** tab. The counters can also be displayed for datastore cluster charts.

Datastore Counters

Table 1-27. Data Counters

File Type	Description
Virtual Disks	Amount of disk space used by virtual disk files. Virtual disk files store the contents of the virtual machine's hard disk drive. It includes information that you write to a virtual machine's hard disk, such as the operating system, program files, and data files. The files have the extension `.vmdk` and appear as a physical disk drive to a guest operating system. **Note** Delta disks, which also have an extension `.vmdk`, are not included in this file type. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1 (4)
Swap Files	Amount of disk space used by swap files. Swap files back up the virtual machine's physical memory. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1 (4)
Snapshots	Amount of disk space used by virtual machine snapshot files. Snapshot files store information about virtual machine snapshots. They include snapshot state files and delta disk files. A snapshot state file stores the running state of the virtual machine at the time of the snapshot. It has the extension `.vmsn`. A delta disk file stores the updates made by the virtual machine to the virtual disks after a snapshot is taken. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1 (4)
Other VM Files	Amount of disk space used by all other virtual machine files, such as configuration files and log files. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1 (4)
Other	Amount of disk space used by all other non-virtual machine files, such as documentation files and backup files.

Table 1-27. Data Counters (continued)

File Type	Description
Free Space	Amount of disk space not currently in use.
Total Space	Amount of disk space available to the datastore. It defines the datastore capacity. The chart displays the information for datastores but not for data centers. total space = virtual disk space + swap file space + snapshot space + other VM file space + other space + free space

Chart Analysis

The datastore is at full capacity when the used space is equal to the capacity. Allocated space can be larger than datastore capacity, for example, when you have snapshots and thin-provisioned disks. If possible, you can provision more space to the datastore, or you can add disks to the datastore or use shared datastores.

If snapshot files are consuming high datastore space, consider consolidating them to the virtual disk when they are no longer needed. Consolidating the snapshots deletes the redo log files and removes the snapshots from the vSphere Web Client user interface. For information about consolidating the data center, see the vSphere documentation.

Space used by Datastore in GB

The Space used by Datastore in GB chart displays the 10 datastores in the data center with the most used disk space.

This chart is located in the **Storage** view of the Datacenter **Performance** tab.

Table 1-28. Data Counters

Chart Label	Description
<datastore>	Amount of used storage space on the 10 datastores with the most used space. ■ Counter: used ■ Stats Type: Absolute ■ Unit: GigaBytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1

Chart Analysis

The datastore is at full capacity when the used space is equal to the capacity. Allocated space can be larger than datastore capacity, for example, when you have snapshots and thin-provisioned disks. If possible, you can provision more space to the datastore, or you can add disks to the datastore or use shared datastores.

If snapshot files are consuming high datastore space, consider consolidating them to the virtual disk when they are no longer needed. Consolidating the snapshots deletes the redo log files and removes the snapshots from the vSphere Web Client user interface. For information about consolidating the data center, see the vSphere documentation.

Space Utilization by Virtual Machine

The Space Utilization by Virtual Machine chart displays the amount of space used by the five virtual machines with the most space used on the datastore or the datastores in the cluster.

Note This chart does not show historical statistics. It only shows the most recently available data, which may be up to 30 minutes late, depending on when the last statistics rollup occurred. In addition, statistics are not collected across all datastores at one time. They are collected asynchronously.

The Space Utilization by Virtual Machine chart is located in the **Space** view of the datastore **Performance** tab. The counter can also be displayed for datastore cluster charts.

Table 1-29. Data Counters

Chart Label	Description
virtual_machine	Amount of datastore space used by the five virtual machines with the most used datastore space. ■ Counter: used ■ Stats Type: Absolute ■ Unit: Gigabytes (GB) ■ Rollup Type: Latest ■ Collection Level: 1

Chart Analysis

The datastore is at full capacity when the used space is equal to the capacity. Allocated space can be larger than datastore capacity, for example, when you have snapshots and thin-provisioned disks. If possible, you can provision more space to the datastore, or you can add disks to the datastore or use shared datastores.

If snapshot files are consuming high datastore space, consider consolidating them to the virtual disk when they are no longer needed. Consolidating the snapshots deletes the redo log files and removes the snapshots from the vSphere Web Client user interface. For information about consolidating the data center, see the vSphere documentation.

Space Allocated by Datastore in GB

The Space allocated by Datastore in GB displays the top 10 datastores, virtual machines in the datastore-cluster with most provisioned space.

This chart is located in the **Space** view of the Datacenter **Performance** tab.

Table 1-30. Data Counters

Chart Label	Description
<datastore>	Amount of provisioned storage space on the top 10 datastores with the most provisioned space. ■ Counter: provisioned ■ Stats Type: Absolute ■ Unit: KiloBytes (KB) ■ Rollup Type: Latest ■ Collection Level: 1

Chart Analysis

The datastore is at full capacity when the used space is equal to the capacity. Allocated space can be larger than datastore capacity, for example, when you have snapshots and thin-provisioned disks. If possible, you can provision more space to the datastore, or you can add disks to the datastore or use shared datastores.

If snapshot files are consuming high datastore space, consider consolidating them to the virtual disk when they are no longer needed. Consolidating the snapshots deletes the redo log files and removes the snapshots from the vSphere Web Client user interface. For information about consolidating the data center, see the vSphere documentation.

Space Capacity by Datastore in GB

The Space capacity by Datastore in GB displays the top 10 configured size of the datastores in the datastore cluster.

This chart is located in the **Space** view of the Datacenter **Performance** tab.

Table 1-31. Data Counters

Chart Label	Description
<datastore>	Configured size of the datastores in the datastore cluster. ■ Counter: capacity ■ Stats Type: Absolute ■ Unit: KiloBytes (KB) ■ Rollup Type: Latest ■ Collection Level: 1

Chart Analysis

The datastore is at full capacity when the used space is equal to the capacity. Allocated space can be larger than datastore capacity, for example, when you have snapshots and thin-provisioned disks. If possible, you can provision more space to the datastore, or you can add disks to the datastore or use shared datastores.

If snapshot files are consuming high datastore space, consider consolidating them to the virtual disk when they are no longer needed. Consolidating the snapshots deletes the redo log files and removes the snapshots from the vSphere Web Client user interface. For information about consolidating the data center, see the vSphere documentation.

Storage I/O Control Normalized Latency

This chart displays the normalized latency in microseconds on the datastore. Storage I/O Control monitors latency to detect congestion on the datastore. This metric computes a weighted response time across all hosts and VMs accessing the datastore. I/O count is used as the weight for the response time. It captures the device level latency and does not include any queuing inside the hypervisor storage stack or inside the VM. It is adjusted for the I/O size. High latencies that are the result of large I/Os are discounted so as not to make the datastore seem slower than it really is. Data for all virtual machines is combined. This chart displays zero values when Storage I/O Control is disabled.

This chart is located in the **Performance** view of the datastore **Performance** tab. The sizeNormalizedDatastoreLatency counter can also be displayed for datastore cluster charts.

Table 1-32. Data Counters

Chart Label	Description
Storage I/O Control Normalized Latency	Storage I/O Control monitors latency to detect congestion on the datastore. ■ Counter: sizeNormalizedDatastoreLatency ■ Stats Type: Absolute ■ Unit: Microseconds ■ Rollup Type: Average ■ Collection Level: 3

Storage I/O Control Aggregate IOPs

This chart displays the number of I/O operations per one second on the datastore, aggregated across all hosts, and virtual machines accessing this datastore. The chart displays zero values when Storage I/O Control is disabled.

This chart is located in the **Performance** view of the datastore or the datastore cluster **Performance** tab. The counter can be displayed for datastore and datastore cluster charts.

Table 1-33. Data Counters

Chart Label	Description
Storage I/O Control Aggregate IOPs	Number of I/O operations per second on the datastore, aggregated across all hosts, and virtual machines accessing the datastore. ■ Counter: datastoreIops ■ Stats Type: Absolute ■ Unit: Number ■ Rollup Type: Average ■ Collection Level: 3

Storage I/O Control Activity

This chart displays the percentage of time during which Storage I/O Control actively controlled latency of the datastore.

This chart is located in the **Performance** views of the datastore **Performance** tabs. The counter can also be displayed for datastore cluster charts.

Table 1-34. Data Counters

Chart Label	Description
Storage I/O Control Activity	This is the percentage of time during which the Storage I/O Control actively controlled the I/O latency for the datastore. ■ Counter: siocActiveTimePercentage ■ Stats Type: Absolute ■ Unit: Percent ■ Rollup Type: Average ■ Collection Level: 3

Average Device Latency per Host

This chart displays the average amount of latency on a host device. The chart displays the 10 hosts with the highest device latency.

This chart is located in the **Performance** view of the datastore **Performance** tab.

Table 1-35. Data Counters

Chart Label	Description
Average Device Latency per Host	Measures the amount of time, in milliseconds, to complete a SCSI command issued from the physical device. ■ Counter: deviceLatency ■ Stats Type: Absolute ■ Unit: Milliseconds (ms) ■ Rollup Type: Average ■ Collection Level: 3

Maximum Queue Depth per Host

This chart displays maximum queue depth that hosts are currently maintaining for the datastore. When Storage I/O is enabled, queue depth can change over time when congestion is detected at the array.

This chart is located in the **Performance** view of the datastore **Performance** tab. The chart displays information about the ten hosts with the highest values.

Table 1-36. Data Counters

Chart Label	Description
Max Queue Depth per Host	Maximum queue depth. Queue depth is the number of commands the SCSI driver queues to the HBA. ■ Counter: maxQueueDepth ■ Stats Type: Absolute ■ Unit: Number ■ Rollup Type: Average ■ Collection Level: 3

Read IOPs per Host

This chart displays the per-host disk read rates for a datastore. The chart displays information about the ten hosts with the highest values.

This chart is located in the **Performance** view of the datastore **Performance** tab.

Table 1-37. Data Counters

Chart Label	Description
Read IOPs per Host	Number of disk read commands completed on each disk on the host, per second. Read rate = blocks read per second × block size ■ Counter: numberReadAveraged ■ Stats Type: Rate ■ Unit: Number ■ Rollup Type: Average ■ Collection Level: 3

Write IOPs Per Host

This chart displays the per-host disk write rates for a datastore. The chart displays information about the 10 hosts with the highest values.

This chart is located in the **Performance** view of the datastore **Performance** tab.

Table 1-38. Data Counters

Chart Label	Description
Write IOPs per Host	Number of disk write commands completed on each disk on the host, per second. Write rate = blocks written per second × block size ■ Counter: numberWriteAveraged ■ Stats Type: Rate ■ Unit: Number ■ Rollup Type: Average ■ Collection Level: 3

Average Read Latency per Virtual Machine Disk

This chart displays the top ten virtual machine disks with the highest average read latency in milliseconds. Data is not displayed when the virtual machine is powered off.

This chart is located in the **Performance** view of the datastore **Performance** tab. The counter can also be displayed for datastore cluster charts.

Table 1-39. Data Counters

Chart Label	Description
Average Read Latency per Virtual Machine Disk	Latency measures the time used to process a SCSI command issued by the guest OS to the virtual machine. The kernel latency is the time VMkernel takes to process an I/O request. The device latency is the time it takes the hardware to handle the request. Total latency = kernelLatency + deviceLatency. ■ Counter: totalReadLatency ■ Stats Type: Absolute ■ Unit: Milliseconds (ms) ■ Rollup Type: Average ■ Collection Level: 3

Average Write Latency per Virtual Machine Disk

This chart displays the top ten virtual machine disks with the highest average write latency in milliseconds. Data is not displayed when the virtual machine is powered off.

This chart is located in the **Performance** view of the datastore **Performance** tab. The counter can also be displayed for datastore cluster charts.

Table 1-40. Data Counters

Chart Label	Description
Average Write Latency per Virtual Machine Disk	Latency measures the time used to process a SCSI command issued by the guest OS to the virtual machine. The kernel latency is the time VMkernel takes to process an I/O request. The device latency is the time it takes the hardware to handle the request. Total latency = kernelLatency + deviceLatency. ■ Counter: totalWriteLatency ■ Stats Type: Absolute ■ Unit: Milliseconds (ms) ■ Rollup Type: Average ■ Collection Level: 3

Read IOPs per Virtual Machine Disk

This chart displays the top ten virtual machines with the highest number of read operations. Data is not displayed when the virtual machine is powered off.

This chart is located in the **Performance** view of the datastore **Performance** tab. The counter can also be displayed for datastore cluster charts.

Table 1-41. Data Counters

Chart Label	Description
Read IOPs per Virtual Machine Disk	Number of disk read commands completed on each virtual machine disk, per second. Read rate = blocks read per second × block size ■ Counter: numberReadAveraged ■ Stats Type: Rate ■ Unit: Number ■ Rollup Type: Average ■ Collection Level: 3

Write IOPs Per Virtual Machine Disk

This chart displays the 10 virtual machines with the highest number of write operations. Data is not displayed when the virtual machine is powered off.

This chart is located in the **Performance** view of the datastore **Performance** tab. The counter can also be displayed for datastore cluster charts.

Table 1-42. Data Counters

Chart Label	Description
Write IOPs per Virtual Machine Disk	Number of disk write commands completed on each virtual machine disk on the host. Write rate = blocks read per second × block size ■ Counter: numberWriteAveraged ■ Stats Type: Rate ■ Unit: Number ■ Rollup Type: Average ■ Collection Level: 3

Virtual Machine Observed Latency per Datastore

This chart displays the average datastore latency as observed by the virtual machines.

This chart is located in the **Performance** view of the datastore cluster **Performance** tab.

Table 1-43. Data Counters

Chart Label	Description
VM observed latency report per Datastore	This is the average datastore latency as observed by the virtual machines in the datastore cluster. ■ Counter: datastoreVMObservedLatency ■ Stats Type: Absolute ■ Unit: Microseconds ■ Rollup Type: Latest ■ Collection Level: 3

Hosts

The hosts charts contain information about CPU, disk, memory, network, and storage usage for hosts. The help topic for each chart contains information about the data counters displayed in that chart. The counters available are determined by the collection level set for vCenter Server.

CPU (%)

The CPU (%) chart displays CPU usage for the host.

This chart is located in the Home view of the Host **Performance** tab.

Table 1-44. Data Counters

Chart Label	Description
Usage	Actively used CPU, as a percentage of the total available CPU, for each physical CPU on the host. Active CPU is approximately equal to the ratio of the used CPU to the available CPU. Available CPU = # of physical CPUs × clock rate. 100% represents all CPUs on the host. For example, if a four-CPU host is running a virtual machine with two CPUs, and the usage is 50%, the host is using two CPUs completely. ■ Counter: usage ■ Stats Type: Rate ■ Unit: Percentage (%) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

A short spike in CPU usage indicates that you are making the best use of the host resources. However, if the value is constantly high, the host is probably lacking the CPU required to meet the demand. A high CPU usage value can lead to increased ready time and processor queuing of the virtual machines on the host.

If performance is impacted, consider taking the following actions.

Table 1-45. CPU Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on every virtual machine on the host.
2	Set the CPU reservations for all high-priority virtual machines to guarantee that they receive the CPU cycles required.
3	Reduce the number of virtual CPUs on a virtual machine to only the number required to execute the workload. For example, a single-threaded application on a four-way virtual machine only benefits from a single vCPU. But the hypervisor's maintenance of the three idle vCPUs takes CPU cycles that could be used for other work.
4	If the host is not already in a DRS cluster, add it to one. If the host is in a DRS cluster, increase the number of hosts and migrate one or more virtual machines onto the new host.

Table 1-45. CPU Performance Enhancement Advice (continued)

#	Resolution
5	Upgrade the physical CPUs or cores on the host if necessary.
6	Use the newest version of hypervisor software, and enable CPU-saving features such as TCP Segmentation Offload, large memory pages, and jumbo frames.

CPU (MHz)

The CPU (MHz) chart displays CPU usage for the host.

This chart is located in the Home view of the Host **Performance** tab.

Table 1-46. Data Counters

Chart Label	Description
Usage	The sum, in megahertz, of the actively used CPU of all powered on virtual machines on a host. The maximum possible value is the frequency of the processors multiplied by the number of processors. For example, if you have a host with four 2GHz CPUs running a virtual machine that is using 4000MHz, the host is using two CPUs completely. 4000 ÷ (4 × 2000) = 0.50 ■ Counter: usagemhz ■ Stats Type: Rate ■ Unit: MegaHertz (MHz) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

A short spike in CPU usage indicates that you are making the best use of the host resources. However, if the value is constantly high, the host is probably lacking the CPU required to meet the demand. A high CPU usage value can lead to increased ready time and processor queuing of the virtual machines on the host.

If performance is impacted, consider taking the following actions.

Table 1-47. CPU Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on every virtual machine on the host.
2	Set the CPU reservations for all high-priority virtual machines to guarantee that they receive the CPU cycles required.
3	Reduce the number of virtual CPUs on a virtual machine to only the number required to execute the workload. For example, a single-threaded application on a four-way virtual machine only benefits from a single vCPU. But the hypervisor's maintenance of the three idle vCPUs takes CPU cycles that could be used for other work.
4	If the host is not already in a DRS cluster, add it to one. If the host is in a DRS cluster, increase the number of hosts and migrate one or more virtual machines onto the new host.

Table 1-47. CPU Performance Enhancement Advice (continued)

#	Resolution
5	Upgrade the physical CPUs or cores on the host if necessary.
6	Use the newest version of hypervisor software, and enable CPU-saving features such as TCP Segmentation Offload, large memory pages, and jumbo frames.

CPU Usage

The CPU Usage chart displays CPU usage of the 10 virtual machines on the host with the most CPU usage.

This chart is located in the Virtual Machines view of the host **Performance** tab.

Table 1-48. Counters

Name	Description
virtual_machine	Amount of CPU actively being used by each virtual machine on the host. 100% represents all CPUs. For example, if a virtual machine has one virtual CPU that is running on a host with four CPUs and the CPU usage is 100%, the virtual machine is using one CPU resource. virtual CPU usage = usagemhz ÷ (number of virtual CPUs × core frequency) **Note** The host's view of the CPU usage, not the guest operating system view. ■ Counter: usage ■ Stats Type: Rate ■ Unit: Percentage (%). Precision is to 1/100%. A value between 0 and 100. ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

A short spike in CPU usage or CPU ready indicates that you are making the best use of the virtual machine resources. However, if the CPU usage value for a virtual machine is above 90% and the CPU ready value is above 20%, performance is being impacted.

If performance is impacted, consider taking the following actions.

Table 1-49. CPU Performance Enhancement Advice

#	Resolution
1	Verify that VMware Tools is installed on every virtual machine on the host.
2	Set the CPU reservations for all high-priority virtual machines to guarantee that they receive the CPU cycles required.
3	Compare the CPU usage value of a virtual machine with the CPU usage of other virtual machines on the host or in the resource pool. The stacked line chart on the host's **Virtual Machine** view shows the CPU usage for virtual machines on the host.
4	Determine whether the high ready time for the virtual machine resulted from its CPU usage time reaching the CPU limit setting. If so, increase the CPU limit on the virtual machine.
5	Increase the CPU shares to give the virtual machine more opportunities to run. The total ready time on the host might remain at the same level if the host system is constrained by CPU. If the host ready time doesn't decrease, set the CPU reservations for high-priority virtual machines to guarantee that they receive the required CPU cycles.

Table 1-49. CPU Performance Enhancement Advice (continued)

#	Resolution
6	Increase the amount of memory allocated to the virtual machine. This decreases disk and or network activity for applications that cache. This might lower disk I/O and reduce the need for the host to virtualize the hardware. Virtual machines with smaller resource allocations generally accumulate more CPU ready time.
7	Reduce the number of virtual CPUs on a virtual machine to only the number required to execute the workload. For example, a single-threaded application on a four-way virtual machine only benefits from a single vCPU. But the hypervisor's maintenance of the three idle vCPUs takes CPU cycles that could be used for other work.
8	If the host is not already in a DRS cluster, add it to one. If the host is in a DRS cluster, increase the number of hosts and migrate one or more virtual machines onto the new host.
9	Upgrade the physical CPUs or cores on the host if necessary.
10	Use the newest version of hypervisor software, and enable CPU-saving features such as TCP Segmentation Offload, large memory pages, and jumbo frames.

Disk (KBps)

The Disk (KBps) chart displays disk I/O of the host.

This chart is located in the Home view of the host **Performance** tab.

Table 1-50. Data Counters

Chart Label	Description
Usage	Average data I/O rate across all LUNs on the host. ■ Counter: usage ■ Stats Type: Rate ■ Unit: Kilobytes per second (KBps) ■ Rollup Type: Average (Minimum/Maximum) ■ Collection Level: 1 (4)

Chart Analysis

Use the disk charts to monitor average disk loads and to determine trends in disk usage. For example, you might notice a performance degradation with applications that frequently read from and write to the hard disk. If you see a spike in the number of disk read or write requests, check whether any such applications were running then.

The best ways to determine if your vSphere environment is experiencing disk problems is to monitor the disk latency data counters. You can use the advanced performance charts to view these statistics.

- The kernelLatency data counter measures the average amount of time, in milliseconds, that the VMkernel spends processing each SCSI command. For best performance, the value must be 0 -1 milliseconds. If the value is greater than 4 ms, the virtual machines on the host are trying to send more throughput to the storage system than the configuration supports. Check the CPU usage, and increase the queue depth.

- The deviceLatency data counter measures the average amount of time, in milliseconds, to complete a SCSI command from the physical device. Depending on your hardware, a number greater than 15 ms indicates probable problems with the storage array. Move the active VMDK to a volume with more spindles or add disks to the LUN.
- The queueLatency data counter measures the average amount of time taken per SCSI command in the VMkernel queue. This value must always be zero. If not, the workload is too high and the array cannot process the data fast enough.

If the disk latency values are high, or if you notice other problems with disk I/O performance, consider taking the following actions.

Table 1-51. Disk I/O Performance Enhancement Advice

#	Resolution
1	Increase the virtual machine memory. It allows more operating system caching, which reduces I/O activity. Note: It might require you to increase the host memory. Increasing memory might reduce the need to store data because databases can utilize the system memory to cache data and avoid disk access. To verify that virtual machines have adequate memory, check swap statistics in the guest operating system. Increase the guest memory, but not to an extent that leads to excessive host memory swapping. Install VMware Tools so that memory ballooning can occur.
2	Defragment the file systems on all guests.
3	Disable antivirus on-demand scans on the VMDK and VMEM files.
4	Use the vendor's array tools to determine the array performance statistics. When too many servers simultaneously access common elements on an array, the disks might have trouble keeping up. To increase throughput, consider array-side improvements.
5	Use Storage vMotion to migrate I/O-intensive virtual machines across multiple hosts.
6	Balance the disk load across all physical resources available. Spread heavily used storage across LUNs that are accessed by different adapters. Use separate queues for each adapter to improve disk efficiency.
7	Configure the HBAs and RAID controllers for optimal use. Verify that the queue depths and cache settings on the RAID controllers are adequate. If not, increase the number of outstanding disk requests for the virtual machine by adjusting the `Disk.SchedNumReqOutstanding` parameter. For more information, see *vSphere Storage*.
8	For resource-intensive virtual machines, separate the virtual machine's physical disk drive from the drive with the system page file. It alleviates disk spindle contention during periods of high use.
9	On systems with sizable RAM, disable memory trimming by adding the line `MemTrimRate=0` to the virtual machine's VMX file.
10	If the combined disk I/O is higher than a single HBA capacity, use multipathing or multiple links.
11	For ESXi hosts, create virtual disks as preallocated. When you create a virtual disk for a guest operating system, select **Allocate all disk space now**. The performance degradation associated with reassigning additional disk space does not occur, and the disk is less likely to become fragmented.
12	Use the most current host hardware.

Disk Rate (KBps)

The Disk Rate chart displays disk read and write rates for LUNs on a host, including average rates.

This chart is located in the **Home** view of the host **Performance** tab.

Table 1-52. Data Counters

Chart Label	Description
Read	Number of disk read commands completed on each disk on the host, per second. The aggregate number of all disk read commands is also displayed in the chart. Read rate = blocksRead per second × blockSize ■ Counter: read ■ Stats Type: Rate ■ Unit: Kilobytes per second (KBps) ■ Rollup Type: Average ■ Collection Level: 3
Write	Number of disk write commands completed on each disk on the host, per second. The aggregate number of all disk write commands is also displayed in the chart. Write rate = blocksWritten per second × blockSize ■ Counter: write ■ Stats Type: Rate ■ Unit: Kilobytes per second (KBps) ■ Rollup Type: Average ■ Collection Level: 3

Chart Analysis

Use the disk charts to monitor average disk loads and to determine trends in disk usage. For example, you might notice a performance degradation with applications that frequently read from and write to the hard disk. If you see a spike in the number of disk read or write requests, check whether any such applications were running then.

The best ways to determine if your vSphere environment is experiencing disk problems is to monitor the disk latency data counters. You can use the advanced performance charts to view these statistics.

- The kernelLatency data counter measures the average amount of time, in milliseconds, that the VMkernel spends processing each SCSI command. For best performance, the value must be 0 -1 milliseconds. If the value is greater than 4 ms, the virtual machines on the host are trying to send more throughput to the storage system than the configuration supports. Check the CPU usage, and increase the queue depth.
- The deviceLatency data counter measures the average amount of time, in milliseconds, to complete a SCSI command from the physical device. Depending on your hardware, a number greater than 15 ms indicates probable problems with the storage array. Move the active VMDK to a volume with more spindles or add disks to the LUN.
- The queueLatency data counter measures the average amount of time taken per SCSI command in the VMkernel queue. This value must always be zero. If not, the workload is too high and the array cannot process the data fast enough.

If the disk latency values are high, or if you notice other problems with disk I/O performance, consider taking the following actions.

Table 1-53. Disk I/O Performance Enhancement Advice

#	Resolution
1	Increase the virtual machine memory. It allows more operating system caching, which reduces I/O activity. Note: It might require you to increase the host memory. Increasing memory might reduce the need to store data because databases can utilize the system memory to cache data and avoid disk access. To verify that virtual machines have adequate memory, check swap statistics in the guest operating system. Increase the guest memory, but not to an extent that leads to excessive host memory swapping. Install VMware Tools so that memory ballooning can occur.
2	Defragment the file systems on all guests.
3	Disable antivirus on-demand scans on the VMDK and VMEM files.
4	Use the vendor's array tools to determine the array performance statistics. When too many servers simultaneously access common elements on an array, the disks might have trouble keeping up. To increase throughput, consider array-side improvements.
5	Use Storage vMotion to migrate I/O-intensive virtual machines across multiple hosts.
6	Balance the disk load across all physical resources available. Spread heavily used storage across LUNs that are accessed by different adapters. Use separate queues for each adapter to improve disk efficiency.
7	Configure the HBAs and RAID controllers for optimal use. Verify that the queue depths and cache settings on the RAID controllers are adequate. If not, increase the number of outstanding disk requests for the virtual machine by adjusting the `Disk.SchedNumReqOutstanding` parameter. For more information, see *vSphere Storage*.
8	For resource-intensive virtual machines, separate the virtual machine's physical disk drive from the drive with the system page file. It alleviates disk spindle contention during periods of high use.
9	On systems with sizable RAM, disable memory trimming by adding the line `MemTrimRate=0` to the virtual machine's VMX file.
10	If the combined disk I/O is higher than a single HBA capacity, use multipathing or multiple links.
11	For ESXi hosts, create virtual disks as preallocated. When you create a virtual disk for a guest operating system, select **Allocate all disk space now**. The performance degradation associated with reassigning additional disk space does not occur, and the disk is less likely to become fragmented.
12	Use the most current host hardware.

Disk Requests (Number)

The Disk Requests chart displays disk usage for the host.

This chart is located in the **Home** view of the host **Performance** tab.

Table 1-54. Data Counters

Chart Label	Description
Read Requests	Number of disk read commands completed on each LUN on the host. The aggregate number of all disk read commands is also displayed in the chart. ■ Counter: numberRead ■ Stats Type: Absolute ■ Unit: Number ■ Rollup Type: Summation ■ Collection Level: 3
Write Requests	Number of disk write commands completed on each LUN on the host. The aggregate number of all disk write commands is also displayed in the chart. ■ Counter: numberWrite ■ Stats Type: Absolute ■ Unit: Number ■ Rollup Type: Summation ■ Collection Level: 3

Chart Analysis

Use the disk charts to monitor average disk loads and to determine trends in disk usage. For example, you might notice a performance degradation with applications that frequently read from and write to the hard disk. If you see a spike in the number of disk read or write requests, check whether any such applications were running then.

The best ways to determine if your vSphere environment is experiencing disk problems is to monitor the disk latency data counters. You can use the advanced performance charts to view these statistics.

- The kernelLatency data counter measures the average amount of time, in milliseconds, that the VMkernel spends processing each SCSI command. For best performance, the value must be 0 -1 milliseconds. If the value is greater than 4 ms, the virtual machines on the host are trying to send more throughput to the storage system than the configuration supports. Check the CPU usage, and increase the queue depth.
- The deviceLatency data counter measures the average amount of time, in milliseconds, to complete a SCSI command from the physical device. Depending on your hardware, a number greater than 15 ms indicates probable problems with the storage array. Move the active VMDK to a volume with more spindles or add disks to the LUN.
- The queueLatency data counter measures the average amount of time taken per SCSI command in the VMkernel queue. This value must always be zero. If not, the workload is too high and the array cannot process the data fast enough.

If the disk latency values are high, or if you notice other problems with disk I/O performance, consider taking the following actions.

Table 1-55. Disk I/O Performance Enhancement Advice

#	Resolution
1	Increase the virtual machine memory. It allows more operating system caching, which reduces I/O activity. Note: It might require you to increase the host memory. Increasing memory might reduce the need to store data because databases can utilize the system memory to cache data and avoid disk access. To verify that virtual machines have adequate memory, check swap statistics in the guest operating system. Increase the guest memory, but not to an extent that leads to excessive host memory swapping. Install VMware Tools so that memory ballooning can occur.
2	Defragment the file systems on all guests.
3	Disable antivirus on-demand scans on the VMDK and VMEM files.
4	Use the vendor's array tools to determine the array performance statistics. When too many servers simultaneously access common elements on an array, the disks might have trouble keeping up. To increase throughput, consider array-side improvements.
5	Use Storage vMotion to migrate I/O-intensive virtual machines across multiple hosts.
6	Balance the disk load across all physical resources available. Spread heavily used storage across LUNs that are accessed by different adapters. Use separate queues for each adapter to improve disk efficiency.
7	Configure the HBAs and RAID controllers for optimal use. Verify that the queue depths and cache settings on the RAID controllers are adequate. If not, increase the number of outstanding disk requests for the virtual machine by adjusting the `Disk.SchedNumReqOutstanding` parameter. For more information, see *vSphere Storage*.
8	For resource-intensive virtual machines, separate the virtual machine's physical disk drive from the drive with the system page file. It alleviates disk spindle contention during periods of high use.
9	On systems with sizable RAM, disable memory trimming by adding the line `MemTrimRate=0` to the virtual machine's VMX file.
10	If the combined disk I/O is higher than a single HBA capacity, use multipathing or multiple links.
11	For ESXi hosts, create virtual disks as preallocated. When you create a virtual disk for a guest operating system, select **Allocate all disk space now**. The performance degradation associated with reassigning additional disk space does not occur, and the disk is less likely to become fragmented.
12	Use the most current host hardware.

Disk (Number)

The Disk (Number) chart displays maximum queue depth for the top ten LUNs on a host.

This chart is located in the **Home** view of the host **Performance** tab.

Table 1-56. Data Counters

Chart Label	Description
Maximum Queue Depth	Maximum queue depth. Queue depth is the number of commands the SCSI driver queues to the HBA. ■ Counter: maxQueueDepth ■ Stats Type: Absolute ■ Unit: Number ■ Rollup Type: Average ■ Collection Level: 1