



OnCommand® Unified Manager 7.3

Workflow Guide for Managing Cluster Performance

November 2020 | 215-12455_2020-11_en-us
doccomments@netapp.com

Contents

- Introduction to OnCommand Unified Manager performance monitoring..... 6**
 - Unified Manager performance monitoring features..... 6
 - Unified Manager interfaces used to manage storage system performance..... 7
 - OnCommand Unified Manager product documentation..... 7
 - Cluster configuration and performance data collection activity..... 7
 - What a data continuity collection cycle is..... 8
 - What the timestamp means in collected data and events..... 9
- Navigating performance workflows in the Unified Manager GUI..... 10**
 - Logging in to the UI..... 10
 - Graphical interface and navigational paths..... 10
 - Monitor cluster object navigation..... 11
 - Monitor cluster performance navigation..... 12
 - Event investigation navigation..... 15
 - Unified Manager administration navigation..... 16
 - Searching for storage objects..... 16
 - Filtering performance inventory page content..... 17
 - Accessing OnCommand System Manager from the Unified Manager interface..... 18
 - Adding to, and removing storage objects from, the Favorites list..... 19
 - Bookmarking frequently viewed product pages..... 19
 - Bookmarking your favorite Help topics..... 20
- Understanding performance events and alerts..... 21**
 - Sources of performance events..... 21
 - Performance event severity types..... 22
 - Configuration changes detected by Unified Manager..... 22
 - What happens when an event is received..... 23
 - What information is contained in an alert email..... 24
 - Adding alerts..... 25
 - Adding alerts for performance events..... 26
 - Types of system-defined performance threshold policies..... 27
- Managing performance thresholds.....30**
 - How user-defined performance threshold policies work..... 30
 - What happens when a performance threshold policy is breached..... 32
 - What performance counters can be tracked using thresholds..... 32
 - What objects and counters can be used in combination threshold policies..... 34
 - Creating user-defined performance threshold policies..... 35
 - Assigning performance threshold policies to storage objects..... 36
 - Viewing performance threshold policies..... 37
 - Editing user-defined performance threshold policies..... 38
 - Removing performance threshold policies from storage objects..... 39
 - What happens when a performance threshold policy is changed..... 39
 - What happens to performance threshold policies when an object is moved..... 40

Monitoring cluster performance from the Performance Dashboard.....41

| | |
|---|----|
| Understanding the Performance dashboard..... | 41 |
| Performance Dashboard cluster banner messages and descriptions..... | 43 |
| Changing the performance statistics collection interval..... | 43 |

Monitoring cluster performance from the Performance Cluster Landing page.....45

| | |
|---|----|
| Understanding the Performance Cluster Landing page..... | 45 |
| Performance Cluster Landing page..... | 46 |
| Performance Cluster Summary page..... | 46 |
| Top Performers page..... | 48 |

Monitoring performance using the Performance Inventory pages..... 51

| | |
|---|----|
| Object monitoring using the Performance object inventory pages..... | 51 |
| Refining Performance inventory page contents..... | 52 |
| Searching on Object Inventory Performance pages..... | 52 |
| Sorting on the Object Inventory Performance pages..... | 52 |
| Filtering data in the Object Inventory Performance pages..... | 52 |

Monitoring performance using the Performance Explorer pages.....55

| | |
|---|----|
| Understanding the root object..... | 55 |
| Apply filtering to reduce the list of correlated objects in the grid..... | 55 |
| Specifying a time range for correlated objects..... | 55 |
| Selecting a predefined time range..... | 56 |
| Specifying a custom time range..... | 56 |
| Defining the list of correlated objects for comparison graphing..... | 57 |
| Understanding counter charts..... | 58 |
| Types of performance counter charts..... | 59 |
| Selecting performance charts to display..... | 61 |
| Expanding the Counter Charts pane..... | 61 |
| Changing the Counter Charts focus to a shorter period of time..... | 61 |
| Viewing event details in the Events Timeline..... | 62 |
| Counter Charts Zoom View..... | 63 |
| Displaying the Counter Charts Zoom View..... | 63 |
| Specifying the time range in Zoom View..... | 63 |
| Selecting performance thresholds in Counter Charts Zoom View..... | 64 |
| Viewing workload QoS minimum and maximum settings..... | 65 |
| How different types of QoS policies are displayed in Unified Manager..... | 66 |
| Viewing volume latency by cluster component..... | 67 |
| Viewing SVM IOPS traffic by protocol | 68 |
| Components of the Object Landing pages..... | 68 |
| Summary page..... | 70 |
| Components of the Performance Explorer page..... | 73 |

Managing performance using performance capacity and available IOPS

information..... 76

| | |
|---|----|
| What performance capacity used is..... | 76 |
| What the performance capacity used value means..... | 77 |
| What available IOPS is..... | 78 |

| | |
|--|------------|
| Viewing node and aggregate performance capacity used values..... | 79 |
| Viewing node and aggregate available IOPS values..... | 79 |
| Viewing performance capacity counter charts to identify issues..... | 80 |
| Performance capacity used performance threshold conditions..... | 81 |
| Using the performance capacity used counter to manage performance..... | 82 |
| Understanding and using the Node Failover Planning page..... | 83 |
| Using the Node Failover Planning page to determine corrective actions..... | 83 |
| Components of the Node Failover Planning page..... | 84 |
| Using a threshold policy with the Node Failover Planning page..... | 85 |
| Using the Performance Capacity Used Breakdown chart for failover planning..... | 86 |
| Setting up a connection between a Unified Manager server and an external data provider..... | 89 |
| Performance data that can be sent to an external server..... | 89 |
| Setting up Graphite to receive performance data from Unified Manager..... | 90 |
| Configuring a connection from a Unified Manager server to an external data provider..... | 90 |
| Collecting data and monitoring workload performance..... | 93 |
| Types of workloads monitored by Unified Manager..... | 93 |
| Workload performance measurement values..... | 95 |
| What the expected range of performance is..... | 96 |
| How the expected range is used in performance analysis | 98 |
| How Unified Manager uses workload latency to identify performance issues..... | 99 |
| How cluster operations can affect workload latency..... | 100 |
| Performance monitoring of MetroCluster configurations..... | 101 |
| Volume behavior during switchover and switchback..... | 102 |
| What performance events are..... | 104 |
| Performance event analysis and notification..... | 105 |
| How Unified Manager determines the performance impact for an event..... | 107 |
| Cluster components and why they can be in contention..... | 109 |
| Roles of workloads involved in a performance event..... | 111 |
| Analyzing workload performance..... | 113 |
| Determining whether a workload has a performance issue..... | 113 |
| Investigating a perceived slow response time for a workload..... | 114 |
| Identifying trends of I/O response time on cluster components..... | 115 |
| Analyzing the performance improvements achieved from moving a volume..... | 117 |
| How moving a FlexVol volume works..... | 118 |
| Performance/Volume Details page..... | 119 |
| Performance statistics displayed in the data breakdown charts..... | 119 |
| How graphs of performance data work..... | 122 |
| Analyzing performance events..... | 124 |
| Displaying information about performance events..... | 124 |
| Analyzing events from user-defined performance thresholds..... | 126 |
| Responding to user-defined performance threshold events..... | 126 |
| Analyzing events from system-defined performance thresholds..... | 127 |
| Responding to system-defined performance threshold events..... | 127 |

| | |
|--|------------|
| Responding to QoS policy group performance events..... | 128 |
| Responding to node resources overutilized performance events..... | 129 |
| Analyzing events from dynamic performance thresholds..... | 130 |
| Identifying victim workloads involved in a performance event..... | 130 |
| Identifying bully workloads involved in a performance event..... | 131 |
| Identifying shark workloads involved in a performance event..... | 132 |
| Performance event analysis for a MetroCluster configuration..... | 134 |
| Responding to a dynamic performance event caused by QoS policy group throttling..... | 138 |
| Responding to a performance event caused by a disk failure..... | 140 |
| Responding to a performance event caused by HA takeover..... | 142 |
| Copyright and trademark..... | 145 |
| Copyright..... | 145 |
| Trademark..... | 145 |

Introduction to OnCommand Unified Manager performance monitoring

OnCommand Unified Manager provides performance monitoring capabilities and event root-cause analysis for systems that are running NetApp ONTAP software.

Unified Manager helps you to identify workloads that are overusing cluster components and decreasing the performance of other workloads on the cluster. By defining performance threshold policies you can also specify maximum values for certain performance counters so that events are generated when the threshold is breached. Unified Manager alerts you about these performance events so that you can take corrective action, and bring performance back to normal levels of operation. You can view and analyze events in the Unified Manager UI.

Unified Manager monitors the performance of two types of workloads:

- User-defined workloads
These workloads consist of FlexVol volumes and FlexGroup volumes that you have created in your cluster.
- System-defined workloads
These workloads consist of internal system activity.

Unified Manager performance monitoring features

Unified Manager collects and analyzes performance statistics from systems running ONTAP software. It uses dynamic performance thresholds and user-defined performance thresholds to monitor a variety of performance counters over many cluster components.

A high response time (latency) indicates that the storage object, for example, a volume, is performing slower than normal. This issue also indicates that the performance has decreased for client applications that are using the volume. Unified Manager identifies the storage component where the performance issue lies and provides a list of suggested actions you can take to address the performance issue.

Unified Manager includes the following features:

- Monitors and analyzes workload performance statistics from a system running ONTAP software.
- Tracks performance counters for clusters, nodes, aggregates, ports, SVMs, volumes, LUNs, and LIFs.
- Displays detailed graphs that plot workload activity over time; including IOPS (operations), MBps (throughput), latency (response time), utilization, performance capacity, and cache ratio.
- Enables you to create user-defined performance threshold policies that trigger events and send email alerts when the thresholds are breached.
- Uses system-defined thresholds and dynamic performance thresholds that learn about your workload activity to identify and alert you to performance issues.
- Clearly identifies the cluster component that is in contention.
- Identifies workloads that are overusing cluster components and the workloads whose performance is impacted by the increased activity.

Unified Manager interfaces used to manage storage system performance

There are two user interfaces that OnCommand Unified Manager provides for monitoring and troubleshooting data storage performance issues: the web user interface and the maintenance console.

Unified Manager web UI

The Unified Manager web UI enables an administrator to monitor and troubleshoot storage system issues relating to performance.

This guide describes some common workflows that an administrator can follow to troubleshoot storage performance issues displayed in the Unified Manager web UI.

Maintenance console

The maintenance console enables an administrator to monitor, diagnose, and address operating system issues, version upgrade issues, user access issues, and network issues related to the Unified Manager server itself. If the Unified Manager web UI is unavailable, the maintenance console is the only form of access to Unified Manager.

This guide provides directions for accessing the maintenance console and using it to resolve issues related to the functioning of the Unified Manager server.

OnCommand Unified Manager product documentation

OnCommand Unified Manager is accompanied by a set of guides that describe how to install and use the product. Online help is also provided in the user interface.

OnCommand Unified Manager Installation and Setup Guide

Provides installation, upgrade, and setup instructions for Unified Manager on the VMware, Red Hat, and Windows platforms.

OnCommand Unified Manager Workflow Guide for Managing Cluster Health

Provides information about using Unified Manager to manage and troubleshoot cluster storage health issues. This guide also describes how to use the Unified Manager maintenance console to perform special operations such as restoring a database backup and connecting to an external data provider to offload performance statistics.

OnCommand Unified Manager Workflow Guide for Managing Cluster Performance

Provides information about using Unified Manager to manage and troubleshoot cluster storage performance issues. This includes identifying workloads that are overusing cluster components so that you can take corrective action to bring performance back to normal levels of operation.

OnCommand Unified Manager Online Help

Provides information about using Unified Manager to manage and troubleshoot cluster storage health and performance issues. Additionally, it provides field level descriptions for every UI page in the product. The online help is included with the software, and is also available as a PDF document that you can review offline.

Cluster configuration and performance data collection activity

The collection interval for *cluster configuration data* is 15 minutes. For example, after you have added a cluster, it takes 15 minutes to display the cluster details in the Unified Manager UI. This interval applies when making changes to a cluster too.

For example, if you add two new volumes to an SVM in a cluster, you see those new objects in the UI after the next polling interval, which could be up to 15 minutes.

Unified Manager collects current *performance statistics* from all monitored clusters every five minutes. It analyzes this data to identify performance events and potential issues. It retains 30 days of five-minute historical performance data and 390 days of one-hour historical performance data. This enables you to view very granular performance details for the current month, and general performance trends for up to a year.

The collection polls are offset by a few minutes so that data from every cluster is not sent at the same time, which could affect performance.

The following table describes the collection activities that Unified Manager performs:

| Activity | Time interval | Description |
|------------------------------------|---------------------------|--|
| Performance statistics poll | Every 5 minutes | Collects real-time performance data from each cluster. |
| Statistical analysis | Every 5 minutes | After every statistics poll, Unified Manager compares the collected data against user-defined, system-defined, and dynamic thresholds. If any performance thresholds have been breached, Unified Manager generates events and sends email to specified users, if configured to do so. |
| Configuration poll | Every 15 minutes | Collects detailed inventory information from each cluster to identify all the storage objects (nodes, SVMs, volumes, and so on). |
| Summarization | Every hour | Summarizes the latest 12 five-minute performance data collections into hourly averages. The hourly average values are used in some of the UI pages, and they are retained for 390 days. |
| Forecast analysis and data pruning | Every day after midnight | Analyzes cluster data to establish dynamic thresholds for volume latency and IOPS for the next 24 hours. Deletes from the database any five-minute performance data older than 30 days. |
| Data pruning | Every day after 2 a.m. | Deletes from the database any events and dynamic thresholds older than 390 days. |
| Data pruning | Every day after 3:30 a.m. | Deletes from the database any one-hour performance data older than 390 days. |

What a data continuity collection cycle is

A data continuity collection cycle retrieves performance data outside of the real-time cluster performance collection cycle that runs, by default, every five minutes. Data continuity collections enable Unified Manager to fill in gaps of statistical data that occur when it was unable to collect real-time data.

Data continuity collection is supported only on clusters installed with ONTAP version 8.3.1 or later software.

Unified Manager performs data continuity collection polls of historical performance data when the following events occur:

- A cluster is initially added to Unified Manager.
Unified Manager gathers historical performance data for the previous 15 days. This enables you to view two weeks of historical performance information for a cluster a few hours after it is added.

Additionally, system-defined threshold events are reported for the previous period, if any exist.

- The current performance data collection cycle does not finish on time.
If the real-time performance poll goes beyond the five-minute collection period, a data continuity collection cycle is initiated to gather that missing information. Without the data continuity collection, the next collection period is skipped.
- Unified Manager has been inaccessible for a period of time and then it comes back online, as in the following situations:
 - It was restarted.
 - It was shut down during a software upgrade or when creating a backup file.
 - A network outage is repaired.
- A cluster has been inaccessible for a period of time and then it comes back online, as in the following situations:
 - A network outage is repaired.
 - A slow wide area network connection delayed the normal collection of performance data.

A data continuity collection cycle can collect a maximum of 24 hours of historical data. If Unified Manager is down for longer than 24 hours, a gap in performance data appears in the UI pages.

A data continuity collection cycle and a real-time data collection cycle cannot run at the same time. The data continuity collection cycle must finish before the real-time performance data collection is initiated. When the data continuity collection is required to collect more than one hour of historical data, then you see a banner message for that cluster at the top of the Performance dashboard.

What the timestamp means in collected data and events

The timestamp that appears in collected health and performance data, or that appears as the detection time for an event, is based on different criteria depending on the version of ONTAP that is running on your clusters.

- When using Unified Manager with ONTAP 8.2.x systems, the timestamp on collected data is based on the Unified Manager server time, adjusted to the time zone set on the web browser.
- When using Unified Manager with ONTAP 8.3.x or later systems, the timestamp on collected data is based on the ONTAP cluster time, adjusted to the time zone set on the web browser.

It is highly recommended that you use a Network Time Protocol (NTP) server to synchronize the time on your Unified Manager servers, ONTAP clusters, and web browsers.

Note: If you see timestamps that look incorrect for a particular cluster, you might want to check that the cluster time has been set correctly.

Navigating performance workflows in the Unified Manager GUI

The Unified Manager interface provides many pages for the collection and display of performance information. You use the left navigation panel to navigate to pages in the GUI, and you use tabs and links on the pages to view and configure information.

You use all of the following pages to monitor and troubleshoot cluster performance information:

- dashboard pages
- storage object inventory pages
- storage object landing pages (including the performance explorer)
- configuration and setup pages
- events pages

Note: A page in Unified Manager might display a large amount of information. To see all of the available information, always scroll to the bottom of the page.

Logging in to the UI

You can log in to the Unified Manager UI using a supported web browser.

Before you begin

- The web browser must meet minimum requirements.
See the Interoperability Matrix at mysupport.netapp.com/matrix for the complete list of supported browser versions.
- You must have the IP address or URL of the Unified Manager server.

About this task

You are automatically logged out of the session after four hours of inactivity.

Steps

1. Enter the URL in your web browser, where *URL* is the IP address or fully qualified domain name (FQDN) of the Unified Manager server:

- For IPv4: **https://URL/**
- For IPv6: **https://[URL]/**

If the server uses a self-signed digital certificate, the browser might display a warning indicating that the certificate is not trusted. You can either acknowledge the risk to continue the access or install a Certificate Authority (CA) signed digital certificate for server authentication.

2. At the login screen, enter your user name and password.
The Dashboards/Overview page is displayed.

Note: If the Unified Manager server is not initialized, a new browser window displays the first experience wizard. You must enter an initial email recipient to which email alerts will be sent, the SMTP server that will handle email communications, and whether AutoSupport is enabled to send information about your Unified Manager installation to technical support. The Unified Manager UI appears after you complete this information.

Graphical interface and navigational paths

Unified Manager has great flexibility and enables you to accomplish multiple tasks in various ways. There are many navigation paths you will discover as you work in Unified Manager. While

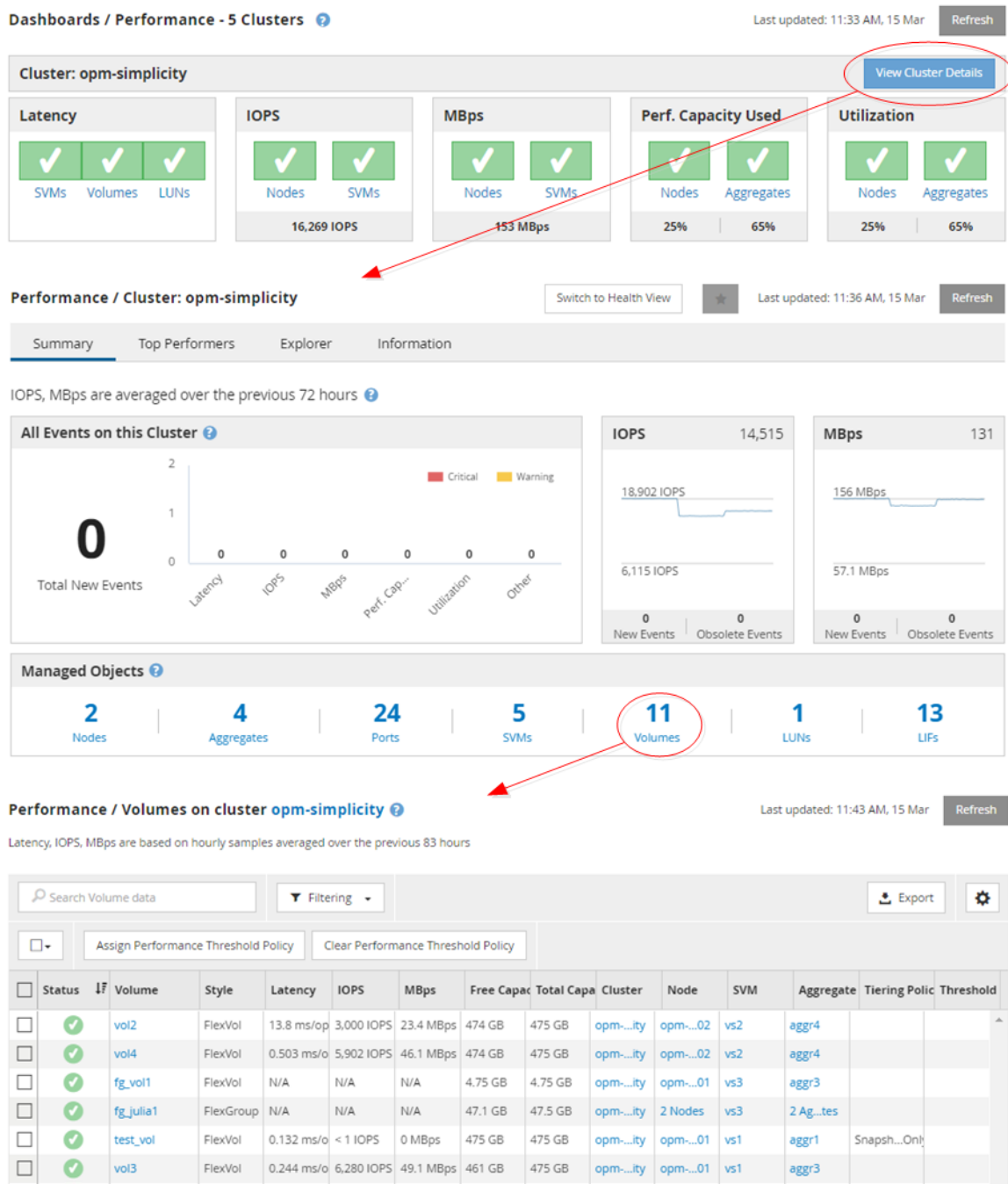
not all of the possible combinations of navigations can be shown, you should be familiar with a few of the more common scenarios.

Monitor cluster object navigation

Unified Manager enables you to monitor the performance of all objects in any cluster managed by Unified Manager. Monitoring your storage objects provides you with an overview of cluster and object performance, and includes performance event monitoring. You can view performance and events at a high level, or you can further investigate any details of object performance and performance events.

This is one example of many possible cluster object navigations:

1. From the Dashboards/Performance page, identify a cluster you want to investigate and navigate to the selected cluster's landing page.
2. From the Performance/Cluster Summary page, identify the cluster object you want to investigate and navigate to that object's inventory page. In this example, **Volumes** is selected to display the Performance/Volumes inventory page.



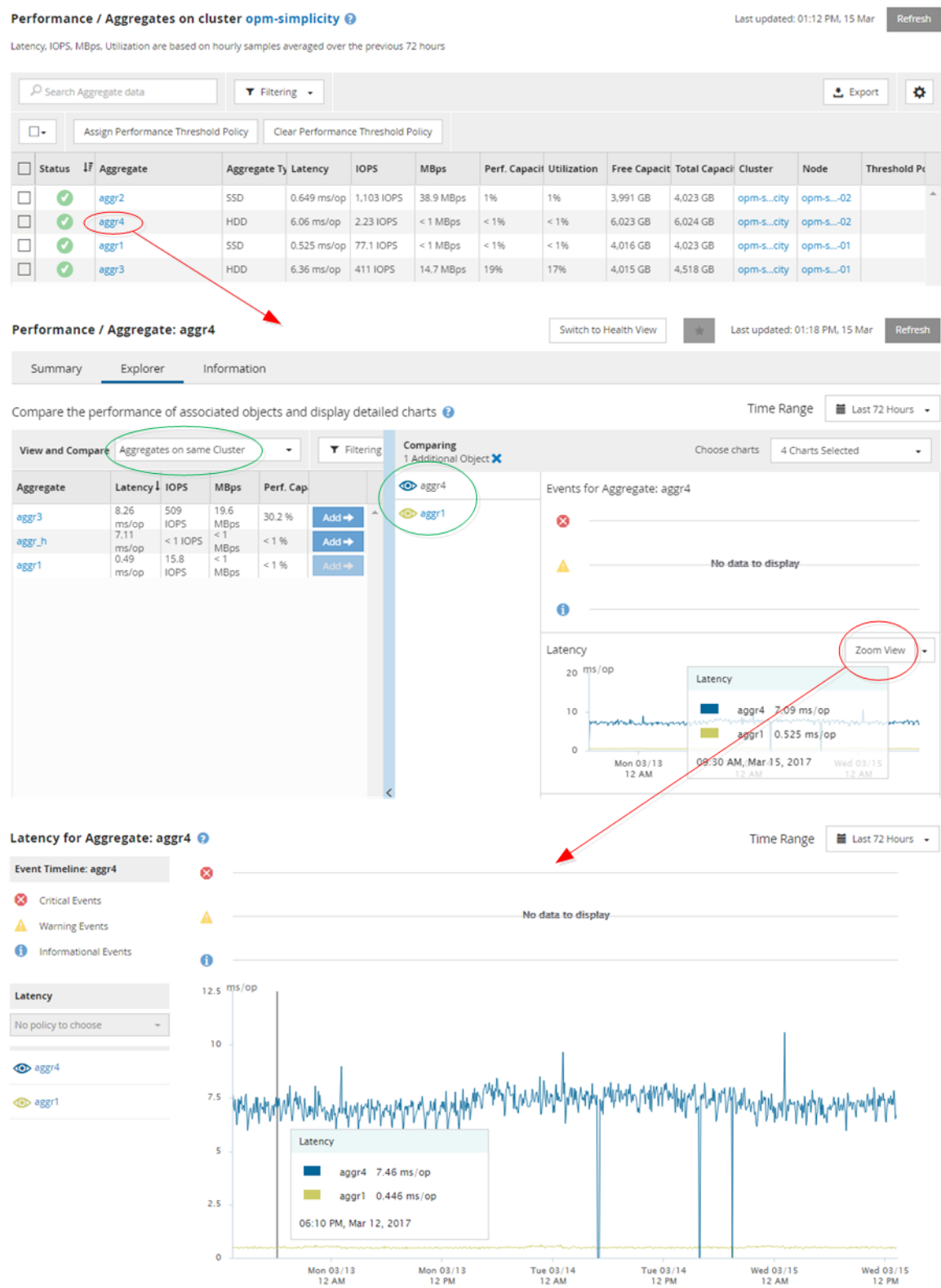
Monitor cluster performance navigation

Unified Manager enables you to monitor the performance of all clusters managed by Unified Manager. Monitoring your clusters provides you with an overview of cluster and object performance and includes performance event monitoring. You can view performance and events at a high level, or you can further investigate any details of cluster and object performance and performance events.

This is one example of many possible cluster performance navigational paths:

- 1. In the Dashboards/Performance page, identify a cluster you want to investigate and click **View Cluster Details** to navigate to the selected cluster’s landing page.

2. From the Performance/Cluster Summary page, identify the object type you want to investigate and click it to view the object inventory page.
In this example, **Aggregates** is selected, displaying the Performance/Aggregates inventory page.
3. In the Performance/Aggregates page, identify the aggregate you want to investigate and click that aggregate name to navigate to the Performance/Aggregate Explorer page.
4. Optionally, select other objects to compare with this aggregate in the View and Compare menu, and then add one of the objects to the comparing pane.
Statistics for both objects will appear in the counter charts for comparison.
5. In the Comparing pane at the right on the Explorer page, click **Zoom View** in one of the counter charts to view details about the performance history for that aggregate.



Event investigation navigation

The Unified Manager event detail pages provide you with an in-depth look at any performance event. This is beneficial when investigating performance events, when troubleshooting, and when fine-tuning system performance.

Depending on the type of performance event, you might see one of three types of event detail pages:

- User-Defined Threshold Event Details page
- System-Defined Threshold Event Details page
- Dynamic Threshold Event Details page

This is one example of an event investigation navigation.

1. In the left navigation pane, click **Events**.
2. In the Events inventory page, check the box for **Performance** in the Impact Area to filter the list of events.
3. Click the name of the event that you want to investigate and the User-Defined Threshold Event Details page is displayed.

Filters

Status [Clear](#)

- ☒ Critical
- ☒ Error
- ☒ Warning
- ☐ Information

State [Clear](#)

- ☒ New
- ☒ Acknowledged
- ☐ Resolved
- ☐ Obsolete

Impact Level [Clear](#)

- ☐ Incident
- ☐ Risk
- ☐ Event

Impact Area [Clear](#)

- ☐ Availability
- ☐ Capacity
- ☐ Protection
- ☒ Performance

Events / All [?](#)

[Assign To](#) [Acknowledge](#) [Mark As Resolved](#) [Add Alert](#)

| Triggered Time | Status | State | Impact Level | Impact Area | Name |
|------------------|---------|--------------|--------------|-------------|---|
| 01:24 PM, 15 Mar | Warning | New | Risk | Performance | Aggregate IOPS Warning Threshold Breached |
| 12:34 PM, 15 Mar | Warning | New | Risk | Performance | Aggregate IOPS Warning Threshold Breached |
| 12:34 PM, 15 Mar | Warning | New | Risk | Performance | Aggregate IOPS Warning Threshold Breached |
| 12:34 PM, 15 Mar | Warning | Acknowledged | Risk | Performance | Aggregate IOPS Warning Threshold Breached |

Event: Aggregate IOPS Warning Threshold Breached [?](#) Last updated: 01:36 PM, 15 Mar [Refresh](#)

Summary

Event Detected Time: 12:34 PM, 15 Mar

State: New

Event Duration: 1 hour

Last Seen: 01:24 PM, 15 Mar

Status: Warning

Impact Level: Risk

Impact Area: Performance

Source: [aggr1](#)

Affected Objects Count: 1

On Cluster: [opm-mobility](#)

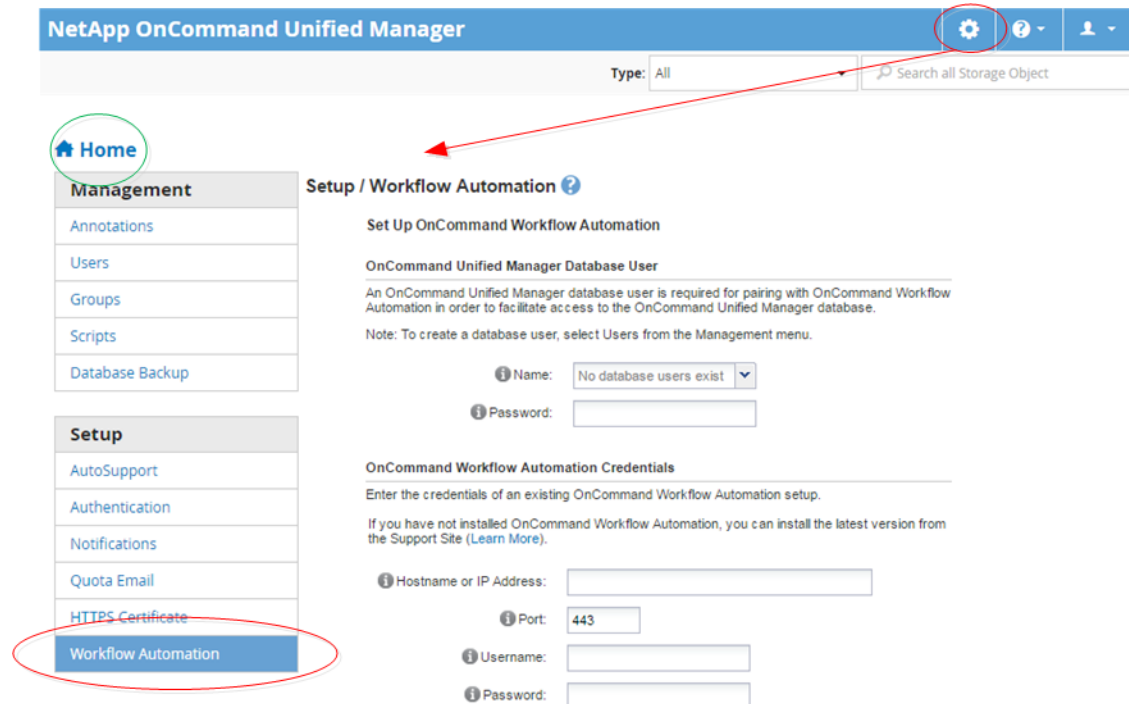
On Policy: [Aggr_IOPS](#)

Description: IOPS value of 75.4 IOPS on aggr1 has triggered a WARNING event based on threshold setting of 2.00 IOPS.

Unified Manager administration navigation

Unified Manager administration functionality enables you to manage users and data sources. You can also accomplish setup tasks such as authentication, AutoSupport, email, HTTPS certificates, networks, and NTP servers using the Unified Manager Administration page.

This is one example of many possible administration navigational paths. To add or remove a connection to a Workflow Automation server, follow this navigation example:



Note: Click the **Home** icon to return to the main Unified Manager navigation page.

Searching for storage objects

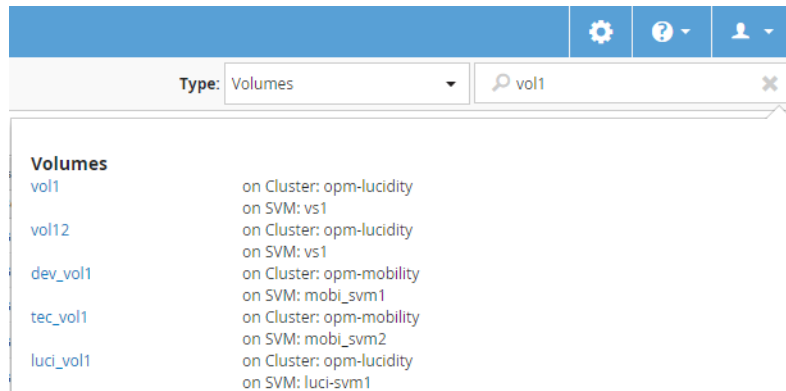
To quickly access a specific object, you can use the **Search all Storage Objects** field at the top-right of the interface. This method of global search across all objects enables you to quickly locate specific objects by type. Search results are sorted by storage object type and you can filter them using the **Type** drop-down menu. A valid search must contain at least three characters.

The global search displays the total number of results, but only the top 20 search results are accessible. Because of this, the global search functionality can be thought of as a shortcut tool for finding specific items if you know the items you want to quickly locate. For complete search results, you can use the search in the object inventory pages and its associated filtering functionality.

You can click the **Type** drop-down box and select **All** to simultaneously search across all objects and events. Alternatively, you can click the **Type** drop-down box to specify the object type. Type any number of characters of the object or event name into the **Search all Storage Objects** field, and then press **Enter** or click **Search All** to display the search results, such as:

- Events: performance event IDs
- Clusters: cluster names
- Nodes: node names
- Aggregates: aggregate names

- SVMs: SVM names
- Volumes: volume names
- LUNs: LUN paths



Note: LIFs and ports are not searchable in the global search bar.

In this example, the **Type** drop-down box has the Volume object type selected. Typing "vol" into the **Search all Storage Objects** field displays a list of all volumes whose names contain these characters. For object searches, you can click any search result to navigate to that object's Performance Explorer page. For event searches, clicking an item in the search result navigates to the Event Details page.

Note: If the search results display several volumes with the same name, the name of the associated clusters and SVMs are not displayed.

Filtering performance inventory page content

You can filter performance inventory data in Unified Manager to quickly locate data based on specific criteria. You can use filtering to narrow the contents of the Unified Manager pages to show only the results in which you are interested. This provides a very efficient method of displaying only the performance data in which you are interested.

About this task

Use **Filtering** to customize the grid view based on your preferences. Available filter options are based on the object type being viewed in the grid. If filters are currently applied, an asterisk (*) displays at the left of the Filtering control.

Four types of filter parameters are supported.

| Parameter | Validation |
|---------------|--|
| String (text) | The operators are contains and starts with . |
| Number | The operators are greater than and less than . |
| Resource | The operators are name contains and name starts with . |
| Status | The operators are is and is not . |

All three fields are required for each filter; the available filters reflect the filterable columns on the current page. The maximum number of filters you can apply is four. Filtered results are based on combined filter parameters. Filtered results apply to all pages in your filtered search, not just the page currently displayed.

You can add filters using the Filtering panel.

1. At the top of the page, click **Filtering**. The Filtering panel displays.
2. In the Filtering panel, click the left drop-down list, and select an object name: for example, *Cluster*, or a performance counter.
3. Click the center drop-down list, and select the boolean operator **name contains** or **name starts with** if the first selection was an object name. If the first selection was a performance counter, select **greater than** or **less than**. If the first selection was **Status**, select **is** or **is not**.
4. If your search criteria requires a numeric value, up and down arrow buttons display in the field at the right. You can click the up and down arrow buttons to display your desired numeric value.
5. If required, type your non-numeric search criteria in the text field at the right.
6. To add filters, click **Add Filter**. An additional filter field displays. Complete this filter using the process described in the preceding steps. Note that upon adding your fourth filter, the **Add Filter** button no longer displays.
7. Click **Apply Filter**. The filter options are applied to the grid and an asterisk (*) is displayed in the Filtering button.
8. Use the Filtering panel to remove individual filters by clicking the trash icon at the right of the filter to be removed.
9. To remove all filters, click **Reset** at the bottom of the filtering panel.

Filtering example

The illustration shows the Filtering panel with three filters. The **Add Filter** button displays when you have fewer than the maximum of four filters.

| | | | | |
|------|------------------|----------|------|---|
| Mbps | greater than | 5 | Mbps | ✕ |
| Node | name starts with | test | | ✕ |
| Type | is | FCP Port | | ✕ |

+ Add Filter

Cancel Apply Filter

After clicking **Apply Filter**, the Filtering panel closes and applies your filters.

Accessing OnCommand System Manager from the Unified Manager interface

When troubleshooting requires that you make configuration changes to a cluster, you can use the System Manager graphical interface instead of the ONTAP command-line interface. System Manager is included with ONTAP as a web service, it is enabled by default, and it is accessible by using a browser.

Before you begin

You must have a cluster user account configured with the **admin** role and the **http**, **ontapi**, and **console** application types.

Steps

1. In the left navigation pane, click **Dashboards > Cluster View**.
2. In the **Dashboards/Cluster View** page, select the cluster that you want to manage.
An overview of the monitoring status, capacity, and performance for that cluster is displayed.
3. Click the **System Manager** icon.
If the cluster uses a self-signed digital certificate, the browser might display a warning indicating that the certificate is not trusted. You can either acknowledge the risk to continue the

access or install a Certificate Authority (CA) signed digital certificate on the cluster for server authentication.

4. Log in to System Manager by using your cluster administrator credentials.

If login to the System Manager user interface is protected using SAML authentication you will enter your credentials in the identity provider (IdP) login page instead of the System Manager login page.


Adding to, and removing storage objects from, the Favorites list

You can add storage objects to a Favorites list so you can monitor the objects for health, capacity, and performance. You can use object status in the Favorites list to determine issues and fix them before they become critical. The Favorites list also provides the most recent monitoring status of a storage object. You can remove storage objects from the Favorites list when you no longer require them to be marked as favorite.


About this task

You can add up to 20 clusters, nodes, aggregates, or volumes to the Favorites list. When you add a node to the Favorites list, it is displayed as a cluster.


Steps

1. Go to the **Details** page of the storage object that you want to mark as a favorite.
2. Click the star icon () to add the storage object to the Favorites list.

Adding an aggregate to the Favorites list

1. In the left navigation pane, click **Health > Aggregates**.
2. In the Health/Aggregates inventory page, click the aggregate that you want to add to the Favorites list.
3. In the Health/Aggregate details page, click the star icon ()

After you finish

To remove a storage object from the Favorites list, go to the Favorites list page, click the star icon () on the object card you want to remove, and then select the **Remove from Favorites** option.

Bookmarking frequently viewed product pages

You can bookmark frequently accessed product pages from the Unified Manager UI. This enables you to quickly return to these pages. When you view the page later, it displays the latest data.

About this task

You can also copy the link (URL) to the current product page so that you can paste it into an email, or another application, to share it with other people.

Step

Create a bookmark using whatever step is required to bookmark a page in your browser. The link for the page is saved with details about the page, but you might want to customize the bookmark text to identify the page: for example, "OnCommand Unified Manager | Node: opm-node-01" or "OnCommand Unified Manager | User-defined Threshold Event: p-udt-opm-clus1-nod-1446".

Bookmarking your favorite Help topics

In the Help Favorites tab, you can bookmark Help topics that you use frequently. Help bookmarks provide fast access to your favorite topics.

Steps

1. Navigate to the Help topic that you want to add as a favorite.
2. Click **Favorites**, and then click **Add**.

Understanding performance events and alerts

Performance events are notifications that Unified Manager generates automatically when a predefined condition occurs, or when a performance counter value crosses a threshold. Events help you identify performance issues in the clusters that are monitored.

You can configure alerts to send email notification automatically when performance events of certain severity types occur.

Sources of performance events

Performance events are issues or configuration changes related to workload performance on a cluster. They help you identify storage objects with slow response times and cluster configuration changes that might have caused, or contributed to, the slow response times.

Unified Manager receives performance events from the following sources:

User-defined performance threshold policy events

Performance issues based on custom threshold values that you have set. You configure performance threshold policies for storage objects; for example, aggregates and volumes, so that events are generated when a threshold value for a performance counter has been breached.

You must define a performance threshold policy and assign it to a storage object to receive these events.

System-defined performance threshold policy events

Performance issues based on threshold values that are system-defined. These threshold policies are included with the installation of Unified Manager to cover common performance problems.

These threshold policies are enabled by default, and you might see events shortly after adding a cluster.

Dynamic performance threshold events

Performance issues that are the result of failures or errors in an IT infrastructure, or from workloads overutilizing cluster resources. The cause of these events might be a simple issue that corrects itself over a period of time or that can be addressed with a repair or configuration change. A dynamic threshold event indicates that volume workloads on an ONTAP system are slow due to other workloads with high usage of shared cluster components.

These thresholds are enabled by default, and you might see events after three days of collecting data from a new cluster.

Configuration change events

A change event is generated when a logical or physical storage object in a system running ONTAP is added, modified, or deleted. A change that impacts the performance of one or more workloads might be a contributor to an event.

Related concepts

[Managing performance thresholds](#) on page 30

Performance threshold policies enable you to determine the point at which Unified Manager generates an event to inform system administrators about issues that could be impacting workload performance. These threshold policies are known as *user-defined* performance thresholds.

Performance event severity types

Each performance event is associated with a severity type to help you prioritize the events that require immediate corrective action.

Critical

A performance event occurred that might lead to service disruption if corrective action is not taken immediately.

Critical events are sent from user-defined thresholds only.

Warning

A performance counter for a cluster object is out of normal range and should be monitored to make sure it does not reach the critical severity. Events of this severity do not cause service disruption, and immediate corrective action might not be required.


Warning events are sent from user-defined, system-defined, or dynamic thresholds.

Information

The event occurs when a new object is discovered, or when a user action is performed. For example, when any storage object is deleted or when there are any configuration changes, the event with severity type Information is generated.

Information events are sent directly from ONTAP when it detects a configuration change.

Configuration changes detected by Unified Manager

Unified Manager monitors your clusters for configuration changes to help you determine whether a change might have caused or contributed to a performance event. The Performance Explorer pages and the Performance/Volume Details page display a change event icon () to indicate the date and time when the change was detected.

You can review the performance charts in the Performance Explorer pages and in the Performance/Volume Details page to see whether the change event impacted the performance of the selected cluster object. If the change was detected at or around the same time as a performance event, the change might have contributed to the issue, which caused the event alert to trigger.

Unified Manager can detect the following change events, which are categorized as Informational events:

- A volume moves between aggregates.
Unified Manager can detect when the move is in progress, completed, or failed. If Unified Manager is down during a volume move, when it is back up it detects the volume move and displays a change event for it.
- The throughput (MBps or IOPS) limit of a QoS policy group that contains one or more monitored workloads changes.
Changing a policy group limit can cause intermittent spikes in the latency (response time), which might also trigger events for the policy group. The latency gradually returns back to normal and any events caused by the spikes become obsolete.
- A node in an HA pair takes over or gives back the storage of its partner node.
Unified Manager can detect when the takeover, partial takeover, or giveback operation has been completed. If the takeover is caused by a panicked node, Unified Manager does not detect the event.
- An ONTAP upgrade or revert operation is completed successfully.

The previous version and new version are displayed.

Related concepts

[How moving a FlexVol volume works](#) on page 118

Knowing how moving a FlexVol volume works helps you to determine whether the volume move satisfies service-level agreements and to understand where a volume move is in the volume move process.

What happens when an event is received

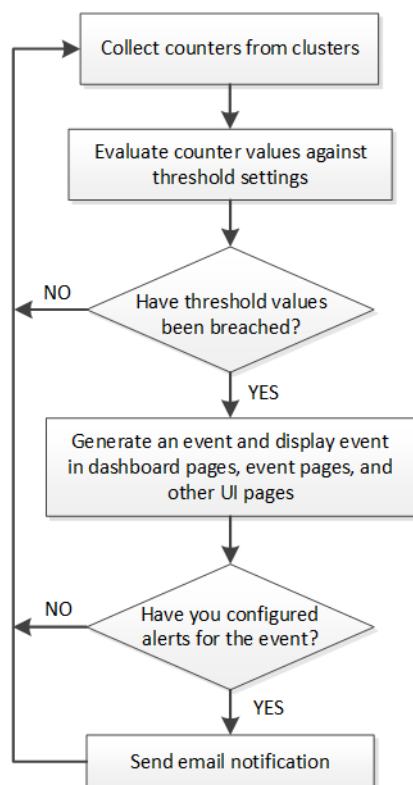
When Unified Manager receives an event, it is displayed in the Dashboards/Overview page, in the Summary and Explorer tabs of the Performance/Cluster page, in the Events inventory page, and in the object-specific inventory page (for example, the Health/Volumes inventory page).

When Unified Manager detects multiple continuous occurrences of the same event condition for the same cluster component, it treats all occurrences as a single event, not as separate events. The duration of the event is incremented to indicate that the event is still active.

Depending on how you configure settings in the Configuration/Alerting page, you can notify other users about these events. The alert causes the following actions to be initiated:

- An email about the event can be sent to all Unified Manager Administrator users.
- The event can be sent to additional email recipients.
- An SNMP trap can be sent to the trap receiver.
- A custom script can be executed to perform an action.

This workflow is shown in the following diagram.



What information is contained in an alert email

Unified Manager alert emails provide the type of event, the severity of the event, the name of the policy that was breached to cause the event, and a description of the event. The email message also provides a hyperlink for each event that enables you to view the details page for the event in the UI.

Alert emails are sent to all users who have subscribed to receive alerts.

If a performance counter or capacity value has a large change during a collection period, it could cause both a critical and a warning event to be triggered at the same time for the same threshold policy. In this case, you may receive one email for the warning event and one for the critical event. This is because Unified Manager enables you to subscribe separately to receive alerts for warning and critical threshold breaches.

Note: After upgrading to Unified Manager 7.2, or greater, links to events and alerts from emails that were sent from older versions of Unified Manager will no longer work because of a change in the event and alert URLs.

A sample alert email is shown below:

From: 10.11.12.13@OnCommand.com [<mailto:10.11.12.13@OnCommand.com>]

Sent: Tuesday, January 31, 2017 7:45 PM

To: sclaus@company.com; user1@company.com>

Subject: Alert from OnCommand Unified Manager: Thin-Provisioned Volume Space At Risk (State: New)

A risk was generated by OnCommand that requires your attention.

Risk - Thin-Provisioned Volume Space At Risk

Impact Area - Capacity

Severity - Warning

State - New

Source - svm_n1:/sm_vol_23

Trigger Condition - The thinly provisioned capacity of the volume is 25.73% of the available space on the host aggregate

The capacity of the volume is at risk because of aggregate capacity issues.

Event details:

<https://OnCommand:443/#/all-events/94>

Source details:

<https://OnCommand:443/#/health/volumes/106>

Alert details:

<https://OnCommand:443/#/alerting/1>

Do not reply to this email. This is an automatically generated email and replies to this email address are not attended to

Related concepts

Sources of performance events on page 21

Performance events are issues or configuration changes related to workload performance on a cluster. They help you identify storage objects with slow response times and cluster configuration changes that might have caused, or contributed to, the slow response times.

Related tasks

[Adding alerts](#) on page 25

You can configure alerts to notify you when a particular event is generated. You can configure alerts for a single resource, for a group of resources, or for events of a particular severity type. You can specify the frequency with which you want to be notified and associate a script to the alert.

Adding alerts

You can configure alerts to notify you when a particular event is generated. You can configure alerts for a single resource, for a group of resources, or for events of a particular severity type. You can specify the frequency with which you want to be notified and associate a script to the alert.

Before you begin

- You must have configured notification settings such as the user email address, SMTP server, and SNMP trap host to enable the Unified Manager server to use these settings to send notifications to users when an event is generated.
- You must know the resources and events for which you want to trigger the alert, and the user names or email addresses of the users that you want to notify.
- If you want to have a script execute based on the event, you must have added the script to Unified Manager by using the Management/Scripts page.
- You must have the OnCommand Administrator or Storage Administrator role.

About this task

You can create an alert directly from the Event details page after receiving an event in addition to creating an alert from the Configuration/Alerting page, as described here.

Steps

1. In the left navigation pane, click **Configuration > Alerting**.
2. In the **Configuration/Alerting** page, click **Add**.
3. In the **Add Alert** dialog box, click **Name**, and enter a name and description for the alert.
4. Click **Resources**, and select the resources to be included in or excluded from the alert.
You can set a filter by specifying a text string in the **Name contains** field to select a group of resources. Based on the text string that you specify, the list of available resources displays only those resources that match the filter rule. The text string that you specify is case-sensitive.
If a resource conforms to both the include and exclude rules that you have specified, the exclude rule takes precedence over the include rule, and the alert is not generated for events related to the excluded resource.
5. Click **Events**, and select the events based on the event name or event severity type for which you want to trigger an alert.
Tip: To select more than one event, press the Ctrl key while you make your selections.
6. Click **Actions**, and select the users that you want to notify, choose the notification frequency, choose whether an SNMP trap will be sent to the trap receiver, and assign a script to be executed when an alert is generated.

Note: If you modify the email address that is specified for the user and reopen the alert for editing, the Name field appears blank because the modified email address is no longer mapped to the user that was previously selected. Also, if you modified the email address of

the selected user from the Management/Users page, the modified email address is not updated for the selected user.

You can also choose to notify users through SNMP traps.

7. Click **Save**.

Example of adding an alert

This example shows how to create an alert that meets the following requirements:

- Alert name: HealthTest
- Resources: includes all volumes whose name contains "abc" and excludes all volumes whose name contains "xyz"
- Events: includes all critical health events
- Actions: includes "sample@domain.com", a "Test" script, and the user has to be notified every 15 minutes

Perform the following steps in the Add Alert dialog box:

1. Click **Name**, and enter **HealthTest** in the **Alert Name** field.
2. Click **Resources**, and in the Include tab, select **Volumes** from the drop-down list.
 - a. Enter **abc** in the **Name contains** field to display the volumes whose name contains "abc".
 - b. Select **<<All Volumes whose name contains 'abc'>>** from the Available Resources area, and move it to the Selected Resources area.
 - c. Click **Exclude**, and enter **xyz** in the **Name contains** field, and then click **Add**.
3. Click **Events**, and select **Critical** from the Event Severity field.
4. Select **All Critical Events** from the Matching Events area, and move it to the Selected Events area.
5. Click **Actions**, and enter **sample@domain.com** in the Alert these users field.
6. Select **Remind every 15 minutes** to notify the user every 15 minutes.

You can configure an alert to repeatedly send notifications to the recipients for a specified time. You should determine the time from which the event notification is active for the alert.
7. In the Select Script to Execute menu, select **Test** script .
8. Click **Save**.

Adding alerts for performance events

You can configure alerts for individual performance events just like any other events received by Unified Manager. Additionally, if you want to treat all performance events alike and have email sent to the same person, you can create a single alert to notify you when any critical or warning performance events are triggered.

Before you begin

You must have the OnCommand Administrator or Storage Administrator role.

About this task

The example below shows how to create an event for all critical latency, IOPS, and MBps events. You can use this same methodology to select events from all performance counters, and for all warning events.

Steps

1. In the left navigation pane, click **Configuration > Alerting**.
2. In the **Configuration/Alerting** page, click **Add**.

3. In the **Add Alert** dialog box, click **Name**, and enter a name and description for the alert.
4. Do not select any resources on the **Resources** page.
Because no resources are selected, the alert is applied to all clusters, aggregates, volumes, and so on, for which these events are received.
5. Click **Events** and perform the following actions:
 - a. In the Event Severity list, select **Critical**.
 - b. In the Event Name Contains field, enter **latency** and then click the arrow to select all the matching events.
 - c. In the Event Name Contains field, enter **iops** and then click the arrow to select all the matching events.
 - d. In the Event Name Contains field, enter **mbps** and then click the arrow to select all the matching events.
6. Click **Actions** and then select the name of the user who will receive the alert email in the **Alert these users** field.
7. Configure any other options on this page for issuing SNMP traps and executing a script.
8. Click **Save**.

Types of system-defined performance threshold policies

Unified Manager provides some standard threshold policies that monitor cluster performance and generate events automatically. These policies are enabled by default, and they generate warning or information events when the monitored performance thresholds are breached.

Note: System-defined performance threshold policies are not enabled on ONTAP Cloud, ONTAP Edge, or ONTAP Select systems.

If you are receiving unnecessary events from any system-defined performance threshold policies, you can disable individual policies from the Configuration/Manage Events page.

Node threshold policies

The system-defined node performance threshold policies are assigned, by default, to every node in the clusters being monitored by Unified Manager:

Node resources over-utilized

Identifies situations in which a single node is operating above the bounds of its operational efficiency, and therefore potentially affecting workload latencies. This is a warning event.

For nodes installed with ONTAP 8.3.x and earlier software, it does this by looking for nodes that are using more than 85% of their CPU and RAM resources (node utilization) for more than 30 minutes.

For nodes installed with ONTAP 9.0 and later software, it does this by looking for nodes that are using more than 100% of their performance capacity for more than 30 minutes.

Node HA pair over-utilized

Identifies situations in which nodes in an HA pair are operating above the bounds of the HA pair operational efficiency. This is an informational event.

For nodes installed with ONTAP 8.3.x and earlier software, it does this by looking at the CPU and RAM usage for the two nodes in the HA pair. If the combined node utilization of the two nodes exceeds 140% for more than one hour, then a controller failover will impact workload latencies.

For nodes installed with ONTAP 9.0 and later software, it does this by looking at the performance capacity used value for the two nodes in the HA pair. If the combined

performance capacity used of the two nodes exceeds 200% for more than one hour, then a controller failover will impact workload latencies.

Node disk fragmentation

Identifies situations in which a disk or disks in an aggregate are fragmented, slowing key system services and potentially affecting workload latencies on a node.

It does this by looking at certain read and write operation ratios across all aggregates on a node. This policy might also be triggered during SyncMirror resynchronization or when errors are found during disk scrub operations. This is a warning event.

Aggregate threshold policies

The system-defined aggregate performance threshold policy is assigned by default to every aggregate in the clusters being monitored by Unified Manager.

Aggregate disks over-utilized

Identifies situations in which an aggregate is operating above the limits of its operational efficiency, thereby potentially affecting workload latencies. It identifies these situations by looking for aggregates where the disks in the aggregate are more than 95% utilized for more than 30 minutes. This multicondition policy then performs the following analysis to help determine the cause of the issue:

- Is a disk in the aggregate currently undergoing background maintenance activity?
Some of the background maintenance activities a disk could be undergoing are disk reconstruction, disk scrub, SyncMirror resynchronization, and reparity.
- Is there a communications bottleneck in the disk shelf Fibre Channel interconnect?
- Is there too little free space in the aggregate?

A warning event is issued for this policy only if one (or more) of the three subordinate policies are also considered breached. A performance event is not triggered if only the disks in the aggregate are more than 95% utilized.

Note: The "Aggregate disks over-utilized" policy analyzes HDD-only aggregates and Flash Pool (hybrid) aggregates; SSD and FabricPool aggregates are not analyzed.

QoS threshold policies

Introduced in Unified Manager 7.3, the system-defined QoS performance threshold policies are assigned to any volume or LUN that has a configured ONTAP QoS maximum throughput policy (IOPS, IOPS/TB, or MBps).

QoS Max IOPS or MBps threshold breached

Identifies volumes and LUNs that have exceeded their QoS maximum IOPS or MBps throughput limit, and that are affecting workload latency. This is a warning event.

It does this by looking for workloads that have exceeded the maximum throughput threshold defined in the assigned QoS policy group during each collection period for the previous hour.

Note: This policy is applied to volumes and LUNs only when a single workload is assigned to a policy group - not when multiple workloads share a single QoS policy.

QoS Peak IOPS/TB threshold breached

Identifies volumes that have exceeded their QoS peak IOPS/TB throughput limit, and that are affecting workload latency. This is a warning event.

It does this by converting the peak IOPS/TB threshold defined in the adaptive QoS policy into a QoS maximum IOPS value based on the size of each volume, and then it looks for

volumes that have exceeded the QoS max IOPS during each performance collection period for the previous hour.

Note: This policy is applied to volumes only when cluster nodes are installed with ONTAP 9.3 and later software.

Managing performance thresholds

Performance threshold policies enable you to determine the point at which Unified Manager generates an event to inform system administrators about issues that could be impacting workload performance. These threshold policies are known as *user-defined* performance thresholds.

This release supports user-defined, system-defined, and dynamic performance thresholds. With dynamic and system-defined performance thresholds, Unified Manager analyzes the workload activity to determine the appropriate threshold value. With user-defined thresholds, you can define the upper performance limits for many performance counters and for many storage objects.

Note: System-defined performance thresholds and dynamic performance thresholds are set by Unified Manager and are not configurable. If you are receiving unnecessary events from any system-defined performance threshold policies, you can disable individual policies from the Configuration/Manage Events page.

How user-defined performance threshold policies work

You set performance threshold policies on storage objects (for example, on aggregates and volumes) so that an event can be sent to the storage administrator to inform the administrator that the cluster is experiencing a performance issue.

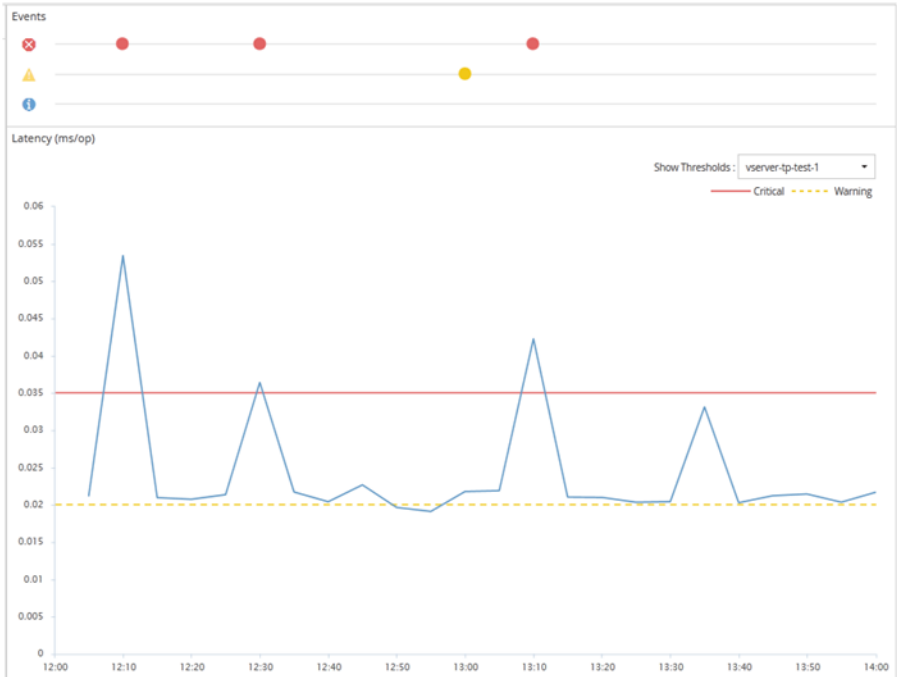
You create a performance threshold policy for a storage object by:

- Selecting a storage object
- Selecting a performance counter associated with that object
- Specifying values that define the performance counter upper limits that are considered warning and critical situations
- Specifying a time period that defines how long the counter must exceed the upper limit

For example, you can set a performance threshold policy on a volume so that you receive a critical event notification whenever IOPS for that volume exceeds 750 operations per second for 10 consecutive minutes. This same threshold policy can also specify that a warning event be sent when IOPS exceeds 500 operations per second for 10 minutes.

Note: The current release provides thresholds that send events when a counter value exceeds the threshold setting. You cannot set thresholds that send events when a counter value falls below a threshold setting.

An example counter chart is shown here, indicating that a warning threshold (yellow icon) was breached at 1:00, and that a critical threshold (red icon) was breached at 12:10, 12:30, and 1:10:



A threshold breach must occur continuously for the specified duration. If the threshold dips below the limit values for any reason, a subsequent breach is considered the start of a new duration.

Some cluster objects and performance counters enable you to create a combination threshold policy that requires two performance counters to exceed their maximum limits before an event is generated. For example, you can create a threshold policy using the following criteria:

| Cluster object | Performance counter | Warning threshold | Critical threshold | Duration |
|----------------|---------------------|-------------------|--------------------|------------|
| Volume | Latency | 10 milliseconds | 20 milliseconds | 15 minutes |
| Aggregate | Utilization | 65% | 85% | |

Threshold policies that use two cluster objects cause an event to be generated only when both conditions are breached. For example, using the threshold policy defined in the table:

| If volume latency is averaging... | And aggregate disk utilization is... | Then... |
|-----------------------------------|--------------------------------------|-------------------------------|
| 15 milliseconds | 50% | No event is reported. |
| 15 milliseconds | 75% | A Warning event is reported. |
| 25 milliseconds | 75% | A Warning event is reported. |
| 25 milliseconds | 90% | A Critical event is reported. |

Related reference

[What performance counters can be tracked using thresholds](#) on page 32

Some common performance counters, such as IOPS and MBps, can have thresholds set for all storage objects. There are other counters that can have thresholds set for only certain storage objects.

[What objects and counters can be used in combination threshold policies](#) on page 34

Only some performance counters can be used together in combination policies. When primary and secondary performance counters are specified, both performance counters must exceed their maximum limits before an event is generated.

What happens when a performance threshold policy is breached

When a counter value exceeds its defined performance threshold value for the amount of time specified in the duration, the threshold is breached and an event is reported.

The event causes the following actions to be initiated:

- The event is displayed in the Performance Dashboard, the Performance Cluster Summary page, the Events page, and the object-specific Performance Inventory page.
- (optional) An email alert about the event can be sent to one or more email recipients, and an SNMP trap can be sent to a trap receiver.
- (optional) A script can be executed to automatically modify or update storage objects.

The first action is always executed. You configure whether the optional actions are performed in the Configuration/Alerting page page. You can define unique actions depending on whether a Warning or a Critical threshold policy is breached.

After a performance threshold policy breach has occurred on a storage object, no further events are generated for that policy until the counter value goes below the threshold value, at which point the duration resets for that limit. While the threshold continues to be exceeded, the end time of the event is continually updated to reflect that this event is ongoing.

A threshold event captures, or freezes, the information related to severity and policy definition so that unique threshold information displays with the event, even if the threshold policy is modified in the future.

Related concepts

[Understanding performance events and alerts](#) on page 21

Performance events are notifications that Unified Manager generates automatically when a predefined condition occurs, or when a performance counter value crosses a threshold. Events help you identify performance issues in the clusters that are monitored.

What performance counters can be tracked using thresholds

Some common performance counters, such as IOPS and MBps, can have thresholds set for all storage objects. There are other counters that can have thresholds set for only certain storage objects.

Available performance counters

| Storage object | Performance counter | Description |
|----------------|---------------------|--|
| Cluster | IOPS | Average number of input/output operations the cluster processes per second. |
| | MBps | Average number of megabytes of data transferred to and from this cluster per second. |

| Storage object | Performance counter | Description |
|-------------------------------|--------------------------------------|--|
| Node | IOPS | Average number of input/output operations the node processes per second. |
| | MBps | Average number of megabytes of data transferred to and from this node per second. |
| | Latency | Average number of milliseconds the node takes to respond to application requests. |
| | Utilization | Average percentage of the node's CPU and RAM that is being used. |
| | Performance Capacity Used | Average percentage of performance capacity that is being consumed by the node. |
| | Performance Capacity Used - Takeover | Average percentage of performance capacity that is being consumed by the node, plus the performance capacity of its partner node. |
| Aggregate | IOPS | Average number of input/output operations the aggregate processes per second. |
| | MBps | Average number of megabytes of data transferred to and from this aggregate per second. |
| | Latency | Average number of milliseconds the aggregate takes to respond to application requests. |
| | Utilization | Average percentage of the aggregate's disks that are being used. |
| | Performance Capacity Used | Average percentage of performance capacity that is being consumed by the aggregate. |
| storage virtual machine (SVM) | IOPS | Average number of input/output operations the SVM processes per second. |
| | MBps | Average number of megabytes of data transferred to and from this SVM per second. |
| | Latency | Average number of milliseconds the SVM takes to respond to application requests. |
| Volume | IOPS | Average number of input/output operations the volume processes per second. |
| | MBps | Average number of megabytes of data transferred to and from this volume per second. |
| | Latency | Average number of milliseconds the volume takes to respond to application requests. |
| | Cache miss ratio | Average percentage of read requests from client applications that are returned from the volume instead of being returned from cache. |
| LUN | IOPS | Average number of input/output operations the LUN processes per second. |
| | MBps | Average number of megabytes of data transferred to and from this LUN per second. |
| | Latency | Average number of milliseconds the LUN takes to respond to application requests. |

| Storage object | Performance counter | Description |
|-------------------------|-----------------------|---|
| Port | Bandwidth utilization | Average percentage of the port's available bandwidth that is being used. |
| | MBps | Average number of megabytes of data transferred to and from this port per second. |
| Logical Interface (LIF) | MBps | Average number of megabytes of data transferred to and from this LIF per second. |

Note: Performance capacity data is available only when the nodes in a cluster are installed with ONTAP 9.0 or later software.

What objects and counters can be used in combination threshold policies

Only some performance counters can be used together in combination policies. When primary and secondary performance counters are specified, both performance counters must exceed their maximum limits before an event is generated.

| Primary storage object and counter | Secondary storage object and counter |
|------------------------------------|---|
| Volume Latency | Volume IOPS |
| | Volume MBps |
| | Aggregate Utilization |
| | Aggregate Performance Capacity Used |
| | Node Utilization |
| | Node Performance Capacity Used |
| | Node Performance Capacity Used - Takeover |
| LUN Latency | LUN IOPS |
| | LUN MBps |
| | Aggregate Utilization |
| | Aggregate Performance Capacity Used |
| | Node Utilization |
| | Node Performance Capacity Used |
| | Node Performance Capacity Used - Takeover |

Note: When a volume combination policy is applied to a FlexGroup volume, instead of to a FlexVol volume, only the "Volume IOPS" and "Volume MBps" attributes can be selected as the secondary counter. If the threshold policy contains one of the node or aggregate attributes, then the policy will not be applied to the FlexGroup volume, and you will receive an error message describing this case. This is because FlexGroup volumes can exist on more than one node or aggregate.

Creating user-defined performance threshold policies

You create performance threshold policies for storage objects so that notifications are sent when a performance counter exceeds a specific value. The event notification identifies that the cluster is experiencing a performance issue.

Before you begin

You must have the OnCommand Administrator role.

About this task

You create performance threshold policies by entering the threshold values on the Create Threshold Policy page. You can create new policies by defining all the policy values in this page, or you can make a copy of an existing policy and change a the values in the copy (called *cloning*).

Valid threshold values are 0.001 through 10,000,000 for numbers, and 0-100 for percentages.

Note: The current release provides thresholds that send events when a counter value exceeds the threshold setting. You cannot set thresholds that send events when a counter value falls below a threshold setting.

Steps

1. In the left navigation pane, select **Configuration > Performance Thresholds**.
The Configuration/Performance Thresholds page is displayed.
2. Click the appropriate button depending on whether you want to build a new policy or if you want to clone a similar policy and modify the cloned version.

| To... | Click... |
|--------------------------|--|
| Create a new policy | Create |
| Clone an existing policy | Select an existing policy and click Clone |

The Create Threshold Policy page or Clone Threshold Policy page is displayed.

3. Define the threshold policy by specifying the performance counter threshold values you want to set for specific storage objects:
 - a. Select the storage object type and specify a name and description for the policy.
 - b. Select the performance counter to be tracked and specify the limit values that define Warning and Critical events.

You must define at least one Warning or one Critical limit. You do not need to define both types of limits.
 - c. Select a secondary performance counter, if required, and specify the limit values for Warning and Critical events.

Including a secondary counter requires that both counters exceed the limit values before the threshold is breached and an event is reported. Only certain objects and counters can be configured using a combination policy.
 - d. Select the duration of time for which the limit values must be breached for an event to be sent.

When cloning an existing policy, you must enter a new name for the policy.

4. Click **Save** to save the policy.
You are returned to the Configuration/Performance Thresholds page. A success message at the top of the page confirms that the threshold policy was created and provides a link to the Inventory page for that object type so that you can apply the new policy to storage objects immediately.

After you finish

If you want to apply the new threshold policy to storage objects at this time, you can click the **Go to object_type now** link to go to the Inventory page.

Related tasks

[Assigning performance threshold policies to storage objects](#) on page 36

You assign a user-defined performance threshold policy to a storage object so that Unified Manager reports an event if the value of the performance counter exceeds the policy setting.

Related reference

[What performance counters can be tracked using thresholds](#) on page 32

Some common performance counters, such as IOPS and MBps, can have thresholds set for all storage objects. There are other counters that can have thresholds set for only certain storage objects.

[What objects and counters can be used in combination threshold policies](#) on page 34

Only some performance counters can be used together in combination policies. When primary and secondary performance counters are specified, both performance counters must exceed their maximum limits before an event is generated.

Assigning performance threshold policies to storage objects

You assign a user-defined performance threshold policy to a storage object so that Unified Manager reports an event if the value of the performance counter exceeds the policy setting.

Before you begin

You must have the OnCommand Administrator role.

The performance threshold policy, or policies, that you want to apply to the object must exist.

About this task

You can apply only one performance policy at a time to an object, or to a group of objects.

You can assign a maximum of three threshold policies to each storage object. When assigning policies to multiple objects, if any of the objects already has the maximum number of policies assigned, Unified Manager performs the following actions:


- Applies the policy to all of the selected objects that have not reached their maximum
- Ignores the objects that have reached the maximum number of policies
- Displays a message that the policy was not assigned to all objects

Additionally, if some objects do not support the counter being tracked in the threshold policy, the policy is not applied to that object. For example, if you create a "Performance Capacity Used" threshold policy, and then you attempt to assign it to a node that does not have ONTAP 9.0 or later software installed, the policy is not applied to that node.

Steps

1. From the Performance inventory page of any storage object, select the object or objects to which you want to assign a threshold policy:

| To assign thresholds to... | Click... |
|----------------------------|---|
| A single object | The check box at the left of that object. |
| Multiple objects | The check box at the left of each object. |
| All objects on the page | The <input type="checkbox"/> drop-down box, and choose Select all objects on this page . |

| To assign thresholds to... | Click... |
|------------------------------|---|
| All objects of the same type | The  drop-down box, and choose Select all objects . |

You can use the sorting and filtering functionality to refine the list of objects on the inventory page to make it easier to apply threshold policies to many objects.

2. Make your selection, and then click **Assign Performance Threshold Policy**.
The Assign Threshold Policy page is displayed, showing a list of threshold policies that exist for that specific type of storage object.
3. Click each policy to display the details of the performance threshold settings to verify that you have selected the correct threshold policy.
4. After you have selected the appropriate threshold policy, click **Assign Policy**.
A success message at the top of the page confirms that the threshold policy was assigned to the object or objects, and provides a link to the Alerting page so that you can configure alert settings for this object and policy.

After you finish

If you want to have alerts sent over email, or as an SNMP trap, to notify you that a particular performance event has been generated, you must configure the alert settings in the Configuration/Alerting page.

Related tasks

[Adding alerts for performance events](#) on page 26

You can configure alerts for individual performance events just like any other events received by Unified Manager. Additionally, if you want to treat all performance events alike and have email sent to the same person, you can create a single alert to notify you when any critical or warning performance events are triggered.

[Viewing performance threshold policies](#) on page 37

You can view all of the currently defined performance threshold policies from the Configuration/Performance Thresholds page.

[Creating user-defined performance threshold policies](#) on page 35

You create performance threshold policies for storage objects so that notifications are sent when a performance counter exceeds a specific value. The event notification identifies that the cluster is experiencing a performance issue.

[Filtering data in the Object Inventory Performance pages](#) on page 52

You can filter data in the Object Inventory Performance pages to quickly locate data based on specific criteria. You can use filtering to narrow the contents of the Object Inventory Performance pages to show only the results you have specified. This provides a very efficient method of displaying only the performance data in which you are interested.

[Sorting on the Object Inventory Performance pages](#) on page 52

You can sort all data on Object Inventory Performance pages by any column in ascending or descending order. This enables you to quickly locate object inventory data, which is helpful when examining performance or beginning a troubleshooting process.

Viewing performance threshold policies

You can view all of the currently defined performance threshold policies from the Configuration/Performance Thresholds page.

About this task

The list of threshold policies is sorted alphabetically by policy name, and it includes policies for all types of storage objects. You can click a column header to sort the policies by that column. If

you are looking for a specific policy, use the filter and search mechanisms to refine the list of threshold policies that appear in the inventory list.

You can hover your cursor over the Policy Name and the Condition name to see the configuration details of the policy. Additionally, you can use the provided buttons to create, clone, edit, and delete user-defined threshold policies.

Step

In the left navigation pane, select **Configuration > Performance Thresholds**.
The Configuration/Performance Thresholds page is displayed.

Related tasks

[Filtering performance inventory page content](#) on page 17

You can filter performance inventory data in Unified Manager to quickly locate data based on specific criteria. You can use filtering to narrow the contents of the Unified Manager pages to show only the results in which you are interested. This provides a very efficient method of displaying only the performance data in which you are interested.

Editing user-defined performance threshold policies

You can edit the threshold settings for existing performance threshold policies. This can be useful if you find that you are receiving too many or too few alerts for certain threshold conditions.

Before you begin

You must have the OnCommand Administrator role.

About this task

You cannot change the policy name or the type of storage object that is being monitored for existing threshold policies.

Steps

1. In the left navigation pane, select **Configuration > Performance Thresholds**.
The Configuration/Performance Thresholds page displays.
2. Select the threshold policy that you want to change and click **Edit**.
The Edit Threshold Policy page is displayed.
3. Make your changes to the threshold policy and click **Save**.
You are returned to the Configuration/Performance Thresholds page.

Result

After they are saved, changes are updated immediately on all storage objects that use the policy.

After you finish

Depending on the type of changes that you made to the policy, you may want to review the alert settings configured for the objects that use the policy in the Configuration/Alerting page.

Related concepts

[What happens when a performance threshold policy is changed](#) on page 39

If you adjust the counter value or duration of an existing performance threshold policy, the policy change is applied to all storage objects that use the policy. The new setting takes place

immediately, and Unified Manager begins to compare performance counter values to the new threshold settings for all newly collected performance data.

Removing performance threshold policies from storage objects

You can remove a user-defined performance threshold policy from a storage object when you no longer want Unified Manager to monitor the value of the performance counter.

Before you begin

You must have the OnCommand Administrator role.

About this task

You can remove only one policy at a time from a selected object.

You can remove a threshold policy from multiple storage objects by selecting more than one object in the list.

Steps

1. From the **inventory** page of any storage object, select one or more objects that have at least one performance threshold policy applied.

| To clear thresholds from... | Do this... |
|------------------------------|--|
| A single object | Select the check box at the left of that object. |
| Multiple objects | Select the check box at the left of each object. |
| All objects on the page | Click <input type="checkbox"/> and select Select all objects on this page . |
| All objects of the same type | Click <input type="checkbox"/> and select Select all objects . |

2. Click **Clear Performance Threshold Policy**.
The Clear Threshold Policy page displays, showing a list of threshold policies that are currently assigned to the storage objects.
3. Select the threshold policy you want to remove from the objects and click **Clear Policy**.
When you select a threshold policy, the details of the policy display so that you can confirm that you have selected the appropriate policy.

What happens when a performance threshold policy is changed

If you adjust the counter value or duration of an existing performance threshold policy, the policy change is applied to all storage objects that use the policy. The new setting takes place immediately, and Unified Manager begins to compare performance counter values to the new threshold settings for all newly collected performance data.

If any new, active events exist for objects that are using the changed threshold policy, the events are marked as obsolete, and the threshold policy begins monitoring the counter as a newly defined threshold policy.

When viewing the counter on which the threshold has been applied in the Counter Charts Detailed View, the critical and warning threshold lines reflect the current threshold settings. The original threshold settings do not appear on this page even if you view historical data when the old threshold setting was in effect.

Note: Because older threshold settings do not appear in the Counter Charts Detailed View, you might see historical events that appear below the current threshold lines.

What happens to performance threshold policies when an object is moved

Because performance threshold policies are assigned to storage objects, if you move an object, all assigned threshold policies remain attached to the object after the move is completed. For example, if you move a volume or LUN to a different aggregate, the threshold policies are still active for the volume or LUN on the new aggregate.

If a secondary counter condition exists for the threshold policy (a combination policy)—for example, if an additional condition is assigned to an aggregate or a node—the secondary counter condition is applied to the new aggregate or node to which the volume or LUN has been moved.

If any new active events exist for objects that are using the changed threshold policy, the events are marked as obsolete, and the threshold policy begins monitoring the counter as a newly defined threshold policy.

A volume move operation causes ONTAP to send an informational change event. A change event icon appears in the Events timeline on the Performance Explorer page and the Performance/Volume Details page to indicate the time when the move operation was completed.

Note: If you move an object to a different cluster, the user-defined threshold policy is removed from the object. If required, you must assign a threshold policy to the object after the move operation is completed. Dynamic and system-defined threshold policies, however, are applied automatically to an object after it has moved to a new cluster.

Threshold policy functionality during HA takeover and giveback

When a takeover or giveback operation occurs in a high-availability (HA) configuration, objects that are moved from one node to the other node retain their threshold policies in the same manner as in the manual move operations. Because Unified Manager checks for cluster configuration changes every 15 minutes, the impact of the switchover to the new node is not identified until the next poll of the cluster configuration.

Note: If both a takeover and giveback operation occur within the 15-minute configuration change collection period, you might not see the performance statistics move from one node to the other node.

Threshold policy functionality during aggregate relocation

If you move an aggregate from one node to another node using the `aggregate relocation start` command, both single and combination threshold policies are retained on all objects, and the node portion of the threshold policy is applied to the new node.

Threshold policy functionality during MetroCluster switchover

Objects that move from one cluster to another cluster in a MetroCluster configuration do not retain their user-defined threshold policy settings. If required, you can apply threshold policies on the volumes and LUNs that have moved to the partner cluster. After an object has moved back to its original cluster, the user-defined threshold policy is reapplied automatically.

[Volume behavior during switchover and switchback](#)

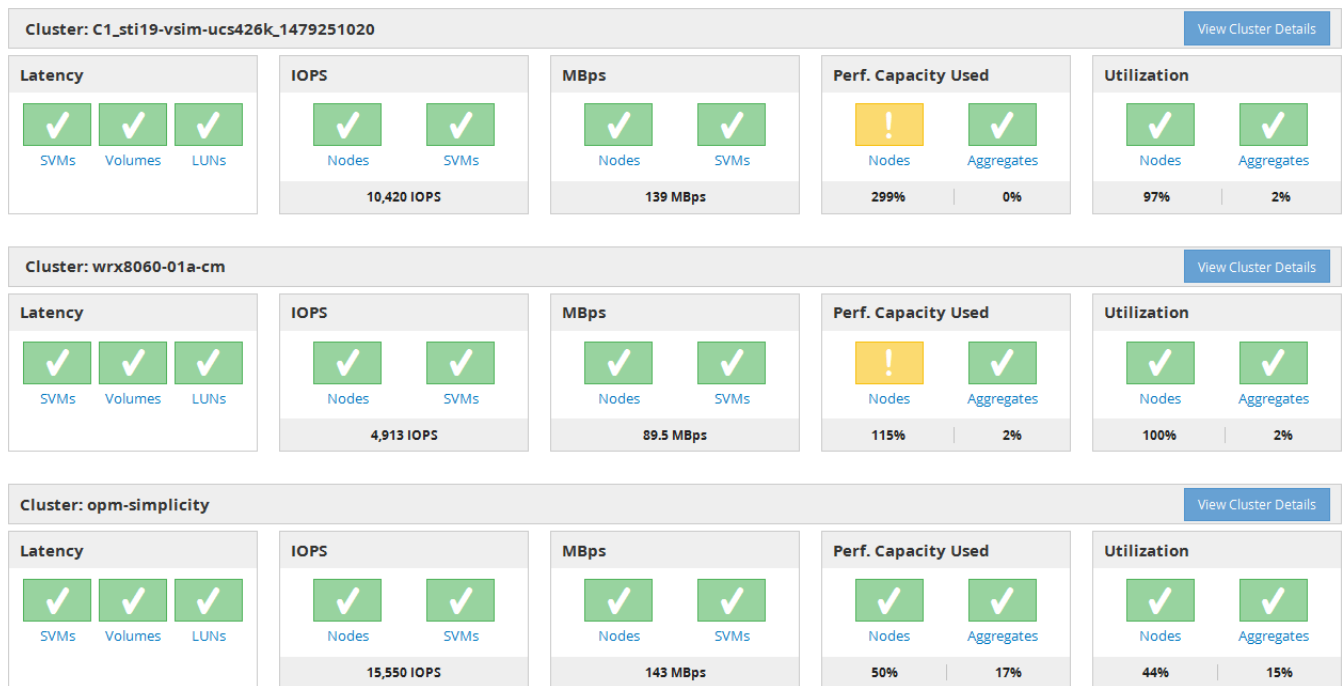
Monitoring cluster performance from the Performance Dashboard

The OnCommand System Manager Performance Dashboard displays the high-level performance status of all clusters being monitored by this instance of Unified Manager. It enables you to assess the overall performance of the managed clusters, and to quickly note, locate, or assign for resolution any specific events identified.

Understanding the Performance dashboard

The Unified Manager Performance dashboard provides a high-level overview of the performance status for all the clusters that are being monitored in your environment. Clusters that have performance issues are ordered at the top of the page by severity. The information on the dashboard is updated automatically at each five-minute performance collection period.

The following image shows an example of a Unified Manager Performance dashboard that is monitoring two clusters:



The status icons that represent the storage objects can be in the following states, sorted from highest severity to lowest severity:

- Critical (✖): One or more new critical performance events have been reported for the object.
- Warning (⚠): One or more new warning performance events have been reported for the object.
- Normal (✓): No new performance events have been reported for the object.

Note: The color indicates whether new events exist for the object. Events that are no longer active, called obsolete events, do not affect the color of the icon.

Cluster performance counters

The following performance categories are displayed for each cluster:

- **Latency**
Shows how quickly the cluster is responding to client application requests, in milliseconds per operation.
- **IOPS**
Shows the operating speed of the cluster, in number of input/output operations per second.
- **MBps**
Shows how much data is being transferred to and from the cluster, in megabytes per second.
- **Performance Capacity Used**
Shows whether any nodes or aggregates are overusing their available performance capacity.
- **Utilization**
Shows whether the resources on any nodes or aggregates are being overused.

To analyze the performance of your cluster and storage objects, you can perform one of the following actions:

- You can click **View Cluster Details** to display the Cluster Landing page, where you can view detailed performance and event information for the selected cluster and storage objects.
- You can click one of the red or yellow status icons of an object to display the Inventory page for that object, where you can view details about the storage object.
For example, clicking a volume icon displays the Performance/Volume inventory page with a list of all the volumes in the selected cluster, sorted from worst performance to best performance.

Related concepts

[Monitoring cluster performance from the Performance Cluster Landing page](#) on page 45

The Performance Cluster Landing page displays the high-level performance status of a selected cluster that is being monitored by an instance of Unified Manager. This page enables you to assess the overall performance of a specific cluster, and to quickly note, locate, or assign for resolution any cluster-specific events that are identified.

[Monitoring performance using the Performance Inventory pages](#) on page 51

The object inventory performance pages display performance information, performance events, and object health for all objects within an object type category. This provides you with an at-a-glance overview of the performance status of each object within a cluster, for example, for all nodes or all volumes.

[Managing performance using performance capacity and available IOPS information](#) on page 76

Performance capacity indicates how much throughput you can get out of a resource without surpassing the useful performance of that resource. When viewed using existing performance counters, performance capacity is the point at which you get the maximum utilization from a node or aggregate before latency becomes an issue.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can

determine the most critical events and then drill down to detailed information to determine the cause of the event.

Performance Dashboard cluster banner messages and descriptions

Unified Manager may display cluster banner messages on the Performance Dashboard to alert you to status issues for a particular cluster.

| Banner message | Description | Resolution |
|--|---|--|
| No performance data is being collected from cluster <code>cluster_name</code> . Restart Unified Manager to correct this issue. | The Unified Manager collection service has stopped and no performance data is being collected from any clusters. | Restart Unified Manager to correct this issue. If this does not correct the issue, contact technical support. |
| More than x hour(s) of historical data is being collected from cluster <code>cluster_name</code> . Current data collections will start after all historical data is collected. | A data continuity collection cycle is currently running to retrieve performance data outside of the real-time cluster performance collection cycle. | No action is required. Current performance data will be collected after the data continuity collection cycle is completed. A data continuity collection cycle runs when a new cluster is added or when Unified Manager has been unable to collect current performance data for some reason. |

Changing the performance statistics collection interval

The default collection interval for performance statistics is 5 minutes. You can change this interval to 10 or 15 minutes if you find that collections from large clusters are not finishing within the default time. This setting affects the collection of statistics from all clusters that this instance of Unified Manager is monitoring.

Before you begin

You must have a user ID and password authorized to log in to the maintenance console of the Unified Manager server.

About this task

The issue of performance statistics collections not finishing on time is indicated by the banner messages Unable to consistently collect from cluster `<cluster_name>` or Data collection is taking too long on cluster `<cluster_name>`.

You should change the collection interval only when required because of a statistics collections issue. Do not change this setting for any other reason.

Important: Changing this value from the default setting of 5 minutes can affect the number and frequency of performance events that Unified Manager reports. For example, system-defined performance thresholds trigger events when the policy is exceeded for 30 minutes. When using 5-minute collections, the policy must be exceeded for six consecutive collections. For 15-minute collections the policy must be exceeded for only two collection periods.

A message at the bottom of the Cluster Data Sources page indicates the current statistical data collection interval.

Steps

1. Log in using SSH as the maintenance user to the Unified Manager host.

The Unified Manager maintenance console prompts are displayed.

2. Type the number of the menu option labeled **Performance Polling Interval Configuration**, and then press Enter.
3. If prompted, enter the maintenance user password again.
4. Type the number for the new polling interval that you want to set, and then press Enter.

After you finish

If you changed the Unified Manager collection interval to 10 or 15 minutes, and you have a current connection to an external data provider (such as Graphite), you must change the data provider transmit interval so that it is equal to, or greater, than the Unified Manager collection interval.

Related tasks

[*Configuring a connection from a Unified Manager server to an external data provider*](#) on page 90

Unified Manager can send cluster performance data to an external server. You can specify the type of statistical data that is sent, and the interval at which data is sent.

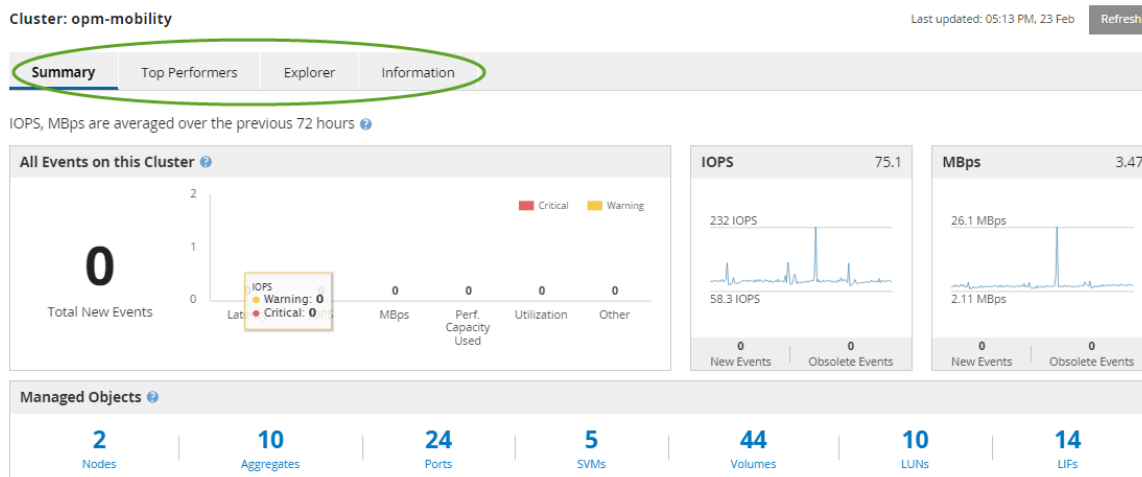
Monitoring cluster performance from the Performance Cluster Landing page

The Performance Cluster Landing page displays the high-level performance status of a selected cluster that is being monitored by an instance of Unified Manager. This page enables you to assess the overall performance of a specific cluster, and to quickly note, locate, or assign for resolution any cluster-specific events that are identified.

Understanding the Performance Cluster Landing page

The Performance Cluster Landing page provides a high-level performance overview of a selected cluster, with an emphasis on the performance status of the top 10 objects within the cluster. Performance issues are displayed at the top of the page, in the All Events on this Cluster panel.

The Performance Cluster Landing page provides a high-level overview of each cluster that is managed by an instance of Unified Manager. This page provides you with information about events and performance, and enables you to monitor and troubleshoot clusters. The following image shows an example of the Performance Cluster Landing page for the cluster called opm-mobility:





The event count on the Cluster Summary page may not match the event count on the Performance Event Inventory page. This is because the Cluster Summary page can show one event each in the Latency and Utilization bars when combination threshold policies have been breached, whereas the Performance Event Inventory page shows only one event when a combination policy has been breached.

Note: If a cluster was removed from being managed by Unified Manager, the status **Removed** is displayed at the right of the cluster name at the top of the page.

Performance Cluster Landing page

The Performance Cluster Landing page displays the high-level performance status of a selected cluster. The page enables you to access complete details of each performance counter for the storage objects on the selected cluster.

You can click the **Favorites** button () to add this object to your list of favorite storage objects.

A blue button () indicates that this object is already a favorite.

The Performance Cluster Landing page includes four tabs that separate the cluster details into four areas of information:

- Summary page
 - Cluster Events pane
 - Managed Objects pane
- Top Performers page
- Explorer page
- Information page

Related concepts

[Components of the Performance Explorer page](#) on page 73

The Performance Explorer page enables you to compare the performance of similar objects in a cluster—for example, all the volumes in a cluster. This is beneficial when troubleshooting performance events and fine-tuning object performance. You can also compare objects with the root object, which is the baseline against which other object comparisons are made.

Related reference

[Performance Cluster Summary page](#) on page 46

The Performance Cluster Summary page provides a summary of the active events, IOPS performance, and MBps performance for a cluster. This page also includes the total count of the storage objects in the cluster.

[Top Performers page](#) on page 48

The Top Performers page displays the storage objects that have the highest performance or the lowest performance, based on the performance counter you select. For example, in the SVMs category, you can display the SVMs that have the highest IOPS, or the highest latency, or the lowest MBps. This page also shows if any of the top performers have new, active performance events.

Performance Cluster Summary page

The Performance Cluster Summary page provides a summary of the active events, IOPS performance, and MBps performance for a cluster. This page also includes the total count of the storage objects in the cluster.

Cluster performance events pane

The Cluster performance events pane displays performance statistics and all new events for the cluster. This is most helpful when monitoring your clusters and all cluster-related performance and events.

All Events on this Cluster pane



The All Events on this Cluster pane displays all new cluster performance events for the preceding 72 hours. The Total New Events is displayed at the far left; this number represents the total of all new events for all storage objects in this cluster. You can click the Total New Events link to navigate to the Performance Event Inventory page, which is filtered to display these events.

Monitoring cluster performance from the Performance Cluster Landing page

The Total New Events bar graph for the cluster displays the total number of new critical and warning events:

- Latency (total for nodes, aggregates, SVMs, volumes, and LUNs)
- IOPS (total for clusters, nodes, aggregates, SVMs, volumes, and LUNs)
- MBps (total for clusters, nodes, aggregates, SVMs, volumes, LUNs, ports, and LIFs)
- Performance Capacity Used (total for nodes and aggregates)
- Utilization (total for nodes, aggregates, and ports)
- Other (cache miss ratio for volumes)

The list contains new performance events triggered from user-defined threshold policies, system-defined threshold policies, and dynamic thresholds.

Graph data (vertical counter bars) is displayed in red () for critical events, and yellow () for warning events. Position your cursor over each vertical counter bar to view the actual type and number of events. You can click **Refresh** to update the counter panel data.

You can show or hide critical and warning events in the Total New Events performance graph by clicking the **Critical** and **Warning** icons in the legend. If you hide certain event types, the legend icons are displayed in gray.

Counter panels

The counter panels display cluster activity and performance events for the preceding 72 hours, and includes the following counters:

IOPS counter panel

IOPS indicates the operating speed of the cluster in number of input/output operations per second. This counter panel provides a high-level overview of the cluster's IOPS health for the preceding 72-hour period. You can position your cursor over the graph trend line to view the IOPS value for a specific time.

MBps counter panel

MBps indicates how much data has been transferred to and from the cluster in megabytes per second. This counter panel provides a high-level overview of the cluster's MBps health for the preceding 72-hour period. You can position your cursor over the graph trend line to view the MBps value for a specific time.

The number at the top right of the chart in the gray bar is the average value from the last 72-hour period. Numbers shown at the bottom and top of the trend line graph are the minimum and maximum values for the last 72-hour period. The gray bar below the chart contains the count of both new and obsolete events from the last 72-hour period.

The counter panels contain two types of events:

New

Indicates that the performance event is currently active. The issue causing the event has not corrected itself or has not been resolved. The performance counter for the storage object remains above the performance threshold.

Obsolete

Indicates that the event is no longer active. The issue causing the event has corrected itself or has been resolved. The performance counter for the storage object is no longer above the performance threshold.

For **New Events**, if there is one event, you can position your cursor over the event icon and click the event number to link to the appropriate Event Details page. If there is more than one event, you can click **View all Events** to display the Performance Event Inventory page, which is filtered to show all events for the selected object counter type.

Managed Objects pane

The Managed Objects pane in the Performance Summary tab provides a top-level overview of the storage object types and counts for the cluster. This pane enables you to track the status of the objects in each cluster.

The managed objects count is point-in-time data as of the last collection period. New objects are discovered at 15-minute intervals.

Clicking the linked number for any object type displays the object performance inventory page for that object type. The object inventory page is filtered to show only the objects on this cluster.

The managed objects are:

Nodes

A physical system in a cluster.

Aggregates

A set of multiple redundant array of independent disks (RAID) groups that can be managed as a single unit for protection and provisioning.

Ports

A physical connection point on nodes that is used to connect to other devices on a network.

SVMs

A virtual machine providing network access through unique network addresses. An SVM might serve data out of a distinct namespace, and is separately administrable from the rest of the cluster.

Volumes

A logical entity holding accessible user data through one or more of the supported access protocols. The count includes both FlexVol volumes and FlexGroup volumes; it does not include FlexGroup constituents or Infinite Volumes.

LUNs

The identifier of a Fibre Channel (FC) logical unit or an iSCSI logical unit. A logical unit typically corresponds to a storage volume, and is represented within a computer operating system as a device.

LIFs

A logical network interface representing a network access point to a node. The count includes all LIF types.

Top Performers page

The Top Performers page displays the storage objects that have the highest performance or the lowest performance, based on the performance counter you select. For example, in the SVMs category, you can display the SVMs that have the highest IOPS, or the highest latency, or the lowest MBps. This page also shows if any of the top performers have new, active performance events.

The Top Performers page displays a maximum of 10 of each object. Note that the Volume object includes both FlexVol volumes and FlexGroup volumes; it does not include FlexGroup constituents or Infinite Volumes.

Time Range

You can select a time range for viewing the top performers; the selected time range applies to all storage objects. Available time ranges:

- Last hour
- Last 24 hours

Monitoring cluster performance from the Performance Cluster Landing page

- Last 72 hours (default)
- Last 1 week

Metric

Click the **Metric** menu to select a different counter. Counter options are unique to the object type. For example, available counters for the **Volumes** object are **Latency**, **IOPS**, and **MBps**. Changing the counter reloads the panel data with the top performers based on the selected counter.

Available counters:

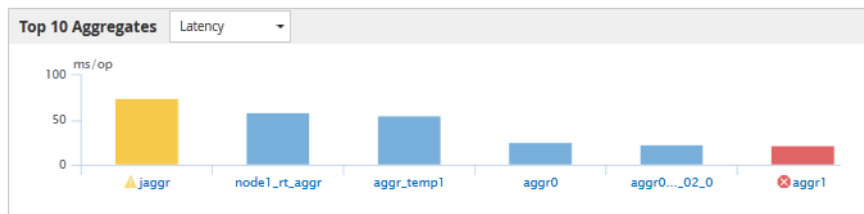
- Latency
- IOPS
- MBps
- Performance Capacity Used (for nodes and aggregates)
- Utilization (for nodes and aggregates)

Sort

Click the **Sort** menu to select an ascending or descending sort for the selected object and counter. The options are **Highest to lowest** and **Lowest to highest**. These options enable you to view the objects with the highest performance or the lowest performance.

Counter bar

The counter bar in the graph shows the performance statistics for each object, represented as a bar for that item. The bar graphs are color-coded. If the counter is not breaching a performance threshold, the counter bar is displayed in blue. If a threshold breach is active (a new event), the bar is displayed in the color for the event: warning events are displayed in yellow (■), and critical events are displayed in red (■). Threshold breaches are further indicated by severity event indicator icons for warning and critical events.



For each graph, the X axis displays the top performers for the selected object type. The Y axis displays units applicable to the selected counter. Clicking the object name link below each vertical bar graph element navigates to the Performance Landing page for the selected object.

Severity Event indicator

The **Severity Event** indicator icon is displayed at the left of an object name for new critical (❌) or warning (⚠️) events in the top performers graphs. Click the **Severity Event** indicator icon to view:

One event

Navigates to the Performance Event Detail page for that event.

Two or more events

Navigates to the Performance Event Inventory page, which is filtered to display all events for the selected object.

Export button

Creates a `.csv` file that contains the data that appears in the counter bar. You can choose to create the file for the single cluster you are viewing or for all clusters in the data center.

Monitoring performance using the Performance Inventory pages

The object inventory performance pages display performance information, performance events, and object health for all objects within an object type category. This provides you with an at-a-glance overview of the performance status of each object within a cluster, for example, for all nodes or all volumes.

Object inventory performance pages provide a high-level overview of object status, enabling you to assess the overall performance of all objects and compare object performance data. You can refine the content of object inventory pages by searching, sorting, and filtering. This is beneficial when monitoring and managing object performance, because it enables you to quickly locate objects with performance issues and to begin the troubleshooting process.

Performance / Nodes ? Last updated: 07:43 AM, 03 Nov Refresh

Latency, IOPS, MBps, Utilization are based on hourly samples averaged over the previous 72 hours

Filtering Export Settings

☐ Assign Performance Threshold Policy

| <input type="checkbox"/> | Status | Node | Latency | IOPS | MBps | Flash Cache F | Perf. Capacity | Utilization | Free Capacity | Total Capacity | Cluster | Policy |
|-------------------------------------|--------|------------------|-------------|------------|-----------|---------------|----------------|-------------|---------------|----------------|---------------|----------|
| <input type="checkbox"/> | ✓ | opm-mobility-02 | 0.704 ms/op | 5,011 IOPS | 49.2 MBps | N/A | 23% | 21% | 93,708 GB | 103,748 GB | opm-m...lity | |
| <input type="checkbox"/> | ✓ | opm-vitality-02 | 0.357 ms/op | < 1 IOPS | 46.8 MBps | 0% | N/A | 20% | 972 GB | 3,563 GB | opm-vitality | |
| <input type="checkbox"/> | ✓ | opm-longevity-01 | 0.523 ms/op | 456 IOPS | 20.9 MBps | N/A | N/A | 6% | 2,162 GB | 2,953 GB | opm-lo...vity | |
| <input type="checkbox"/> | ✓ | opm-mobility-01 | 61.3 ms/op | 2,750 IOPS | 25.7 MBps | N/A | 9% | 8% | 80,175 GB | 90,361 GB | opm-m...lity | headroom |
| <input checked="" type="checkbox"/> | ✓ | opm-vitality-01 | 15.2 ms/op | 3,575 IOPS | 146 MBps | 0% | N/A | 25% | 2,835 GB | 4,800 GB | opm-vitality | |
| <input type="checkbox"/> | ✓ | opm-longevity-02 | 0.106 ms/op | < 1 IOPS | 7.93 MBps | N/A | N/A | 8% | 5,743 GB | 6,762 GB | opm-lo...vity | |

By default, objects on the performance inventory pages are sorted based on object performance criticality. Objects with new critical performance events are listed first, and objects with warning events are listed second. This provides an immediate visual indication of issues that must be addressed. All performance data is based on a 72-hour average.

You can easily navigate from the object inventory performance page to an object details page by clicking the object name in the object name column. For example, on the Performance/Nodes inventory page, you would click a node object in the **Nodes** column. The object details page provides in-depth information and detail about the selected object, including side-by-side comparison of active events.

Object monitoring using the Performance object inventory pages

The Performance object inventory pages enable you to monitor object performance based on the values of specific performance counters or based on performance events. This is beneficial because identifying objects with performance events enables you to investigate the cause of cluster performance issues.

The Performance object inventory pages display the associated counters, associated objects, and performance threshold policies for all objects in all clusters. These pages also enable you to apply performance threshold policies to objects. You can sort the page based on any column, and you can search across all object names or data.

You can export data from these pages to a comma-separated values (.csv) file by using the **Export** button, and then use the exported data to build reports.

Refining Performance inventory page contents

The inventory pages for performance objects contain tools to help you refine object inventory data content, enabling you to locate specific data quickly and easily.

Information contained within the Performance object inventory pages can be extensive, often spanning multiple pages. This kind of comprehensive data is excellent for monitoring, tracking, and improving performance; however, locating specific data requires tools to enable you to quickly locate the data for which you are looking. Therefore, the Performance object inventory pages contain functionality for searching, sorting, and filtering. Additionally, searching and filtering can work together to further narrow your results.

Searching on Object Inventory Performance pages

You can search strings on Object Inventory Performance pages. Use the **Search** field located at the top right of the page to quickly locate data based on either object name or policy name. This enables you to quickly locate specific objects and their associated data, or to quickly locate policies and view associated policy object data.

Step

Perform one of the following options, based on your search requirements:

| To locate this... | Type this... |
|---|--|
| A specific object | The object name into the Search field, and click Search . The object for which you searched and its related data is displayed. |
| A user-defined performance threshold policy | All or part of the policy name into the Search field, and click Search . The objects assigned to the policy for which you searched are displayed. |

Sorting on the Object Inventory Performance pages

You can sort all data on Object Inventory Performance pages by any column in ascending or descending order. This enables you to quickly locate object inventory data, which is helpful when examining performance or beginning a troubleshooting process.

About this task

The selected column for sorting is indicated by a highlighted column heading name and an arrow icon indicating the sorting direction at the right of the name. An up arrow indicates ascending order; a down arrow indicates descending order. The default sort order is by **Status** (event criticality) in descending order, with the most critical performance events listed first.

Step

You can click a column name to toggle the sort order of the column in ascending or descending order.

The Object Inventory Performance page contents are sorted in ascending or descending order, based on the selected column.

Filtering data in the Object Inventory Performance pages

You can filter data in the Object Inventory Performance pages to quickly locate data based on specific criteria. You can use filtering to narrow the contents of the Object Inventory Performance

pages to show only the results you have specified. This provides a very efficient method of displaying only the performance data in which you are interested.

About this task

You can use the Filtering panel to customize the grid view based on your preferences. Available filter options are based on the correlated object type being viewed in the grid. If filters are currently applied, an asterisk (*) displays at the left of the Filtering control.

Four types of filter parameters are supported.

| Parameter | Validation |
|---------------|--|
| String (text) | The operators are contains and starts with . |
| Number | The operators are greater than and less than . |
| Resource | The operators are name contains and name starts with . |
| Status | The operators are is and is not . |

All three fields are required for each filter; the available filters reflect the filterable columns on the current page. The maximum number of filters you can apply is four. Filtered results are based on combined filter parameters. Filtered results apply to all pages in your filtered search, not just the page currently displayed.

You can add filters using the Filtering panel.

1. At the top of the page, click **Filtering**. The Filtering panel displays.
2. In the Filtering panel, click the left drop-down list, and select an object name: for example, *Cluster*, or a performance counter.
3. Click the center drop-down list, and select the boolean operator **name contains** or **name starts with** if the first selection was an object name. If the first selection was a performance counter, select **greater than** or **less than**. If the first selection was **Status**, select **is** or **is not**.
4. If your search criteria requires a numeric value, up and down arrow buttons display in the field at the right. You can click the up and down arrow buttons to display your desired numeric value.
5. If required, type your non-numeric search criteria in the text field at the right.
6. To add filters, click **Add Filter**. An additional filter field displays. Complete this filter using the process described in the preceding steps. Note that upon adding your fourth filter, the **Add Filter** button no longer displays.
7. Click **Apply Filter**. The filter options are applied to the grid and an asterisk (*) is displayed in the Filtering button.
8. Use the Filtering panel to remove individual filters by clicking the trash icon at the right of the filter to be removed.
9. To remove all filters, click **Reset** at the bottom of the filtering panel.

Filtering example

The illustration shows the Filtering panel with three filters. The **Add Filter** button displays when you have fewer than the maximum of four filters.

| | | | | |
|-------------------------|------------------|----------|------|-------------------------------|
| MBps | greater than | 5 | MBps | |
| Node | name starts with | test | | |
| Type | is | FCP Port | | |
| <div>+ Add Filter</div> | | | | |
| | | | | <div>CancelApply Filter</div> |

After clicking **Apply Filter**, the Filtering panel closes and applies your filters.

Filtering

3 filters applied

Monitoring performance using the Performance Explorer pages

The Performance Explorer pages display detailed information about the performance of each object in a cluster. The page provides a detailed view into the performance of all cluster objects, enabling you to select and compare the performance data of specific objects across various time periods.

You can also assess the overall performance of all objects, and compare object performance data in a side-by-side format.

If an object is no longer managed by Unified Manager, the status **Removed** is displayed to the right of the object's name at the top of the Performance Explorer page.

Understanding the root object

The root object is the baseline against which other object comparisons are made. This enables you to view and compare the data from other objects to the root object, providing performance data analysis that helps you to troubleshoot and improve object performance.

The root object name displays at the top of the Comparing pane. Additional objects display below the root object. Although there is no limit to the number of additional objects you can add to the Comparing pane, only one root object is allowed. Data for the root object automatically displays in the graphs in the Counter Charts pane.

You cannot change the root object; it is always set to the object page you are viewing. For example, if you open the Volume Performance Explorer page of Volume1, then Volume1 is the root object and cannot be changed. If you want to compare against a different root object, then you must click the link for an object and open its landing page.

Note: Events and Thresholds are displayed only for root objects.

Apply filtering to reduce the list of correlated objects in the grid

Filtering enables you to display a smaller, more well-defined subset of objects in the grid. For example, if you have 25 volumes in the grid, filtering enables you to view only those volumes that have throughput less than 90 MBps, or latency greater than 1 ms/op.

Related tasks

[Filtering performance inventory page content](#) on page 17

You can filter performance inventory data in Unified Manager to quickly locate data based on specific criteria. You can use filtering to narrow the contents of the Unified Manager pages to show only the results in which you are interested. This provides a very efficient method of displaying only the performance data in which you are interested.

Specifying a time range for correlated objects

The Time Range selector on the Performance Explorer page enables you to specify the time range for object data comparison. Specifying a time range refines the contents of the Performance Explorer pages to show only the object data within the time range you have specified.

About this task

Refining the time range provides an efficient method of displaying only the performance data in which you are interested. You can select a predefined time range or specify a custom time range. The default time range is the preceding 72 hours.

Selecting a predefined time range

Selecting a predefined time range is a quick and efficient way for you to customize and focus data output when viewing cluster object performance data. When selecting a predefined time range, data for up to 13 months is available.

Steps

1. At the top right of the **Performance Explorer** page, click **Time Range**.
2. From the right side of the **Time Range Selection** panel, select a predefined time range.
3. Click **Apply Range**.

Specifying a custom time range

The Performance Explorer page enables you to specify the date and time range for your performance data. Specifying a custom time range provides greater flexibility than using predefined time ranges when refining cluster object data.

About this task

You can select a time range between one hour and 390 days. 13 months equals 390 days because each month is counted as 30 days. Specifying a date and time range provides more detail and enables you to zoom in on specific performance events or series of events. Specifying a time range also aids in troubleshooting potential performance issues, as specifying a date and time range displays data surrounding the performance event in finer detail. Use the **Time Range** control to select predefined date and time ranges, or specify your own custom date and time range of up to 390 days. Buttons for predefined time ranges vary from the **Last Hour** through the **Last 13 Months**.

Selecting the **Last 13 Months** option or specifying a custom date range greater than 30 days displays a dialog box alerting you that performance data displayed for a period greater than 30 days is charted using hourly averages and not 5-minute data polling. Therefore, a loss of timeline visual granularity might occur. If you click the **Do not show again** option in the dialog box, the message does not appear when you select the **Last 13 Months** option or specify a custom date range greater than 30 days. Summary data also applies on a smaller time range, if the time range includes a time/date that is more than 30 days from today.

When selecting a time range (either custom or predefined), time ranges of 30 days or fewer are based on 5-minute interval data samples. Time ranges greater than 30 days are based on one-hour interval data samples.

The screenshot shows a 'Time Range Selection' dialog box. It features two calendar views for April 2015. The 'From' calendar has the 12th selected, and the 'To' calendar has the 15th selected. To the right of the calendars is a list of predefined time ranges: Last Hour, Last 24 Hours, Last 72 Hours, Last 7 Days, Last 30 Days, Last 13 Months, and Custom Range. At the bottom, there are time selectors set to 6:00 am and buttons for Cancel and Apply Range.

1. Click the **Time Range** drop-down box and the Time Range panel displays.
2. To select a predefined time range, click one of the **Last...** buttons at the right of the **Time Range** panel. When selecting a predefined time range, data for up to 13 months is available. The predefined time range button you selected is highlighted, and the corresponding days and time display in the calendars and time selectors.

3. To select a custom date range, click the start date in the **From** calendar on the left. Click < or > to navigate forward or backward in the calendar. To specify the end date, click a date in the **To** calendar on the right. Note that the default end date is today unless you specify a different end date. The **Custom Range** button at the right of the Time Range panel is highlighted, indicating that you have selected a custom date range.
4. To select a custom time range, click the **Time** control below the **From** calendar and select the start time. To specify the end time, click the **Time** control below the **To** calendar on the right and select the end time. The **Custom Range** button at the right of the Time Range panel is highlighted, indicating that you have selected a custom time range.
5. Optionally, you can specify the start and end times when selecting a predefined date range. Select the predefined date range as previously described, then select the start and end times as previously described. The selected dates are highlighted in the calendars, your specified start and end times display in the **Time** controls, and the **Custom Range** button is highlighted.
6. After selecting the date and time range, click **Apply Range**. The performance statistics for that time range display in the charts and in the Events timeline .

Defining the list of correlated objects for comparison graphing


You can define a list of correlated objects for data and performance comparison in the Counter Chart pane. For example, if your storage virtual machine (SVM) is experiencing a performance issue, you can compare all volumes in the SVM to identify which volume might be causing the issue.


About this task

You can add any object in the correlated objects grid to the Comparing and Counter Chart panes. This enables you to view and compare data of multiple objects and with the root object. You can add and remove objects to and from the correlated objects grid; however, the root object in the Comparing pane is not removable.

Note: Adding many objects to the Comparing pane may have a negative impact on performance. To maintain performance, you should select a limited number of charts for data comparison.

Steps

1. In the objects grid, locate the object that you want to add, and click the **Add** button. The **Add** button turns gray, and the object is added to the additional objects list in the Comparing pane. The object's data is added to the graphs in the Counter Charts panes. The color of the object's eye icon () matches the color of the object's data trend line in the graphs.
2. Optional: Hide or show data for selected objects:

| To do this... | Take this action... |
|------------------------|--|
| Hide a selected object | Click the selected object's eye icon () in the Comparing pane. The object's data is hidden, and the eye icon for that object turns gray. |
| Show a hidden object | Click the gray eye icon of the selected object in the Comparing pane. The eye icon returns to its original color, and the object data is added back into the graphs in the Counter Charts pane. |

3. Optional: Remove selected objects from the **Comparing** pane:

| To do this... | Take this action... |
|-----------------------------|--|
| Remove a selected object | <p>Hover over the selected object's name in the Comparing pane to show the remove object button (X), and then click the button.</p> <p>The object is removed from the Comparing pane, and its data is cleared from the counter charts.</p> |
| Remove all selected objects | <p>Click the remove all object's button (X) at the top of the Comparing pane.</p> <p>All selected objects and their data are removed, leaving only the root object.</p> |

Understanding counter charts

Charts in the Counter Charts pane enable you to view and compare performance data for the root object and for objects you have added from the correlated objects grid. This can help you understand performance trends and isolate and resolve performance issues.

Counter charts displayed by default are Events, Latency, IOPS, and MBps. Optional charts that you can choose to display are Utilization, Performance Capacity Used, Available IOPS, IOPS/TB, and Cache Miss Ratio. Additionally, you can choose to view total values or breakdown values for the Latency, IOPS, MBps, and Performance Capacity Used charts.

The Performance Explorer displays certain counter charts by default; whether the storage object supports them all or not. When a counter is not supported, the counter chart is empty and the message `Not applicable for <object>` is displayed.

The charts display performance trends for the root object and for all objects you have selected in the Comparing pane. Data in each chart is arranged as follows:

X axis

Displays the specified time period. If you have not specified a time range, the default is the preceding 72-hour period.

Y axis

Displays counter units unique to the selected object, or objects.

Trend line colors match the color of the object name as displayed in the Comparing pane. You can position your cursor over a point on any trend line to view details for time and value for that point.

If you want to investigate a specific period of time within a chart, you can use one of the following methods:

- Use the < button to expand the Counter Charts pane to span the width of the page.
- Use the cursor (when it transitions to a magnifying glass) to select a portion of the timeframe in the chart to focus and enlarge that area. You can click Reset Chart Zoom to return the chart to the default timeframe.
- Use the **Zoom View** button to display a large single counter chart that contains expanded details and threshold indicators.

Note: Occasionally, gaps in the trend lines display. Gaps mean that either Unified Manager failed to collect performance data from the storage system or that Unified Manager might have been down.

Related tasks

[Selecting performance charts to display](#) on page 61

The Choose charts drop-down list enables you to select the types of performance counter charts to display in the Counter Charts pane. This enables you to view specific data and counters, based on your performance requirements.

[Expanding the Counter Charts pane](#) on page 61

You can expand the Counter Charts pane so that the charts are larger and more readable.

[Changing the Counter Charts focus to a shorter period of time](#) on page 61

You can use your mouse to reduce the time range to focus on a specific period of time in the Counter Chart pane or in the Counter Charts Zoom View window. This enables you to see a more granular and microscopic view of any part of the timeline of performance data, events, and thresholds.

[Displaying the Counter Charts Zoom View](#) on page 63

The Counter Charts Zoom View provides a finer level of detail for the selected counter chart and its associated timeline. This magnifies the counter chart data, enabling you to have a sharper view into performance events and their underlying causes.

Types of performance counter charts

There are standard performance charts that display the counter values for the selected storage object. Each of the Breakdown counter charts display the total values separated out into read, write, and other categories. Furthermore, some Breakdown counter charts display additional detail when the chart is displayed in Zoom view.

The following table shows the available performance counter charts.

| Available charts | Chart description |
|------------------------------|---|
| Events | Displays warning, critical, and information performance events in correlation with the statistical charts for the root object. All event types display: <ul style="list-style-type: none">• System-defined• User-defined• Dynamic |
| Latency - Total | Number of milliseconds required to respond to application requests. Note that the average latency values are I/O weighted. |
| Latency - Breakdown | The same information shown in Latency Total, but with the performance data separated into read and write latency. This chart option applies only when the selected object is an SVM, node, aggregate, volume, or LUN. |
| Latency - Cluster Components | The same information shown in Latency Total, but with the performance data separated into latency by cluster component. This chart option applies only when the selected object is a volume. |
| IOPS - Total | Number of input/output operations processed per second. |
| IOPS - Breakdown | The same information shown in IOPS Total, but with the performance data separated into read, write, and other IOPS. When displayed in Zoom view the volumes chart displays QoS minimum and maximum throughput values, if configured in ONTAP. This chart option applies only when the selected object is an SVM, node, aggregate, volume, or LUN. |

| Available charts | Chart description |
|---------------------------------------|---|
| IOPS - Protocols | The same information shown in IOPS Total, but the performance data is separated into individual charts for CIFS, NFS, FCP, and iSCSI protocol traffic. This chart option applies only when the selected object is an SVM. |
| IOPS/TB - Total | Number of input/output operations processed per second based on the total space that is being consumed by the workload, in terabytes. Also called I/O density, this counter measures how much performance can be delivered by a given amount of storage capacity. When displayed in Zoom view the volumes chart displays QoS expected and peak throughput values, if configured in ONTAP. This chart option applies only when the selected object is a volume. |
| MBps - Total | Number of megabytes of data transferred to and from the object per second. |
| MBps - Breakdown | The same information shown in the MBps chart, but with the MBps data separated into disk reads, Flash Cache reads, writes, and other. When displayed in Zoom view, the volumes chart displays QoS maximum throughput values, if configured in ONTAP. This chart option applies only when the selected object is an SVM, node, aggregate, volume, or LUN. Note: Flash Cache data is displayed only for nodes, and only when a Flash Cache module is installed in the node. |
| Performance Capacity Used - Total | Percentage of performance capacity that is being consumed by the node or aggregate. Note: Performance capacity data is available only when the nodes in a cluster are installed with ONTAP 9.0 or later software. |
| Performance Capacity Used - Breakdown | Performance Capacity Used data separated into user protocols and system background processes. Additionally, the amount of free performance capacity is shown. |
| Available IOPS - Total | Number of input/output operations per second that are currently available (free) on this object. This number is the result of subtracting the currently used IOPS from the total IOPS that Unified Manager calculates that the object can perform. This chart option applies only when the selected object is a node or aggregate. Note: Available IOPS data is available only when the nodes in a cluster are installed with ONTAP 9.0 or later software. |
| Utilization - Total | Available resource percentage of the object that is being used. Utilization indicates node utilization for nodes, disk utilization for aggregates, and bandwidth utilization for ports. This chart option applies only when the selected object is a node, aggregate, or port. |
| Cache Miss Ratio - Total | Percentage of read requests from client applications that are returned from the disk instead of being returned from the cache. This chart option applies only when the selected object is a volume. |

Selecting performance charts to display

The Choose charts drop-down list enables you to select the types of performance counter charts to display in the Counter Charts pane. This enables you to view specific data and counters, based on your performance requirements.

Steps

1. In the **Counter Charts** pane, click the **Choose charts** drop-down list.
2. Add or remove charts:

| To... | Do this... |
|---------------------------------|---|
| Add or remove individual charts | Click the check boxes next to the charts you want to show or hide |
| Add all charts | Click Select All |
| Remove all charts | Click Unselect All |

Your chart selections are displayed in the Counter Charts pane. Note that as you add charts, the new charts are inserted into the Counter Charts pane to match the order of the charts listed in the Choose charts drop-down list. Selecting additional charts might require additional scrolling.

Related concepts

[Sources of performance events](#) on page 21

Performance events are issues or configuration changes related to workload performance on a cluster. They help you identify storage objects with slow response times and cluster configuration changes that might have caused, or contributed to, the slow response times.

Related reference

[Types of system-defined performance threshold policies](#) on page 27

Unified Manager provides some standard threshold policies that monitor cluster performance and generate events automatically. These policies are enabled by default, and they generate warning or information events when the monitored performance thresholds are breached.

Expanding the Counter Charts pane

You can expand the Counter Charts pane so that the charts are larger and more readable.

About this task

After you have defined the comparison objects and the time range for counters, you can view a larger Counter Charts pane. You use the < button in the middle of the Performance Explorer window to expand the pane.

Step

Expand or reduce the **Counter Charts** pane.

| To... | Do this... |
|--|--------------------|
| Expand the Counter Charts pane to fit the width of the page | Click the < button |
| Reduce the Counter Charts pane to the right half of the page | Click the > button |

Changing the Counter Charts focus to a shorter period of time

You can use your mouse to reduce the time range to focus on a specific period of time in the Counter Chart pane or in the Counter Charts Zoom View window. This enables you to see a more

granular and microscopic view of any part of the timeline of performance data, events, and thresholds.

Before you begin

The cursor must have changed to a magnifying glass to indicate that this functionality is active.

Note: When using this feature, which alters the timeline to display values that correspond to the more granular display, the time and date range on the **Time Range** selector does not change from the original values for the chart.

Steps

1. To zoom into a specific period of time, click using the magnifying glass and drag the mouse to highlight the area that you want to see in detail.
The counter values for the time period you select fills the counter chart.
2. To return to the original period of time as set in the **Time Range** selector, click the **Reset Chart Zoom** button.
The counter chart displays in its original state.

Viewing event details in the Events Timeline

You can view all performance events and their related details in the Events Timeline pane of Performance Explorer. This is a quick and efficient method of viewing all the threshold events that occurred on the root object during a specified time range, which can be helpful when troubleshooting performance issues.

About this task

The Events Timeline pane shows critical, warning, and informational events that occurred on the root object during the selected time range. Critical events are sent when a critical limit in a threshold policy is exceeded. Warning events are sent when a warning limit in a threshold policy is exceeded, or when dynamic thresholds are exceeded. Informational events are sent when ONTAP configuration change events occur.

Critical, warning, and informational events have their own timelines. Single and multiple events are represented by an event point on the timeline. You can position your cursor over an event point to see the event details. To increase the visual granularity of multiple events, you can decrease the time range. This spreads out multiple events into single events, enabling you to separately view and investigate each event.

The event points on the Events Timeline line up vertically with their corresponding spikes in the counter charts trend lines that are displayed below the Events Timeline. This provides a direct visual correlation between events and overall performance.

Steps

1. On the **Events Timeline** pane, position the cursor over an event point on a timeline to view a summary of the event or events at that event point.
A pop-up dialog displays information about the event types, the date and time when the events occurred, the state, and the event duration.
2. View full event details for one event or multiple events:

| To do this... | Click this... |
|---------------------------------|--|
| View details for a single event | View Event Detail in the pop-up dialog. |

| To do this... | Click this... |
|----------------------------------|---|
| View details for multiple events | View Event Details in the pop-up dialog. Note: Clicking a single event ID on the multiple events dialog displays the appropriate Event Details page. |

Related concepts

Sources of performance events on page 21

Performance events are issues or configuration changes related to workload performance on a cluster. They help you identify storage objects with slow response times and cluster configuration changes that might have caused, or contributed to, the slow response times.

Counter Charts Zoom View

The Counter Charts provide a Zoom View that enables you to zoom in on performance details over your specified time period. This enables you to see performance details and events with much higher granularity, which is beneficial when troubleshooting performance issues.

When displayed in Zoom View, some of the breakdown charts provide additional information than what appears when the chart is not in Zoom View. For example, the IOPS, IOPS/TB, and MBps Breakdown chart Zoom View pages display QoS policy values for volumes and LUNs if they have been set in ONTAP.

Note: For system-defined performance threshold policies, only the "Node resources over-utilized" and "QoS throughput limit breached" policies are available from the **Policies** list. The other system-defined threshold policies are not available at this time.

Displaying the Counter Charts Zoom View

The Counter Charts Zoom View provides a finer level of detail for the selected counter chart and its associated timeline. This magnifies the counter chart data, enabling you to have a sharper view into performance events and their underlying causes.

About this task

You can display the Counter Charts Zoom View for any counter chart.

Steps

1. Click **Zoom View** to open the selected chart a new browser window.
2. If you are viewing a Breakdown chart and then click **Zoom View** the Breakdown chart is shown in Zoom View. You can select **Total** while in Zoom View if you want to change the view option.

Specifying the time range in Zoom View

The **Time Range** control in the Counter Charts Zoom View window enables you to specify a date and time range for the selected chart. This enables you to quickly locate specific data based on either a preset time range or your own custom time range.

About this task

You can select a time range between one hour and 390 days. 13 months equals 390 days because each month is counted as 30 days. Specifying a date and time range provides more detail and enables you to zoom in on specific performance events or series of events. Specifying a time range also aids in troubleshooting potential performance issues, as specifying a date and time range displays data surrounding the performance event in finer detail. Use the **Time Range** control to select predefined date and time ranges, or specify your own custom date and time range of up to

390 days. Buttons for predefined time ranges vary from the **Last Hour** through the **Last 13 Months**.

Selecting the **Last 13 Months** option or specifying a custom date range greater than 30 days displays a dialog box alerting you that performance data displayed for a period greater than 30 days is charted using hourly averages and not 5-minute data polling. Therefore, a loss of timeline visual granularity might occur. If you click the **Do not show again** option in the dialog box, the message does not appear when you select the **Last 13 Months** option or specify a custom date range greater than 30 days. Summary data also applies on a smaller time range, if the time range includes a time/date that is more than 30 days from today.

When selecting a time range (either custom or predefined), time ranges of 30 days or fewer are based on 5-minute interval data samples. Time ranges greater than 30 days are based on one-hour interval data samples.

The screenshot shows a 'Time Range' selection interface. It includes two calendar panels, 'From' and 'To', both for April 2015. In the 'From' calendar, the 12th is selected. In the 'To' calendar, the 15th is selected. Below each calendar is a 'Time' dropdown menu, both set to '6:00 am'. To the right of the calendars is a vertical list of buttons for predefined time ranges: 'Last Hour', 'Last 24 Hours', 'Last 72 Hours', 'Last 7 Days', 'Last 30 Days', 'Last 13 Months', and 'Custom Range'. The 'Custom Range' button is currently highlighted. At the bottom right of the panel are 'Cancel' and 'Apply Range' buttons.

1. Click the **Time Range** drop-down box and the Time Range panel displays.
2. To select a predefined time range, click one of the **Last...** buttons at the right of the **Time Range** panel. When selecting a predefined time range, data for up to 13 months is available. The predefined time range button you selected is highlighted, and the corresponding days and time display in the calendars and time selectors.
3. To select a custom date range, click the start date in the **From** calendar on the left. Click < or > to navigate forward or backward in the calendar. To specify the end date, click a date in the **To** calendar on the right. Note that the default end date is today unless you specify a different end date. The **Custom Range** button at the right of the Time Range panel is highlighted, indicating that you have selected a custom date range.
4. To select a custom time range, click the **Time** control below the **From** calendar and select the start time. To specify the end time, click the **Time** control below the **To** calendar on the right and select the end time. The **Custom Range** button at the right of the Time Range panel is highlighted, indicating that you have selected a custom time range.
5. Optionally, you can specify the start and end times when selecting a predefined date range. Select the predefined date range as previously described, then select the start and end times as previously described. The selected dates are highlighted in the calendars, your specified start and end times display in the **Time** controls, and the **Custom Range** button is highlighted.
6. After selecting the date and time range, click **Apply Range**. The performance statistics for that time range display in the charts and in the Events timeline .

Selecting performance thresholds in Counter Charts Zoom View

Applying thresholds in the Counter Charts Zoom View provides a detailed view of occurrences of performance threshold events. This enables you to apply or remove thresholds, and immediately


view the results, which can be helpful while deciding whether troubleshooting should be your next step.

About this task

Selecting thresholds in the Counter Charts Zoom View enables you to view precise data about performance threshold events. You can apply any threshold that appears under the **Policies** area of the Counter Charts Zoom View.

Only one policy at a time can be applied to the object in the Counter Charts Zoom View.

Step

Select or deselect the  that is associated with a policy.
The selected threshold is applied to the Counter Charts Zoom View. Critical thresholds are displayed as a red line; warning thresholds are displayed as a yellow line.

Viewing workload QoS minimum and maximum settings

You can view the ONTAP-defined quality of service (QoS) policy settings on a volume or LUN in the Performance Explorer charts. A throughput maximum setting limits the impact of competing workloads on system resources. A throughput minimum setting ensures that a critical workload meets minimum throughput targets regardless of demand by competing workloads.

About this task

QoS throughput "minimum" and "maximum" IOPS and MBps settings are displayed in the counter charts only if they have been configured in ONTAP. Throughput minimum settings are available only on systems running ONTAP 9.2 or later software, only on AFF systems, and they can be set only for IOPS at this time.

Adaptive QoS policies are available starting with ONTAP 9.3 and are expressed using IOPS/TB instead of IOPS. These policies automatically adjust the QoS policy value based on the volume size, per workload, thereby maintaining the ratio of IOPS to terabytes as the size of the volume changes. You can apply an adaptive QoS policy group to volumes only. The QoS terminology "expected" and "peak" are used for adaptive QoS policies instead of minimum and maximum .

Unified Manager generates warning events for QoS policy breaches when workload throughput has exceeded the defined QoS maximum policy setting during each performance collection period for the previous hour. Workload throughput may exceed the QoS threshold for only a short period of time during each collection period, but Unified Manager displays the "average" throughput during the collection period on the chart. For this reason you may see QoS events while the throughput for a workload might not have crossed the policy threshold shown in the chart.

Steps

- 1. In the **Performance Explorer** page for your selected volume or LUN, perform the following actions to view the QoS ceiling and floor settings:

| If you want to... | Do this... |
|-------------------------------------|--|
| View the IOPS ceiling (the QoS max) | In the IOPS Total or Breakdown chart, click Zoom View . |
| View the MBps ceiling (the QoS max) | In the MBps Total or Breakdown chart, click Zoom View . |
| View the IOPS floor (the QoS min) | In the IOPS Total or Breakdown chart, click Zoom View . |

| If you want to... | Do this... |
|---|---|
| View the IOPS/TB ceiling (the QoS peak) | For volumes, in the IOPS/TB chart, click Zoom View . |
| View the IOPS/TB floor (the QoS expected) | For volumes, in the IOPS/TB chart, click Zoom View . |

The dashed, horizontal line indicates the maximum or minimum throughput value set in ONTAP. You can also view when changes to the QoS values were implemented.

- To view the specific IOPS and MBps values compared to the QoS setting, move your cursor into the chart area to see the popup window.

After you finish

If you notice that certain volumes or LUNs have very high IOPS or MBps and are stressing system resources, you can use System Manager or the ONTAP CLI to adjust the QoS settings so that these workloads do not affect the performance of other workloads.

For more information on adjusting QoS settings, see the *ONTAP 9 Performance Monitoring Power Guide*.

[ONTAP 9 Performance Monitoring Power Guide](#)

Related concepts

[How different types of QoS policies are displayed in Unified Manager](#) on page 66

You can view the ONTAP-defined quality of service (QoS) policy settings that have been applied to a volume or LUN in the Performance Explorer IOPS, IOPS/TB, and MBps charts. The information displayed in the charts is different depending on the type of QoS policy that has been applied to the workload.

How different types of QoS policies are displayed in Unified Manager

You can view the ONTAP-defined quality of service (QoS) policy settings that have been applied to a volume or LUN in the Performance Explorer IOPS, IOPS/TB, and MBps charts. The information displayed in the charts is different depending on the type of QoS policy that has been applied to the workload.

A throughput "ceiling" setting defines the maximum throughput that the workload can consume, and thereby limits the impact on competing workloads for system resources. A throughput "floor" setting defines the minimum throughput that must be available to the workload so that a critical workload meets minimum throughput targets regardless of demand by competing workloads.

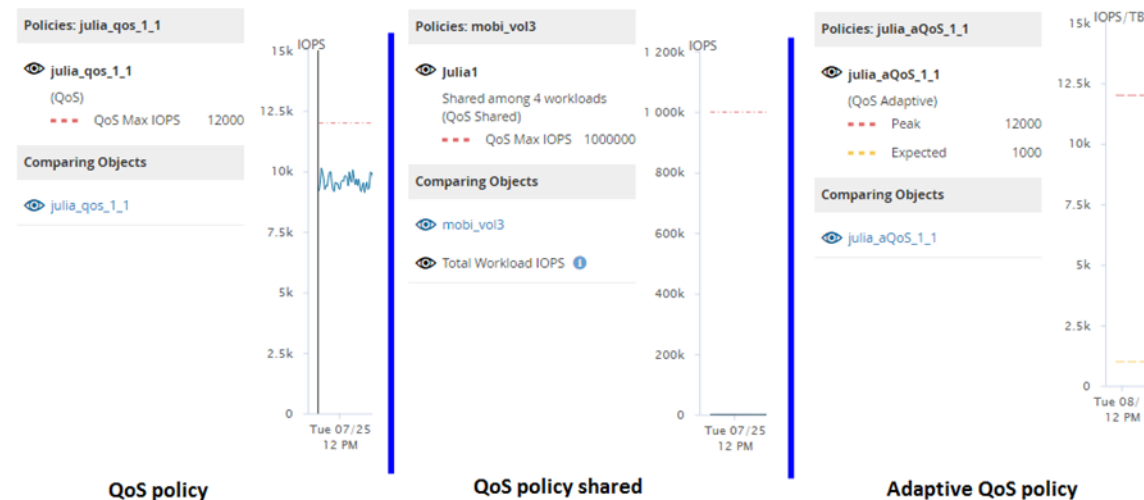
Normal QoS policies for IOPS and MBps use the terms "minimum" and "maximum" to define the floor and ceiling. Adaptive QoS policies for IOPS/TB, which were introduced in ONTAP 9.3, use the terms "expected" and "peak" to define the floor and ceiling.

While ONTAP enables you to create these two types of QoS policies, depending on how they are applied to workloads there are three ways that the QoS policy will be displayed in the performance charts.

| Type of policy | Functionality | Indicator in Unified Manager interface |
|---|--|--|
| QoS policy assigned to a single workload | Workload can consume the entire throughput setting | Displays "(QoS)" |
| QoS policy assigned to multiple workloads | Workloads share the throughput setting | Displays "(QoS Shared)" |

| Type of policy | Functionality | Indicator in Unified Manager interface |
|---|---|--|
| Adaptive QoS policy assigned to a single workload or multiple workloads | Workloads can consume the entire throughput setting | Displays "(QoS Adaptive)" |

The following figure shows an example of how the three options are shown in the counter charts.



When a normal QoS policy that has been defined in IOPS appears in the IOPS/TB chart for a workload, Unified Manager converts the IOPS value to an IOPS/TB value and displays that policy in the IOPS/TB chart along with the text "QoS, defined in IOPS".

When an adaptive QoS policy that has been defined in IOPS/TB appears in the IOPS chart for a workload, Unified Manager converts the IOPS/TB value to an IOPS value and displays that policy in the IOPS chart along with the text "QoS Adaptive, defined in IOPS/TB".

Note: The IOPS/TB chart displays performance data only when the logical capacity used by the volume is greater than or equal to 1 TB. Gaps are displayed in the chart when the used capacity falls below 1 TB during the selected timeframe.

Related tasks

[Viewing workload QoS minimum and maximum settings](#) on page 65

You can view the ONTAP-defined quality of service (QoS) policy settings on a volume or LUN in the Performance Explorer charts. A throughput maximum setting limits the impact of competing workloads on system resources. A throughput minimum setting ensures that a critical workload meets minimum throughput targets regardless of demand by competing workloads.

Viewing volume latency by cluster component


You can view detailed latency information for a volume by using the Performance/Volume Explorer page. The Latency - Total counter chart shows total latency on the volume, and the Latency - Breakdown counter chart is useful for determining the impact of read and write latency on the volume.

About this task

Additionally, the Latency - Cluster Components chart shows a detailed comparison of the latency of each cluster component to help determine how each component contributes to the total latency on the volume. The following cluster components are displayed:

- Network
- QoS Policy
- Network Processing
- Cluster Interconnect
- Data Processing
- Aggregate Operations
- MetroCluster Resources

Steps

1. In the **Performance/Volume Explorer** page for your selected volume, from the Latency chart, select **Cluster Components** from the drop-down menu.
The Latency - Cluster Components chart is displayed.
2. To view a larger version of the chart, select **Zoom View**.
The cluster component comparative chart is displayed. You can restrict the comparison by deselecting or selecting the  that is associated with each cluster component.
3. To view the specific values, move your cursor into the chart area to see the popup window.

Viewing SVM IOPS traffic by protocol


You can view detailed IOPS information for an SVM by using the Performance/SVM Explorer page. The IOPS - Total counter chart shows total IOPS usage on the SVM, and the IOPS - Breakdown counter chart is useful for determining the impact of read, write, and other IOPS on the SVM.

About this task

Additionally, the IOPS - Protocols chart shows a detailed comparison of the IOPS traffic for each protocol that is being used on the SVM. The following protocols are available:

- CIFS
- NFS
- FCP
- iSCSI

Steps

1. In the **Performance/SVM Explorer** page for your selected SVM, from the IOPS chart, select **Protocols** from the drop-down menu.
The IOPS - Protocols chart is displayed.
2. To view a larger version of the chart, select **Zoom View**.
The IOPS advanced protocol comparative chart is displayed. You can restrict the comparison by deselecting or selecting the  that is associated with a protocol.
3. To view the specific values, move your cursor into the chart area of either chart to see the popup window.

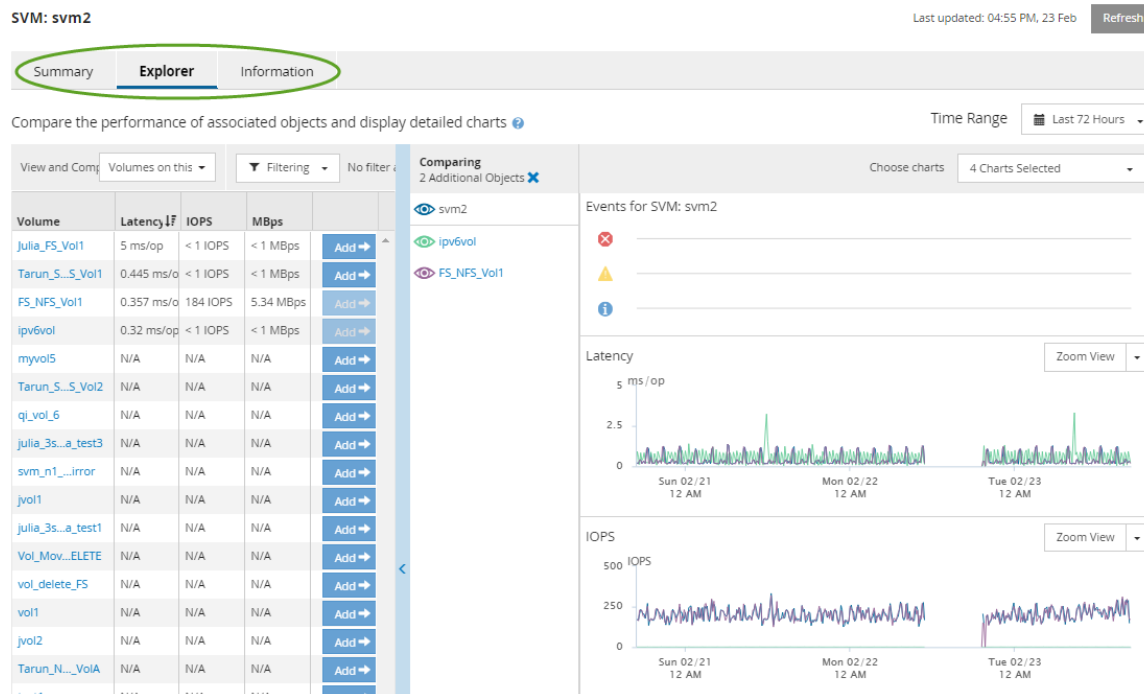
Components of the Object Landing pages

The Object Landing pages provide details about all critical, warning, and informational events. They provide a detailed view into the performance of all cluster objects, enabling you to select and compare individual objects across various time periods.

The Object Landing pages enable you to examine the overall performance of all objects, and to compare object performance data in a side-by-side format. This is beneficial when assessing performance and when troubleshooting events.

Note: The data displayed in the counter summary panels and in the Counter Charts are based on a five-minute sampling interval. The data displayed in the objects inventory grid in the left side of the page is based on a one-hour sampling interval.

The following image shows an example of an Object Landing page displaying the Explorer information:



Depending on the storage object that is being viewed, the Object Landing page can have the following tabs that provide performance data about the object:

- **Summary**
Displays three or four counter charts containing the events and performance per object for the preceding 72-hour period, including a trend line that shows the high and low values during that period.
- **Explorer**
Displays a grid of storage objects that are related to the current object, which enables you to compare the performance values of the current object with those of the related objects. This tab includes up to eleven counter charts and a time range selector, which enable you to perform a variety of comparisons.
- **Information**
Displays values for non-performance configuration attributes about the storage object, including the installed version of ONTAP software, HA partner name, and number of ports and LIFs.
- **Top Performers**
For clusters: Displays the storage objects that have the highest performance or the lowest performance, based on the performance counter that you select.
- **Failover Planning**
For nodes: Displays the estimate of the performance impact on a node if the HA partner of the node fails.
- **Details**

For volumes: Displays detailed performance statistics for all I/O activity and operations for the selected volume workload. This tab is available for FlexVol volumes, FlexGroup volumes, and constituents of FlexGroups.

Related concepts

[Sources of performance events](#) on page 21

Performance events are issues or configuration changes related to workload performance on a cluster. They help you identify storage objects with slow response times and cluster configuration changes that might have caused, or contributed to, the slow response times.

[Components of the Performance Explorer page](#) on page 73

The Performance Explorer page enables you to compare the performance of similar objects in a cluster—for example, all the volumes in a cluster. This is beneficial when troubleshooting performance events and fine-tuning object performance. You can also compare objects with the root object, which is the baseline against which other object comparisons are made.

Related tasks

[Viewing event details in the Events Timeline](#) on page 62

You can view all performance events and their related details in the Events Timeline pane of Performance Explorer. This is a quick and efficient method of viewing all the threshold events that occurred on the root object during a specified time range, which can be helpful when troubleshooting performance issues.

Related reference

[Summary page](#) on page 70

The Summary page displays counter charts that contain details about the events and performance per object for the preceding 72-hour period. This data is not automatically refreshed, but is current as of the last page load. The charts in the Summary page answer the question *Do I need to look further?*

[Performance Cluster Summary page](#) on page 46

The Performance Cluster Summary page provides a summary of the active events, IOPS performance, and MBps performance for a cluster. This page also includes the total count of the storage objects in the cluster.

[Top Performers page](#) on page 48

The Top Performers page displays the storage objects that have the highest performance or the lowest performance, based on the performance counter you select. For example, in the SVMs category, you can display the SVMs that have the highest IOPS, or the highest latency, or the lowest MBps. This page also shows if any of the top performers have new, active performance events.

[Understanding and using the Node Failover Planning page](#) on page 83

The Performance/Node Failover Planning page estimates the performance impact on a node if the node's high-availability (HA) partner node fails. Unified Manager bases the estimates on the historical performance of the nodes in the HA pair.

Summary page

The Summary page displays counter charts that contain details about the events and performance per object for the preceding 72-hour period. This data is not automatically refreshed, but is current as of the last page load. The charts in the Summary page answer the question *Do I need to look further?*

Charts and counter statistics

The summary charts provide a quick, high-level overview for the last 72-hour period, and help you to identify possible issues that require further investigation.

The Summary page counter statistics are displayed in graphs.

You can position your cursor over the trend line in a graph to view the counter values for a particular point in time. The summary charts also display the total number of critical and warning events for the preceding 72-hour period for the following counters:

Latency

Average response time for all I/O requests; expressed in milliseconds per operation.

Displayed for all object types.

IOPS

Average operating speed; expressed in input/output operations per second.

Displayed for all object types.

MBps

Average throughput; expressed in megabytes per second.

Displayed for all object types.

Performance Capacity Used

Percentage of performance capacity that is being consumed by a node or aggregate.

Displayed for nodes and aggregates only. This chart is displayed only when using ONTAP 9.0 or later software.

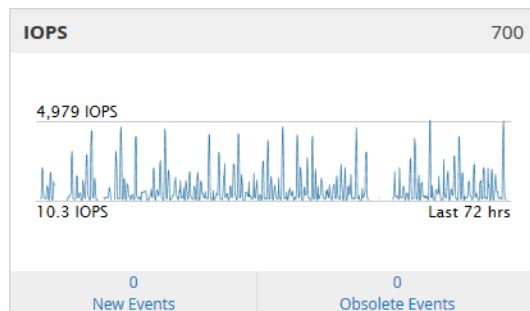
Utilization

Percentage of object utilization for nodes and aggregates, or bandwidth utilization for ports.

Displayed for nodes, aggregates, and ports only.

Positioning the cursor over the event count for new events shows the type and number of events.

The number at the top right of the chart in the gray bar is the average value from the last 72-hour period. Numbers shown at the bottom and top of the trend line graph are the minimum and maximum values for the last 72-hour period. The gray bar below the chart contains the count of both new and obsolete events from the last 72-hour period.



Latency counter chart

The Latency counter chart provides a high-level overview of the object latency for the preceding 72-hour period. Latency refers to the average response time for all I/O requests; expressed in milliseconds per operation, the service time, wait time, or both experienced by a data packet or block in the cluster storage component under consideration.

Top (counter value): The number in the header displays the average for the preceding 72-hour period.

Middle (performance graph): The number at the bottom of the graph displays the lowest latency, and the number at the top of the graph displays the highest latency for the preceding 72-hour period. Position your cursor over the graph trend line to view the latency value for a specific time.

Bottom (events): On hover, the pop-up displays the details of the events. Click the **New Events** link below the graph to navigate to the Event Inventory page to view complete event details.

IOPS counter chart

The IOPS counter chart provides a high-level overview of the object IOPS health for the preceding 72-hour period. IOPS indicates the speed of the storage system in number of input/output operations per second.

Top (counter value): The number in the header displays the average for the preceding 72-hour period.

Middle (performance graph): The number at the bottom of the graph displays the lowest IOPS, and the number at the top of the graph displays the highest IOPS for the preceding 72-hour period. Position your cursor over the graph trend line to view the IOPS value for a specific time.

Bottom (events): On hover, the pop-up displays the details of the events. Click the **New Events** link below the graph to navigate to the Event Inventory page to view complete event details.

MBps counter chart

The MBps counter chart displays the object MBps performance, and indicates how much data has been transferred to and from the object in megabytes per second. The MBps counter chart provides a high-level overview of the object's MBps health for the preceding 72-hour period.

Top (counter value): The number in the header displays the average number of MBps for the preceding 72-hour period.

Middle (performance graph): The value at the bottom of the graph displays the lowest number of MBps, and the value at the top of the graph displays the highest number of MBps for the preceding 72-hour period. Position your cursor over the graph trend line to view the MBps value for a specific time.

Bottom (events): On hover, the pop-up displays the details of the events. Click the **New Events** link below the graph to navigate to the Event Inventory page to view complete event details.

Performance Capacity Used counter chart

The Performance Capacity Used counter chart displays the percentage of performance capacity that is being consumed by the object.

Top (counter value): The number in the header displays the average used performance capacity for the preceding 72-hour period.

Middle (performance graph): The value at the bottom of the graph displays the lowest used performance capacity percentage, and the value at the top of the graph displays the highest used performance capacity percentage for the preceding 72-hour period. Position your cursor over the graph trend line to view the used performance capacity value for a specific time.

Bottom (events): On hover, the pop-up displays the details of the events. Click the **New Events** link below the graph to navigate to the Event Inventory page to view complete event details.

Utilization counter chart



The Utilization counter chart displays the object utilization percentage. The Utilization counter chart provides a high-level overview of the percentage of the object or bandwidth utilization for the preceding 72-hour period.

- Top (counter value):** The number in the header displays the average utilization percentage for the preceding 72-hour period.
- Middle (performance graph):** The value at the bottom of the graph displays the lowest utilization percentage, and the value at the top of the graph displays the highest utilization percentage for the preceding 72-hour period. Position your cursor over the graph trend line to view the utilization value for a specific time.
- Bottom (events):** On hover, the pop-up displays the details of the events. Click the **New Events** link below the graph to navigate to the Event Inventory page to view complete event details.

Events


The counter panels contain two types of events.


| Event type | Event description |
|-----------------|--|
| New Events | <p>If a performance threshold event has occurred, position your cursor over the New Events icon to view an overview of the events in the Event Summary dialog panel. In the Event Summary dialog, click View Event Details to see each issue.</p> <p>Multiple events are ranked by severity, with the most severe events listed first. If there is more than one event, then clicking the event count number opens the Events inventory page, which is filtered to show all events for the selected object counter type. Events are sorted by highest to lowest level of severity, with new events first, followed by obsolete events.</p> |
| Obsolete Events | An obsolete event is an event that is no longer active. |

Critical events are displayed in red () , and warning events are displayed in yellow () .

Components of the Performance Explorer page

The Performance Explorer page enables you to compare the performance of similar objects in a cluster—for example, all the volumes in a cluster. This is beneficial when troubleshooting performance events and fine-tuning object performance. You can also compare objects with the root object, which is the baseline against which other object comparisons are made.

You can click the **Favorites** button () to add this object to your list of favorite storage objects.

A blue button () indicates that this object is already a favorite.

You can click the **Switch to Health View** button to display the Health details page for this object. In some cases you can learn important information about the storage configuration settings for this object that may help when troubleshooting an issue.

The Performance Explorer page displays a list of cluster objects and their performance data. This page displays all the cluster objects of the same type (for example, volumes and their object-specific performance statistics) in a tabular format. This view provides an efficient overview of cluster object performance.

Note: If "N/A" appears in any cell of the table, it means that a value for that counter is not available because there is no I/O on that object at this time.

The Performance Explorer page contains the following components:

Time Range

- Enables you to select a time range for the object data.
- You can choose a predefined range, or specify your own custom time range.

View and Compare

Enables you to select which type of correlated object is displayed in the grid.

The options available depend on the root object type and its available data. You can click the View and Compare drop-down list to select an object type. The object type that you select is displayed in the list.

Filtering

Enables you to narrow the amount of data you receive, based on your preferences.

You can create filters that apply to the object data—for example, IOPS greater than 4. You can add up to four simultaneous filters.

Comparing

Displays a list of the objects that you have selected for comparison with the root object.

Data for the objects in the Comparing pane is displayed in the Counter Charts.

Events Timeline

Displays performance events occurring across the timeline that you selected in the Time Range component.

Counter Charts

Displays graphed data for each object performance category.

Typically, only three or four charts are displayed by default. The Choose charts component enables you to display additional charts, or hide specific charts. You can also choose to show or hide the Events Timeline.

Related concepts

[Understanding counter charts](#) on page 58

Charts in the Counter Charts pane enable you to view and compare performance data for the root object and for objects you have added from the correlated objects grid. This can help you understand performance trends and isolate and resolve performance issues.

Related tasks

[Selecting a predefined time range](#) on page 56

Selecting a predefined time range is a quick and efficient way for you to customize and focus data output when viewing cluster object performance data. When selecting a predefined time range, data for up to 13 months is available.

[Specifying a custom time range](#) on page 56

The Performance Explorer page enables you to specify the date and time range for your performance data. Specifying a custom time range provides greater flexibility than using predefined time ranges when refining cluster object data.

[Filtering performance inventory page content](#) on page 17

You can filter performance inventory data in Unified Manager to quickly locate data based on specific criteria. You can use filtering to narrow the contents of the Unified Manager pages to show only the results in which you are interested. This provides a very efficient method of displaying only the performance data in which you are interested.

[Viewing event details in the Events Timeline](#) on page 62

You can view all performance events and their related details in the Events Timeline pane of Performance Explorer. This is a quick and efficient method of viewing all the threshold events that occurred on the root object during a specified time range, which can be helpful when troubleshooting performance issues.

[Defining the list of correlated objects for comparison graphing](#) on page 57

You can define a list of correlated objects for data and performance comparison in the Counter Chart pane. For example, if your storage virtual machine (SVM) is experiencing a performance issue, you can compare all volumes in the SVM to identify which volume might be causing the issue.

[*Selecting performance charts to display*](#) on page 61

The Choose charts drop-down list enables you to select the types of performance counter charts to display in the Counter Charts pane. This enables you to view specific data and counters, based on your performance requirements.

Managing performance using performance capacity and available IOPS information

Performance capacity indicates how much throughput you can get out of a resource without surpassing the useful performance of that resource. When viewed using existing performance counters, performance capacity is the point at which you get the maximum utilization from a node or aggregate before latency becomes an issue.

Unified Manager collects performance capacity statistics from nodes and aggregates in each cluster. *Performance capacity used* is the percentage of performance capacity that is currently being used, and *performance capacity free* is the percentage of performance capacity that is still available.

While performance capacity free provides a percentage of the resource that is still available, *available IOPS* tells you the number of IOPS that can be added to the resource before reaching the maximum performance capacity. By using this metric, you can be sure that you can add workloads of a predetermined number of IOPS to a resource.

Monitoring the performance capacity information has the following benefits:

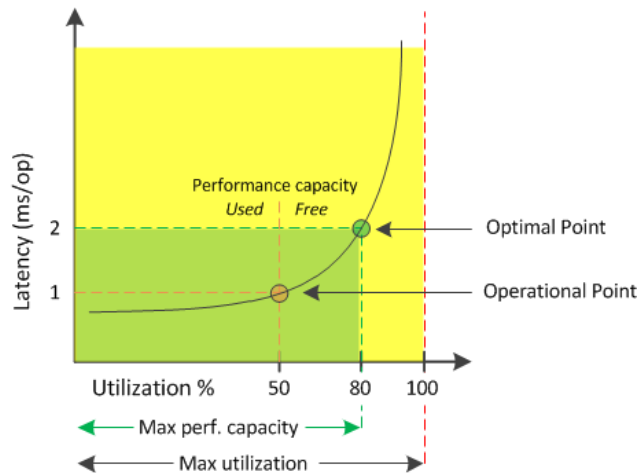
- Assists with workflow provisioning and balancing.
- Helps you prevent overloading a node or pushing its resources beyond the optimal point, thus reducing the need to troubleshoot.
- Helps you determine with greater precision where additional storage equipment might be needed.

What performance capacity used is

The performance capacity used counter helps you to identify whether the performance of a node or an aggregate is reaching a point where the performance might degrade if the workloads increase. It can also show you if a node or aggregate is currently being overused during specific periods of time. Performance capacity used is similar to utilization, but the former provides more insight about the available performance capabilities in a physical resource for a specific workload.

Note: Performance capacity data is available only when the nodes in a cluster are installed with ONTAP 9.0 or later software.

The optimal used performance capacity is the point at which a node or an aggregate has optimal utilization and latency (response time), and is being used efficiently. A sample latency versus utilization curve is shown for an aggregate in the following figure.



The *operational point* identifies that the aggregate is currently operating at 50% utilization with latency of 1.0 ms/op. Based on the statistics captured from the aggregate, Unified Manager determines that additional performance capacity is available for this aggregate. The *optimal point* is identified as the point when the aggregate is at 80% utilization with latency of 2.0 ms/op. Therefore, you can add more volumes and LUNs to this aggregate so that your systems are used more efficiently.

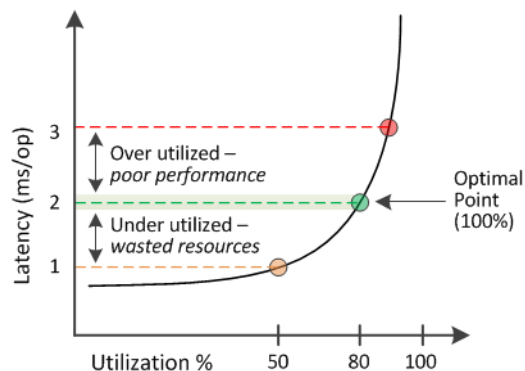
The performance capacity used counter is expected to be a larger number than the "utilization" counter because performance capacity adds in the impact on latency. For example, if a node or aggregate is 70% used, the performance capacity value may be in the 80% to 100% range, depending on the latency value.

In some cases, however, the utilization counter may be higher on the Dashboards/Performance page. This is normal because the dashboard refreshes the current counter values at each collection period; it does not display averages over a period of time like the other pages in the Unified Manager user interface. The performance capacity used counter is best used as an indicator of performance averaged over a period of time, whereas the utilization counter is best used for determining the instantaneous usage of a resource.

What the performance capacity used value means

The performance capacity used value helps you identify the nodes and aggregates that are currently being overutilized or underutilized. This enables you to redistribute workloads in order to make your storage resources more efficient.

The following figure shows the latency versus utilization curve for a resource and identifies, with colored dots, three areas where the current operational point could be located.



- A performance capacity used percentage equal to 100 is at the optimal point.

Resources are being used efficiently at this point.

- A performance capacity used percentage above 100 indicates that the node or aggregate is overutilized, and that workloads are receiving sub-optimal performance.
No new workloads should be added to the resource, and the existing workloads may need to be redistributed.
- A performance capacity used percentage below 100 indicates that the node or aggregate is underutilized, and that resources are not being used effectively.
More workloads can be added to the resource.

Note: Unlike utilization, the performance capacity used percentage can be above 100%. There is no maximum percentage, but resources will typically be in the 110% to 140% range when they are being overutilized. Higher percentages would indicate a resource with serious issues.

What available IOPS is

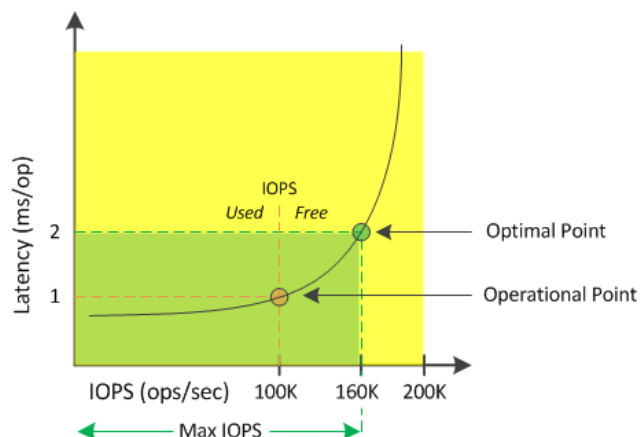
The available IOPS counter identifies the remaining number of IOPS that can be added to a node or an aggregate before the resource reaches its limit. The total IOPS that a node can provide is based on the physical characteristics of the node—for example, the number of CPUs, the CPU speed, and the amount of RAM. The total IOPS that an aggregate can provide is based on the physical properties of the disks—for example, a SATA, SAS, or SSD disk.

While the performance capacity free counter provides the percentage of a resource that is still available, the available IOPS counter tells you the exact number of IOPS (workloads) can be added to a resource before reaching the maximum performance capacity.

For example, if you are using a pair of FAS2520 and FAS8060 storage systems, a performance capacity free value of 30% means that you have some free performance capacity. However, that value does not provide visibility into how many more workloads you can deploy to those nodes. The available IOPS counter may show that you have 500 available IOPS on the FAS8060, but only 100 available IOPS on the FAS2520.

Note: Available IOPS data is available only when the nodes in a cluster are installed with ONTAP 9.0 or later software.

A sample latency versus IOPS curve for a node is shown in the following figure.



The maximum number of IOPS that a resource can provide is the number of IOPS when the performance capacity used counter is at 100% (the optimal point). The operational point identifies that the node is currently operating at 100K IOPS with latency of 1.0 ms/op. Based on the statistics captured from the node, Unified Manager determines that the maximum IOPS for the node is 160K, which means that there are 60K free or available IOPS. Therefore, you can add more workloads to this node so that your systems are used more efficiently.

Managing performance using performance capacity and available IOPS information

Note: When there is minimal user activity in the resource, the available IOPS value is calculated assuming a generic workload based on approximately 4,500 IOPS per CPU core. This is because Unified Manager lacks the data to accurately estimate the characteristics of the workload being served.

Viewing node and aggregate performance capacity used values

You can monitor the performance capacity used values for all nodes or for all aggregates in a cluster, or you can view details for a single node or aggregate.

Performance capacity used values appear in the Performance Dashboard, Performance Inventory pages, Top Performers page, Create Threshold Policy page, Performance Explorer pages, and in detail charts. For example, the Performance/Aggregate Inventory page provides a column Perf. Capacity Used to view the performance capacity used value for all aggregates.

Aggregates ⓘ Last updated: 04:11 PM, 08 Feb Refresh

Latency, IOPS, MBps, Utilization are based on hourly samples averaged over the previous 72 hours

Filtering: No filter applied Search Aggregates Data Search

Assign Threshold Policy Clear Threshold Policy

| <input type="checkbox"/> | Status | Aggregate | Latency | IOPS | MBps | Perf. Capacity Used | Utilization | Free Capacity | Total Capacity | Cluster | Node | Policy |
|--------------------------|--------|------------------|------------|----------|-----------|---------------------|-------------|---------------|----------------|---------------|----------------|-----------|
| <input type="checkbox"/> | ✓ | opm_mo...agg0 | 16.3 ms/op | 124 IOPS | < 1 MBps | 45% | 9% | 154 GB | 3,179 GB | opm-mobility | opm-m...-02 | |
| <input type="checkbox"/> | ✓ | rt_agg2 | 19.8 ms/op | 290 IOPS | < 1 MBps | 45% | 15% | 6,692 GB | 6,693 GB | opm-mobility | opm-m...-02 | |
| <input type="checkbox"/> | ✓ | aggr_snap_mirror | 13.9 ms/op | 267 IOPS | < 1 MBps | 38% | 12% | 6,692 GB | 6,693 GB | opm-mobility | opm-m...-02 | |
| <input type="checkbox"/> | ✓ | sdot_agg | 17.3 ms/op | 745 IOPS | < 1 MBps | 24% | 11% | 26,621 GB | 26,774 GB | opm-mobility | opm-m...-02 | |
| <input type="checkbox"/> | ✓ | aggr1 | 15.5 ms/op | 434 IOPS | < 1 MBps | 16% | 6% | 4,390 GB | 20,080 GB | opm-mobility | opm-m...-01 | |
| <input type="checkbox"/> | ✓ | rt_agg1 | 22.3 ms/op | 267 IOPS | < 1 MBps | 11% | 6% | 6,691 GB | 6,693 GB | opm-mobility | opm-m...-01 | |
| <input type="checkbox"/> | ✓ | aggr2 | 15.6 ms/op | 259 IOPS | 1.03 MBps | 11% | 5% | 18,472 GB | 20,080 GB | opm-mobility | opm-m...-02 | |
| <input type="checkbox"/> | ✓ | aggr2 | 9.52 ms/op | 87 IOPS | 20.8 MBps | Not Supported | 5% | 847 GB | 984 GB | opm-lo...vity | opm-lo...ty-01 | aggr_IOPS |
| <input type="checkbox"/> | ⚠ | RTaggr | 7.62 ms/op | 199 IOPS | 34.7 MBps | Not Supported | 6% | 1,292 GB | 1,477 GB | opm-lo...vity | opm-lo...ty-01 | aggr_IOPS |

The status "N/A" is displayed when nodes are not installed with ONTAP 9.0 or later software.

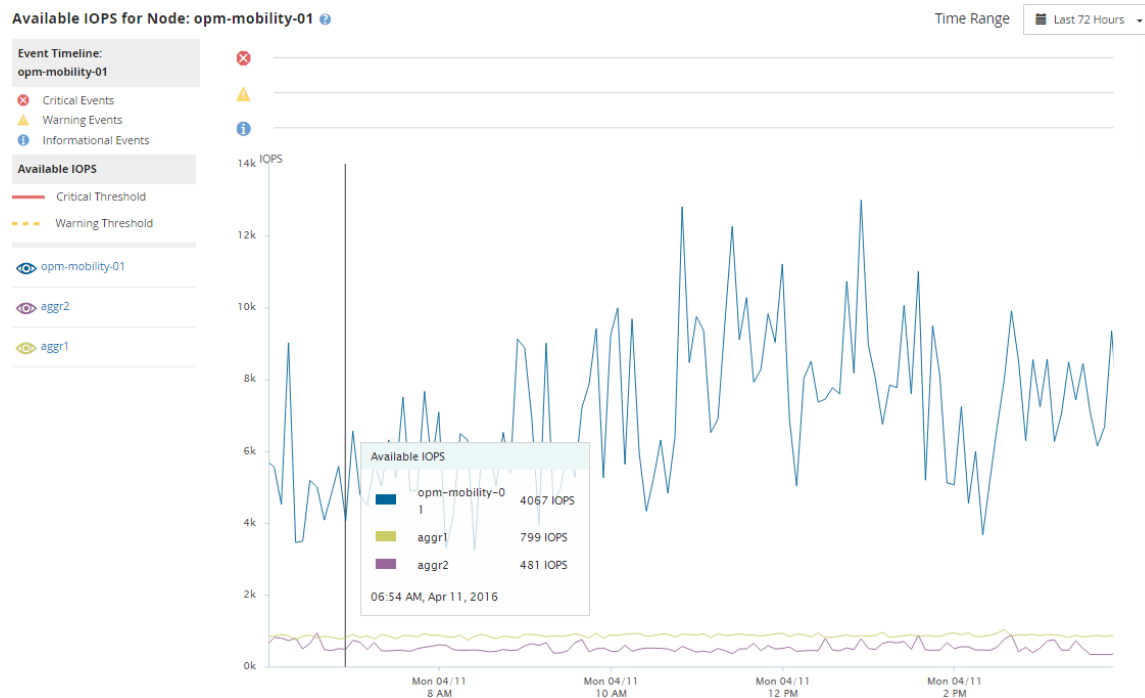
Monitoring the performance capacity used counter enables you to identify the following:

- Whether any nodes or aggregates on any clusters have a high performance capacity used value
- Whether any nodes or aggregates on any clusters have active performance capacity used events
- The nodes and aggregates that have the highest and lowest performance capacity used value in a cluster
- Latency and utilization counter values in conjunction with nodes or aggregates that have high performance capacity used values
- How the performance capacity used values for nodes in an HA pair will be affected if one of the nodes fails
- The busiest volumes and LUNs on an aggregate that has a high performance capacity used value

Viewing node and aggregate available IOPS values

You can monitor the available IOPS values for all nodes or for all aggregates in a cluster, or you can view details for a single node or aggregate.

Available IOPS values appear in the Performance Explorer page charts. For example, when viewing a node in the Performance/Node Explorer page, you can select the "Available IOPS" counter chart from the list so you can compare the available IOPS values for multiple aggregates on that node.



Monitoring the available IOPS counter enables you to identify:

- The nodes or aggregates that have the greatest available IOPS values to help determine where future workloads can be deployed.
- The nodes or aggregates that have the smallest available IOPS values to identify the resources you should monitor for potential future performance issues.
- The busiest volumes and LUNs on an aggregate that has a small available IOPS value.

Viewing performance capacity counter charts to identify issues

You can view performance capacity used charts for nodes and aggregates on the Performance Explorer page. This enables you to view detailed performance capacity data for the selected nodes and aggregates for a specific timeframe.

About this task

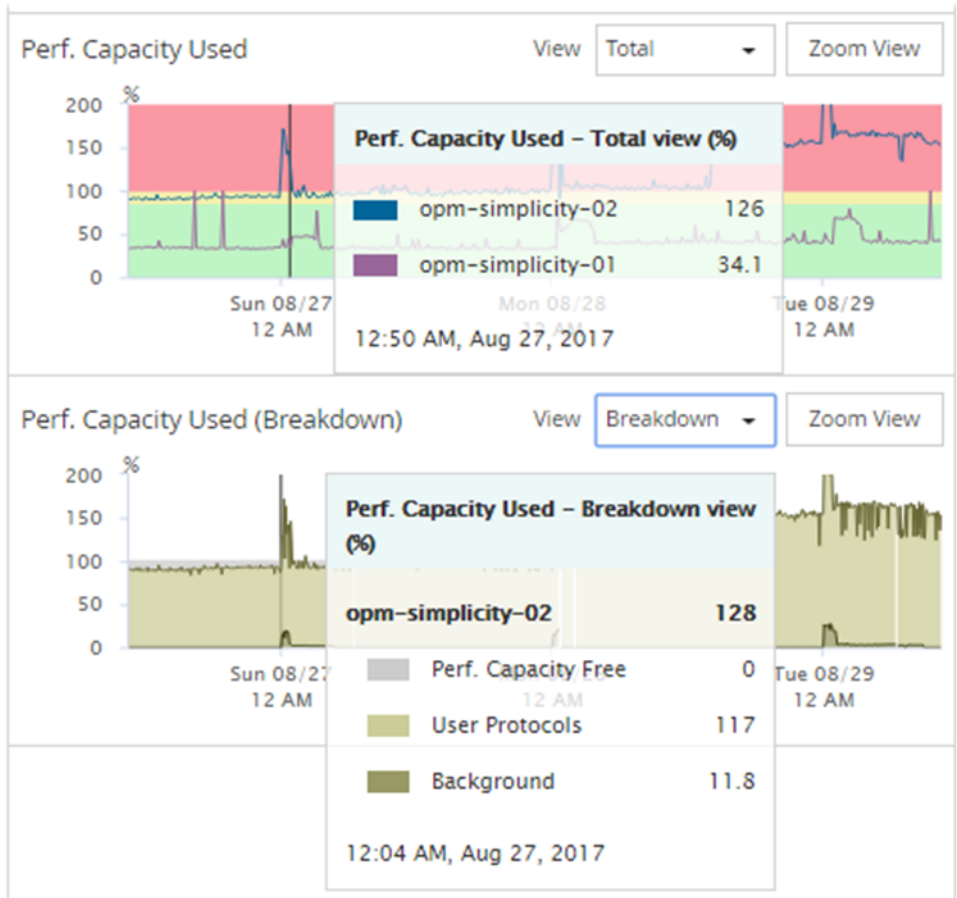
The standard counter chart displays the performance capacity used values for the selected nodes or aggregates. The Breakdown counter chart displays the total performance capacity values for the root object separated into usage based on user protocols versus background system processes. Additionally, the amount of free performance capacity is also shown.

Note: Because some background activities associated with system and data management are identified as user workloads and categorized as user protocols, the user protocols percentage may appear artificially high when those processes run. These processes typically run around midnight when cluster usage is low. If you see a spike in user protocol activity around midnight, verify if cluster backup jobs or other background activities are configured to run at that time.

Steps

1. Select the **Explorer** tab from a node or aggregate **Landing** page.
2. In the **Counter Charts** pane, click **Choose charts**, and then select the **Perf. Capacity Used** chart.
3. Scroll down until you can view the chart.

The colors of the standard chart show when the object is in the optimal range (yellow), when the object is underutilized (green), and when the object is overutilized (red). The Breakdown chart shows detailed performance capacity details for the root object only.



4. If you want to view either chart in a full size format, click **Zoom View**.
In this manner you can open multiple counter charts in a separate windows to compare performance capacity used values with IOPS or MBps values over the same timeframe.

Performance capacity used performance threshold conditions

You can create user-defined performance threshold policies so that events are triggered when the performance capacity used value for a node or aggregate exceeds the defined performance capacity used threshold setting.

Additionally, nodes can be configured with a "Performance capacity used takeover" threshold policy. This threshold policy totals the performance capacity used statistics for both nodes in an HA pair to determine whether either node would lack sufficient capacity if the other node fails. Because the workload during failover is the combination of the two partner nodes' workloads, the same performance capacity used takeover policy can be applied to both nodes.

Note: This performance capacity used equivalency is generally true between nodes. However, if there is significantly more cross-node traffic destined for one of the nodes through its failover partner, the total performance capacity used when running all workloads on one partner node versus the other partner node could be slightly different depending on which node has failed.

The performance capacity used conditions can also be used as secondary performance threshold settings to create a combination threshold policy when defining thresholds for LUNs and volumes. The performance capacity used condition is applied to the aggregate or node on which the volume

or LUN resides. For example, you can create a combination threshold policy using the following criteria:

| Storage object | Performance counter | Warning threshold | Critical threshold | Duration |
|----------------|---------------------------|-------------------|--------------------|------------|
| Volume | Latency | 15 ms/op | 25 ms/op | 20 minutes |
| Aggregate | Performance capacity used | 80% | 95% | |

Combination threshold policies cause an event to be generated only when both conditions are breached for the entire duration.

Related tasks

[Creating user-defined performance threshold policies](#) on page 35

You create performance threshold policies for storage objects so that notifications are sent when a performance counter exceeds a specific value. The event notification identifies that the cluster is experiencing a performance issue.

[Assigning performance threshold policies to storage objects](#) on page 36

You assign a user-defined performance threshold policy to a storage object so that Unified Manager reports an event if the value of the performance counter exceeds the policy setting.

Related reference

[What performance counters can be tracked using thresholds](#) on page 32

Some common performance counters, such as IOPS and MBps, can have thresholds set for all storage objects. There are other counters that can have thresholds set for only certain storage objects.

[What objects and counters can be used in combination threshold policies](#) on page 34

Only some performance counters can be used together in combination policies. When primary and secondary performance counters are specified, both performance counters must exceed their maximum limits before an event is generated.

Using the performance capacity used counter to manage performance

Typically, organizations want to operate with a performance capacity used percentage below 100 so that resources are being efficiently used while reserving some additional performance capacity to support peak period demands. You can use threshold policies to customize when alerts are sent for high performance capacity used values.

You can establish specific goals based on your performance requirements. For example, financial services firms might reserve more performance capacity to guarantee the timely execution of trades. These companies might want to set performance capacity used thresholds in the 70-80 percent range. Manufacturing companies with smaller margins might choose to reserve less performance capacity if they are willing to risk performance to better manage IT costs. These companies might set performance capacity used thresholds in the 85-95 percent range.

When the performance capacity used value exceeds the percentage set in a user-defined threshold policy, Unified Manager sends an alert email and adds the event to the Event Inventory page. This enables you to manage potential problems before they impact performance. These events can also be used as indicators that you need to make workload moves and changes within your nodes and aggregates.

Understanding and using the Node Failover Planning page

The Performance/Node Failover Planning page estimates the performance impact on a node if the node's high-availability (HA) partner node fails. Unified Manager bases the estimates on the historical performance of the nodes in the HA pair.

Estimating the performance impact of a failover helps you to plan in the following scenarios:

- If a failover consistently degrades the takeover node's estimated performance to an unacceptable level, you can consider taking corrective actions to reduce the performance impact due to a failover.
- Before initiating a manual failover to perform hardware maintenance tasks, you can estimate how the failover affects the performance of the takeover node in order to determine the best time to perform the task.

Related concepts

[Using the Node Failover Planning page to determine corrective actions](#) on page 83

Based on the information that is displayed in the Performance/Node Failover Planning page, you can take actions to ensure that a failover does not cause the performance of an HA pair to drop below an acceptable level.

[Using a threshold policy with the Node Failover Planning page](#) on page 85

You can create a node threshold policy so that you can be notified in the Performance/Node Failover Planning page when a potential failover would degrade the performance of the takeover node to an unacceptable level.

Related tasks

[Using the Performance Capacity Used Breakdown chart for failover planning](#) on page 86

The detailed Performance Capacity Used - Breakdown chart shows the performance capacity used for the Primary node and the Partner node. It also shows the amount of free performance capacity on the Estimated Takeover node. This information helps you determine whether you might have a performance issue if the partner node fails.

Related reference

[Components of the Node Failover Planning page](#) on page 84

The components of the Performance/Node Failover Planning page are displayed in a grid and in the Comparing pane. These sections enable you to assess the impact of a node failover on the performance of the takeover node.

Using the Node Failover Planning page to determine corrective actions

Based on the information that is displayed in the Performance/Node Failover Planning page, you can take actions to ensure that a failover does not cause the performance of an HA pair to drop below an acceptable level.

For example, to reduce the estimated performance impact of a failover, you can move some volumes or LUNs from a node in the HA pair to other nodes in the cluster. Doing so ensures that the primary node can continue to deliver acceptable performance after a failover.

Components of the Node Failover Planning page

The components of the Performance/Node Failover Planning page are displayed in a grid and in the Comparing pane. These sections enable you to assess the impact of a node failover on the performance of the takeover node.

Performance statistics grid

The Performance/Node Failover Planning page displays a grid containing statistics for latency, IOPS, utilization, and performance capacity used.

Note: IOPS values displayed in this page and in the Performance/Node Performance Explorer page might not be the same.

In the grid, each node is assigned one of the following roles:

- **Primary**
The node that takes over for the HA partner when the partner fails. The root object is always the Primary node.
- **Partner**
The node that fails in the failover scenario.
- **Estimated Takeover**
The same as the Primary node. Performance statistics displayed for this node show the takeover node's performance after it takes over the failed partner.

Note: Although the workload of the takeover node is equivalent to the combined workloads of both nodes after a failover, the statistics for the Estimated Takeover node are not the sum of the statistics of the Primary node and the Partner node. For example, if the latency of the Primary node is 2 ms/op and the latency of the Partner node is 3 ms/op, the Estimated Takeover node might have a latency of 4 ms/op. This value is a calculation that Unified Manager performs.

You can click the name of the Partner node if you want it to become the root object. After the Performance/Node Performance Explorer page is displayed, you can click the **Failover Planning** tab to see how performance changes in this node failure scenario. For example, if Node1 is the Primary node and Node2 is the Partner node, you can click Node2 to make it the Primary node. In this way, you can see how the estimated performance changes depending on which node fails.

Comparing pane

The following list describes the components displayed in the Comparing pane by default:

Events charts

They are displayed in the same format as those in the Performance/Node Performance Explorer page. They pertain to the Primary node only.

Counter charts

They display historical statistics for the performance counter shown in the grid. In each chart, the graph for the Estimated Takeover node shows the estimated performance if a failover had occurred at any given time.

For example, suppose the Utilization chart shows 73% for the Estimated Takeover node at 11 a.m. on February 8. If a failover had occurred at that time, the utilization of the takeover node would have been 73%.

The historical statistics help you find the optimal time for initiating a failover, minimizing the possibility of overloading the takeover node. You can schedule a failover only at times when the predicted performance of the takeover node is acceptable.

By default, statistics for both the root object and the partner node are displayed in the Comparing pane. Unlike in the Performance/Node Performance Explorer page, this page does not display the **Add** button for you to add objects for statistics comparison.

You can customize the Comparing pane in the same way as you do in the Performance/Node Performance Explorer page. The following list shows examples of customizing the charts:

- Click a node name to show or hide the node's statistics in the Counter charts.
- Click **Zoom View** to display a detailed chart for a particular counter in a new window.

Related concepts

[Understanding the root object](#) on page 55

The root object is the baseline against which other object comparisons are made. This enables you to view and compare the data from other objects to the root object, providing performance data analysis that helps you to troubleshoot and improve object performance.

[Understanding counter charts](#) on page 58

Charts in the Counter Charts pane enable you to view and compare performance data for the root object and for objects you have added from the correlated objects grid. This can help you understand performance trends and isolate and resolve performance issues.

Related tasks

[Specifying the time range in Zoom View](#) on page 63

The **Time Range** control in the Counter Charts Zoom View window enables you to specify a date and time range for the selected chart. This enables you to quickly locate specific data based on either a preset time range or your own custom time range.

[Viewing event details in the Events Timeline](#) on page 62

You can view all performance events and their related details in the Events Timeline pane of Performance Explorer. This is a quick and efficient method of viewing all the threshold events that occurred on the root object during a specified time range, which can be helpful when troubleshooting performance issues.

Using a threshold policy with the Node Failover Planning page

You can create a node threshold policy so that you can be notified in the Performance/Node Failover Planning page when a potential failover would degrade the performance of the takeover node to an unacceptable level.

The system-defined performance threshold policy named "Node HA pair over-utilized" generates a warning event if the threshold is breached for six consecutive collection periods (30 minutes). The threshold is considered breached if the combined performance capacity used of the nodes in an HA pair exceeds 200%.

The event from the system-defined threshold policy alerts you to the fact that a failover will cause the latency of the takeover node to increase to an unacceptable level. When you see an event that is generated by this policy for a particular node, you can navigate to the Performance/Node Failover Planning page for that node to view the predicted latency value due to a failover.

In addition to using this system-defined threshold policy, you can create threshold policies by using the "Performance Capacity Used - Takeover" counter, and then apply the policy to selected nodes. Specifying a threshold lower than 200% enables you to receive an event before the threshold for the system-defined policy is breached. You can also specify the minimum period of time for which the threshold is exceeded to less than 30 minutes if you want to be notified before the system-defined policy event is generated.

For example, you can define a threshold policy to generate a warning event if the combined performance capacity used of the nodes in an HA pair exceeds 175% for more than 10 minutes. You can apply this policy to Node1 and Node2, which form an HA pair. After receiving a warning

event notification for either Node1 or Node2, you can view the Performance/Node Failover Planning page for that node to assess the estimated performance impact on the takeover node. You can take corrective actions to avoid overloading the takeover node if a failover does happen. If you take action when the combined performance capacity used of the nodes is under 200%, the takeover node's latency does not reach an unacceptable level even if a failover happens during this time.

Related concepts

[How user-defined performance threshold policies work](#) on page 30

You set performance threshold policies on storage objects (for example, on aggregates and volumes) so that an event can be sent to the storage administrator to inform the administrator that the cluster is experiencing a performance issue.

[What happens when a performance threshold policy is breached](#) on page 32

When a counter value exceeds its defined performance threshold value for the amount of time specified in the duration, the threshold is breached and an event is reported.

Related tasks

[Creating user-defined performance threshold policies](#) on page 35

You create performance threshold policies for storage objects so that notifications are sent when a performance counter exceeds a specific value. The event notification identifies that the cluster is experiencing a performance issue.

Using the Performance Capacity Used Breakdown chart for failover planning

The detailed Performance Capacity Used - Breakdown chart shows the performance capacity used for the Primary node and the Partner node. It also shows the amount of free performance capacity on the Estimated Takeover node. This information helps you determine whether you might have a performance issue if the partner node fails.

About this task

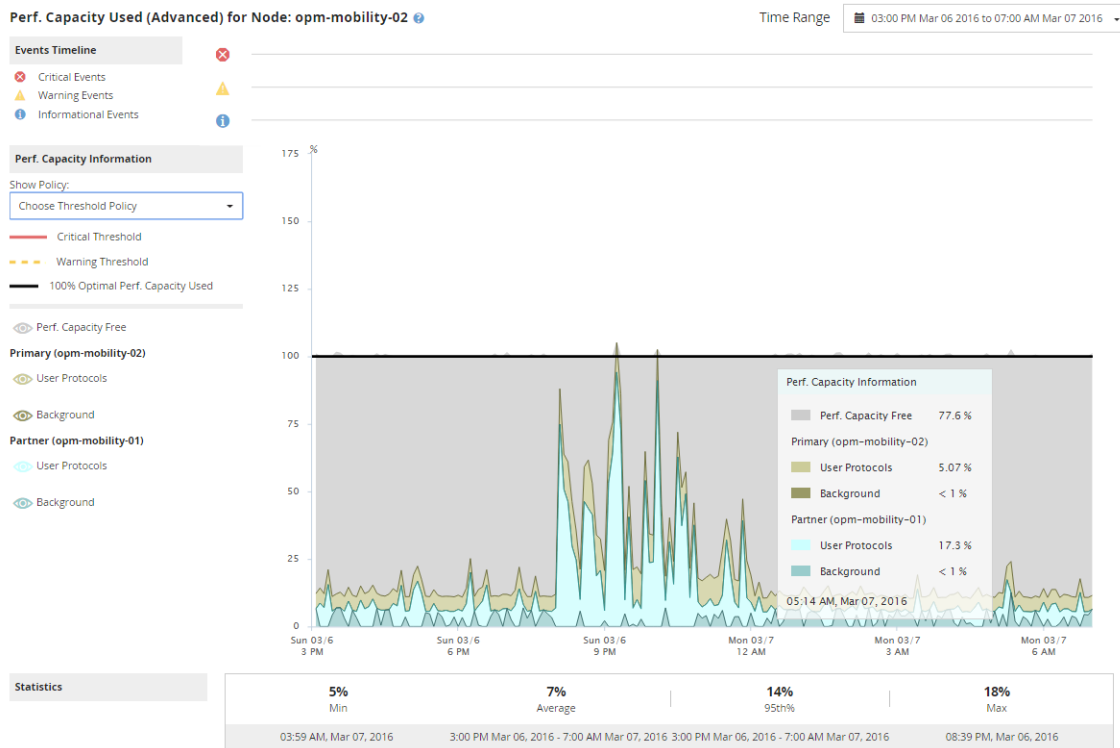
In addition to showing the total performance capacity used for the nodes, the Breakdown chart breaks the values for each node into user protocols and background processes.

- User protocols are the I/O operations from user applications to and from the cluster.
- Background processes are the internal system processes involved with storage efficiency, data replication, and system health.

This additional level of detail enables you to determine whether a performance issue is caused by user application activity or background system processes, such as deduplication, RAID reconstruct, disk scrubbing, and SnapMirror copies.

Steps

1. Go to the **Performance/Node Failover Planning** page for the node that will serve as the Estimated Takeover node.
2. From the **Time Range** selector, choose the period of time for which the historical statistics are displayed in the counter grid and counter charts.
The counter charts with statistics for the Primary node, Partner node, and Estimated Takeover node are displayed.
3. From the **Choose charts** list, select **Perf. Capacity Used**.
4. In the **Perf. Capacity Used** chart, select **Breakdown** and click **Zoom View**.
The detailed chart for Perf. Capacity Used is displayed.



5. Move the cursor over the detailed chart to view the performance capacity used information in the popup window.

The Perf. Capacity Free percentage is the performance capacity available on the Estimated Takeover node. It indicates how much performance capacity is left on the takeover node after a failover. If it is 0%, a failover will cause the latency to increase to an unacceptable level on the takeover node.

6. Consider taking corrective actions to avoid a low performance capacity free percentage.

If you plan to initiate a failover for node maintenance, choose a time to fail the partner node when the performance capacity free percentage is not at 0.

Related concepts

[What performance capacity used is](#) on page 76

The performance capacity used counter helps you to identify whether the performance of a node or an aggregate is reaching a point where the performance might degrade if the workloads increase. It can also show you if a node or aggregate is currently being overused during specific periods of time. Performance capacity used is similar to utilization, but the former provides more insight about the available performance capabilities in a physical resource for a specific workload.

[Types of workloads monitored by Unified Manager](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

Related tasks

[Selecting performance charts to display](#) on page 61

The Choose charts drop-down list enables you to select the types of performance counter charts to display in the Counter Charts pane. This enables you to view specific data and counters, based on your performance requirements.

[Displaying the Counter Charts Zoom View](#) on page 63

The Counter Charts Zoom View provides a finer level of detail for the selected counter chart and its associated timeline. This magnifies the counter chart data, enabling you to have a sharper view into performance events and their underlying causes.

Setting up a connection between a Unified Manager server and an external data provider

A connection between a Unified Manager server and an external data provider enables you to send cluster performance data to an external server so that storage managers can chart the performance metrics using third-party software.

A connection between a Unified Manager server and an external data provider is established through the menu option labeled "External Data Provider" in the maintenance console.

Performance data that can be sent to an external server

Unified Manager collects a variety of performance data from all the clusters that it is monitoring. You can send specific groups of data to an external server.

Depending on the performance data that you want to chart, you can choose to send one of the following groups of statistics:

| Statistics group | Data included | Details |
|----------------------|---|--|
| Performance Monitor | High-level performance statistics for the following objects: <ul style="list-style-type: none">LUNsVolumes | This group provides total IOPS or latency for all LUNs and volumes in all monitored clusters. This group provides the smallest number of statistics. |
| Resource Utilization | Resource utilization statistics for the following objects: <ul style="list-style-type: none">NodesAggregates | This group provides utilization statistics for the node and aggregate physical resources in all monitored clusters. It also provides the statistics collected in the Performance Monitor group. |
| Drill Down | Low-level read/write and per-protocol statistics for all tracked objects: <ul style="list-style-type: none">NodesAggregatesLUNsVolumesDisksLIFsPorts/NICs | This group provides read/write and per-protocol breakdowns for all seven tracked object types in all monitored clusters. It also provides the statistics collected in the Performance Monitor group and in the Resource Utilization group. This group provides the largest number of statistics. |

Important: If the name of a cluster, or cluster object, is changed on the storage system, both the old and the new objects will contain performance data on the external server (called the "metric_path"). The two objects are not correlated as the same object. For example, if you change the name of a volume from "volume1_acct" to "acct_voll", you will see old performance data for the old volume, and new performance data for the new volume.

See the Knowledge Base article for the list of all performance counters that can be sent to an external data provider.

[Unified Manager performance counters that can be exported to an External Data Provider](#)

Setting up Graphite to receive performance data from Unified Manager

Graphite is an open software tool for gathering and graphing performance data from computer systems. Your Graphite server and software must be configured correctly to receive statistical data from Unified Manager.

After you have installed Graphite according to the installation instructions, you need to make the following changes to support statistical data transfer from Unified Manager:

- In the `/opt/graphite/conf/carbon.conf` file, the maximum number of files that can be created on the Graphite server per minute must be set to `200` (`MAX_CREATES_PER_MINUTE = 200`).

Depending on the number of clusters in your configuration and the statistics objects you have selected to send, there might be thousands of new files that need to be created initially. At 200 files per minute it might take 15 minutes or longer before all metric files are initially created. After all the unique metric files have been created, this parameter is no longer relevant.

- If you are running Graphite on a server deployed using an IPv6 address, the value for `LINE_RECEIVER_INTERFACE` in the `/opt/graphite/conf/carbon.conf` file must be changed from `"0.0.0.0"` to `:::` (`LINE_RECEIVER_INTERFACE = :::`)
- In the `/opt/graphite/conf/storage-schemas.conf` file, the `retentions` parameter must be used to set the frequency to 5 minutes and the retention period to the number of days that is relevant for your environment.

The retention period can be as long as what your environment allows, but the frequency value must be set to 5 minutes for at least one retention setting. In the following example, a section is defined for Unified Manager using the `pattern` parameter, and the values set the initial frequency to 5 minutes and the retention period to 100 days:

```
[OPM]
pattern = ^netapp-performance\..*
retentions = 5m:100d
```

Note: If the default vendor tag is changed from `"netapp-performance"` to something different, that change must be reflected in the `pattern` parameter as well.

Important: If the Graphite server is unavailable when the Unified Manager server is attempting to send performance data, the data is not sent and there will be a gap in collected data.

Configuring a connection from a Unified Manager server to an external data provider

Unified Manager can send cluster performance data to an external server. You can specify the type of statistical data that is sent, and the interval at which data is sent.

Before you begin

- You must have a user ID authorized to log in to the maintenance console of the Unified Manager server.
- You must have the following information about the external data provider:
 - Server name or IP address (IPv4 or IPv6)
 - Server default port (if not using default port 2003)
- You must have configured the remote server and third-party software so that it can receive statistical data from the Unified Manager server.
- You must know which group of statistics you want to send:
 - `PERFORMANCE_INDICATOR`: Performance monitor statistics

Setting up a connection between a Unified Manager server and an external data provider

- **RESOURCE_UTILIZATION**: Resource utilization and Performance monitor statistics
- **DRILL_DOWN**: All statistics
- You must know the time interval at which you want to transmit statistics: 5, 10, or 15 minutes
By default, Unified Manager collects statistics at 5-minute intervals. If you set the transmit interval to 10 (or 15) minutes, the amount of data that is sent during each transmission is two (or three) times larger than when using the default 5-minute interval.

Note: If you change the Unified Manager performance collection interval to 10 or 15 minutes, you must change the transmit interval so that it is equal to, or larger, than the Unified Manager collection interval.

About this task

You can configure a connection between one Unified Manager server and one external data provider server.

Steps

1. Log in as the maintenance user to the maintenance console of the Unified Manager server. The Unified Manager maintenance console prompts are displayed.
2. In the maintenance console, type the number of the **External Data Provider** menu option. The External Server Connection menu is displayed.
3. Type the number of the **Add/Modify Server Connection** menu option. The current server connection information is displayed.
4. When prompted, type **y** to continue.
5. When prompted, enter the IP address or name of the destination server and the server port information (if different from the default port 2003).
6. When prompted, type **y** to verify that the information you entered is correct.
7. Press any key to return to the External Server Connection menu.
8. Type the number of the **Modify Server Configuration** menu option. The current server configuration information is displayed.
9. When prompted, type **y** to continue.
10. When prompted, enter the type of statistics to send, the time interval at which the statistics are sent, and whether you want to enable the transmission of statistics now:

| For.. | Enter... |
|---------------------|---|
| Statistics group ID | 0 - PERFORMANCE_INDICATOR (default) 1 - RESOURCE_UTILIZATION 2 - DRILL_DOWN |
| Vendor tag | A descriptive name for the folder where the statistics will be stored on the external server. "netapp-performance" is the default name, but you can enter another value. By using dotted notation you can define a hierarchical folder structure. For example, by entering stats.performance.netapp the statistics will be located in stats > performance > netapp . |
| Transmit interval | 5 (default), 10 , or 15 minutes |

| For.. | Enter... |
|----------------|----------------------|
| Enable/disable | 0 - Disable |
| | 1 - Enable (default) |

- 11. When prompted, type **y** to verify that the information you entered is correct.
- 12. Press any key to return to the External Server Connection menu.
- 13. Type **x** to exit the maintenance console.

Result

After you have configured the connection, the selected performance data is sent to the destination server at the time interval you specified. It takes a few minutes before the metrics start to appear in Graphite. You might need to refresh your browser to see the new metrics in the metric hierarchy.

Related tasks

[Changing the performance statistics collection interval](#) on page 43

The default collection interval for performance statistics is 5 minutes. You can change this interval to 10 or 15 minutes if you find that collections from large clusters are not finishing within the default time. This setting affects the collection of statistics from all clusters that this instance of Unified Manager is monitoring.

Collecting data and monitoring workload performance

Unified Manager collects and analyzes workload activity every 5 minutes to identify performance events, and it detects configuration changes every 15 minutes. It retains a maximum of 30 days of 5-minute historical performance and event data, and it uses this data to forecast the expected range for all monitored workloads.

Note: This chapter describes how dynamic thresholds work and how they are used to help monitor workload performance. This chapter is not applicable for statistics or events caused by user-defined or system-defined performance threshold breaches.

Unified Manager must collect a minimum of 3 days of workload activity before it can begin its analysis and before the expected range for I/O response time and operations can be displayed on the Performance/Volume Details page and in the Dynamic Threshold Event Details page. While this activity is being collected, the expected range does not display all changes occurring from workload activity. After collecting 3 days of activity, Unified Manager adjusts the expected range, every 24 hours at 12:00 a.m., to reflect workload activity changes and establish a more accurate performance threshold.

During the first 4 days that Unified Manager is monitoring a volume, if more than 24 hours have passed since the last data collection, the charts on the Performance/Volume Details page will not display the expected range for that volume. Events detected prior to the last collection are still available.

Note: Daylight savings time (DST) changes the system time, which alters the expected range of performance statistics for monitored workloads. Unified Manager immediately begins to correct the expected range, which takes approximately 15 days to complete. During this time you can continue to use Unified Manager, but, since Unified Manager uses the expected range to detect events, some events might not be accurate. Events detected prior to the time change are not affected. Manually changing the time on a cluster, or on a Unified Manager server, to an earlier time will also affect the event analysis results.

Related concepts

[*What the expected range of performance is*](#) on page 96

The expected range of values is a forecast, or prediction, of what the upper and lower performance values are expected to be at a specific time. For the workload latency, the upper values form the performance threshold. When the actual value crosses the performance threshold, Unified Manager triggers a performance event alert.

Related reference

[*Workload performance measurement values*](#) on page 95

Unified Manager measures the performance of workloads on a cluster based on historical and expected statistical values, which form the expected range of values for the workloads. It compares the actual workload statistical values to the expected range to determine when workload performance is too high or too low. A workload that is not performing as expected triggers a performance event report to notify you.

Types of workloads monitored by Unified Manager

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

User-defined workloads

The I/O throughput from applications to the cluster. These are processes involved in read and write requests. A FlexVol volume or FlexGroup volume is a user-defined workload.

Note: Unified Manager only monitors the workload activity on the cluster. It does not monitor the applications, the clients, or the paths between the applications and the cluster.

Unified Manager requires that the volumes you want to monitor be in a QoS policy group:

- When using ONTAP 8.3 or later, a policy group is assigned to all volumes, either by the administrator or by ONTAP.
- When using ONTAP 8.2.x, a policy group is assigned to all volumes, either by the administrator or by Unified Manager when the cluster is added to the UI. When Unified Manager analyzes the cluster for configuration changes every 15 minutes, it adds any new volumes not in a policy group to the default policy group.

Note: With ONTAP 8.2.x, if an SVM, LUN, or File storage object is in a policy group, Unified Manager cannot monitor the volumes contained in that object and the overall analysis is impacted. You must remove the storage object from the policy group to correct this issue.

If one or more of the following is true for a workload, it cannot be monitored by Unified Manager:

- It is a data protection (DP) copy in read-only mode. (Note that when using ONTAP 8.3 and later, DP volumes are monitored for user-generated traffic.)
- It is an Infinite Volume.
- It is an offline data clone.
- It is a mirrored volume in a MetroCluster configuration.

System-defined workloads

The internal processes involved with storage efficiency, data replication, and system health, including:

- Storage efficiency, such as deduplication
- Disk health, which includes RAID reconstruct, disk scrubbing, and so on
- Data replication, such as SnapMirror copies
- Management activities
- File system health, which includes various WAFL activities
- File system scanners, such as WAFL scan
- Copy offload, such as offloaded storage efficiency operations from VMware hosts
- System health, such as volume moves, data compression, and so on
- Unmonitored volumes

Performance data for system-defined workloads is displayed in the GUI only when the cluster component used by these workloads is in contention. For example, you cannot search for the name of a system-defined workload to view its performance data in the GUI. If multiple system-defined workloads of the same type are displayed, a letter is appended to the workload name. The letter is intended for use by support personnel.

Related concepts

[*Roles of workloads involved in a performance event*](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

[*Cluster components and why they can be in contention*](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

Related reference

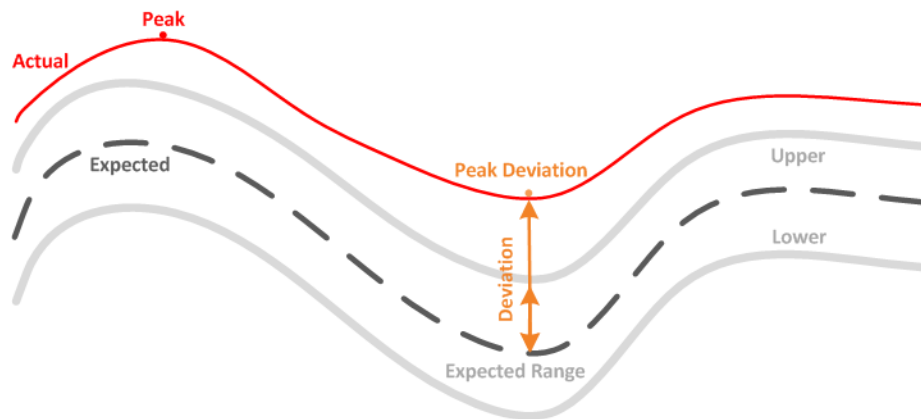
[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Workload performance measurement values

Unified Manager measures the performance of workloads on a cluster based on historical and expected statistical values, which form the expected range of values for the workloads. It compares the actual workload statistical values to the expected range to determine when workload performance is too high or too low. A workload that is not performing as expected triggers a performance event report to notify you.

In the following illustration, the actual value, in red, represents the actual performance statistics in the time frame. The actual value has crossed the performance threshold, which is the upper bounds of the expected range. The peak is the highest actual value in the time frame. The deviation measures the change between the expected values and the actual values, while the peak deviation indicates the largest change between the expected values and the actual values.



The following table lists the workload performance measurement values.

| Measurement | Description |
|-------------|--|
| Activity | The percentage of the QoS limit used by the workloads in the policy group. Note: If Unified Manager detects a change to a policy group, such as adding or removing a volume or changing the QoS limit, the actual and expected values might exceed 100% of the set limit. If a value exceeds 100% of the set limit it is displayed as >100%. If a value is less than 1% of the set limit it is displayed as <1%. |
| Actual | The measured performance value at a specific time for a given workload. |

| Measurement | Description |
|------------------|---|
| Deviation | The change between the expected values and the actual values. It is the ratio of the actual value minus the expected value to the upper value of the expected range minus the expected value. Note: A negative deviation value indicates that workload performance is lower than expected, while a positive deviation value indicates that workload performance is higher than expected. If the expected values and the actual value are very low, in the hundredths or thousandths of a percent for example, the deviation will display N/A. |
| Expected | The expected values are based on the analysis of historical performance data for a given workload. Unified Manager analyzes these statistical values to determine the expected range of values. |
| Expected Range | The expected range of values is a forecast, or prediction, of what the upper and lower performance values are expected to be at a specific time. For the workload latency, the upper values form the performance threshold. When the actual value crosses the performance threshold, Unified Manager triggers a performance event alert. |
| Peak | The maximum value measured over a period of time. |
| Peak Deviation | The maximum deviation value measured over a period of time. |
| Queue Depth | The number of pending I/O requests that are waiting at the interconnect component. |
| Utilization | For the network processing, data processing, and aggregate components, the percentage of busy time to complete workload operations over a period of time. For example, the percentage of time for the network processing or data processing components to process an I/O request or for an aggregate to fulfill a read or write request. |
| Write Throughput | The amount of write throughput, in Megabytes per second (MBps), from workloads on a local cluster to the partner cluster in a MetroCluster configuration. |

Related concepts

[What the expected range of performance is](#) on page 96

The expected range of values is a forecast, or prediction, of what the upper and lower performance values are expected to be at a specific time. For the workload latency, the upper values form the performance threshold. When the actual value crosses the performance threshold, Unified Manager triggers a performance event alert.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

What the expected range of performance is

The expected range of values is a forecast, or prediction, of what the upper and lower performance values are expected to be at a specific time. For the workload latency, the upper values form the performance threshold. When the actual value crosses the performance threshold, Unified Manager triggers a performance event alert.

For example, during regular business hours between 9:00 a.m. and 5:00 p.m., most employees might check their email between 9:00 a.m. and 10:30 a.m. The increased demand on the email servers means an increase in workload activity on the back-end storage during this time. Employees might notice slow response time from their email clients.

During the lunch hour between 12:00 p.m. and 1:00 p.m. and at the end of the work day after 5:00 p.m., most employees are likely away from their computers. The demand on the email servers

typically decreases, also decreasing the demand on back-end storage. Alternatively, there could be scheduled workload operations, such as storage backups or virus scanning, that start after 5:00 p.m. and increase activity on the back-end storage.

Over several days, the increase and decrease in workload activity determines the expected range of activity, with upper and lower boundaries for a workload. When the actual workload activity for an object is outside the upper or lower boundaries, and remains outside the boundaries for a period of time, this might indicate that the object is being overused or underused.

How the expected range is formed

Unified Manager must collect a minimum of 3 days of workload activity before it can begin its analysis and before the expected range for I/O response time and operations can be displayed in the GUI. The minimum required data collection does not account for all changes occurring from workload activity. After collecting the first 3 days of activity, Unified Manager adjusts the expected range, every 24 hours at 12:00 a.m., to reflect workload activity changes and establish a more accurate performance threshold.

Note: Daylight savings time (DST) changes the system time, which alters the expected range of performance statistics for monitored workloads. Unified Manager immediately begins to correct the expected range, which takes approximately 15 days to complete. During this time you can continue to use Unified Manager, but, since Unified Manager uses the expected range to detect events, some events might not be accurate. Events detected prior to the time change are not affected. Manually changing the time on a cluster, or on a Unified Manager server, to an earlier time will also affect the event analysis results.

Related concepts

[Collecting data and monitoring workload performance](#) on page 93

Unified Manager collects and analyzes workload activity every 5 minutes to identify performance events, and it detects configuration changes every 15 minutes. It retains a maximum of 30 days of 5-minute historical performance and event data, and it uses this data to forecast the expected range for all monitored workloads.

Related tasks

[Determining whether a workload has a performance issue](#) on page 113

You can use Unified Manager to determine whether a detected performance event was truly caused by a performance issue on the cluster. The event might have been caused a spike in activity, for example, that drove up its response time, but now the response time has returned to its usual levels.

Related reference

[How the expected range is used in performance analysis](#) on page 98

Unified Manager uses the expected range to represent the typical I/O latency (response time) and IOPS (operations) activity for your monitored workloads. It alerts you when the actual latency for a workload is above the upper bounds of the expected range, which triggers a performance event, so that you can analyze the performance issue and take corrective action for resolving it.

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

[Workload performance measurement values](#) on page 95

Unified Manager measures the performance of workloads on a cluster based on historical and expected statistical values, which form the expected range of values for the workloads. It compares the actual workload statistical values to the expected range to determine when workload performance is too high or too low. A workload that is not performing as expected triggers a performance event report to notify you.

How the expected range is used in performance analysis

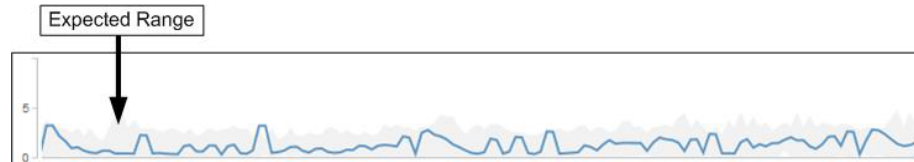
Unified Manager uses the expected range to represent the typical I/O latency (response time) and IOPS (operations) activity for your monitored workloads. It alerts you when the actual latency for a workload is above the upper bounds of the expected range, which triggers a performance event, so that you can analyze the performance issue and take corrective action for resolving it.

The expected range sets the performance baseline for the workload. Over time, Unified Manager learns from past performance measurements to forecast the expected performance and activity levels for the workload. The upper boundary of the expected range establishes the performance threshold. Unified Manager uses the baseline to determine when the actual latency or operations are above or below a threshold, or outside the bounds of their expected range. The comparison between the actual values and the expected values creates a performance profile for the workload.

When the actual latency for a workload exceeds the performance threshold, due to contention on a cluster component, the latency is high and the workload performs more slowly than expected. The performance of other workloads that share the same cluster components might also be slower than expected.

Unified Manager analyzes the threshold crossing event and determines whether the activity is a performance event. If the high workload activity remains consistent for a long period of time, such as several hours, Unified Manager considers the activity to be normal and dynamically adjusts the expected range to form the new performance threshold.

Some workloads might have consistently low activity, where the expected range for the operations or the latency does not have a high rate of change over time. To minimize the number of event alerts, during analysis of performance events, Unified Manager triggers an event only for low-activity volumes whose operations and latencies are much higher than expected.



In this example, the latency for a volume has an expected range, in gray, of 0 milliseconds per operation (ms/op) at its lowest and 5 ms/op at its highest. If the actual latency, in blue, suddenly increases to 10 ms/op, due to an intermittent spike in network traffic or contention on a cluster component, it is then above the expected range and has exceeded the performance threshold.

When network traffic has decreased, or the cluster component is no longer in contention, the latency returns within the expected range. If the latency remains at or above 10 ms/op for a long period of time, you might need to take corrective action to resolve the event.

Related concepts

[What the expected range of performance is](#) on page 96

The expected range of values is a forecast, or prediction, of what the upper and lower performance values are expected to be at a specific time. For the workload latency, the upper values form the performance threshold. When the actual value crosses the performance threshold, Unified Manager triggers a performance event alert.

[Collecting data and monitoring workload performance](#) on page 93

Unified Manager collects and analyzes workload activity every 5 minutes to identify performance events, and it detects configuration changes every 15 minutes. It retains a maximum of 30 days of 5-minute historical performance and event data, and it uses this data to forecast the expected range for all monitored workloads.

Related tasks

[Determining whether a workload has a performance issue](#) on page 113

You can use Unified Manager to determine whether a detected performance event was truly caused by a performance issue on the cluster. The event might have been caused a spike in activity, for example, that drove up its response time, but now the response time has returned to its usual levels.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

[Workload performance measurement values](#) on page 95

Unified Manager measures the performance of workloads on a cluster based on historical and expected statistical values, which form the expected range of values for the workloads. It compares the actual workload statistical values to the expected range to determine when workload performance is too high or too low. A workload that is not performing as expected triggers a performance event report to notify you.

How Unified Manager uses workload latency to identify performance issues

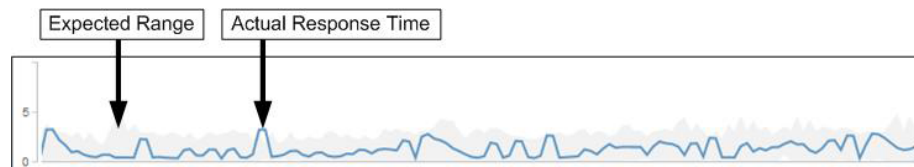
The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

A high latency means that requests from applications to a volume on a cluster are taking longer than usual. The cause of the high latency could be on the cluster itself, due to contention on one or more cluster components. High latency could also be caused by issues outside of the cluster, such as network bottlenecks, issues with the client hosting the applications, or issues with the applications themselves.

Note: Unified Manager only monitors the workload activity on the cluster. It does not monitor the applications, the clients, or the paths between the applications and the cluster.

Operations on the cluster, such as making backups or running deduplication, that increase their demand of cluster components shared by other workloads can also contribute to high latency. If the actual latency exceeds the performance threshold of the expected range, Unified Manager analyzes the event to determine whether it is a performance event that you might need to resolve. The latency is measured in milliseconds per operation (ms/op).

On the Performance/Volume Details page, you can view an analysis of the latency statistics to see how the activity of individual processes, such as read and write requests, compares to the overall latency statistics. The comparison helps you determine which operations have the highest activity or whether specific operations have abnormal activity that is impacting the latency for a volume. When analyzing performance events, you can use the latency statistics to determine whether an event was caused by an issue on the cluster. You can also identify the specific workload activities or cluster components that are involved in the event.



This example shows the Latency chart on the Performance/Volume Details page. The actual response time (latency) activity is a blue line and the expected range is gray.

Note: There can be gaps in the blue line if Unified Manager was unable to gather data. This can occur because the cluster or volume was unreachable, Unified Manager was turned off during that time, or the collection was taking longer than the 5 minute collection period.

Related concepts

[What the expected range of performance is](#) on page 96

The expected range of values is a forecast, or prediction, of what the upper and lower performance values are expected to be at a specific time. For the workload latency, the upper values form the performance threshold. When the actual value crosses the performance threshold, Unified Manager triggers a performance event alert.

[How cluster operations can affect workload latency](#) on page 100

Operations (IOPS) represent the activity of all user-defined and system-defined workloads on a cluster. The IOPS statistics help you determine whether cluster processes, such as making backups or running deduplication, are impacting workload latency (response time) or might have caused, or contributed to, a performance event.

[How graphs of performance data work](#) on page 122

Unified Manager uses graphs or charts to show you volume performance statistics and events over a specified period of time.

Related tasks

[Determining whether a workload has a performance issue](#) on page 113

You can use Unified Manager to determine whether a detected performance event was truly caused by a performance issue on the cluster. The event might have been caused a spike in activity, for example, that drove up its response time, but now the response time has returned to its usual levels.

[Investigating a perceived slow response time for a workload](#) on page 114

You can use Unified Manager to determine whether operations on the cluster might have contributed to the slow response time (latency) for a volume workload.

Related reference

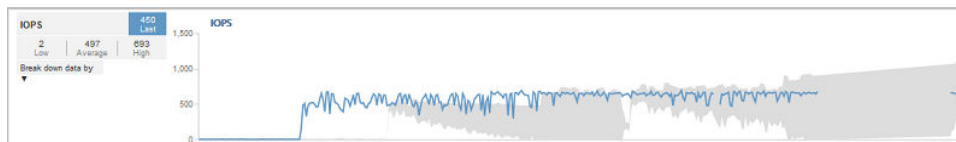
[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

How cluster operations can affect workload latency

Operations (IOPS) represent the activity of all user-defined and system-defined workloads on a cluster. The IOPS statistics help you determine whether cluster processes, such as making backups or running deduplication, are impacting workload latency (response time) or might have caused, or contributed to, a performance event.

When analyzing performance events, you can use the IOPS statistics to determine whether a performance event was caused by an issue on the cluster. You can identify the specific workload activities that might have been the main contributors to the performance event. IOPS are measured in operations per second (ops/sec).



This example shows the IOPS chart on the Performance/Volume Details page. The actual operations statistics is a blue line and the expected range of operations statistics is gray.

Note: In some cases where a cluster is overloaded, Unified Manager might display the message *Data collection is taking too long on Cluster `cluster_name`*. This means that not enough statistics have been collected for Unified Manager to analyze. You need to reduce the resources the cluster is using so that statistics can be collected.

Related concepts

[What the expected range of performance is](#) on page 96

The expected range of values is a forecast, or prediction, of what the upper and lower performance values are expected to be at a specific time. For the workload latency, the upper values form the performance threshold. When the actual value crosses the performance threshold, Unified Manager triggers a performance event alert.

[How Unified Manager uses workload latency to identify performance issues](#) on page 99

The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

[How graphs of performance data work](#) on page 122

Unified Manager uses graphs or charts to show you volume performance statistics and events over a specified period of time.

Related tasks

[Investigating a perceived slow response time for a workload](#) on page 114

You can use Unified Manager to determine whether operations on the cluster might have contributed to the slow response time (latency) for a volume workload.

Performance monitoring of MetroCluster configurations

Unified Manager enables you to monitor the write throughput between clusters in a MetroCluster configuration to identify workloads with a high amount of write throughput. If these high-performing workloads are causing other volumes on the local cluster to have high I/O response times, Unified Manager triggers performance events to notify you.

When a local cluster in a MetroCluster configuration mirrors its data to its partner cluster, the data is written to NVRAM and then transferred over the interswitch links (ISLs) to the remote aggregates. Unified Manager analyzes the NVRAM to identify the workloads whose high write throughput is overutilizing the NVRAM, placing the NVRAM in contention.

Workloads whose deviation in response time has exceeded the performance threshold are called *victims* and workloads whose deviation in write throughput to the NVRAM is higher than usual, causing the contention, are called *bullies*. Because only the write requests are mirrored to the partner cluster, Unified Manager does not analyze read throughput.

Unified Manager treats the clusters in a MetroCluster configuration as individual clusters. It does not distinguish between clusters that are partners or correlate the write throughput from each cluster.

Related concepts

[Performance event analysis for a MetroCluster configuration](#) on page 134

You can use Unified Manager to analyze a performance event for a MetroCluster configuration. You can identify the workloads involved in the event and review the suggested actions for resolving it.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

Related tasks

[*Identifying victim workloads involved in a performance event*](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[*Identifying bully workloads involved in a performance event*](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

[*Identifying shark workloads involved in a performance event*](#) on page 132

In Unified Manager, you can identify which workloads have the highest deviation in usage for a storage component in contention. Identifying these workloads helps you determine if these workloads should be moved to a less-utilized cluster.

Related reference

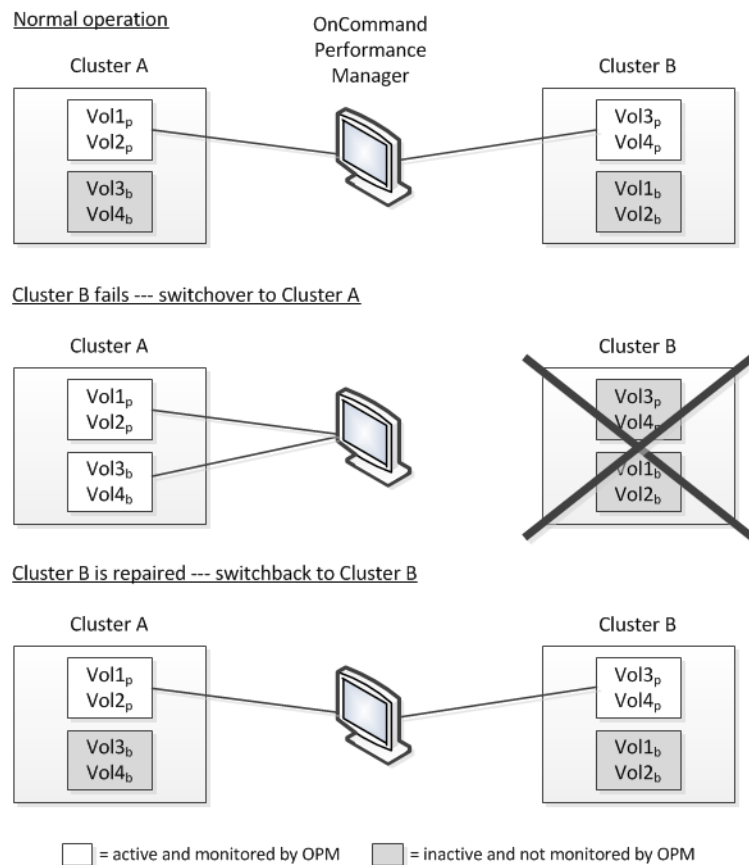
[*Performance event analysis and notification*](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Volume behavior during switchover and switchback

Events that trigger a switchover or switchback cause active volumes to be moved from one cluster to the other cluster in the disaster recovery group. The volumes on the cluster that were active and serving data to clients are stopped, and the volumes on the other cluster are activated and start serving data. Unified Manager monitors only those volumes that are active and running.

Because volumes are moved from one cluster to another, it is recommended that you monitor both clusters. A single instance of Unified Manager can monitor both clusters in a MetroCluster configuration, but sometimes the distance between the two locations necessitates using two Unified Manager instances to monitor both clusters. The following figure shows a single instance of Unified Manager:



The volumes with _p in their names indicate the primary volumes, and the volumes with _b in their names are mirrored backup volumes that are created by SnapMirror.

During normal operation:

- Cluster A has two active volumes: Vol1_p and Vol2_p.
- Cluster B has two active volumes: Vol3_p and Vol4_p.
- Cluster A has two inactive volumes: Vol3_b and Vol4_b.
- Cluster B has two inactive volumes: Vol1_b and Vol2_b.

Information pertaining to each of the active volumes (statistics, events, and so on) is collected by Unified Manager. Vol1_p and Vol2_p statistics are collected by Cluster A, and Vol3_p and Vol4_p statistics are collected by Cluster B.

After a catastrophic failure causes a switchover of active volumes from Cluster B to Cluster A:

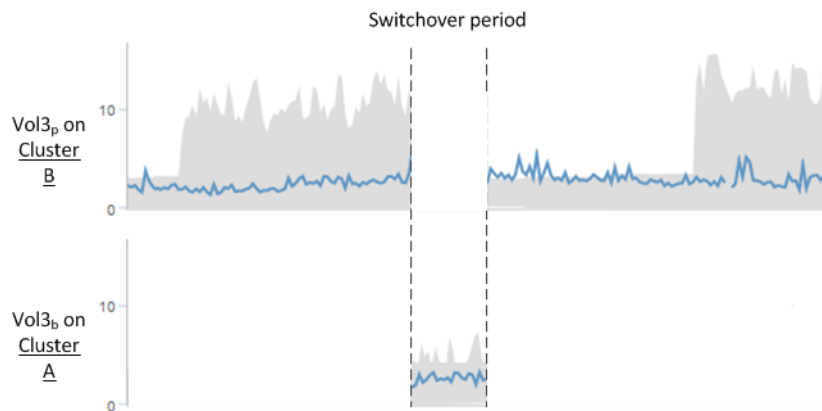
- Cluster A has four active volumes: Vol1_p, Vol2_p, Vol3_b, and Vol4_b.
- Cluster B has four inactive volumes: Vol3_p, Vol4_p, Vol1_b, and Vol2_b.

As during normal operation, information pertaining to each of the active volumes is collected by Unified Manager. But in this case, Vol1_p and Vol2_p statistics are collected by Cluster A, and Vol3_b and Vol4_b statistics are also collected by Cluster A.

Note that Vol3_p and Vol3_b are not the same volumes, because they are on different clusters. The information in Unified Manager for Vol3_p is not the same as Vol3_b:

- During switchover to Cluster A, Vol3_p statistics and events are not visible.
- On the very first switchover, Vol3_b looks like a new volume with no historical information.

When Cluster B is repaired and a switchback is performed, Vol3_p is active again on Cluster B, with the historical statistics and a gap of statistics for the period during the switchover. Vol3_b is not viewable from Cluster A until another switchover occurs:



Note:

- MetroCluster volumes that are inactive, for example, Vol3_b on Cluster A after switchback, are identified with the message "This volume was deleted". The volume is not actually deleted, but it is not currently being monitored by Unified Manager because it is not the active volume.
- If a single Unified Manager is monitoring both clusters in a MetroCluster configuration, volume search returns information for whichever volume is active at that time. For example, a search for "Vol3" would return statistics and events for Vol3_b on Cluster A if a switchover has occurred and Vol3 has become active on Cluster A.

What performance events are

Performance events are incidents or configuration changes related to workload performance on a cluster. They help you identify workloads with slow response times and cluster configuration changes that might have caused or contributed to the slow response times.

When Unified Manager detects multiple occurrences of the same event condition for the same cluster component, it treats all occurrences as a single event, not as separate events.

Related concepts

[What the expected range of performance is](#) on page 96

The expected range of values is a forecast, or prediction, of what the upper and lower performance values are expected to be at a specific time. For the workload latency, the upper values form the performance threshold. When the actual value crosses the performance threshold, Unified Manager triggers a performance event alert.

[Configuration changes detected by Unified Manager](#) on page 22

Unified Manager monitors your clusters for configuration changes to help you determine whether a change might have caused or contributed to a performance event. The Performance Explorer pages and the Performance/Volume Details page display a change event icon (●) to indicate the date and time when the change was detected.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

[Types of workloads monitored by Unified Manager](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Performance event analysis and notification

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Unified Manager monitors the I/O latency (response time) and IOPS (operations) for volumes on a cluster. When other workloads overuse a cluster component, for example, the component is in contention and cannot perform at an optimal level to meet workload demands. The performance of other workloads that are using the same component might be impacted, causing their latencies to increase. If the latency crosses the performance threshold, Unified Manager triggers a performance event and sends an email alert to notify you.

Event analysis

Unified Manager performs the following analyses, using the previous 15 days of performance statistics, to identify the victim workloads, bully workloads, and the cluster component involved in an event:

- Identifies victim workloads whose latency has crossed the performance threshold, which is the upper boundary of the expected range:
 - For volumes on HDD or Flash Pool (hybrid) aggregates, events are triggered only when the latency is greater than 5 milliseconds (ms) and the IOPS are more than 10 operations per second (ops/sec).
 - For volumes on all-SSD aggregates or FabricPool (composite) aggregates, events are triggered only when the latency is greater than 1 ms and the IOPS are more than 100 ops/sec.
- Identifies the cluster component in contention.

Note: If the latency of victim workloads at the cluster interconnect is greater than 1 ms, Unified Manager treats this as significant and triggers an event for the cluster interconnect.
- Identifies the bully workloads that are overusing the cluster component and causing it to be in contention.
- Ranks the workloads involved, based on their deviation in utilization or activity of a cluster component, to determine which bullies have the highest change in usage of the cluster component and which victims are the most impacted.

An event might occur for only a brief moment and then correct itself after the component it is using is no longer in contention. A continuous event is one that reoccurs for the same cluster

component within a five-minute interval and remains in the new state. For continuous events, Unified Manager triggers an alert after detecting the same event during two consecutive analysis intervals. Events that remain unresolved, which have a state of new, can display different description messages as workloads involved in the event change.

When an event is resolved, it remains available in Unified Manager as part of the record of past performance issues for a volume. Each event has a unique ID that identifies the event type and the volumes, cluster, and cluster components involved.

Note: A single volume can be involved in more than one event at the same time.

Event state

Events can be in one of the following states:

New

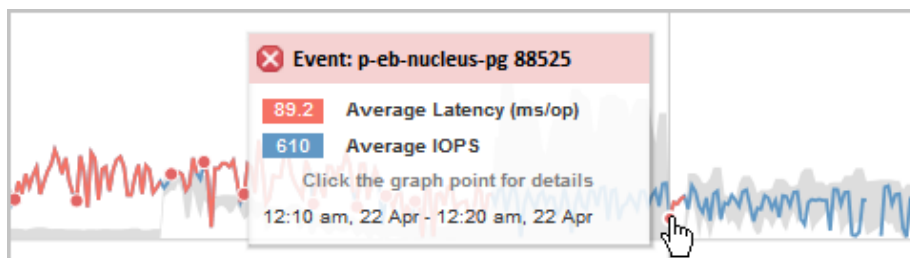
Indicates that the performance event is currently active. The issue causing the event has not corrected itself or has not been resolved. The performance counter for the storage object remains above the performance threshold.

Obsolete

Indicates that the event is no longer active. The issue causing the event has corrected itself or has been resolved. The performance counter for the storage object is no longer above the performance threshold.

Event notification

The event alerts are displayed on the Dashboards/Overview page, Dashboards/Performance page, Performance/Volume Details page, and they are sent to specified email addresses. You can view detailed analysis information about an event and get suggestions for resolving it on the Dynamic Threshold Event Details page.



In this example, an event is indicated by a red dot (●) on the Latency chart on the Performance/Volume Details page. Hovering your mouse cursor over the red dot displays a popup with more details about the event and options for analyzing it.

Event interaction

On the Performance/Volume Details page, you can interact with events in the following ways:

- Moving the pointer over a red dot displays a message that shows the event ID, along with the latency, number of operations per second, and the date and time when the event was detected. If there are multiple events for the same time period, the message shows the number of events, along with the average latency and operations per second for the volume.
- Clicking a single event displays a dialog box that shows more detailed information about the event, including the cluster components that are involved, similar to the Summary section on the Dynamic Threshold Event Details page.

The component in contention is circled and highlighted red. You can click either the event ID or **View full analysis** to view the full analysis on the Dynamic Threshold Event Details page. If there are multiple events for the same time period, the dialog box shows details about the

three most recent events. You can click an event ID to view the event analysis on the Dynamic Threshold Event Details page. If there are more than three events for the same time period, clicking the red dot does not display the dialog box.

Related concepts

[Collecting data and monitoring workload performance](#) on page 93

Unified Manager collects and analyzes workload activity every 5 minutes to identify performance events, and it detects configuration changes every 15 minutes. It retains a maximum of 30 days of 5-minute historical performance and event data, and it uses this data to forecast the expected range for all monitored workloads.

[How Unified Manager determines the performance impact for an event](#) on page 107

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

[Cluster components and why they can be in contention](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

[Types of workloads monitored by Unified Manager](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[Identifying bully workloads involved in a performance event](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

How Unified Manager determines the performance impact for an event

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

Unified Manager compares the last analyzed values for a workload to the expected range of values. The difference between the values last analyzed and the expected range of values identifies the workloads whose performance was most impacted by the event.

For example, suppose a cluster contains two workloads: Workload A and Workload B. The expected range for Workload A is 5-10 milliseconds per operation (ms/op) and its actual latency is usually around 7 ms/op. The expected range for Workload B is 10-20 ms/op and its actual latency is usually around 15 ms/op. Both workloads are well within their expected range for latency. Due to contention on the cluster, the latency of both workloads increases to 40 ms/op, crossing the performance threshold, which is the upper bounds of the expected range, and triggering events. The deviation in latency, from the expected values to the values above the performance threshold, for Workload A is around 33 ms/op, and the deviation for Workload B is around 25 ms/op. The latency of both workloads spike to 40 ms/op, but Workload A had the bigger performance impact because it had the higher latency deviation at 33 ms/op.

On the Dynamic Threshold Event Details page, in the Workload Details table, you can sort workloads by their deviation in activity, utilization, or throughput for a cluster component. You can also sort workloads by latency. When you select a sort option, Unified Manager analyzes the deviation in activity, utilization, throughput, or latency since the event was detected from the expected values to determine the workload sort order. For the latency, the red dots (●) indicate a performance threshold crossing by a victim workload, and the subsequent impact to the latency. Each red dot indicates a higher level of deviation in latency, which helps you identify the victim workloads whose latency was impacted the most by an event.

Related concepts

[Collecting data and monitoring workload performance](#) on page 93

Unified Manager collects and analyzes workload activity every 5 minutes to identify performance events, and it detects configuration changes every 15 minutes. It retains a maximum of 30 days of 5-minute historical performance and event data, and it uses this data to forecast the expected range for all monitored workloads.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

[Cluster components and why they can be in contention](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

[Types of workloads monitored by Unified Manager](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[Identifying bully workloads involved in a performance event](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Cluster components and why they can be in contention

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

A component that is in contention cannot perform at an optimal level. Its performance has declined, and the performance of other cluster components and workloads, called *victims*, might have increased latency. To bring a component out of contention, you must reduce its workload or increase its ability to handle more work, so that the performance can return to normal levels. Because Unified Manager collects and analyzes workload performance in five-minute intervals, it detects only when a cluster component is consistently overused. Transient spikes of overusage that last for only a short duration within the five-minute interval are not detected.

For example, a storage aggregate might be under contention because one or more workloads on it are competing for their I/O requests to be fulfilled. Other workloads on the aggregate can be impacted, causing their performance to decrease. To reduce the amount of activity on the aggregate, there are different steps you can take, such as moving one or more workloads to a less busy aggregate, to lessen the overall workload demand on the current aggregate. For a QoS policy group, you can adjust the throughput limit, or move workloads to a different policy group, so that the workloads are no longer being throttled.

Unified Manager monitors the following cluster components to alert you when they are in contention:

Network

Represents the wait time of I/O requests by the iSCSI protocols or the Fibre Channel (FC) protocols on the cluster. The wait time is time spent waiting for iSCSI Ready to Transfer (R2T) or FCP Transfer Ready (XFER_RDY) transactions to finish before the cluster can respond to an I/O request. If the network component is in contention, it means high wait time at the block protocol layer is impacting the latency of one or more workloads.

Network Processing

Represents the software component in the cluster involved with I/O processing between the protocol layer and the cluster. The node handling network processing might have changed since the event was detected. If the network processing component is in contention, it means high utilization at the network processing node is impacting the latency of one or more workloads.

QoS Policy

Represents the storage Quality of Service (QoS) policy group of which the workload is a member. If the policy group component is in contention, it means all workloads in the policy group are being throttled by the set throughput limit, which is impacting the latency of one or more of those workloads.

Cluster Interconnect

Represents the cables and adapters with which clustered nodes are physically connected. If the cluster interconnect component is in contention, it means high wait time for I/O requests at the cluster interconnect is impacting the latency of one or more workloads.

Data Processing

Represents the software component in the cluster involved with I/O processing between the cluster and the storage aggregate that contains the workload. The node handling data processing might have changed since the event was detected. If the data processing component is in contention, it means high utilization at the data processing node is impacting the latency of one or more workloads.

MetroCluster Resources

Represents the MetroCluster resources, including NVRAM and interswitch links (ISLs), used to mirror data between clusters in a MetroCluster configuration. If the MetroCluster component is in contention, it means high write throughput from workloads on the local cluster or a link health issue is impacting the latency of one or more workloads on the local cluster. If the cluster is not in a MetroCluster configuration, this icon is not displayed.

Aggregate or SSD Aggregate Ops

Represents the storage aggregate on which the workloads are running. If the aggregate component is in contention, it means high utilization on the aggregate is impacting the latency of one or more workloads. An aggregate consists of all HDDs, or a mix of HDDs and SSDs (a Flash Pool aggregate). An "SSD Aggregate" consists of all SSDs (an all-flash aggregate), or a mix of SSDs and an external capacity tier (a FabricPool aggregate).

Related concepts

[Collecting data and monitoring workload performance](#) on page 93

Unified Manager collects and analyzes workload activity every 5 minutes to identify performance events, and it detects configuration changes every 15 minutes. It retains a maximum of 30 days of 5-minute historical performance and event data, and it uses this data to forecast the expected range for all monitored workloads.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

[Types of workloads monitored by Unified Manager](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[Identifying bully workloads involved in a performance event](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Roles of workloads involved in a performance event

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

The following table defines the workload roles:

| Role | Description |
|--------|---|
| Victim | A user-defined workload whose performance has decreased due to other workloads, called bullies, that are over-using a cluster component. Only user-defined workloads are identified as victims. Unified Manager identifies victim workloads based on their deviation in latency, where the actual latency, during an event, has greatly increased from its expected range of latency. |
| Bully | A user-defined or system-defined workload whose over-use of a cluster component has caused the performance of other workloads, called victims, to decrease. Unified Manager identifies bully workloads based on their deviation in usage of a cluster component, where the actual usage, during an event, has greatly increased from its expected range of usage. |
| Shark | A user-defined workload with the highest usage of a cluster component compared to all workloads involved in an event. Unified Manager identifies shark workloads based on their usage of a cluster component during an event. |

Workloads on a cluster can share many of the cluster components, such as storage aggregates and the CPU for network and data processing. When a workload, such as a volume, increases its usage of a cluster component to the point that the component cannot efficiently meet workload demands, the component is in contention. The workload that is over-using a cluster component is a bully. The other workloads that share those components, and whose performance is impacted by the bully, are the victims. Activity from system-defined workloads, such as deduplication or Snapshot copies, can also escalate into "bullying".

When Unified Manager detects an event, it identifies all workloads and cluster components involved, including the bully workloads that caused the event, the cluster component that is in contention, and the victim workloads whose performance has decreased due to the increased activity of bully workloads.

Note: If Unified Manager cannot identify the bully workloads, it only alerts on the victim workloads and the cluster component involved.

Unified Manager can identify workloads that are victims of bully workloads, and also identify when those same workloads become bully workloads. A workload can be a bully to itself. For example, a high-performing workload that is being throttled by a policy group limit causes all workloads in the policy group to be throttled, including itself. A workload that is a bully or a victim in an ongoing performance event might change its role or no longer be a participant in the event. On the Performance/Volume Details page, in the Events List table, when the selected volume changes its participant role, the date and time of the role change is displayed.

Related concepts

[*Cluster components and why they can be in contention*](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

[*Types of workloads monitored by Unified Manager*](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

Related tasks

[*Displaying information about performance events*](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[*Identifying victim workloads involved in a performance event*](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[*Identifying bully workloads involved in a performance event*](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

Related reference

[*Performance event analysis and notification*](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Analyzing workload performance

Unified Manager enables you to monitor and analyze I/O performance of volume workloads on your clusters. You can determine whether a performance issue is on the cluster and whether storage is the issue.

Note: This chapter describes how to analyze workload performance using the Performance/Volume Details page and the Dynamic Threshold Event Details page.

Related concepts

[Collecting data and monitoring workload performance](#) on page 93

Unified Manager collects and analyzes workload activity every 5 minutes to identify performance events, and it detects configuration changes every 15 minutes. It retains a maximum of 30 days of 5-minute historical performance and event data, and it uses this data to forecast the expected range for all monitored workloads.

[Types of workloads monitored by Unified Manager](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

[How Unified Manager uses workload latency to identify performance issues](#) on page 99

The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

Determining whether a workload has a performance issue

You can use Unified Manager to determine whether a detected performance event was truly caused by a performance issue on the cluster. The event might have been caused a spike in activity, for example, that drove up its response time, but now the response time has returned to its usual levels.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- You must have identified the name of the volume, or associated LUN, you want to analyze.
- Unified Manager must have collected and analyzed a minimum of five days of performance statistics from the cluster.

About this task

If you are viewing the Dynamic Threshold Event Details page, you can click the name link for a volume to go directly to the Performance/Volume Details page.

Steps

1. In the **Search** bar, type at least the first three characters of the volume name.
The name of the volume is displayed in the search results.
2. Click the name of the volume.
The volume is displayed on the Performance/Volume Details page.
3. In the **Historic data** chart, click **5d** to display the last five days of historical data.
4. Review the **Latency** chart to answer the following questions:
 - Are there new performance events?
 - Are there historic performance events, indicating that the volume has had issues in the past?
 - Are there spikes in the response time, even if the spikes are within the expected range?
 - Have there been configuration changes on the cluster that might have impacted performance?

If the response time for the volume does not display performance events, spikes in activity, or recent configuration changes that might have impacted the response time, you can rule out the performance issue being caused by the cluster.

Related concepts

[Types of workloads monitored by Unified Manager](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

[How Unified Manager uses workload latency to identify performance issues](#) on page 99

The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

[How graphs of performance data work](#) on page 122

Unified Manager uses graphs or charts to show you volume performance statistics and events over a specified period of time.

Related tasks

[Investigating a perceived slow response time for a workload](#) on page 114

You can use Unified Manager to determine whether operations on the cluster might have contributed to the slow response time (latency) for a volume workload.

Investigating a perceived slow response time for a workload

You can use Unified Manager to determine whether operations on the cluster might have contributed to the slow response time (latency) for a volume workload.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- You must have identified the name of the volume, or associated LUN, you want to analyze.
- Unified Manager must have collected and analyzed a minimum of five days of performance statistics from the cluster.

About this task

If you are viewing the Dynamic Threshold Event Details page, you can click the name for a volume to go directly to the Performance/Volume Details page.

Steps

1. In the **Search** bar, type the name of the volume.
The name of the volume is displayed in the search results.
2. Click the name of the volume.
The volume is displayed on the Performance/Volume Details page.
3. On the Historic data chart, click **5d** to display the last five days of historical data.
4. Review the **IOPS** chart to answer the following questions:
 - Are there dramatic spikes in the activity?
 - Are there dramatic drops in the activity?
 - Are there abnormal changes in the operations pattern?

If the operations do not display dramatic spikes or drops in activity, and there were no changes to the cluster configuration during this time, the storage administrator can confirm that other workloads have not impacted volume performance.
5. On the **Break down data by** menu, under **IOPS**, select **Reads/writes/other**.
6. Click **Submit**.
The Reads/writes/other chart is displayed below the IOPS chart.

7. Review the **Reads/writes/other** chart to identify dramatic spikes or drops in the amount of reads or writes for the volume.

If there are no dramatic spikes or drops in reads or writes, the storage administrator can confirm that I/O on the cluster is operating normally. Any performance issues might be on the network or the connected clients.

Related concepts

[Types of workloads monitored by Unified Manager](#) on page 93

You can use Unified Manager to monitor the performance of two types of workloads: user-defined and system-defined.

[How Unified Manager uses workload latency to identify performance issues](#) on page 99

The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

[How graphs of performance data work](#) on page 122

Unified Manager uses graphs or charts to show you volume performance statistics and events over a specified period of time.

Related tasks

[Determining whether a workload has a performance issue](#) on page 113

You can use Unified Manager to determine whether a detected performance event was truly caused by a performance issue on the cluster. The event might have been caused a spike in activity, for example, that drove up its response time, but now the response time has returned to its usual levels.

Identifying trends of I/O response time on cluster components

You can use Unified Manager to view the performance trends for all monitored cluster components for a volume workload. You can see, over time, which components have the highest usage, whether the highest usage is from read or write requests, and how the usage has impacted the workload response time.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- You must have identified the name of the volume or associated LUN you want to analyze.
- To display 30 days of performance statistics, Unified Manager must have collected and analyzed a minimum of 30 days of performance statistics from the cluster.

About this task

Identifying performance trends for the cluster components helps the administrator decide whether the cluster is being overused or underused.

If you are viewing the Dynamic Threshold Event Details page, you can click the name for a volume to go directly to the Performance/Volume Details page.

Steps

1. In the **Search** bar, type the name of the volume.
The name of the volume is displayed in the search results.
2. Click the name of the volume.
The volume is displayed on the Performance/Volume Details page.
3. On the Historic data chart, click **30d** to display the last 30 days of historical data.
4. Click **Break down data by**.
5. Under **Latency**, select **Cluster Components** and **Reads/writes latency**.
6. Click **Submit**.

Both charts are displayed below the Latency chart.

7. Review the **Cluster Components** chart.
The chart breaks down the total response time by cluster component. The response time at the aggregate is the highest.
8. Compare the **Cluster Components** chart to the **Latency** chart.
The Latency chart shows spikes in the total response time that are aligned with the spikes in response time for the aggregate. There are a few at the end of the 30-day time frame, where the performance threshold was crossed.
9. Review the **Reads/writes latency** chart.
The chart shows a higher response time for write requests than read requests, indicating that the client applications are waiting longer than usual to have their write requests fulfilled.
10. Compare the **Reads/writes latency** chart to the **Latency** chart.
The spikes in total response time that align with the aggregate in the Cluster Components chart also align with the writes in the Reads/writes latency chart. The administrator must decide whether the client applications using the workload must be addressed or whether the aggregate is being overused.

Related concepts

[How Unified Manager uses workload latency to identify performance issues](#) on page 99

The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

[How Unified Manager determines the performance impact for an event](#) on page 107

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

Related tasks

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[Identifying bully workloads involved in a performance event](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

Related reference

[Performance statistics displayed in the data breakdown charts](#) on page 119

You can use the graphs to view performance trending for a volume. You can also view statistics for reads and writes, network protocol activity, the impact of QoS policy group throttling on latency,

the ratio of reads and writes to cache storage, the total cluster CPU time used by a workload, and specific cluster components.

Analyzing the performance improvements achieved from moving a volume

You can use Unified Manager to investigate the impact of a volume move operation on the latency (response time) of other volumes on the cluster. Moving a high performing volume to a less busy aggregate or an aggregate with flash storage enabled allows the volume to perform more efficiently.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- You must have identified the name of the volume, or associated LUN, you want to analyze.
- Unified Manager must have collected and analyzed seven days of data.

About this task

Unified Manager identifies when a volume moves between aggregates. It can detect when the volume move is occurring, completed, or failed. The Performance/Volume Details page displays a change event icon for each state of the volume move, which helps you track when a move operation occurred and helps you determine whether it might have contributed to a performance event.


If you are viewing the Dynamic Threshold Event Details page, you can click the name of a volume to go directly to the Performance/Volume Details page.

Steps

1. In the **Search** bar, type the name of the volume.
2. Click the name of the volume.
The volume is displayed on the Performance/Volume Details page.
3. In the **Historic data** chart, adjust the sliders to show activity from the previous work week.
4. Analyze the **Latency** chart and the **IOPS** chart to see how the volume performed over the last few days.

Assume that you notice a consistent pattern of very high average response times of over 42 milliseconds per operation (ms/op), with performance events, each day of the week and decide to move the volume to a less busy aggregate to improve performance. Using OnCommand System Manager, you can move the volume to an aggregate with Flash Pool enabled for an increased performance boost. Approximately an hour after the volume move has been completed, you can return to Unified Manager to confirm that the move operation was completed successfully and that the latency has improved.

5. If the **Performance/Volume Details** page is not displayed, search for the volume you want to view.
6. On the **Historic data** chart, click **1d** to view the activity from the last one day, a few hours since the volume move was completed.

At the bottom of the page, in the Events time line, a change event icon () is displayed to indicate the time that the volume move operation was completed. A black, vertical line is also displayed from the change event icon to the Latency chart.

7. Point your cursor to the change event icon to view details about the event in the **Events List**.
Because the volume moved to an aggregate with Flash Pool enabled, you can see the change in read and write I/O to cache.
8. On the **Break down data** by menu, under **MBps**, select **Cache hit ratio**.
The Cache hit ratio chart displays statistics about the reads and writes to cache.

The volume successfully moved to a less busy aggregate and the change event is highlighted in the Events List on the right. The average latency decreased significantly from over 42 ms/op to around 24 ms/op. The current latency is around 1.5 ms/op. In the Cache hit ratio chart, the amount of successful read and write hits to cache is now at 100% because the volume is now on an aggregate with Flash Pool enabled.

Related concepts


[Collecting data and monitoring workload performance](#) on page 93

Unified Manager collects and analyzes workload activity every 5 minutes to identify performance events, and it detects configuration changes every 15 minutes. It retains a maximum of 30 days of 5-minute historical performance and event data, and it uses this data to forecast the expected range for all monitored workloads.

[What performance events are](#) on page 104

Performance events are incidents or configuration changes related to workload performance on a cluster. They help you identify workloads with slow response times and cluster configuration changes that might have caused or contributed to the slow response times.

[Configuration changes detected by Unified Manager](#) on page 22

Unified Manager monitors your clusters for configuration changes to help you determine whether a change might have caused or contributed to a performance event. The Performance Explorer pages and the Performance/Volume Details page display a change event icon () to indicate the date and time when the change was detected.

[Analyzing performance events](#) on page 124

You can analyze performance events to identify when they were detected, whether they are new (active) or obsolete, the workloads and cluster components involved, and the options for resolving the events on your own.

Related reference

[Performance statistics displayed in the data breakdown charts](#) on page 119

You can use the graphs to view performance trending for a volume. You can also view statistics for reads and writes, network protocol activity, the impact of QoS policy group throttling on latency, the ratio of reads and writes to cache storage, the total cluster CPU time used by a workload, and specific cluster components.

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

How moving a FlexVol volume works

Knowing how moving a FlexVol volume works helps you to determine whether the volume move satisfies service-level agreements and to understand where a volume move is in the volume move process.

FlexVol volumes are moved from one aggregate or node to another within the same storage virtual machine (SVM). A volume move does not disrupt client access during the move.

Moving a volume occurs in multiple phases:

- A new volume is made on the destination aggregate.
- The data from the original volume is copied to the new volume.
During this time, the original volume is intact and available for clients to access.
- At the end of the move process, client access is temporarily blocked.

During this time the system performs a final replication from the source volume to the destination volume, swaps the identities of the source and destination volumes, and changes the destination volume to the source volume.

- After completing the move, the system routes client traffic to the new source volume and resumes client access.

The move is not disruptive to client access because the time in which client access is blocked ends before clients notice a disruption and time out. Client access is blocked for 35 seconds by default. If the volume move operation cannot finish in the time that access is denied, the system aborts this final phase of the volume move operation and allows client access. The system attempts the final phase three times by default. After the third attempt, the system waits an hour before attempting the final phase sequence again. The system runs the final phase of the volume move operation until the volume move is complete.

Performance/Volume Details page

This page provides detailed performance statistics for all I/O activity and operations for the selected FlexVol volume, FlexGroup volume, or FlexGroup constituent workload. You can select a specific time frame over which to view the statistics and events for the volume. The events identify performance events and changes that might be impacting I/O performance.

Historic data chart

Plots the historical performance analysis data for the selected volume. You can click and drag the sliders to specify a time frame. The sliders increase and decrease the time frame window. The data outside the time frame window is grayed out. You can use the slider at the bottom of the chart to move the time frame window across the historical data. The entire page, including the displayed charts and events, reflects the data available within the time frame window. Unified Manager retains a maximum of 30 days of historical data on this page.

Note: On the historic data chart, if you select a time frame of more than 1 day, depending on your screen resolution, the charts display the maximum values for response time and IOPS across the number of days.

Options

Time selector

Specifies the time range over which to view the volume performance statistics for the entire page. You can click 1 day (**1d**) through 30 days (**30d**), or click **Custom** to select a custom range. For a custom range, you can select a beginning and end date, and then click **Update** to update the entire page.

Note: If you access the Performance/Volume Details page by clicking the name link of a volume on the Dynamic Threshold Event Details page, a time range, such as 1 day or 5 days prior to the current day, is automatically selected by default. When you move the slider in the historic data chart, the time range changes to a custom range, but the **Custom** time selector is not selected. The default time selector remains selected.

Break down data by

Provides a list of charts you can add to the Performance/Volume Details page to display more detailed performance statistics for the selected volume.

Performance statistics displayed in the data breakdown charts

You can use the graphs to view performance trending for a volume. You can also view statistics for reads and writes, network protocol activity, the impact of QoS policy group throttling on latency,

the ratio of reads and writes to cache storage, the total cluster CPU time used by a workload, and specific cluster components.

These views display a maximum of 30 days of statistics from the current day. On the historic data chart, if you select a time frame of more than 1 day, depending on your screen resolution, the charts display the maximum values for latency and IOPS across the number of days.

Note: You can use the **Select All** check box to select, or deselect, all the listed chart options.

Latency

The following charts detail the latency, or response time, information for the selected workload:

Cluster Components

Displays a graph of the time spent at each cluster component used by the selected volume.

The chart helps you determine the latency impact by each component as it relates to the total latency. You can use the check box next to each component to show and hide its graph.

For QoS policy groups, data is only displayed for user-defined policy groups. Zeros are displayed for system-defined policy groups, such as default policy groups.

Reads/writes latency

Displays a graph of the latencies of the successful read and write requests from the selected volume workload over the selected time frame.

Write requests are an orange line and read requests are a blue line. The requests are specific to the latency for the selected volume workload, not all workloads on the cluster.

Note: The read and write statistics might not always add up to the total latency statistics displayed in the Latency chart. This is expected behavior based on how Unified Manager collects and analyzes read and write statistics for a workload.

Policy Group Impact

Displays a graph of the percentage of the latency for the selected volume workload that is impacted by the throughput limit on its QoS policy group.

If the workload is throttled, the percentage indicates how much the throttling contributed to the latency at a specific point in time. The percentage values indicate the amount of throttling:

- 0% = no throttling
- > 0% = throttling
- > 20% = critical throttling

If the cluster can handle more work, you can reduce throttling by increasing the policy group limit. Another option is to move the workload to a less busy aggregate.

Note: The chart displays for workloads in a user-defined QoS policy group with a set throughput limit only. It does not display if the workloads are in a system-defined policy group, such as the default policy group, or a policy group that does not have a QoS limit. For a QoS policy group, you can point the cursor to the name of the policy group to display its throughput limit and the last time it was modified. If the policy group was modified before the associated cluster was added to Unified Manager, the last modified time is the date and time when Unified Manager first discovered the cluster.

IOPS

The following charts detail the IOPS data for the selected workload:

Reads/writes/other

Displays a graph showing the number of read and write IOPS and other IOPS, per second, over the selected time frame.

Other IOPS are protocol activities initiated by the client that are not reads or writes. For example, in an NFS environment, this could be metadata operations such as `getattr`, `setattr`, or `fsstat`. In a CIFS environment, this could be attribute lookups, directory listings, or antivirus scans. Write IOPS are an orange line and read requests are a blue line. The requests are specific to all operations for the selected volume workload, not all operations on the cluster.

MBps

The following charts detail the throughput data for the selected workload:

Cache hit ratio

Displays a graph of the percentage of read requests from client applications satisfied by cache over the selected time frame.

The cache could be on Flash Cache cards or solid state drives (SSDs) in Flash Pool aggregates. A cache hit, in blue, is a read from cache. A cache miss, in orange, is a read from a disk in the aggregate. The requests are specific to the selected volume workload, not all workloads on the cluster.

You can view more detailed information about volume cache usage in the Unified Manager Health pages and in OnCommand System Manager.

Components

The following charts detail the data by cluster component used by the selected workload:

Cluster CPU Time

Displays a graph of the CPU usage time, in ms, for all nodes in the cluster used by the selected workload.

The graph displays the combined CPU usage time for network processing and data processing. The CPU time for system-defined workloads that are associated to the selected workload, and are using the same nodes for data processing, is also included. You can use the chart to determine whether the workload is a high consumer of the CPU resources on the cluster. You can also use the chart, in combination with the Reads/writes latency chart under the Latency chart, or the Reads/writes/other chart under the IOPS chart, to determine how changes to workload activity over time impact cluster CPU utilization.

Disk Utilization

Displays a graph showing the percentage of utilization on the data disks in the storage aggregate over the selected time frame.

The utilization includes disk read and write requests from the selected volume workload only. Reads from cache are not included. The utilization is specific to the selected volume workload, not all workloads on the disks. If a monitored volume is involved in a volume move, the utilization values in this chart are for the target aggregate to which the volume moved.

How graphs of performance data work

Unified Manager uses graphs or charts to show you volume performance statistics and events over a specified period of time.

The graphs enable you to customize the range of time for which to view data. The data is displayed with the time frame on the horizontal axis of the graph and the counters on the vertical axis, with point intervals along the graph lines. The vertical axis is dynamic; the values adjust based on the peaks of the expected or actual values.

Selecting time frames

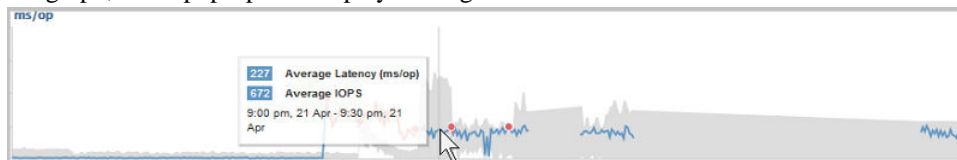
On the Performance/Volume Details page, the Historic data chart enables you to select a time frame for all graphs on the page. The 1d, 5d, 10d, and 30d buttons specify 1 day through 30 days (1 month) and the **Custom** button enables you to specify a custom time range within that 30 days. Each point on a graph represents a 5-minute collection interval, and a maximum of 30 days of historical performance data is retained. Note that intervals also account for network delays and other anomalies.



In this example, the Historic data chart has a time frame set to the beginning and the end of the month of March. In the selected time frame, all historic data before March is grayed out.

Viewing data point information

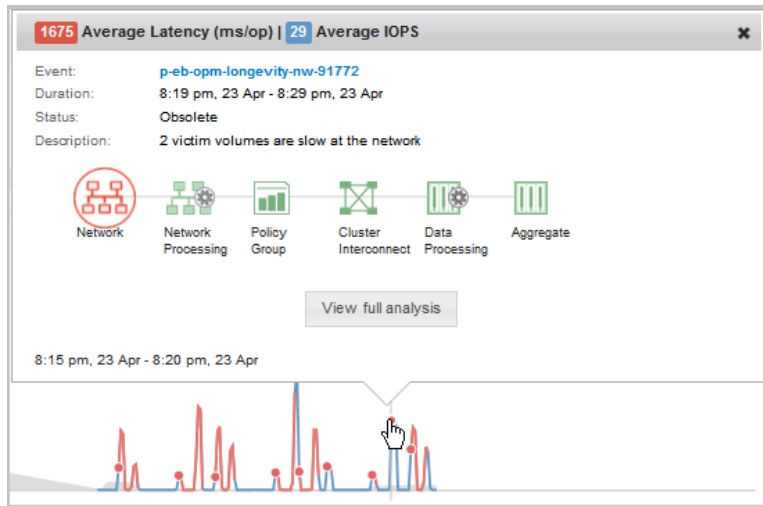
To view data point information on a graph, you can position the cursor over a specific point within the graph, and a pop-up box displays listing the value and date and time information.



In this example, positioning the cursor over the IOPS chart on the Performance/Volume Details page displays the response time and operations values between 3:50 a.m. and 3:55 a.m. on October 20th.

Viewing performance event information

To view event information on a graph, you can position the cursor over an event icon to view summary information in a pop-up box, or you can click the event icon for more detailed information.



In this example, on the Performance/Volume Details page, clicking an event icon on the Latency chart displays detailed information about the event in a pop-up box. The event is also highlighted in the Events List.

Related concepts

[Navigating performance workflows in the Unified Manager GUI](#) on page 10

The Unified Manager interface provides many pages for the collection and display of performance information. You use the left navigation panel to navigate to pages in the GUI, and you use tabs and links on the pages to view and configure information.

Related reference

[Performance statistics displayed in the data breakdown charts](#) on page 119

You can use the graphs to view performance trending for a volume. You can also view statistics for reads and writes, network protocol activity, the impact of QoS policy group throttling on latency, the ratio of reads and writes to cache storage, the total cluster CPU time used by a workload, and specific cluster components.

Analyzing performance events

You can analyze performance events to identify when they were detected, whether they are new (active) or obsolete, the workloads and cluster components involved, and the options for resolving the events on your own.

Related concepts

[Cluster components and why they can be in contention](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

[How Unified Manager determines the performance impact for an event](#) on page 107

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[Identifying bully workloads involved in a performance event](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

[Identifying shark workloads involved in a performance event](#) on page 132

In Unified Manager, you can identify which workloads have the highest deviation in usage for a storage component in contention. Identifying these workloads helps you determine if these workloads should be moved to a less-utilized cluster.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Displaying information about performance events

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.

- There must be new or obsolete performance events.

About this task

The list of events is sorted by detected time, with the most recent events listed first. You can click a column header to sort the events based on that column. For example, you can sort by the Status column to view events by severity. If you are looking for a specific event, or for a specific type of event, you can use the filter and search mechanisms to refine the list of events that appear in the list.

Events from all sources are displayed on this page. The Event Type column lists the source of the event. When you select an event ID to view details about the event, depending on the event type, one of the following pages is displayed.

| If the event originated from a... | View the event details in the... |
|---|---|
| User-defined performance threshold policy | User-Defined Threshold Event Details page |
| System-defined performance threshold policy | System-Defined Threshold Event Details page |
| Dynamic performance threshold | Dynamic Threshold Event Details page |

Steps

1. In the left navigation pane, click **Events**.
2. Locate an event that you want to analyze and click the event ID.
The details page for the event displays.

Note: You can also display the details page for an event by clicking the event name link from the Performance Explorer page and from an alert email.

3. Record the event ID number, located at the top of the page, using an application such as a text editor.
You can search on this ID to locate the event later.

Related concepts

[Analyzing performance events](#) on page 124

You can analyze performance events to identify when they were detected, whether they are new (active) or obsolete, the workloads and cluster components involved, and the options for resolving the events on your own.

[Cluster components and why they can be in contention](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads

involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Analyzing events from user-defined performance thresholds

Events generated from user-defined thresholds indicate that a performance counter for a certain storage object, for example, an aggregate or volume, has crossed the threshold you defined in the policy. This indicates that the cluster object is experiencing a performance issue.

You use the User-Defined Threshold Event Details page to analyze the performance event and take corrective action, if necessary, to return performance back to normal.

Related concepts

[Managing performance thresholds](#) on page 30

Performance threshold policies enable you to determine the point at which Unified Manager generates an event to inform system administrators about issues that could be impacting workload performance. These threshold policies are known as *user-defined* performance thresholds.

Related reference

[Performance event severity types](#) on page 22

Each performance event is associated with a severity type to help you prioritize the events that require immediate corrective action.

Responding to user-defined performance threshold events

You can use Unified Manager to investigate performance events caused by a performance counter crossing a user-defined warning or critical threshold. You can also use Unified Manager to check the health of the cluster component to see whether recent health events detected on the component contributed to the performance event.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

Steps

1. Display the **User-Defined Threshold Event Details** page to view information about the event.
2. Review the top of the page to view the event ID and the cluster object, for example, aggregate or volume, on which the event occurred.
3. Under **Summary**, read the **Description**, which describes the threshold breach that caused the event.

For example, the message "Latency value of 456 ms/op has triggered a WARNING event based on threshold setting of 400 ms/op" indicates that a latency warning event occurred for the cluster object.
4. Hover your cursor over the policy name to display details about the threshold policy that triggered the event.

This includes the policy name, the performance counter being evaluated, the counter value that must be breached to be considered a critical or warning event, and the duration by which the counter must exceed the value.
5. Make a note of the **Event Detection Time** so you can investigate whether other events might have occurred at the same time that could have contributed to this event.
6. Follow one of the options below to further investigate the event, to determine whether you need to perform any actions to solve the performance problem:

| Option | Possible investigation actions |
|---|--|
| Click the object name to display the Explorer page for that object. | This page enables you to view the object details and compare this object with other similar storage objects to see whether other storage objects have a performance issue around the same time. For example, to see whether other volumes on the same aggregate are also having a performance issue. |
| Click the cluster name to display the Cluster Explorer page. | This page enables you to view the details for the cluster on which this object resides to see whether other storage objects have a performance issue around the same time. You might need to use the time range selector to display the same time period when the event occurred. |

Analyzing events from system-defined performance thresholds

Events generated from system-defined performance thresholds indicate that a performance counter, or set of performance counters, for a certain storage object has crossed the threshold from a system-defined policy. This indicates that the storage object, for example, an aggregate or node, is experiencing a performance issue.

You use the System-Defined Threshold Event Details page to analyze the performance event and take corrective action, if necessary, to return performance back to normal.

Note: System-defined threshold policies are not enabled on ONTAP Cloud, ONTAP Edge, or ONTAP Select systems.

Related reference

[Performance event severity types](#) on page 22

Each performance event is associated with a severity type to help you prioritize the events that require immediate corrective action.

[Types of system-defined performance threshold policies](#) on page 27

Unified Manager provides some standard threshold policies that monitor cluster performance and generate events automatically. These policies are enabled by default, and they generate warning or information events when the monitored performance thresholds are breached.

Responding to system-defined performance threshold events

You can use Unified Manager to investigate performance events caused by a performance counter crossing a system-defined warning threshold. You can also use Unified Manager to check the health of the cluster component to see whether recent events detected on the component contributed to the performance event.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

Steps

1. Display the **System-Defined Threshold Event Details** page to view information about the event.
2. Review the top of the page to view the event ID and the cluster object, for example, aggregate or volume, on which the event occurred.
3. Under the **Summary** section, read the **Description**, which describes the threshold breach that caused the event.

For example, the message "Node utilization value of 90 % has triggered a WARNING event based on threshold setting of 85 %" indicates that a node utilization warning event occurred for the cluster object.

4. Make a note of the **Event Detection Time** so you can investigate whether other events might have occurred at the same time that could have contributed to this event.
5. Under **System Diagnosis**, review the brief description of the type of analysis the system-defined policy is performing on the cluster object.

For some events a green or red icon is displayed next to the diagnosis to indicate whether an issue was found in that particular diagnosis. For other types of system-defined events counter charts display the performance for the object.
6. Under **Suggested Actions**, click the **Help me do this** link to view the suggested actions you can perform to try and resolve the performance event on your own.

Responding to QoS policy group performance events

Unified Manager generates QoS policy warning events when workload throughput (IOPS, IOPS/TB, or MBps) has exceeded the defined QoS policy setting and workload latency is becoming affected. These system-defined events provide the opportunity to correct potential performance issues before many workloads are affected by latency.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

About this task

Unified Manager generates warning events for QoS policy breaches when workload throughput has exceeded the defined QoS policy setting during each performance collection period for the previous hour. Workload throughput may exceed the QoS threshold for only a short period of time during each collection period, but Unified Manager displays only the "average" throughput during the collection period on the chart. For this reason you may receive QoS events while the throughput for a workload might not have crossed the policy threshold shown in the chart.

You can use System Manager or the ONTAP commands to manage policy groups, including the following tasks:

- Creating a new policy group for the workload
- Adding or removing workloads in a policy group
- Moving a workload between policy groups
- Changing the throughput limit of a policy group
- Moving a workload to a different aggregate or node

Steps

1. Display the **System-Defined Threshold Event Details** page to view information about the event.
2. Review the top of the page to view the storage object, for example, LUN or volume, on which the event occurred.
3. Under the **Summary** section, read the **Description**, which describes the threshold breach that caused the event.

For example, the message "IOPS value of 1,352 IOPS on vol1_NFS1 has triggered a WARNING event to identify potential performance problems for the workload" indicates that a QoS Max IOPS event occurred on volume vol1_NFS1.
4. Under the **System Diagnosis** section, review the two charts: one for total average IOPS or MBps (depending on the event), and one for latency. When arranged this way you can see which cluster components are most affecting latency when the workload approached the QoS max limit.

Note that for adaptive QoS policy events that the IOPS chart shows IOPS values that have been converted from the assigned IOPS/TB threshold policy based on the size of the volume.

5. Under **Suggested Actions** section, review the suggestions and determine which actions you should perform to avoid an increase in latency for the workload.

If required, click the **Help** button to view more details about the suggested actions you can perform to try and resolve the performance event.

Related concepts

[How different types of QoS policies are displayed in Unified Manager](#) on page 66

You can view the ONTAP-defined quality of service (QoS) policy settings that have been applied to a volume or LUN in the Performance Explorer IOPS, IOPS/TB, and MBps charts. The information displayed in the charts is different depending on the type of QoS policy that has been applied to the workload.

Related reference

[Types of system-defined performance threshold policies](#) on page 27

Unified Manager provides some standard threshold policies that monitor cluster performance and generate events automatically. These policies are enabled by default, and they generate warning or information events when the monitored performance thresholds are breached.

Responding to node resources overutilized performance events

Unified Manager generates node resources overutilized warning events when a single node is operating above the bounds of its operational efficiency, and therefore potentially affecting workload latencies. These system-defined events provide the opportunity to correct potential performance issues before many workloads are affected by latency.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

About this task

Unified Manager generates warning events for node resources overutilized policy breaches by looking for nodes that are using more than 100% of their performance capacity for more than 30 minutes.

You can use System Manager or the ONTAP commands to correct this type of performance issue, including the following tasks:

- Creating and applying a QoS policy to any volumes or LUNs that are overusing system resources
- Reducing the QoS maximum throughput limit of a policy group to which workloads have been applied
- Moving a workload to a different aggregate or node
- Increasing capacity by adding disks to the node, or by upgrading to a node with a faster CPU and more RAM

Steps

1. Display the **System-Defined Threshold Event Details** page to view information about the event.
2. Under the **Summary** section, read the **Description**, which describes the threshold breach that caused the event.

For example, the message "Perf. Capacity Used value of 139% on simplicity-02 has triggered a WARNING event to identify potential performance problems in the data processing unit."

indicates that performance capacity on node simplicity-02 is overused and affecting node performance.

3. Under the **System Diagnosis** section, review the three charts: one for performance capacity used on the node, one for average storage IOPS being used by the top workloads, and one for latency on the top workloads. When arranged in this way you can see which workloads are the cause of the latency on the node.

You can view which workloads have QoS policies applied, and which do not, by moving your cursor over the IOPS chart.

4. Under **Suggested Actions** section, review the suggestions and determine which actions you should perform to avoid an increase in latency for the workload.

If required, click the **Help** button to view more details about the suggested actions you can perform to try and resolve the performance event.

Analyzing events from dynamic performance thresholds

Events generated from dynamic thresholds indicate that the actual response time (latency) for a workload is too high, or too low, compared to the expected response time range. You use the Dynamic Threshold Event Details page to analyze the performance event and take corrective action, if necessary, to return performance back to normal.

Note: Dynamic performance thresholds are not enabled on ONTAP Cloud, ONTAP Edge, or ONTAP Select systems.

Related reference

[Performance event severity types](#) on page 22

Each performance event is associated with a severity type to help you prioritize the events that require immediate corrective action.

Identifying victim workloads involved in a performance event

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

About this task

The Dynamic Threshold Event Details page displays a list of the user-defined and system-defined workloads, ranked by the highest deviation in activity or usage on the component or most impacted by the event. The values are based on the peaks that Unified Manager identified when it detected and last analyzed the event.

Steps

1. Display the **Dynamic Threshold Event Details** page to view information about the event. In the Workload Details table, the workloads are sorted on **Victims - Peak Deviation in Latency**.

Note: When the table is sorted by peak deviation in latency, only user-defined workloads, such as volumes, are displayed. Workloads with very low latency values are not displayed in the table.

2. Click the name of a volume to view its current and historical latency and events on the **Performance/Volume Details** page.

Related concepts

[How Unified Manager determines the performance impact for an event](#) on page 107

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

[Cluster components and why they can be in contention](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying bully workloads involved in a performance event](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

[Identifying shark workloads involved in a performance event](#) on page 132

In Unified Manager, you can identify which workloads have the highest deviation in usage for a storage component in contention. Identifying these workloads helps you determine if these workloads should be moved to a less-utilized cluster.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Identifying bully workloads involved in a performance event

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

About this task

The Dynamic Threshold Event Details page displays a list of the user-defined and system-defined workloads ranked by the highest usage of the component or most impacted by the event. The values are based on the peaks that Unified Manager identified when it detected and last analyzed the event.

Steps

1. Display the **Dynamic Threshold Event Details** page to view information about the event.
2. In the **Workload Details** table, select **Bullies - Peak Deviation in Activity** or **Bullies - Peak Deviation in Utilization**.

Note: By default, the table is sorted on **Victims - Peak Deviation in Latency**. When the Workload details table is sorted by peak deviation in usage, workloads with low deviation in usage are not displayed in the table.

The workloads with the highest deviation in usage are displayed at the top of the table.

3. Click the name of a volume workload to view detailed information about its current and historical performance activity on the **Performance/Volume Details** page.

Related concepts

[How Unified Manager determines the performance impact for an event](#) on page 107

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

[Cluster components and why they can be in contention](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[Identifying shark workloads involved in a performance event](#) on page 132

In Unified Manager, you can identify which workloads have the highest deviation in usage for a storage component in contention. Identifying these workloads helps you determine if these workloads should be moved to a less-utilized cluster.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Identifying shark workloads involved in a performance event

In Unified Manager, you can identify which workloads have the highest deviation in usage for a storage component in contention. Identifying these workloads helps you determine if these workloads should be moved to a less-utilized cluster.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There are new or obsolete performance event.

About this task

The Dynamic Threshold Event Details page displays a list of the user-defined and system-defined workloads ranked by the highest usage of the component or most impacted by the event. The

values are based on the peaks that Unified Manager identified when it detected and last analyzed the event.

Steps

1. Display the **Dynamic Threshold Event Details** page to view information about the event.
2. In the **Workload Details** table, select **Sharks - Peak Utilization** or **Sharks - Peak Activity**.

Note: By default, the table is sorted on **Victims - Peak Deviation in Latency**. When the Workload details table is sorted by peak deviation in usage, workloads with low deviation in usage are not displayed in the table.

The workload with the highest usage for the component in contention, depending on the component type, is displayed at the top of the table.

3. Click the name of a volume workload to view detailed information about its current and historical performance activity on the **Performance/Volume Details** page.

Related concepts

[How Unified Manager determines the performance impact for an event](#) on page 107

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

[Cluster components and why they can be in contention](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[Identifying bully workloads involved in a performance event](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads

involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Performance event analysis for a MetroCluster configuration

You can use Unified Manager to analyze a performance event for a MetroCluster configuration. You can identify the workloads involved in the event and review the suggested actions for resolving it.

MetroCluster performance events might be due to *bully* workloads that are over-utilizing the interswitch links (ISLs) between the clusters, or due to link health issues. Unified Manager monitors each cluster in a MetroCluster configuration independently, without consideration of performance events on a partner cluster.

Performance events from both clusters in the MetroCluster configuration are also displayed on the Unified Manager Dashboards/Overview page. You can also view the Health pages of Unified Manager to check the health of each cluster and to view their relationship.

Related concepts

[Performance monitoring of MetroCluster configurations](#) on page 101

Unified Manager enables you to monitor the write throughput between clusters in a MetroCluster configuration to identify workloads with a high amount of write throughput. If these high-performing workloads are causing other volumes on the local cluster to have high I/O response times, Unified Manager triggers performance events to notify you.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

Related tasks

[Analyzing a performance event on a cluster in a MetroCluster configuration](#) on page 134

You can use Unified Manager to analyze the cluster in a MetroCluster configuration on which a performance event was detected. You can identify the cluster name, event detection time, and the *bully* and *victim* workloads involved.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Analyzing a performance event on a cluster in a MetroCluster configuration

You can use Unified Manager to analyze the cluster in a MetroCluster configuration on which a performance event was detected. You can identify the cluster name, event detection time, and the *bully* and *victim* workloads involved.

Before you begin

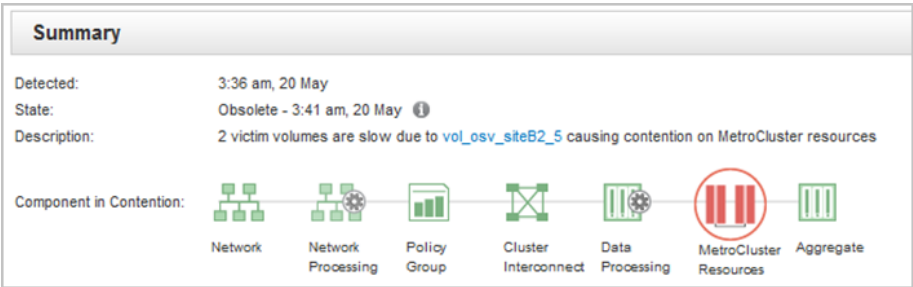
- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events for a MetroCluster configuration.
- Both clusters in the MetroCluster configuration must be monitored by the same instance of Unified Manager.

Steps

1. Display the **Dynamic Threshold Event Details** page to view information about the event.

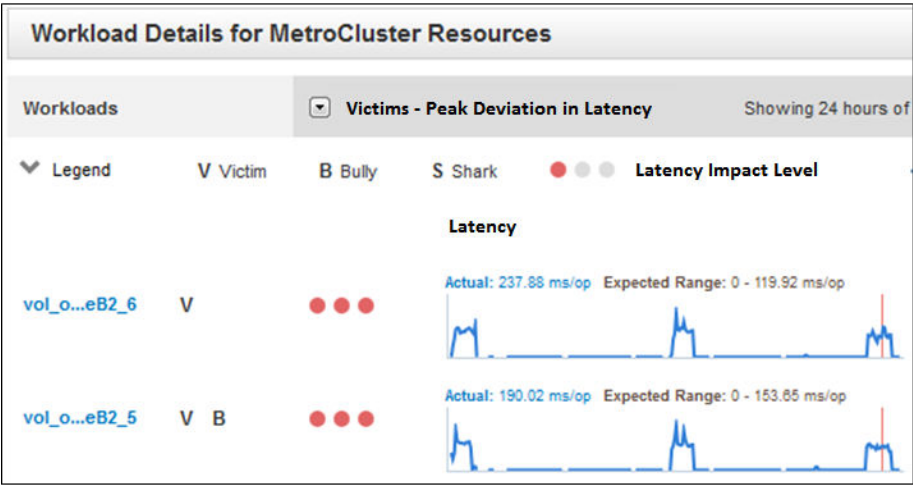
- 2. Review the event description to see the names of the workloads involved and the number of workloads involved.

In this example, the MetroCluster Resources icon is red, indicating that the MetroCluster resources are in contention. You position your cursor over the icon to display a description of the icon. At the top of the page in the event ID, the cluster name identifies the name of the cluster on which the event was detected.



- 3. Make a note of the cluster name and the event detection time, which you can use to analyze performance events on the partner cluster.
- 4. In the **Workload Details** table, review the *victim* workloads to confirm that their response times are higher than the performance threshold.

In this example, the victim workloads are displayed at the top of the table. The Latency charts display, at a high-level, a consistent latency pattern for the victim workloads involved. Even though the abnormal latency of the victim workloads triggered the event, a consistent latency pattern might indicate that the workloads are performing within their expected range, but that a spike in I/O increased the latency and triggered the event. By default, the workloads are sorted by victims.

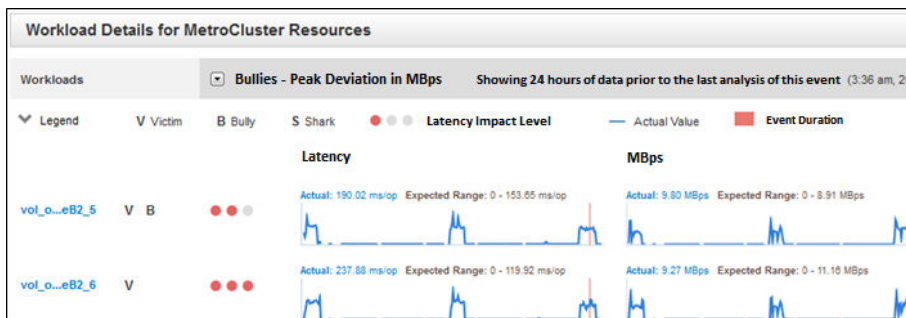


If you recently installed an application on a client that accesses these volume workloads and that application sends a high amount of I/O to them, you might be anticipating their latencies to increase. If the latency for the workloads returns within the expected range, the event state changes to obsolete, and remains in this state for more than 30 minutes, you can probably ignore the event. If the event is ongoing, and remains in the new state, you can investigate it further to determine whether other issues caused the event.

- 5. In the **Workload Details** table, select **Bullies - Peak Deviation in Write MBps** to display the bully workloads at the top of the table.

In this example, one bully workload is displayed at the top of the table. The presence of bully workloads indicates that the event might have been caused by one or more workloads on the

local cluster overutilizing the MetroCluster resources. The bully workloads have a high deviation in write throughput (MBps).



The Total Write MBps charts display, at a high-level, the write throughput (MBps) pattern for the workloads. You can review the write MBps pattern to identify abnormal throughput, which might indicate that a workload is over-utilizing the MetroCluster resources.

If no bully workloads are involved in the event, the event might have been caused by a health issue with the link between the clusters or a performance issue on the partner cluster. You can use Unified Manager to check the health of both clusters in a MetroCluster configuration. You can also use Unified Manager to check for and analyze performance events on the partner cluster.

Related concepts

[Performance event analysis for a MetroCluster configuration](#) on page 134

You can use Unified Manager to analyze a performance event for a MetroCluster configuration. You can identify the workloads involved in the event and review the suggested actions for resolving it.

[Performance monitoring of MetroCluster configurations](#) on page 101

Unified Manager enables you to monitor the write throughput between clusters in a MetroCluster configuration to identify workloads with a high amount of write throughput. If these high-performing workloads are causing other volumes on the local cluster to have high I/O response times, Unified Manager triggers performance events to notify you.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

Related tasks

[Analyzing a performance event for a remote cluster on a MetroCluster configuration](#) on page 137

You can use Unified Manager to analyze performance events on a remote cluster in a MetroCluster configuration. The analysis helps you determine whether an event on the remote cluster caused an event on its partner cluster.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads

involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Analyzing a performance event for a remote cluster on a MetroCluster configuration

You can use Unified Manager to analyze performance events on a remote cluster in a MetroCluster configuration. The analysis helps you determine whether an event on the remote cluster caused an event on its partner cluster.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- You must have analyzed a performance event on a local cluster in a MetroCluster configuration and obtained the event detection time.
- You must have checked the health of the local cluster and its partner cluster involved in the performance event and obtained the name of the partner cluster.

Steps

1. Log in to the Unified Manager instance that is monitoring the partner cluster.
2. In the left navigation pane, click **Events** to display the event list.
3. From the **Navigation bar**, select **Events**.
The Events inventory page is displayed.
4. From the **Time Range** selector, select **Last Hour**, and then click **Apply Range**.
5. In the **Filtering** selector, select **Cluster** from the left drop-down menu, type the name of the partner cluster in the text field, and then click **Apply Filter**.

If there are no events for the selected cluster over the last hour, this indicates that the cluster has not experienced any performance issues during the time that the event was detected on its partner.
6. If the selected cluster has events detected over the last hour, compare the event detection time to the event detection time for the event on the local cluster.

If these events involve bully workloads causing contention on the data processing component, one or more of these bullies might have caused the event on the local cluster. You can click the event to analyze it and review the suggested actions for resolving it on the Dynamic Threshold Event Details page.

If these events do not involve bully workloads, they did not cause the performance event on the local cluster.

Related concepts

[Performance monitoring of MetroCluster configurations](#) on page 101

Unified Manager enables you to monitor the write throughput between clusters in a MetroCluster configuration to identify workloads with a high amount of write throughput. If these high-performing workloads are causing other volumes on the local cluster to have high I/O response times, Unified Manager triggers performance events to notify you.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

Related tasks

[Analyzing a performance event on a cluster in a MetroCluster configuration](#) on page 134

You can use Unified Manager to analyze the cluster in a MetroCluster configuration on which a performance event was detected. You can identify the cluster name, event detection time, and the *bully* and *victim* workloads involved.

Related reference

[Performance event analysis and notification](#) on page 105

Performance events notify you about I/O performance issues on a volume workload caused by contention on a cluster component. Unified Manager analyzes the event to identify all workloads involved, the component in contention, and whether the event is still an issue that you might need to resolve.

Responding to a dynamic performance event caused by QoS policy group throttling

You can use Unified Manager to investigate a performance event caused by a Quality of Service (QoS) policy group throttling workload throughput (MBps). The throttling increased the response times (latency) of volume workloads in the policy group. You can use the event information to determine whether new limits on the policy groups are needed to stop the throttling.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.


Steps

1. Display the **Dynamic Threshold Event Details** page to view information about the event.
2. Under **Summary**, read the **Description**, which displays the name of the workloads impacted by the throttling.

Note: The description can display the same workload for the victim and bully, because the throttling makes the workload a victim of itself. For a QoS policy group, you can point the cursor to the name of the policy group to display its throughput limit and the last time it was modified. If the policy group was modified before the associated cluster was added to Unified Manager, the last modified time is the date and time when Unified Manager first discovered the cluster.

3. Record the name of the volume, using an application such as a text editor.
You can search on the volume name to locate it later.
4. In the **Workload Details** table, click **Bullies - Peak Deviation in Activity**.
The workloads in the policy group are sorted by highest deviation of actual activity from their expected activity. The workload at the top of the list has the highest deviation and caused the throttling to occur. The activity is the percentage of the policy group limit used by each workload.
5. In the **Workloads** column, click the name of the top workload.
The Performance/Volume Details page is displayed, with detailed performance data for the selected workload.
6. Select **Break down data by**.
7. Select the check box next to **Latency** to select all latency breakdown charts.
8. Under **IOPS**, select **Reads/writes/other**.
9. Click **Submit**.
The breakdown charts are displayed under the Latency chart and the IOPS chart.
10. Compare the **Policy Group Impact** chart to the **Latency** chart to see what percentage of throttling impacted the latency at the time of the event.
The policy group has a maximum throughput of 1,000 operations per second (op/sec), which the workloads in it cannot collectively exceed. At the time of the event, the workloads in the policy group had a combined throughput of over 1,200 op/sec, which caused the policy group

to throttle its activity back to 1,000 op/sec. The Policy Group Impact chart shows that the throttling caused 10% of the total latency, confirming that the throttling caused the event to occur.

11. Review the **Cluster Components** chart, which shows the total latency by cluster component. The latency is highest at the policy group, further confirming that the throttling caused the event.
12. Compare the **Reads/writes latency** chart to the **Reads/writes/other** chart. Both charts show a high number of read requests with high latency, but the number of requests and amount of latency for write requests is low. These values help you determine whether there is a high amount of throughput or number of operations that increased the latency. You can use these values when deciding to put a policy group limit on the throughput or operations.
13. Use OnCommand System Manager to increase the current limit on the policy group to 1,300 op/sec.
14. After a day, return to Unified Manager and search for the name of the workload that you recorded in Step 3. The Performance/Volume Details page is displayed.
15. Select **Break down data by > IOPS**.
16. Click **Submit**. The Reads/writes/other chart is displayed.
17. At the bottom of the page, point your cursor to the change event icon () for the policy group limit change.
18. Compare the **Reads/writes/other** chart to the **Latency** chart. The read and write requests are the same, but the throttling has stopped and the latency has decreased.

Related concepts

[How Unified Manager uses workload latency to identify performance issues](#) on page 99

The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

[Cluster components and why they can be in contention](#) on page 109

You can identify cluster performance issues when a cluster component goes into contention. The performance of volume workloads that use the component slow down and their response time (latency) for client requests increases, which triggers an event in Unified Manager.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads

helps you understand why the client applications accessing them have been performing slower than usual.

Identifying bully workloads involved in a performance event on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

Identifying shark workloads involved in a performance event on page 132

In Unified Manager, you can identify which workloads have the highest deviation in usage for a storage component in contention. Identifying these workloads helps you determine if these workloads should be moved to a less-utilized cluster.

Related reference

Performance statistics displayed in the data breakdown charts on page 119

You can use the graphs to view performance trending for a volume. You can also view statistics for reads and writes, network protocol activity, the impact of QoS policy group throttling on latency, the ratio of reads and writes to cache storage, the total cluster CPU time used by a workload, and specific cluster components.

Responding to a performance event caused by a disk failure

You can use Unified Manager to investigate a performance event caused by workloads overutilizing an aggregate. You can also use Unified Manager to check the health of the aggregate to see if recent health events detected on the aggregate contributed to the performance event.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

Steps

1. Display the **Dynamic Threshold Event Details** page to view information about the event.
2. Under **Summary**, read the **Description**, which describes the workloads involved in the event and the cluster component in contention.
There are multiple victim volumes, whose latency was impacted by the cluster component in contention. The aggregate, which is in the middle of a RAID reconstruct to replace the failed disk with a spare disk, is the cluster component in contention. Under Component in Contention, the Aggregate icon is highlighted red and the name of the aggregate is displayed in parentheses.
3. In the **Workload Details** table, click **Bullies - Peak Deviation in Utilization** to sort the workloads on the aggregate by peak utilization.
The top workloads with the highest peak utilization since the event was detected are displayed at the top of the table. One of the top workloads in the table is the system-defined workload Disk Health, which indicates a RAID reconstruct. A reconstruct is the internal process involved with rebuilding the aggregate with the spare disk. The Disk Health workload, along with other workloads on the aggregate, likely caused the contention on the aggregate and the associated event.
4. After confirming that the activity from the Disk Health workload caused the event, wait for approximately 30 minutes for the reconstruction to finish and for Unified Manager to analyze the event and detect whether the aggregate is still in contention.
5. In Unified Manager, search for the event ID you recorded in Step 2.
The event for the disk failure is displayed on the Dynamic Threshold Event Details page. After the RAID reconstruction is complete, under Summary, the Status is obsolete, indicating that the event is resolved.

6. In the **Workload Details** table, click **Bullies - Peak Deviation in Utilization** to sort the workloads on the aggregate by peak utilization.
7. Click the name of a top volume workload.
Details for the selected volume are displayed on the Performance/Volume Details page.
8. Click **1d** to display the last 24 hours (1 day) of data for the selected volume.
In the Latency chart, a red dot (●) indicates when the disk failure event occurred.
9. Select **Break down data by**.
10. Under **Components**, select **Disk Utilization**.
11. Click **Submit**.
The Disk Utilization chart displays a graph of all read and write requests from the selected workload to the disks of the target aggregate.
12. Compare the data in the **Disk Utilization** chart to the data at the time of the event in the **Latency** chart.
At the time of the event, the Disk Utilization shows a high amount of read and write activity, caused by the RAID reconstruction processes, which increased the latency of the selected volume. A few hours after the event occurred, both the reads and writes and the latency have decreased, confirming that the aggregate is no longer in contention.

Related concepts

[How Unified Manager uses workload latency to identify performance issues](#) on page 99

The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

[Configuration changes detected by Unified Manager](#) on page 22

Unified Manager monitors your clusters for configuration changes to help you determine whether a change might have caused or contributed to a performance event. The Performance Explorer pages and the Performance/Volume Details page display a change event icon (●) to indicate the date and time when the change was detected.

[How Unified Manager determines the performance impact for an event](#) on page 107

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can determine the most critical events and then drill down to detailed information to determine the cause of the event.

[Identifying victim workloads involved in a performance event](#) on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

[Identifying bully workloads involved in a performance event](#) on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

[Identifying shark workloads involved in a performance event](#) on page 132

In Unified Manager, you can identify which workloads have the highest deviation in usage for a storage component in contention. Identifying these workloads helps you determine if these workloads should be moved to a less-utilized cluster.

Related reference

[Performance statistics displayed in the data breakdown charts](#) on page 119

You can use the graphs to view performance trending for a volume. You can also view statistics for reads and writes, network protocol activity, the impact of QoS policy group throttling on latency, the ratio of reads and writes to cache storage, the total cluster CPU time used by a workload, and specific cluster components.


Responding to a performance event caused by HA takeover

You can use Unified Manager to investigate a performance event caused by high data processing on a cluster node that is in a high-availability (HA) pair. You can also use Unified Manager to check the health of the nodes to see whether any recent health events detected on the nodes contributed to the performance event.

Before you begin

- You must have the Operator, OnCommand Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

Steps

1. Display the **Dynamic Threshold Event Details** page to view information about the event.
2. Under **Summary**, read the **Description**, which describes the workloads involved in the event and the cluster component in contention.
There is one victim volume, whose latency was impacted by the cluster component in contention. The data processing node, which took over all workloads from its partner node, is the cluster component in contention. Under Component in Contention, the Data Processing icon is highlighted red and the name of the node that was handling data processing at the time of the event is displayed in parentheses.
3. In the **Description**, click the name of the victim volume.
The Performance/Volume Details page is displayed. At the bottom of the page, in the Events time line, a change event icon () indicates the time that Unified Manager detected the start of the HA takeover.
4. Point your cursor to the change event icon for the HA takeover.
Details about the HA takeover are displayed in the Events List table. In the Latency chart, an event indicates that the selected volume crossed the performance threshold due to high latency around the same time as the HA takeover.
5. Select **Break down data by**.
6. Under **Latency**, select **Cluster Components**.
7. Click **Submit**.
The Cluster Components chart is displayed. The chart breaks down the total latency by cluster component.
8. At the bottom of the page, point your mouse cursor to the change event icon for the start of the HA takeover.
9. In the **Cluster Components** chart, compare the latency for data processing to the total latency in the **Latency** chart.

At the time of the HA takeover, there was a spike in data processing from the increased workload demand on the data processing node. The increased CPU utilization drove up the latency and triggered the event.


10. After fixing the failed node, use OnCommand System Manager to perform an HA giveback, which moves the workloads from the partner node to the fixed node.
11. After the HA giveback is complete, in Unified Manager, search for the event ID you recorded in Step 2.
The event triggered by the HA takeover is displayed on the Dynamic Threshold Event Details page. The event now has a state of obsolete, which indicates that the event is resolved.
12. In the **Description**, click the name of the victim volume.
The Performance/Volume Details page is displayed. At the bottom of the page, in the Events time line, a change event icon indicates the time that Unified Manager detected the completion of the HA giveback.
13. Select **Break down data by**.
14. Under **Latency**, select **Cluster Components**.
The Cluster Components chart is displayed.
15. At the bottom of the page, point your cursor to the change event icon for the HA giveback. The change event is highlighted in the Events List table and indicates that the HA giveback was completed successfully.
16. In the **Cluster Components** chart, compare the latency for data processing to the total latency in the **Latency** chart.
The latency at the data processing component has decreased, which has decreased the total latency. The node that the selected volume is now using for data processing has resolved the event.

Related concepts

[How Unified Manager uses workload latency to identify performance issues](#) on page 99

The workload latency (response time) is the time it takes for a volume on a cluster to respond to I/O requests from client applications. Unified Manager uses the latency to detect and alert you to performance events.

[Configuration changes detected by Unified Manager](#) on page 22

Unified Manager monitors your clusters for configuration changes to help you determine whether a change might have caused or contributed to a performance event. The Performance Explorer pages and the Performance/Volume Details page display a change event icon () to indicate the date and time when the change was detected.

[How Unified Manager determines the performance impact for an event](#) on page 107

Unified Manager uses the deviation in activity, utilization, write throughput, cluster component usage, or I/O latency (response time) for a workload to determine the level of impact to workload performance. This information determines the role of each workload in the event and how they are ranked on the Dynamic Threshold Event Details page.

[Roles of workloads involved in a performance event](#) on page 111

Unified Manager uses roles to identify the involvement of a workload in a performance event. The roles include victims, bullies, and sharks. A user-defined workload can be a victim, bully, and shark at the same time.

Related tasks

[Displaying information about performance events](#) on page 124

You can use the Events inventory page to view a list of all the new and obsolete performance events on the clusters being monitored by Unified Manager. By viewing this information you can

determine the most critical events and then drill down to detailed information to determine the cause of the event.

Identifying victim workloads involved in a performance event on page 130

In Unified Manager, you can identify which volume workloads have the highest deviation in response time (latency) caused by a storage component in contention. Identifying these workloads helps you understand why the client applications accessing them have been performing slower than usual.

Identifying bully workloads involved in a performance event on page 131

In Unified Manager, you can identify which workloads have the highest deviation in usage for a cluster component in contention. Identifying these workloads helps you understand why certain volumes on the cluster have slow response times (latency).

Identifying shark workloads involved in a performance event on page 132

In Unified Manager, you can identify which workloads have the highest deviation in usage for a storage component in contention. Identifying these workloads helps you determine if these workloads should be moved to a less-utilized cluster.

Related reference

Performance statistics displayed in the data breakdown charts on page 119

You can use the graphs to view performance trending for a volume. You can also view statistics for reads and writes, network protocol activity, the impact of QoS policy group throttling on latency, the ratio of reads and writes to cache storage, the total cluster CPU time used by a workload, and specific cluster components.

Copyright and trademark

Copyright

Copyright © 2020 NetApp, Inc. All rights reserved. Printed in the U.S.

No part of this document covered by copyright may be reproduced in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, or storage in an electronic retrieval system—without prior written permission of the copyright owner.

Software derived from copyrighted NetApp material is subject to the following license and disclaimer:

THIS SOFTWARE IS PROVIDED BY NETAPP "AS IS" AND WITHOUT ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WHICH ARE HEREBY DISCLAIMED. IN NO EVENT SHALL NETAPP BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

NetApp reserves the right to change any products described herein at any time, and without notice. NetApp assumes no responsibility or liability arising from the use of products described herein, except as expressly agreed to in writing by NetApp. The use or purchase of this product does not convey a license under any patent rights, trademark rights, or any other intellectual property rights of NetApp.

The product described in this manual may be protected by one or more U.S. patents, foreign patents, or pending applications.

Data contained herein pertains to a commercial item (as defined in FAR 2.101) and is proprietary to NetApp, Inc. The U.S. Government has a non-exclusive, non-transferrable, non-sublicensable, worldwide, limited irrevocable license to use the Data only in connection with and in support of the U.S. Government contract under which the Data was delivered. Except as provided herein, the Data may not be used, disclosed, reproduced, modified, performed, or displayed without the prior written approval of NetApp, Inc. United States Government license rights for the Department of Defense are limited to those rights identified in DFARS clause 252.227-7015(b).

Trademark

NETAPP, the NETAPP logo, and the marks listed on the NetApp Trademarks page are trademarks of NetApp, Inc. Other company and product names may be trademarks of their respective owners.

<http://www.netapp.com/us/legal/netapptmlist.aspx>