Monitor and manage cluster performance

Active IQ Unified Manager

NetApp
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Monitor and manage cluster performance

Introduction to Active IQ Unified Manager performance monitoring

Active IQ Unified Manager (formerly 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, NVMe namespaces, and network interfaces (LIFs).
- Displays detailed graphs that plot workload activity over time; including IOPS (operations), MB/s (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.

- Identifies the quality of service (QoS) policies and Performance Service Level policies (PSLs) that are applied to your volumes and LUNs.
- 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

These sections contain information about the two user interfaces that Active IQ Unified Manager provides for troubleshooting data storage capacity, availability, and protection issues. The two UIs are the Unified Manager web UI and the maintenance console.

If you want to use the protection features in Unified Manager, you must also install and configure OnCommand Workflow Automation (WFA).

Unified Manager web UI

The Unified Manager web UI enables an administrator to monitor and troubleshoot cluster issues relating to data storage capacity, availability, and protection.

These sections describe some common workflows that an administrator can follow to troubleshoot storage capacity, data availability, or protection issues displayed in the Unified Manager web UI.

Maintenance console

The Unified Manager 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.

You can use this information for accessing the maintenance console and using it to resolve issues related to the functioning of the Unified Manager server.

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 180 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 180 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 older than 180 days and dynamic thresholds older than 180 days.
Data pruning	Every day after 3:30 a.m.	Deletes from the database any one-hour performance data older than 180 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.

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 Notifications pane.

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 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.

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

Navigate 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 page
- storage and network object inventory pages
- storage object details pages (including the performance explorer)
- configuration and setup pages
- events pages

Log 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.

You are automatically logged out of the session after 1 hour of inactivity. This timeframe can be configured under **General** > **Feature Settings**.

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. . At the login screen, enter your user name and password.

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

The Dashboard page is displayed.

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.

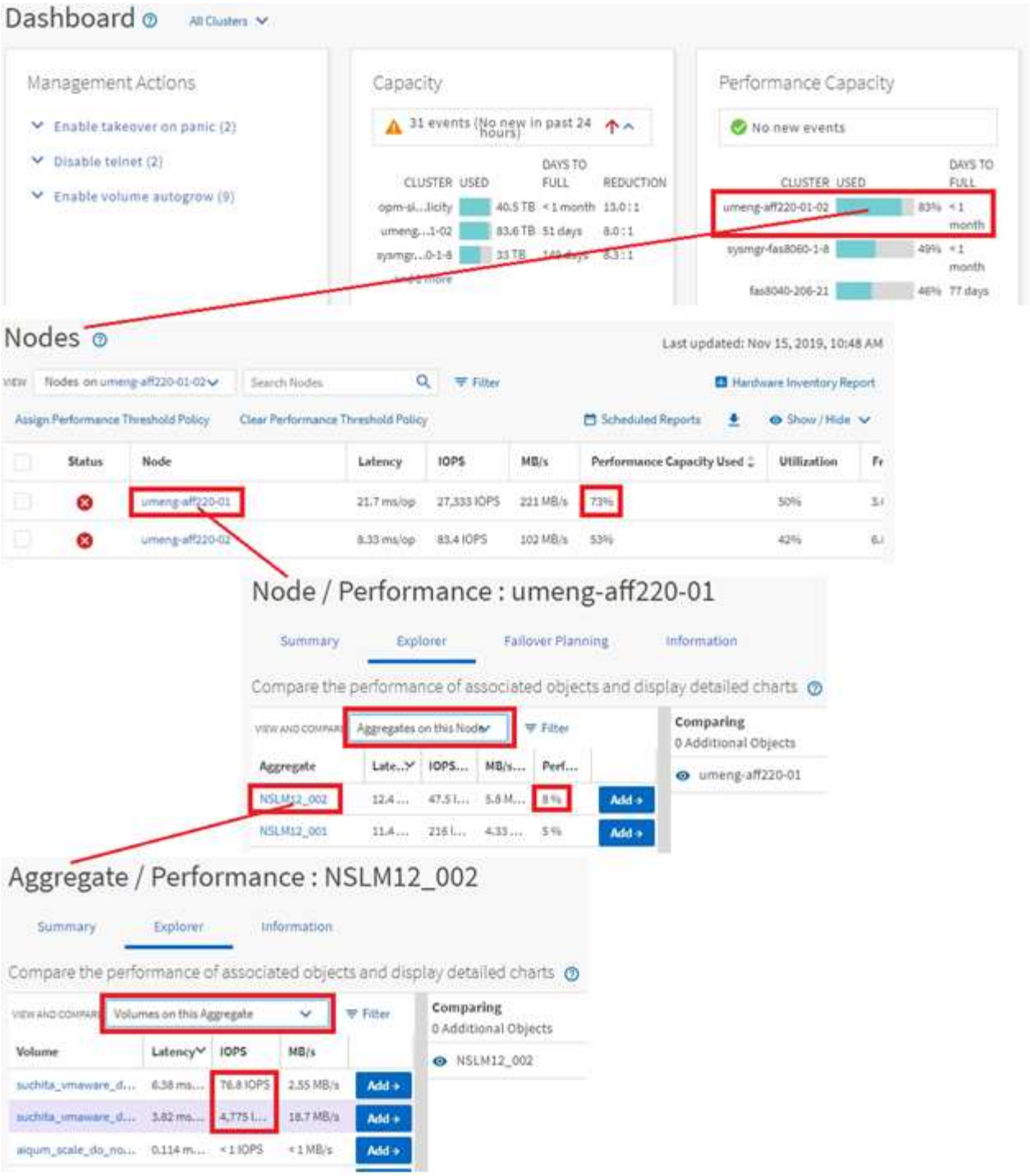
Monitor cluster object navigation

You can 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 Dashboard page, review the details in the Performance Capacity panel to identify the cluster that is using the most performance capacity and click the bar chart to navigate to the list of nodes for that cluster.
2. Identify the node with the highest performance capacity used value and click that node.
3. From the Node / Performance Explorer page, click **Aggregates on this Node** from the View and Compare menu.
4. Identify the aggregate that is using the most performance capacity and click that aggregate.
5. From the Aggregate / Performance Explorer page, click **Volumes on this Aggregate** from the View and Compare menu.
6. Identify the volumes that are using the most IOPS.

You should investigate these volumes to see if you should apply a QoS policy or Performance Service Level policy, or change the policy settings, so that those volumes do not use such a large percentage of IOPS on the cluster.



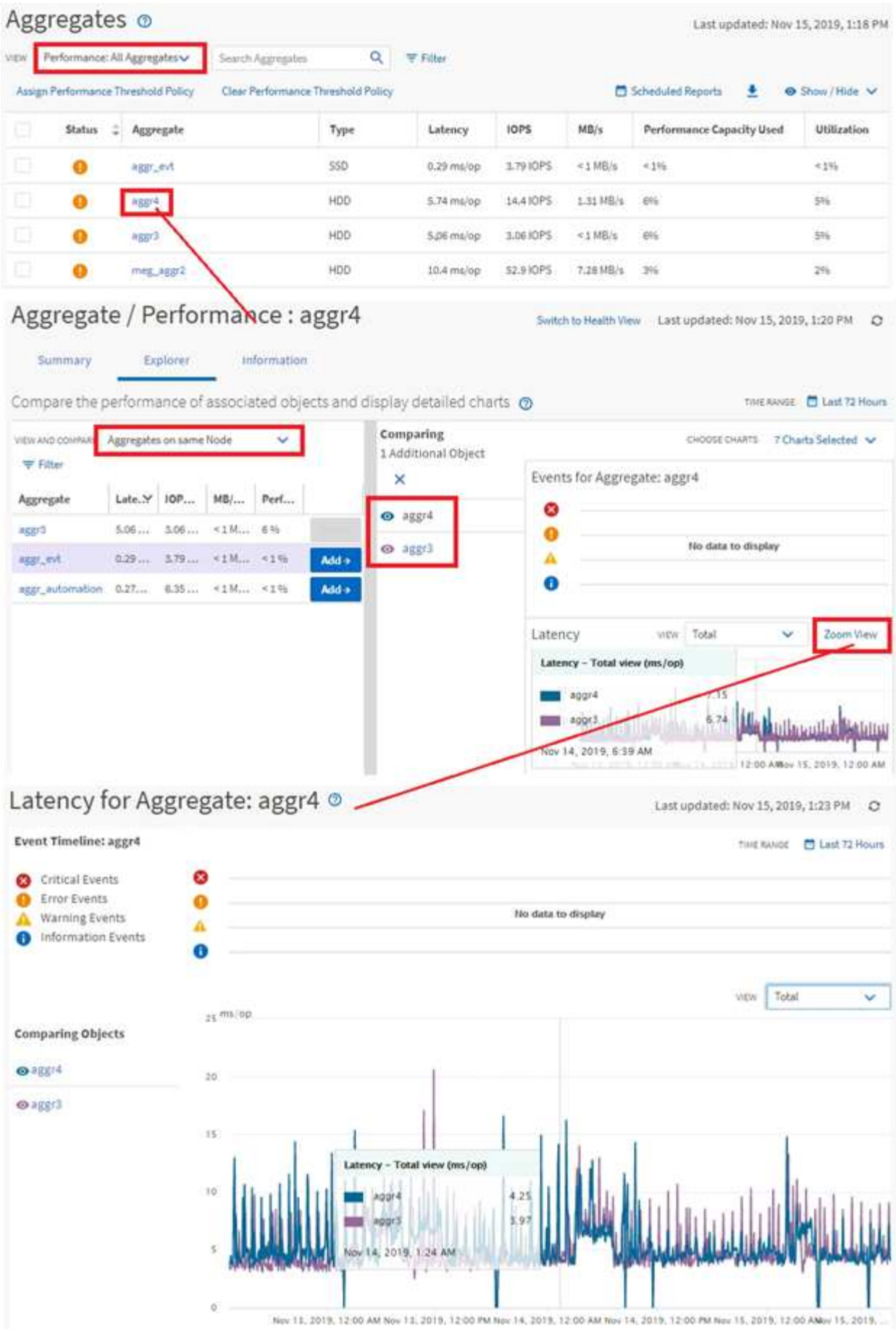
Monitor cluster performance navigation

You can 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 left navigation pane, click **Storage** > **Aggregates**.
2. To view information about the performance in those aggregates, select the Performance: All Aggregates view.
3. Identify the aggregate you want to investigate and click that aggregate name to navigate to the Aggregate / Performance 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.


Aggregates
Last updated: Nov 15, 2019, 1:18 PM
VIEW
Performance: All Aggregates
Search Aggregates
Filter
Assign Performance Threshold Policy
Clear Performance Threshold Policy
Scheduled Reports
Show / Hide
Status
Aggregate
Type
Latency
IOPS
MB/s
Performance Capacity Used
Utilization
aggr_evt
SSD
0.29 ms/op
3.79 IOPS
< 1 MB/s
< 1%
aggr4
HDD
5.74 ms/op
14.4 IOPS
1.31 MB/s
6%
5%
aggr3
HDD
5.06 ms/op
3.06 IOPS
< 1 MB/s
6%
5%
meg_aggr2
HDD
10.4 ms/op
52.9 IOPS
7.28 MB/s
3%
2%
Aggregate / Performance : aggr4
Switch to Health View
Last updated: Nov 15, 2019, 1:20 PM
Summary
Explorer
Information
Compare the performance of associated objects and display detailed charts
TIME RANGE
Last 72 Hours
VIEW AND COMPARE
Aggregates on same Node
Filter
Aggregate
Late...
IOP...
MB/...
Perf...
aggr3
5.06 ...
3.06 ...
< 1 M...
6 %
aggr_evt
0.29 ...
3.79 ...
< 1 M...
< 1 %
Add
aggr_automation
0.27...
6.35 ...
< 1 M...
< 1 %
Add
Comparing
1 Additional Object
aggr4
aggr3
CHOOSE CHARTS
7 Charts Selected
Events for Aggregate: aggr4
No data to display
Latency
VIEW
Total
Zoom View
Latency – Total view (ms/op)
aggr4
7.15
aggr3
6.74
Nov 14, 2019, 6:39 AM
12:00 AM
Nov 15, 2019, 12:00 AM
Latency for Aggregate: aggr4
Last updated: Nov 15, 2019, 1:23 PM
Event Timeline: aggr4
TIME RANGE
Last 72 Hours
Critical Events
Error Events
Warning Events
Information Events
No data to display
VIEW
Total
Comparing Objects
aggr4
aggr3
25
ms/op
20
15
10
5
0
Latency – Total view (ms/op)
aggr4
4.25
aggr3
3.97
Nov 14, 2019, 1:24 AM
Nov 13, 2019, 12:00 AM
Nov 13, 2019, 12:00 PM
Nov 14, 2019, 12:00 AM
Nov 14, 2019, 12:00 PM
Nov 15, 2019, 12:00 AM
Nov 15, 2019,

Event investigation navigation

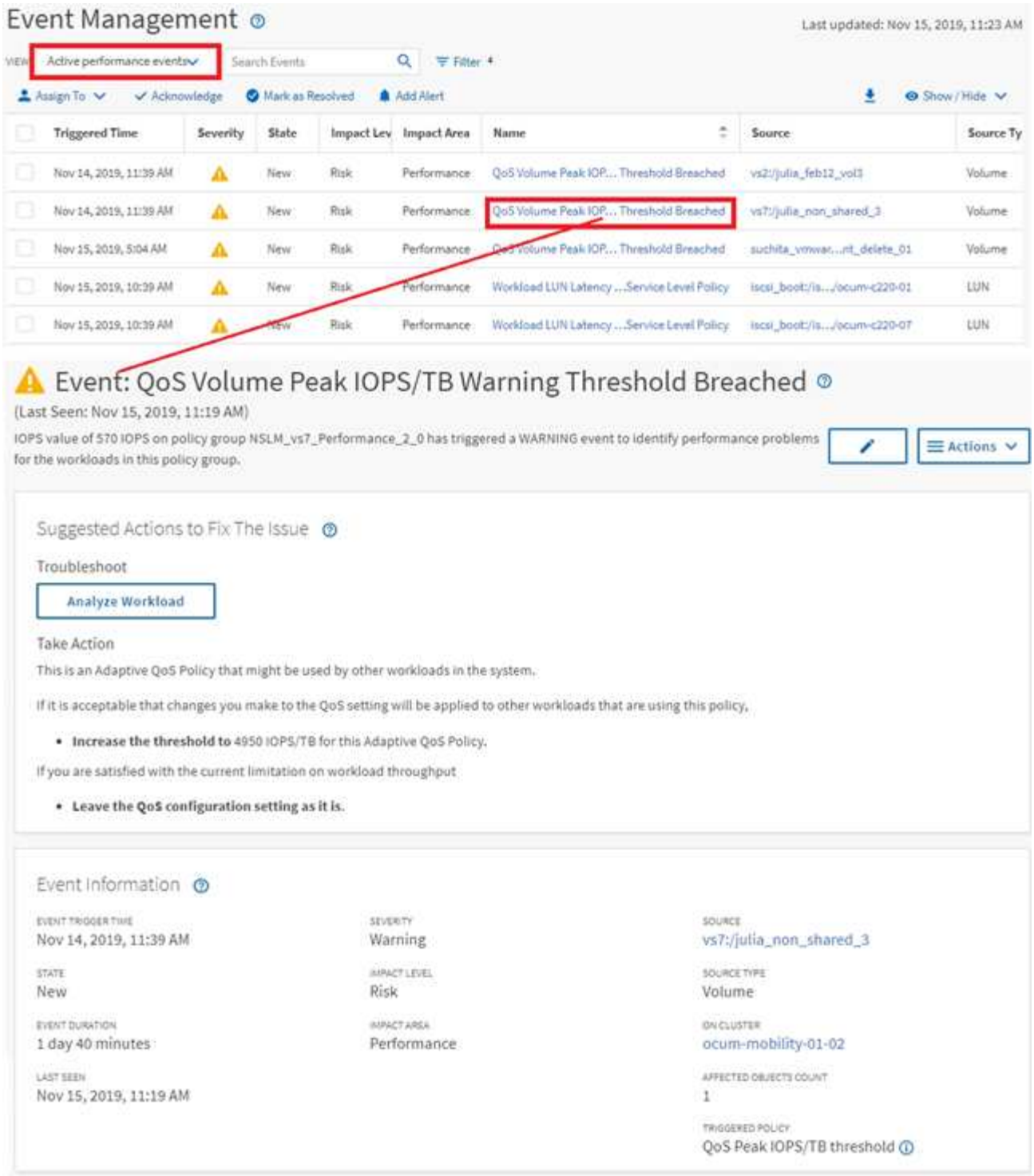
The Unified Manager event detail pages provide you with an in-depth look at any performance event. This is beneficial when investigating performance events, when troubleshooting, and when fine-tuning system performance.

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

- Event details page for user-defined and system-defined threshold policy events
- Event details page for dynamic threshold policy events

This is one example of an event investigation navigation.

1. In the left navigation pane, click **Event Management**.
2. From the View menu, click **Active performance events**.
3. Click the name of the event that you want to investigate and the Event details page is displayed.
4. View the Description of the event and review the Suggested Actions (where available) to view more details about the event that may help you resolve the issue. You can click the **Analyze Workload** button to display detailed performance charts to help further analyze the issue.



Search for storage objects

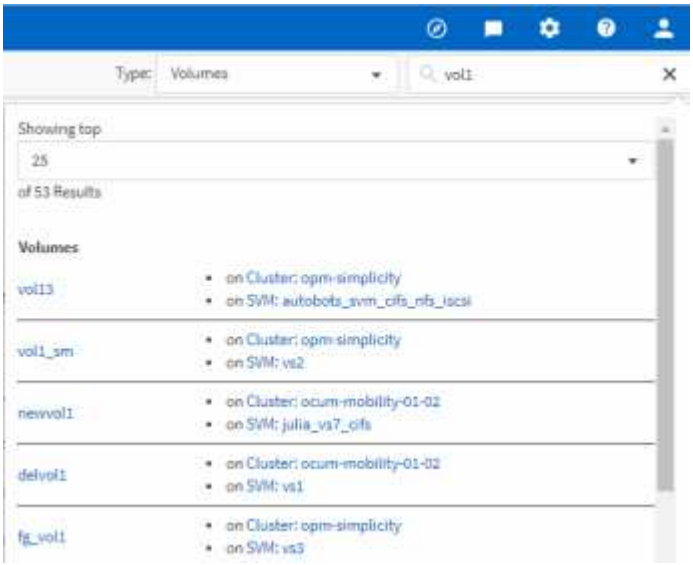
To quickly access a specific object, you can use the **Search all Storage Objects** field at the top of the menu bar. This method of global search across all objects enables you to quickly locate specific objects by type. Search results are sorted by storage object type and you can filter them using the 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 25 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 drop-down box and select **All** to simultaneously search across all objects and events. Alternatively, you can click the drop-down box to specify the object type. Type a minimum of three characters of the object or event name into the **Search all Storage Objects** field, and then press **Enter** to display the search results, such as:

- Clusters: cluster names
- Nodes: node names
- Aggregates: aggregate names
- SVMs: SVM names
- Volumes: volume names
- LUNs: LUN paths



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

In this example, the 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.

Filter inventory page content

You can filter inventory page 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 data in which you are interested.

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, the number of applied filters displays at the right of the Filter button.

Three types of filter parameters are supported.

Parameter	Validation
String (text)	The operators are **contains**, **starts with**, **ends with**, and **does not contain**.
Number	The operators are **greater than**, **less than**, **in the last**, and **between**.
Enum (text)	The operators are **is** and **is not**.

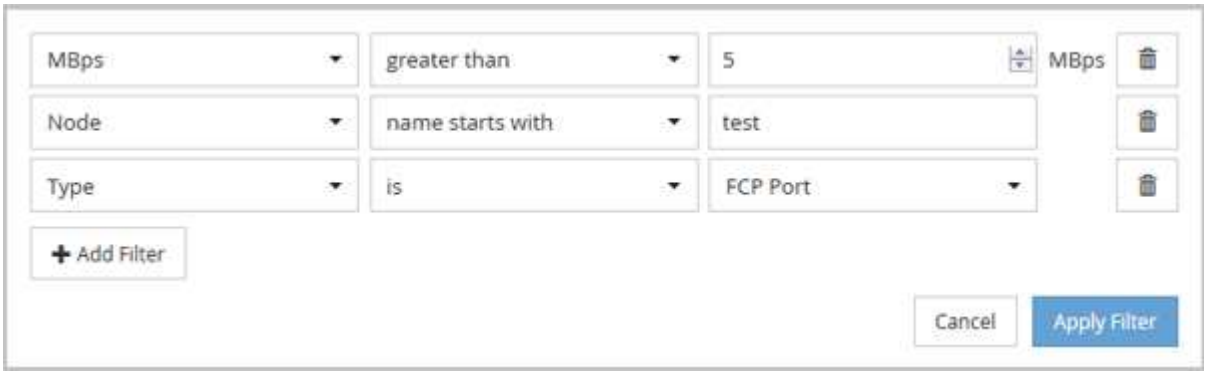
The Column, Operator, and Value fields are required for each filter; the available filters reflect the filterable columns on the current page. The maximum number of filters you can apply is four. Filtered results are based on combined filter parameters. Filtered results apply to all pages in your filtered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

You can add filters using the Filtering panel.

1. At the top of the page, click the **Filter** button. The Filtering panel displays.
2. Click the left drop-down list and select an object; for example, *Cluster*, or a performance counter.
3. Click the center drop-down list, and select the operator you want to use.
4. In the last list, select or enter a value to complete the filter for that object.
5. To add another filter, 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.
6. Click **Apply Filter**. The filter options are applied to the grid and the number of filters is displayed to the right of the Filter button.
7. Use the Filtering panel to remove individual filters by clicking the trash icon at the right of the filter to be removed.
8. 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.



After clicking **Apply Filter**, the Filtering panel closes, applies your filters, and shows the number of filters

applied ( ).

Monitor cluster performance from the Dashboard

The Unified Manager Dashboard provides a few panels that display 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.

Understand performance panels on the Dashboard

The Unified Manager Dashboard provides a few panels that display high-level performance status for all the clusters that are being monitored in your environment. You can choose to view status for all clusters or for an individual cluster.

In addition to showing performance information, most of the panels also display the number of active events in that category, and the number of new events added over the previous 24 hours. This information helps you decide which clusters you may need to analyze further to resolve reported events. Clicking on the events displays the top few events and provides a link to the Event Management inventory page filtered to show the events in that category.

The following panels provide performance status.

- **Performance Capacity panel**

  When viewing all clusters, this panel displays the performance capacity value for each cluster (averaged over the previous 1 hour) and the number of days until performance capacity reaches the upper limit (based on daily growth rate). Clicking the bar chart takes you to the Nodes inventory page for that cluster. Note that the Nodes inventory page displays the performance capacity averaged over the previous 72 hours, so this value may not match the Dashboard value.

  When viewing a single cluster, this panel displays the cluster performance capacity, total IOPS, and total throughput values.

- **Workload IOPS panel**

  When workload active management is enabled, and when viewing a single cluster, this panel displays the total number workloads that are currently running in a certain range of IOPS.

- **Workload Performance panel**

  When workload active management is enabled, this panel displays the total number of conforming and non-conforming workloads that are assigned to each defined Performance Service Level. Clicking a bar chart takes you to the workloads assigned to that policy in the Workloads page.

- **Usage Overview panel**

  When viewing all clusters, you can choose to view clusters sorted by highest IOPS or throughput (MB/s).

  When viewing a single cluster, you can choose to view workloads on that cluster sorted by highest IOPS or throughput (MB/s).

Performance banner messages and descriptions

Unified Manager may display banner messages on the Notifications page (from the Notification bell) to alert you to status issues for a particular cluster.

Banner message	Description	Resolution
`No performance data is being collected from cluster cluster_name. 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 cluster_name. 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.

Change 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.

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.

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 Setup 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.

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.

Troubleshoot workloads using the workload analyzer

The workload analyzer provides a way to view important health and performance criteria for a single workload on a single page to assist in troubleshooting. By viewing all current and past events for a workload you can get a better idea why the workload may be having a performance or capacity issue now.

Using this tool can also help you determine if storage is the cause of any performance issues for an application or if the issue is caused by a networking or other related issue.

You can initiate this functionality from a variety of places in the user interface:

- From the Workload Analysis selection on the left-navigation menu
- From the Event details page by clicking the **Analyze Workload** button
- From any workload inventory page (volume, LUN, workload, NFS share, or SMB/CIFS share), by clicking the more icon , then **Analyze Workload**
- From the Virtual Machines page by clicking the **Analyze Workload** button from any Datastore object

When you launch the tool from the left-navigation menu, you can enter the name of any workload that you want to analyze and select the time range for which you want to troubleshoot. When you launch the tool from any of the workload or virtual machine inventory pages, the name of the workload is filled in automatically, and the workload's data is presented with the default 2 hour time range. When you launch the tool from the Event details page, the name of the workload is filled in automatically, and the data of 10 days is displayed.

What data does the workload analyzer display

The workload analyzer page displays information about any current events that could be affecting the workload, recommendations to potentially fix the issue causing the event, and charts for analyzing performance and capacity history.

At the top of the page you specify the name of the workload (volume or LUN) that you want to analyze and the timeframe over which you want to see statistics. You can change the timeframe at any point if you want to view a shorter or longer period of time.

The other areas of the page display the analysis results and the performance and capacity charts.

Workload charts for LUNs do not provide the same level of statistics as those charts for volumes, so you will notice differences when analyzing these two types of workloads.

- **Events summary area**

  Displays a brief overview of the number and types of events that have occurred over the timeframe. When there are events from different impact areas (for example, performance and capacity), this information is displayed so you can select details for the type of event you are interested in. Click the event type to view a list of the event names.

  If there is only one event during the timeframe, then a list of recommendations to fix the issue is listed for some events.

- **Event Timeline**

  Shows all occurrences of events during the specified timeframe. Hover your cursor over each event to view the event name.

  If you arrived at this page by clicking the **Analyze Workload** button from the Event details page, the icon for the selected event appears larger so that you can identify the event.

- **Performance charts area**

  Displays charts for latency, throughput (both IOPS and MB/s), and utilization (for both the node and aggregate) based on the timeframe you selected. You can click the View performance details link to display the Performance Explorer page for the workload in case you want to perform further analysis.

  - **Latency** displays the latency for the workload over the selected timeframe. The chart has three views that enable you to see:
    - **Total** latency
    - **Breakdown** latency (broken out by reads, writes, and other processes)
    - **Cluster Components** latency (broken out by cluster component)

See Cluster components and why they can be in contention for a description of the cluster components that are displayed here. **Throughput displays both IOPS and MB/s throughput for the workload over the selected timeframe. The chart has four views that enable you to see:** * **Total** throughput *** Breakdown throughput (broken out by reads, writes, and other processes)** * **Cloud Throughput** (the MB/s being used to write data to and read data from the cloud; for those workloads that are tiering capacity to the cloud) *** IOPS with Forecast (a prediction of what the upper and lower IOPS throughput values were expected to be over the timeframe) This chart also displays Quality of Service (QoS) maximum and minimum throughput threshold settings, if configured, so you can see where the system may be limiting the throughput intentionally with QoS policies. Utilization** displays utilization for both the aggregate and node on which the workload is running over the selected timeframe. From here you can see if your aggregate or node are overutilized, possibly causing high latency. When analyzing FlexGroup volumes there are multiple nodes and multiple aggregates listed on the utilization charts.

- **Capacity chart area**

  Displays charts for data capacity and Snapshot capacity for the past one month for the workload.

  For volumes, you can click the View capacity details link to display the Health Details page for the workload in case you want to perform further analysis. LUNs do not provide this link because there is no Health Details page for LUNs.

- **Capacity View** displays the total available space allocated for the workload and the logical used space (after all NetApp optimizations).
- **Snapshot View** displays the total space reserved for Snapshot copies, and the amount of space currently being used. Note that LUNs do not provide a Snapshot View.
- **Cloud Tier View** displays how much capacity is being used in the local performance tier and how much is being used in the cloud tier. These charts include an estimate of the amount of time remaining before the capacity is full for this workload. This information is based on historical usage and requires a minimum of 10 days of data. When less than 30 days of capacity remain, Unified Manager identifies the storage as “almost full”.

When would I use the workload analyzer

You would typically use the workload analyzer to troubleshoot a latency issue reported by a user, to more thoroughly analyze a reported event or alert, or to explore a workload that you see is operating abnormally.

In the case where users have contacted you to say that the application they are using is running very slowly, you can check the latency, throughput, and utilization charts for the workload over which the application is running to see if storage is the cause of the performance issue. You can use the capacity chart as well to see if capacity is low because an ONTAP system in which capacity is over 85% used can cause performance issues. These charts will help you determine if the issue is caused by storage or by a networking or other related issue.

In the case where Unified Manager has generated a performance event and you want to review the cause of the issue more thoroughly, you can launch the workload analyzer from the Event details page by clicking the **Analyze Workload** button to research some of the latency, throughput, and capacity trends for the workload.

In the case where you notice a workload that appears to be operating abnormally when viewing any workload inventory page (volume, LUN, workload, NFS share, or SMB/CIFS share), you can click the more icon ⋮, then **Analyze Workload** to open the Workload Analysis page to examine the workload further.

Use the workload analyzer

There are many ways to start the workload analyzer from the user interface. Here we describe launching the tool from the left-navigation pane.

Steps

1. In the left navigation pane, click **Workload Analysis**.

   The Workload Analysis page is displayed.

2. If you know the workload name, enter the name. If you are not sure of the full name, enter a minimum of 3 characters and the system displays a list of workloads that match the string.
3. Select the time range if you want to view statistics for longer than the default 2 hours and click **Apply**.
4. View the Summary area to see the events that have occurred during the timeframe.
5. View the performance and capacity charts to see when any of the metrics are abnormal and see if any events align with the abnormal entry.

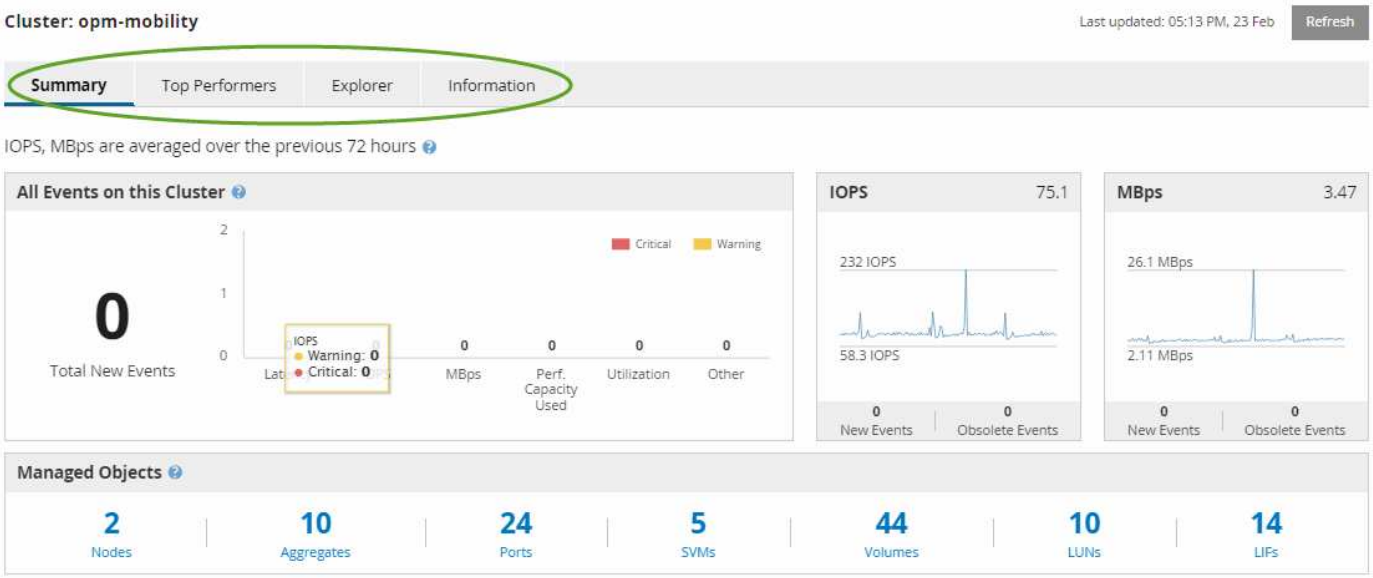
Monitor cluster performance from the Performance Cluster Landing page

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.

Understand 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.

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.

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

- Summary page
  - Cluster Events pane
  - MB/s and IOPS performance charts
  - Managed Objects pane
- Top Performers page
- Explorer page
- Information page

Performance Cluster Summary page

The Performance Cluster Summary page provides a summary of the active events, IOPS performance, and MB/s 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 active 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 active cluster performance events for the preceding 72 hours. The Total Active Events is displayed at the far left; this number represents the total of all New and Acknowledged events for all storage objects in this cluster. You can click the Total Active Events link to navigate to the Events Inventory page, which is filtered to display these events.

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

- Latency (total for nodes, aggregates, SVMs, volumes, LUNs, and namespaces)
- IOPS (total for clusters, nodes, aggregates, SVMs, volumes, LUNs, and namespaces)
- MB/s (total for clusters, nodes, aggregates, SVMs, volumes, LUNs, namespaces, 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 active 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 Active 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.

- **MB/s counter panel**

  MB/s 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 MB/s health for the preceding 72-hour period. You can position your cursor over the graph trend line to view the MB/s 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 active (new and acknowledged) events and obsolete events from the last 72-hour period.

The counter panels contain two types of events:

- **Active**

  Indicates that the performance event is currently active (new or acknowledged). 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 **Active 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 Events 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.

- **Storage VMs**

  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.

- **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.

- **Network Interfaces**

  A logical network interface representing a network access point to a node. The count includes all interface 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 Storage VMs category, you can display the SVMs that have the highest IOPS, or the highest latency, or the lowest MB/s. This page also shows if any of the top performers have any active performance events (New or Acknowledged).

The Top Performers page displays a maximum of 10 of each object. Note that the Volume object includes both FlexVol volumes and FlexGroup 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
- Last 72 Hours (default)
- Last 7 Days

- **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 **MB/s**. Changing the counter reloads the panel data with the top performers based on the selected counter.

  Available counters:

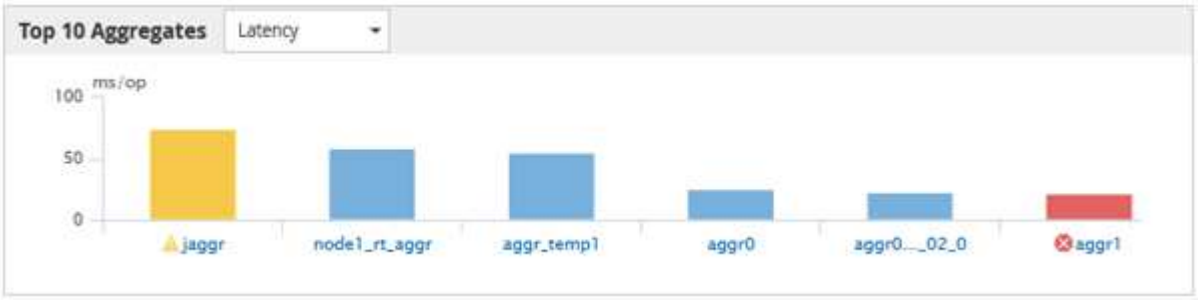
  - Latency
  - IOPS
  - MB/s
  - Performance Capacity Used (for nodes and aggregates)
  - Utilization (for nodes and aggregates)

- **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 or acknowledged 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 active critical ( ) or warning ( ) events in the top performers graphs. Click the **Severity Event** indicator icon to view:

  - **One event**

Navigates to the Event details page for that event.

- **Two or more events**

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

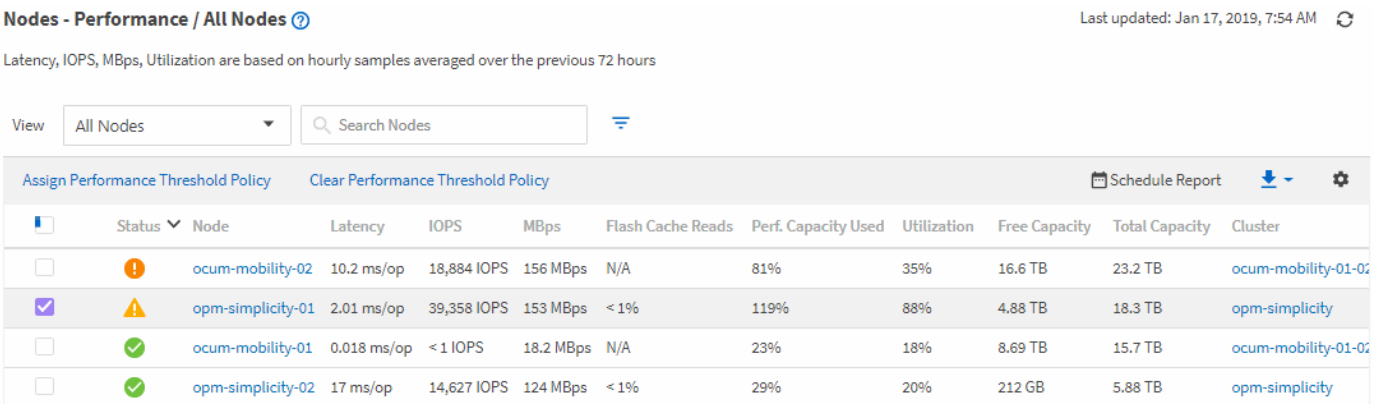
- **Export button**

  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.

Monitor 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.



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/All 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.

View Performance inventory pages for all storage objects

You use the Performance inventory pages to see a summary of performance information about each of the available storage objects, such as clusters, aggregates, volumes, and

so on. You can link to the Performance object detail pages to view detailed information for a particular object.

By default, objects in the view pages are sorted based on event criticality. Objects with critical events are listed first, and objects with warning events are listed second. This provides an immediate visual indication of issues that must be addressed.

You can export data from these pages to a comma-separated values (`.csv`) file, Microsoft Excel file (`.xlsx`), or (`.pdf`) document by using the **Reports** button, and then use the exported data to build reports. Additionally, you can customize the page and then schedule a report to be created and emailed on a regular basis by using the **Scheduled Reports** button.

All the fields on these pages can be used in custom views and in reports. Some of the fields are linked to related pages enabling a more detailed view.

Performance: All Clusters view

The Performance: All Clusters view displays an overview of the performance events, data, and configuration information for each cluster that is monitored by an instance of Unified Manager. This page enables you to monitor the performance of your clusters, and to troubleshoot performance issues and threshold events.

You can assign performance threshold policies to, or clear threshold policies from, any object on the object inventory pages using the **Assign Performance Threshold Policy** and **Clear Performance Threshold Policy** buttons.

The following are some important fields in the Performance: All Clusters view.

- Cluster FQDN: The fully qualified domain name (FQDN) of the cluster.
- IOPS: The input/output operations per second on the cluster.
- MB/s: The throughput on the cluster, measured in MiB per second.
- Capacity fields: Free and total capacity in GiB.
- Host Name or IP Address: The host name or IP address (IPv4 or IPv6) of the cluster management LIF.
- OS Version: The version of ONTAP software that is installed on the cluster.

  If different versions of ONTAP software are installed on the nodes in the cluster, the lowest version number is listed. You can view the ONTAP version that is installed on each node from the Performance: All Nodes view.

- Threshold Policy: The user-defined performance threshold policy, or policies, that are active on this storage object. You can position your cursor over policy names containing an ellipsis (…) to view the full policy name or the list of assigned policy names. The Assign Performance Threshold Policy and Clear Performance Threshold Policy buttons remain disabled until you select one or more objects by clicking the check boxes located at the far left.

Performance: All Volumes view

The Performance: All Volumes view displays an overview of the performance events, counter data, and configuration information for each FlexVol volume and FlexGroup volume that is being monitored by an instance of Unified Manager. This enables you to quickly monitor the performance of your volumes, and to troubleshoot performance issues and threshold events.

If you want to analyze the latency and throughput of a specific object, click the more options button ⋮ then

Analyze Workload and you can view performance and capacity charts on the Workload Analysis page. You can view the details on System Manager, given you have valid credentials for System Manager.

> For data protection (DP) volumes, only counter values for user-generated traffic are displayed. Root volumes are not displayed on this page.

The following are some important fields in the Performance: All Volumes view.

- Style: Either FlexVol or FlexGroup.
- Latency: For FlexVol volumes, this is the average response time of the volume for all I/O requests, expressed in milliseconds per operation. For FlexGroup volumes, this is the average latency of all constituent volumes.
- IOPS/TB: The number of input/output operations processed per second based on the total space that is being consumed by the workload, in terabytes. This counter measures how much performance can be delivered by a given amount of storage capacity.
- IOPS: For FlexVol volumes, this is the number of input/output operations per second for the volume. For FlexGroup volumes, this is the sum of IOPS for all constituent volumes.
- MB/s: For FlexVol volumes, this is the throughput on the volume, measured in megabytes per second. For FlexGroup volumes, this is the sum of MB/s for all constituent volumes.
- Capacity fields: Free and total capacity in GiB.

See the following links for more information:

- Assigning performance threshold policies to storage objects
- Removing performance threshold policies from storage objects
- Types of workloads monitored by Unified Manager
- Viewing the QoS policy group settings applied to specific volumes or LUNs
- Understanding the Unified Manager recommendations to tier data to the cloud
- Viewing performance charts to compare volumes or LUNs that are in the same QoS policy group

Performance: All Aggregates view

The Performance: All Aggregates view displays an overview of the performance events, data, and configuration information for each aggregate that is monitored by an instance of Unified Manager. This page enables you to monitor the performance of your aggregates, and to troubleshoot performance issues and threshold events.

The following are some important fields in the Performance: All Aggregates view.

- Type: The type of aggregate:
  - HDD
  - Hybrid. Combines HDDs and SSDs, but Flash Pool has not been enabled.
  - Hybrid (Flash Pool). Combines HDDs and SSDs, and Flash Pool has been enabled.
  - SSD
  - SSD (FabricPool). Combines SSDs and a cloud tier
  - HDD (FabricPool). Combines HDDs and a cloud tier

    - VMDisk (SDS). Virtual disks within a virtual machine
    - VMDisk (FabricPool). Combines virtual disks and a cloud tier
    - LUN (FlexArray)
- Inactive Data Reporting: Whether the inactive data reporting capability is enabled or disabled on this aggregate. When enabled, volumes on this aggregate display the amount of cold data in the Performance: All Volumes view. The value in this field is "N/A" when the version of ONTAP does not support inactive data reporting.
- Threshold Policy: The user-defined performance threshold policy, or policies, that are active on this storage object. You can position your cursor over policy names containing an ellipsis (…) to view the full policy name or the list of assigned policy names. The Assign Performance Threshold Policy and Clear Performance Threshold Policy buttons remain disabled until you select one or more objects by clicking the check boxes located at the far left. See the following links for more information:
- Assigning performance threshold policies to storage objects
- Removing performance threshold policies from storage objects

Performance: All Nodes view

The Performance: All Nodes view displays an overview of the performance events, data, and configuration information for each node that is being monitored by an instance of Unified Manager. This enables you to quickly monitor the performance of your nodes, and to troubleshoot performance issues and threshold events.

Flash Cache Reads returns the percentage of read operations on the node that are satisfied by cache, instead of being returned from the disk. Flash Cache data is displayed only for nodes, and only when a Flash Cache module is installed in the node.

In the **Reports** menu, the **Hardware Inventory Report** option is provided when Unified Manager, and the clusters it is managing, are installed in a site with no external network connectivity. This button generates a .csv file that contains a complete list of cluster and node information; such as hardware model numbers and serial numbers, disk types and counts, installed licenses, and more. This reporting functionality is helpful for contract renewal within secure sites that are not connected to the NetApp Active IQ platform. You can assign performance threshold policies to, or clear threshold policies from, any object on the object inventory pages using the **Assign Performance Threshold Policy** and **Clear Performance Threshold Policy** buttons.

See the following links for more information:

- Assigning performance threshold policies to storage objects
- Removing performance threshold policies from storage objects
- Generating a hardware inventory report for contract renewal

Performance: All Storage VMs view

The Performance: All Storage VMs view displays an overview of the performance events, data, and configuration information for each storage virtual machine (SVM) that is being monitored by an instance of Unified Manager. This enables you to quickly monitor the performance of your SVMs, and to troubleshoot performance issues and threshold events. The Latency field on this page reports the average response time for all I/O requests, expressed in milliseconds per operation.

The SVMs that are listed on this page include only Data and Cluster SVMs. Unified Manager does not use or display Admin or Node SVMs.

See the following links for more information:

- Assigning performance threshold policies to storage objects
- Removing performance threshold policies from storage objects

Performance: All LUNs view

The Performance: All LUNs view displays an overview of the performance events, data, and configuration information for each LUN that is being monitored by an instance of Unified Manager. This enables you to quickly monitor the performance of your LUNs, and to troubleshoot performance issues and threshold events.

If you want to analyze the latency and throughput of a specific object, click the more icon ⋮, then **Analyze Workload** and you can view performance and capacity charts on the **Workload Analysis** page.

See the following links for more information:

- Monitoring LUNs in a Consistency Group relationship
- Provisioning LUNs
- Assigning performance threshold policies to storage objects
- Removing performance threshold policies from storage objects
- Viewing volumes or LUNs that are in the same QoS policy group.
- Viewing the QoS policy group settings applied to specific volumes or LUNs
- Provisioning LUNs by using APIs

Performance: All NVMe Namespaces view

The Performance: All NVMe Namespaces view displays an overview of the performance events, data, and configuration information for each NVMe Namespace that is being monitored by an instance of Unified Manager. This enables you to quickly monitor the performance and health of your Namespaces, and to troubleshoot issues and threshold events.

The following information, among others is reported: The current state of the Namespace. * Offline - Read or write access to the Namespace is not allowed. * Online - Read and write access to the Namespace is allowed. * NVFail - The Namespace was automatically taken offline due to an NVRAM failure. * Space Error - The Namespace has run out of space.

See the following links for more information:

- Assigning performance threshold policies to storage objects
- Removing performance threshold policies from storage objects

Performance: All Network Interfaces view

The Performance: All Network Interfaces view displays an overview of the performance events, data, and configuration information for each network interface (LIF) that is being monitored by this instance of Unified Manager. This page enables you to quickly monitor the performance of your interfaces, and to troubleshoot performance issues and threshold events. The following are some important fields in the Performance: All Network Interfaces view.

- IOPS: The input/output operations per second. IOPS is not applicable to NFS LIFs and CIFS LIFs, and is displayed as N/A for these types.

- Latency: The average response time for all I/O requests, expressed in milliseconds per operation. Latency is not applicable to NFS LIFs and CIFS LIFs, and is displayed as N/A for these types.
- Home Location: The home location for the interface, displayed as node name and port name, separated by a colon (:). If the location is displayed with an ellipsis (…), you can position your cursor over the location name to view the full location.
- Current Location: The current location for the interface, displayed as node name and port name, separated by a colon (:). If the location is displayed with an ellipsis (…), you can position your cursor over the location name to view the full location.
- Role: The interface role: Data, Cluster, Node Management, or Intercluster.

The interfaces that are listed on this page include Data LIFs, Cluster LIFs, Node Management LIFs, and intercluster LIFs. Unified Manager does not use or display System LIFs.

Performance: All Ports view

The Performance: All Ports view displays an overview of the performance events, data, and configuration information for each port that is being monitored by an instance of Unified Manager. This enables you to quickly monitor the performance of your ports, and to troubleshoot performance issues and threshold events. For a port role, the network port function is displayed, either Data or Cluster. FCP ports cannot have a role, and the role is displayed as N/A.

Performance counter values are displayed for physical ports only. Counter values are not displayed for VLANs or interface groups.

See the following links for more information:

- Assigning performance threshold policies to storage objects
- Removing performance threshold policies from storage objects

Performance: QoS Policy Groups view

The QoS Policy Groups view displays the QoS policy groups available on the clusters that Unified Manager is monitoring. This includes traditional QoS policies, adaptive QoS policies, and QoS policies assigned by using Performance Service Levels.

The following are some important fields in the Performance: QoS Policy Groups view.

- QoS Policy Group: The name of the QoS policy group. For NetApp Service Level Manager (NSLM) 1.3 policies that have been imported into Unified Manager 9.7 or greater, the name displayed here includes the SVM name and other information that is not in the name when the Performance Service Levelwas defined in NSLM. For example, the name "NSLM_vs6_Performance_2_0" means this is the NSLM system-defined "Performance" PSL policy created on SVM "vs6" with an expected latency of "2 ms/op".
- SVM: The storage VM (SVM) to which the QoS policy group belongs. You can click the storage VM name to navigate to that storage VM's details page. Note that this field is blank if the QoS policy has been created on the Admin storage VM as this storage VM type represents the cluster.
- Min Throughput: The minimum throughput, in IOPS, that the policy group will be guaranteed to provide. For adaptive policies this is the minimum expected IOPS per TB allocated to the volume or LUN, based on the storage object allocated size.
- Max Throughput: The throughput, in IOPS and/or MB/s, that the policy group must not exceed. When this field is blank it means the max throughout defined in ONTAP is infinite. For adaptive policies this is the

maximum (peak) possible IOPS per TB allocated to the volume or LUN, based on either the storage object allocated size or the storage object used size.

- Absolute Minimum IOPS: For adaptive policies this is the absolute minimum IOPS value that is used as an override when the expected IOPS is less than this value.
- Block Size: The block size specified for the QoS adaptive policy.
- Min Allocation: Whether "allocated space" or "used space" is used to determine the maximum throughput (peak) IOPS.
- Expected Latency: The expected average latency for storage input/output operations.
- Shared: For traditional QoS policies, whether the throughput values defined in the policy group are shared among multiple objects.
- Associated Objects: The number of workloads that are assigned to the QoS policy group. You can click the expand button ( ) next to the QoS Policy Group Name to view more details about the policy group.
- Allocated Capacity: The amount of space that the objects that are in the QoS policy group are currently using.
- Associated Objects: The number of workloads that are assigned to the QoS policy group, separated into volumes and LUNs. You can click the number to navigate to a page that provides more details about the selected volumes or LUNs.

For more information see the topics under Managing performance using QoS policy group information.

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.

Search 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

1. 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.

To locate this…	Type this…
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.

Sort 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.

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

1. 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.

Filter 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.

You can use the Filtering panel 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, the number of applied filters displays at the right of the Filter button.

Three types of filter parameters are supported.

Parameter	Validation
String (text)	The operators are **contains**, **starts with**, **ends with**, and **does not contain**.
Number	The operators are **greater than**, **less than**, **in the last**, and **between**.
Enum (text)	The operators are **is** and **is not**.

The Column, Operator, and Value 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

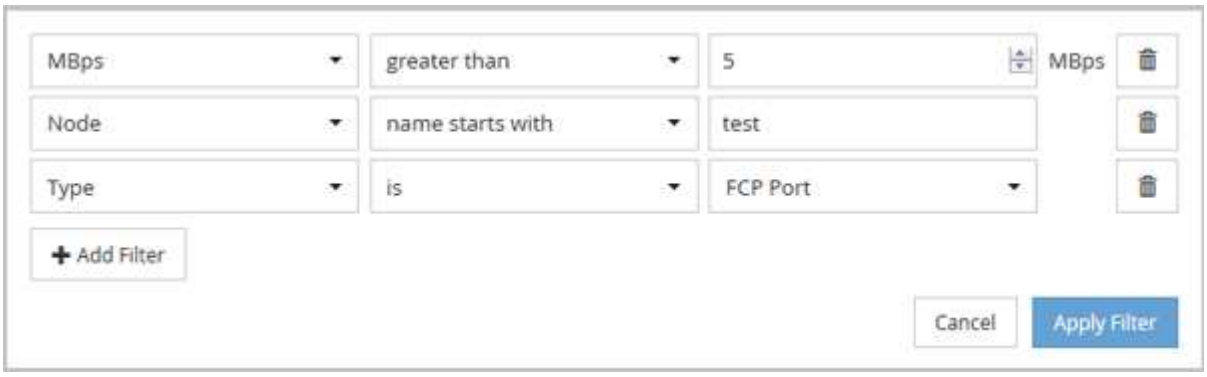
on combined filter parameters. Filtered results apply to all pages in your filtered search, not just the page currently displayed.

You can add filters using the Filtering panel.

1. At the top of the page, click the **Filter** button. The Filtering panel displays.
2. Click the left drop-down list and select an object; for example, *Cluster*, or a performance counter.
3. Click the center drop-down list, and select the operator you want to use.
4. In the last list, select or enter a value to complete the filter for that object.
5. To add another filter, 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.
6. Click **Apply Filter**. The filter options are applied to the grid and the number of filters is displayed to the right of the Filter button.
7. Use the Filtering panel to remove individual filters by clicking the trash icon at the right of the filter to be removed.
8. 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.



After clicking **Apply Filter**, the Filtering panel closes, applies your filters, and shows the number of filters applied (3).

Understand the Unified Manager recommendations to tier data to the cloud

The Performance: All Volumes view displays information related to the size of the user data stored on the volume that is inactive (cold). In some cases, Unified Manager identifies certain volumes that would benefit by tiering the inactive data to the cloud tier (cloud provider or StorageGRID) of a FabricPool-enabled aggregate.

FabricPool was introduced in ONTAP 9.2, so if you are using a version of ONTAP software prior to 9.2, the Unified Manager recommendation to tier data requires upgrading your ONTAP software. Additionally, the **`auto`** tiering policy was introduced in ONTAP 9.4, and the **`all`** tiering policy was introduced in ONTAP 9.6, so if the recommendation is to use the auto tiering policy, you must upgrade to ONTAP 9.4 or greater.

The following three fields on Performance: All Volumes view provide information about whether you can improve your storage system's disk utilization and save space on the performance tier by moving inactive data to the cloud tier.

- **Tiering Policy**

  The tiering policy determines whether the data on the volume remains on the performance tier or whether some of the data is moved from the performance tier to the cloud tier.

  The value in this field indicates the tiering policy set on the volume, even if the volume does not currently reside on a FabricPool aggregate. The tiering policy takes effect only when the volume is on a FabricPool aggregate.

- **Cold Data**

  The cold data displays the size of the user data stored on the volume that is inactive (cold).

  A value is displayed here only when using ONTAP 9.4 or greater software because it requires that the aggregate on which the volume is deployed has the **`inactive data reporting parameter`** set to **`enabled`**, and that the minimum number of cooling days threshold has been met (for volumes that use the **`snapshot-only`** or **`auto`** tiering policy). Otherwise the value is listed as "N/A".

- **Cloud Recommendation**

  After enough information has been captured about the data activity on the volume, Unified Manager may determine there is no action required, or that you could save space on the performance tier by tiering inactive data to the cloud tier.

The Cold Data field is updated every 15 minutes, but the Cloud Recommendation field is updated every 7 days when the cold data analysis is performed on the volume. Therefore, the exact amount of cold data may differ between the fields. The Cloud Recommendation field displays the date when the analysis was run.

When Inactive Data Reporting is enabled, the Cold Data field displays the exact amount of inactive data. Without the inactive data reporting capability Unified Manager uses performance statistics to determine if data is inactive on a volume. The amount of inactive data is not displayed in the Cold Data field in this case, but it is displayed when you hover your cursor over the word **Tier** to view the cloud recommendation.

The cloud recommendations you will see are:

- **Learning**. Not enough data has been collected to make a recommendation.
- **Tier**. Analysis has determined that the volume contains inactive (cold) data and that you should configure the volume to move that data to the cloud tier. In some cases this may require that you move the volume to a FabricPool-enabled aggregate first. In other cases where the volume is already on a FabricPool aggregate, you just have to change the tiering policy.
- **No Action**. Either the volume has very little inactive data, the volume is already set to the "auto" tiering

policy on a FabricPool aggregate, or the volume is a data protection volume. This value is also displayed when the volume is offline or when it is being used in a MetroCluster configuration.

To move a volume, or to change the volume tiering policy or the aggregate inactive data reporting settings, use ONTAP System Manager, the ONTAP CLI commands, or a combination of these tools.

If you are logged in to Unified Manager with the Application Administrator or Storage Administrator role, the **Configure Volume** link is available in the cloud recommendation when you hover your cursor over the word **Tier**. Click this button to open the Volumes page in System Manager to make the recommended change.

Monitor 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.

Understand 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.

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.

Specify 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.

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.

Select 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**.

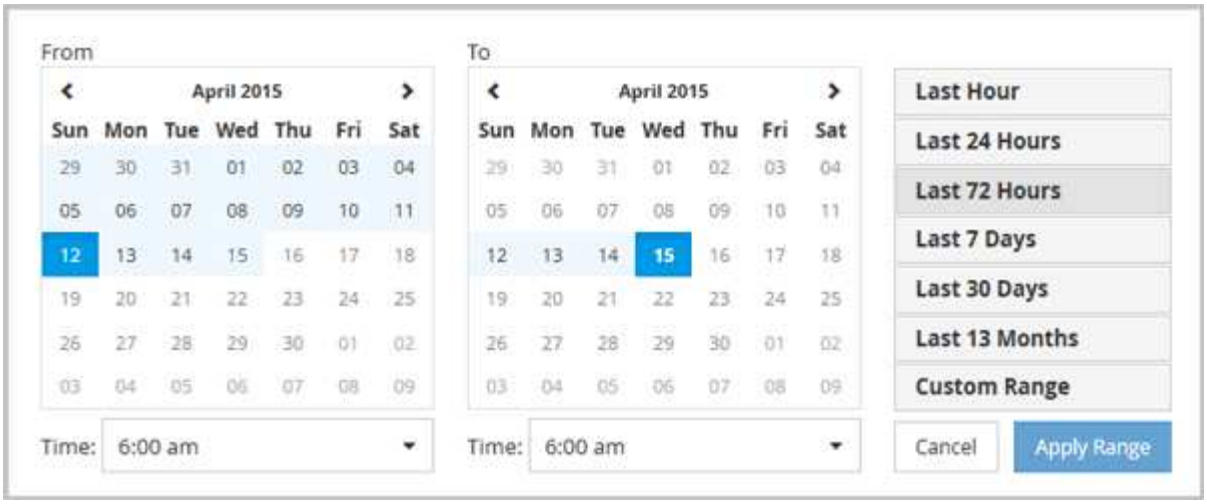
Specify a custom time range

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.

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.



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.

Define 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.

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.

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	Hover over the selected object's name in the Comparing pane to show the remove object button (**X**), and then click the button. The object is removed from the Comparing pane, and its data is cleared from the counter charts.
Remove all selected objects	Click the remove all object's button (**X**) at the top of the Comparing pane. All selected objects and their data are removed, leaving only the root object.

Understand 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.

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.

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 critical, error, warning, and information events in correlation with the statistical charts for the root object. Health events display in addition to performance events to provide a complete picture of the reasons performance may be affected.
Latency - Total	Number of milliseconds required to respond to application requests. Note that the average latency values are I/O weighted.

Available charts	Chart description
Latency - Breakdown	The same information shown in Latency Total, but with the performance data separated into read, write, and other latency. This chart option applies only when the selected object is an SVM, node, aggregate, volume, LUN, or namespace.
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. When displayed for a node, selecting “Total” displays the IOPS for data moving through this node that may reside on the local or the remote node, and selecting “Total (Local)” displays the IOPS for data that resides only on the current node.
IOPS - Breakdown	The same information shown in IOPS Total, but with the performance data separated into read, write, and other IOPS. This chart option applies only when the selected object is an SVM, node, aggregate, volume, LUN, or namespace. When displayed in Zoom view, the volumes chart displays QoS minimum and maximum throughput values, if configured in ONTAP. When displayed for a node, selecting “Breakdown” displays the IOPS breakdown for data moving through this node that may reside on the local or the remote node, and selecting “Breakdown (Local)” displays the IOPS breakdown for data that resides only on the current node.
IOPS - Protocols	The same information shown in IOPS Total, but the performance data is separated into individual charts for CIFS, NFS, FCP, NVMe, and iSCSI protocol traffic. This chart option applies only when the selected object is an SVM.

Available charts	Chart description
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.
MB/s - Total	Number of megabytes of data transferred to and from the object per second.
MB/s - Breakdown	The same information shown in the MB/s chart, but with the throughput 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, LUN, or namespace. 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.
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.

Available charts	Chart description
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.

Select 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.

Expand the Counter Charts pane

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

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

1. 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

Change 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.

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.

View event details in the Events Timeline

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

The Events Timeline pane shows critical, error, warning, and informational events that occurred on the root object during the selected time range. Each event severity has its own timeline. Single and multiple events are represented by an event dot on the timeline. You can position your cursor over an event dot 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.

Each performance event dot on the Events Timeline lines up vertically with a corresponding spike in the counter charts trend lines that are displayed below the Events Timeline. This provides a direct visual correlation between events and overall performance. Health events are displayed on the timeline as well, but these types of events do not necessarily line up with a spike in one of the performance charts.

Steps

1. On the **Events Timeline** pane, position the cursor over an event dot 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.
View details for multiple events	**View Event Details** in the pop-up dialog. Clicking a single event on the multiple events dialog displays the appropriate Event Details page.

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.

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.

Display 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.

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.

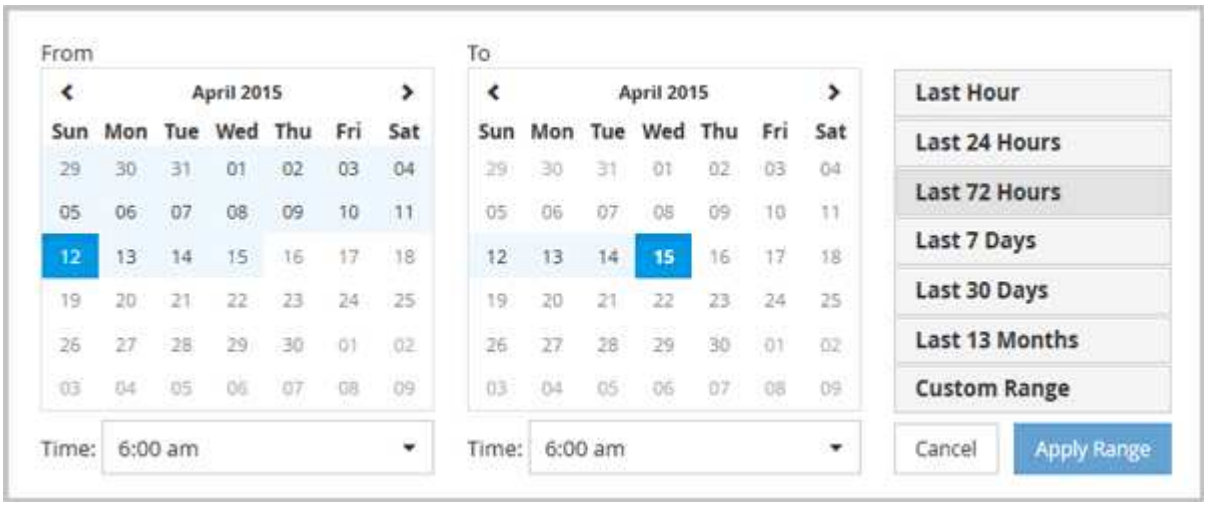
Specify the time range in Zoom View

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.

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.



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.

Select 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.

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

1. 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.

View volume latency by cluster component

You can view detailed latency information for a volume by using the Volume Performance 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.

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 Limit Max
- QoS Limit Min
- Network Processing
- Cluster Interconnect
- Data Processing
- Aggregate Operations
- Volume Activation
- MetroCluster Resources
- Cloud Latency

- Sync SnapMirror

Steps

1. In the **Volume Performance 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.

View 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.

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
- NVMe-FC

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.

View volume and LUN latency charts to verify performance guarantee

You can view the volumes and LUNs that you have subscribed to the “Performance Guarantee” program to verify that latency has not exceeded the level you have been guaranteed.

The latency performance guarantee is a millisecond per operation value that should not be exceeded. It is

based on an hourly average, not on the default five minute performance collection period.

Steps

1. In the **Performance: All Volumes** view or **Performance: All LUNs** view, select the volume or LUN that you are interested in.
2. In the **Performance Explorer** page for your selected volume or LUN, choose **Hourly Average** from the **View statistics in** selector.

   The horizontal line in the Latency chart will show a smoother line as the five-minute collections are replaced with the hourly average.

3. If you have other volumes on the same aggregate that are under the performance guarantee, you can add those volumes to view their latency value in the same chart.

View the performance for All SAN Array clusters

You can use the Performance: All Clusters view to display the performance status of your All SAN Array clusters.

Before you begin

You must have the Operator, Application Administrator, or Storage Administrator role.

You can view overview information for All SAN Array clusters in the Performance: All Clusters view, and details in the Cluster / Performance Explorer page.

Steps

1. In the left navigation pane, click **Storage** > **Clusters**.
2. Make sure that the “Personality” column is displayed in the **Health: All Clusters** view, or add it using the **Show / Hide** control.

   This column displays “All SAN Array” for your All SAN Array clusters.

3. To view information about the performance in those clusters, select the **Performance: All Clusters** view.

   View the performance information for the All SAN Array cluster.

4. To view detailed information about performance in those clusters, click the name of an All SAN Array cluster.
5. Click the **Explorer** tab.
6. On the **Cluster / Performance Explorer** page, select **Nodes on this Cluster** from the **View and Compare** menu.

   You can compare the performance statistics of both nodes on this cluster to make sure the load is almost identical on both nodes. If there are large discrepancies between the two nodes you can add the second node to the charts and compare the values over a longer timeframe to identify any configuration issues.

View node IOPS based on workloads that reside only on the local node

The node IOPS counter chart can highlight where operations are only passing through the local node using a network LIF to perform read/write operations on volumes on a remote node. The IOPS - “Total (Local)” and “Breakdown (Local)” charts display the IOPS

for data that resides in local volumes only on the current node.

The “Local” versions of these counter charts are similar to the node charts for Performance Capacity and Utilization because they also show only the statistics for data that resides on local volumes.

By comparing the “Local” versions of these counter charts to the regular Total versions of these counter charts you can see if there is a lot of traffic moving through the local node to access volumes on the remote node. This situation could cause performance issues, possibly indicated by high utilization on the node, if there are too many operations passing through the local node to reach a volume on a remote node. In these cases you may want to move a volume to the local node, or to create a LIF on the remote node where traffic from hosts accessing that volume can be connected.

Steps

1. In the **Performance/Node Explorer** page for your selected node, from the IOPS chart, select **Total** from the drop-down menu.

   The IOPS - Total chart is displayed.

2. Click **Zoom View** to display a larger version of the chart in a new browser tab.
3. Back in the **Performance/Node Explorer** page, from the IOPS chart, select **Total (Local)** from the drop-down menu.

   The IOPS - Total (Local) chart is displayed.

4. Click **Zoom View** to display a larger version of the chart in a new browser tab.
5. View both of the charts next to each other and identify areas where the IOPS values appear to be quite different.
6. Move your cursor over these areas to compare the local and total IOPS for a specific point in time.

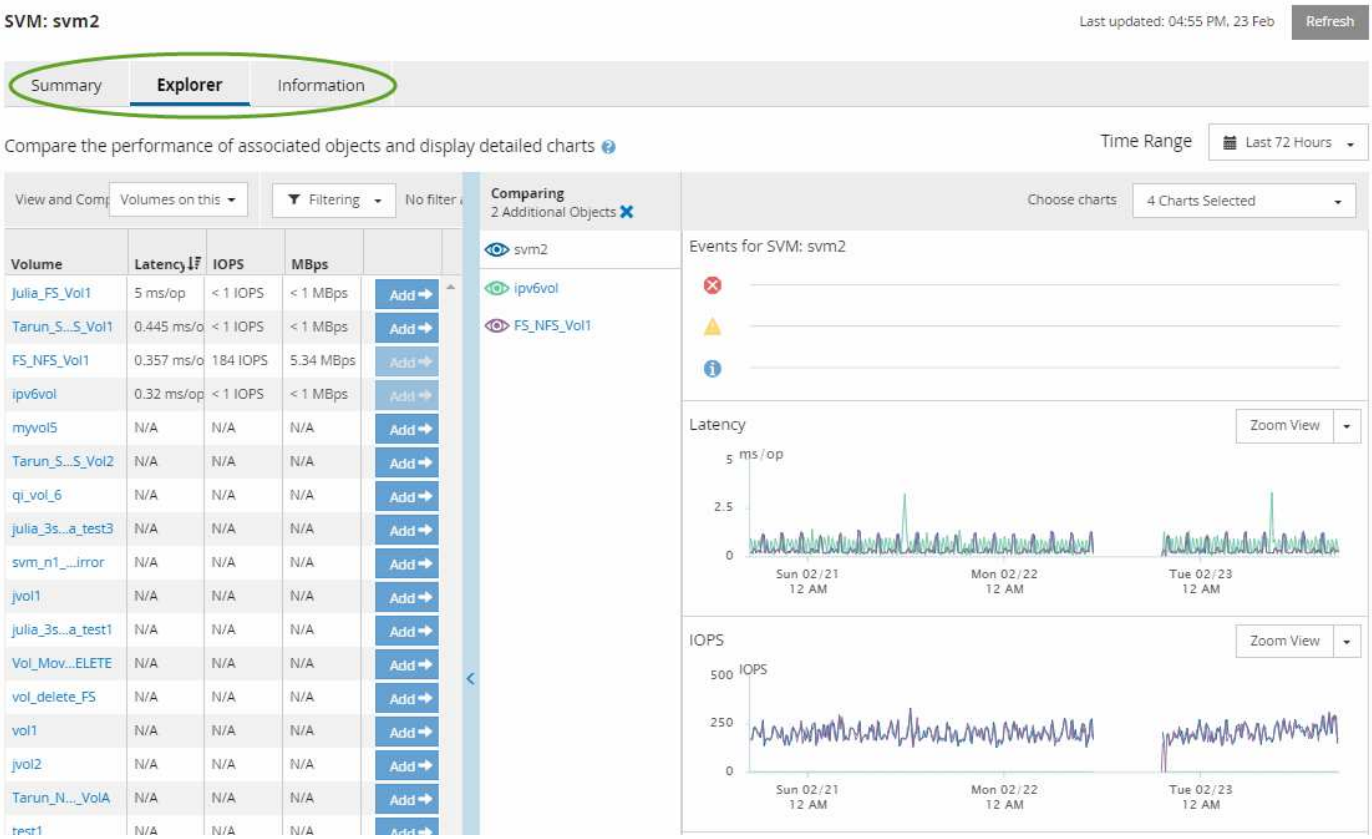
Components of the Object Landing pages

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.

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.

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 active 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.

- **MB/s**

  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.

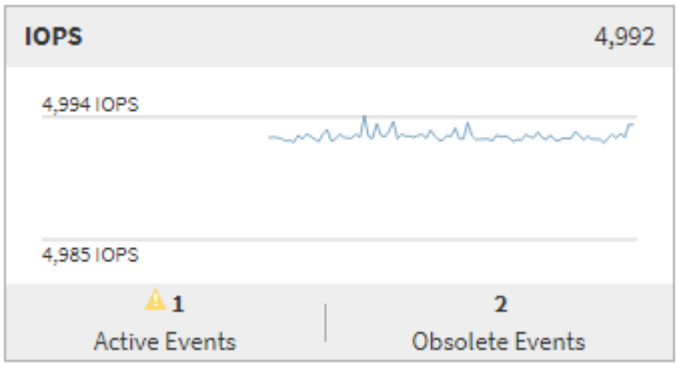
- **Utilization**

  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 Active events shows the type and number of events. Critical events are displayed in red (), and warning events are displayed in yellow ().

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 active (new and acknowledged) events 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 **Active Events** link below the graph to navigate to the Events 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 **Active Events** link below the graph to navigate to the Events Inventory page to view complete event details.

- **MB/s counter chart**

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

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

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

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

Events

The events history table, where applicable, lists the most recent events that occurred on that object. Clicking the event name displays details of the event on the Event Details page.

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 **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.

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.

- **View Statistics In**

  For volume and LUNs, enables you to select whether the statistics are displayed after each collection cycle (default 5 minutes), or whether the statistics are shown as an hourly average. This functionality enables you to view the latency chart in support of the NetApp "Performance Guarantee" program.

- **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.

- **Events Timeline**

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

Manage performance using QoS policy group information

Unified Manager enables you to view the quality of service (QoS) policy groups that are available on all the clusters you are monitoring. The policies may have been defined using ONTAP software (System Manager or the ONTAP CLI) or by Unified Manager Performance Service Level policies. Unified Manager also displays which volumes and LUNs have a QoS policy group assigned.

For more information on adjusting QoS settings, see Performance management overview

How storage QoS can control workload throughput

You can create a Quality of Service (QoS) policy group to control the I/O per second (IOPS) or throughput (MB/s) limit for the workloads it contains. If the workloads are in a policy group with no set limit, such as the default policy group, or the set limit does not meet your needs, you can increase the limit or move the workloads to a new or existing policy group that has the desired limit.

“Traditional” QoS policy groups can be assigned to individual workloads; for example, a single volume or LUN. In this case the workload can use the full throughput limit. QoS policy groups also can be assigned to multiple workloads; in which case the throughput limit is “shared” among the workloads. For example, a QoS limit of 9,000 IOPS assigned to three workloads would restrict the combined IOPS from exceeding 9,000 IOPS.

“Adaptive” QoS policy groups can also be assigned to individual workloads or multiple workloads. However, even when assigned to multiple workloads, each workload gets the full throughput limit instead of sharing the throughput value with other workloads. Additionally, adaptive QoS policies automatically adjust the throughput setting based on the volume size, per workload, thereby maintaining the ratio of IOPS to terabytes as the size of the volume changes. For example, if the peak is set to 5,000 IOPS/TB in an adaptive QoS policy, a 10 TB volume will have a throughput maximum of 50,000 IOPS. If the volume is resized later to 20 TB, adaptive QoS adjusts the maximum to 100,000 IOPS.

Starting with ONTAP 9.5 you can include the block size when defining an adaptive QoS policy. This effectively converts the policy from an IOPS/TB threshold to a MB/s threshold for cases when workloads are using very large block sizes and ultimately using a large percentage of throughput.

For shared group QoS policies, when the IOPS or MB/s of all workloads in a policy group exceeds the set limit, the policy group throttles the workloads to restrict their activity, which can decrease the performance of all workloads in the policy group. If a dynamic performance event is generated by policy group throttling, the event description displays the name of the policy group involved.

In the Performance: All Volumes view, you can sort the affected volumes by IOPS and MB/s to see which workloads have the highest usage that might have contributed to the event. In the Performance/Volumes Explorer page, you can select other volumes, or LUNs on the volume, to compare to the affected workload IOPS or MBps throughput usage.

By assigning the workloads that are overusing the node resources to a more restrictive policy group setting, the policy group throttles the workloads to restrict their activity, which can reduce the use of the resources on that node. However, if you want the workload to be able to use more of the node resources, you can increase the value of the policy group.

You can use System Manager, the ONTAP commands, or Unified Manager Performance Service Levels to manage policy groups, including the following tasks:

- Creating a policy group
- 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 and/or node

View all QoS policy groups available on all clusters

You can display a list of all the QoS policy groups available on the clusters that Unified Manager is monitoring. This includes traditional QoS policies, adaptive QoS policies, and QoS policies managed by Unified Manager Performance Service Level policies.

Steps

1. In the left navigation pane, click **Storage** > **QoS Policy Groups**.

   The Performance: Traditional QoS Policy Groups view is displayed by default.

2. View the detailed configuration settings for each available traditional QoS policy group.
3. Click the expand button ( ) next to the QoS Policy Group name to view more details about the policy group.
4. In the View menu, select one of the additional options to view all the adaptive QoS policy groups or to view all the QoS policy groups that were created using Unified Manager Performance Service Levels.

View volumes or LUNs that are in the same QoS policy group

You can display a list of the volumes and LUNs that have been assigned to the same QoS policy group.

In the case of traditional QoS policy groups that are “shared” among multiple volumes, this can be helpful to see if certain volumes are overusing the throughput defined for the policy group. It can also help you decide if you can add other volumes to the policy group without a negative affect to the other volumes.

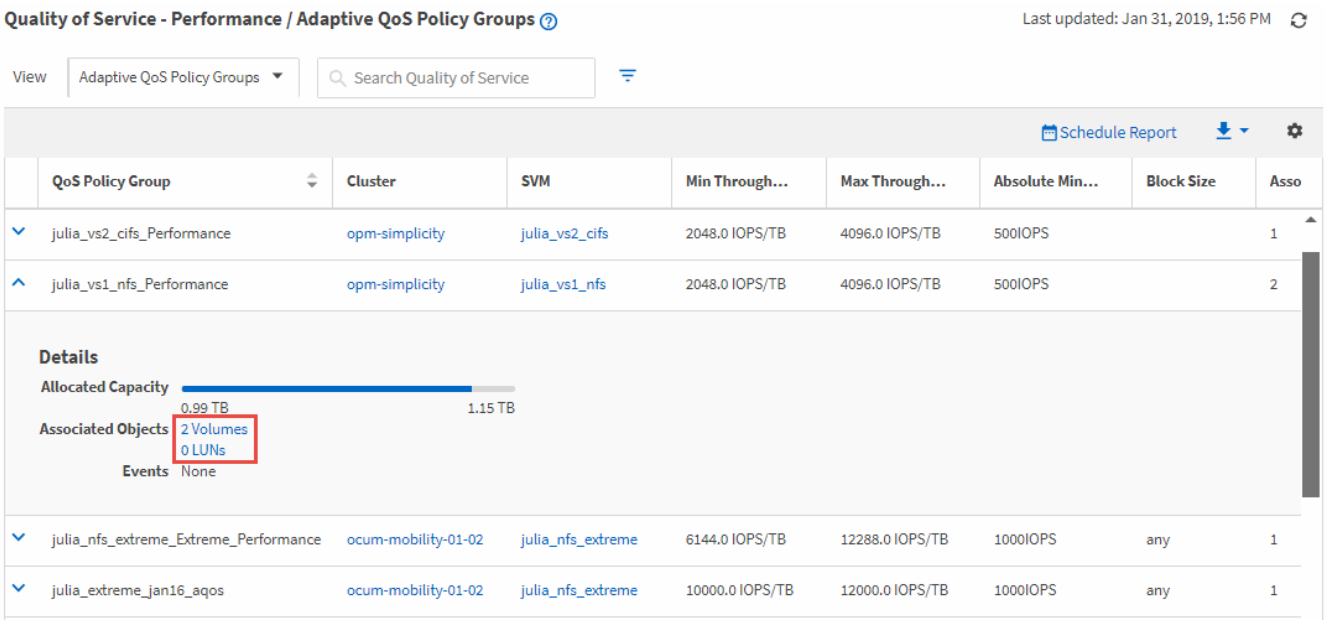
In the case of adaptive QoS policies and Unified Manager Performance Service Levels policies, this can be helpful to view all the volumes or LUNs that are using a policy group so that you can see which objects would be affected if you changed the configuration settings for the QoS policy.

Steps

1. In the left navigation pane, click **Storage** > **QoS Policy Groups**.

   The Performance: Traditional QoS Policy Groups view is displayed by default.

2. If you are interested in traditional policy group, stay on this page. Otherwise, select one of the additional View options to display all the adaptive QoS policy groups or all the QoS policy groups that were created by Unified Manager Performance Service Levels.
3. In the QoS policy that you are interested in, click the expand button ( ) next to the QoS Policy Group name to view more
   details.



4. Click the Volumes or the LUNs link to view the objects using this QoS policy.

   The Performance inventory page for Volumes or LUNs is displayed with the sorted list of objects that are using the QoS policy.

View the QoS policy group settings applied to specific volumes or LUNs

You can view the QoS policy groups that have been applied to your volumes and LUNs, and you can link to the Performance/QoS Policy Groups view to display the detailed configuration settings for each QoS policy.

The steps to view the QoS policy that is applied to a volume are shown below. The steps to view this information for a LUN are similar.

Steps

1. In the left navigation pane, click **Storage** > **Volumes**.

   The Health: All Volumes view is displayed by default.

2. In the View menu, select **Performance: Volumes in QoS Policy Group**.
3. Locate the volume that you want to review and scroll to the right until you see the **QoS Policy Group** column.
4. Click the QoS Policy Group name.

   The corresponding Quality of Service page is displayed depending on whether it is a traditional QoS policy, an adaptive QoS policy, or a QoS policy that was created using Unified Manager Performance Service Levels.

5. View the detailed configuration settings for the QoS policy group.
6. Click the expand button ( ) next to the QoS Policy Group name to view more details about the policy group.

View performance charts to compare volumes or LUNs that are in the same QoS policy group

You can view the volumes and LUNs that are in the same QoS policy groups and then compare the performance on a single IOPS, MB/s, or IOPS/TB chart to identify any issues.

The steps to compare the performance of volumes in the same QoS policy group are shown below. The steps to view this information for a LUN are similar.

Steps

1. In the left navigation pane, click **Storage** > **Volumes**.

   The Health: All Volumes view is displayed by default.

2. In the View menu, select **Performance: Volumes in QoS Policy Group**.
3. Click the name of the volume that you want to review.

   The Performance Explorer page is displayed for the volume.

4. In the View and Compare menu, select **Volumes in same QoS Policy Group**.

   The other volumes that share the same QoS policy are listed in the table below.

5. Click the **Add** button to add those volumes to the charts so that you can compare the IOPS, MB/s, IOPS/TB, and other performance counters for all the selected volumes in the charts.

   You can change the time range to view the performance over different time intervals other than the default of 72 hours.

How different types of QoS policies are displayed in the throughput charts

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 and Workload Analysis IOPS, IOPS/TB, and MB/s charts. The information displayed in the charts is different depending on the type of QoS policy that has been applied to the workload.

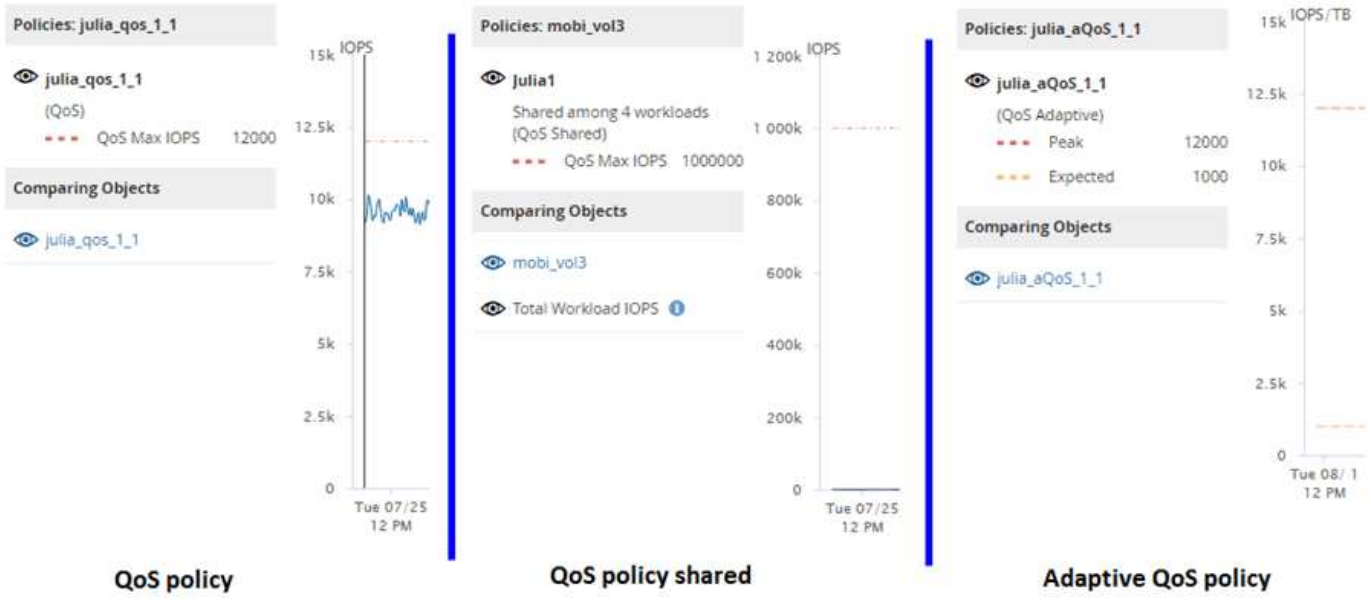
A throughput maximum (or “peak”) setting defines the maximum throughput that the workload can consume, and thereby limits the impact on competing workloads for system resources. A throughput minimum (or “expected”) setting defines the minimum throughput that must be available to the workload so that a critical workload meets minimum throughput targets regardless of demand by competing workloads.

Shared and non-shared QoS policies for IOPS and MB/s 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 shared policy assigned to a single workload, or QoS non-shared policy assigned to a single workload or multiple workloads	Each workload can consume the specified throughput setting	Displays “(QoS)”
QoS shared policy assigned to multiple workloads	All workloads share the specified throughput setting	Displays “(QoS Shared)”
Adaptive QoS policy assigned to a single workload or multiple workloads	Each workload can consume the specified 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, ONTAP converts the IOPS value to an IOPS/TB value and Unified Manager 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, ONTAP converts the IOPS/TB value to an IOPS value and Unified Manager displays that policy in the IOPS chart along with the text “QoS Adaptive - Used, defined in IOPS/TB” or “QoS Adaptive - Allocated, defined in IOPS/TB” depending on how the peak IOPS allocation setting is configured. When the allocation setting is set to “allocated-space”, the peak IOPS is calculated based on the size of the volume. When the allocation setting is set to “used-space”, the peak IOPS is calculated based on the amount of data stored in the volume, taking into account storage efficiencies.

The IOPS/TB chart displays performance data only when the logical capacity used by the volume is greater than or equal to 128 GB. Gaps are displayed in the chart when the used capacity falls below 128 GB during the selected timeframe.

View workload QoS minimum and maximum settings in the Performance Explorer

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.

QoS throughput “minimum” and “maximum” IOPS and MB/s 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 MB/s ceiling (the QoS max)	In the MB/s Total or Breakdown chart, click **Zoom View**.
View the IOPS floor (the QoS min)	In the IOPS Total or Breakdown chart, click **Zoom View**.
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.

2. To view the specific IOPS and MB/s values compared to the QoS setting, move your cursor into the chart area to see the popup window.

If you notice that certain volumes or LUNs have very high IOPS or MB/s 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 Performance management overview

Manage 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.

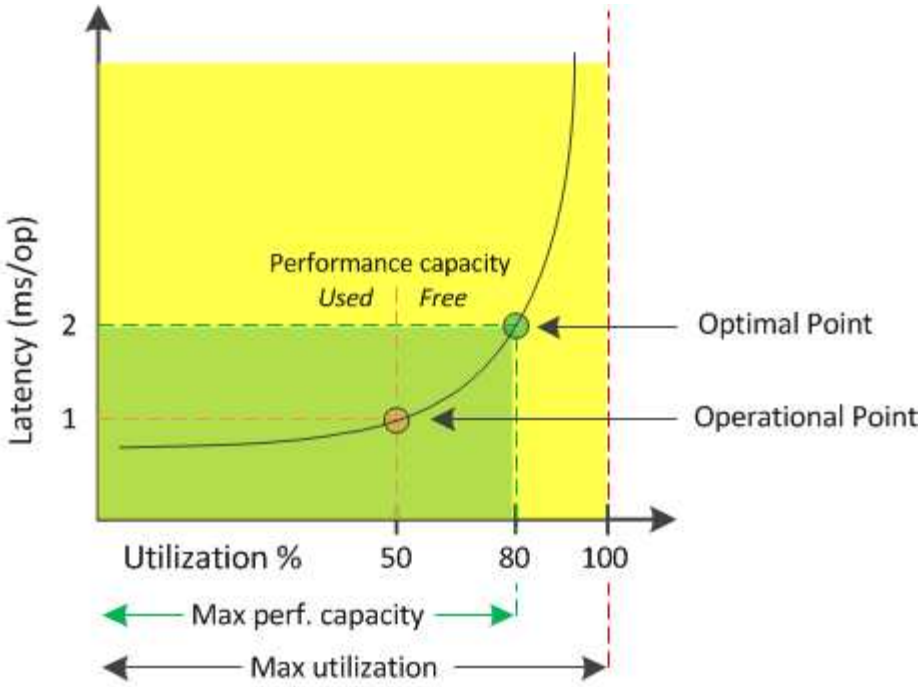
Monitor the performance capacity information has the following benefits:

- 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.

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.



In this example, 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. In this example, 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.

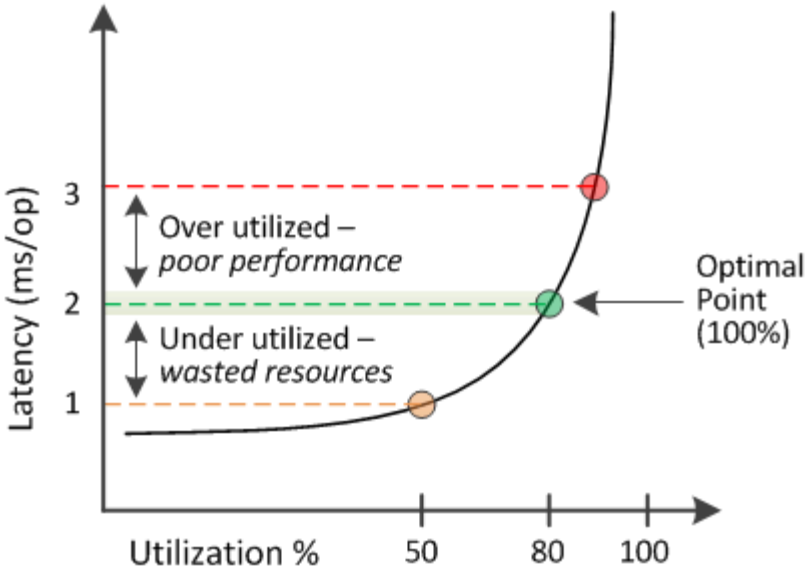
The performance capacity used counter is expected to be a larger number than the “utilization” counter because performance capacity adds in the impact on latency. For example, if a node or aggregate is 70% used, the performance capacity value may be in the 80% to 100% range, depending on the latency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

In some cases, however, the utilization counter may be higher on the Dashboard 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.

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.

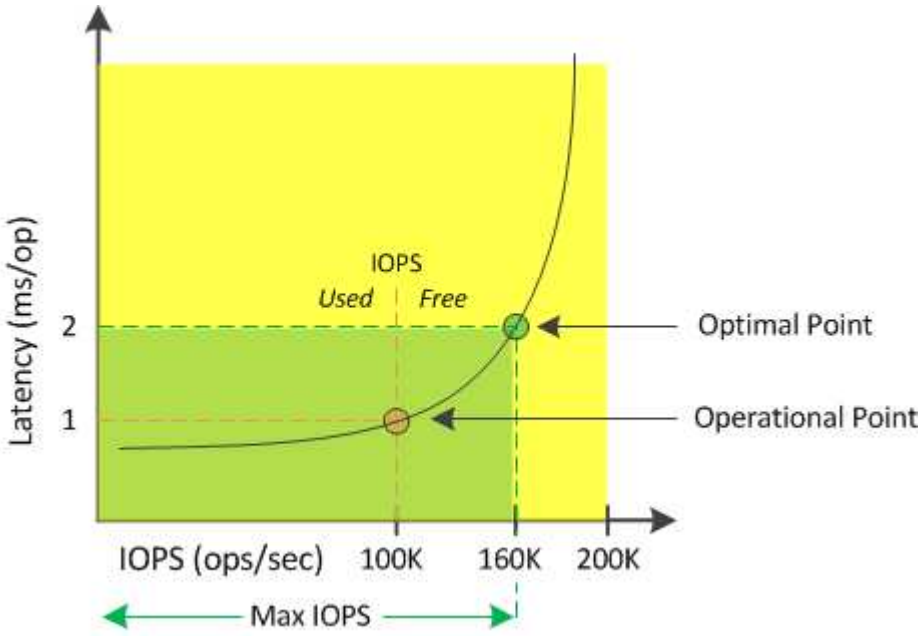
The total IOPS that a node can provide is based on the physical characteristics of the node—for example, the number of CPUs, the CPU speed, and the amount of RAM. The total IOPS that an aggregate can provide is based on the physical properties of the disks—for example, a SATA, SAS, or SSD disk.

The total IOPS of all the volumes in an aggregate might not match the total IOPS of the aggregate. This is discussed in the following knowledge base article: KB Why does the sum of all volume IOPs in an aggregate not match the aggregate IOPs?

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.

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.

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.

View 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 Dashboard, Performance Inventory pages, Top Performers page, Create Threshold Policy page, Performance Explorer pages, and in detail charts. For example, the Performance: All Aggregates page provides a column Performance Capacity Used to view the performance capacity used value for all aggregates.

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

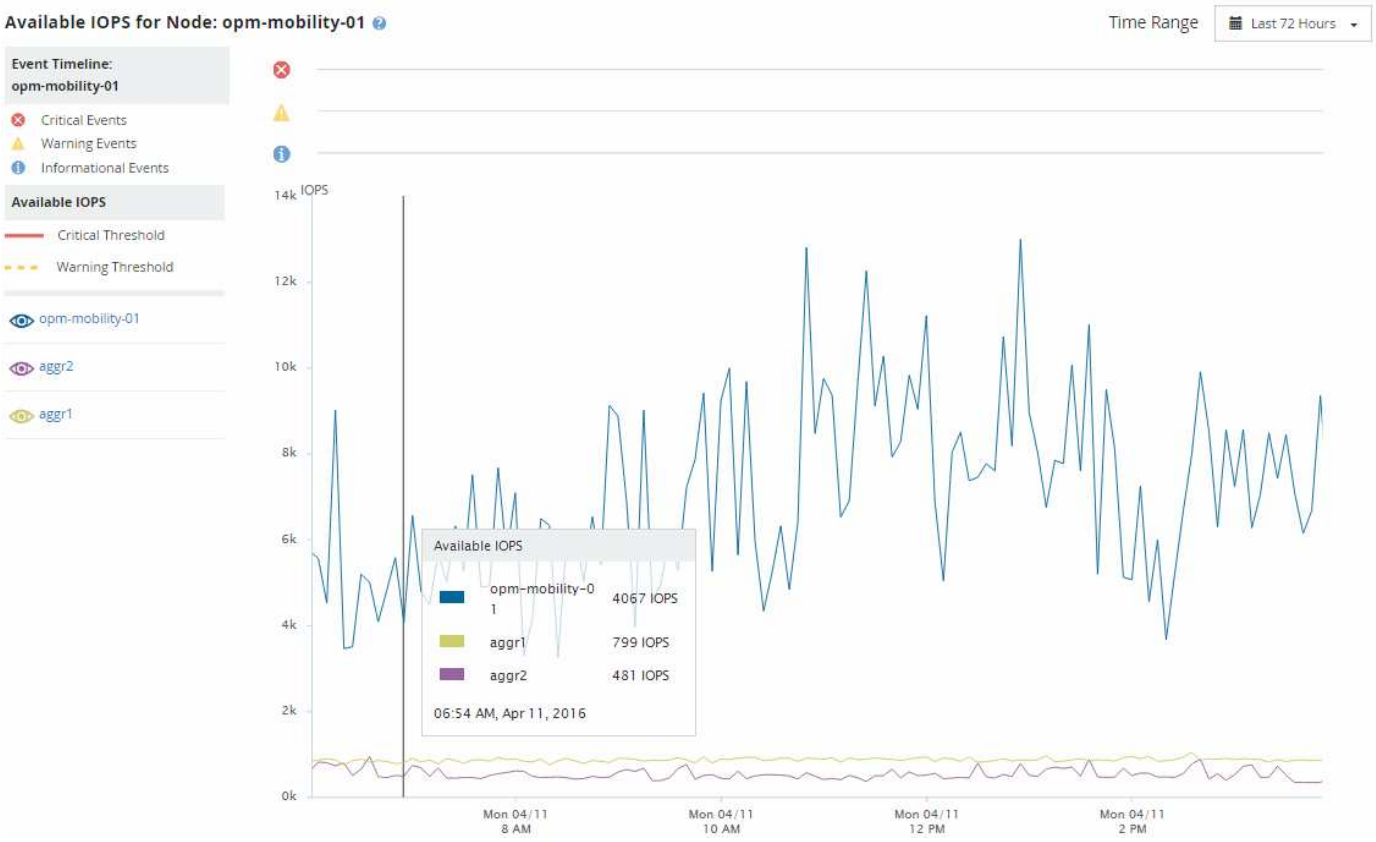
- Whether any nodes or aggregates on any clusters have a high performance capacity used value
- Whether any nodes or aggregates on any clusters have active performance capacity used events

- 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

View 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 Inventory pages and in the Performance Explorer page charts for nodes and aggregates. For example, when viewing a node in the Node/Performance Explorer page, you can select the “Available IOPS” counter chart from the list so you can compare the available IOPS values for the node and multiple aggregates on that node.



Monitor 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.

View 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.

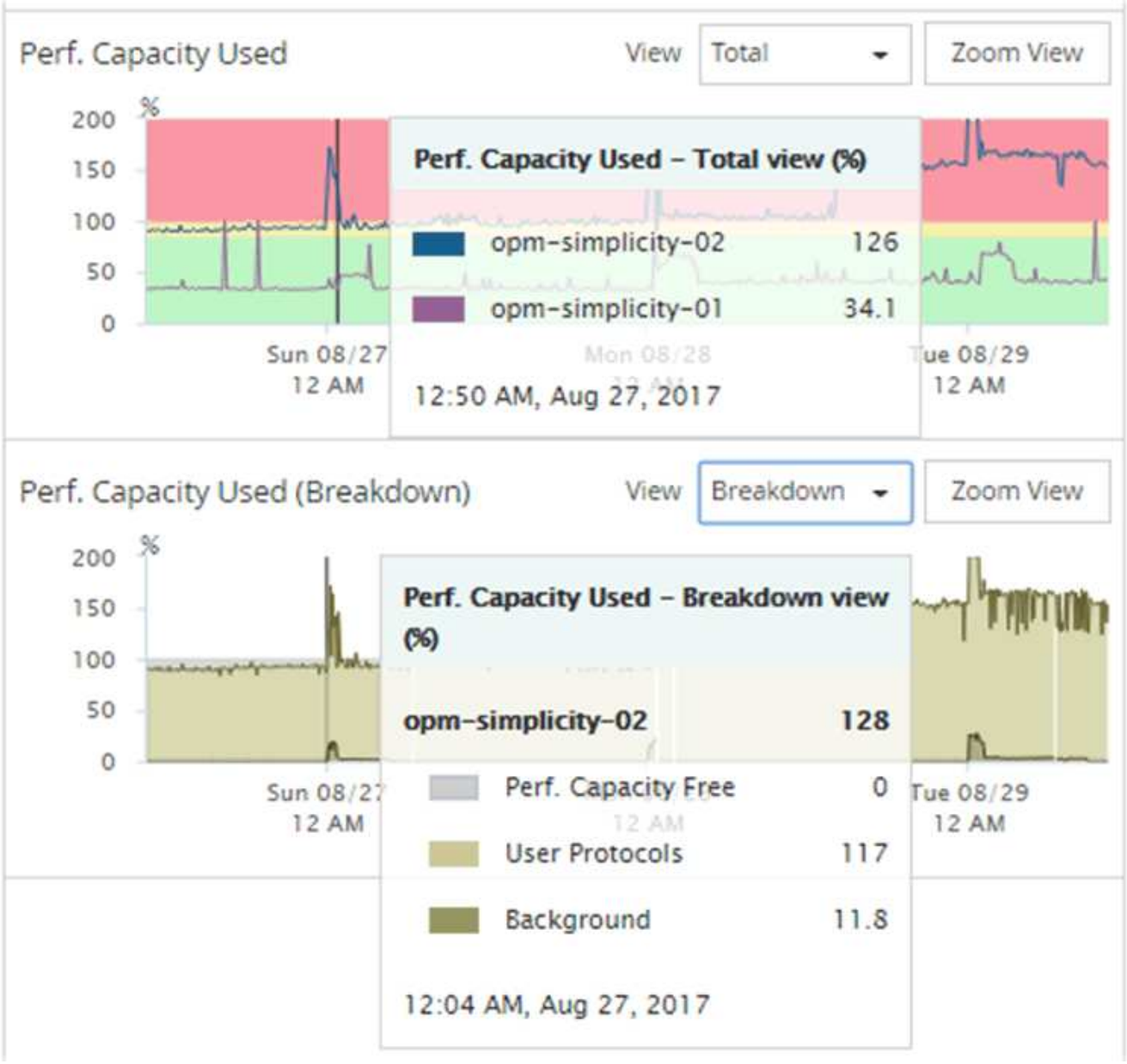
The standard counter chart displays the performance capacity used values for the selected nodes or aggregates. The Breakdown counter chart displays the total performance capacity values for the root object separated into usage based on user protocols versus background system processes. Additionally,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

> 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.

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.

Use 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.

Understand and use 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.

Use 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.

> Latency and IOPS values displayed in this page and in the Performance/Node Performance Explorer page might not match because different performance counters are used to calculate the values to predict node failover.

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.

> 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.

Use 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.

Use 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.

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.

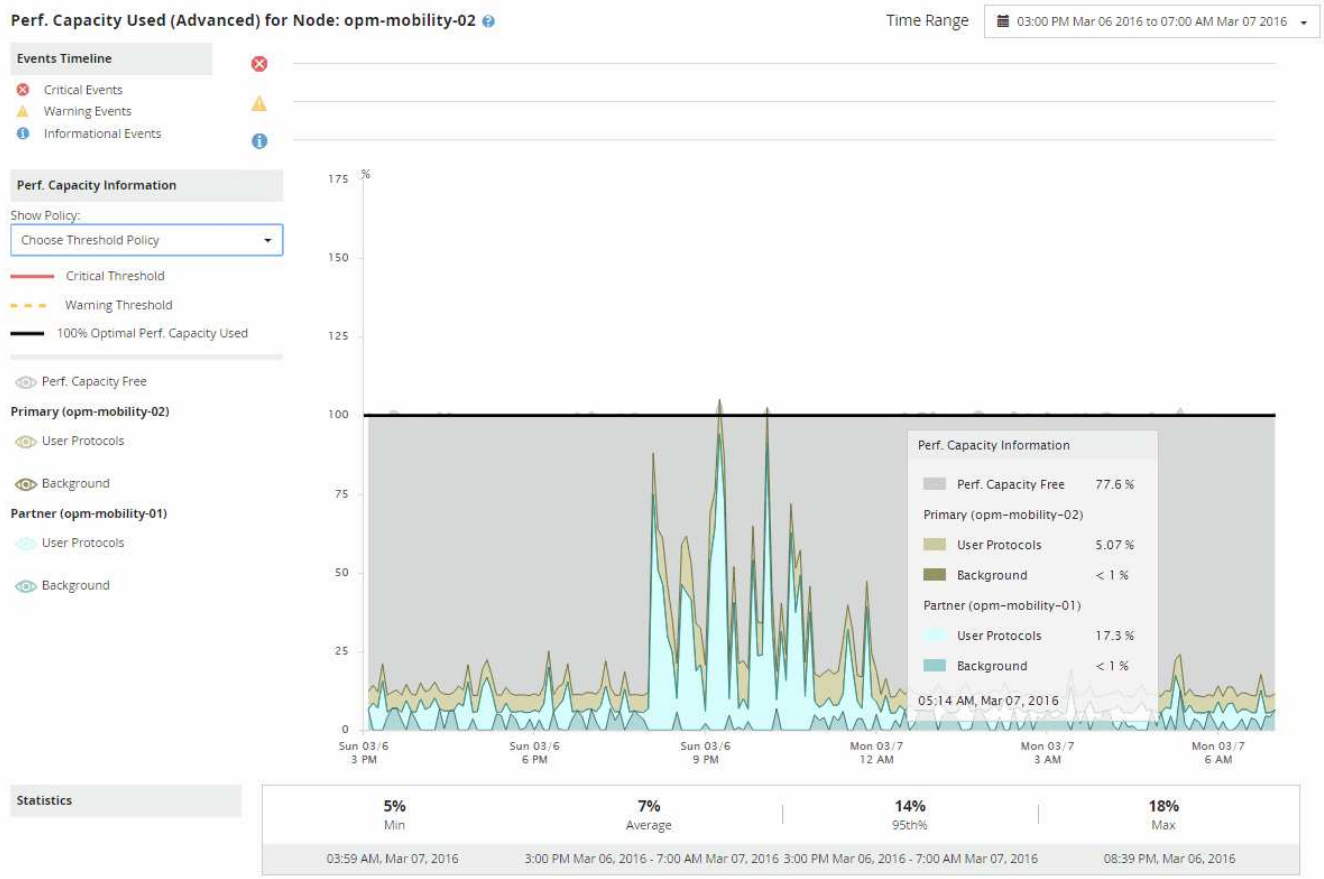
Steps

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.

Collect data and monitor 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 latency range for all monitored workloads.

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

During the first 4 days that Unified Manager is monitoring a workload, if more than 24 hours have passed since the last data collection, the latency charts will not display the latency forecast for that workload. Events detected prior to the last collection are still available.

Daylight savings time (DST) changes the system time, which alters the latency forecast of performance statistics for monitored workloads. Unified Manager immediately begins to correct the latency forecast, which takes approximately 15 days to complete. During this time you can continue to use Unified Manager, but, since Unified Manager uses the latency forecast to detect dynamic events, some events might not be accurate. Events detected prior to the time change are not affected.

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 volume, LUN, NFS share, SMB/CIFS share, and a workload is a user-defined workload.

  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.

  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. (DP volumes are monitored for user-generated traffic.)
  - 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:

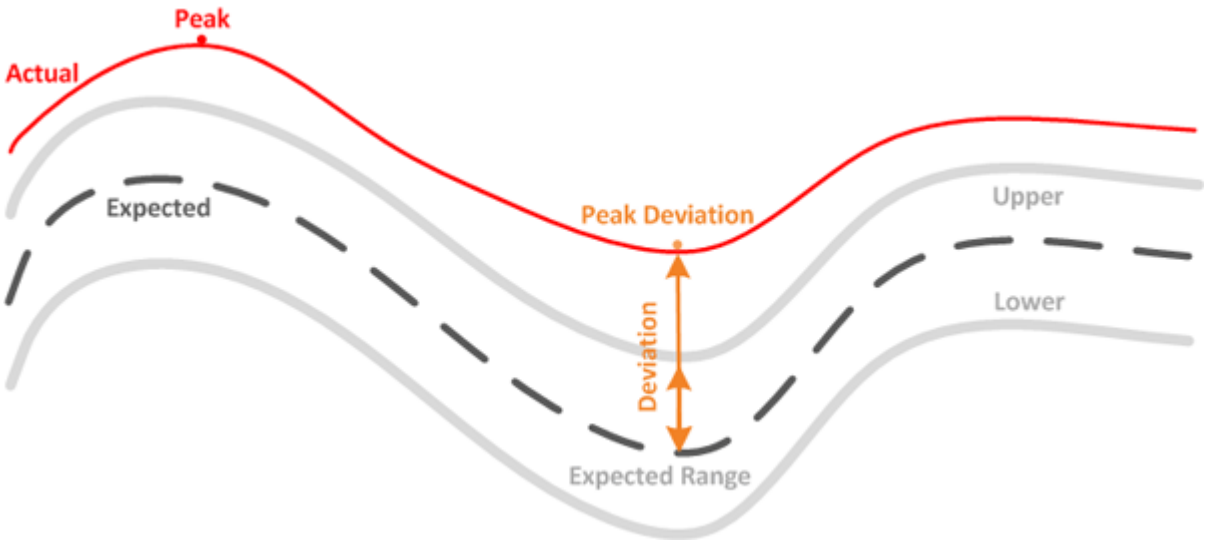
  - Storage efficiency, such as deduplication
  - Disk health, which includes RAID reconstruct, disk scrubbing, and so on
  - Data replication, such as SnapMirror copies
  - Management activities
  - File system health, which includes various WAFL activities
  - File system scanners, such as WAFL scan
  - 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.

Workload performance measurement values

Unified Manager measures the performance of workloads on a cluster based on historical and expected statistical values, which form the latency forecast of values for the workloads. It compares the actual workload statistical values to the latency forecast to determine when workload performance is too high or too low. A workload that is not performing as expected triggers a dynamic performance event 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 latency forecast. The peak is the highest actual value in the time frame. The deviation measures the change between the expected values (the forecast) 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. 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. 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.
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 (latency forecast) of values.
Latency Forecast (Expected Range)	The latency forecast is a 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 dynamic performance event.
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 (MB/s), from workloads on a local cluster to the partner cluster in a MetroCluster configuration.

What the expected range of performance is

The latency forecast is a 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 dynamic performance event.

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 (latency forecast) 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 latency forecast is formed

Unified Manager must collect a minimum of 3 days of workload activity before it can begin its analysis and before the latency forecast for I/O response time 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 latency forecast every 24 hours at 12:00 a.m. to reflect workload activity changes and establish a more accurate dynamic performance threshold.

Daylight savings time (DST) changes the system time, which alters the latency forecast of performance statistics for monitored workloads. Unified Manager immediately begins to correct the latency forecast, which takes approximately 15 days to complete. During this time you can continue to use Unified Manager, but, since Unified Manager uses the latency forecast to detect dynamic events, some events might not be accurate. Events detected prior to the time change are not affected.

How the latency forecast is used in performance analysis

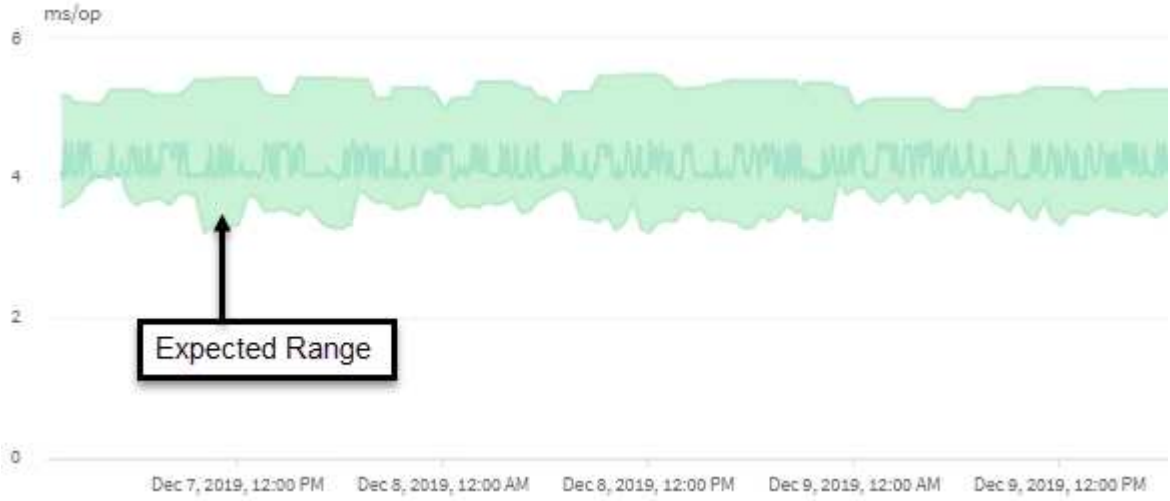
Unified Manager uses the latency forecast to represent the typical I/O latency (response time) activity for your monitored workloads. It alerts you when the actual latency for a workload is above the upper bounds of the latency forecast, which triggers a dynamic performance event, so that you can analyze the performance issue and take corrective action for resolving it.

The latency forecast 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 dynamic performance threshold. Unified Manager uses the baseline to determine when the actual latency is 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 dynamic 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 latency forecast to form the new dynamic performance threshold.

Some workloads might have consistently low activity, where the latency forecast for latency does not have a high rate of change over time. To minimize the number of events 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 a latency forecast, in gray, of 3.5 milliseconds per operation (ms/op) at its lowest and 5.5 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 latency forecast and has exceeded the dynamic performance threshold.

When network traffic has decreased, or the cluster component is no longer in contention, the latency returns within the latency forecast. 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.

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.

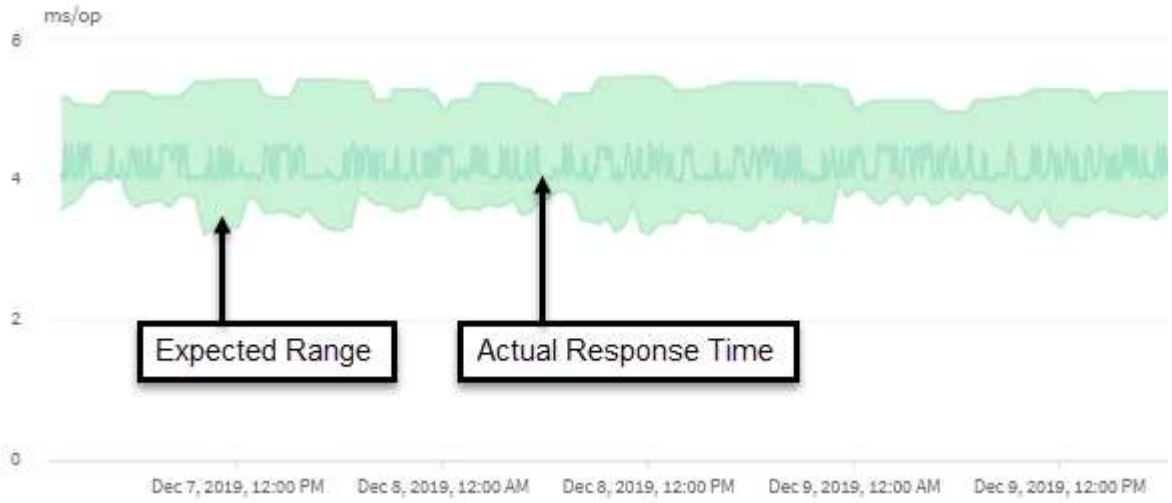
A high latency means that requests from applications to a volume on a cluster are taking longer than usual. The cause of the high latency could be on the cluster itself, due to contention on one or more cluster components. High latency could also be caused by issues outside of the cluster, such as network bottlenecks, issues with the client hosting the applications, or issues with the applications themselves.

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 dynamic performance threshold of the expected range (latency forecast), 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 Latency Total chart in the Workload Analysis 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.



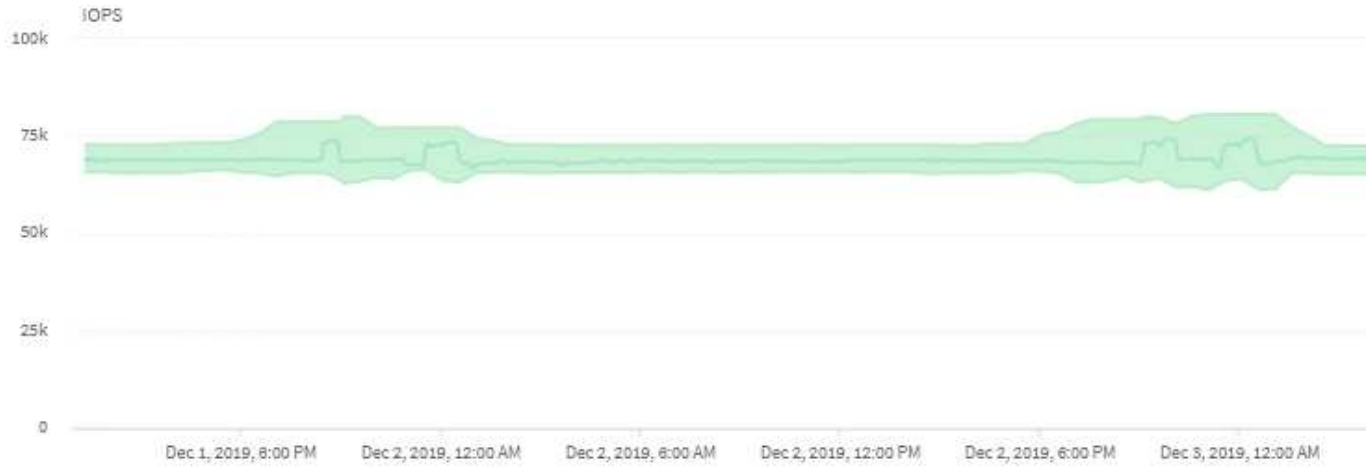
This example shows the Latency chart . The actual response time (latency) activity is a blue line and the latency forecast (expected range) is green.

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.

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. The actual operations statistics is a blue line and the IOPS forecast of operations statistics is green.

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.

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.

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.

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.

You can view the throughput of any of the clusters in a MetroCluster configuration by analyzing the workloads of the corresponding LUNs and volumes from the following screens. You can filter the results by the cluster. From the left navigation pane:

- **Storage > Clusters > Performance: All Clusters** view. See
- **Storage > Volumes > Performance: All Volumes** view.

- **Storage > LUNs > Performance: All LUNs** view.
- **Workload Analysis > All workloads**

Related information

Performance event analysis and notification

Performance event analysis for a MetroCluster configuration

Roles of workloads involved in a performance event

Identifying victim workloads involved in a performance event

Identifying bully workloads involved in a performance event

Identifying shark workloads involved in a performance event

Understand performance events and alerts

Performance events are incidents related to workload performance on a cluster. They help you identify workloads with slow response times. Together with health events that occurred at the same time, you can determine the issues 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.

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 related to workload performance on a cluster. They help you identify storage objects with slow response times, also known as high latency. Together with other health events that occurred at the same time, you can determine the issues 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 the 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.

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.

For more information, see the following links:

- What happens when an event is received
- What information is contained in an alert email
- Adding alerts
- Adding alerts for performance events

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 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 Workload Analysis 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 (MB/s 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 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.

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.

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

If you are receiving unnecessary events from any system-defined performance threshold policies, you can disable the events for individual policies from the Event Setup page.

Cluster threshold policies

The system-defined cluster performance threshold policies are assigned, by default, to every cluster being monitored by Unified Manager:

- **Cluster load imbalance**

  Identifies situations in which one node is operating at a much higher load than other nodes in the cluster, and therefore potentially affecting workload latencies.

It does this by comparing the performance capacity used value for all nodes in a cluster to see if any node has exceeded the 30% threshold value for more than 24 hours. This is a warning event.

- **Cluster capacity imbalance**

  Identifies situations in which one aggregate has a much higher used capacity than other aggregates in the cluster, and therefore potentially affecting space required for operations.

  It does this by comparing the used capacity value for all aggregates in the cluster to see if there is a difference of 70% between any aggregates. This is a warning event.

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:

- **Performance Capacity Used Threshold Breached**

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

  It does this by looking for nodes that are using more than 100% of their performance capacity for more than 12 hours. This is a warning event.

- **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.

  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 12 hours, then a controller failover will impact workload latencies. This is an informational event.

- **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.

  The “Node disk fragmentation” policy analyzes HDD-only aggregates; Flash Pool, SSD, and FabricPool aggregates are not analyzed.

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.

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

Workload latency threshold policies

The system-defined workload latency threshold policies are assigned to any workload that has a configured Performance Service Level policy that has a defined “expected latency” value:

- **Workload Volume/LUN Latency Threshold Breached as defined by Performance Service Level**

  Identifies volumes (file shares) and LUNs that have exceeded their “expected latency” limit, and that are affecting workload performance. This is a warning event.

  It does this by looking for workloads that have exceeded the expected latency value for 30% of the time during the previous hour.

QoS threshold policies

The system-defined QoS performance threshold policies are assigned to any workload that has a configured ONTAP QoS maximum throughput policy (IOPS, IOPS/TB, or MB/s). Unified Manager triggers an event when the workload throughput value is 15% less than the configured QoS value:

- **QoS Max IOPS or MB/s threshold**

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

  When a single workload is assigned to a policy group, 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.

  When multiple workloads share a single QoS policy, it does this by adding the IOPS or MB/s of all workloads in the policy and checking that total against the threshold.

- **QoS Peak IOPS/TB or IOPS/TB with Block Size threshold**

  Identifies volumes that have exceeded their adaptive QoS peak IOPS/TB throughput limit (or IOPS/TB with Block Size 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.

> This policy is applied to volumes only when the cluster is installed with ONTAP 9.3 and later software.

When the “block size” element has been defined in the adaptive QoS policy, the threshold is converted into a QoS maximum MB/s value based on the size of each volume. Then it looks for volumes that have exceeded the QoS max MB/s during each performance collection period for the previous hour.

> This policy is applied to volumes only when the cluster is installed with ONTAP 9.5 and later software.

Performance event analysis and notification

Performance events notify you about I/O performance issues on a 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 dynamic performance threshold, Unified Manager triggers a performance event 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 dynamic performance threshold, which is the upper boundary of the latency forecast:
  - For volumes on HDD or Flash Pool hybrid aggregates (local tier), 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 aggregates (cloud tier), 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.

> 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 active state. For continuous events, Unified Manager triggers an alert after

detecting the same event during two consecutive analysis intervals.

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.

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:

- **Active**

  Indicates that the performance event is currently active (new or acknowledged). 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 events are displayed on the Dashboard page and on many other pages in the user interface, and alerts for those events are sent to specified email addresses. You can view detailed analysis information about an event and get suggestions for resolving it on the Event details page and on the Workload Analysis page.

Event interaction

On the Event details page and on the Workload Analysis page, you can interact with events in the following ways:

- Moving the mouse over an event displays a message that shows 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.

- Clicking a single event displays a dialog box that shows more detailed information about the event, including the cluster components that are involved.

  The component in contention is circled and highlighted red. You can click **View full analysis** to view the full analysis on the 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 to view the event analysis on the Event details page.

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 Event details page.

Unified Manager compares the last analyzed values for a workload to the expected range (latency forecast) 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 latency forecast for Workload A is 5-10 milliseconds per operation (ms/op) and its actual latency is usually around 7 ms/op. The latency forecast for Workload B is 10-20 ms/op and its actual latency is usually around 15 ms/op. Both workloads are well within their latency forecast. Due to contention on the cluster, the latency of both workloads increases to 40 ms/op, crossing the dynamic performance threshold, which is the upper bounds of the latency forecast, 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 Event details page, in the System Diagnosis section, 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.

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 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 or node, 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 external networking protocols on the cluster. The wait time is time spent waiting for “transfer ready” 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 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.

  When using an All SAN Array cluster in an active-active configuration, the network processing latency value is displayed for both nodes so you can verify the nodes are sharing the load equally.

- **QoS Limit Max**

  Represents the throughput maximum (peak) setting of the storage Quality of Service (QoS) policy group assigned to the workload. 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.

- **QoS Limit Min**

  Represents the latency to a workload that is being caused by QoS throughput minimum (expected) setting assigned to other workloads. If the QoS minimum set on certain workloads use the majority of the bandwidth to guarantee the promised throughput, other workloads will be throttled and see more latency.

- **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.

- **Volume Activation**

  Represents the process that tracks the usage of all active volumes. In large environments where more than 1000 volumes are active, this process tracks how many critical volumes need to access resources through the node at the same time. When the number of concurrent active volumes exceeds the recommended maximum threshold, some of the non-critical volumes will experience latency as identified here.

- **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), or a mix of HDDs and a cloud tier (a FabricPool aggregate). An “SSD Aggregate” consists of all SSDs (an all-flash aggregate), or a mix of SSDs and a cloud tier (a FabricPool aggregate).

- **Cloud Latency**

  Represents the software component in the cluster involved with I/O processing between the cluster and the cloud tier on which user data is stored. If the cloud latency component is in contention, it means that a large amount of reads from volumes that are hosted on the cloud tier are impacting the latency of one or more workloads.

- **Sync SnapMirror**

  Represents the software component in the cluster involved with replicating user data from the primary volume to the secondary volume in a SnapMirror Synchronous relationship. If the sync SnapMirror component is in contention, it means that the activity from SnapMirror Synchronous operations are impacting the latency of one or more workloads.

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.

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 latency forecast (expected range).
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 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.

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.

Manage 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.

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 Event Setup 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:

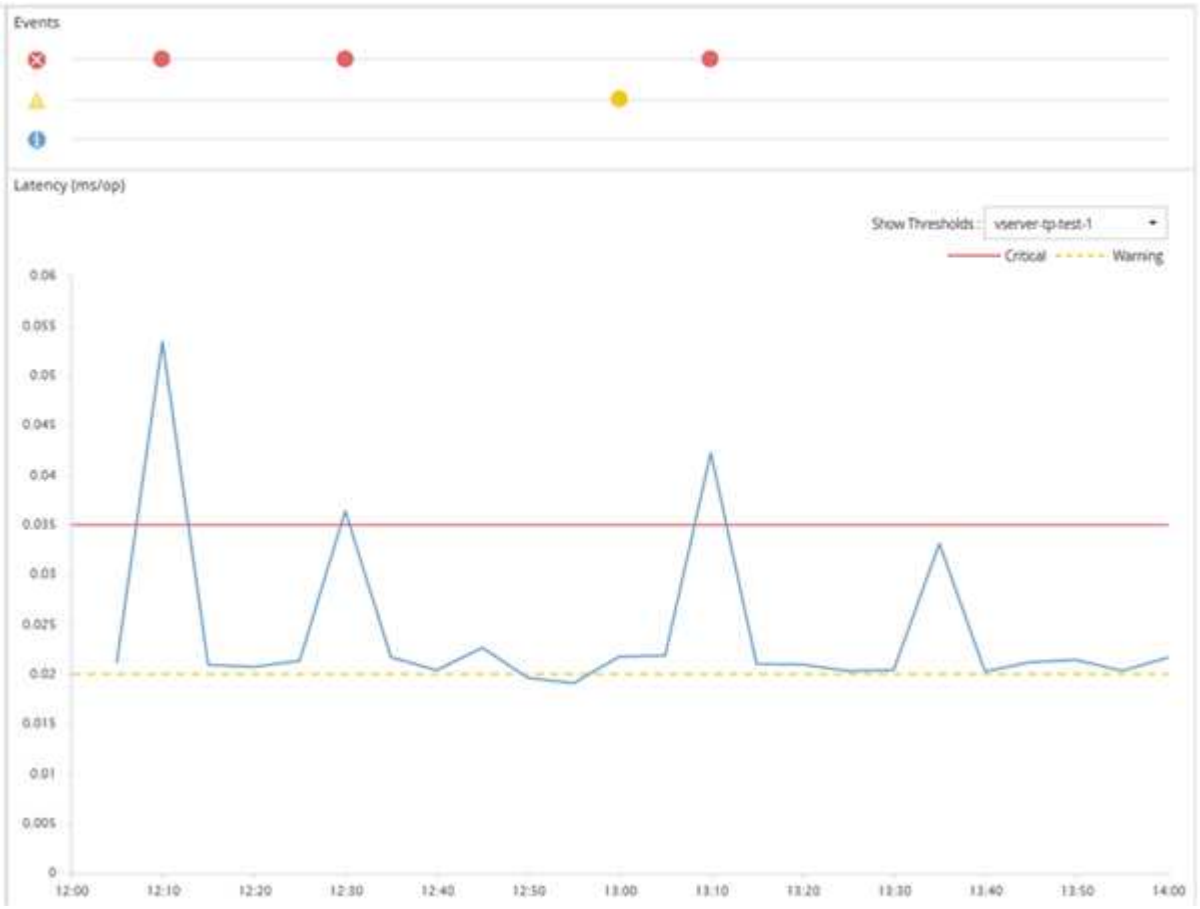
- Selecting a storage object
- Selecting a performance counter associated with that object
- Specifying values that define the performance counter upper limits that are considered warning and critical situations
- Specifying a time period that defines how long the counter must exceed the upper limit

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.

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.

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 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 Alert Setup 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.

What performance counters can be tracked using thresholds

Some common performance counters, such as IOPS and MB/s, 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.
	MB/s	Average number of megabytes of data transferred to and from this cluster per second.
Node	IOPS	Average number of input/output operations the node processes per second.
	MB/s	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.

Storage object	Performance counter	Description
Aggregate	IOPS	Average number of input/output operations the aggregate processes per second.
	MB/s	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 VM	IOPS	Average number of input/output operations the SVM processes per second.
	MB/s	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.

Storage object	Performance counter	Description
Volume	IOPS	Average number of input/output operations the volume processes per second.
	MB/s	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.
	MB/s	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.
Namespace	IOPS	Average number of input/output operations the namespace processes per second.
	MB/s	Average number of megabytes of data transferred to and from this namespace per second.
	Latency	Average number of milliseconds the namespace 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.
	MB/s	Average number of megabytes of data transferred to and from this port per second.
Network Interface (LIF)	MB/s	Average number of megabytes of data transferred to and from this LIF per second.

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 MB/s
	Aggregate Utilization
	Aggregate Performance Capacity Used
	Node Utilization
	Node Performance Capacity Used
	Node Performance Capacity Used - Takeover

Primary storage object and counter	Secondary storage object and counter
LUN Latency	LUN IOPS
	LUN MB/s
	Aggregate Utilization
	Aggregate Performance Capacity Used
	Node Utilization
	Node Performance Capacity Used
	Node Performance Capacity Used - Takeover

When a volume combination policy is applied to a FlexGroup volume, instead of to a FlexVol volume, only the “Volume IOPS” and “Volume MB/s” 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.

Create 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 Application Administrator role.

You create performance threshold policies by entering the threshold values on the Create Performance 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 the values in the copy (called *cloning*).

Valid threshold values are 0.001 through 10,000,000 for numbers, 0.001-100 for percentages, and 0.001-200 for Performance Capacity Used percentages.

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 **Event Thresholds** > **Performance**.

   The 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 Performance Threshold Policy page or Clone Performance 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 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.

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.

Assign 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 Application Administrator role.

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

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

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 drop-down box, and choose **Select all objects on this page**.
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 Performance 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.

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 Alert Setup page.

View performance threshold policies

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

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

1. In the left navigation pane, select **Event Thresholds** > **Performance**.

   The Performance Thresholds page is displayed.

Edit 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 Application Administrator role.

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 **Event Thresholds** > **Performance**.

   The Performance Thresholds page displays.

2. Select the threshold policy that you want to change and click **Edit**.

   The Edit Performance Threshold Policy page is displayed.

3. Make your changes to the threshold policy and click **Save**.

   You are returned to the Performance Thresholds page.

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

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 Alert Setup page.

Remove 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 Application Administrator role.

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 in the column header.

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 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.

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 Workload Analysis page to indicate the time when the move operation was completed.

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.

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.

For information, see Volume behavior during switchover and switchback.

Analyze performance events

You can analyze performance events to identify when they were detected, whether they are active (new or acknowledged) or obsolete, the workloads and cluster components involved, and the options for resolving the events on your own.

Display information about performance events

You can use the Event Management inventory page to view a list of all the 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, Application Administrator, or Storage Administrator role.

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:

- User-defined performance threshold policy
- System-defined performance threshold policy
- Dynamic performance threshold

The Event Type column lists the source of the event. You can select an event to view details about the event in the Event details page.

Steps

1. In the left navigation pane, click **Event Management**.
2. From the View menu, select **Active performance events**.

   The page displays all New and Acknowledged Performance events that have been generated in the past 7 days.

3. Locate an event that you want to analyze and click the event name.

   The details page for the event displays.

> 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.

Analyze 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 Event details page to analyze the performance event and take corrective action, if necessary, to return performance back to normal.

Respond 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, Application Administrator, or Storage Administrator role.

- There must be new or obsolete performance events.

Steps

1. Display the **Event details** page to view information about the event.
2. Review 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 object.

3. 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.

4. Make a note of the **Event Trigger Time** so you can investigate whether other events might have occurred at the same time that could have contributed to this event.
5. Follow one of the options below to further investigate the event, to determine whether you need to perform any actions to resolve the performance problem:

Option	Possible investigation actions
Click the Source 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 Summary page.	This page enables you to view the details for the cluster on which this object resides to see whether other performance issues have occurred around the same time.

Analyze 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 Event details page to analyze the performance event and take corrective action, if necessary, to return performance back to normal.

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

Respond 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, Application Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

Steps

1. Display the **Event details** page to view information about the event.
2. Review 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.

3. Make a note of the **Event Trigger Time** so you can investigate whether other events might have occurred at the same time that could have contributed to this event.
4. 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.

5. 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.

Respond 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 ONTAP 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, Application Administrator, or Storage Administrator role.
- There must be new, acknowledged, or obsolete performance events.

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 **Event details** page to view information about the event.
2. Review 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.

3. Review the **Event Information** section to see more details about when the event occurred and how long the event has been active.

   Additionally, for volumes or LUNs that are sharing the throughput of a QoS policy you can see the names of the top three workloads that are consuming the most IOPS or MBps.

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.

   For a shared QoS policy event, the top three workloads are shown in the throughput chart. If more than three workloads are sharing the QoS policy, then additional workloads are added together in an “Other workloads” category. Additionally, the Latency chart shows the average latency on all workloads that are part of the QoS policy.

   Note that for adaptive QoS policy events that the IOPS and MBps charts show IOPS or MBps values that ONTAP has converted from the assigned IOPS/TB threshold policy based on the size of the volume.

5. Under the **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.

Understand events from adaptive QoS policies that have a defined block size

Adaptive QoS policy groups automatically scale a throughput ceiling or floor based on the volume size, maintaining the ratio of IOPS to TBs as the size of the volume changes. Starting with ONTAP 9.5 you can specify the block size in the QoS policy to effectively apply a MB/s threshold at the same time.

Assigning an IOPS threshold in an adaptive QoS policy places a limit only on the number of operations that occur in each workload. Depending on the block size that is set on the client that generates the workloads, some IOPS include much more data and therefore place a much larger burden on the nodes that process the operations.

The MB/s value for a workload is generated using the following formula:

```
MB/s = (IOPS * Block Size) / 1000
```

If a workload is averaging 3,000 IOPS and the block size on the client is set to 32 KB, then the effective MB/s for this workload is 96. If this same workload is averaging 3,000 IOPS and the block size on the client is set to 48 KB, then the effective MB/s for this workload is 144. You can see that the node is processing 50% more data when the block size is larger.

Let's look at the following adaptive QoS policy that has a defined block size and how events are triggered based on the block size that is set on the client.

Create a policy and set the peak throughput to 2,500 IOPS/TB with a block size of 32KB. This effectively sets the MB/s threshold to 80 MB/s ((2500 IOPS * 32KB) / 1000) for a volume with 1 TB used capacity. Note that Unified Manager generates a Warning event when the throughput value is 10% less than the defined threshold. Events are generated under the following situations:

Used Capacity	**Event is generated when throughput exceeds this number of …**	
	IOPS	MB/s
1 TB	2,250 IOPS	72 MB/s
2 TB	4,500 IOPS	144 MB/s
5 TB	11,250 IOPS	360 MB/s

If the volume is using 2TB of the available space, and the IOPS is 4,000, and the QoS block size is set to 32KB on the client, then the MB/ps throughput is 128 MB/s ((4,000 IOPS * 32 KB) / 1000). No event is generated in this scenario because both 4,000 IOPS and 128 MB/s are below the threshold for a volume that is using 2 TB of space.

If the volume is using 2TB of the available space, and the IOPS is 4,000, and the QoS block size is set to 64KB on the client, then the MB/s throughput is 256 MB/s ((4,000 IOPS * 64 KB) / 1000). In this case the 4,000 IOPS does not generate an event, but the MB/s value of 256 MB/s is above the threshold of 144 MB/s and an event is generated.

For this reason, when an event is triggered based on a MB/s breach for an adaptive QoS policy that includes the block size, a MB/s chart is displayed in the System Diagnosis section of the Event details page. If the event is triggered based on an IOPS breach for the adaptive QoS policy, an IOPS chart is displayed in the System Diagnosis section. If a breach occurs for both IOPS and MB/s you will receive two events.

For more information on adjusting QoS settings, see Performance management overview.

Respond 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, Application Administrator, or Storage Administrator role.
- There must be new or obsolete performance events.

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 **Event details** page to view information about the event.
2. Review 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 the **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.

Respond to cluster imbalance performance events

Unified Manager generates cluster imbalance warning events when one node in a cluster is operating at a much higher load than other nodes, 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, Application Administrator, or Storage Administrator role.

Unified Manager generates warning events for cluster imbalance threshold policy breaches by comparing the performance capacity used value for all nodes in the cluster to see if there is a load difference of 30% between any nodes.

These steps help you identify the following resources so that you can move high-performing workloads to a lower utilized node:

- The nodes on the same cluster that are less utilized
- The aggregates on the new node that are the least utilized
- The highest-performing volumes on the current node

Steps

1. Display the **Event** details page to view information about the event.
2. Review the **Description**, which describes the threshold breach that caused the event.

   For example, the message “The performance capacity used counter indicates a load difference of 62% between the nodes on cluster Dallas-1-8 and has triggered a WARNING event based on the system threshold of 30%” indicates that performance capacity on one of the nodes is overused and affecting node performance.

3. Review the text in the **Suggested Actions** to move a high-performing volume from the node with the high performance capacity used value to a node with the lowest performance capacity used value.
4. Identify the nodes with the highest and lowest performance capacity used value:
   a. In the **Event Information** section, click the name of the source cluster.
   b. In the **Cluster / Performance Summary** page, click **Nodes** in the **Managed Objects** area.
   c. In the **Nodes** inventory page, sort the nodes by the **Performance Capacity Used** column.
   d. Identify the nodes with the highest and lowest performance capacity used value and write down those names.
5. Identify the volume using the most IOPS on the node that has the highest performance capacity used value:
   a. Click the node with the highest performance capacity used value.
   b. In the **Node / Performance Explorer** page, select **Aggregates on this Node** from the **View and Compare** menu.
   c. Click the aggregate with the highest performance capacity used value.
   d. In the **Aggregate / Performance Explorer** page, select **Volumes on this Aggregate** from the **View and Compare** menu.
   e. Sort the volumes by the **IOPS** column, and write down the name of the volume using the most IOPS, and the name of the aggregate where the volume resides.
6. Identify the aggregate with the lowest utilization on the node that has the lowest performance capacity used value:
   a. Click **Storage** > **Aggregates** to display the **Aggregates** inventory page.
   b. Select the **Performance: All Aggregates** view.
   c. Click the **Filter** button and add a filter where “Node” equals the name of the node with the lowest performance capacity used value that you wrote down in step 4.
   d. Write down the name of the aggregate that has the lowest performance capacity used value.
7. Move the volume from the overloaded node to the aggregate you identified as having low utilization on the new node.

   You can perform the move operation by using ONTAP System Manager, OnCommand Workflow

Automation, ONTAP commands, or a combination of these tools.

After a few days, check to see whether you are receiving the same cluster imbalance event from this cluster.

Analyze 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 Event details page to analyze the performance event and take corrective action, if necessary, to return performance back to normal.

Dynamic performance thresholds are not enabled on Cloud Volumes ONTAP, ONTAP Edge, or ONTAP Select systems.

Identify victim workloads involved in a dynamic 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, Application Administrator, or Storage Administrator role.
- There must be new, acknowledged, or obsolete dynamic performance events.

The 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 **Event details** page to view information about the event.
2. In the Workload Latency and Workload Activity charts, select **Victim Workloads**.
3. Hover your cursor over the charts to view the top user-defined workloads that are affecting the component, and the name of the victim workload.

Identify bully workloads involved in a dynamic 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, Application Administrator, or Storage Administrator role.
- There must be new, acknowledged, or obsolete dynamic performance events.

The 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 Event details page to view information about the event.
2. In the Workload Latency and Workload Activity charts, select **Bully Workloads**.
3. Hover your cursor over the charts to view the top user-defined bully workloads that are affecting the component.

Identify shark workloads involved in a dynamic 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, Application Administrator, or Storage Administrator role.
- There are new, acknowledged, or obsolete performance dynamic event.

The 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 **Event details** page to view information about the event.
2. In the Workload Latency and Workload Activity charts, select **Shark Workloads**.
3. Hover your cursor over the charts to view the top user-defined workloads that are affecting the component, and the name of the shark workload.

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 Dashboard page. You can also view the Health pages of Unified Manager to check the health of each cluster and to view their relationship.

Analyze a dynamic 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, Application Administrator, or Storage Administrator role.
- There must be new, acknowledged, or obsolete performance events for a MetroCluster configuration.

- Both clusters in the MetroCluster configuration must be monitored by the same instance of Unified Manager.

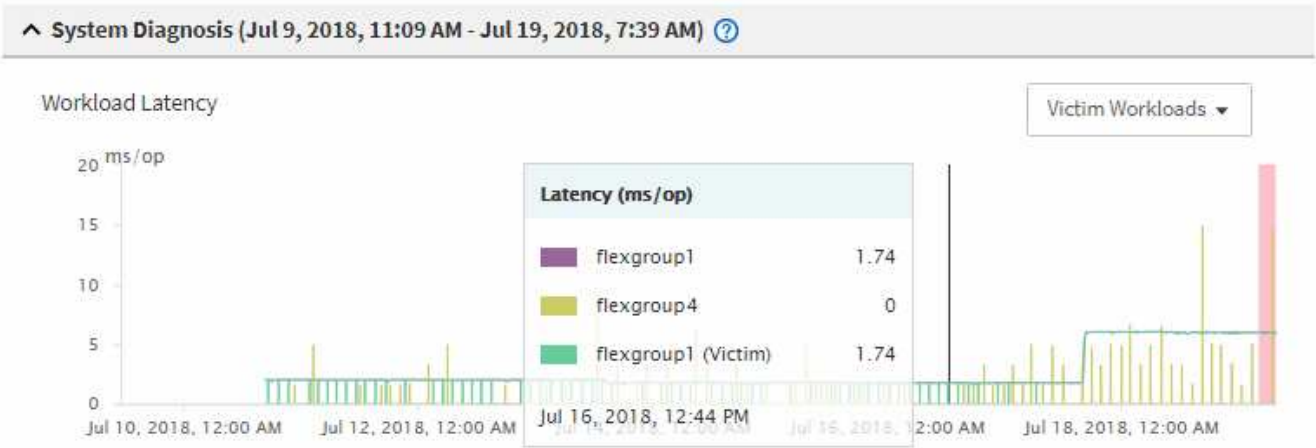
Steps

1. Display the **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.

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 charts, review the *victim* workloads to confirm that their response times are higher than the performance threshold.

   In this example, the victim workload is displayed in the hover text. 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.



   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 Throughput chart, select **Bully Workloads** to display the bully workloads.

   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 (MB/s).

This chart displays, at a high-level, the write throughput (MB/s) pattern for the workloads. You can review the write MB/s 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.

Analyze a dynamic performance event for a remote cluster on a MetroCluster configuration

You can use Unified Manager to analyze dynamic 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, Application 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 **Time Range** selector, select **Last Hour**, and then click **Apply Range**.
4. 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.

5. 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 Event details page.

   If these events do not involve bully workloads, they did not cause the performance event on the local cluster.

Respond 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 (MB/s). 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, Application Administrator, or Storage Administrator role.
- There must be new, acknowledged, or obsolete performance events.

Steps

1. Display the **Event details** page to view information about the event.
2. Read the **Description**, which displays the name of the workloads impacted by the throttling.

   The description can display the same workload for the victim and bully, because the throttling makes the workload a victim of itself.

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 Latency and Workload Utilization charts, select **Bully Workloads**.
5. Hover your cursor over the charts to view the top user-defined workloads that are affecting the policy group.

   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.

6. In the **Suggested Actions** area, click the **Analyze Workload** button for the top workload.
7. In the Workload Analysis page, set the Latency chart to view all Cluster Components, and the Throughput chart to view Breakdown.

   The breakdown charts are displayed under the Latency chart and the IOPS chart.

8. Compare the QoS Limits in the **Latency** chart to see what amount of throttling impacted the latency at the time of the event.

   The QoS 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.

9. Compare the **Reads/writes latency** values to the **Reads/writes/other** values.

   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.

10. Use ONTAP System Manager to increase the current limit on the policy group to 1,300 op/sec.
11. After a day, return to Unified Manager and enter the workload that you recorded in Step 3 in the **Workload Analysis** page.
12. Select the Throughput Breakdown chart.

The Reads/writes/other chart is displayed.

13. At the top of the page, point your cursor to the change event icon ( ) for the policy group limit change.
14. 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.

Respond to a dynamic 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, Application Administrator, or Storage Administrator role.
- There must be new, acknowledged, or obsolete performance events.

Steps

1. Display the **Event details** page to view information about the event.
2. 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 Utilization chart, select **Bully Workloads**.
4. Hover your cursor over the chart to view the top bully workloads that are affecting the component.

   The top workloads with the highest peak utilization since the event was detected are displayed at the top of the chart. One of the top workloads 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.

5. 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.
6. Refresh the **Event details**.

   After the RAID reconstruction is complete, check that the State is obsolete, indicating that the event is resolved.

7. In the Workload Utilization chart, select **Bully Workloads** to view the workloads on the aggregate by peak utilization.
8. In the **Suggested Actions** area, click the **Analyze Workload** button for the top workload.
9. In the **Workload Analysis** page, set the Time Range to display the last 24 hours (1 day) of data for the selected volume.

In the Event Timeline, a red dot (🔴) indicates when the disk failure event occurred.

10. In the Node and Aggregate Utilization chart, hide the line for the Node statistics so that just the Aggregate line remains.
11. Compare the data in this chart to the data at the time of the event in the **Latency** chart.

    At the time of the event, the Aggregate 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.

Respond to a dynamic 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, Application Administrator, or Storage Administrator role.
- There must be new, acknowledged, or obsolete performance events.

Steps

1. Display the **Event details** page to view information about the event.
2. 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 volume.

   The Volume Performance Explorer page is displayed. At the top 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 and details about the HA takeover are displayed in hover text.

   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. Click **Zoom View** to display the Latency chart on a new page.
6. In the View menu, select **Cluster Components** to view the total latency by cluster component.
7. Point your mouse cursor to the change event icon for the start of the HA takeover and compare the latency for data processing to the total latency.

   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.

8. After fixing the failed node, use ONTAP System Manager to perform an HA giveback, which moves the workloads from the partner node to the fixed node.
9. After the HA giveback is complete, after the next configuration discovery in Unified Manager (approximately 15 minutes), find the event and workload that triggered by the HA takeover in the **Event Management** inventory page.

   The event triggered by the HA takeover now has a state of obsolete, which indicates that the event is resolved. 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.

Resolve performance events

You can use the suggested actions to try and resolve performance events on your own. The first three suggestions are always displayed, and the actions under the fourth suggestion are specific to the type of event displayed.

The **Help me do this** links provide additional information for each suggested action, including instructions for performing a specific action. Some of the actions may involve using Unified Manager, ONTAP System Manager, OnCommand Workflow Automation, ONTAP CLI commands, or a combination of these tools.

Confirm that the latency is within the expected range

When a cluster component is in contention, volume workloads that use it might have decreased response time (latency). You can review the latency of each victim workload on the component in contention to confirm that its actual latency is within its expected range. You can also click a volume name to view the historical data for the volume.

If the performance event is in the obsolete state, the latency of each victim involved in the event might have returned within its expected range.

Review the impact of configuration changes on workload performance

Configuration changes on the cluster, such as a failed disk, HA failover, or a moved volume, could negatively impact volume performance and cause increased latency.

In Unified Manager, you can review the Workload Analysis page to see when a recent configuration change occurred and compare it to the operations and latency (response time) to see whether there was a change in activity for the selected volume workload.

The performance pages of Unified Manager can only detect a limited number of change events. The health pages provide alerts for other events caused by configuration changes. You can search for the volume in Unified Manager to see the event history.

Options for improving workload performance from the client-side

You can check your client workloads, such as applications or databases, that are sending I/O to volumes involved in a performance event to determine if a client-side change might correct the event.

When the clients that are connected to volumes on a cluster increase their I/O requests, the cluster must work

harder to meet the demand. If you know which clients have a high number of I/O requests to a particular volume on the cluster, you can improve cluster performance by adjusting the number of clients accessing the volume or decreasing the amount of I/O to the volume. You can also apply or increase a limit on the QoS policy group of which the volume is a member.

You can investigate clients and their applications to determine whether the clients are sending more I/O than usual, which might be causing contention on a cluster component. On the Event details page, the System Diagnosis section displays the top volume workloads using the component in contention. If you know which client is accessing a particular volume, you can go to the client to determine whether the client hardware or an application is not operating as expected or is doing more work than usual.

In a MetroCluster configuration, write requests to a volume on a local cluster are mirrored to a volume on the remote cluster. Keeping the source volume on the local cluster in sync with the destination volume on the remote cluster can also increase the demand of both clusters in the MetroCluster configuration. By reducing write requests to these mirrored volumes, the clusters can perform fewer sync operations, which reduces the performance impact on other workloads.

Check for client or network issues

When the clients that are connected to volumes on a cluster increase their I/O requests, the cluster must work harder to meet the demand. The increased demand on the cluster can put a component in contention, increase the latency of workloads that use it, and trigger an event in Unified Manager.

On the Event details page, the System Diagnosis section displays the top volume workloads using the component in contention. If you know which client is accessing a particular volume, you can go to the client to determine whether the client hardware or an application is not operating as expected or is doing more work than usual. You might need to contact your client administrator or application vendor for assistance.

You can check your network infrastructure to determine whether there are hardware issues, bottlenecks, or competing workloads that might have caused I/O requests between the cluster and connected clients to perform slower than expected. You might need to contact your network administrator for assistance.

Verify whether other volumes in the QoS policy group have unusually high activity

You can review the workloads in the Quality of Service (QoS) policy group with the highest change in activity to determine whether more than one workload caused the event. You can also see whether other workloads are still exceeding the set throughput limit or whether they are back within their expected range of activity.

On the Event details page, in the System Diagnosis section, you can sort the workloads by peak deviation in activity to display the workloads with the highest change in activity at the top of the table. These workloads might be the “bullies” whose activity exceeded the set limit and might have caused the event.

You can navigate to the Workload Analysis page for each volume workload to review its IOPS activity. If the workload has periods of very high operations activity, it might have contributed to the event. You can change the policy group settings for the workload or move the workload to a different policy group.

You can use ONTAP System Manager or the ONTAP CLI commands to manage policy groups, as follows:

- Create a policy group.
- Add or remove workloads in a policy group.

- Move a workload between policy groups.
- Change the throughput limit of a policy group.

Move logical interfaces (LIFs)

Moving logical interfaces (LIFs) to a less busy port can help improve load balancing, assist with maintenance operations and performance tuning, and reduce indirect access.

Indirect access can reduce system efficiency. It occurs when a volume workload is using different nodes for network processing and data processing. To reduce indirect access, you can rearrange LIFs, which involves moving LIFs to use the same node for network processing and data processing. You can configure load balancing to have ONTAP automatically move busy LIFs to a different port or you can move a LIF manually.

Benefits	Considerations
• Improve load balancing. • Reduce indirect access.	When moving a LIF connected to CIFS shares, clients accessing the CIFS shares are disconnected. Any read or write requests to the CIFS shares are disrupted.

You use the ONTAP commands to configure load balancing. For more information, see the ONTAP networking documentation.

You use ONTAP System Manager and the ONTAP CLI commands to move LIFs manually.

Run storage efficiency operations at less busy times

You can modify the policy or schedule that handles storage efficiency operations to run when the impacted volume workloads are less busy.

Storage efficiency operations can use a high amount of cluster CPU resources and become a bully to the volumes on which the operations are being run. If the victim volumes have high activity at the same time when the storage efficiency operations are run, their latency can increase and trigger an event.

On the Event details page, the System Diagnosis section displays workloads in the QoS policy group by peak deviation in activity to identify the bully workloads. If you see “storage efficiency” displayed near the top of the table, these operations are bullying the victim workloads. By modifying the efficiency policy or schedule to run when these workloads are less busy, you can prevent the storage efficiency operations from causing contention on a cluster.

You can use ONTAP System Manager to manage efficiency policies. You can use the ONTAP commands to manage efficiency policies and schedules.

What storage efficiency is

Storage efficiency enables you to store the maximum amount of data for the lowest cost and accommodates rapid data growth while consuming less space. NetApp strategy for storage efficiency is based on the built-in foundation of storage virtualization and unified storage provided by its core ONTAP operating system and Write Anywhere File Layout

(WAFL) file system.

Storage efficiency includes using technologies such as thin provisioning, Snapshot copy, deduplication, data compression, FlexClone, thin replication with SnapVault and volume SnapMirror, RAID-DP, Flash Cache, Flash Pool aggregate, and FabricPool-enabled aggregates which help to increase storage utilization and decrease storage costs.

The unified storage architecture allows you to efficiently consolidate a storage area network (SAN), network-attached storage (NAS), and secondary storage on a single platform.

High-density disk drives, such as serial advanced technology attachment (SATA) drives configured within Flash Pool aggregate or with Flash Cache and RAID-DP technology, increase efficiency without affecting performance and resiliency.

A FabricPool-enabled aggregate includes an all SSD aggregate or HDD aggregate (starting with ONTAP 9.8) as the local performance tier and an object store that you specify as the cloud tier. Configuring FabricPool helps you manage which storage tier (the local tier or the cloud tier) data should be stored based on whether the data is frequently accessed.

Technologies such as thin provisioning, Snapshot copy, deduplication, data compression, thin replication with SnapVault and volume SnapMirror, and FlexClone offer better savings. You can use these technologies individually or together to achieve maximum storage efficiency.

Add disks and reallocate data

You can add disks to an aggregate to increase the storage capacity and the performance of that aggregate. After adding the disks, you will see an improvement in read performance only after reallocating the data across the disks you added.

You can use these instructions when Unified Manager has received aggregate events triggered by dynamic thresholds or by system-defined performance thresholds:

- When you have received a dynamic threshold event, on the Event details page, the cluster component icon that represents the aggregate in contention is highlighted red.

  Beneath the icon, in parentheses, is the name of the aggregate, which identifies the aggregate to which you can add disks.

- When you have received a system-defined threshold event, on the Event details page, the event description text lists the name of the aggregate that is having the problem.

  You can add disks and reallocate data on this aggregate.

The disks you add to the aggregate must already exist in the cluster. If the cluster does not have extra disks available, you might need to contact your administrator or purchase more disks. You can use ONTAP System Manager or the ONTAP commands to add disks to an aggregate.

You should reallocate data when using HDD and Flash Pool aggregates only. Do not reallocate data on SSD or FabricPool aggregates.

How enabling Flash Cache on a node can improve workload performance

You can improve workload performance by enabling Flash Cache™ intelligent data caching on each node in the cluster.

A Flash Cache module, or Performance Acceleration Module PCIe-based memory module, optimizes the performance of random read-intensive workloads by functioning as an intelligent external read cache. This hardware works in tandem with the WAFL External Cache software component of ONTAP.

In Unified Manager, on the Event details page, the cluster component icon that represents the aggregate in contention is highlighted red. Beneath the icon, in parentheses, is the name of the aggregate, which identifies the aggregate. You can enable Flash Cache on the node on which the aggregate resides.

You can use ONTAP System Manager or the ONTAP commands to see whether Flash Cache is installed or enabled, and to enable it if not already enabled. The following command indicates whether Flash Cache is enabled on a specific node: **`cluster::> run local options flexscale.enable`**

For more information about Flash Cache and the requirements for using it, see the following technical report:

Technical Report 3832: Flash Cache Best Practices Guide

How enabling Flash Pool on a storage aggregate can improve workload performance

You can improve workload performance by enabling the Flash Pool feature on an aggregate. A Flash Pool is an aggregate that incorporates both HDDs and SSDs. The HDDs are used for primary storage and the SSDs provide a high-performance read and write cache to boost aggregate performance.

In Unified Manager, the Event details page displays the name of the aggregate in contention. You can use ONTAP System Manager or the ONTAP commands to see whether Flash Pool is enabled for an aggregate. If you have SSDs installed, you can use the command-line interface to enable it. If you have SSDs installed, you can run the following command on the aggregate to see whether Flash Pool is enabled: **`cluster::> storage aggregate show -aggregate aggr_name -field hybrid-enabled`**

In this command, *`aggr_name`* is the name of the aggregate, such as the aggregate in contention.

For more information about Flash Pool and the requirements for using it, see the *Clustered Data ONTAP Physical Storage Management Guide*.

MetroCluster configuration health check

You can use Unified Manager to review the health of the clusters in a MetroCluster configuration over IP or FC. The health status and events help you determine whether there are hardware or software issues that might be impacting the performance of your workloads.

If you configure Unified Manager to send email alerts, you can check your email for any health issues on the local or remote cluster that might have contributed to a performance event. In the Unified Manager GUI, you can select **Event Management** to see a list current events and then use the filters to display MetroCluster configuration events only.

For more information, see Checking the health of clusters in a MetroCluster configuration

MetroCluster configuration verification

You can prevent performance issues for mirrored workloads in a MetroCluster over FC and IP configurations by ensuring that the MetroCluster configuration is set up correctly. You can also improve workload performance by changing the configuration or upgrading software or hardware components.

Refer to MetroCluster Documentation for the instructions of setting up the clusters in the MetroCluster configuration, including the Fibre Channel (FC) switches, cables, and inter-switch links (ISLs). It also helps you configure the MetroCluster software so that the local and remote clusters can communicate with mirror volume data. For information specific to your MetroCluster over IP setup, see Install a MetroCluster IP configuration.

You can compare your MetroCluster configuration to the requirements in MetroCluster Documentation to determine whether changing or upgrading components in your MetroCluster configuration might improve workload performance. This comparison can help you answer the following questions:

- Are the controllers appropriate for your workloads?
- Do you need to upgrade your ISL bundles to a larger bandwidth to handle more throughput?
- Can you adjust the buffer-to-buffer credits (BBC) on your switches to increase the bandwidth?
- If your workloads have high write throughput to solid state drive (SSD) storage, do you need to upgrade your FC-to-SAS bridges to accommodate the throughput?

Related information

- For information about replacing or upgrading MetroCluster components, see the MetroCluster Documentation.
- For information about upgrading controllers see Upgrading controllers in a MetroCluster FC configuration using switchover and switchback and Upgrading controllers in a MetroCluster IP configuration using switchover and switchback

Move workloads to a different aggregate

You can use Unified Manager to help identify an aggregate that is less busy than the aggregate where your workloads currently reside, and then you can move selected volumes or LUNs to that aggregate. Moving high performing workloads to a less busy aggregate, or an aggregate with flash storage enabled, allows the workload to perform more efficiently.

Before you begin

- You must have the Operator, Application Administrator, or Storage Administrator role.
- You must have recorded the name of the aggregate that is currently having a performance issue.
- You must have recorded the date and time at which the aggregate received the event.
- Unified Manager must have collected and analyzed a month or more of performance data.

These steps help you identify the following resources so that you can move high-performing workloads to a lower utilized aggregate:

- The aggregates on the same cluster that are less utilized
- The highest-performing volumes on the current aggregate

Steps

1. Identify the aggregate in the cluster that is the least utilized:
   a. From the **Event** details page, click the name of the cluster on which the aggregate resides.

      The cluster details are displayed in the Performance/Cluster Landing page.

   b. On the **Summary** page, click **Aggregates** from the **Managed Objects** pane.

      The list of aggregates on this cluster are displayed.

   c. Click the **Utilization** column to sort the aggregates by least utilized.

      You can also identify those aggregates that have the greatest **Free Capacity**. This provides a list of potential aggregates to which you might want to move workloads.

   d. Write down the name of the aggregate to which you want to move the workloads.
2. Identify the high-performing volumes from the aggregate that received the event:
   a. Click the aggregate that is having the performance issue.

      The aggregate details are displayed in the Performance/Aggregate Explorer page.

   b. From the **Time Range** selector, select **Last 30 Days**, and then click **Apply Range**.

      This enables you to view a longer performance history period than the default 72 hours. You want to move a volume that is using a lot of resources on a consistent basis, not just over the past 72 hours.

   c. From the **View and Compare** control, select **Volumes on this Aggregate**.

      A list of FlexVol volumes and FlexGroup constituent volumes on this aggregate are displayed.

   d. Sort the volumes by highest MB/s, and then by highest IOPS, to see the highest performing volumes.
   e. Write down the names of the volumes that you want to move to a different aggregate.
3. Move the high-performing volumes to the aggregate you identified as having low utilization.

   You can perform the move operation by using ONTAP System Manager, OnCommand Workflow Automation, ONTAP commands, or a combination of these tools.

After a few days, check to see whether you are receiving the same type of events from this node or aggregate.

Move workloads to a different node

You can use Unified Manager to help identify an aggregate on a different node that is less busy than the node on which your workloads are currently running, and then you can move selected volumes to that aggregate. Moving high-performing workloads to an aggregate on a less busy node allows the workloads on both nodes to perform more efficiently.

Before you begin

- You must have the Operator, Application Administrator, or Storage Administrator role.
- You must have recorded the name of the node that is currently having a performance issue.
- You must have recorded the date and time at which the node received the performance event.
- Unified Manager must have collected and analyzed performance data for a month or longer.

This procedure helps you to identify the following resources so that you can move high-performing workloads to a lower utilized node:

- The nodes on the same cluster that have the greatest free performance capacity
- The aggregates on the new node that have the greatest free performance capacity
- The highest-performing volumes on the current node

Steps

1. Identify a node in the cluster that has the greatest free performance capacity:
   a. On the **Event Details** page, click the name of the cluster on which the node resides.

      The cluster details are displayed in the Performance/Cluster Landing page.

   b. On the **Summary** tab, click **Nodes** from the **Managed Objects** pane.

      The list of nodes on this cluster are displayed.

   c. Click the **Performance Capacity Used** column to sort the nodes by least percentage used.

      This provides a list of potential nodes to which you might want to move workloads.

   d. Write down the name of the node to which you want to move the workloads.
2. Identify an aggregate on the new node that is the least utilized:
   a. In the left navigation pane, click **Storage** > **Aggregates** and select **Performance** > **All Aggregates** from the View menu.

      The Performance: All Aggregates view is displayed.

   b. Click **Filtering**, select **Node** from the left drop-down menu, type the name of the node in the text field, and then click **Apply Filter**.

      The Performance: All Aggregates view is redisplayed with the list of aggregates that are available on this node.

   c. Click the **Performance Capacity Used** column to sort the aggregates by least used.

      This provides a list of potential aggregates to which you might want to move workloads.

   d. Write down the name of the aggregate to which you want to move the workloads.
3. Identify the high-performing workloads from the node that received the event:
   a. Return to the **Event Details** page for the event.
   b. In the **Affected Volumes** field, click the link for the number of volumes.

      The Performance: All Volumes view is displayed with a filtered list of the volumes on that node.

c. Click the **Total Capacity** column to sort the volumes by the largest allocated space.

   This provides a list of potential volumes that you may want to move.

d. Write down the names of the volumes that you want to move, and the names of the current aggregates on which they reside.

4. Move the volumes to the aggregates that you identified as having greatest free performance capacity on the new node.

   You can perform the move operation by using ONTAP System Manager, OnCommand Workflow Automation, ONTAP commands, or a combination of these tools.

After a few days, you can check whether you are receiving the same type of events from this node or aggregate.

Move workloads to an aggregate on a different node

You can use Unified Manager to help identify an aggregate on a different node that is less busy than the node where your workloads are currently running, and then you can move selected volumes to that aggregate. Moving high-performing workloads to an aggregate on a less busy node allows workloads on both nodes to perform more efficiently.

Before you begin

- You must have the Operator, Application Administrator, or Storage Administrator role.
- You must have recorded the name of the node that is currently having a performance issue.
- You must have recorded the date and time at which the node received the performance event.
- Unified Manager must have collected and analyzed a month or more of performance data.

These steps help you identify the following resources so that you can move high-performing workloads to a lower utilized node:

- The nodes on the same cluster that are less utilized
- The aggregates on the new node that are the least utilized
- The highest-performing volumes on the current node

Steps

1. Identify a node in the cluster that is the least utilized:
   a. From the **Event** details page, click the name of the cluster on which the node resides.

      The cluster details are displayed in the Performance/Cluster Landing page.

   b. On the **Summary** page, click **Nodes** from the **Managed Objects** pane.

      The list of nodes on this cluster are displayed.

   c. Click the **Utilization** column to sort the nodes by least utilized.

      You can also identify those nodes that have the greatest **Free Capacity**. This provides a list of potential nodes to which you might want to move workloads.

d. Write down the name of the node to which you want to move the workloads.

2. Identify an aggregate on the new node that is the least utilized:
   a. In the left navigation pane, click **Storage** > **Aggregates** and select **Performance** > **All Aggregates** from the View menu.

      The Performance: All Aggregates view is displayed.

   b. Click **Filtering**, select **Node** from the left drop-down menu, type the name of the node in the text field, and then click **Apply Filter**.

      The Performance: All Aggregates view is redisplayed with the list of aggregates that are available on this node.

   c. Click the **Utilization** column to sort the aggregates by least utilized.

      You can also identify those aggregates that have the greatest **Free Capacity**. This provides a list of potential aggregates to which you might want to move workloads.

   d. Write down the name of the aggregate to which you want to move the workloads.
3. Identify the high-performing workloads from the node that received the event:
   a. Return to the **Event** details page for the event.
   b. In the **Affected Volumes** field, click the link for the number of volumes.

      The Performance: All Volumes view is displayed with a filtered list of the volumes on that node.

   c. Click the **Total Capacity** column to sort the volumes by the largest allocated space.

      This provides a list of potential volumes that you may want to move.

   d. Write down the names of the volumes that you want to move, and the names of the current aggregates on which they reside.
4. Move the volumes to the aggregates you identified as having low utilization on the new node.

   You can perform the move operation by using ONTAP System Manager, OnCommand Workflow Automation, ONTAP commands, or a combination of these tools.

After a few days, check to see whether you are receiving the same type of events from this node or aggregate.

Move workloads to a node in a different HA pair

You can use Unified Manager to help identify an aggregate on a node in a different high-availability (HA) pair that has more free performance capacity than the HA pair where your workloads are currently running. Then you can move selected volumes to aggregates on the new HA pair.

Before you begin

- You must have the Operator, Application Administrator, or Storage Administrator role.
- Your cluster must consist of a minimum of two HA pairs

  You cannot use this remediation process if you have only one HA pair in your cluster.

- You must have recorded the names of the two nodes in the HA pair that are currently having a performance issue.
- You must have recorded the date and time at which the nodes received the performance event.
- Unified Manager must have collected and analyzed performance data for a month or longer.

Moving high-performing workloads to an aggregate on a node with more free performance capacity allows workloads on both nodes to perform more efficiently. This procedure helps you to identify the following resources so that you can move high-performing workloads to a node that has more free performance capacity on a different HA pair:

- The nodes in a different HA pair on the same cluster that have the greatest free performance capacity
- The aggregates on the new nodes that have the greatest free performance capacity
- The highest-performing volumes on the current nodes

Steps

1. Identify the nodes that are part of a different HA pair on the same cluster:
   a. On the **Event Details** page, click the name of the cluster on which the nodes reside.

      The cluster details are displayed in the Performance/Cluster Landing page.

   b. On the **Summary** page, click **Nodes** from the **Managed Objects** pane.

      The list of nodes on this cluster is displayed in the Performance: All Nodes view.

   c. Write down the names of the nodes that are in different HA pairs from the HA pair that is currently having a performance issue.
2. Identify a node in the new HA pair that has the greatest free performance capacity:
   a. On the **Performance: All Nodes** view, click the **Performance Capacity Used** column to sort the nodes by least percentage used.

      This provides a list of potential nodes to which you might want to move workloads.

   b. Write down the name of the node on a different HA pair to which you want to move the workloads.
3. Identify an aggregate on the new node that has the greatest free performance capacity:
   a. On the **Performance: All Nodes** view, click the node.

      The node details are displayed in the Performance/Node Explorer page.

   b. In the **View and Compare** menu, select **Aggregates on this Node**.

      The aggregates on this node are displayed in the grid.

   c. Click the **Performance Capacity Used** column to sort the aggregates by least used.

      This provides a list of potential aggregates to which you might want to move workloads.

   d. Write down the name of the aggregate to which you want to move the workloads.
4. Identify the high-performing workloads from the nodes that received the event:
   a. Return to the **Event** details page for the event.

b. In the **Affected Volumes** field, click the link for the number of volumes for the first node.

   The Performance: All Volumes view is displayed with a filtered list of the volumes on that node.

c. Click the **Total Capacity** column to sort the volumes by the largest allocated space.

   This provides a list of potential volumes that you might want to move.

d. Write down the names of the volumes that you want to move, and the names of the current aggregates on which they reside.

e. Perform steps 4c and 4d for the second node that was part of this event to identify possible volumes that you want to move from that node as well.

5. Move the volumes to the aggregates that you identified as having greatest free performance capacity on the new node.

   You can perform the move operation by using ONTAP System Manager, OnCommand Workflow Automation, ONTAP commands, or a combination of these tools.

After a few days, you can check whether you are receiving the same type of events from this node or aggregate.

Move workloads to another node in a different HA pair

You can use Unified Manager to help identify an aggregate on a node in a different HA pair that is less busy than the HA pair where your workloads are currently running. Then you can move selected volumes to aggregates on the new HA pair. Moving high-performing workloads to an aggregate on a less busy node allows workloads on both nodes to perform more efficiently.

Before you begin

- You must have the Operator, Application Administrator, or Storage Administrator role.
- Your cluster must consist of a minimum of two HA pairs; you cannot use this remediation process if you have only one HA pair in your cluster.
- You must have recorded the names of the two nodes in the HA pair that are currently having the performance issue.
- You must have recorded the date and time at which the nodes received the performance event.
- Unified Manager must have collected and analyzed a month or more of performance data.

These steps help you identify the following resources so that you can move high-performing workloads to a lower utilized node on a different HA pair:

- The nodes in a different HA pair on the same cluster that are less utilized
- The aggregates on the new nodes that are the least utilized
- The highest-performing volumes on the current nodes

Steps

1. Identify the nodes that are part of a different HA pair on the same cluster:

   a. In the left navigation pane, click **Storage** > **Clusters** and select **Performance** > **All Clusters** from the

View menu.

The Performance: All Clusters view is displayed.

b. Click the number in the **Node Count** field for the current cluster.

The Performance: All Nodes view is displayed.

c. Write down the names of the nodes that are in different HA pairs from the HA pair that is currently having the performance issue.

2. Identify a node in the new HA pair that is the least utilized:

a. Click the **Utilization** column to sort the nodes by least utilized.

You can also identify those nodes that have the greatest **Free Capacity**. This provides a list of potential nodes to which you might want to move workloads.

b. Write down the name of the node to which you want to move the workloads.

3. Identify an aggregate on the new node that is the least utilized:

a. In the left navigation pane, click **Storage** > **Aggregates** and select **Performance** > **All Aggregates** from the View menu.

The Performance: All Aggregates view is displayed.

b. Click **Filtering**, select **Node** from the left drop-down menu, type the name of the node in the text field, and then click **Apply Filter**.

The Performance: All Aggregates view is redisplayed with the list of aggregates that are available on this node.

c. Click the **Utilization** column to sort the aggregates by least utilized.

You can also identify those aggregates that have the greatest **Free Capacity**. This provides a list of potential aggregates to which you might want to move workloads.

d. Write down the name of the aggregate to which you want to move the workloads.

4. Identify the high-performing workloads from the nodes that received the event:

a. Return to the **Event** details page for the event.

b. In the **Affected Volumes** field, click the link for the number of volumes for the first node.

The Performance: All Volumes view is displayed with a filtered list of the volumes on that node.

c. Click the **Total Capacity** column to sort the volumes by the largest allocated space.

This provides a list of potential volumes that you might want to move.

d. Write down the names of the volumes that you want to move, and the names of the current aggregates on which they reside.

e. Perform steps 4c and 4d for the second node that was part of this event to identify possible volumes that you want to move from that node as well.

5. Move the volumes to the aggregates you identified as having low utilization on the new node.

You can perform the move operation by using ONTAP System Manager, OnCommand Workflow

Automation, ONTAP commands, or a combination of these tools.

After a few days, check to see whether you are receiving the same type of events from this node or aggregate.

Use QoS policy settings to prioritize the work on this node

You can set a limit on a QoS policy group to control the I/O per second (IOPS) or MBps throughput limit for the workloads it contains. If workloads are in a policy group with no set limit, such as the default policy group, or the set limit does not meet your needs, you can increase the set limit or move the workloads to a new or existing policy group that has the desired limit.

If a performance event on a node is caused by workloads overusing the node resources, the event description on the Event details page displays a link to the list of volumes involved. In the Performance/Volumes page, you can sort the affected volumes by IOPS and MBps to see which workloads have the highest usage that might have contributed to the event.

By assigning the volumes that are overusing the node resources to a more restrictive policy group setting, the policy group throttles the workloads to restrict their activity, which can reduce the use of the resources on that node.

You can use ONTAP System Manager or the ONTAP commands to manage policy groups, including the following tasks:

- Creating a policy group
- Adding or removing workloads in a policy group
- Moving a workload between policy groups
- Changing the throughput limit of a policy group

Remove inactive volumes and LUNs

When aggregate free space has been identified as an issue, you can search for unused volumes and LUNs and delete them from the aggregate. This can help to alleviate the low disk space issue.

If a performance event on an aggregate is caused by low disk space, there are a few ways you can determine which volumes and LUNs are no longer being used.

To identify unused volumes:

- On the Event details page, the **Affected Objects Count** field provides a link that displays the list of affected volumes.

  Click the link to display the volumes on the Performance: All Volumes view. From there you can sort the affected volumes by **IOPS** to see which volumes have not been active.

To identify unused LUNs:

1. From the Event details page, write down the name of the aggregate on which the event occurred.
2. In the left navigation pane, click **Storage** > **LUNs** and select **Performance** > **All LUNs** from the View

menu.

3. Click **Filtering**, select **Aggregate** from the left drop-down menu, type the name of the aggregate in the text field, and then click **Apply Filter**.
4. Sort the resulting list of affected LUNs by **IOPS** to view the LUNs that are not active.

After you have identified the unused volumes and LUNs, you can use ONTAP System Manager or the ONTAP commands to delete those objects.

Add disks and perform aggregate layout reconstruction

You can add disks to an aggregate to increase the storage capacity and the performance of that aggregate. After adding the disks, you only see an improvement in performance after reconstructing the aggregate.

When you receive a system-defined threshold event on the Event details page, the event description text lists the name of the aggregate that is having the problem. You can add disks and reconstruct data on this aggregate.

The disks you add to the aggregate must already exist in the cluster. If the cluster does not have extra disks available, you might need to contact your administrator or purchase more disks. You can use ONTAP System Manager or the ONTAP commands to add disks to an aggregate.

Technical Report 3838: Storage Subsystem Configuration Guide

Set 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: • LUNs • Volumes	This group provides total IOPS or latency for all LUNs and volumes in all monitored clusters. This group provides the smallest number of statistics.

Statistics group	Data included	Details
Resource Utilization	Resource utilization statistics for the following objects: • Nodes • Aggregates	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: • Nodes • Aggregates • LUNs • Volumes • Disks • LIFs • Ports/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.

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_vol1”, you will see old performance data for the old volume, and new performance data for the new volume.

See Knowledge Base article 30096 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

Set 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.

NetApp does not test or verify specific versions of Graphite or other third-party tools.

The Graphite server does not receive performance data for Volumes 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
  ```

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

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.

Configure 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
  - 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.

> 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.

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

For..	Enter…
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
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.

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 the external tool. You might need to refresh your browser to see the new metrics in the metric hierarchy.

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