

# Oracle ZFS Storage Appliance Analytics Guide, Release OS8.8.x



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# Working with Analytics

Oracle ZFS Storage Appliance is equipped with an advanced DTrace-based facility for server analytics so you can examine the details of different layers of the storage stack. Analytics provides real-time graphs of various statistics, which you can save for later viewing. It is designed for both long-term monitoring and short-term analysis.

To manage and monitor Analytics, use these tasks:

- Setting a Retention Policy - [BUI](#), [CLI](#)
- Setting a Hostname Lookup Policy - [BUI](#), [CLI](#)
- Creating a Worksheet - [BUI](#), [CLI](#)
- Closing a Worksheet - [BUI](#)
- Saving a Worksheet - [BUI](#)
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- When to Add More Write Log Devices - [BUI](#), [CLI](#)
- When to Add More Disks - [BUI](#), [CLI](#)
- Configuring a Threshold Alert - [BUI](#), [CLI](#)
- Exporting a Worksheet - [BUI](#), [CLI](#)
- Downloading a Dataset to a CSV File - [BUI](#)
- Viewing a Dataset in a CSV Format - [CLI](#)

For information about Analytics worksheets, datasets, and statistics, see these topics:

- [Analytics Data Retention Policies](#)
- [Understanding Analytics Worksheets](#)
- [About Analytics Datasets](#)
- [Understanding Analytics Statistics](#)
- [Using Advanced Analytics Statistics](#)

## Setting a Retention Policy (BUI)

Use the following task to set a retention policy, which limits the amount of data collected over a retention period. To preserve disk space, it is strongly recommended that you set retention policies to meet your minimum business requirements. The maximum retention period is two years.

1. From the **Analytics** menu, select **Settings**.
2. Type an integer value into the text box.
3. From the drop-down menu, select one of the following retention periods: **hours**, **days**, **weeks**, **months**.
4. Click **APPLY** to save the retention settings.

## Setting a Retention Policy (CLI)

Use the following task to set a retention policy, which limits the amount of data collected over a retention period. To preserve disk space, it is strongly recommended that you set retention policies to meet your minimum business requirements. The maximum retention period is two years, or 17520 hours.

1. Go to analytics settings.  

```
hostname:> analytics settings
```
2. Enter show to view a list of data retention properties.  

```
hostname:analytics settings> show
```

```
Properties:  
retain_second_data = all  
retain_minute_data = all  
retain_hour_data = all  
hostname_lookup = true
```

3. Set the data retention interval and define a retention policy.

The retention policy is measured in hours. If you want to set your policy to a certain number of days, weeks, or months, you must first calculate the number of hours in that period. In the following example, set `retain_second_data=72` retains data recorded at a per-second interval for 72 hours, or 3 days.

```
hostname:analytics settings> set retain_second_data=72  
retain_second_data = 3 days (uncommitted)
```

4. Enter commit.

```
hostname:analytics settings> commit
```

## Setting a Hostname Lookup Policy (BUI)

Use the following task to enable or disable a hostname lookup policy for statistics that are broken down by client or by hostname. Enabling hostname lookup performs hostname resolution for each IP address in the breakdown, and then stores and displays the data by hostname. This is the default setting.

Disabling hostname lookup saves all client breakdowns by their IP addresses, which reduces overhead and improves performance.

Changing the hostname lookup policy results in a breakdown that contains both hostnames and IP addresses. For example, if you disable hostname lookup and then enable it, the old breakdowns display as IP addresses and the new breakdowns display as hostnames.

1. From the **Analytics** menu, select **Settings**.
2. Perform one of the following actions:
  - To save client breakdowns by hostname: Select **Enable Hostname Lookup**.
  - To save client breakdowns by IP address: Deselect **Enable Hostname Lookup**.
3. Click **APPLY**.

## Setting a Hostname Lookup Policy (CLI)

Use the following task to enable or disable a hostname lookup policy for statistics that are broken down by client or by hostname. Enabling hostname lookup performs hostname resolution for each IP address in the breakdown, and then stores and displays the data by hostname. This is the default setting.

Disabling hostname lookup saves all client breakdowns by their IP addresses, which reduces overhead and improves performance.

Changing the hostname lookup policy results in a breakdown that contains both hostnames and IP addresses. For example, if you disable hostname lookup and then enable it, the old breakdowns display as IP addresses and the new breakdowns display as hostnames.

1. Go to analytics settings.

```
hostname:> analytics settings
```

2. Enter show.

```
hostname:analytics settings> show
Properties:
retain_second_data = 1 weeks
retain_minute_data = 2 weeks
retain_hour_data = 730 days
hostname_lookup = true
```

3. Perform one of the following actions:

- To save client breakdowns by hostname: Ensure the policy is set to `true`. If not, enter `set hostname_lookup=true` and then enter `commit`.

```
hostname:analytics settings> set hostname_lookup=true
hostname_lookup = true (uncommitted)
hostname:analytics settings> commit
```

- To save client breakdowns by IP address: Ensure the policy is set to `false`. If not, enter `set hostname_lookup=false` and then enter `commit`.

```
hostname:analytics settings> set hostname_lookup=false
                           hostname_lookup = false (uncommitted)
hostname:analytics settings> commit
```

## Managing Worksheets

Worksheets are the main interface for Analytics. To work with worksheets, use the following tasks:

- Creating a Worksheet - [BUI](#), [CLI](#)
- Closing a Worksheet - [BUI](#)
- Saving a Worksheet - [BUI](#)
- Renaming a Worksheet - [CLI](#)
- Destroying a Worksheet - [BUI](#), [CLI](#)
- Cloning a Worksheet - [BUI](#)
- Removing a Dataset from a Worksheet - [BUI](#), [CLI](#)
- Viewing When a Worksheet was Last Modified - [CLI](#)
- Showing Graph Hierarchy - [BUI](#)
- Viewing Available Datasets - [BUI](#), [CLI](#)
- Reading Datasets - [CLI](#)
- Suspending and Resuming All Datasets - [BUI](#), [CLI](#)
- Discarding Data in a Dataset - [BUI](#), [CLI](#)

### Creating a Worksheet (BUI)

Use the following procedure to create a worksheet using the BUI. To save the worksheet after you have created it, see [Saving a Worksheet \(BUI\)](#).

1. From the **Analytics** menu, select **Open Worksheets**, then **New**.
2. Click on **Untitled worksheet**, click in the field, and type a name for the worksheet.
3. Click the add icon  and select a statistic to add to the worksheet.

### Creating a Worksheet (CLI)

Use the following procedure to create a worksheet using the CLI. To add statistics to the worksheet after you have created it, use the tasks in [Working with Analytics](#). The worksheet is automatically saved after you create it.

1. Go to `analytics worksheets`.

```
hostname:> analytics worksheets
```

2. Enter `create` and type the new name of your worksheet.

```
hostname:analytics worksheets> create example_1
```

3. Enter `show` to view a list of open worksheets, including the one that you created.

```
hostname:analytics worksheets> show
Worksheets:
```

WORKSHEET	OWNER	NAME
worksheet-000	root	example_1

## Closing a Worksheet (BUI)

Use the following procedure to close an open worksheet and consequently discard all statistics in the worksheet.

In the CLI, only saved worksheets can be viewed; therefore, there is no CLI equivalent procedure to close an open worksheet.

1. From the **Analytics** menu, select **Open Worksheets**.
2. Click **Worksheets** to view a list of open worksheets.
3. Select the worksheet that you want to close.
4. Click **Close**.

## Saving a Worksheet (BUI)

Worksheets can be saved for later viewing. In consequence, all visible statistics will be archived, meaning that they will continue to save new data after the saved worksheet has been closed.

In the CLI, worksheets are automatically saved after they are created.

1. From the **Analytics** menu, select **Open Worksheets**.
2. Click **Worksheets** to view a list of open worksheets.
3. Select the worksheet that you want to save.
4. Click **Save**.

 **Note:**

When you create a worksheet on a standalone or clustered system, the worksheet statistics are not permanently saved on the controller until you click **Save**.

## Renaming a Worksheet (CLI)

Use the following procedure to rename a saved worksheet.

1. Go to `analytics worksheets`.
2. Enter `show` to view a list of saved worksheets.

```
hostname:> analytics worksheets
Worksheets:
```

```
WORKSHEET      OWNER      NAME
worksheet-000    root      worksheet
...
```

3. Select the worksheet you want to rename, and then list its properties.

```
analytics worksheets> select worksheet-000
analytics worksheet-000> ls
Properties:
        uuid = a442e761-4048-4738-b95f-be0824d7ed09
        name = worksheet
        owner = root
        ctime = 2020-12-14 03:58:28
        mtime = 2020-12-14 03:58:28
```

4. Enter `set name=` and the new name for the worksheet.

```
analytics worksheet-000> set name=test
                           name = test (uncommitted) hostname:
```

5. Commit the change, and list the properties to confirm the new worksheet name.

```
analytics worksheet-000> commit
analytics worksheet-000> ls
Properties:
        uuid = a442e761-4048-4738-b95f-be0824d7ed09
        name = test
        owner = root
        ctime = 2020-12-14 03:58:28
        mtime = 2020-12-14 03:58:28
```

## Destroying a Worksheet (BUI)

Use the following procedure to destroy a saved worksheet.

Datasets in saved worksheets are archived. As such, data is not discarded when a worksheet is destroyed. To discard data in a dataset, see [Discarding Data in a Dataset \(BUI\)](#).

1. From the **Analytics** menu, select **Saved Worksheets**.
2. Hover over a worksheet, and click the discard icon .
3. Click **OK** to confirm your action.

## Destroying a Worksheet (CLI)

Use the following procedure to destroy a saved worksheet.

Datasets in saved worksheets are archived. As such, data is not discarded when a worksheet is destroyed. To discard data in a dataset, see [Discarding Data in a Dataset \(CLI\)](#).

1. Go to `analytics worksheets`.  
  
hostname:> **analytics worksheets**
2. Enter `show` to view a list of saved worksheets.

```
hostname:analytics worksheets> show
Worksheets:
```

```
WORKSHEET      OWNER      NAME
worksheet-000    root      example_1
```

3. Enter `destroy` and the worksheet that you want to destroy.

```
hostname:analytics worksheets> destroy worksheet-000
```

4. Enter `Y` to confirm your action.

```
This will destroy "worksheet-000". Are you sure? (Y/N) Y
hostname:analytics worksheets>
```

## Cloning a Worksheet (BUI)

Use the following procedure to clone, or create a copy of, a worksheet. To save the cloned worksheet after you have created it, see [Saving a Worksheet \(BUI\)](#).

This procedure cannot be performed in the CLI.

1. From the **Analytics** menu, select **Open Worksheets**.
2. Click **Worksheets** to view a list of open worksheets.
3. Select the worksheet that you want to clone.
4. Click **Clone**.
5. To name the cloned worksheet, click on the worksheet name and type a new name for the worksheet.

### Related Topics

- [Closing a Worksheet \(BUI\)](#)
- [Removing a Dataset from a Worksheet \(BUI\)](#)

## Removing a Dataset from a Worksheet (BUI)

Datasets in saved worksheets are archived. As such, data is not discarded when a dataset is removed from a worksheet. To discard data in a dataset, see [Discarding Data in a Dataset \(BUI\)](#).

1. From the **Analytics** menu, select **Saved Worksheets**.
2. Click on the worksheet from which you want to remove a dataset.
3. Click the exit icon  on the upper right-hand corner of the statistic to remove it from the worksheet.

## Removing a Dataset from a Worksheet (CLI)

Datasets in saved worksheets are archived. As such, data is not discarded when a dataset is removed from a worksheet. To discard data in a dataset, see [Discarding Data in a Dataset \(CLI\)](#).

1. Go to `analytics worksheets`.
- ```
hostname:> analytics worksheets
```
2. Enter `show` to view a list of open worksheets.

```
hostname:analytics worksheets> show
Worksheets:
```

| WORKSHEET     | OWNER | NAME      |
|---------------|-------|-----------|
| worksheet-000 | root  | example_1 |
| worksheet-001 | root  | example_2 |

3. Enter **select** and the worksheet from which you want to remove a dataset.

```
hostname:analytics worksheets> select worksheet-000
```

4. Enter **show** to view a list of datasets in the worksheet.

```
hostname:analytics worksheet-000> show
Properties:
```

|                                             |
|---------------------------------------------|
| uuid = e268333b-c1f0-401b-97e9-ff7f8ee8dc9b |
| name = 830 MB/s NFSv3 disk                  |
| owner = root                                |
| ctime = 2020-9-4 20:04:28                   |
| mtime = 2020-9-4 20:07:24                   |

```
Datasets:
```

| DATASET     | DATE     | SECONDS | NAME                  |
|-------------|----------|---------|-----------------------|
| dataset-000 | 2020-9-4 | 60      | nic.kilobytes[device] |
| dataset-001 | 2020-9-4 | 60      | io.bytes[op]          |

5. Enter **remove** and the dataset that you want to remove.

```
hostname:analytics worksheet-000> remove dataset-000
This will remove "dataset-000". Are you sure? (Y/N)
```

6. Enter **Y** to confirm your action.

The modified worksheet is automatically saved.

## Viewing When a Worksheet was Last Modified (CLI)

Use this procedure to view the time that a saved worksheet was last modified. This time can be useful for auditing purposes, and for determining the time that a dataset within the worksheet was modified. For example, it is helpful to know when a dataset was added to a worksheet when troubleshooting a problem. The worksheet last modified time can also be compared to such events as a dataset suspension. This procedure is not supported in the BUI.

1. Go to **analytics worksheets**.

```
hostname:> analytics worksheets
```

2. Enter **select** and the name of the saved worksheet.

```
hostname:analytics worksheets> select worksheet-001
```

3. Enter **get mtime**.

```
hostname:analytics worksheet-001> get mtime
mtime = 2020-6-1 13:09:01
```

## Showing Graph Hierarchy

Graphs that are broken down by filename have a special feature that allows you to view the hierarchical breakdown of traced filenames. As with graphs, the left panel will show components based on the statistic breakdown. If the filenames become too long

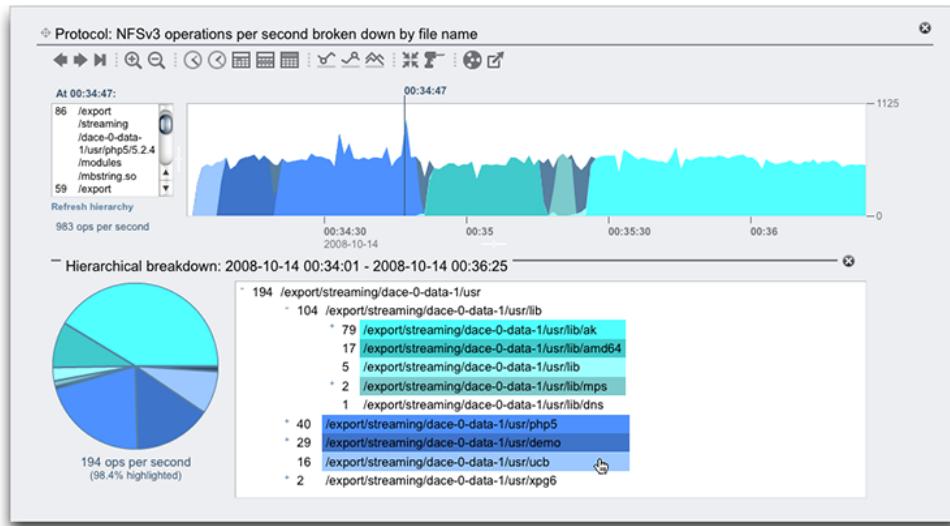
to fit in the left panel, you can expand it by clicking and dragging the divider between the panel and the graph.

1. Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
2. Click the add icon  and select a statistic broken down by filename.

Not all statistics can be broken down by filename. The following statistics can be broken down by filename:

- CACHE: ARC accesses
- CACHE: L2ARC accesses
- DATA MOVEMENT: Shadow migration bytes
- DATA MOVEMENT: Shadow migration ops
- DATA MOVEMENT: Shadow migration requests
- PROTOCOL: FTP bytes
- PROTOCOL: HTTP/WebDAV requests
- PROTOCOL: NDMP bytes
- PROTOCOL: NDMP operations
- PROTOCOL: NFSv2 bytes
- PROTOCOL: NFSv2 operations
- PROTOCOL: NFSv3 bytes
- PROTOCOL: NFSv3 operations
- PROTOCOL: NFSv4 bytes
- PROTOCOL: NFSv4 operations
- PROTOCOL: NFSv4.1 bytes
- PROTOCOL: NFSv4.1 operations
- PROTOCOL: SFTP bytes
- PROTOCOL: SMB operations
- PROTOCOL: SMB2 operations

3. Click **Show hierarchy** on the left side of the statistic.
4. Click **Refresh hierarchy** to update the pie chart and tree view.
5. Click the exit icon  , in the upper-right corner, to close the hierarchical breakdown.



### Related Topics

- [Adjusting Graphs](#)
- [Adjusting Quantize Plots](#)
- [Background Patterns](#)
- [Toolbar Reference](#)

## Viewing Available Datasets (BUI)

Statistics that are being viewed in an open worksheet are temporary datasets that disappear when the worksheet is closed. You can view these temporary datasets, as well as statistics that are archived to disk, as a list on one page.

In the BUI, you can also view since when the analytics dataset was created, and when the data was last accessed. The last access time of an Analytics dataset is updated when a dataset is created, read, saved, resumed, or used to plot graph in the BUI.

- From the **Analytics** menu, select **Datasets**.

## Viewing Available Datasets (CLI)

Use the following procedure to view available datasets using the CLI.

1. Go to `analytics datasets`.
2. Enter `show` to view a list of active and suspended datasets.

In the example below, `dataset-007` is a temporary statistic because `ONDISK size` is `0` (zero). All other statistics are archived.

**Note:**

The names of the statistics are abbreviated versions of what is visible in the BUI. For example, `dnlc.accesses` is short for Cache: DNLC accesses per second.

```
hostname:analytics datasets> show
Datasets:

DATASET      STATE     INCORE ONDISK NAME
dataset-000  active    674K  35.7K arc.accesses[hit/miss]
dataset-001  active    227K  31.1K arc.l2_accesses[hit/miss]
dataset-002  active    227K  31.1K arc.l2_size
dataset-003  active    227K  31.1K arc.size
dataset-004  active    806K  35.7K arc.size[component]
dataset-005  active    227K  31.1K cpu.utilization
dataset-006  active    451K  35.6K cpu.utilization[mode]
dataset-007  active    57.7K   0 dnlc.accesses
dataset-008  active    490K  35.6K dnlc.accesses[hit/miss]
dataset-009  active    227K  31.1K http.reqs
dataset-010  active    227K  31.1K io.bytes
dataset-011  active    268K  31.1K io.bytes[op]
dataset-012  active    227K  31.1K io.ops
...

```

3. To view specific dataset properties, enter `select` and the name of the dataset.

```
hostname:analytics datasets> select dataset-007
```

4. Enter `show` to list the properties for the selected dataset. The properties include when the dataset was created and last accessed. The last access date and time is updated when a dataset is created, read, saved or resumed.

```
hostname:analytics dataset-007> show
Properties:
          name = dnlc.accesses
          grouping = Cache
          explanation = DNLC accesses per second
          incore = 65.5K
          size = 0
          suspended = false
          since = m 2020-1-2 08:30:11
          last_access = 2020-10-3 01:35:47
```

## Reading Datasets (CLI)

Use the following procedure to read datasets.

In the BUI, the same information is presented in a graph. For more information, see [Worksheet Graphs and Plots](#).

1. Go to `analytics datasets`.
2. Enter `show` to view a list of available datasets.
3. Enter `select` and the name of the dataset that you want to read.

```
hostname:analytics datasets> select dataset-007
```

4. Enter `read` and the number of previous seconds to display.

```
hostname:analytics dataset-007> read 10
DATE/TIME          /SEC      /SEC BREAKDOWN
2020-10-14 21:25:19   137      - -
2020-10-14 21:25:20   215      - -
2020-10-14 21:25:21   156      - -
2020-10-14 21:25:22   171      - -
2020-10-14 21:25:23  2722      - -
2020-10-14 21:25:24   190      - -
2020-10-14 21:25:25   156      - -
2020-10-14 21:25:26   166      - -
2020-10-14 21:25:27   118      - -
2020-10-14 21:25:28  1354      - -
```

Breakdowns will also be listed, if available. The following example shows CPU utilization broken down by CPU mode (user/kernel), which corresponds to dataset-006.

In this example, line 21:30:10 shows 14% kernel time and 1% user time, which adds up to 15% total utilization.

```
hostname:analytics datasets> select dataset-006
hostname:analytics dataset-006> read 5
DATE/TIME          %UTIL      %UTIL BREAKDOWN
2020-10-14 21:30:07    7        6 kernel
0 user
2020-10-14 21:30:08    7        7 kernel
0 user
2020-10-14 21:30:09    0        - -
2020-10-14 21:30:10   15        14 kernel
1 user
2020-10-14 21:30:11   25        24 kernel
1 user
```

5. To print comma-separated values (CSV) for a number of seconds of data, enter `csv` and the number of seconds.

```
hostname:analytics datasets> select dataset-022
hostname:analytics dataset-022> csv 10
Time (UTC),Operations per second
2020-03-21 18:30:02,0
2020-03-21 18:30:03,0
2020-03-21 18:30:04,0
2020-03-21 18:30:05,0
2020-03-21 18:30:06,0
2020-03-21 18:30:07,0
2020-03-21 18:30:08,0
2020-03-21 18:30:09,0
2020-03-21 18:30:10,0
2020-03-21 18:30:11,0
```

## Suspending and Resuming a Dataset (BUI)

Use the following procedure to suspend and resume a single dataset. It is not possible to suspend or resume all datasets with one action using the BUI; you must use the CLI. To suspend or resume all datasets at once, see [Suspending and Resuming All Datasets \(CLI\)](#).

1. From the **Analytics** menu, select **Datasets**.

2. Hover over a dataset, and click the suspend/resume icon  to suspend it.  
The green icon indicating that a dataset is actively collecting data will turn gray.
3. Hover over a suspended dataset, and click the suspend/resume icon  again to resume it.  
The gray icon indicating that a dataset is suspended will turn green.

## Suspending and Resuming a Dataset (CLI)

The CLI has the ability to suspend and resume individual or all datasets. Use the following procedure to suspend or resume an individual dataset. To suspend or resume all datasets at once, see [Suspending and Resuming All Datasets \(CLI\)](#).

1. Go to analytics datasets.
2. Enter `select` and the name of the dataset that you want to suspend.

```
hostname:analytics datasets> select dataset-043
```

3. Enter `set suspended=true`.

```
hostname:analytics dataset-043> set suspended=true
suspended = true (uncommitted)
```

4. Enter `commit`.

```
hostname:analytics dataset-043> commit
```

5. To resume the dataset, enter `set suspended=false`.

```
hostname:analytics dataset-043> set suspended=false
suspended = false (uncommitted)
```

6. Enter `commit`.

```
hostname:analytics dataset-043> commit
```

## Suspending and Resuming All Datasets (CLI)

Use the following procedure to suspend or resume all datasets at once. To suspend or resume an individual dataset, see [Suspending and Resuming a Dataset \(CLI\)](#).

In the BUI, it is not possible to suspend or resume all datasets at once. Datasets must be suspended or resumed individually.

1. Go to analytics datasets.
2. Enter `suspend` to suspend all datasets.

```
hostname:analytics datasets> suspend
This will suspend all datasets. Are you sure? (Y/N) Y
```

3. Enter `Y` to confirm that you want to suspend all datasets.
4. Enter `show` to view a list of suspended datasets.

```
hostname:analytics datasets> show
Datasets:
```

| DATASET     | STATE   | INCORE | ONDISK | NAME                   |
|-------------|---------|--------|--------|------------------------|
| dataset-000 | suspend | 638K   | 584K   | arc.accesses[hit/miss] |

```
dataset-001 suspend 211K 172K arc.12_accesses[hit/miss]
dataset-002 suspend 211K 133K arc.12_size
dataset-003 suspend 211K 133K arc.size
...
```

5. Enter **resume** to resume all datasets.

```
hostname:analytics datasets> resume
```

6. Enter **show** to view a list of active datasets.

```
hostname:analytics datasets> show
Datasets:
```

| DATASET     | STATE  | INCORE | ONDISK | NAME                      |
|-------------|--------|--------|--------|---------------------------|
| dataset-000 | active | 642K   | 588K   | arc.accesses[hit/miss]    |
| dataset-001 | active | 215K   | 174K   | arc.12_accesses[hit/miss] |
| dataset-002 | active | 215K   | 134K   | arc.12_size               |
| dataset-003 | active | 215K   | 134K   | arc.size                  |

```
...
```

## Discarding Data in a Dataset (BUI)

Use the following procedure to discard an entire archived dataset, or a portion of an archived dataset. Datasets are automatically pruned according to the existing retention policy, but they can also be pruned manually. This process might take several minutes to complete, depending on the size of the dataset and the amount of pruning required. If you discard an entire dataset, the **ONDISK** size is 0 (zero). If you discard only a portion of the dataset, the **ONDISK** size is reduced. Note that datasets can only be pruned when they are active.

1. From the **Analytics** menu, select **Dataset**.
2. Hover over a dataset, and click the discard icon .
3. Select one of the following options:
  - a. To discard the entire dataset, select **Entire dataset** and skip to step 5.
  - b. To discard only a portion of the dataset, uncheck **Entire dataset**, select a data granularity of **second**, **minute**, or **hour**, and continue to step 4.
4. Select one of the following options:
  - a. To discard all data from the selected granularity, select **All**.
  - b. To discard data after a certain period of time, select **Older than**, type an integer value into the text box, and select one of the following time periods: **hours**, **days**, **weeks**, or **months**.
5. Click **OK**.

## Discarding Data in a Dataset (CLI)

Use the following procedure to discard an entire archived dataset, or a portion of an archived dataset. Datasets are automatically pruned according to the existing retention policy, but they can also be pruned manually. This process might take several minutes to complete, depending on the size of the dataset and the amount of pruning required. Note that datasets can only be pruned when they are active.

1. Go to analytics datasets.

2. Enter `show` to view a list of active datasets.

```
hostname:analytics datasets> show
Datasets:

DATASET      STATE      INCORE    ONDISK   NAME
dataset-000  active     1.27M    15.5M   arc.accesses[hit/miss]
dataset-001  active      517K    9.21M   arc.accesses[hit/miss=metadata hits][L2ARC
eligibility]
...
dataset-005  active     290K    7.80M   cpu.utilization
```

3. Select one of the following options:

- a. To discard an entire archived dataset, enter `destroy` and the dataset. Then enter `Y` to confirm your action.

```
hostname:analytics datasets> destroy dataset-005
This will destroy "dataset-005". Are you sure? (Y/N) Y
```

- b. To discard only a portion of an archived dataset, enter `select` and the name of the archived dataset that you want to prune. Then enter `prune`, with any of these options: `date`, `time`, or `granularity`.

- `date` - A date before which all data is removed. If a date is not specified, then the default is the present date and time. Enter the date using this format: `year-month-date`.
- `time` - The time before which all data is removed. If a time is not specified, then the default is 12:00 AM, or 00:00 in 24-hour notation. Enter the time in 24-hour notation, using this format: `hour:minute:second`.
- `granularity` - The level of data that is removed. The granularity can be presented as one of the following: `second`, `minute`, or `hour`.

If `minute` or `hour` is specified, the lower level of data granularity is also deleted. For example, using the `prune hour` command also deletes the per-second and per-minute data.

Detailed datasets can be pruned on several levels to reduce the quantity of saved data, which allows you to archive only a portion of the dataset. For example, use a series of `prune` commands to keep a day's worth of per-second data, a couple weeks of per-minute data, and six months of per-hour data. See Example 1-4.

### Example 1-1 Pruning by Granularity

In the following example, only the granularity is specified. This example discards all per-second and per-minute data collected before 4:56 PM on April 2, 2020.

```
hostname:analytics datasets> select dataset-001
hostname:analytics dataset-001> prune minute
This will remove per-second and minute data collected prior to 2020-04-02
16:56:52.
```

Are you sure? (Y/N) Y

### Example 1-2 Pruning by Date

In the following example, only a date is specified. This example discards all per-second data collected before midnight on December 1, 2020.

```
hostname:analytics dataset-001> prune 2020-12-01 second
This will remove per-second data collected prior to 2020-12-1 00:00.
```

Are you sure? (Y/N) **Y**

### Example 1-3 Pruning by Date and Time

In the following example, both a date and time are specified. This example discards per-second data collected at and before 12 PM on June 3, 2020.

```
hostname:analytics dataset-001> prune 2020-06-03 12:00:01 second
This will remove per-second data collected prior to 2020-6-3 12:00:01.
```

Are you sure? (Y/N) **Y**

### Example 1-4 Pruning Detailed Datasets

The following **prune** commands keep a day's worth of per-second data, a couple weeks of per-minute data, and six months of per-hour data older than December 15, 2020.

```
hostname:analytics dataset-001> prune 2020-12-14 second
hostname:analytics dataset-001> prune 2020-12-01 minute
hostname:analytics dataset-001> prune 2020-6-01 hour
```

## Identifying CPU Performance Issues (BUI)

Use the following procedure to identify and remedy CPU hardware bottlenecks on Oracle ZFS Storage Appliance. Based on the results of two analytic datasets, suggested corrective actions are provided to increase data throughput.

1. Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
2. Click the add icon  next to **Add statistic**.
3. From the **CPU** menu, select **Percent utilization**, then **As a raw statistic**.
4. Click the add icon  again.
5. From the **CPU** menu, select **Percent utilization**, then **Broken down by CPU identifier**.
6. Wait at least 15 minutes.

#### Note:

Fifteen minutes is a general guideline. This amount of time may be adjusted if you have frequent, short-duration workloads that are CPU intensive.

7. Examine the graph of CPUs broken down by percent utilization.  
If the appliance CPUs reach 100% utilization for more than 15 minutes, you should consider adding more CPUs or upgrading to faster CPUs.
8. Examine the graph of CPU percent utilization broken down by CPU identifier.  
A single CPU core operating at 100% utilization while the others are relatively idle is a likely indication of a single-threaded and/or single-client workload. Consider

dividing your workload among multiple clients, or investigate a multi-threaded implementation of your client application to better utilize the many CPU cores offered by other controller models.

## Identifying CPU Performance Issues (CLI)

Use the following procedure to identify and remedy CPU hardware bottlenecks on Oracle ZFS Storage Appliance. Based on the results of two analytic datasets, suggested corrective actions are provided to increase data throughput.

1. Create a worksheet as described in [Creating a Worksheet \(CLI\)](#), select that worksheet, and then enter dataset.

```
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheet-000> dataset
```

2. Enter `set name=cpu.utilization`, and then enter `commit` to add CPU percent utilization as a raw statistic to your worksheet.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set name=cpu.utilization
name = cpu.utilization
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

3. Enter dataset.

```
hostname:analytics worksheet-000> dataset
```

4. Enter `set name=cpu.utilization[cpu]`, and then enter `commit` to add CPU percent utilization broken down by CPU identifier to your worksheet.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set
name=cpu.utilization[cpu]
name = cpu.utilization[cpu]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

5. Enter done, and then enter done again to exit the context.

```
hostname:analytics worksheet-000> done
hostname:analytics worksheets> done
```

6. Wait at least 15 minutes, and then go to analytics datasets.

### Note:

Fifteen minutes is a general guideline. This amount of time may be adjusted if you have frequent, short-duration workloads that are CPU intensive.

```
hostname:> analytics datasets
```

7. Enter `show` to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:

DATASET      STATE      INCORE    ONDISK   NAME
dataset-000  active     1.27M    15.5M   arc.accesses[hit/miss]
dataset-001  active      517K    9.21M   arc.accesses[hit/miss=metadata hits][L2ARC
eligibility]
...
```

```
dataset-005 active    290K   7.80M  cpu.utilization
hostname:analytics datasets>
```

8. Enter `select` and the dataset with the name `cpu.utilization`.

In this example, dataset name `cpu.utilization` corresponds to `dataset-005`.

```
hostname:analytics datasets> select dataset-005
```

9. Enter `read 900` to read the last 900 seconds, or 15 minutes, of the dataset. When you are finished examining the data, enter `done`.

If the appliance CPUs reach 100% utilization for more than 15 minutes, you should consider adding more CPUs or upgrading to faster CPUs.

```
hostname:analytics dataset-005> read 900
...
hostname:analytics dataset-005> done
```

10. Enter `show` to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:

DATASET      STATE     INCORE   ONDISK   NAME
dataset-000  active    1.27M    15.5M   arc.accesses[hit/miss]
dataset-001  active     517K    9.21M   arc.accesses[hit/miss=metadata hits]
[L2ARC eligibility]
...
dataset-006  active    290K    7.80M   cpu.utilization[cpu]
hostname:analytics datasets>
```

11. Enter `select` and the dataset with the name `cpu.utilization[cpu]`.

In this example, dataset name `cpu.utilization[cpu]` corresponds to `dataset-006`.

```
hostname:analytics datasets> select dataset-006
```

12. Enter `read 900` to read the last 900 seconds, or 15 minutes, of the dataset. When you are finished examining the data, enter `done`.

```
hostname:analytics dataset-006> read 900
...
hostname:analytics dataset-006> done
```

A single CPU core operating at 100% utilization while the others are relatively idle is a likely indication of a single-threaded and/or single-client workload. Consider dividing your workload among multiple clients, or investigate a multi-threaded implementation of your client application to better utilize the many CPU cores offered by other controller models.

## Identifying Network Performance Issues (BUI)

Use the following procedure to identify and remedy network hardware bottlenecks on Oracle ZFS Storage Appliance. Based on the results of the analytic dataset, suggested corrective actions are provided to increase network throughput.

1. Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
2. Click the add icon  next to **Add statistic**.

3. Go to **NETWORK: Device bytes: Broken down by device**.
4. Wait at least 10 minutes.

 **Note:**

Ten minutes is a general guideline. This amount of time may be adjusted if you have shorter-duration workloads that demand maximum available network bandwidth.

5. Examine the graph.

If any network device reaches 95% of its maximum throughput for more than 10 minutes, you might need to install additional network devices.

## Identifying Network Performance Issues (CLI)

Use the following procedure to identify and remedy network hardware bottlenecks on Oracle ZFS Storage Appliance. Based on the results of the analytic dataset, suggested corrective actions are provided to increase network throughput.

1. Create a worksheet as described in [Creating a Worksheet \(CLI\)](#), select that worksheet, and then enter dataset.

```
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheet-000> dataset
```

2. Enter `set name=nic.kilobytes[device]`, and then enter `commit` to add network device bytes broken down by device to your worksheet.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set
name=nic.kilobytes[device]
      name = nic.kilobytes[device]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

3. Enter `done`, and then enter `done` again to exit the context.

```
hostname:analytics worksheet-000> done
hostname:analytics worksheets> done
```

4. Wait at least 10 minutes, and then go to analytics datasets.

 **Note:**

Ten minutes is a general guideline. This amount of time may be adjusted if you have shorter-duration workloads that demand maximum available network bandwidth.

```
hostname:> analytics datasets
```

5. Enter `show` to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:
```

| DATASET | STATE | INCORE | ONDISK | NAME |
|---------|-------|--------|--------|------|
|---------|-------|--------|--------|------|

```

dataset-000 active    1.27M  15.5M  arc.accesses[hit/miss]
dataset-001 active     517K   9.21M  arc.accesses[hit/miss=metadata hits]
[L2ARC eligibility]
...
dataset-032 active    290K   7.80M  nic.kilobytes[device]
hostname:analytics datasets>

```

6. Enter `select` and the dataset with the name `nic.kilobytes[device]`.

In this example, dataset name `nic.kilobytes[device]` corresponds to dataset-032.

```
hostname:analytics datasets> select dataset-032
```

7. Enter `read 600` to read the last 600 seconds, or 10 minutes, of the dataset. When you are finished examining the data, enter `done`.

```

hostname:analytics dataset-032> read 600
...
hostname:analytics dataset-032> done

```

If any network device reaches 95% of its maximum throughput for more than 10 minutes, you might need to install additional network devices.

## Identifying Memory Performance Issues (BUI)

Use the following procedure to identify and remedy memory hardware bottlenecks on Oracle ZFS Storage Appliance. Based on the results of the analytic dataset, suggested corrective actions are provided to increase memory performance by installing more DRAM.

1. Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
2. Click the add icon  next to **Add statistic**.
3. Go to **CACHE: ARC accesses: Broken down by hit/miss**.
4. Wait at least 10 minutes.

 **Note:**

Ten minutes is a general guideline. The amount of time may be adjusted if you have shorter-duration workloads that are memory intensive.

5. Examine the graph.

You might want to install more DRAM when all of the conditions in the following table are present.

| Condition                                                                         | Description                                                                                         |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| ARC access hits for data or metadata are at least 75-97% compared to misses       | The ARC is providing a benefit by storing data or metadata that the applications need.              |
| ARC access hits for data or metadata are significantly greater than prefetch hits | The majority of the ARC accesses are for real applications rather than just the prefetch mechanism. |

| Condition                                                                   | Description                                                                                                                                                                |
|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ARC is accessed at least 10,000 times per second                            | Oracle ZFS Storage Appliance is hitting DRAM, which is not the typical utilization of an idle system.                                                                      |
| Nearly all memory is consumed by the ARC, leaving very little unused memory | Oracle ZFS Storage Appliance is utilizing all of the DRAM possible for the ARC, not just serving a hot workload out of a small subset of the DRAM that is already present. |

## Identifying Memory Performance Issues (CLI)

Use the following procedure to identify and remedy memory hardware bottlenecks on Oracle ZFS Storage Appliance. Based on the results of the analytic dataset, suggested corrective actions are provided to increase memory performance by installing more DRAM.

1. Create a worksheet as described in [Creating a Worksheet \(CLI\)](#), select that worksheet, and then enter `dataset`.

```
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheet-000> dataset
```

2. Enter `set name=arc.accesses[hit/miss]`, and then enter `commit` to add cache ARC accesses broken down by hit/miss to your worksheet.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set
name=arc.accesses[hit/miss]
      name = arc.accesses[hit/miss]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

3. Enter `done`, and then enter `done` again to exit the context.

```
hostname:analytics worksheet-000> done
hostname:analytics worksheets> done
```

4. Wait at least 10 minutes, and then go to analytics datasets.

 **Note:**

Ten minutes is a general guideline. The amount of time may be adjusted if you have shorter-duration workloads that are memory intensive.

```
hostname:> analytics datasets
```

5. Enter `show` to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:

DATASET      STATE      INCORE    ONDISK   NAME
dataset-000  active     1.27M    15.5M   arc.accesses[hit/miss]
dataset-001  active      517K    9.21M   arc.accesses[hit/miss=metadata hits][L2ARC
eligibility]
...
hostname:analytics datasets>
```

6. Enter `select` and the dataset with the name `arc.accesses [hit/miss]`.

In this example, dataset name `arc.accesses[hit/miss]` corresponds to dataset-000.

```
hostname:analytics datasets> select dataset-000
```

- 7.** Enter `read 600` to read the last 600 seconds, or 10 minutes, of the dataset.

```
hostname:analytics dataset-000> read 600
```

- 8.** Examine the data.

You might want to install more DRAM when all of the conditions in the following table are present.

| Condition                                                                         | Description                                                                                                                                                                |
|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ARC access hits for data or metadata are at least 75-97% compared to misses       | The ARC is providing a benefit by storing data or metadata that the applications need.                                                                                     |
| ARC access hits for data or metadata are significantly greater than prefetch hits | The majority of the ARC accesses are for real applications rather than just the prefetch mechanism.                                                                        |
| ARC is accessed at least 10,000 times per second                                  | Oracle ZFS Storage Appliance is hitting DRAM, which is not the typical utilization of an idle system.                                                                      |
| Nearly all memory is consumed by the ARC, leaving very little unused memory       | Oracle ZFS Storage Appliance is utilizing all of the DRAM possible for the ARC, not just serving a hot workload out of a small subset of the DRAM that is already present. |

## When to Add the First Read Cache Device (BUI)

Use the following procedure to determine if you need a first read cache device for Oracle ZFS Storage Appliance. To determine if you need more than one device, see [When to Add More Read Cache Devices \(BUI\)](#).

- 1.** Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
- 2.** Click the add icon  next to **Add statistic**.
- 3.** Go to **CACHE: ARC accesses: Broken down by hit/miss**.
- 4.** Click **metadata hits** under the **Range average** column to show the graph of ARC accesses per second, broken down by hit/miss.
- 5.** Click the drilldown icon  and select **By L2ARC eligibility**.
- 6.** Click **data hits** to show the graph of ARC accesses per second, broken down by hit/miss.
- 7.** Click the drilldown icon  and select **By L2ARC eligibility**.
- 8.** Wait several minutes.

 **Note:**

This wait time can be adjusted to better determine your peak I/O. Capturing analytics for 24 hours during normal business operations may reveal the best understanding of your I/O patterns.

9. Examine the graphs.

Consider adding the first read cache device when all of the following conditions are present:

- There are at least 1500 L2ARC-eligible ARC access misses for data and/or metadata per second
- Oracle ZFS Storage Appliance has an active filesystem or LUN with a ZFS record size of 32 k or smaller

## When to Add the First Read Cache Device (CLI)

Use the following procedure to determine if you need a first read cache device for Oracle ZFS Storage Appliance. To determine if you need more than one device, see [When to Add More Read Cache Devices \(CLI\)](#).

1. Create a worksheet as described in [Creating a Worksheet \(CLI\)](#), select that worksheet, and then enter dataset.

```
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheet-000> dataset
```

2. Enter `set name=arc.accesses [hit/miss]`, and then enter `commit` to add cache ARC access broken down by hit/miss to your worksheet.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set
name=arc.accesses [hit/miss]
      name = arc.accesses[hit/miss]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

3. Enter dataset.

```
hostname:analytics worksheet-000> dataset
```

4. Repeat steps 2 and 3 to add the following datasets:

- Cache ARC accesses broken down by metadata hits and misses  
("arc.accesses[hit/miss=metadata hits] [L2ARC eligibility]")
- Cache ARC accesses broken down by data hits and misses  
("arc.accesses[hit/miss=data hits] [L2ARC eligibility]")

```
hostname:analytics worksheet-000 dataset (uncommitted)> set
name="arc.accesses [hit/miss=metadata hits] [L2ARC eligibility]"
      name = arc.accesses[hit/miss=metadata hits] [L2ARC
eligibility]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
hostname:analytics worksheet-000> dataset
hostname:analytics worksheet-000 dataset (uncommitted)> set
name="arc.accesses [hit/miss=data hits] [L2ARC eligibility]"
      name = arc.accesses[hit/miss=data hits] [L2ARC
eligibility]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

5. Enter `done`, and then enter `done` again to exit the context.

```
hostname:analytics worksheet-000> done
hostname:analytics worksheets> done
```

6. Wait several minutes, and then go to `analytics datasets`.

 **Note:**

This wait time can be adjusted to better determine your peak I/O. Capturing analytics for 24 hours during normal business operations may reveal the best understanding of your I/O patterns.

```
hostname:> analytics datasets
```

7. Enter **show** to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:
```

| DATASET     | STATE  | INCORE | ONDISK | NAME                                                        |
|-------------|--------|--------|--------|-------------------------------------------------------------|
| dataset-000 | active | 1.27M  | 15.5M  | arc.accesses[hit/miss]                                      |
| dataset-001 | active | 517K   | 9.21M  | arc.accesses[hit/miss=metadata hits]<br>[L2ARC eligibility] |
| ...         |        |        |        |                                                             |

```
hostname:analytics datasets>
```

8. Enter **select** and the dataset with the name `arc.accesses[hit/miss=metadata hits] [L2ARC eligibility]`.

In this example, dataset name `arc.accesses[hit/miss=metadata hits] [L2ARC eligibility]` corresponds to dataset-001.

```
hostname:analytics datasets> select dataset-001
```

9. Enter **read 86400** to read the last 86,400 seconds, or 24 hours, of the dataset. When you are finished examining the data, enter **done**.

```
hostname:analytics dataset-001> read 86400
...
hostname:analytics dataset-001> done
```

Consider adding the first read cache device when all of the following conditions are present:

- There are at least 1500 L2ARC-eligible ARC access misses for metadata per second
- Oracle ZFS Storage Appliance has an active filesystem or LUN with a ZFS recordsize of 32 k or smaller

10. Enter **show** to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:
```

| DATASET     | STATE  | INCORE | ONDISK | NAME                                                        |
|-------------|--------|--------|--------|-------------------------------------------------------------|
| dataset-000 | active | 1.27M  | 15.5M  | arc.accesses[hit/miss]                                      |
| dataset-001 | active | 517K   | 9.21M  | arc.accesses[hit/miss=metadata hits]<br>[L2ARC eligibility] |
| dataset-002 | active | 780K   | 9.20M  | arc.accesses[hit/miss=data hits] [L2ARC eligibility]        |
| ...         |        |        |        |                                                             |

```
hostname:analytics datasets>
```

11. Enter **select** and the dataset with the name `arc.accesses[hit/miss=data hits] [L2ARC eligibility]`.

In this example, dataset name `arc.accesses[hit/miss=data hits] [L2ARC eligibility]` corresponds to dataset-002.

```
hostname:analytics datasets> select dataset-002
```

- 12.** Enter `read 86400` to read the last 86,400 seconds, or 24 hours, of the dataset. When you are finished examining the data, enter `done`.

```
hostname:analytics dataset-002> read 86400  
...  
hostname:analytics dataset-002> done
```

Consider adding the first read cache device when all of the following conditions are present:

- There are at least 1500 L2ARC-eligible ARC access misses for data per second
- Oracle ZFS Storage Appliance has an active filesystem or LUN with a ZFS recordsize of 32 k or smaller

## When to Add More Read Cache Devices (BUI)

Use the following procedure to determine if you need more read cache devices for Oracle ZFS Storage Appliance.

### Before You Begin

From the **Maintenance** menu, select **Hardware** to identify which chassis and slots contain read cache devices.

1. Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
2. Click the add icon  next to **Add statistic**.
3. Go to **DISK: I/O operations: Broken down by disk**.
4. Select a read cache device.
5. Click the drilldown icon  and select **Percent utilization**.
6. Repeat steps 4 and 5 for all existing read cache devices.
7. Wait at least 10 minutes.
8. Examine the graph(s).

You might want to add more read cache devices when existing devices are 90% utilized.

## When to Add More Read Cache Devices (CLI)

Use the following procedure to determine if you need more read cache devices for Oracle ZFS Storage Appliance.

### Before You Begin

Go to `maintenance hardware show` to identify which chassis and slots contain read cache devices.

1. Create a worksheet as described in [Creating a Worksheet \(CLI\)](#), select that worksheet, and then enter `dataset`.

```
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheet-000> dataset
```

- 2.** Add a read cache device to the worksheet, broken down by percent utilization, and then enter `commit`. Repeat for each read cache device used by the appliance.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set
name="io.utilization[disk=hostname/HDD 13]"
    name = io.utilization[disk=hostname/HDD 13]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

- 3.** Enter `done`, and then enter `done` again to exit the context.

```
hostname:analytics worksheet-000> done
hostname:analytics worksheets> done
```

- 4.** Wait at least 10 minutes, and then go to `analytics datasets`.

```
hostname:> analytics datasets
```

- 5.** Enter `show` to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:
```

| DATASET             | STATE  | INCORE | ONDISK | NAME                                 |
|---------------------|--------|--------|--------|--------------------------------------|
| dataset-000         | active | 1.27M  | 15.5M  | arc.accesses[hit/miss]               |
| dataset-001         | active | 517K   | 9.21M  | arc.accesses[hit/miss=metadata hits] |
| [L2ARC eligibility] |        |        |        |                                      |
| ...                 |        |        |        |                                      |
| dataset-021         | active | 290K   | 7.80M  | io.utilization[disk=hostname/HDD 13] |

```
hostname:analytics datasets>
```

- 6.** Enter `select` and the first dataset that you added.

In this example, dataset name `io.utilization[disk=hostname/HDD 13]` corresponds to dataset-021.

```
hostname:analytics datasets> select dataset-021
```

- 7.** Enter `read 600` to read the last 600 seconds, or 10 minutes, of the dataset.

```
hostname:analytics dataset-021> read 600
```

- 8.** Repeat steps 6 and 7 for each dataset that you added to the worksheet.

- 9.** Examine the data.

You might want to add more read cache devices when existing devices are 90% utilized.

## When to Add the First Write Log Device (BUI)

Use this procedure to determine if you need a first write log device for Oracle ZFS Storage Appliance. Fibre Channel and iSCSI writes are synchronous and benefit from log devices when the write cache is enabled. Be sure to thoroughly read and understand the documented implications of enabling write caching on LUNs before proceeding. For more information, see [Space Management for Shares in Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x](#).

To determine if you need to add more than one write log device, see [When to Add More Write Log Devices \(BUI\)](#).

1. Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
2. Click the add icon  next to **Add statistic**.
3. Go to **PROTOCOL: NFSv2 operations: Broken down by type of operation**.
4. Repeat steps 2 and 3 for each protocol that is configured for your appliance.
5. Wait at least 15 minutes.

 **Note:**

Fifteen minutes is a general guideline. This amount of time may be adjusted if you have a performance-sensitive, short-duration synchronous write workload.

6. Examine the graph(s).

Consider adding a write log device when one or all of the following conditions are present:

- The sum of iSCSI writes, Fibre Channel writes, and NFS/SMB synchronous operations is at least 1000 per second
- There are at least 100 NFS commits per second

## When to Add the First Write Log Device (CLI)

Use this procedure to determine if you need a first write log device for Oracle ZFS Storage Appliance. Fibre Channel and iSCSI writes are synchronous and benefit from log devices when the write cache is enabled. Be sure to thoroughly read and understand the documented implications of enabling write caching on LUNs before proceeding. For more information, see [Space Management for Shares](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*.

To determine if you need to add more than one write log device, see [When to Add More Write Log Devices \(CLI\)](#).

1. Create a worksheet as described in [Creating a Worksheet \(CLI\)](#), select that worksheet, and then enter `dataset`.

```
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheet-000> dataset
```

2. Enter `set name=nfs2.ops [op]`, and then enter `commit` to add NFSv2 operations per second broken down by type of operation to your worksheet.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set name=nfs2.ops [op]
  name = nfs2.ops[op]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

3. Enter `dataset`.

4. Repeat steps 2 and 3 to add the following datasets:

- NFSv3 operations per second, broken down by type of operation (`nfs3.ops [op]`)
- NFSv4 operations per second, broken down by type of operation (`nfs4.ops [op]`)
- NFSv4.1 operations per second, broken down by type of operation (`nfs4-1.ops [op]`)

- iSCSI operations per second, broken down by type of operation (`iscsi.ops[op]`)
- Fibre Channel operations per second, broken down by type of operation (`fc.ops[op]`)
- SMB operations per second, broken down by type of operation (`smb.ops[op]`)

```

hostname:analytics worksheet-000 dataset (uncommitted)> set
name=nfs3.ops[op]
    name = nfs3.ops[op]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
hostname:analytics worksheet-000> dataset
hostname:analytics worksheet-000 dataset (uncommitted)> set
name=nfs4.ops[op]
    name = nfs4.ops[op]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
hostname:analytics worksheet-000> dataset
hostname:analytics worksheet-000 dataset (uncommitted)> set
name=nfs4-1.ops[op]
    name = nfs4-1.ops[op]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
hostname:analytics worksheet-000> dataset
hostname:analytics worksheet-000 dataset (uncommitted)> set
name=iscsi.ops[op]
    name = iscsi.ops[op]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
hostname:analytics worksheet-000> dataset
hostname:analytics worksheet-000 dataset (uncommitted)> set name=fc.ops[op]
    name = fc.ops[op]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
hostname:analytics worksheet-000> dataset
hostname:analytics worksheet-000 dataset (uncommitted)> set
name=smb.ops[op]
    name = smb.ops[op]
hostname:analytics worksheet-000 dataset (uncommitted)> commit

```

5. Enter `done`, and then enter `done` again to exit the context.

```

hostname:analytics worksheet-000> done
hostname:analytics worksheets> done

```

6. Wait at least 15 minutes, and then go to analytics datasets.

 **Note:**

Fifteen minutes is a general guideline. This amount of time may be adjusted if you have a performance-sensitive, short-duration synchronous write workload.

```
hostname:> analytics datasets
```

7. Enter `show` to view a list of available datasets.

```

hostname:analytics datasets> show
Datasets:

```

```
DATASET      STATE      INCORE    ONDISK   NAME
dataset-000  active     1.27M    15.5M   arc.accesses[hit/miss]
dataset-001  active     517K    9.21M   arc.accesses[hit/miss=metadata hits][L2ARC
eligibility]
...
dataset-030  active     290K    7.80M   nfs2.ops[op]
hostname:analytics datasets>
```

8. Enter **select** and the dataset with the name **nfs2.ops [op]**.

In this example, dataset name **nfs2.ops [op]** corresponds to dataset-030.

```
hostname:analytics datasets> select dataset-030
```

9. Enter **read 900** to read the last 900 seconds, or 15 minutes, of the dataset, and copy and save the data to your environment for future reference.

```
hostname:analytics dataset-030> read 900
```

10. Enter **done**.

```
hostname:analytics dataset-030> done
```

11. Repeat steps 7 through 10 for the following datasets:

- NFSv3 operations per second, broken down by type of operation (**nfs3.ops [op]**)
- NFSv4 operations per second, broken down by type of operation (**nfs4.ops [op]**)
- NFSv4.1 operations per second, broken down by type of operation (**nfs4-1.ops [op]**)
- iSCSI operations per second, broken down by type of operation (**iscsi.ops [op]**)
- Fibre Channel operations per second, broken down by type of operation (**fc.ops [op]**)
- SMB operations per second, broken down by type of operation (**smb.ops [op]**)

 **Note:**

Remember to copy and save the data for each dataset to your environment for future reference.

```
hostname:analytics datasets> show
...
hostname:analytics datasets> select dataset-032
hostname:analytics dataset-032> read 900
...
hostname:analytics dataset-032> done
hostname:analytics datasets> show
...
hostname:analytics datasets> select dataset-034
...
hostname:analytics datasets> select dataset-27
...
hostname:analytics datasets> select dataset-13
...
hostname:analytics datasets> select dataset-07
...
hostname:analytics datasets> select dataset-40
```

**12.** Examine the data.

You might want to add the first write log device when one or all of the following conditions are present:

- The sum of iSCSI writes, Fibre Channel writes, and NFS/SMB synchronous operations is at least 1000 per second
- There are at least 100 NFS commits per second

## When to Add More Write Log Devices (BUI)

Use the following procedure to determine if you need more write log devices for Oracle ZFS Storage Appliance.

### Before You Begin

From the **Maintenance** menu, select **Hardware** to identify which chassis and slots contain write cache devices.

1. Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
2. Click the add icon  next to **Add statistic**.
3. Go to **DISK: Disks: Broken down by percent utilization**.
4. Select a write log device.
5. Click the drilldown icon  and select **As a raw statistic**.
6. Repeat steps 4 and 5 for all existing write log devices.
7. Wait at least 10 minutes.

#### Note:

Ten minutes is a general guideline. This amount of time may be adjusted if you have a performance-sensitive, short-duration synchronous write workload.

8. Examine the graph(s).

You might want to add more write log devices when existing devices are 90% utilized.

## When to Add More Write Log Devices (CLI)

Use the following procedure to determine if you need more write log devices for Oracle ZFS Storage Appliance.

1. Create a worksheet as described in [Creating a Worksheet \(CLI\)](#), select that worksheet, and then enter dataset.

```
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheet-000> dataset
```

2. Enter `set name="io.disks[utilization=90]"`, and then enter `commit` to add disks with utilization of at least 90% to your worksheet.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set
name="io.disks[utilization=90]"
    name = io.disks[utilization=90]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

3. Enter done, and then enter done again to exit the context.

```
hostname:analytics worksheet-000> done
hostname:analytics worksheets> done
```

4. Wait at least 10 minutes, and then go to analytics datasets.

 **Note:**

Ten minutes is a general guideline. This amount of time may be adjusted if you have a performance-sensitive, short-duration synchronous write workload.

```
hostname:> analytics datasets
```

5. Enter show to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:
```

| DATASET     | STATE  | INCORE | ONDISK | NAME                                                     |
|-------------|--------|--------|--------|----------------------------------------------------------|
| dataset-000 | active | 1.27M  | 15.5M  | arc.accesses[hit/miss]                                   |
| dataset-001 | active | 517K   | 9.21M  | arc.accesses[hit/miss=metadata hits] [L2ARC eligibility] |
| ...         |        |        |        |                                                          |
| dataset-019 | active | 290K   | 7.80M  | io.disks[utilization=90]                                 |

6. Enter select and the dataset with the name io.disks[utilization=90].

In this example, dataset name io.disks[utilization=90] corresponds to dataset-019.

```
hostname:analytics datasets> select dataset-019
```

7. Enter read 600 to read the last 600 seconds, or 10 minutes, of the dataset.

```
hostname:analytics dataset-019> read 600
```

8. Examine the data.

You might want to add more write log devices when existing devices are 90% utilized.

## When to Add More Disks (BUI)

Use this procedure to determine if you need to add more disks. Note that disks can be over-utilized by making a poor choice for the RAID profile and/or ZFS record size. In this case, it might be possible to reduce existing disk utilization by moving from RAIDZ to mirrored profiles, and/or matching ZFS record sizes to client I/O sizes.

In addition, if the system is configured with no read- or write-optimized flash drives, then all of the I/O operations beyond DRAM are served by disks. For better performance, consider using flash for any workload that includes random reads or synchronous writes.

1. Create a worksheet as described in [Creating a Worksheet \(BUI\)](#).
2. Click the add icon  next to **Add statistic**.

3. Go to **DISK: Disks: Broken down by percent utilization**.
4. Right-click on **70% range average** and click **By disk**.
5. Wait at least 30 minutes.

 **Note:**

Thirty minutes is a general guideline. If you have short-duration workloads that are bottlenecked on disk utilization, you may want to consider selecting additional disks at less than 30 minutes.

6. Examine the graphs.

You might want to use more disks when at least 50% of existing disks are at least 70% utilized.

## When to Add More Disks (CLI)

Use this procedure to determine if you need to add more disks. Note that disks can be over-utilized by making a poor choice for the RAID profile and/or ZFS record size. In this case, it might be possible to reduce existing disk utilization by moving from RAIDZ to mirrored profiles, and/or matching ZFS record sizes to client I/O sizes.

In addition, if the system is configured with no read- or write-optimized flash drives, then all of the I/O operations beyond DRAM are served by disks. For better performance, consider using flash for any workload that includes random reads or synchronous writes.

1. Create a worksheet as described in [Creating a Worksheet \(CLI\)](#), select that worksheet, and then enter dataset.

```
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheet-000> dataset
```

2. Enter `set name="io.disks[utilization=70]"` and then enter `commit` to add disks with utilization of at least 70% to your worksheet.

```
hostname:analytics worksheet-000 dataset (uncommitted)> set
name="io.disks[utilization=70]"
      name = io.disks[utilization=70]
hostname:analytics worksheet-000 dataset (uncommitted)> commit
```

3. Enter `done`, and then enter `done` again to exit the context.

```
hostname:analytics worksheet-000> done
hostname:analytics worksheets> done
```

4. Wait at least 30 minutes, and then go to `analytics datasets`.

 **Note:**

Thirty minutes is a general guideline. If you have short-duration workloads that are bottlenecked on disk utilization, you may want to consider selecting additional disks at less than 30 minutes.

```
hostname:> analytics datasets
```

5. Enter **show** to view a list of available datasets.

```
hostname:analytics datasets> show
Datasets:

DATASET      STATE      INCORE    ONDISK   NAME
dataset-000  active     1.27M    15.5M   arc.accesses[hit/miss]
dataset-001  active      517K    9.21M   arc.accesses[hit/miss=metadata hits][L2ARC
eligibility]
...
dataset-025  active     290K    7.80M   io.disks[utilization=70]
hostname:analytics datasets>
```

6. Enter **select** and the dataset with the name **io.disks[utilization=70]**.

In this example, dataset name **io.disks[utilization=70]** corresponds to dataset-025.

```
hostname:analytics datasets> select dataset-025
```

7. Enter **read 1800** to read the last 1800 seconds, or 30 minutes, of the dataset.

```
hostname:analytics dataset-025> read 1800
```

8. Examine the data.

You might want to use more disks when at least 50% of existing disks are at least 70% utilized.

## Configuring a Threshold Alert (BUI)

Use this procedure to be automatically notified when a specific dataset exceeds or falls below a set threshold level.

If the automatic suspend policy is enabled, the dataset and the corresponding statistics will be automatically suspended when the maximum idle time you set for the threshold is exceeded. To improve the system performance, you can enable this policy and set a shorter time period for the configurable threshold. Note that the automatic suspend policy does not apply to dashboard datasets and datasets used to collect trendable statistics.

1. From the **Configuration** menu, select **Alerts**.
2. Click **Threshold alerts**, and then click its add icon .
3. For **Threshold**, select a dataset, when the alert should be generated, and type the percentage value.
4. For **Timing**, type a value and select an interval.
5. If you want to be notified of events only within a certain time period, or only on certain days, select the appropriate check boxes and values.
6. If you want to be notified of the same event continuously while the condition exists, select the appropriate repost check boxes, enter values, and select intervals.
7. For **Alert actions**, select an action and complete any accompanying fields.
8. Click **TEST** to test the alert action.
9. Click **APPLY**.

For more information about setting threshold alerts, see [Adding Threshold Alerts](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*.

## Configuring a Threshold Alert (CLI)

Use this procedure to be automatically notified when a specific dataset exceeds or falls below a set threshold level.

If the automatic suspend policy is enabled, the dataset and the corresponding statistics will be automatically suspended when the maximum idle time you set for the threshold is exceeded. To improve the system performance, you can enable this policy and set a shorter time period for the configurable threshold. Note that the automatic suspend policy does not apply to dashboard datasets and datasets used to collect trendable statistics.

1. Go to configuration alerts thresholds.

2. Enter `create`.

```
hostname:configuration alerts thresholds> create
```

3. Enter `show` to view a list of threshold alert properties.

4. Set the properties.

This example sets a capacity threshold alert for the system pool when it exceeds 80 percent for at least one hour on any day of the week. The alert reposts every day while the condition persists, and an alert is also posted when the condition clears for at least one day.

```
hostname:configuration alerts threshold (uncommitted)> set
statname=syscap.percentused
                                statname = syscap.percentused
(uncommitted)
hostname:configuration alerts threshold (uncommitted)> set limit=80
                                limit = 80 (uncommitted)
hostname:configuration alerts threshold (uncommitted)> set minpost=3600
                                minpost = 1 hours (uncommitted)
hostname:configuration alerts threshold (uncommitted)> set days=all
                                days=all (uncommitted)
hostname:configuration alerts threshold (uncommitted)> set frequency=86400
                                frequency = 1 days (uncommitted)
hostname:configuration alerts threshold (uncommitted)> set minclear=86400
                                minclear = 1 days (uncommitted)
```

5. Enter `commit` to complete the task.

```
hostname:configuration alerts threshold (uncommitted)> commit
```

For more information about setting threshold alerts, see [Adding Threshold Alerts](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*.

## Exporting a Worksheet (BUI)

Use this procedure to export a worksheet for the Phone Home Service.

1. Create a worksheet containing the datasets of interest, as described in [Creating a Worksheet \(BUI\)](#).
2. Use this worksheet to collect data during a period of time for which further analysis is needed.

3. Click the synchronize icon  to synchronize the datasets.
4. Click the pause icon .
5. Click the zoom in  and zoom out  icons to view the period of interest.

 **Note:**

Only the data in the view will be included in the Analytics support bundle.

6. Click **Save**.
7. From the **Analytics** menu, select **Saved Worksheets**.
8. Hover over the worksheet that you want to export, and click the export icon .

 **Note:**

Oracle ZFS Storage Appliance must be registered for the Phone Home Service before attempting to upload. For more information, see [Phone Home Configuration](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*.

9. Enter a Service Request (SR) number, which is provided by Oracle support personnel when requesting a worksheet.
10. Click **APPLY**.
11. Record the filename of the support bundle, and provide it to Oracle support personnel for retrieval.

## Exporting a Worksheet (CLI)

Use this procedure to export a worksheet for the Phone Home Service.

1. Go to `analytics worksheets`.
2. Enter `show` to view a list of available worksheets.

```
hostname:analytics worksheets> show
Worksheets:
```

| WORKSHEET     | OWNER | NAME      |
|---------------|-------|-----------|
| worksheet-000 | root  | example_1 |
| worksheet-001 | root  | example_2 |

3. Enter `select` and the worksheet that you want to export.

```
hostname:analytics worksheets> select worksheet-000
```

4. Enter `bundle` and the Service Request (SR) number, which is provided by Oracle support personnel when requesting a worksheet.

```
hostname:analytics worksheet-000> bundle 3-7596250401
```

A support bundle is being created and sent to Oracle. You will receive an alert when the bundle has finished uploading. Please save the following filename, as Oracle support personnel will need it in order to access the bundle:

/upload/issue/3-7596250401/3-7596250401\_ak.9a4c3d7b-50c5-6eb9-c2a6-ec9808ae1cd8.tar.gz

## Downloading a Dataset to a CSV File (BUI)

Use the following information to download a dataset to a comma-separated values (CSV) file. While it is not possible to download a dataset in the CLI, you can view the data in a CSV format. See [Viewing a Dataset in a CSV Format \(CLI\)](#).

1. Navigate to the open or saved worksheet with the dataset that you want to download.
2. Click the export data icon  , located above the dataset that you want to download.
3. Save the file locally.

## Viewing a Dataset in a CSV Format (CLI)

Use the following information to view data from a dataset in a comma-separated values (CSV) format. To download a dataset to a CSV file, see [Downloading a Dataset to a CSV File \(BUI\)](#).

1. Go to analytics worksheets.

```
hostname:> analytics worksheets
```

2. Enter show to view a list of saved worksheets.

```
hostname:analytics worksheets> show  
Worksheets:
```

| WORKSHEET     | OWNER | NAME      |
|---------------|-------|-----------|
| worksheet-000 | root  | example_1 |
| worksheet-001 | root  | example_2 |

3. Enter select and the worksheet that contains the dataset for which you want to view the data.

```
hostname:analytics worksheets> select worksheet-000
```

4. Enter show to view a list of datasets in the worksheet.

```
hostname:analytics worksheet-000> show  
Properties:  
    uuid = 66d05260-8d26-4b69-aae5-f98391048af0  
    name = example_1  
    owner = root  
    ctime = 2020-12-8 23:55:58  
    mtime = 2020-12-8 23:56:09
```

Datasets:

| DATASET     | DATE | SECONDS | NAME                            |
|-------------|------|---------|---------------------------------|
| dataset-000 | -    | 60      | arc.accesses[L2ARC eligibility] |
| dataset-001 | -    | 60      | cap.bytesused[pool]             |

5. Enter select and the dataset for which you want to view the data.

```
hostname:analytics worksheet-000> select dataset-000
```

6. Enter `csv`.

```
hostname:analytics worksheet-000 dataset-000> csv
Time (UTC),Value per second
2020-12-09 00:02:31,40599
2020-12-09 00:02:32,20134
2020-12-09 00:02:33,22425
2020-12-09 00:02:34,3954
2020-12-09 00:02:35,2185
```

# Analytics Data Retention Policies

## Default Retention Policy

By default, Oracle ZFS Storage Appliance retains per-second data for 7 days, per-minute data for 14 days, and per-hour data for 90 days. However, it is strongly recommended that you specify a data retention policy that suits your business needs. Retention policies are especially important if you plan to retain large amounts of historical data for an extended period. The maximum retention period is two years. Software updates to OS8.6.0 or later will cap any previous retention policy settings to a maximum of two years. Modifications to the retention policy are recorded in the audit log. This default retention policy is effective with software version OS8.6.0 and later.

## Enabling a Retention Policy

A retention policy limits the minimum amount of data collected by a granularity of per-second, per-minute, or per-hour over a period of time, or retention period. You could set one retention policy per granularity. For example, you could define a retention policy to save a minimum of one day of data at the per-second interval, a second policy to save a minimum of one week of data at the per-minute interval, and a third policy to save a minimum of one month of data at the per-hour interval. It is recommended that you only keep the minimum amount of data according to your business requirements, including compliance needs.

Per-second data is the highest granularity and requires more memory and disk space than per-minute or per-hour data. Likewise, setting a longer retention period corresponds to storing more data. Monitor the size of the datasets in the BUI by navigating to the **Analytics** menu and selecting **Datasets**. In the CLI, use the `analytics datasets` context. Adjust retention policies accordingly to meet business requirements while occupying the least amount of space. Retention policies apply to all active datasets; suspended datasets are not affected.

Note that you must increase the retention time with each increase in granularity. For example, you cannot define a retention period of weeks for per-second data and then define a retention period of days for per-minute data.

When you enable a data retention policy, you should assume that old data is immediately removed. For example, if you set a per-second policy for at least three hours, you should assume that any data over three hours old is deleted. In actuality, Oracle ZFS Storage Appliance periodically deletes old data and may delay removing old data to avoid causing a performance impact. You can significantly reduce the space used by Analytics by setting a retention policy that periodically discards the highest data granularity.

To enable a retention policy, you must have super-user privileges or have configured authorization within the Dataset scope.

## Viewing Retained Data

Worksheet graphs are displayed in the highest data granularity available to Oracle ZFS Storage Appliance. For example, if your retention policies do not collect per-second data but do collect per-minute data, the graphs are rendered using per-minute data.

## See Also

- For more information on defining authorization scopes for users, see [Configuring Users](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*.
- To learn more about the properties for analytics policies, see [Data Retention Properties](#).

## Data Retention Properties

For each of the properties below you either select "All" or "At least". If you select "All", you are not defining a retention policy for the data retention interval, and Oracle ZFS Storage Appliance will not limit active datasets. If you select "At least", enter an integer value into the text box. Then select the period for the retention policy: hours, days, weeks or months. These settings apply to all active datasets and should be set according to business requirements, including compliance needs.

**Table 2-1 Setting Properties**

| Property        | Description                                                                                                         |
|-----------------|---------------------------------------------------------------------------------------------------------------------|
| Per-second data | Use this setting to define the amount of time to retain data recorded at a per-second interval for active datasets. |
| Per-minute data | Use this setting to define the amount of time to retain data recorded at a per-minute interval for active datasets. |
| Per-hour data   | Use this setting to define the amount of time to retain data recorded at a per-hour interval for active datasets.   |

# 3

## Understanding Analytics Worksheets

A worksheet is the BUI screen on which statistics are graphed. Multiple statistics can be plotted at the same time, and worksheets may be assigned a title and saved for future viewing. The act of saving a worksheet will automatically execute the archive action on all open statistics, which means that whatever statistics were open, will continue to be read and archived forever.

For information on how to use worksheets, see [Managing Worksheets](#).

For more information about worksheets, see the following topics:

- [Worksheet Graphs and Plots](#)
- [Adjusting Graphs](#)
- [Adjusting Quantize Plots](#)
- [Background Patterns](#)
- [Toolbar Reference](#)
- [Worksheet Tips](#)
- [Saved Worksheet Properties](#)
- [BUI Icon Reference](#)

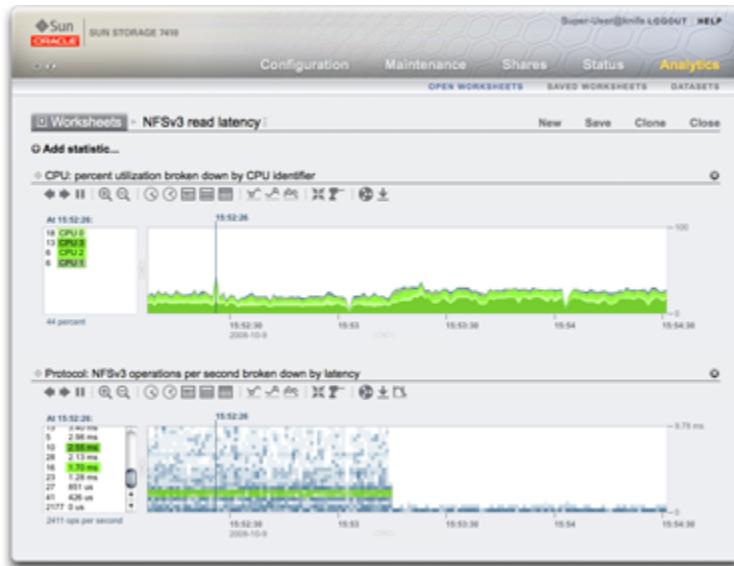
## Worksheet Graphs and Plots

Worksheets are the main interface for Analytics. A worksheet is a view where multiple statistics may be graphed. The following screen shot shows two statistics:

- CPU: percent utilization broken down by CPU identifier - as a **graph**
- Protocol: NFSv3 operations per second broken down by latency - as a **quantize plot**

The following sections introduce Analytics features based on the following screen shot.

### NFSv3 by Latency



## Adjusting Graphs

Graphs provide the following features:

- The left panel lists components of the graph, if available. Because the example graph was **broken down by CPU identifier**, the left panel lists CPU identifiers. Only components that had activity in the visible window (or selected time) will be listed on the left.
- Left panel components can be clicked on to highlight their data in the main plot window.
- Left panel components can be shift-clicked on to highlight multiple components at a time (such as in this example, with all four CPU identifiers highlighted).
- Left panel components can be right-clicked on to show available drilldowns.
- Only ten left panel components will be shown to begin with, followed by "...". You can click on "..." to reveal more. Keep clicking to expand the list completely.
- The graph window on the right can be clicked on to highlight a point in time. In the example screen shot, **15:52:26** was selected. Click the pause button followed by the zoom icon to zoom into the selected time. Click the time text to remove the vertical time bar.
- If a point in time is highlighted, the left panel of components will list details for that point in time only. Note that the text above the left box reads **At 15:52:26:**, to indicate what the component details are for. If a time was not selected, the text would read **Range average**.
- Y-axis auto scales to keep the highest point in the graph (except for utilization statistics, where are fixed at 100%).
- The line graph button will change this graph to plot just lines without the flood-fill. This can be useful for a couple of reasons: Some of the finer detail in line plots can be lost in the flood-fill, and so selecting line graphs can improve resolution. This feature can also be used to vertical zoom into component graphs: First, select one or more components on the left, then switch to the line graph.

- To magnify a time range, click where you want the range to begin, shift-click at the end, and click the zoom-in icon .

The following features are common to graphs and quantize plots:

- The height may be expanded. Look for a white line beneath in the middle of the graph, click it and drag downward.
- The width will expand to match the size of your browser.
- Click on and drag the move icon  to switch the vertical location of the statistics.

## Adjusting Quantize Plots

The NFS latency statistic in the screen shot is rendered as a quantize plot. The name refers to the how the data is collected and displayed. For each statistic update, data is quantized into buckets, which are drawn as blocks on the plot. The more events in that bucket for that second, the darker the block will be drawn.

The example screen shot shows NFSv3 operations were spread out to 9 ms and beyond, with latency on the y-axis, until an event kicked in about halfway, and the latency dropped to less than 1 ms. Other statistics can be plotted to explain the drop in latency (the filesystem cache hit rate showed steady misses go to zero at this point: A workload had been randomly reading from disk (0 to 9+ ms latency), and switched to reading files that were cached in DRAM).

Quantize plots are used for I/O latency, I/O offset, and I/O size, and provide the following features:

- Detailed understanding of data profile (not just the average, maximum or minimum) these visualize all events and promote pattern identification.
- Vertical outlier elimination. Without this, the y-axis would always be compressed to include the highest event. Click on the crop outliers icon  to toggle between different percentages of outlier elimination. Hover over this icon to see the current value.
- Vertical zoom: Click on a low point from the list in the left box, then shift-click on a high point. Now click on the crop outliers icon  to zoom to this range.
- The height may be expanded. Look for a white line beneath in the middle of the plot, click on it, and drag downward.
- The width will expand to match the size of your browser.
- Click on and drag the move icon  to switch the vertical location of the statistics.

## Background Patterns

Normally, graphs are displayed with various colors against a white background. If data is unavailable for any reason, the graph will be filled with a pattern to indicate the specific reason for data unavailability:

-  The gray pattern indicates that the given statistic was not being recorded for the time period indicated. This is either because the user had not yet specified the statistic, or because data gathering had been explicitly suspended.

- The red pattern indicates that data gathering was unavailable during that period. This is most commonly seen because the Oracle ZFS Storage Appliance system was down during the time period indicated.
- The orange pattern indicates an unexpected failure while gathering the given statistic. This can be caused by a number of aberrant conditions. If it is seen persistently or in critical situations, contact your authorized support resource and/or submit a support bundle. For more information on how to submit a support bundle, see [Working with Support Bundles](#) in *Oracle ZFS Storage Appliance Customer Service Manual, Release OS8.8.x*.

## Toolbar Reference

A toolbar of buttons is shown above graphed statistics. The following table is a reference for their function.

**Table 3-1 Toolbar Reference**

| Icon | Click                              | Shift-Click                               |
|------|------------------------------------|-------------------------------------------|
|      | Move backward in time (moves left) | Move backward in time (moves left)        |
|      | Move forward in time (moves right) | Move forward in time (moves right)        |
|      | Forward to now                     | Forward to now                            |
|      | Pause                              | Pause                                     |
|      | Zoom out                           | Zoom out                                  |
|      | Zoom in                            | Zoom in                                   |
|      | Show one minute                    | Show two minutes, three, four, ...        |
|      | Show one hour                      | Show two hours, three, four, ...          |
|      | Show one day                       | Show two days, three, four, ...           |
|      | Show one week                      | Show two weeks, three, four, ...          |
|      | Show one month                     | Show two months, three, four, ...         |
|      | Show minimum                       | Show next minimum, next next minimum, ... |
|      | Show maximum                       | Show next maximum, next next maximum, ... |
|      | Show line graph                    | Show line graph                           |
|      | Show mountain graph                | Show mountain graph                       |
|      | Crop outliers                      | Crop outliers                             |
|      | Sync worksheet to this statistic   | Sync worksheet to this statistic          |
|      | Unsync worksheet statistics        | Unsync worksheet statistics               |
|      | Drilldown                          | Rainbow highlight                         |
|      | Save statistical data              | Save statistical data                     |
|      | Export statistical data            | Export statistical data                   |

Hover over each button to see a tooltip that describes the click behavior.

## Worksheet Tips

- If you want to save a worksheet that displays an interesting event, make sure the statistics are paused first (sync all statistics, then hit pause). Otherwise, the graphs will continue to scroll, and when you open the worksheet later, the event might no longer be on the screen.
- If you analyze issues after the fact, you will be restricted to the datasets that were already being archived. Visual correlations can be made between them when the time axis is synchronized. If the same pattern is visible in different statistics, there is a good chance that it is related activity.
- Be patient when zooming out to the month view and longer. Analytics effectively manages long periods of data; however, there can be delays when zooming out to long periods.
- When a worksheet is saved on one node in a clustered system, a copy of the worksheet with the same title is propagated to the peer. To permanently save the worksheet statistics on the peer, click **Save**.

## Saved Worksheet Properties

The following properties are stored for saved worksheets.

**Table 3-2 Properties for Saved Worksheets**

| Field    | Description                                                                                                 |
|----------|-------------------------------------------------------------------------------------------------------------|
| Name     | Configurable name of the saved worksheet, which is displayed at the top of the <b>Open Worksheets</b> view. |
| Comment  | Optional comment (only visible in the BUI).                                                                 |
| Owner    | User who owns the worksheet.                                                                                |
| Created  | Time the worksheet was created.                                                                             |
| Modified | Time the worksheet was last modified (only visible in the CLI).                                             |

## BUI Icon Reference

Hover over saved worksheet entries to expose the following controls.

**Table 3-3 BUI Icons**

| Icon | Description                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|      | Upload this worksheet bundle to Oracle Support for analysis. Oracle ZFS Storage Appliance must be registered for the Phone Home Service (see <a href="#">Phone Home Configuration</a> in <i>Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x</i> ) before attempting to upload. You will be prompted to enter a Service Request (SR) number, which is provided by Oracle Support personnel when requesting a worksheet. |
|      | Append the datasets saved in this worksheet to the current worksheet in <b>Open Worksheets</b> .                                                                                                                                                                                                                                                                                                                                          |
|      | Edit the worksheet to change the name and comment.                                                                                                                                                                                                                                                                                                                                                                                        |

**Table 3-3 (Cont.) BUI Icons**

| Icon                                                                              | Description             |
|-----------------------------------------------------------------------------------|-------------------------|
|  | Destroy this worksheet. |

# About Analytics Datasets

The term *dataset* refers to the in-memory cached and on-disk saved data for a statistic, and is presented as an entity in Analytics with administration controls. Datasets are automatically created whenever you view statistics in **Open Worksheets**. A dataset is not saved to disk for future viewing unless you archive it. See [Statistics Actions](#).

The **Analytics: Datasets** BUI screen lists all datasets. These include open statistics that are being viewed in a worksheet (and as such are temporary datasets that disappear when the worksheet is closed), and statistics that are being archived to disk.

The following fields are displayed in the **Datasets** view for all datasets.

**Table 4-1 Field Descriptions of Datasets**

| Field       | Description                                                                                                                                                                                                                                                                                                                                                   |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Status icon | See the next table.                                                                                                                                                                                                                                                                                                                                           |
| Overhead    | Low, medium or high performance impact of the dataset; see the next table. Also see <a href="#">Storage Performance Impact</a> and <a href="#">Execution Performance Impact</a> .                                                                                                                                                                             |
| Name        | Name of the statistic/dataset.                                                                                                                                                                                                                                                                                                                                |
| Since       | First timestamp in dataset. For open statistics, this is the time the statistic was opened, which might be minutes earlier. For archived statistics, this is the first time in the archived dataset, which indicates how far back in the past this dataset goes, which might be days, weeks, months. Sorting this column shows the oldest datasets available. |
| On Disk     | Space this dataset consumes on disk.                                                                                                                                                                                                                                                                                                                          |
| In Core     | Space this dataset consumers in main memory.                                                                                                                                                                                                                                                                                                                  |

The following icons are visible in the BUI view; some of these are only visible during hover-over of a dataset entry.

**Table 4-2 BUI Icons**

| Icon | Description                                          |
|------|------------------------------------------------------|
| ●    | Dataset is actively collecting data.                 |
| ○    | Dataset is currently suspended from collecting data. |
| ●●   | Dataset has a low overhead.                          |
| ●●●  | Dataset has a medium overhead.                       |
| ●●●● | Dataset has a high overhead.                         |
| ↻    | Suspend/Resume archived datasets.                    |
| 🌐    | Enable archiving of this dataset to disk.            |
| ☒    | Discard all or some data from this dataset.          |

See [Statistics Actions](#) for descriptions for these dataset actions.

# Understanding Analytics Statistics

Analytics statistics provide incredible observability into Oracle ZFS Storage Appliance, showing how the appliance is behaving, and how clients on the network are using it. While the statistics presented by Analytics might appear straightforward, there might be additional details to be aware of when interpreting their meaning. This is especially true for the purposes of performance analysis, where precise understanding of the statistics is often necessary.

To minimize service downtime in clustered systems, statistics and datasets are not available during failback and takeover operations. Data is not collected, and any attempt to suspend or resume statistics is delayed until failback and takeover operations have completed and data collection automatically resumes.

For information about performance impact, actions, and default statistics, see the following topics:

- [Storage Performance Impact](#)
- [Execution Performance Impact](#)
- [Statistics Actions](#)
- [Default Statistics](#)

For information about the Analytics statistics available for monitoring, see the following topics:

- [Active Directory: Operations](#)
- [Active Directory: MSRPC Bindings](#)
- [Active Directory: Average Latency](#)
- [CPU: Percent Utilization](#)
- [Cache: ARC Accesses](#)
- [Cache: L2ARC I/O Bytes](#)
- [Cache: L2ARC Accesses](#)
- [Capacity: Capacity Bytes Used - BUI, CLI](#)
- [Capacity: Capacity Percent Used - BUI, CLI](#)
- [Capacity: Meta Device Capacity Bytes Used \(BUI\)](#)
- [Capacity: Meta Device Capacity Percent Used \(BUI\)](#)
- [Capacity: System Pool Bytes Used](#)
- [Capacity: System Pool Percent Used](#)
- [Data Movement: Cloud Bytes](#)
- [Data Movement: Cloud Requests](#)
- [Data Movement: Shadow Migration Bytes](#)
- [Data Movement: Shadow Migration Ops](#)

- Data Movement: Shadow Migration Requests
- Data Movement: NDMP Bytes Statistics
- Data Movement: NDMP Operations Statistics
- Data Movement: Replication Bytes
- Data Movement: Replication Operations
- Disk: Disks
- Disk: I/O Bytes
- Disk: I/O Operations
- Name Service: Lookups
- Network: Device Bytes
- Network: Device Errors
- Network: Interface Bytes
- Protocol: Fibre Channel Bytes
- Protocol: Fibre Channel Operations
- Protocol: FTP Bytes
- Protocol: HTTP/WebDAV Requests
- Protocol: iSCSI Bytes
- Protocol: iSCSI Operations
- Protocol: NFSv[2-4] Bytes
- Protocol: NFSv[2-4] Operations
- Protocol: OISP Bytes
- Protocol: OISP Operations
- Protocol: SFTP Bytes
- Protocol: SMB Operations
- Protocol: SMBv[1-2] Bytes
- Protocol: SRP Bytes
- Protocol: SRP Operations

## Storage Performance Impact

Analytics statistic collection comes at some cost to overall performance. This should not be an issue if you understand what that cost will be, and how to minimize or avoid it.

Analytics statistics can be archived, meaning they will be a dataset that is continually read and saved to the Oracle ZFS Storage Appliance system disks in one-second summaries. This allows statistics to be viewed month by month, day by day, right down to second by second. Data is not discarded. If an Oracle ZFS Storage Appliance system has been running for two years, you can zoom down to by-second views for any time in the previous two years for your archived datasets. Depending on the type of statistic, this could present an issue with system disk usage.

You can monitor the growing sizes of the datasets, and destroy datasets that are growing too large. The system disks have compression enabled, so the sizes visible in the datasets view will be larger than the space consumed on disk after compression. For system disk usage and available space, see [Viewing System Disks Status in Oracle ZFS Storage Appliance Customer Service Manual, Release OS8.8.x](#).

The following are example sizes taken from an Oracle ZFS Storage Appliance system that has been running for over four months.

**Table 5-1 Sizes Taken from an Oracle ZFS Storage Appliance System Running for over Four Months**

| Category | Statistic                                                    | Span     | Dataset Size* | Disk Consumed* |
|----------|--------------------------------------------------------------|----------|---------------|----------------|
| CPU      | Percent utilization                                          | 130 days | 127 MB        | 36 MB          |
| Protocol | NFSv3 operations per second                                  | 130 days | 127 MB        | 36 MB          |
| Protocol | NFSv3 operations per second broken down by type of operation | 130 days | 209 MB        | 63 MB          |
| CPU      | Percent utilization broken down by CPU mode                  | 130 days | 431 MB        | 91 MB          |
| Network  | Device bytes per second broken down by device                | 130 days | 402 MB        | 119 MB         |
| Disk     | I/O bytes per second broken down by disk                     | 130 days | 2.18 GB       | 833 MB         |
| Disk     | I/O operations per second broken down by latency             | 31 days  | 1.46 GB       | 515 MB         |

\* These sizes will vary depending on your workload; they have been provided as a rough guideline.

It is worth noting that Oracle ZFS Storage Appliance has been intended to have 500 gigabyte mirrored system disks, most of which will be available to store datasets.

The factors that affect consumed disk space are:

- Type of statistic: Raw versus breakdowns
- For breakdowns: Number of breakdowns, and breakdown name length
- Activity rate

Monitor the size in **Datasets**. If a dataset is growing too large, and you want to stop it from growing but keep the historic data, use the suspend action.

### Raw Statistics

Statistics that are a single value (sometimes written "as a raw statistic") will not consume much disk space for these reasons:

- Integer values consume a fixed and small amount of space
- The archives are compressed when saved, which significantly reduces the size for statistics that are mostly zero

Examples:

- CPU: Percent utilization

- Protocol: NFSv3 operations per second

### Breakdowns

Statistics that have breakdowns can consume much more data, as shown in the previous table, because:

- Each breakdown is saved per second. For by-file and by-hostname breakdowns, the number of breakdowns per second may reach into the hundreds (how many different files or hosts had activity in a one-second summary), and all of which must be saved to disk.
- Breakdowns have dynamic names, which themselves can be long. You may only have ten active files in your breakdown by-file statistics, but each pathname could be dozens of characters in size. This might not sound like much, but the dataset will grow steadily when this data is saved every second.

Examples:

- CPU: Percent utilization broken down by CPU mode
- Protocol: NFSv3 operations per second broken down by type of operation
- Disk: I/O bytes per second broken down by disk
- Disk: I/O bytes per second broken down by latency

### Exporting Statistics

At some point in time, you might want to archive statistics on a different server, either to free up disk space on Oracle ZFS Storage Appliance or for other purposes. For more information about exporting statistics or downloading statistic data in a comma-separated values (CSV) format, see [Working with Analytics](#).

## Execution Performance Impact

Enabling statistics will incur some CPU cost for data collection and aggregation. In many situations, this overhead will not make a noticeable difference on system performance. However, for Oracle ZFS Storage Appliance systems under maximum load, including benchmark loads, the small overhead of statistic collection can begin to be noticeable.

Here are some tips for handling execution overheads:

- For dynamic statistics, only archive those that are important to record 24x7.
- Statistics can be suspended, eliminating data collection and the collection overhead. This can be useful if gathering a short interval of a statistic is sufficient for your needs (such as troubleshooting performance). Enable the statistic, wait some minutes, then click the power icon  in the **Datasets** view to suspend it. Suspended datasets keep their data for later viewing.
- Monitor overall performance via the static statistics when enabling and disabling dynamic statistics.
- Be aware that drilldowns will incur overhead for all events. For example, you might trace NFSv3 operations per second for client `deimos` when there is currently no NFSv3 activity from client `deimos`. This does not mean that there is no execution overhead for this statistic. Oracle ZFS Storage Appliance must still trace every NFSv3 event, then compare the host with `deimos` to determine if the data

should be recorded in this dataset; however, most of the execution cost has been paid at this point.

### Static Statistics

Some statistics are sourced from operating system counters are always maintained, which may be called *static statistics*. Gathering these statistics has negligible effect on the performance of the Oracle ZFS Storage Appliance system because, to an extent, the system is already maintaining them (they are usually gathered by an operating system feature called `kstat`). Examples of these statistics are:

**Table 5-2 Static Statistics**

| Category | Statistic                                                                  |
|----------|----------------------------------------------------------------------------|
| CPU      | Percent utilization                                                        |
| CPU      | Percent utilization broken down by CPU mode                                |
| Cache    | ARC accesses per second broken down by hit/miss                            |
| Cache    | ARC size                                                                   |
| Disk     | I/O bytes per second                                                       |
| Disk     | I/O bytes per second broken down by type of operation                      |
| Disk     | I/O operations per second                                                  |
| Disk     | I/O operations per second broken down by disk                              |
| Disk     | I/O operations per second broken down by type of operation                 |
| Network  | Device bytes per second                                                    |
| Network  | Device bytes per second broken down by device                              |
| Network  | Device bytes per second broken down by direction                           |
| Protocol | NFSv3/NFSv4/NFSv4.1 operations per second                                  |
| Protocol | NFSv3/NFSv4/NFSv4.1 operations per second broken down by type of operation |

When seen in the BUI, those from the previous list without **broken down by** text will have **as a raw statistic**.

Because these statistics have negligible execution cost and provide a broad view of system behavior, many are archived by default. See [Default Statistics](#).

### Dynamic Statistics

These statistics are created dynamically, and are not usually maintained by the Oracle ZFS Storage Appliance system (they are gathered by an operating system feature called *DTrace*). Each event is traced, and each second this trace data is aggregated into the statistic. Thus, the cost of this statistic is proportional to the number of events.

Tracing disk details when the activity is 1000 operations/second is unlikely to have a noticeable affect on performance; however, measuring network details when pushing 100,000 packets/second *is* likely to have a negative effect. The type of information gathered is also a factor: Tracing filenames and client names will increase the performance impact.

Examples of dynamic statistics include:

**Table 5-3 Dynamic Statistics**

| Category | Statistic                                                  |
|----------|------------------------------------------------------------|
| Protocol | SMB operations per second                                  |
| Protocol | SMB operations per second broken down by type of operation |
| Protocol | HTTP/WebDAV requests per second                            |
| Protocol | ... operations per second broken down by client            |
| Protocol | ... operations per second broken down by file name         |
| Protocol | ... operations per second broken down by share             |
| Protocol | ... operations per second broken down by project           |
| Protocol | ... operations per second broken down by latency           |
| Protocol | ... operations per second broken down by size              |
| Protocol | ... operations per second broken down by offset            |

"..." denotes any of the protocols.

The best way to determine the impact of these statistics is to enable and disable them while running under a steady load. Benchmark software may be used to apply that steady load. See [Working with Analytics](#) for the steps to calculate performance impact in this way.

## Statistics Actions

The following actions can be performed on statistics/datasets:

**Table 5-4 Actions Performed on Statistics/Datasets**

| Action  | Description                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Open    | Begin reading from the statistic (every second), and cache values in memory as a dataset. In <b>Open Worksheets</b> , statistics are opened when they are added to the view, allowing them to be graphed in real-time. The data is kept in memory while the statistic is being viewed.                                                                                                                                                 |
| Close   | Closes the statistic view, discarding the in-memory cached dataset.                                                                                                                                                                                                                                                                                                                                                                    |
| Archive | Sets the statistic to be permanently opened and archived to disk. If the statistic had already been opened, then all cached data in memory is also archived to disk. Archiving statistics creates permanent datasets, visible in the <b>Datasets</b> view (those with a non-zero "on disk" value). This is how statistics may be recorded 24x7, so that activity from days, weeks and months in the past can be viewed after the fact. |

**Table 5-4 (Cont.) Actions Performed on Statistics/Datasets**

| Action       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Discard data | Manage the amount of data stored for a particular statistic. You can select to discard the entire dataset or select to remove one of the following granularities of archived data: second, minute, or hour. Note that if you want to delete a higher level of granularity, you must also delete any lower level of granularity. For example, to delete the minute granularity, you must also delete the second granularity. If you select to not discard the entire dataset, you can discard older data and retain only newer data. You enter an integer value in the <b>Older than</b> text box, and then select the unit of time: <b>hours</b> , <b>days</b> , <b>weeks</b> , or <b>months</b> . For example, if you want to only retain three weeks of stored data for the selected statistic, enter 3 into the <b>Older than</b> text box, and then select <b>weeks</b> from the drop-down menu. |
| Suspend      | Pause an archived statistic. New data will not be read, but the existing disk archive will be left intact.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Resume       | Resumes a previously suspended statistic, so that it will continue reading data and writing to the archive.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

## Default Statistics

The following statistics are enabled and archived by default on a factory-installed Oracle ZFS Storage Appliance. These are the statistics you see in the **Datasets** view when you first configure and log in to the Oracle ZFS Storage Appliance system.

For information about average latency statistics for protocols, see [Protocols: Average Latency Statistics](#).

**Table 5-5 Default Statistics**

| Category         | Statistic                                                        |
|------------------|------------------------------------------------------------------|
| Active Directory | Operations                                                       |
| Active Directory | MSRPC bindings                                                   |
| Active Directory | Average latency                                                  |
| CPU              | Percent utilization                                              |
| CPU              | Percent utilization broken down by CPU mode                      |
| Cache            | ARC accesses per second broken down by hit/miss                  |
| Cache            | ARC size                                                         |
| Cache            | ARC size broken down by component                                |
| Cache            | DNLC accesses per second broken down by hit/miss                 |
| Cache            | L2ARC accesses per second broken down by hit/miss                |
| Cache            | L2ARC size                                                       |
| Data Movement    | NDMP bytes transferred to/from disk per second                   |
| Disk             | Disk with utilization of at least 95 percent broken down by disk |
| Disk             | I/O bytes per second                                             |
| Disk             | I/O bytes per second broken down by type of operation            |

**Table 5-5 (Cont.) Default Statistics**

| Category | Statistic                                                    |
|----------|--------------------------------------------------------------|
| Disk     | I/O operations per second                                    |
| Disk     | I/O operations per second broken down by disk                |
| Disk     | I/O operations per second broken down by type of operation   |
| Network  | Device bytes per second                                      |
| Network  | Device bytes per second broken down by device                |
| Network  | Device bytes per second broken down by direction             |
| Protocol | SMB operations per second                                    |
| Protocol | SMB operations per second broken down by type of operation   |
| Protocol | SMB2 operations per second                                   |
| Protocol | SMB2 operations per second broken down by type of operation  |
| Protocol | FTP bytes per second                                         |
| Protocol | Fibre Channel bytes per second                               |
| Protocol | Fibre Channel operations per second                          |
| Protocol | HTTP/WebDAV requests per second                              |
| Protocol | NFSv2 operations per second                                  |
| Protocol | NFSv2 operations per second broken down by type of operation |
| Protocol | NFSv3 operations per second                                  |
| Protocol | NFSv3 operations per second broken down by type of operation |
| Protocol | NFSv4 operations per second                                  |
| Protocol | NFSv4 operations per second broken down by type of operation |
| Protocol | SFTP bytes per second                                        |
| Protocol | iSCSI operations per second                                  |
| Protocol | iSCSI bytes per second                                       |

These default statistics give broad observability across protocols with minimal statistic collection overhead, and are usually left enabled even when benchmarking. For more discussion on statistic overhead, see [Storage Performance Impact](#) and [Execution Performance Impact](#).

## Active Directory: Operations

This statistic shows the total number of Active Directory (AD) operations at a point in time, and measures operations per second for a period of time. This statistic also shows the results of these operations.

The AD operations statistic should be used only to diagnose issues that might be related to `smbd`. AD analytics should not be run continuously because they will unnecessarily consume system resources. You could generate an alert if the average latency substantially increases for a period of time, and the alert will appear on the dashboard. To set a threshold alert, see [Configuring a Threshold Alert - BUI, CLI](#).

### When to Check Active Directory Operations

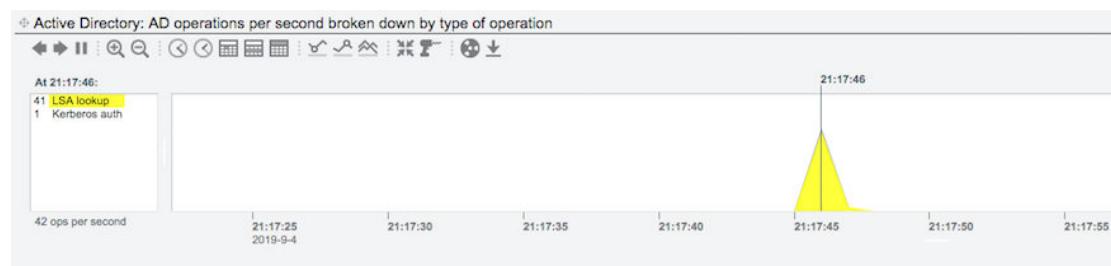
This statistic provides information, such as the following:

- User login rate
- User authentication mechanisms used (NTLM versus Kerberos)
- LSA lookup rate

This statistic helps identify problems, such as the following:

- AD server connection issues
- User authentication failures
- AD domain join failure caused by misconfigured DNS domain name issue. For example, a symptom of such misconfiguration might be a false alarm of a duplicate machine trust account in AD.

The AD operations statistic can help identify a user account that is a member of a large number of AD groups. Normally, a single-user domain authentication is associated with one or two LSA lookup exchanges. If a user is a member of a large number of AD groups, that user will have one authentication operation (either Kerberos or NTLM authentication) followed by many LSA lookup operations. One LSA lookup operation can resolve up to 25 group SIDs to AD group names. In the following figure, the user being authenticated is a member of at most 1025 (41 \* 25) AD groups.



This statistic also provides error codes associated with AD operations, such as the following:

- The `NT_STATUS_PIPE_NOT_AVAILABLE` error might indicate that the domain controller (DC) has limited named pipe resources.
- A Microsoft RPC (MSRPC) service provider rejection error might indicate that the DC is being patched with Microsoft Windows updates that might have limited the MSRPC services being run.

### Active Directory Operations Breakdowns

This statistic can be broken down by operation and result.

**Table 5-6 Breakdowns of Active Directory Operations**

| Breakdown         | Description                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | The operation performed. Examples: <ul style="list-style-type: none"> <li>• LSA lookup</li> <li>• Locate trust account</li> <li>• NTLM auth</li> <li>• Kerberos auth</li> <li>• DC failover</li> <li>• DC monitor</li> <li>• DC discovery</li> <li>• Domain join</li> <li>• Negotiate authentication mechanism</li> </ul>                                                                                 |
| result            | The result of the operation. Examples: <ul style="list-style-type: none"> <li>• SUCCESS</li> <li>• UNSUCCESSFUL</li> <li>• DOMAIN_CONTROLLER_NOT_FOUND</li> <li>• NONE_MAPPED</li> <li>• Key table entry not found</li> <li>• Ticket not yet valid</li> <li>• Workstation trust account update failed: The name is in use</li> <li>• NO_SUCH_USER</li> <li>• NT status</li> <li>• System error</li> </ul> |

#### Further Analysis

- [Active Directory: Average Latency](#) for average latency per second
- [Active Directory: MSRPC Bindings](#)

## Active Directory: MSRPC Bindings

All AD operations except Kerberos authentication involve one or more MSRPC bindings with the remote AD server. Oracle ZFS Storage Appliance must successfully bind to the remote MSRPC services running on the AD server before making any MSRPC requests. Any connection issues with the AD server are normally seen as failures during MSRPC bind exchanges.

This statistic shows the total number of successful or failed MSRPC bind exchanges at a point in time, and measures the MSRPC bind rate in operations per second for a period of time.

The AD MSRPC bindings statistic should be used only to diagnose issues that might be related to `smbd`. AD analytics should not be run continuously because they will unnecessarily consume system resources. You could generate an alert if the average latency substantially increases for a period of time, and the alert will appear on the dashboard. To set a threshold alert, see Configuring a Threshold Alert - [BUI](#), [CLI](#).

#### When to Check Active Directory MSRPC Bindings

The MSRPC binding hostname breakdown can identify:

- Slow or misbehaving AD servers
- Both the failed and alternate AD servers that were used before and after a DC failover event

The MSRPC binding result breakdown can identify:

- SMB client authentication issues caused by incorrect user password specified during AD domain join
- Connection timeout

### **Active Directory MSRPC Bindings Breakdowns**

This statistic can be broken down by hostname and result.

**Table 5-7 Breakdowns of MSRPC Binding Exchanges**

| Breakdown | Description                                                                                                                                                                                                                                                  |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| hostname  | The hostname of the AD server.                                                                                                                                                                                                                               |
| result    | The result of the MSRPC bind. Examples: <ul style="list-style-type: none"> <li>• SUCCESS</li> <li>• UNSUCCESSFUL</li> <li>• smb/client authentication failed</li> <li>• Connection timed out</li> <li>• NT status</li> <li>• Locate trust account</li> </ul> |

### **Further Analysis**

- [Active Directory: Average Latency](#) for average latency per second
- [Active Directory: Operations](#)

## **Active Directory: Average Latency**

This statistic shows average latency per second for MSRPC bind operations and the following AD operations:

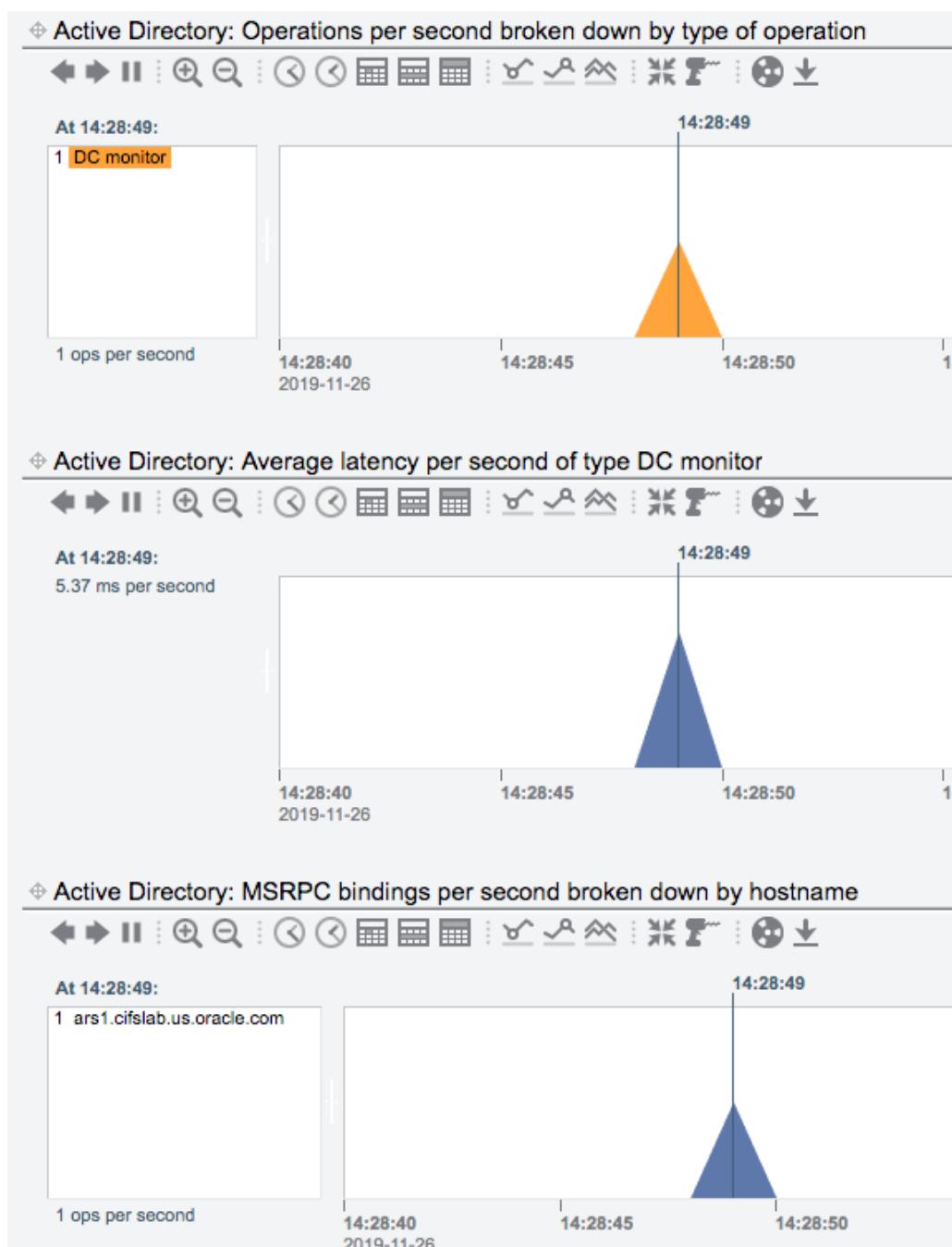
- LSA lookup
- NTLM authentication
- Kerberos authentication
- DC failover
- DC monitor
- DC discovery
- Domain join
- Negotiate authentication mechanism
- Locate system's AD computer account

The AD average latency statistic should be used only to diagnose issues that might be related to `smbd`, and to help analyze AD performance issues and AD server latency. AD analytics should not be run continuously because they will unnecessarily consume system

resources. You could generate an alert if the average latency substantially increases for a period of time, and the alert will appear on the dashboard. To set a threshold alert, see [Configuring a Threshold Alert - BUI, CLI](#).

### When to Check Active Directory Average Latency

The AD average latency statistic helps analyze AD performance issues. This statistic also helps measure latency of the various AD servers in the domain. For example, you can use the latency of the DC monitor operation to determine which AD server in a multiple-DC domain environment has a faster response. Then you can set the low-latency DC to be the preferred DC. The following figure shows that the DC monitor operation for a particular host has an average latency of 5.37ms per second.



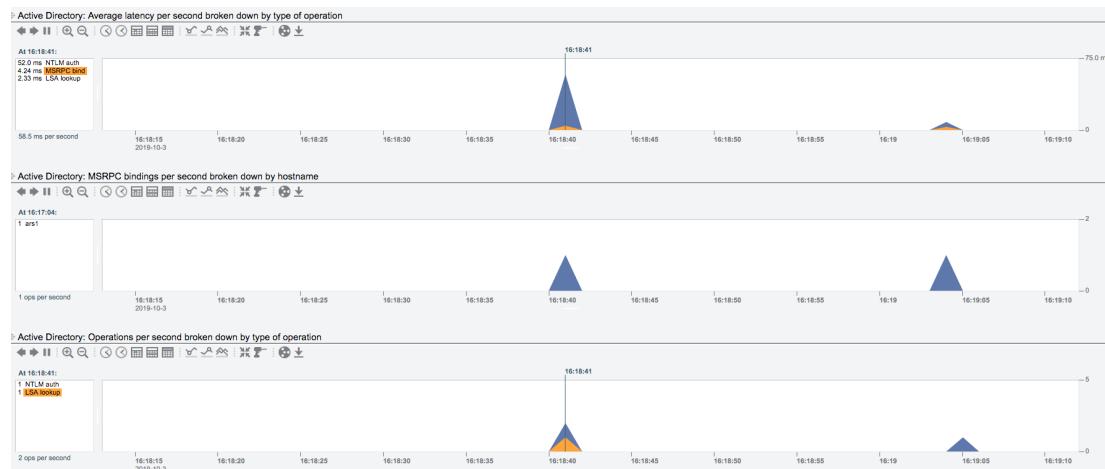
## Active Directory Average Latency Breakdowns

This statistic can be broken down by operation and result.

**Table 5-8 Breakdowns of Active Directory Average Latency**

| Breakdown | Description                                                                                                              |
|-----------|--------------------------------------------------------------------------------------------------------------------------|
| operation | See the list at the beginning of this section.                                                                           |
| result    | The result of the operation. Examples: <ul style="list-style-type: none"> <li>NT status</li> <li>System error</li> </ul> |

The following figure shows all three variants of AD statistics: average latency, MSRPC bindings, and operations.

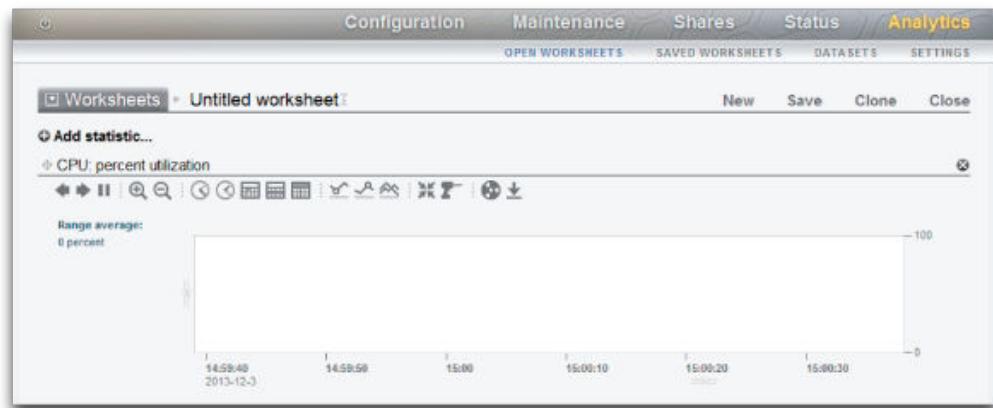


## Further Analysis

- [Active Directory: MSRPC Bindings](#)
- [Active Directory: Operations](#)

## CPU: Percent Utilization

This statistic shows the average utilization of the Oracle ZFS Storage Appliance CPUs. A CPU may be a core on a socket or a hardware thread; the number and type can be seen under analytics interface. For example, a system might have four sockets of quad-core CPUs, meaning there are 16 CPUs available to Oracle ZFS Storage Appliance. The utilization shown by this statistic is the average across all CPUs.



Oracle ZFS Storage Appliance CPUs can reach 100% utilization, which might or might not be a problem. For some performance tests, the appliance is deliberately driven to 100% CPU utilization to measure it at peak performance.

### Example

The figure in section [CPU: Percent Utilization](#) shows CPU: Percent utilization broken down by CPU mode, while Oracle ZFS Storage Appliance served over 2 Gbytes/second of cached data over NFSv3.

An average of 82% utilization suggests that there could be more headroom available, and that appliance might be able to serve more than 2 Gbytes/second (it can). (The breakdowns only add up to 81%; the extra 1% is due to rounding.)

The high level of CPU utilization means that overall latency of NFS operations might increase, which can be measured by [Protocol NFS operations](#) broken down by latency, as operations might be waiting for CPU resources more often.

### When to Check CPU Percent Utilization

You can check CPU percent utilization when investigating system bottlenecks. You can also check this statistic when enabling features that consume CPU, such as compression, to gauge the CPU cost of that feature.

### CPU: Percent Utilization Breakdowns

The available breakdowns of CPU percent utilization are:

**Table 5-9 Breakdowns of Percent Utilization**

| Breakdown          | Description                                                            |
|--------------------|------------------------------------------------------------------------|
| CPU mode           | Either user or kernel; see the following CPU modes table.              |
| CPU identifier     | Numeric operating system identifier of the CPU.                        |
| application name   | Name of the application which is on-CPU.                               |
| process identifier | Operating system process ID (PID).                                     |
| user name          | Name of the user who owns the process or thread that is consuming CPU. |

The CPU modes are:

**Table 5-10 CPU Modes**

| CPU Mode | Description                                                                                                                                                                               |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| user     | This is a user-land process. The most common user-land process consuming CPU is akd, the Oracle ZFS Storage Appliance kit daemon, which provides administrative control of the appliance. |
| kernel   | This is a kernel-based thread that is consuming CPU. Many of the Oracle ZFS Storage Appliance services are kernel-based, such as NFS and SMB.                                             |

**Further Analysis**

A problem with this CPU utilization average is that it can hide issues when a single CPU is at 100% utilization, which might happen if a single software thread is saturated with work. Use the Advanced Analytic CPUs broken down by percent utilization, which represents utilization as a heat map of CPUs, allowing a single CPU at 100% to be easily identified.

**Details**

CPU utilization represents the time spent processing CPU instructions in user and kernel code that are not part of the idle thread. Instruction time includes stall cycles on the memory bus, so high utilization can be caused by the I/O movement of data.

## Cache: ARC Accesses

The ARC is the Adaptive Replacement Cache, and is an in-DRAM cache for filesystem and volume data. This statistic shows accesses to the ARC, and allows its usage and performance to be observed.

**When to Check ARC Accesses**

You can check ARC accesses when investigating performance issues, to understand how well the current workload is caching in the ARC.

**ARC Accesses Breakdowns**

The available breakdowns of Cache ARC accesses are:

**Table 5-11 Breakdowns of ARC Accesses**

| Breakdown         | Description                                                                                                                                                                                                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| hit/miss          | The result of the ARC lookup. Hit/Miss states are described in the following table.                                                                                                                        |
| filename          | The filename that was requested from the ARC. Using this breakdown allows hierarchy mode to be used, so that filesystem directories can be navigated.                                                      |
| L2ARC eligibility | This is the eligibility of L2ARC caching, as measured at the time of ARC access. A high level of ARC misses that are L2ARC eligible suggests that the workload would benefit from 2nd-level cache devices. |
| project           | This shows the project that is accessing the ARC.                                                                                                                                                          |
| share             | This shows the share that is accessing the ARC.                                                                                                                                                            |
| LUN               | This shows the LUN that is accessing the ARC.                                                                                                                                                              |

As described in [Execution Performance Impact](#), breakdown such as by filename would be the most expensive to leave enabled.

The hit/miss states are:

**Table 5-12 Hit/Miss Breakdowns**

| Hit/Miss Breakdown                     | Description                                                                                                                                                                                      |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| data hits                              | A data block was in the ARC DRAM cache and returned.                                                                                                                                             |
| data misses                            | A data block was not in the ARC DRAM cache. It will be read from the L2ARC cache devices (if available and the data is cached on them) or the pool disks.                                        |
| metadata hits                          | A metadata block was in the ARC DRAM cache and returned. Metadata includes the on-disk filesystem framework, which refers to the data blocks. Other metadata examples are in the following list. |
| metadata misses                        | A metadata block was not in the ARC DRAM cache. It will be read from the L2ARC cache devices (if available and the data is cached on them) or the pool disks.                                    |
| prefetched data/ metadata hits/ misses | ARC accesses triggered by the prefetch mechanism, not directly from an application request. More details on prefetch follow.                                                                     |

### Metadata

Examples of metadata:

- Filesystem block pointers
- Directory information
- Data deduplication tables
- ZFS uberblock

### Prefetch

Prefetch is a mechanism to improve the performance of streaming read workloads. It examines I/O activity to identify sequential reads, and can issue extra reads ahead of time so that the data can be in cache before the application requests it. Prefetch occurs *before the ARC* by performing accesses to the ARC: Remember this when trying to understand prefetch ARC activity. For example, if you see:

**Table 5-13 Prefetch Types**

| Type                   | Description                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| prefetched data misses | Prefetch identified a sequential workload, and requested that the data be cached in the ARC ahead of time by performing ARC accesses for that data. The data was not in the cache already, and so this is a "miss" and the data is read from disk. This is normal, and is how prefetch populates the ARC from disk.                                                          |
| prefetched data hits   | Prefetch identified a sequential workload, and requested that the data be cached in the ARC ahead of time by performing ARC accesses for that data. As it turned out, the data was already in the ARC; so these accesses returned as "hits" (and so the prefetch ARC access was not actually needed). This happens if cached data is repeatedly read in a sequential manner. |

After data has been prefetched, the application can then request it with its own ARC accesses. Note that the sizes might be different: Prefetch might occur with a 128 Kbyte I/O size, while the application might be reading with an 8 Kbyte I/O size. For example, the following does not appear directly related:

- Data hits: 368
- Prefetch data misses: 23

However, it can be related if prefetch was requesting with a 128 Kbyte I/O size,  $23 \times 128 = 2944$  Kbytes. And if the application was requesting with an 8 Kbyte I/O size,  $368 \times 8 = 2944$  Kbytes.

### Further Analysis

To investigate ARC misses, check that the ARC has grown to use available DRAM using [Cache: ARC Size](#).

## Cache: L2ARC I/O Bytes

The L2ARC is the 2nd Level Adaptive Replacement Cache, and is an SSD-based cache that is accessed before reading from the much slower pool disks. The L2ARC is currently intended for random read workloads. This statistic shows the read and write byte rates to the L2ARC cache devices, if cache devices are present.

### When to Check L2ARC I/O Bytes

The [Cache: L2ARC I/O Bytes](#) statistic is useful to check during warmup. The write bytes will show the rate of L2ARC warmup time.

### L2ARC I/O Bytes Breakdowns

**Table 5-14 Breakdowns of L2ARC I/O Bytes**

| Breakdown         | Description                                                                                                       |
|-------------------|-------------------------------------------------------------------------------------------------------------------|
| type of operation | Read or write. Read bytes are hits on the cache devices. Write bytes show the cache devices populating with data. |

### Further Analysis

See also [Cache: L2ARC Accesses](#).

## Cache: L2ARC Accesses

The L2ARC is the 2nd Level Adaptive Replacement Cache, and is an SSD-based cache that is accessed before reading from the much slower pool disks. The L2ARC is currently intended for random read workloads. This statistic shows L2ARC accesses if L2ARC cache devices are present, allowing its usage and performance to be observed.

### When to Check L2ARC Accesses

When investigating performance issues, to check how well the current workload is caching in the L2ARC.

### L2ARC Accesses Breakdowns

**Table 5-15 Breakdowns of L2ARC Accesses**

| Breakdown         | Description                                                                                                                                             |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| hit/miss          | The result of the L2ARC lookup.                                                                                                                         |
| filename          | The filename that was requested from the L2ARC. Using this breakdown allows hierarchy mode to be used, so that filesystem directories can be navigated. |
| L2ARC eligibility | This is the eligibility of L2ARC caching, as measured at the time of L2ARC access.                                                                      |
| project           | This shows the project that is accessing the L2ARC.                                                                                                     |
| share             | This shows the share that is accessing the L2ARC.                                                                                                       |
| LUN               | This shows the LUN that is accessing the L2ARC.                                                                                                         |

As described in [Execution Performance Impact](#), breakdown such as by filename would be the most expensive to leave enabled.

#### Further Analysis

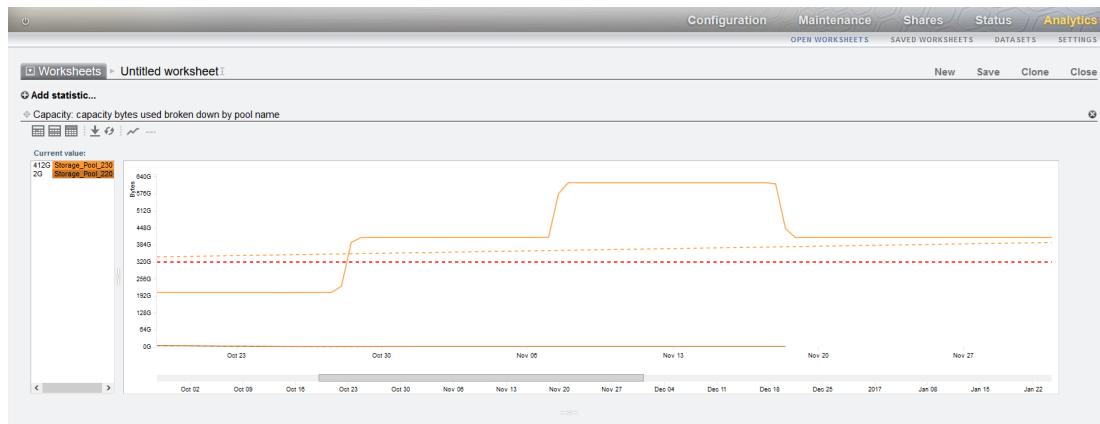
To investigate L2ARC misses, check that the L2ARC has grown enough in size using the Advanced Analytic Cache: L2ARC Size. The L2ARC typically takes hours, if not days, to warm up hundreds of gigabytes when feeding from small random reads. The rate can also be checked by examining writes from [Cache: L2ARC I/O Bytes](#). Also check the Advanced Analytic Cache: L2ARC Errors to see if there are any errors preventing the L2ARC from warming up.

[Cache: ARC Accesses](#) by L2ARC eligibility can also be checked to see if the data is eligible for L2ARC caching in the first place. Because the L2ARC is intended for random read workloads, it will ignore sequential or streaming read workloads, allowing them to be returned from the pool disks instead.

## Capacity: Capacity Bytes Used (BUI)

This is a "trendable" statistic that graphically renders datasets, and displays the trends over the full time span of the datasets in the worksheet. These trend graphs can be both viewed and manipulated. This particular statistic shows the trends for storage capacity usage in gigabyte units, and is broken down by storage pools. To set a threshold alert for capacity usage by bytes, see [Capacity: Capacity Bytes Used \(CLI\)](#).

The following figure shows the bytes-used capacity trend broken down by storage pools over the full time span of the datasets.



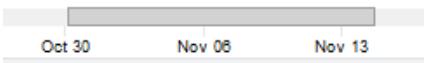
The red-dotted line is the reference line, while other dotted lines show the individual trends. The solid lines reflect the actual capacity usage. The dotted lines, except the red-dotted reference line, are color coded with the solid lines to match the color associated with the storage pool, as seen in the **Current value** pane. When mousing over a pool in the **Current value** pane, a box displays the pool name, target (or reference) bytes number, and intercept date. The intercept date is when the pool reaches the target (or reference) byte size. When mousing over a pool in the graph, the capacity is displayed for the point in time.

You can control which storage pools are displayed, the time span, the value for the reference line, whether the trend lines are displayed, and when to reload the data, as described in the following table. The reference line is not displayed until a value is set for it.

**Table 5-16 Modifying the Capacity Bytes Used Graph**

| Graph Icon | Element        | Description                                                                                                                                                                                                                                                                                                        |
|------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|            | Storage Pool   | Select a pool in the <b>Current value</b> pane to highlight it and display it in the graph. Select an already highlighted pool to hide it.                                                                                                                                                                         |
|            | Reference Line | Select the reference line icon to set a value for the reference line. To hide the reference line, select the icon again. To set a new reference line value, select to show the icon again. The value measurements are: <ul style="list-style-type: none"><li>• * G = Gigabytes</li><li>• * T = Terabytes</li></ul> |
|            | Trend Line     | To show the trend lines, click the trend line icon. To hide the trend lines, select the icon again.                                                                                                                                                                                                                |
|            | Reload Data    | To reload data from the back-end, and to redisplay data over the full interval on which the data are available, click the reload data icon. Both the reference line and the trend lines are removed.                                                                                                               |

**Table 5-16 (Cont.) Modifying the Capacity Bytes Used Graph**

| Graph Icon                                                                        | Element   | Description                                                                                                                                                                                                                              |
|-----------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Time Span | Select a time span by dragging the mouse on the bar between the dates. After a time span is selected, you can drag the entire, highlighted span to new settings, or you can select an end of the time span and drag it to a new setting. |

### When to Check Capacity Bytes Used

This statistic can be used to view the capacity usage trend over a set period of time. The information can be used for storage capacity planning on a storage pool basis. To set a threshold alert for capacity usage based on bytes, see [Capacity: Capacity Bytes Used \(CLI\)](#).

### Capacity Bytes Used Breakdowns

Pool - Name of the pool for which the capacity trend is shown

## Capacity: Capacity Bytes Used (CLI)

This statistic shows the used bytes, in gigabyte units, for storage capacity, including data, metadata, and snapshots, except for reservations. It is used as a threshold alert and cannot be displayed in a graph. Unlike other statistics, it is updated every five minutes instead of every second. Various breakdowns are available to show the pool, project, and share capacity used.

To create this capacity alert for datasets in the CLI, navigate to the `analytics datasets` context. Next, use the command `create` to set the alert.

```
hostname:> analytics datasets
hostname:analytics datasets> create cap.bytesused[name]
```

If using worksheets, navigate to the `analytics worksheets` context, select the desired worksheet, and then navigate to the dataset context. Next, use the command `set name` to set the alert. Finally, commit your changes. In the following example, the "\ character denotes a line break.

```
hostname:> analytics worksheets
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheets worksheet-000> dataset
hostname:analytics worksheets worksheet-000 dataset \
(uncommitted)> set name="cap.bytesused[name]"
hostname:analytics worksheets worksheet-000 dataset \
(uncommitted)> commit
```

For `cap.bytesused`, substitute the appropriate parameters for `[name]` according to the following table.

**Table 5-17 Parameters for Capacity Bytes Used Alert**

| Parameter                                                                             | Description                                                                       |
|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| [pool]                                                                                | Selects all pools                                                                 |
| [pool= <i>poolname</i> ]                                                              | Selects the pool named <i>poolname</i>                                            |
| [project]                                                                             | Selects all projects                                                              |
| [project= <i>projectname</i> ]                                                        | Selects the project named <i>projectname</i>                                      |
| [pool= <i>poolname</i> ] [project]                                                    | Selects all projects in <i>poolname</i>                                           |
| [pool= <i>poolname</i> ] [project= <i>projectname</i> ]                               | Selects the project named <i>projectname</i> in <i>poolname</i>                   |
| [share]                                                                               | Selects all shares                                                                |
| [share= <i>sharename</i> ]                                                            | Selects the share named <i>sharename</i>                                          |
| [pool= <i>poolname</i> ] [share]                                                      | Selects all shares in <i>poolname</i>                                             |
| [pool= <i>poolname</i> ] [share= <i>sharename</i> ]                                   | Selects the share named <i>sharename</i> in <i>poolname</i>                       |
| [project= <i>projectname</i> ] [share]                                                | Selects all shares in <i>projectname</i>                                          |
| [project= <i>projectname</i> ] [share= <i>sharename</i> ]                             | Selects the share named <i>sharename</i> in <i>projectname</i>                    |
| [pool= <i>poolname</i> ] [project= <i>projectname</i> ]<br>[share]                    | Selects all shares in <i>projectname</i> in <i>poolname</i>                       |
| [pool= <i>poolname</i> ] [project= <i>projectname</i> ]<br>[share= <i>sharename</i> ] | Selects the share named <i>sharename</i> in <i>projectname</i> in <i>poolname</i> |

**When to Check Capacity Bytes Used**

This statistic can be used as a threshold alert for the used storage capacity in bytes. If the threshold is exceeded and the alert is triggered, you can mitigate the situation before storage becomes too full and performance is impacted.

**Capacity Bytes Used Breakdowns**

- Pool - Name of the pool to set the alert on
- Project - Name of the project to set the alert on
- Share - Name of the share to set the alert on

**Further Analysis**

See [Capacity: Capacity Percent Used \(CLI\)](#) for a threshold alert for the percentage of storage used capacity.

## Capacity: Capacity Percent Used (BUI)

This is a "trendable" statistic that graphically renders datasets, and displays the trends over the full time span of the datasets in the worksheet. These trend graphs can be both viewed and manipulated. This particular statistic shows the trends for storage capacity usage as a percentage, and is broken down by storage pools. To set a threshold alert for capacity usage by percentage, see [Capacity: Capacity Percent Used \(CLI\)](#).

The following figure shows the percent-used capacity trend broken down by storage pools over the full time span of the datasets.



The red-dotted line is the reference line, while other dotted lines show the individual trends. The solid lines reflect the actual capacity usage. The dotted lines, except the red-dotted reference line, are color coded with the solid lines to match the color associated with the storage pool, as seen in the **Current value** pane. When mousing over a pool in the **Current value** pane, a box displays the pool name, target (or reference) percentage, and intercept date. The intercept date is when the pool reaches the target (or reference) percentage. When mousing over a pool in the graph, the capacity is displayed for the point in time.

You can control which storage pools are displayed, the time span, the value for the reference line, whether the trend lines are displayed, and when to reload the data, as described in the following table. The reference line is not displayed until a value is set for it.

**Table 5-18 Modifying the Capacity Percentage Used Graph**

| Graph Icon | Element        | Description                                                                                                                                                                                |
|------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|            | Storage Pool   | Select a pool in the <b>Current value</b> pane to highlight it and display it in the graph. Select an already highlighted pool to hide it.                                                 |
|            | Reference Line | Select the reference line icon to set a value for the reference line. To hide the reference line, select the icon again. To set a new reference line value, select to show the icon again. |

**Table 5-18 (Cont.) Modifying the Capacity Percentage Used Graph**

| Graph Icon | Element     | Description                                                                                                                                                                                                                              |
|------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|            | Trend Line  | To show the trend lines, click the trend line icon. To hide the trend lines, select the icon again.                                                                                                                                      |
|            | Reload Data | To reload data from the back-end, and to redisplay data over the full interval on which the data are available, click the reload data icon. Both the reference line and the trend lines are removed.                                     |
|            | Time Span   | Select a time span by dragging the mouse on the bar between the dates. After a time span is selected, you can drag the entire, highlighted span to new settings, or you can select an end of the time span and drag it to a new setting. |

**When to Check Capacity Percent Used**

This statistic can be used to view the capacity usage trend over a set period of time. The information can be used for storage capacity planning on a storage-pool basis. To set a threshold alert for capacity usage based on percentage, see [Capacity: Capacity Percent Used \(CLI\)](#).

**Capacity Percent Used Breakdowns**

Pool - Name of the pool for which the capacity trend is shown

## Capacity: Capacity Percent Used (CLI)

This statistic shows the used percentage for storage capacity, including data, metadata, and snapshots, except for reservations. It is used as a threshold alert and cannot be displayed in a graph. Unlike other statistics, it is updated every five minutes instead of every second. Various breakdowns are available to show the pool, project, and share capacity used.

For shares, the storage capacity is the quota, if one exists, or the maximum size on a dynamic LUN. If neither of those exist, the capacity is that of the parent project. For projects, the capacity is the quota, if one exists, or the raw size of the parent pool. For data pools, the capacity is the raw pool size.

To create a capacity alert for datasets in the CLI, navigate to the analytics datasets context. Next, use the command `create` to set the alert.

```
hostname:> analytics datasets
hostname:analytics datasets> create cap.percentused[name]
```

If using worksheets, navigate to the analytics worksheets context, select the desired worksheet, and then navigate to the dataset context. Next, use the command `set name` to set the alert. Finally, commit your changes. In the following example, the "\n" character denotes a line break.

```

hostname:> analytics worksheets
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheets worksheet-000> dataset
hostname:analytics worksheets worksheet-000 dataset \
(uncommitted)> set name="cap.percentused[name]"
hostname:analytics worksheets worksheet-000 dataset \
(uncommitted)> commit

```

For `cap.percentused`, substitute the appropriate parameters for `[name]` according to the following table.

**Table 5-19 Parameters for Capacity Percent Used Alert**

| Parameter                                                            | Description                                                                       |
|----------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| <code>[pool]</code>                                                  | Selects all pools                                                                 |
| <code>[pool=poolname]</code>                                         | Selects the pool named <i>poolname</i>                                            |
| <code>[project]</code>                                               | Selects all projects                                                              |
| <code>[project=projectname]</code>                                   | Selects the project named <i>projectname</i>                                      |
| <code>[pool=poolname] [project]</code>                               | Selects all projects in <i>poolname</i>                                           |
| <code>[pool=poolname] [project=projectname]</code>                   | Selects the project named <i>projectname</i> in <i>poolname</i>                   |
| <code>[share]</code>                                                 | Selects all shares                                                                |
| <code>[share=sharename]</code>                                       | Selects the share named <i>sharename</i>                                          |
| <code>[pool=poolname] [share]</code>                                 | Selects all shares in <i>poolname</i>                                             |
| <code>[pool=poolname] [share=sharename]</code>                       | Selects the share named <i>sharename</i> in <i>poolname</i>                       |
| <code>[project=projectname] [share]</code>                           | Selects all shares in <i>projectname</i>                                          |
| <code>[project=projectname] [share=sharename]</code>                 | Selects the share named <i>sharename</i> in <i>projectname</i>                    |
| <code>[pool=poolname] [project=projectname] [share]</code>           | Selects all shares in <i>projectname</i> in <i>poolname</i>                       |
| <code>[pool=poolname] [project=projectname] [share=sharename]</code> | Selects the share named <i>sharename</i> in <i>projectname</i> in <i>poolname</i> |

### When to Check Capacity Percent Used

This statistic can be used as a threshold alert for the percentage of used storage capacity. If the threshold is exceeded and the alert is triggered, you can mitigate the situation before storage becomes too full and performance is impacted.

### Capacity Percent Used Breakdowns

- Pool - Name of the pool to set the alert on
- Project - Name of the project to set the alert on
- Share - Name of the share to set the alert on

### Further Analysis

See [Capacity: Capacity Bytes Used \(CLI\)](#) for a threshold alert, in bytes, for the storage used capacity.

## Capacity: Meta Device Capacity Bytes Used (BUI)

This statistic shows the amount of bytes used on a meta device, broken down by pool name. This statistic provides trending data, similar to the statistic [Capacity: Capacity Bytes Used \(BUI\)](#).

Use this statistic to monitor meta device storage used as bytes, examine the trend of meta device usage, and to alert when capacity reaches a specific threshold.

This statistic is useful only when meta devices are configured for data deduplication.

### When to Check Capacity Bytes Used

This statistic can be used as a threshold alert for the used meta device capacity, in bytes. A high capacity of bytes used indicates a need to add more meta devices to the configuration. If the threshold is exceeded and an alert is triggered, you can mitigate the situation before a meta device becomes too full and performance is impacted.

### Capacity Bytes Used Breakdown

Pool - Name of the pool for which the capacity trend is shown

## Capacity: Meta Device Capacity Percent Used (BUI)

This statistic shows the percentage of space used on a meta device, broken down by pool name. This statistic provides trending data, similar to the statistic [Capacity: Capacity Percent Used \(BUI\)](#).

Use this statistic to monitor meta device storage usage as a percentage, examine the trend of meta device usage, and to alert when capacity reaches a specific threshold.

This statistic is useful only when meta devices are configured for data deduplication.

### When to Check Capacity Percent Used

This statistic can be used as a threshold alert for the percentage of used meta device capacity. A high percentage use indicates a need to add more meta devices to the configuration. Oracle ZFS Storage Appliance generates an alert when a meta device, used in any pool, reaches a threshold of 85 percent. If the threshold is exceeded and an alert is triggered, you can mitigate the situation before a meta device becomes too full and performance is impacted.

### Capacity Percent Used Breakdown

Pool - Name of the pool for which the capacity trend is shown

## Capacity: System Pool Bytes Used

This statistic shows the used bytes, in gigabyte units, for the system pool capacity, including data, metadata, and snapshots, except for reservations. It is used as a threshold alert and cannot be displayed in a graph. Unlike other statistics, it is updated every five minutes instead of every second.

Use one of the following methods to create this capacity alert in the CLI.

If you are not using worksheets, navigate to the `analytics` and `datasets` context, and use the command `create`.

```
hostname:> analytics
hostname:analytics> datasets
hostname:analytics datasets> create syscap.bytesused
```

If you are using worksheets, navigate to the `analytics` and `worksheets` context, the desired worksheet, the dataset context, and use the command `set name`. The "`\`" character below denotes a line break.

```
hostname:> analytics
hostname:analytics> worksheets
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheets worksheet-000> dataset
hostname:analytics worksheets worksheet-000 dataset \
(uncommitted)> set name="syscap.bytesused"
hostname:analytics worksheets worksheet-000 dataset \
(uncommitted)> commit
```

### When to Check System Pool Bytes Used

This statistic can be used as a threshold alert for the used system pool capacity in bytes. If the threshold is exceeded and the alert is triggered, you can mitigate the situation before the system pool becomes too full and performance is impacted.

#### System Pool Bytes Used Breakdowns

None

#### Further Analysis

See [Capacity: System Pool Percent Used](#) for a threshold alert for the percentage of the system pool used capacity.

## Capacity: System Pool Percent Used

This statistic shows the used percentage of the system pool capacity based on the raw pool size. It is used as a threshold alert and cannot be displayed in a graph. Unlike other statistics, it is updated every five minutes instead of every second.

Use one of the following methods to create this capacity alert in the CLI.

If you are not using worksheets, navigate to the `analytics` and `datasets` context, and use the command `create`.

```
hostname:> analytics datasets
hostname:analytics datasets> create syscap.percentused
```

If you are using worksheets, navigate to the `analytics` and `worksheets` context, the desired worksheet, the dataset context, and use the command `set name`. The "`\`" character below denotes a line break.

```
hostname:> analytics
hostname:analytics> worksheets
hostname:analytics worksheets> select worksheet-000
hostname:analytics worksheets worksheet-000> dataset
hostname:analytics worksheets worksheet-000 dataset \
```

```
(uncommitted) > set name="syscap.percentused"
hostname:analytics worksheets worksheet-000 dataset \
(uncommitted) > commit
```

### When to Check System Pool Percent Used

This statistic can be used as a threshold alert for the used system pool capacity in a percentage. If the threshold is exceeded and the alert is triggered, you can mitigate the situation before the system pool becomes too full and performance is impacted. It is recommended that you set the threshold alert to 80 percent. For information on setting threshold alerts, see [Configuring a Threshold Alert \(BUI\)](#) or [Configuring a Threshold Alert \(CLI\)](#).

### System Pool Percent Used Breakdowns

None

### Further Analysis

See [Capacity: System Pool Bytes Used](#) for a threshold alert, in bytes, for the system pool used capacity.

## Data Movement: Cloud Bytes

This statistic tracks the total bytes transferred to and from Oracle Cloud Infrastructure Object Storage as the result of cloud snapshot operations. The total does not apply to metadata for the transfers; the total only applies to contents of the snapshots that are backed up or restored. Exact measurements that include metadata can be viewed in network analytics.

### When to Check Cloud Bytes

Use this statistic when investigating cloud snapshot activity to determine transfer rates to and from Oracle Cloud Infrastructure Object Storage.

### Cloud Bytes Breakdowns

**Table 5-20 Breakdowns of Cloud Bytes**

| Breakdown          | Description                                                         |
|--------------------|---------------------------------------------------------------------|
| type of operation  | Total bytes for each type of operation, read or write.              |
| cloud target       | Total bytes broken down by cloud targets configured in the service. |
| raw (no breakdown) | Total bytes transferred to all targets and all operation types.     |

### Further Analysis

To examine cloud backup requests instead of bytes transferred, see [Data Movement: Cloud Requests](#).

## Data Movement: Cloud Requests

This statistic tracks the total number of cloud requests that occur to Oracle Cloud Infrastructure Object Storage as the result of cloud snapshot operations. A request often consists of many bytes or, in some cases, a request might not transfer any data. A request is equivalent to a coarse-grained HTTP request. For example, deleting a cloud backup would

result in several cloud requests but no bytes transferred. By comparison, a backup would result in many `nwrite` requests, each of which results in many thousands of bytes transferred.

### **When to Check Cloud Bytes**

Use this statistic when investigating cloud snapshot activity to determine whether requests are succeeding and how many requests are being processed. In conjunction with cloud bytes, observers can see the rate at which their snapshots are progressing (restore or backup) and determine how quickly requests are being processed successfully.

### **Cloud Requests Breakdowns**

**Table 5-21 Breakdowns of Cloud Requests**

| Breakdown          | Description                                                                                                                                                       |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation  | Total requests for each type of operation: <code>nread</code> (read), <code>nwrite</code> (write), <code>ntrim</code> (remove), and <code>nerror</code> (errors). |
| cloud target       | Total requests broken down by cloud targets configured in the service.                                                                                            |
| raw (no breakdown) | Total requests to all targets and all operation types.                                                                                                            |

### **Further Analysis**

To examine cloud backup bytes transferred instead of requests, see [Data Movement: Cloud Bytes](#).

## **Data Movement: Shadow Migration Bytes**

This statistic tracks total shadow migration bytes per second transferred as part of migrating file or directory contents. This does not apply to metadata (extended attributes, ACLs, and so on). It gives a rough approximation of the data transferred, but source datasets with a large amount of metadata will show a disproportionately small bandwidth. The complete bandwidth can be observed by looking at network analytics.

### **When to Check Shadow Migration Bytes**

When investigating shadow migration activity.

### **Shadow Migration Bytes Breakdowns**

**Table 5-22 Breakdowns of Shadow Migration Bytes**

| Breakdown | Description                                                                                                                             |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------|
| filename  | The filename that was migrated. Using this breakdown allows hierarchy mode to be used, so that filesystem directories can be navigated. |
| project   | This shows the project that contains a shadow migration.                                                                                |
| share     | This shows the share that is being migrated.                                                                                            |

### **Further Analysis**

See also [Data Movement: Shadow Migration Ops](#) and [Data Movement: Shadow Migration Requests](#).

## Data Movement: Shadow Migration Ops

This statistic tracks shadow migration operations that require going to the source filesystem.

### When to Check Shadow Migration Ops

When investigating shadow migration activity.

### Shadow Migration Ops Breakdowns

**Table 5-23 Breakdowns of Shadow Migration Ops**

| Breakdown | Description                                                                                                                             |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------|
| filename  | The filename that was migrated. Using this breakdown allows hierarchy mode to be used, so that filesystem directories can be navigated. |
| project   | This shows the project that contains a shadow migration.                                                                                |
| share     | This shows the share that is being migrated.                                                                                            |
| latency   | Measure the latency of requests from the shadow migration source.                                                                       |

### Further Analysis

See also [Data Movement: Shadow Migration Bytes](#) and [Data Movement: Shadow Migration Requests](#).

## Data Movement: Shadow Migration Requests

This statistic tracks shadow migration requests for files or directories that are not cached and known to be local to the filesystem. It does account for both migrated and unmigrated files and directories, and can be used to track the latency incurred as part of shadow migration, as well as track the progress of background migration. It currently encompasses both synchronous and asynchronous (background) migration, so it is not possible to view only latency visible to clients.

### When to Check Shadow Migration Requests

When investigating shadow migration activity.

### Shadow Migration Requests Breakdowns

**Table 5-24 Breakdowns of Shadow Migration Requests**

| Breakdown | Description                                                                                                                             |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------|
| filename  | The filename that was migrated. Using this breakdown allows hierarchy mode to be used, so that filesystem directories can be navigated. |
| project   | This shows the project that contains a shadow migration.                                                                                |
| share     | This shows the share that is being migrated.                                                                                            |
| latency   | Measure the latency incurred as part of shadow migration.                                                                               |

### Further Analysis

See also [Data Movement: Shadow Migration Ops](#) and [Data Movement: Shadow Migration Bytes](#).

## Data Movement: NDMP Bytes Statistics

This statistic shows total NDMP bytes transferred per second during backup or restore operations. It indicates how much data is being read or written for NDMP backups or restores. This statistic is zero unless NDMP is configured and active.

### **When to Check NDMP Bytes Statistics**

When investigating NDMP backup and restore performance.

### **NDMP Bytes Statistics Breakdowns**

**Table 5-25 Breakdowns of NDMP Bytes**

| Breakdown         | Description                                        |
|-------------------|----------------------------------------------------|
| type of operation | Read or write.                                     |
| client            | Remote hostname or IP address of the NDMP client.  |
| session           | Set of data streams managed by NDMP.               |
| type of I/O       | Network, disk, tape, and so on.                    |
| file              | Used with <code>tar</code> and <code>dump</code> . |

### **Further Analysis**

See also [Data Movement: NDMP Operations Statistics](#).

## Data Movement: NDMP Operations Statistics

This statistic shows total NDMP backup or restore operations performed per second. This statistic is zero unless NDMP is configured and active.

### **When to Check NDMP Operations Statistics**

When investigating NDMP backup and restore performance.

### **NDMP Operations Statistics Breakdowns**

**Table 5-26 Breakdowns of NDMP Operations**

| Breakdown         | Description                                               |
|-------------------|-----------------------------------------------------------|
| type of operation | Read or write.                                            |
| client            | Remote hostname or IP address of the NDMP client.         |
| session           | Set of data streams managed by NDMP.                      |
| type of I/O       | Network, disk, tape, and so on.                           |
| latency           | Time elapsed between operations.                          |
| size              | Number of bytes read/written per operation.               |
| offset            | Location within a backup stream, buffer, file, and so on. |

**Further Analysis**

See also [Data Movement: NDMP Bytes Statistics](#).

## Data Movement: Replication Bytes

This statistic tracks network data throughput of project or share replication in bytes per second.

**When to Check Replication Bytes**

When investigating replication activity and replication network usage.

**Replication Bytes Breakdowns****Table 5-27 Breakdowns of Replication Bytes**

| Breakdown          | Description                                                                                |
|--------------------|--------------------------------------------------------------------------------------------|
| direction          | Shows bytes broken down by direction, to or from Oracle ZFS Storage Appliance.             |
| type of operation  | Shows bytes broken down by the type of operation with the remote appliance, read or write. |
| peer               | Shows bytes broken down by the name of the remote appliances.                              |
| pool name          | Shows bytes broken down by the name of the pools.                                          |
| project            | Shows bytes broken down by the name of the projects.                                       |
| dataset            | Shows bytes broken down by the name of the shares.                                         |
| as a raw statistic | Shows bytes as raw statistics.                                                             |

**Further Analysis**

See also [Data Movement: Replication Operations](#).

## Data Movement: Replication Operations

This statistic tracks replication read and write operations performed by the replication service.

**When to Check Replication Operations**

When investigating replication activity.

**Replication Operations Breakdowns****Table 5-28 Breakdowns of Replication Operations**

| Breakdown         | Description                                                                                     |
|-------------------|-------------------------------------------------------------------------------------------------|
| direction         | Shows I/O operations broken down by direction, to or from Oracle ZFS Storage Appliance.         |
| type of operation | Shows I/O operations broken down by type of operation with the remote appliance, read or write. |
| peer              | Shows I/O operations broken down by the name of the remote appliances.                          |
| pool name         | Shows I/O operations broken down by the name of the pools.                                      |

**Table 5-28 (Cont.) Breakdowns of Replication Operations**

| Breakdown          | Description                                                                                                   |
|--------------------|---------------------------------------------------------------------------------------------------------------|
| project            | Shows I/O operations broken down by the name of the projects.                                                 |
| dataset            | Shows I/O operations broken down by the name of the shares.                                                   |
| latency            | Measures the current network latency experienced during replication data transfer.                            |
| offset             | Measures the offset in all replication transfers relative to the start of each individual replication update. |
| size               | Measures the read/write operations size performed by replication service.                                     |
| as a raw statistic | Shows I/O operations as raw statistics.                                                                       |

**Further Analysis**

See also [Data Movement: Replication Bytes](#).

To examine data throughput of project/share replication at the ZFS send/receive internal interface, see [Data Movement: Replication Send/Receive Bytes](#).

## Disk: Disks

The Disks statistic is used to display the heat map for disks broken down by percent utilization. This is the best way to identify when pool disks are under heavy load. It can also identify problem disks that are beginning to perform poorly, before their behavior triggers a fault and automatic removal from the pool.

**When to Check Disks**

Any investigation into disk performance.

**Disks Breakdowns****Table 5-29 Breakdowns of Disks**

| Breakdown           | Description                                                                                                                                                  |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| percent utilization | A heat map with utilization on the Y-axis and each level on the Y-axis colored by the number of disks at that utilization: from light (none) to dark (many). |

**Interpretation**

Utilization is a better measure of disk load than IOPS or throughput. Utilization is measured as the time during which that disk was busy performing requests (see **Details** at the end of this section). At 100% utilization, the disk might not be able to accept more requests, and additional I/O might wait on a queue. This I/O wait time will cause latency to increase and overall performance to decrease.

In practice, disks with a consistent utilization of 75% or higher are an indication of a heavy disk load.

The heat map allows a particular pathology to be easily identified: a single disk misperforming and reaching 100% utilization (a bad disk). Disks can exhibit this

symptom before they fail. After disks fail, they are automatically removed from the pool with a corresponding alert. This particular problem is during the time *before* they fail, when their I/O latency is increasing and slowing down overall Oracle ZFS Storage Appliance performance, but their status is considered healthy; they have yet to identify any error state. This situation will be seen as a faint line at the top of the heat map, showing that a single disk has stayed at 100% utilization for some time.

Suggested interpretation summary:

**Table 5-30 Interpretation Summary**

| Observed                                | Suggested Interpretation                            |
|-----------------------------------------|-----------------------------------------------------|
| Most disks consistently over 75%        | Available disk resources are being exhausted.       |
| Single disk at 100% for several seconds | This can indicate a bad disk that is about to fail. |

### Further Analysis

To understand the nature of the I/O, such as IOPS, throughput, I/O sizes, and offsets, see [Disk: I/O Operations](#) and [Disk: I/O Bytes](#).

### Details

This statistic is actually a measure of percent busy, which serves as a reasonable approximation of percent utilization because Oracle ZFS Storage Appliance manages the disks directly. Technically, this is not a direct measure of disk utilization: At 100% busy, a disk might be able to accept more requests which it serves concurrently by inserting into and reordering its command queue, or serves from its on-disk cache.

## Disk: I/O Bytes

This statistic shows the back-end throughput to the disks, in I/O bytes per second, after Oracle ZFS Storage Appliance has processed logical I/O into physical I/O based on share settings and software RAID settings. To configure the RAID settings, see [Configuring Storage in Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x](#).

For example, an 8 Kbyte write over NFSv3 can become a 128 Kbyte write after the record size is applied from the share settings, which can then become a 256 Kbyte write to the disks after mirroring is applied, plus additional bytes for filesystem metadata. On the same mirrored environment, an 8 Kbyte NFSv3 read can become a 128 Kbyte disk read after the record size is applied; however, this does not get doubled by mirroring (the data only needs to be read from one half of the mirrored environment). It can help to monitor throughput at all layers at the same time to examine this behavior; for example, by viewing:

- [Network: Device Bytes](#) - Data rate on the network (logical)
- [Disk: ZFS Logical I/O Bytes](#) - Data rate to the share (logical)
- [Disk: I/O Bytes](#) - Data rate to the disks (physical)

When viewing the I/O bytes per second broken down by operation type, the operation pane shows the read and write statistics. Select an operation in the pane to highlight it and display it separately, by color, in the graph. Select an already highlighted operation to not display it separately in the graph.

When viewing the I/O bytes per second broken down by disk, the disk breakdown pane shows the statistics per the name of the storage pool disk or system disk. Select a disk in the disk breakdown pane to highlight it and display it separately, by color, in the graph. Select an

already highlighted disk to not display it separately in the graph. When mousing over a disk in this pane, a box displays the following information:

- Disk name - Controller or disk shelf name/label: I/O bytes per second
- **Disk Type:** - Typically **HDD** or **SSD**
- **Type:** - Typically **System**, **Data**, **Cache**, or **Log**
- **Size**
- **RPM** - Not displayed for SSDs

To display the hierarchy view for all disks, click **View Hierarchy**, below the disk breakdown pane. The I/O bytes per second are shown for the controller and each disk shelf. Click **Refresh hierarchy** to refresh the hierarchical breakdown visible in the graph. To close this view, click the close icon .

### When to Check I/O Bytes

Use this statistic to understand the nature of back-end disk I/O, based on bytes, after an issue based on disk utilization or latency has been observed. It is difficult to identify an issue from disk I/O throughput alone: A single disk might be performing well at 50 Mbytes/sec (sequential I/O), yet poorly at 5 Mbytes/sec (random I/O).

Use the disk breakdown pane and the hierarchy view to determine if the disk shelves are balanced in regard to disk I/O throughput. When examining disk throughput, it is common that cache and log devices have higher throughput than other storage pool disks.

### I/O Bytes Breakdowns

**Table 5-31 Breakdowns of I/O Bytes**

| Breakdown         | Description                                                                                                                           |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | Read or write.                                                                                                                        |
| disk              | Storage pool disk or system disk. This breakdown can identify system disk I/O versus pool disk I/O, and I/O to cache and log devices. |

### Further Analysis

For the best measure of disk utilization, see [Disk: Disks](#). To examine operations/second instead of bytes/second, see [Disk: I/O Operations](#).

## Disk: I/O Operations

This statistic shows the back-end I/O operations per second to the disks (disk IOPS) after Oracle ZFS Storage Appliance has processed logical I/O into physical I/O based on share settings and software RAID settings. To configure the RAID settings, see [Configuring Storage](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*.

For example, 16 sequential 8 Kbyte NFSv3 writes might become a single 128 Kbyte write sometime later after the data has been buffered in the ARC DRAM cache, which might then become multiple disk writes due to RAID, such as two writes to each half of a mirror. It can help to monitor I/O at all layers at the same time to examine this behavior; for example, by viewing:

- [Protocol: NFSv\[2-4\] Operations](#) - NFS writes (logical)
- [Disk: ZFS Logical I/O Operations](#) - Share I/O (logical)
- Disk: I/O Operations - I/O to the disks (physical)

This statistic includes a breakdown of disk I/O latency, which is a direct measure of performance for synchronous I/O, and also useful as a measure of the magnitude of back-end disk load. It is difficult to identify issues from disk IOPS alone without considering latency: A single disk might be performing well at 400 IOPS (sequential and small I/O hitting mostly from the disk's on-board DRAM cache), yet poorly at 110 IOPS (random I/O causing head seek and waiting on disk rotation).

The latency breakdown is presented as a heat map, showing the pattern of I/O latency, along with outliers. Mouse over the outliers icon  to see the current value, and click on the icon to toggle between different percentages of outlier elimination. Disk I/O latency is often related to the performance of the delivered logical I/O, such as with synchronous reads (non-prefetch) and synchronous writes. Sometimes the latency is not directly related to logical I/O performance, such as for asynchronous writes that are later flushed to disk, and for prefetch reads.

Because it is difficult to determine a per-disk IOPS limit, also examine the disk IOPS by the offset, which helps identify the IOPS type as either random or sequential, and the I/O size. Use the following breakdowns to observe these attributes:

- Disk: I/O Operations - Broken down by offset
- Disk: I/O Operations - Broken down by size

When viewing a breakdown, select an individual result in the pane to highlight it and display it separately, by color, in the graph. Select an already highlighted result to not display it separately in the graph.

When viewing the disk IOPS by the disk breakdown, mousing over a disk in the disk breakdown pane displays a box with the following information:

- Disk name - Controller or disk shelf name/label: I/O operations per second
- **Disk Type:** - Typically **HDD** or **SSD**
- **Type:** - Typically **System**, **Data**, **Cache**, or **Log**
- **Size**
- **RPM** - Not displayed for SSDs

To display the hierarchy view for all disks, click **View Hierarchy**, below the disk breakdown pane. The I/O operations per second are shown for the controller and each disk shelf. Click **Refresh hierarchy** to refresh the hierarchical breakdown visible in the graph. To close this view, click the close icon .

### When to Check I/O Operations

Use this statistic to understand the nature of back-end disk I/O, based on disk I/O operations per second (IOPS), after an issue based on disk utilization or latency has been observed.

Use the disk breakdown pane and the hierarchy view to determine if the disk shelves are balanced in regard to disk IOPS. When examining disk IOPS, it is common that cache and log devices have higher throughput than other storage pool disks.

### I/O Operations Breakdowns

**Table 5-32 Breakdowns of I/O Operations**

| Breakdown         | Description                                                                                                                                                                                                                                         |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | Read or write.                                                                                                                                                                                                                                      |
| disk              | Storage pool disk or system disk. This breakdown can identify system disk I/O versus pool disk I/O, and I/O to cache and log devices.                                                                                                               |
| size              | Heat map showing the distribution of I/O sizes.                                                                                                                                                                                                     |
| latency           | Heat map showing the latency of disk I/O, as measured from when the I/O was requested to the disk to when the disk returned the completion.                                                                                                         |
| offset            | Heat map showing the disk location offset of disk I/O. This can be used to identify random or sequential disk IOPS. To better see details, use the zoom-in icon  . |

### Further Analysis

For the best measure of disk utilization, see [Disk: Disks](#). To examine bytes/second instead of operations/second, see [Disk: I/O Bytes](#).

## Name Service: Lookups

This statistic shows requests made by the name service to back-end sources, such as LDAP, DNS, and NIS.

An understanding of operating system internals is helpful to interpret this statistic.

### When to Check Name Service Lookups

Check the latency breakdown if long latencies are experienced on Oracle ZFS Storage Appliance, especially during administrative logins. The database name breakdown shows what the latency is for, and the source breakdown shows which remote server is responsible. For average latency, see [Name Service: Lookups Average Latency](#).

Name service analytics should be used primarily to analyze performance and diagnose name service problems during investigations. Name service analytics should not be run continuously because they will unnecessarily consume system resources. You could generate an alert if the average latency substantially increases for a period of time, and the alert will appear on the dashboard. To set a threshold alert, see [Configuring a Threshold Alert - BUI, CLI](#).

### Name Service Lookups Breakdowns

**Table 5-33 Breakdowns of Name Service Lookups**

| Breakdown         | Description                                       |
|-------------------|---------------------------------------------------|
| database name     | Name service database, such as LDAP, DNS, or NIS. |
| type of operation | Request type.                                     |
| latency           | Time for this request to complete.                |
| result            | Success or fail.                                  |
| source            | Hostname or IP address of this request.           |

## Further Analysis

For average latency, see [Name Service: Lookups Average Latency](#). To examine operations instead of lookups, see [Name Service: Operations](#).

# Network: Device Bytes

This statistic measures network device activity in bytes/second. Network devices are the physical network ports (see [Network Configuration](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*). The bytes measured by this statistic include all network payload headers (Ethernet, IP, TCP, NFS, SMB, and so on).

## When to Check Device Bytes

Network bytes can be used a rough measure of Oracle ZFS Storage Appliance load. It should also be checked whenever performance issues are investigated, especially for 1 Gbit/sec interfaces, in case the bottleneck is the network device. The maximum practical throughput for network devices in each direction (in or out) based on speed:

- 1 Gbit/sec Ethernet: ~120 Mbytes/sec device bytes
- 10 Gbit/sec Ethernet: ~1.16 Gbytes/sec device bytes

If a network device shows a higher rate than these, use the direction breakdown to see the inbound and outbound components.

## Device Bytes Breakdowns

**Table 5-34 Breakdowns of Device Bytes**

| Breakdown | Description                                                                                                                                            |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| direction | In or out, relative to the Oracle ZFS Storage Appliance system. For example, NFS reads to the appliance would be show as out(bound) network bytes.     |
| device    | Network device (see "Devices" in <a href="#">Network Configuration</a> in <i>Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x</i> ). |

## Further Analysis

See also [Network: Interface Bytes](#) for network throughput at the interface level, instead of the device level.

# Network: Device Errors

This statistic tracks and displays NIC devices errors per second. These errors are created by dropped inbound or outbound packets. Each NIC driver can include different error messages, so not all drivers will generate the same errors.

In the BUI, this report is under the **Network** group and is called **Device errors**. In the CLI, this statistic appears as `nic.errors`.

## When to Check Device Errors

The Device Errors analytic should be checked routinely to see if there are any problems.

## Device Errors Breakdowns

**Table 5-35 Breakdowns of Device Errors**

| Breakdown | Description                                                                                                                                                                                                                          |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| direction | In or out, relative to the Oracle ZFS Storage Appliance system. For example, NFS reads to the appliance would be show as out(bound) network bytes. In the CLI, this breakdown is identified as <code>nic.errors[direction]</code> .  |
| device    | Network device (see "Devices" in <a href="#">Network Configuration</a> in <i>Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x</i> ). In the CLI, this breakdown is identified as <code>nic.errors[device]</code> . |

## Network: Interface Bytes

This statistic measures network interface activity in bytes/second. Network interfaces are the logical network interfaces (see [Network Configuration](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*). The measured bytes by this statistic includes all network payload headers (Ethernet, IP, TCP, NFS/SMB, and so on).

### Example

See [Network: Device Bytes](#) for an example of a similar statistic with similar breakdowns.

### When to Check Interface Bytes

Network bytes can be used a rough measure of Oracle ZFS Storage Appliance load. This statistic can be used to see the rate of network bytes through different interfaces. To examine network devices that make up an interface, especially to identify if there are balancing problems with LACP aggregations, use statistic [Network: Device Bytes](#).

### Interface Bytes Breakdowns

**Table 5-36 Breakdowns of Interface Bytes**

| Breakdown | Description                                                                                                                                                  |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| direction | In or out, relative to the Oracle ZFS Storage Appliance system. For example, NFS reads to the appliance would be show as out(bound) network bytes.           |
| interface | Network interface (see "Interfaces" in <a href="#">Network Configuration</a> in <i>Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x</i> ). |

### Further Analysis

See also [Network: Device Bytes](#) for network throughput at the device level, instead of at the interface level.

## Protocol: Fibre Channel Bytes

This statistic shows Fibre Channel bytes/second requested by initiators to Oracle ZFS Storage Appliance.

**Example**

See [Protocol: iSCSI Bytes](#) for an example of a similar statistic with similar breakdowns.

**When to Check Fibre Channel Bytes**

Fibre Channel bytes/sec can be used as an indication of FC load, in terms of throughput. For a deeper analysis of FC activity, see [Protocol: Fibre Channel Operations](#).

**Fibre Channel Bytes Breakdowns**

**Table 5-37 Breakdowns of Fibre Channel Bytes**

| Breakdown | Description                      |
|-----------|----------------------------------|
| initiator | Fibre Channel client initiator.  |
| target    | Local SCSI target.               |
| project   | The project for this FC request. |
| lun       | The LUN for this FC request.     |

See [Configuring Storage Area Network \(SAN\)](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x* for terminology definitions.

**Further Analysis**

- [Protocol: Fibre Channel Operations](#) for numerous other breakdowns on FC operations
- [Protocol: Fibre Channel Average Latency](#) for average latency per second
- [Cache: ARC Accesses](#) to learn how well an FC read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: Fibre Channel Operations

This statistic shows Fibre Channel operations/second (FC IOPS) requested by initiators to Oracle ZFS Storage Appliance. Various useful breakdowns are available: to show the initiator, target, type, and latency of the FC I/O.

**Example**

See [Protocol: iSCSI Operations](#) for an example of a similar statistic with similar breakdowns.

**When to Check Fibre Channel Operations**

Fibre Channel operations/sec can be used as an indication of FC load, and can also be viewed on the dashboard.

Use the latency breakdown when investigating FC performance issues, especially to quantify the magnitude of the issue. This measures the I/O latency component for which Oracle ZFS Storage Appliance is responsible, and displays it as a heat map so that the overall latency pattern can be seen, along with outliers. If the FC latency is high, drill down further on latency to identify the client initiator, the type of operation, and LUN for the high latency, and check other statistics for both CPU and Disk load to investigate why Oracle ZFS Storage Appliance is slow to respond. If latency is low, Oracle ZFS Storage Appliance is performing quickly, and any performance issues experienced on the client initiator are more likely to be caused by other factors in the environment, such as the network infrastructure, and CPU load on the client itself.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the client initiator, lun, and command breakdowns.

### Fibre Channel Operations Breakdowns

**Table 5-38 Breakdowns of Fibre Channel Operations**

| Breakdown         | Description                                                                                                                                                                                                                                                                     |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| initiator         | Fibre Channel client initiator.                                                                                                                                                                                                                                                 |
| target            | Local SCSI target.                                                                                                                                                                                                                                                              |
| project           | The project for this FC request.                                                                                                                                                                                                                                                |
| lun               | The LUN for this FC request.                                                                                                                                                                                                                                                    |
| type of operation | FC operation type. This shows how the SCSI command is transported by the FC protocol, which can give an idea to the nature of the I/O.                                                                                                                                          |
| command           | SCSI command sent by the FC protocol. This can show the real nature of the requested I/O (read/write/sync-cache/...).                                                                                                                                                           |
| latency           | A heat map showing the latency of FC I/O, as measured from when the FC request arrived on Oracle ZFS Storage Appliance from the network, to when the response is sent; this latency includes the time to process the FC request, and to perform any disk I/O.                   |
| offset            | A heat map showing the file offset of FC I/O. This can be used to identify random or sequential FC IOPS. Use the <a href="#">Disk: I/O Operations</a> statistic to check whether random FC IOPS maps to random Disk IOPS after the LUN and RAID configuration has been applied. |
| size              | A heat map showing the distribution of FC I/O sizes.                                                                                                                                                                                                                            |

These breakdowns can be combined to produce powerful statistics. For example, use [Protocol: Fibre Channel operations per second](#) of command read broken down by latency to examine latency for SCSI reads only.

### Further Analysis

- [Protocol: Fibre Channel Bytes](#) for FC bytes/second
- [Protocol: Fibre Channel Average Latency](#) for average latency per second
- [Cache: ARC Accesses](#) to learn how well an FC read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: FTP Bytes

This statistic shows FTP bytes/second requested by clients to Oracle ZFS Storage Appliance. Various useful breakdowns are available: to show the client, user, and filename of the FTP requests.

### Example

FTP

### When to Check FTP Bytes

FTP bytes/sec can be used as an indication of FTP load, and can be viewed on the dashboard.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the `client`, `user`, and `filename` breakdowns, and the filename hierarchy view. It might be best to enable these breakdowns for short periods only: The by-filename breakdown can be one of the most expensive in terms of storage and execution overhead, and might not be suitable to leave enabled permanently on appliances with high rates of FTP activity.

### FTP Bytes Breakdowns

**Table 5-39 Breakdowns of FTP Bytes**

| Breakdown         | Description                                                                                                                                     |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | FTP operation type (get/put/...).                                                                                                               |
| user              | Username of the client.                                                                                                                         |
| filename          | Filename for the FTP operation, if known, and cached by Oracle ZFS Storage Appliance. If the filename is not known it is reported as <unknown>. |
| share             | The share for this FTP request.                                                                                                                 |
| project           | The project for this FTP request.                                                                                                               |
| client            | Remote hostname or IP address of the FTP client.                                                                                                |

These breakdowns can be combined to produce powerful statistics. For example, use Protocol: FTP bytes per second for client `hostname.example.com` broken down by `filename` to view which files a particular client is accessing.

### Further Analysis

See [Cache: ARC Accesses](#) to learn how well an FTP read workload is returning from cache, and [Disk: I/O Operations](#) for the back-end disk I/O caused.

## Protocol: HTTP/WebDAV Requests

This statistic shows HTTP/WebDAV requests/second requested by HTTP clients. Various useful breakdowns are available: to show the client, filename, and latency of the HTTP request.

### When to Check HTTP/WebDAV Requests

HTTP/WebDAV requests/sec can be used as an indication of HTTP load, and can also be viewed on the dashboard.

Use the latency breakdown when investigating HTTP performance issues, especially to quantify the magnitude of the issue. This measures the latency component for which Oracle ZFS Storage Appliance is responsible, and displays it as a heat map so that the overall latency pattern can be seen, along with outliers. If the HTTP latency is high, drill down further on latency to identify the file, size, and response code for the high-latency HTTP requests, and check other statistics for both CPU and Disk load to investigate why Oracle ZFS Storage Appliance is slow to respond; if latency is low, the appliance is performing quickly, and any performance issues experienced on the client initiator are more likely to be caused by other factors in the environment, such as the network infrastructure, and CPU load on the client itself.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the `client`, `response code`, and `requested filename` breakdowns.

## HTTP/WebDAV Requests Breakdowns

**Table 5-40 Breakdowns of HTTP/WebDAV Requests**

| Breakdown         | Description                                                                                                                                                                                                                                                              |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | HTTP request type (get/post).                                                                                                                                                                                                                                            |
| response code     | HTTP response (200/404/...).                                                                                                                                                                                                                                             |
| client            | Client hostname or IP address.                                                                                                                                                                                                                                           |
| filename          | Filename requested by HTTP.                                                                                                                                                                                                                                              |
| latency           | A heat map showing the latency of HTTP requests, as measured from when the HTTP request arrived on Oracle ZFS Storage Appliance from the network, to when the response is sent; this latency includes the time to process the HTTP request, and to perform any disk I/O. |
| size              | A heat map showing the distribution of HTTP request sizes.                                                                                                                                                                                                               |

These breakdowns can be combined to produce powerful statistics. For example:

- Protocol: HTTP/WebDAV operations per second of type get broken down by latency (**to examine latency for HTTP GETs only**)
- Protocol: HTTP/WebDAV requests per second for response code '404' broken down by filename (**to see which non-existent files were requested**)
- Protocol: HTTP/WebDAV requests per second for client 'deimos.sf.fishpong.com' broken down by filename (**to examine files requested by a particular client**)

### Further Analysis

See [Network: Device Bytes](#) for a measure of network throughput caused by HTTP activity. Also see [Cache: ARC Accesses](#) to learn how well an HTTP read workload is returning from cache, and [Disk: I/O Operations](#) for the back-end disk I/O caused.

## Protocol: iSCSI Bytes

This statistic shows iSCSI bytes/second requested by initiators to Oracle ZFS Storage Appliance.

### When to Check iSCSI Bytes

iSCSI bytes/sec can be used as an indication of iSCSI load, in terms of throughput. For a deeper analysis of iSCSI activity, see [Protocol: iSCSI Operations](#).

### iSCSI Bytes Breakdowns

**Table 5-41 Breakdowns of iSCSI Bytes**

| Breakdown | Description                         |
|-----------|-------------------------------------|
| initiator | iSCSI client initiator.             |
| target    | Local SCSI target.                  |
| project   | The project for this iSCSI request. |
| lun       | The LUN for this iSCSI request.     |

**Table 5-41 (Cont.) Breakdowns of iSCSI Bytes**

| Breakdown | Description                                     |
|-----------|-------------------------------------------------|
| client    | The remote iSCSI client hostname or IP address. |

For terminology definitions, see [Configuring Storage Area Network \(SAN\)](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*.

### Further Analysis

- [Protocol: iSCSI Operations](#) for numerous other breakdowns on iSCSI operations
- [Protocol: iSCSI Average Latency](#) for average latency per second
- [Cache: ARC Accesses](#) to learn how well an iSCSI read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: iSCSI Operations

This statistic shows iSCSI operations/second (iSCSI IOPS) requested by initiators to Oracle ZFS Storage Appliance. Various useful breakdowns are available: to show the initiator, target, type, and latency of the iSCSI I/O.

### When to Check iSCSI Operations

iSCSI operations/sec can be used as an indication of iSCSI load, and can also be viewed on the dashboard.

Use the latency breakdown when investigating iSCSI performance issues, especially to quantify the magnitude of the issue. This measures the I/O latency component for which Oracle ZFS Storage Appliance is responsible, and displays it as a heat map so that the overall latency pattern can be seen, along with outliers. If the iSCSI latency is high, drill down further on latency to identify the client initiator, the type of operation, and LUN for the high latency, and check other statistics for both CPU and Disk load to investigate why the appliance is slow to respond; if latency is low, the appliance is performing quickly, and any performance issues experienced on the client initiator are more likely to be caused by other factors in the environment, such as the network infrastructure, and CPU load on the client itself.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the client initiator, lun, and command breakdowns.

### iSCSI Operations Breakdowns

**Table 5-42 Breakdowns of iSCSI Operations**

| Breakdown | Description                         |
|-----------|-------------------------------------|
| initiator | iSCSI client initiator.             |
| target    | Local SCSI target.                  |
| project   | The project for this iSCSI request. |
| lun       | The LUN for this iSCSI request.     |

**Table 5-42 (Cont.) Breakdowns of iSCSI Operations**

| Breakdown         | Description                                                                                                                                                                                                                                                             |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | iSCSI operation type. This shows how the SCSI command is transported by the iSCSI protocol, which can give an idea to the nature of the I/O.                                                                                                                            |
| command           | SCSI command sent by the iSCSI protocol. This can show the real nature of the requested I/O (read/write/sync-cache/...).                                                                                                                                                |
| latency           | A heat map showing the latency of iSCSI I/O, as measured from when the iSCSI request arrived on Oracle ZFS Storage Appliance from the network, to when the response is sent; this latency includes the time to process the iSCSI request, and to perform any disk I/O.  |
| offset            | A heat map showing the file offset of iSCSI I/O. This can be used to identify random or sequential iSCSI IOPS. Use the Disk I/O operations statistic to check whether random iSCSI IOPS maps to random Disk IOPS after the LUN and RAID configuration has been applied. |
| size              | A heat map showing the distribution of iSCSI I/O sizes.                                                                                                                                                                                                                 |

These breakdowns can be combined to produce powerful statistics. For example:

- Protocol: iSCSI operations per second of command read broken down by latency (to examine latency for SCSI reads only)

#### Further Analysis

- Protocol: iSCSI Bytes for iSCSI bytes/second
- Protocol: iSCSI Average Latency for average latency per second
- Cache: ARC Accesses to learn how well an iSCSI read workload is returning from cache
- Disk: I/O Operations for the back-end disk I/O caused

## Protocol: NFSv[2-4] Bytes

This statistic shows NFSv[2-4] bytes/second transferred between NFS clients and Oracle ZFS Storage Appliance. Supported NFS versions are: NFSv2, NFSv3, NFSv4.0, and NFSv4.1. Bytes statistics can be broken down by: operation, client, filename, share, and project.

#### When to Check NFSv[2-4] Bytes

NFSv[2-4] bytes/sec can be used as an indication of NFS load. The best way to improve performance is to eliminate unnecessary work, which can be identified through the client and filename breakdowns, and the filename hierarchy view. Client and especially filename breakdowns can be very expensive in terms of storage and execution overhead. Therefore, it is not recommended to permanently enable these breakdowns on a busy production Oracle ZFS Storage Appliance.

#### NFSv[2-4] Bytes Breakdowns

**Table 5-43 Breakdowns of NFS Bytes**

| Breakdown         | Description                                                                                                                                                                                                                                                                                                                                                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | NFS operation type (read/write/getattr/setattr/lookup/...).                                                                                                                                                                                                                                                                                                |
| client            | Remote hostname or IP address of the NFS client.                                                                                                                                                                                                                                                                                                           |
| filename          | Filename for the NFS I/O, if known, and cached by Oracle ZFS Storage Appliance. There are some circumstances where the filename is not known, such as after a cluster failover, and when clients continue to operate on NFS file handles without issuing an open request to identify the filename; in these situations the filename reported is <unknown>. |
| Application ID    | Identity of the client application issuing the I/O. This breakdown is available only for OISP-enabled NFSv4.0 and NFSv4.1 clients.                                                                                                                                                                                                                         |
| share             | The share for this NFS I/O.                                                                                                                                                                                                                                                                                                                                |
| project           | The project for this NFS I/O.                                                                                                                                                                                                                                                                                                                              |

These breakdowns can be combined to produce powerful statistics. For example, use [Protocol: NFSv3 bytes per second](#) for client `hostname.example.com` broken down by `filename` to view which files a particular client is accessing.

### Further Analysis

- [Protocol: NFSv\[2-4\] Operations](#) for numerous other breakdowns on NFS operations
- [Protocol: NFSv\[2-4\] Average Latency](#) for average latency per second
- [Network: Device Bytes](#) for a measure of network throughput caused by the NFS activity
- [Cache: ARC Accesses](#) to learn how well an NFS read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: NFSv[2-4] Operations

This statistic shows NFSv[2-4] operations/second (NFS IOPS) requested by clients to Oracle ZFS Storage Appliance. Supported NFS versions are: NFSv2, NFSv3, NFSv4.0, and NFSv4.1. Various breakdowns are available to show the client, filename, and latency of the NFS I/O.

### When to Check NFSv[2-4] Operations

NFSv[2-4] operations/sec can be used as an indication of NFS load, and can be viewed on the dashboard.

Use the latency breakdown when investigating NFS performance issues, especially to quantify the magnitude of the issue. This measures the I/O latency component for which Oracle ZFS Storage Appliance is responsible, and displays it as a heat map so that the overall latency pattern can be seen, along with outliers. If the NFS latency is high, drill down further on latency to identify the type of operation and filename for the high latency, and check other statistics for both CPU and Disk load to investigate why the appliance is slow to respond; if latency is low, the appliance is performing quickly, and any performance issues experienced on the client are more likely to be caused by other factors in the environment, such as the network infrastructure, and CPU load on the client itself.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the `client` and `filename` breakdowns, and the `filename hierarchy` view.

Client and especially filename breakdowns can be very expensive in terms of storage and execution overhead. Therefore, it is not recommended to permanently enable these breakdowns on a busy production Oracle ZFS Storage Appliance.

### NFSv[2-4] Operations Breakdowns

**Table 5-44 Breakdowns of NFS Operations**

| Breakdown         | Description                                                                                                                                                                                                                                                                                                                                                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | NFS operation type (read/write/getattr/setattr/lookup/...).                                                                                                                                                                                                                                                                                                |
| client            | Remote hostname or IP address of the NFS client.                                                                                                                                                                                                                                                                                                           |
| filename          | Filename for the NFS I/O, if known, and cached by Oracle ZFS Storage Appliance. There are some circumstances where the filename is not known, such as after a cluster failover, and when clients continue to operate on NFS file handles without issuing an open request to identify the filename; in these situations the filename reported is <unknown>. |
| Application ID    | Identity of the client application issuing the I/O. This breakdown is available only for OISP-enabled NFSv4.0 and NFSv4.1 clients.                                                                                                                                                                                                                         |
| share             | The share for this NFS I/O.                                                                                                                                                                                                                                                                                                                                |
| project           | The project for this NFS I/O.                                                                                                                                                                                                                                                                                                                              |
| latency           | A heat map showing the latency of NFS I/O, as measured from when the NFS request arrived on Oracle ZFS Storage Appliance from the network, to when the response is sent; this latency includes the time to process the NFS request, and to perform any disk I/O.                                                                                           |
| size              | A heat map showing the distribution of NFS I/O sizes.                                                                                                                                                                                                                                                                                                      |
| offset            | A heat map showing the file offset of NFS I/O. This can be used to identify random or sequential NFS IOPS. Use the Disk I/O operations statistic to check whether random NFS IOPS maps to random Disk IOPS after the filesystem and RAID configuration has been applied.                                                                                   |

These breakdowns can be combined to produce powerful statistics. For example:

- Protocol: NFSv3 operations per second of type read broken down by latency (to examine latency for reads only)
- Protocol: NFSv3 operations per second for file '/export/fs4/10ga' broken down by offset (to examine file access pattern for a particular file)
- Protocol: NFSv3 operations per second for client *hostname.example.com* broken down by filename (to view which files a particular client is accessing)

### Further Analysis

- [Protocol: NFSv\[2-4\] Bytes](#) for NFSv[2-4] bytes/second
- [Protocol: NFSv\[2-4\] Average Latency](#) for average latency per second
- [Network: Device Bytes](#) for a measure of network throughput caused by the NFS activity
- [Cache: ARC Accesses](#) to learn how well an NFS read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

# Protocol: OISP Bytes

This statistic shows Oracle Intelligent Storage Protocol (OISP) bytes/second transferred between OISP clients and Oracle ZFS Storage Appliance. Bytes statistics can be broken down by client, filename, database name, database filetype, database function, share, and project.

## When to Check OISP Bytes

OISP bytes/sec can be used as an indication of OISP load, and can be viewed on the dashboard.

Breakdowns by database filetype and function allow database and storage administrators to correlate database statistics with storage statistics. This provides much better diagnosability to narrow down an abrupt rise not only to a particular database, but also to the database function creating the increase and the filetype associated with it.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the client and filename breakdowns, and the filename hierarchy view. Client and especially filename breakdowns can be very expensive in terms of storage and execution overhead. Therefore, it is not recommended to permanently enable these breakdowns on a busy production Oracle ZFS Storage Appliance.

## OISP Bytes Breakdowns

**Table 5-45 Breakdowns of OISP Bytes**

| Breakdown         | Description                                                                                                                                                                                                                      |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| client            | Remote hostname or IP address of the OISP client.                                                                                                                                                                                |
| filename          | Filename for the OISP I/O, if known, and cached by Oracle ZFS Storage Appliance.                                                                                                                                                 |
| database name     | Name of the database issuing the I/O.                                                                                                                                                                                            |
| database filetype | Type of file to which the database is writing.                                                                                                                                                                                   |
| database function | Reason for the database I/O. Acronyms used in this breakdown include RMAN (Oracle Recovery Manager), DBWR (Database Writer for Oracle Database), ARCH (Archiver for Oracle Database), and LGWR (Log Writer for Oracle Database). |
| share             | The share for this OISP I/O.                                                                                                                                                                                                     |
| project           | The project for this OISP I/O.                                                                                                                                                                                                   |

These breakdowns can be combined to produce powerful statistics. For example, use Protocol: OISP bytes per second for client `hostname.example.com` broken down by `filename` to view which files a particular client is accessing.

## Further Analysis

See also [Protocol: OISP Operations](#).

# Protocol: OISP Operations

This statistic shows Oracle Intelligent Storage Protocol (OISP) operations/second requested by clients to Oracle ZFS Storage Appliance. Operations statistics can be broken down by

client, filename, database name, database filetype, database function, share, project, latency, size, and offset.

### When to Check OISP Operations

OISP operations/sec can be used as an indication of OISP load, and can be viewed on the dashboard.

Breakdowns by database filetype and function allow database and storage administrators to correlate database statistics with storage statistics. This provides much better diagnosability to narrow down an abrupt rise not only to a particular database, but also to the database function creating the increase and the filetype associated with it.

Use the latency breakdown when investigating OISP performance issues, especially to quantify the magnitude of the issue. This measures the I/O latency component for which Oracle ZFS Storage Appliance is responsible, and displays it as a heat map so that the overall latency pattern can be seen, along with outliers. If the OISP latency is high, drill down further on latency to identify the type of operation and filename for the high latency, and check other statistics for both CPU and disk load to investigate why the appliance is slow to respond. If latency is low, the appliance is performing quickly, and any performance issues experienced on the client are more likely to be caused by other factors in the environment, such as the network infrastructure, and CPU load on the client itself.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the `client` and `filename` breakdowns, and the filename hierarchy view. Client and especially filename breakdowns can be very expensive in terms of storage and execution overhead. Therefore, it is not recommended to permanently enable these breakdowns on a busy production Oracle ZFS Storage Appliance.

### OISP Operations Breakdowns

**Table 5-46 Breakdowns of OISP Operations**

| Breakdown         | Description                                                                                                                                                                                                                                                        |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| client            | Remote hostname or IP address of the OISP client.                                                                                                                                                                                                                  |
| filename          | Filename for the OISP I/O, if known, and cached by Oracle ZFS Storage Appliance.                                                                                                                                                                                   |
| database name     | Name of the database issuing the I/O.                                                                                                                                                                                                                              |
| database filetype | Type of file to which the database is writing.                                                                                                                                                                                                                     |
| database function | Reason for the database I/O. Acronyms used in this breakdown include RMAN (Oracle Recovery Manager), DBWR (Database Writer for Oracle Database), ARCH (Archiver for Oracle Database), and LGWR (Log Writer for Oracle Database).                                   |
| share             | The share for this OISP I/O.                                                                                                                                                                                                                                       |
| project           | The project for this OISP I/O.                                                                                                                                                                                                                                     |
| latency           | A heat map showing the latency of OISP I/O, as measured from when the OISP request arrived on Oracle ZFS Storage Appliance from the network, to when the response is sent. The latency includes the time to process the OISP request, and to perform any disk I/O. |
| size              | A heat map showing the distribution of OISP I/O sizes.                                                                                                                                                                                                             |

**Table 5-46 (Cont.) Breakdowns of OISP Operations**

| Breakdown | Description                                                                                             |
|-----------|---------------------------------------------------------------------------------------------------------|
| offset    | A heat map showing the file offset of OISP I/O. This can be used to identify random or sequential OISP. |

These breakdowns can be combined to produce powerful statistics. For example:

- To examine the file access pattern for a particular file, use OISP operations per second for that file, broken down by offset.
- To view which files a particular client is accessing, use OISP operations per second for that client, broken down by filename.

#### Further Analysis

See also [Protocol: OISP Bytes](#).

## Protocol: SFTP Bytes

This statistic shows SFTP bytes/second requested by clients to Oracle ZFS Storage Appliance. Various useful breakdowns are available: to show the client, user, and filename of the SFTP requests.

#### Example

See [Protocol: FTP Bytes](#) for an example of a similar statistic with similar breakdowns.

#### When to Check SFTP Bytes

SFTP bytes/sec can be used as an indication of SFTP load, and can be viewed on the dashboard.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the `client`, `user`, and `filename` breakdowns, and the filename hierarchy view. It might be best to enable these breakdowns for short periods only: The by-filename breakdown can be one of the most expensive in terms of storage and execution overhead, and might not be suitable to leave enabled permanently on appliances with high rates of SFTP activity.

#### SFTP Bytes Breakdowns

**Table 5-47 Breakdowns of SFTP Bytes**

| Breakdown         | Description                                                                                                                                      |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | SFTP operation type (get/put/...).                                                                                                               |
| user              | Username of the client.                                                                                                                          |
| filename          | Filename for the SFTP operation, if known, and cached by Oracle ZFS Storage Appliance. If the filename is not known it is reported as <unknown>. |
| share             | The share for this SFTP request.                                                                                                                 |
| project           | The project for this SFTP request.                                                                                                               |
| client            | Remote hostname or IP address of the SFTP client.                                                                                                |

These breakdowns can be combined to produce powerful statistics. For example, use Protocol: SFTP bytes per second for client `hostname.example.com` broken down by filename to view which files a particular client is accessing.

### Further Analysis

See [Cache: ARC Accesses](#) to learn how well an SFTP read workload is returning from cache, and [Disk: I/O Operations](#) for the back-end disk I/O caused.

Because SFTP uses SSH to encrypt FTP, there will be additional CPU overhead for this protocol. To check overall CPU utilization of Oracle ZFS Storage Appliance, see [CPU: Percent Utilization](#).

## Protocol: SMB Operations

This statistic shows SMB operations/second (SMB IOPS) requested by clients to Oracle ZFS Storage Appliance. Various useful breakdowns are available to show the client, filename, and latency of the SMB I/O.

### Example

See [Protocol: NFSv\[2-4\] Operations](#) for an example of a similar statistic with similar breakdowns.

### When to Check SMB Operations

SMB operations/sec can be used as an indication of SMB load, and can be viewed on the dashboard.

Use the latency breakdown when investigating SMB performance issues, especially to quantify the magnitude of the issue. This measures the I/O latency component for which Oracle ZFS Storage Appliance is responsible, and displays it as a heat map so that the overall latency pattern can be seen, along with outliers. If the SMB latency is high, drill down further on latency to identify the type of operation and filename for the high latency, and check other statistics for both CPU and Disk load to investigate why the appliance is slow to respond; if latency is low, the appliance is performing quickly, and any performance issues experienced on the client are more likely to be caused by other factors in the environment, such as the network infrastructure, and CPU load on the client itself.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the `client` and `filename` breakdowns, and the filename hierarchy view. Client and especially filename breakdowns can be very expensive in terms of storage and execution overhead. Therefore, it is not recommended to permanently enable these breakdowns on a busy production Oracle ZFS Storage Appliance.

### SMB Operations Breakdowns

**Table 5-48 Breakdowns of SMB Operations**

| Breakdown         | Description                                                                                                                               |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | SMB operation type (read/write/readX/writeX/...).                                                                                         |
| client            | Remote hostname or IP address of the SMB client.                                                                                          |
| filename          | Filename for the SMB I/O, if known, and cached by Oracle ZFS Storage Appliance. If the filename is not known it is reported as <unknown>. |

**Table 5-48 (Cont.) Breakdowns of SMB Operations**

| Breakdown | Description                                                                                                                                                                                                                                                              |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| share     | The share for this SMB I/O.                                                                                                                                                                                                                                              |
| project   | The project for this SMB I/O.                                                                                                                                                                                                                                            |
| latency   | A heat map showing the latency of SMB I/O, as measured from when the SMB request arrived on Oracle ZFS Storage Appliance from the network, to when the response is sent; this latency includes the time to process the SMB request, and to perform any disk I/O.         |
| size      | A heat map showing the distribution of SMB I/O sizes.                                                                                                                                                                                                                    |
| offset    | A heat map showing the file offset of SMB I/O. This can be used to identify random or sequential SMB IOPS. Use the Disk I/O operations statistic to check whether random SMB IOPS maps to random Disk IOPS after the filesystem and RAID configuration has been applied. |

These breakdowns can be combined to produce powerful statistics. For example:

- Protocol: SMB operations per second of type read broken down by latency (to examine latency for reads only)
- Protocol: SMB operations per second for file '/export/fs4/10ga' broken down by offset (to examine file access pattern for a particular file)
- Protocol: SMB operations per second for client 'phobos.sf.fishpong.com' broken down by filename (to view which files a particular client is accessing)

### Further Analysis

- [Protocol: SMBv\[1-2\] Bytes](#) for SMB bytes/second
- [Protocol: SMBv\[1-3\] Average Latency](#) for average latency per second
- [Cache: ARC Accesses](#) to learn how well an SMB read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: SMBv[1-2] Bytes

These statistics show SMB bytes/second transferred between SMB clients and Oracle ZFS Storage Appliance. Supported SMB versions are SMB and SMB2. Bytes statistics can be broken down by: operation, client, filename, share, and project.

### When to Check SMB/SMB2 Bytes

SMB bytes/sec can be used as an indication of SMB load. The best way to improve performance is to eliminate unnecessary work, which can be identified through the `client` and `filename` breakdowns, and the `filename` hierarchy view. Client and especially `filename` breakdowns can be very expensive in terms of storage and execution overhead. Therefore, it is not recommended to permanently enable these breakdowns on a busy production Oracle ZFS Storage Appliance.

### SMB/SMB2 Bytes Breakdowns

**Table 5-49 Breakdowns of SMB Bytes**

| Breakdown         | Description                                                                                                                                                                                                                                                                                                                                                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| type of operation | SMB/SMB2 operation type (read/write/getattr/setattr/lookup/...).                                                                                                                                                                                                                                                                                           |
| client            | Remote hostname or IP address of the SMB client.                                                                                                                                                                                                                                                                                                           |
| filename          | Filename for the SMB I/O, if known, and cached by Oracle ZFS Storage Appliance. There are some circumstances where the filename is not known, such as after a cluster failover, and when clients continue to operate on SMB file handles without issuing an open request to identify the filename; in these situations the filename reported is <unknown>. |
| share             | The share for this SMB I/O.                                                                                                                                                                                                                                                                                                                                |
| project           | The project for this SMB I/O.                                                                                                                                                                                                                                                                                                                              |

These breakdowns can be combined to produce powerful statistics. For example, use [Protocol: SMB2 bytes per second for client \*hostname.example.com\*](#) broken down by [filename](#) to view which files a particular client is accessing.

#### Further Analysis

- [Protocol: SMB Operations](#) for numerous other breakdowns on SMB operations
- [Protocol: SMBv\[1-3\] Average Latency](#) for average latency per second
- [Cache: ARC Accesses](#) to learn how well an SMB read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: SRP Bytes

This statistic shows SRP bytes/second requested by initiators to Oracle ZFS Storage Appliance.

#### Example

See [Protocol: iSCSI Bytes](#) for an example of a similar statistic with similar breakdowns.

#### When to Check SRP Bytes

SRP bytes/sec can be used as an indication of SRP load, in terms of throughput. For a deeper analysis of SRP activity, see [Protocol: SRP Operations](#).

#### SRP Bytes Breakdowns

**Table 5-50 Breakdowns of SRP Bytes**

| Breakdown | Description                       |
|-----------|-----------------------------------|
| initiator | SRP client initiator.             |
| target    | Local SCSI target.                |
| project   | The project for this SRP request. |
| lun       | The LUN for this SRP request.     |

See [Configuring Storage Area Network \(SAN\)](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x* for terminology definitions.

### Further Analysis

- [Protocol: SRP Operations](#) for numerous other breakdowns on SRP operations
- [Protocol: SRP Average Latency](#) for average latency per second
- [Cache: ARC Accesses](#) to learn how well an SRP read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: SRP Operations

This statistic shows SRP operations/second (SRP IOPS) requested by initiators to Oracle ZFS Storage Appliance. Various useful breakdowns are available: to show the initiator, target, type, and latency of the SRP I/O.

### Example

See [Protocol: iSCSI Bytes](#) for an example of a similar statistic with similar breakdowns.

### When to Check SRP Operations

SRP operations/sec can be used as an indication of SRP load.

Use the latency breakdown when investigating SRP performance issues, especially to quantify the magnitude of the issue. This measures the I/O latency component for which Oracle ZFS Storage Appliance is responsible, and displays it as a heat map so that the overall latency pattern can be seen, along with outliers. If the SRP latency is high, drill down further on latency to identify the client initiator, the type of operation and LUN for the high latency, and check other statistics for both CPU and Disk load to investigate why the appliance is slow to respond; if latency is low, the appliance is performing quickly, and any performance issues experienced on the client initiator are more likely to be caused by other factors in the environment, such as the network infrastructure, and CPU load on the client itself.

The best way to improve performance is to eliminate unnecessary work, which can be identified through the client `initiator`, `lun`, and `command` breakdowns.

### SRP Operations Breakdowns

**Table 5-51 Breakdowns of SRP Operations**

| Breakdown         | Description                                                                                                                              |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| initiator         | SRP client initiator.                                                                                                                    |
| target            | Local SCSI target.                                                                                                                       |
| project           | The project for this SRP request.                                                                                                        |
| lun               | The LUN for this SRP request.                                                                                                            |
| type of operation | SRP operation type. This shows how the SCSI command is transported by the SRP protocol, which can give an idea to the nature of the I/O. |
| command           | SCSI command sent by the SRP protocol. This can show the real nature of the requested I/O (read/write/sync-cache/...).                   |

**Table 5-51 (Cont.) Breakdowns of SRP Operations**

| Breakdown | Description                                                                                                                                                                                                                                                       |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| latency   | A heat map showing the latency of SRP I/O, as measured from when the SRP request arrived on Oracle ZFS Storage Appliance from the network, to when the response is sent; this latency includes the time to process the SRP request, and to perform any disk I/O.  |
| offset    | A heat map showing the file offset of SRP I/O. This can be used to identify random or sequential SRP IOPS. Use the Disk I/O operations statistic to check whether random SRP IOPS maps to random Disk IOPS after the LUN and RAID configuration has been applied. |
| size      | A heat map showing the distribution of SRP I/O sizes.                                                                                                                                                                                                             |

These breakdowns can be combined to produce powerful statistics. For example:  
Protocol: SRP operations per second of command read broken down by latency  
(to examine latency for SCSI reads only).

#### Further Analysis

- [Protocol: SRP Bytes](#) for SRP bytes/second
- [Protocol: SRP Average Latency](#) for average latency per second
- [Cache: ARC Accesses](#) to learn how well an SRP read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

# 6

## Using Advanced Analytics Statistics

These statistics are only visible if Advanced Analytics is enabled in [Preferences](#) (see [Setting Appliance Preferences](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*). These are statistics of lesser interest and are not typically needed for system observability. They are often dynamic, which can induce higher overhead, and expose more complex areas of the system that require additional expertise to understand properly.

To learn more about Advanced Analytics statistics, use the following tasks:

- [CPU: CPUs](#)
- [CPU: Kernel Spins](#)
- [Cache: ARC Adaptive Parameter](#)
- [Cache: ARC Evicted Bytes](#)
- [Cache: ARC Size](#)
- [Cache: ARC Target Size](#)
- [Cache: DNLC Accesses](#)
- [Cache: DNLC Entries](#)
- [Cache: L2ARC Errors](#)
- [Cache: L2ARC Size](#)
- [Data Movement: NDMP Bytes Transferred to/from Disk](#)
- [Data Movement: NDMP Bytes Transferred to/from Tape](#)
- [Data Movement: NDMP File System Operations](#)
- [Data Movement: NDMP Jobs](#)
- [Data Movement: Replication Latencies](#)
- [Data Movement: Replication Send/Receive Bytes](#)
- [Disk: Average Number of I/O Operations](#)
- [Disk: Percent Utilization](#)
- [Disk: ZFS DMU Operations](#)
- [Disk: ZFS Logical I/O Bytes](#)
- [Disk: ZFS Logical I/O Operations](#)
- [Memory: Dynamic Memory Usage](#)
- [Memory: Kernel Memory](#)
- [Memory: Kernel Memory in Use](#)
- [Memory: Kernel Memory Allocated, But Not in Use](#)
- [Name Service: Lookups Average Latency](#)
- [Name Service: Operations](#)

- Name Service: Operations Average Latency
- Network: Datalink Bytes
- Network: IP Bytes
- Network: IP Packets
- Network: TCP Bytes
- Network: TCP Packets
- Network: TCP Retransmissions
- Protocols: Average Latency Statistics

## CPU: CPUs

The CPUs statistic is used to display the heat map for CPUs broken down by percent utilization. This is the most accurate way to examine how CPUs are utilized.

### When to Check CPUs

When investigating CPU load, after checking the utilization average from [CPU: Percent Utilization](#).

This statistic is particularly useful for identifying if a single CPU is fully utilized, which can happen if a single thread is saturated with load. If the work performed by this thread cannot be offloaded to other threads so that it can be run concurrently across multiple CPUs, then that single CPU can become the bottleneck. This will be seen as a single CPU stuck at 100% utilization for several seconds or more, while the other CPUs are idle.

### CPUs Breakdowns

**Table 6-1 A Breakdown of CPUs**

| Breakdown           | Description                                                                                                                                                |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| percent utilization | A heat map with utilization on the Y-axis and each level on the Y-axis colored by the number of CPU at that utilization: from light (none) to dark (many). |

### Details

CPU utilization includes the time to process instructions (that are not part of the idle thread), which includes memory stall cycles. CPU utilization can be caused by:

- Executing code (including spinning on locks)
- Memory load

Because Oracle ZFS Storage Appliance primarily exists to move data, memory load often dominates. Therefore, a system with high CPU utilization might actually be high when it is moving data.

## CPU: Kernel Spins

This statistic counts the number of spin cycles on kernel locks, which consume CPU.

An understanding of operating system internals is required to properly interpret this statistic.

### When to Check Kernel Spins

When investigating CPU load, after checking [CPU: Percent Utilization](#) and [CPU: CPUs](#) broken down by percent utilization.

Some degree of kernel spins is normal for processing any workload, due to the nature of multi-threaded programming. Compare the behavior of kernel spins over time and for different workloads, to develop an expectation for what is normal.

### Kernel Spins Breakdowns

**Table 6-2 Breakdowns of CPU Kernel Spins**

| Breakdown                         | Description                          |
|-----------------------------------|--------------------------------------|
| type of synchronization primitive | Type of lock (mutex/...).            |
| CPU identifier                    | CPU identifier number (0/1/2/3/...). |

## Cache: ARC Adaptive Parameter

This is `arc_p` from the ZFS ARC. This shows how the ARC is adapting its MRU and MFU list size depending on the workload.

An understanding of ZFS ARC internals might be required to properly interpret this statistic.

### When to Check ARC Adaptive Parameter

Rarely; this could be useful for identifying internal behavior of the ARC; however, there are other statistics to check before this one.

If there are caching issues on Oracle ZFS Storage Appliance, check the [Cache: ARC Accesses](#) statistic to see how well the ARC is performing, and the Protocol statistics to understand the requested workload. Then, check the Advanced Analytics [Cache: ARC Size](#) and [Cache: ARC Evicted Bytes](#) for further details on the ARC behavior.

### ARC Adaptive Parameter Breakdowns

None

## Cache: ARC Evicted Bytes

This statistic shows bytes that were evicted from the ZFS ARC, as part of its usual housekeeping. The breakdown allows L2ARC eligibility to be examined.

An understanding of ZFS ARC internals might be required to properly interpret this statistic.

### When to Check ARC Evicted Bytes

This could be checked if you are considering to install cache devices (L2ARC) because this statistic can be broken down by L2ARC state. If L2ARC eligible data was frequently being evicted from the ARC, then the presence of cache devices could improve performance.

This might also be useful to check if you have issues with cache device warmup. The reason might be that your workload is not L2ARC eligible.

If there are caching issues on Oracle ZFS Storage Appliance, check the [Cache: ARC Accesses](#) statistic to see how well the ARC is performing, and the Protocol statistics to understand the requested workload. Then, check the Advanced Analytics [Cache: ARC Size](#) and [Cache: ARC Evicted Bytes](#) for further details on the ARC behavior.

### ARC Evicted Bytes Breakdowns

**Table 6-3 A Breakdown of ARC Evicted Bytes**

| Breakdown   | Description                                                       |
|-------------|-------------------------------------------------------------------|
| L2ARC state | Shows L2ARC cached or uncached, and L2ARC eligible or ineligible. |

## Cache: ARC Size

This statistic shows the size of the primary filesystem cache, the DRAM-based ZFS ARC.

An understanding of ZFS ARC internals might be required to properly interpret this statistic.

### When to Check ARC Size

When examining the effectiveness of the ARC on the current workload. The ARC should automatically increase in size to fill most of available DRAM, when enough data can be accessed by the current workload to be placed in the cache. The breakdown allows the contents of the ARC to be identified by type.

This can also be checked when using cache devices (L2ARC) on systems with limited DRAM, as the ARC can become consumed with L2ARC headers.

If there are ARC caching issues on Oracle ZFS Storage Appliance, also check the [Cache: ARC Accesses](#) statistic to see how well the ARC is performing, and the Protocol statistics to understand the requested workload.

### ARC Size Breakdowns

**Available breakdowns:**

**Table 6-4 A Breakdown of ARC Size**

| Breakdown | Description                                       |
|-----------|---------------------------------------------------|
| component | Type of data in the ARC; see the following table. |

**ARC component types:**

**Table 6-5 ARC Component Types**

| Component   | Description                                                                                                                                                                                      |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ARC data    | Cached contents, including filesystem data and filesystem metadata.                                                                                                                              |
| ARC headers | Space consumed by metadata of the ARC itself. The ratio of headers to data is relative to the ZFS record size used; a small record size might mean more ARC headers to refer to the same volume. |
| ARC other   | Other kernel consumers of the ARC.                                                                                                                                                               |

**Table 6-5 (Cont.) ARC Component Types**

| Component     | Description                                                                                                                                                  |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L2ARC headers | Space consumed by tracking buffers stored on L2ARC devices. If the buffer is on the L2ARC and yet still in ARC DRAM, it is considered "ARC headers" instead. |

## Cache: ARC Target Size

This is `arc_c` from the ZFS ARC. This shows the target size that the ARC is attempting to maintain. For the actual size, see the Advanced Analytic [Cache: ARC Size](#).

An understanding of ZFS ARC internals might be required to properly interpret this statistic.

### When to Check ARC Target Size

Rarely; this might be useful for identifying internal behavior of the ARC; however, there are other statistics to check before this one.

If there are caching issues on Oracle ZFS Storage Appliance, check the [Cache: ARC Accesses](#) statistic to see how well the ARC is performing, and the Protocol statistics to understand the requested workload. Then, check the Advanced Analytics [Cache: ARC Size](#) and [Cache: ARC Evicted Bytes](#) for further details on the ARC behavior.

### ARC Target Size Breakdowns

None

## Cache: DNLC Accesses

This statistic shows accesses to the Directory Name Lookup Cache (DNLC). The DNLC caches pathname to inode lookups.

An understanding of operating system internals might be required to properly interpret this statistic.

### When to Check DNLC Accesses

This can be useful to check if a workload accesses millions of small files, for which the DNLC can help.

If there are generic caching issues on Oracle ZFS Storage Appliance, first check the [Cache: ARC Accesses](#) statistic to see how well the ARC is performing, and the Protocol statistics to understand the requested workload. Then, check the Advanced Analytics [Cache: ARC Size](#) for the size of the ARC.

### DNLC Accesses Breakdowns

**Table 6-6 A Breakdown of DNLC Accesses**

| Breakdown | Description                                                                         |
|-----------|-------------------------------------------------------------------------------------|
| hit/miss  | Shows counts for hits/misses, allowing the effectiveness of the DNLC to be checked. |

## Cache: DNLC Entries

This shows the number of entries in the Directory Name Lookup Cache (DNLC). The DNLC caches pathname to inode lookups.

An understanding of operating system internals might be required to properly interpret this statistic.

### When to Check DNLC Entries

This can be useful to check if a workload accesses millions of small files, for which the DNLC can help.

If there are generic caching issues on Oracle ZFS Storage Appliance, first check the [Cache: ARC Accesses](#) statistic to see how well the ARC is performing, and the Protocol statistics to understand the requested workload. Then, check the Advanced Analytic [Cache: ARC Size](#) for the size of the ARC.

### DNLC Entries Breakdowns

None

## Cache: L2ARC Errors

This statistic shows 2nd Level Adaptive Replacement Cache (L2ARC) error statistics.

### When to Check L2ARC Errors

This can be useful to leave enabled when using cache devices, for when troubleshooting L2ARC issues beyond the standard statistics.

### L2ARC Errors Breakdowns

**Available breakdowns:**

**Table 6-7 A Breakdown of L2ARC Errors**

| Breakdown | Description                                |
|-----------|--------------------------------------------|
| error     | L2ARC error type; see the following table. |

**L2ARC error types:**

**Table 6-8 L2ARC Error Types**

| Error        | Description                                                                                                                                                                                           |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| memory abort | The L2ARC chose not to populate for a one-second interval, due to a shortage of system memory (DRAM), which holds the L2ARC metadata. Continual memory aborts will prevent the L2ARC from warming up. |
| bad checksum | A read from a cache device failed the ZFS ARC checksum. This might be an indicator that a cache device is beginning to fail.                                                                          |
| io error     | A cache device returned an error. This might be an indicator that a cache device is beginning to fail.                                                                                                |

## Cache: L2ARC Size

This shows the size of data stored on the 2nd Level Adaptive Replacement Cache (L2ARC) cache devices. This is expected to increase in size over a period of hours or days, until the amount of constant L2ARC eligible data is cached, or the cache devices are full.

### When to Check L2ARC Size

When troubleshooting L2ARC warmup. If the size is small, check that the workload applied should be populating the L2ARC using the statistic [Cache: ARC Evicted Bytes](#) broken down by L2ARC state, and use the Protocol breakdowns, such as by size and by offset, to confirm that the workload is of random I/O. Sequential I/O does not populate the L2ARC. Another statistic to check is [Cache: L2ARC Errors](#).

The L2ARC size shrinks, if data that was cached is deleted from the filesystem.

### L2ARC Size Breakdowns

None

## Data Movement: NDMP Bytes Transferred to/from Disk

This statistic indicates disk throughput during an NDMP backup or restore operation. This statistic is zero unless NDMP is configured and active.

### When to Check NDMP Bytes Transferred to/from Disk

When investigating NDMP backup and restore performance. This can also be checked when trying to identify an unknown disk load, some of which might be caused by NDMP.

### NDMP Bytes Transferred to/from Disk Breakdowns

**Table 6-9 Breakdowns of NDMP Bytes Transferred to/from Disk**

| Breakdown         | Description    |
|-------------------|----------------|
| type of operation | Read or write. |
| raw statistic     | Raw statistic. |

### Further Analysis

See also [Data Movement: NDMP Bytes Transferred to/from Tape](#).

## Data Movement: NDMP Bytes Transferred to/from Tape

This statistic indicates tape throughput during an NDMP backup or restore operation. This statistic is zero unless NDMP is configured and active.

### When to Check NDMP Bytes Transferred to/from Tape

When investigating NDMP backup and restore performance.

### NDMP Bytes Transferred to/from Tape Breakdowns

**Table 6-10 Breakdowns of NDMP Bytes Transferred to/from Tape**

| Breakdown         | Description    |
|-------------------|----------------|
| type of operation | Read or write. |
| raw statistic     | Raw statistic. |

#### Further Analysis

See also [Data Movement: NDMP Bytes Transferred to/from Disk](#).

## Data Movement: NDMP File System Operations

This statistic shows access per second to the filesystem during NDMP backup or restore. This statistic is only meaningful for tar-based backups because they occur at the file, not block, level.

#### When to Check NDMP File System Operations

This can be useful to check when investigating the source of ZFS load. First, check all other sources of filesystem activity via the Protocol statistics. Also see the Advanced Analytics statistics [Data Movement: NDMP Bytes Transferred to/from Disk](#) and [Data Movement: NDMP Bytes Transferred to/from Tape](#).

#### NDMP File System Operations Breakdowns

**Table 6-11 Breakdowns of NDMP File System Operations**

| Breakdown         | Description    |
|-------------------|----------------|
| type of operation | Read or write. |
| raw statistic     | Raw statistic. |

## Data Movement: NDMP Jobs

This statistic shows active NDMP job counts.

#### When to Check NDMP Jobs

When monitoring NDMP progress, and troubleshooting NDMP. Also see the Advanced Analytics statistics [Data Movement: NDMP Bytes Transferred to/from Disk](#) and [Data Movement: NDMP Bytes Transferred to/from Tape](#).

#### NDMP Jobs Breakdowns

**Table 6-12 A Breakdown of NDMP Jobs**

| Breakdown         | Description                  |
|-------------------|------------------------------|
| type of operation | Type of job: backup/restore. |

# Data Movement: Replication Latencies

This statistic shows the average latency per second as a single value per unit of time instead of a heat map that shows multiple values per unit of time. In many cases, this statistic provides sufficient detail without going to the heat map. Typically heat-map-based statistics are more expensive.

## When to Check Replication Latencies

When monitoring replication progress, and troubleshooting replication. Also see the standard Analytics statistics [Data Movement: Replication Bytes](#) and [Data Movement: Replication Operations](#).

## Replication Latencies Breakdowns

**Table 6-13 Breakdowns of Replication Latencies**

| Breakdown          | Description                                                                              |
|--------------------|------------------------------------------------------------------------------------------|
| direction          | Shows latency broken down by direction, to or from Oracle ZFS Storage Appliance.         |
| type of operation  | Shows latency broken down by type of operation with the remote appliance, read or write. |
| peer               | Shows latency broken down by the name of the remote appliances.                          |
| pool name          | Shows latency broken down by the name of the pools.                                      |
| project            | Shows latency broken down by the name of the projects.                                   |
| dataset            | Shows latency broken down by the name of the shares.                                     |
| as a raw statistic | Shows latency as raw statistics.                                                         |

# Data Movement: Replication Send/Receive Bytes

This statistic tracks data throughput of project or share replication in bytes per second at the ZFS send/receive internal interface. This statistic omits the effect of the compression/decompression stage in the replication data pipeline.

## When to Check Replication Send/Receive Bytes

When investigating replication activity or evaluating the benefit of enabling compression for a replication action.

## Replication Send/Receive Bytes Breakdowns

**Table 6-14 Breakdowns of Replication Send/Receive Bytes**

| Breakdown         | Description                                                                                             |
|-------------------|---------------------------------------------------------------------------------------------------------|
| direction         | Shows send/receive bytes broken down by direction, to or from Oracle ZFS Storage Appliance.             |
| type of operation | Shows send/receive bytes broken down by the type of operation with the remote appliance, read or write. |
| peer              | Shows send/receive bytes broken down by the name of the remote appliances.                              |

**Table 6-14 (Cont.) Breakdowns of Replication Send/Receive Bytes**

| Breakdown          | Description                                                       |
|--------------------|-------------------------------------------------------------------|
| pool name          | Shows send/receive bytes broken down by the name of the pools.    |
| project            | Shows send/receive bytes broken down by the name of the projects. |
| dataset            | Shows send/receive bytes broken down by the name of the shares.   |
| as a raw statistic | Shows send/receive bytes as raw statistics.                       |

#### Further Analysis

See also [Data Movement: Replication Bytes](#) for replication data throughput after any compression in the replication data pipeline.

## Disk: Average Number of I/O Operations

This statistic shows the average number of disk I/O operations per second.

#### When to Check Average Number of I/O Operations

This statistic shows how busy the I/O subsystem is on Oracle ZFS Storage Appliance. High wait times could indicate that you need more disks or a different RAID profile.

#### Average Number of I/O Operations Breakdowns

**Table 6-15 Breakdowns of Average Number of Disk Operations**

| Breakdown          | Description                                                                                                       |
|--------------------|-------------------------------------------------------------------------------------------------------------------|
| state of operation | Average number of I/O operations for active and waiting disks. Drill down on a selected state to examine further. |
| by disk            | Average number of I/O operations for system and data disks. Drill down on a selected disk to examine further.     |
| as a raw statistic | Average number of I/O operations as raw statistics.                                                               |

## Disk: Percent Utilization

This statistic shows average utilization across all disks. The per-disk breakdown shows the utilization that each disk contributed to the total average, not the utilization of each disk.

#### When to Check Percent Utilization

This statistic might be useful to trigger an alert based on the average for all disks.

Investigating disk utilization is usually much more effective using the standard Analytics statistic [Disk: Disks](#) broken down by percent utilization, which, instead of averaging utilization, presents it as a heat map. This allows individual disk utilization to be examined.

#### Percent Utilization Breakdowns

**Table 6-16 A Breakdown of Percent Utilization**

| Breakdown | Description                             |
|-----------|-----------------------------------------|
| disk      | Disks, including system and pool disks. |

The `disk` breakdown shows the contribution to the average percent that each disk made.

#### Notes

A system with 100 disks would never show more than 1 for any disk breakdown, unless that disk was selected and displayed separately as a raw statistic. Such a system would also show 0 percent utilization for disks less than 50% busy, due to rounding. Because this could be a source of confusion, and there is a better statistic available for most situations ([Disk: Disks](#)), this statistic has been placed in the Advanced category.

See [Disk: Disks](#) for a different and usually more effective way to display this data.

## Disk: ZFS DMU Operations

This statistic shows ZFS Data Management Unit (DMU) operations/second.

An understanding of ZFS internals is required to properly interpret this statistic.

#### When to Check ZFS DMU Operations

Troubleshooting performance issues, after all relevant standard Analytics have been examined.

The `DMU` object type breakdown can identify if there is excessive Data Deduplication Table (DDT) activity. For more information about data deduplication, see [Data Deduplication](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*.

#### ZFS DMU Operations Breakdowns

**Table 6-17 Breakdowns of ZFS DMU Operations**

| Breakdown         | Description                                              |
|-------------------|----------------------------------------------------------|
| type of operation | Read/write/...                                           |
| DMU object level  | Integer                                                  |
| DMU object type   | ZFS plain file/ZFS directory/DMU dnode/SPA space map/... |

## Disk: ZFS Logical I/O Bytes

This statistic shows logical access to the ZFS filesystem as bytes/second. Logical I/O refers to the type of operations as those that are requested to the filesystem, such as by NFS, as opposed to physical I/O, which are the requests by the filesystem to the back-end pool disks.

#### When to Check ZFS Logical I/O Bytes

This could be useful while investigating how I/O is processed between the Protocol layer and pool disks.

#### ZFS Logical I/O Bytes Breakdowns

**Table 6-18 Breakdowns of ZFS Logical I/O Bytes**

| Breakdown         | Description            |
|-------------------|------------------------|
| type of operation | Read/write/...         |
| pool name         | Name of the disk pool. |

## Disk: ZFS Logical I/O Operations

This statistic shows logical access to the ZFS filesystem as operations/second. Logical I/O refers to the type of operations as those that are requested to the filesystem, such as by NFS, as opposed to physical I/O, which are the requests by the filesystem to the back-end pool disks.

### When to Check ZFS Logical I/O Operations

This could be useful while investigating how I/O is processed between the Protocol layer and pool disks.

### ZFS Logical I/O Operations Breakdowns

**Table 6-19 Breakdowns of ZFS Logical I/O Operations**

| Breakdown         | Description            |
|-------------------|------------------------|
| type of operation | Read/write/...         |
| pool name         | Name of the disk pool. |

## Memory: Dynamic Memory Usage

This statistic gives a high-level view of memory (DRAM) consumers, updated every second.

### When to Check Dynamic Memory Usage

This can be used to check that the filesystem cache has grown to consume available memory.

### Dynamic Memory Usage Breakdowns

Available breakdowns:

**Table 6-20 A Breakdown of Dynamic Memory Usage**

| Breakdown        | Description              |
|------------------|--------------------------|
| application name | See the following table. |

Application names:

**Table 6-21 Application Names**

| Application Name | Description                                                                                                                               |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| cache            | The ZFS filesystem cache (ARC). This will grow to consume as much of available memory as possible, as it caches frequently accessed data. |
| kernel           | The operating system kernel.                                                                                                              |
| mgmt             | Oracle ZFS Storage Appliance management software.                                                                                         |
| unused           | Unused space.                                                                                                                             |

## Memory: Kernel Memory

This statistic shows kernel memory, which is allocated and can be broken down by kernel cache (kmem cache).

An understanding of operating system internals is required to understand this statistic.

### When to Check Kernel Memory

Rarely. If the dashboard were to show kernel memory as a large consumer of available DRAM (in the Usage: Memory section), then this can be used when troubleshooting the cause. Also see [Memory: Kernel Memory in Use](#) and [Memory: Kernel Memory Allocated, But Not in Use](#).

### Kernel Memory Breakdowns

**Table 6-22 A Breakdown of Kernel Memory**

| Breakdown  | Description               |
|------------|---------------------------|
| kmem cache | Kernel memory cache name. |

## Memory: Kernel Memory in Use

This statistic shows kernel memory that is in use (populated), and can be broken down by kernel cache (kmem cache).

An understanding of operating system internals is required to understand this statistic.

### When to Check Kernel Memory in Use

Rarely. If the dashboard were to show kernel memory as a large consumer of available DRAM (in the Usage: Memory section), then this can be used when troubleshooting the cause. Also see [Memory: Kernel Memory Allocated, But Not in Use](#).

### Kernel Memory in Use Breakdowns

**Table 6-23 A Breakdown of Kernel Memory in Use**

| Breakdown  | Description               |
|------------|---------------------------|
| kmem cache | Kernel memory cache name. |

## Memory: Kernel Memory Allocated, But Not in Use

This statistic shows kernel memory that is allocated, but not in use, and can be broken down by kernel cache (kmem cache). Such a state can occur when memory is freed (for example, when cached filesystem data is deleted) and the kernel has yet to recover the memory buffers.

An understanding of operating system internals is required to understand this statistic.

### When to Check Kernel Memory Allocated, But Not in Use

Rarely. If the dashboard were to show kernel memory as a large consumer of available DRAM (in the Usage: Memory section), then this can be used when troubleshooting the cause. See also [Memory: Kernel Memory in Use](#).

### Kernel Memory Allocated, But Not in Use Breakdowns

**Table 6-24 A Breakdown of Kernel Memory Allocated, But Not in Use**

| Breakdown  | Description               |
|------------|---------------------------|
| kmem cache | Kernel memory cache name. |

## Name Service: Lookups Average Latency

This statistic shows average latency per second for name service lookup operations.

### When to Check Name Service Lookups Average Latency

Monitor name service lookups average latency when SMB is experiencing performance issues, to determine whether the root cause of that performance problem is actually name service lookup latency.

Name service analytics should be used primarily to analyze performance and diagnose name service problems during investigations. Name service analytics should not be run continuously because they will unnecessarily consume system resources. You can generate an alert if the average latency substantially increases for a period of time, and the alert will appear on the dashboard. To set a threshold alert, see [Configuring a Threshold Alert - BUI, CLI](#).

### Name Service Lookups Average Latency Breakdowns

**Table 6-25 Breakdowns of Name Service Lookups Average Latency**

| Breakdown         | Description                                       |
|-------------------|---------------------------------------------------|
| database name     | Name service database, such as LDAP, DNS, or NIS. |
| type of operation | Request type.                                     |
| result            | Success or fail.                                  |
| source            | Hostname or IP address of this request.           |

### Further Analysis

See also [Name Service: Lookups](#).

# Name Service: Operations

This statistic shows requests made to the name service.

An understanding of operating system internals is helpful to interpret this statistic.

## When to Check Name Service Operations

Use the `hit/miss` breakdown to check the effectiveness of the NSCD cache. Misses become backend requests to remote sources, which can be examined by using the type of operation breakdown of the name service lookups statistic. See [Name Service: Lookups](#).

Name service analytics should be used primarily to analyze performance and diagnose name service problems during investigations. Name service analytics should not be run continuously because they will unnecessarily consume system resources. You can generate an alert if the average latency substantially increases for a period of time, and the alert will appear on the dashboard. To set a threshold alert, see [Configuring a Threshold Alert - BUI, CLI](#).

## Name Service Operations Breakdowns

**Table 6-26 Breakdowns of NSCD Operations**

| Breakdown         | Description                                       |
|-------------------|---------------------------------------------------|
| type of operation | Request type.                                     |
| result            | Success or fail.                                  |
| database name     | Name service database, such as LDAP, DNS, or NIS. |
| latency           | Time for this request to complete.                |
| hit/miss          | Result from the cache lookup.                     |

## Further Analysis

For average latency, see [Name Service: Operations Average Latency](#). To examine lookups instead of operations, see [Name Service: Lookups](#).

# Name Service: Operations Average Latency

This statistic shows average latency per second for name service operations.

## When to Check Name Service Operations Average Latency

Monitor name service operations average latency when SMB is experiencing performance issues, to determine whether the root cause of that performance problem is actually name service lookup latency.

Name service analytics should be used primarily to analyze performance and diagnose name service problems during investigations. Name service analytics should not be run continuously because they will unnecessarily consume system resources. You can generate an alert if the average latency substantially increases for a period of time, and the alert will appear on the dashboard. To set a threshold alert, see [Configuring a Threshold Alert - BUI, CLI](#).

## Name Service Operations Average Latency Breakdowns

**Table 6-27 Breakdowns of Name Service Operations Average Latency**

| Breakdown         | Description                                       |
|-------------------|---------------------------------------------------|
| raw statistic     | Latency as a raw statistic.                       |
| database name     | Name service database, such as LDAP, DNS, or NIS. |
| type of operation | Request type.                                     |
| hit/miss          | Result from the cache lookup.                     |
| result            | Success or fail.                                  |

#### Further Analysis

See also [Name Service: Operations](#).

## Network: Datalink Bytes

This statistic measures network datalink activity in bytes/second. Network datalinks are logical entities constructed from network devices (see [Network Configuration](#) in *Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x*). The measured bytes by this statistic includes all network payload headers (Ethernet, IP, TCP, NFS/SMB, and so on).

#### Example

See [Network: Device Bytes](#) for an example of a similar statistic with similar breakdowns.

#### When to Check Datalink Bytes

Network bytes can be used a rough measure of Oracle ZFS Storage Appliance load. This statistic can be used to see the rate of network bytes through different datalinks.

#### Datalink Bytes Breakdowns

**Table 6-28 Breakdowns of Datalink Bytes**

| Breakdown | Description                                                                                                                                                |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| direction | In or out, relative to Oracle ZFS Storage Appliance. For example, NFS reads to the appliance would be show as out(bound) network bytes.                    |
| datalink  | Network datalink (see "Datalinks" in <a href="#">Network Configuration</a> in <i>Oracle ZFS Storage Appliance Administration Guide, Release OS8.8.x</i> ). |

#### Further Analysis

See also [Network: Device Bytes](#) and [Network: Interface Bytes](#) for network throughput at the device and interface level, respectively.

## Network: IP Bytes

This statistic shows IP payload bytes/second, excluding the Ethernet/IB and IP headers.

### When to Check IP Bytes

Rarely. Network throughput monitoring can be achieved using the standard Analytics statistic [Network: Device Bytes](#), which is enabled and achieved by default. Examining by-client throughput can usually be achieved through the Protocol statistic (for example, Protocol iSCSI bytes, which allows other useful breakdowns based on the protocol). This statistic is most useful if the previous two were not appropriate for some reason.

### IP Bytes Breakdowns

**Table 6-29 Breakdowns of IP Bytes**

| Breakdown | Description                                        |
|-----------|----------------------------------------------------|
| hostname  | Remote client, either as a hostname or IP address. |
| protocol  | IP protocol: tcp/udp.                              |
| direction | Relative to Oracle ZFS Storage Appliance, in/out.  |

## Network: IP Packets

This statistic shows IP packets/second.

### When to Check IP Packets

Rarely. Because packets usually map to protocol operations, it is often more useful to examine these using the Protocol statistics (for example, Protocol iSCSI operations, which allows other useful breakdowns based on the protocol).

### IP Packets Breakdowns

**Table 6-30 Breakdowns of IP Packets**

| Breakdown | Description                                        |
|-----------|----------------------------------------------------|
| hostname  | Remote client, either as a hostname or IP address. |
| protocol  | IP protocol: tcp/udp.                              |
| direction | Relative to Oracle ZFS Storage Appliance, in/out.  |

## Network: TCP Bytes

This statistic shows TCP payload bytes/second, excluding the Ethernet/IB, IP and TCP headers.

### When to Check TCP Bytes

Rarely. Network throughput monitoring can be achieved using the standard Analytics statistic [Network: Device Bytes](#), which is enabled and achieved by default. Examining by-client throughput can usually be achieved through the Protocol statistic (for example, Protocol iSCSI bytes, which allows other useful breakdowns based on the protocol). This statistic is most useful if the previous two were not appropriate for some reason.

### TCP Bytes Breakdowns

**Table 6-31 Breakdowns of TCP Bytes**

| Breakdown        | Description                                                                        |
|------------------|------------------------------------------------------------------------------------|
| client           | Remote client, either as a hostname or IP address.                                 |
| local service    | TCP port: http/ssh/215(administration)/...                                         |
| direction        | Relative to Oracle ZFS Storage Appliance, in/out.                                  |
| local IP address | Oracle ZFS Storage Appliance IP address that packets are sent from or received on. |

## Network: TCP Packets

This statistic shows TCP packets/second.

### When to Check TCP Packets

Rarely. Because packets usually map to protocol operations, it is often more useful to examine these using the Protocol statistics (for example, Protocol iSCSI operations, which allows other useful breakdowns based on the protocol).

### TCP Packets Breakdowns

**Table 6-32 Breakdowns of TCP Packets**

| Breakdown        | Description                                                                        |
|------------------|------------------------------------------------------------------------------------|
| client           | Remote client, either as a hostname or IP address.                                 |
| local service    | TCP port: http/ssh/215(administration)/...                                         |
| direction        | Relative to Oracle ZFS Storage Appliance, in/out.                                  |
| local IP address | Oracle ZFS Storage Appliance IP address that packets are sent from or received on. |
| packet size      | Size of the transmitted packet.                                                    |
| latency          | Time between when a packet is sent and when the ack is received.                   |

## Network: TCP Retransmissions

This statistic shows TCP retransmissions.

### When to Check TCP Retransmissions

Rarely. Because packets usually map to protocol operations, it is often more useful to examine these using the Protocol statistics. However, certain network types, as well as client receive buffers sizes, are more prone to TCP retransmissions, which can manifest as high latency.

### TCP Retransmissions Breakdowns

**Table 6-33 Breakdowns of TCP Retransmissions**

| Breakdown        | Description                                                                        |
|------------------|------------------------------------------------------------------------------------|
| client           | Remote client, either as a hostname or IP address.                                 |
| local service    | TCP port: http/ssh/215(administration)/...                                         |
| local IP address | Oracle ZFS Storage Appliance IP address that packets are sent from or received on. |
| packet size      | Size of the transmitted packet.                                                    |

## Protocols: Average Latency Statistics

Average latency statistics are available for the Fibre Channel, iSCSI, NFS, SMB, and SRP protocols:

- [Protocol: Fibre Channel Average Latency](#)
- [Protocol: iSCSI Average Latency](#)
- [Protocol: NFSv\[2-4\] Average Latency](#)
- [Protocol: SMBv\[1-3\] Average Latency](#)
- [Protocol: SRP Average Latency](#)

Average latency statistics provide average latency per second. A pair of timestamp values is used to determine the time of the operation, and then add the elapsed time to the average aggregation. Use these statistics to characterize performance issues associated with these protocols. Average latency can be broken down by type of operation and pool.

### When to Check Average Latency

Monitor average latency if you suspect performance issues. For example, you might want to generate an alert if the average latency substantially increases for a period of time. Average latency can be viewed on the dashboard.

### Further Analysis

See also “Protocols” in [Default Statistics](#).

## Protocol: Fibre Channel Average Latency

**Table 6-34 Breakdowns of Fibre Channel Average Latency**

| Breakdown         | Description                                               |
|-------------------|-----------------------------------------------------------|
| type of operation | Fibre Channel operation performed, such as read or write. |

### Further Analysis

- [Protocol: Fibre Channel Bytes](#) for FC bytes/second
- [Protocol: Fibre Channel Operations](#) for numerous other breakdowns on FC operations
- [Cache: ARC Accesses](#) to learn how well an FC read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: iSCSI Average Latency

**Table 6-35 Breakdowns of iSCSI Average Latency**

| Breakdown         | Description                                       |
|-------------------|---------------------------------------------------|
| type of operation | iSCSI operation performed, such as read or write. |
| pool              | Storage pool on which the operation is performed. |

### Further Analysis

- [Protocol: iSCSI Bytes](#) for iSCSI bytes/second
- [Protocol: iSCSI Operations](#) for numerous other breakdowns on iSCSI operations
- [Cache: ARC Accesses](#) to learn how well an iSCSI read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: NFSv[2-4] Average Latency

Supported NFS versions are: NFSv2, NFSv3, NFSv4.0, and NFSv4.1.

**Table 6-36 Breakdowns of NFS Average Latency**

| Breakdown         | Description                                           |
|-------------------|-------------------------------------------------------|
| type of operation | NFS operation performed, such as read or write.       |
| pool              | Storage pool on which the NFS operation is performed. |

### Further Analysis

- [Protocol: NFSv\[2-4\] Bytes](#) for NFSv[2-4] bytes/second
- [Protocol: NFSv\[2-4\] Operations](#) for numerous other breakdowns on NFS operations
- [Network: Device Bytes](#) for a measure of network throughput caused by the NFS activity
- [Cache: ARC Accesses](#) to learn how well an NFS read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: SMBv[1-3] Average Latency

Supported SMB versions are SMB, SMB2, and SMB3.

**Table 6-37 Breakdowns of SMB Average Latency**

| Breakdown         | Description                                     |
|-------------------|-------------------------------------------------|
| type of operation | SMB operation performed, such as read or write. |

**Table 6-37 (Cont.) Breakdowns of SMB Average Latency**

| Breakdown | Description                                           |
|-----------|-------------------------------------------------------|
| pool      | Storage pool on which the SMB operation is performed. |

**Further Analysis**

- [Protocol: SMBv\[1-2\] Bytes](#) for SMB bytes/second
- [Protocol: SMB Operations](#) for numerous other breakdowns on SMB operations
- [Cache: ARC Accesses](#) to learn how well an SMB read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused

## Protocol: SRP Average Latency

**Table 6-38 Breakdowns of SRP Latency**

| Breakdown         | Description                                     |
|-------------------|-------------------------------------------------|
| type of operation | SRP operation performed, such as read or write. |

**Further Analysis**

- [Protocol: SRP Bytes](#) for SRP bytes/second
- [Protocol: SRP Operations](#) for numerous other breakdowns on SRP operations
- [Cache: ARC Accesses](#) to learn how well an SRP read workload is returning from cache
- [Disk: I/O Operations](#) for the back-end disk I/O caused