Space Optimization of Data on Dell PS Series Storage

Implementing compression on PS Series systems with firmware version 8

Dell Engineering
June 2015
## Revisions

<table>
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<tr>
<th>Date</th>
<th>Description</th>
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<tr>
<td>June 2015</td>
<td>Initial release</td>
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Executive summary

The seemingly bottomless appetite for information storage and data retention requires intelligent storage systems that provide more efficient ways to store data. Dell PS Series storage provides several data efficiency methods such as compression. PS Series compression optimizes the capacity required by compressing the least-used data, infrequently accessed snapshots and replicas, within the PS Series group. Compressing these types of cold data minimizes impact from a performance perspective and enables the use of larger, cost-effective drives.

This document describes how data compression works with PS Series arrays and provides the steps to enable, suspend, and view compression within a Dell Storage PS Series array.
1 Introduction

Data optimization has become an increasingly important topic for IT managers due to the staggering amount of data required to maintain regulatory compliance, enable workforce mobility, and meet the demands of cloud and virtualized infrastructures. Typically, large amounts of infrequently used data are retained for various purposes such as meeting legal requirements, providing information agility, and enabling improved customer relationship and recognition. Although this data is often stagnant in nature, it is still important and must be easily retrievable as the business requires.

To help reduce the capacity required by data and ensure easy retrieval, Dell PS Series storage utilizes compression. This feature is available with any PS Series pool that includes a PS6210 or PS6610 array as a member, with an additional requirement that all members in the PS Series group must have firmware version 8 or above. Previous generations of PS Series arrays may also reap the benefits of data compression with the addition of a compression-enabled PS6210 or PS6610 to the pool.

PS Series compression works on inactive snapshot and replication data, which are typically the least active data types and are ideal candidates for compression. Compressing snapshot and replica capacity increases the free space available to users, and allows them to decrease the storage reserved for snapshots and replicas. The PS Series solution permits compressed snapshot data to be stored separately from the base volume data that it is protecting. This allows less-expensive, dense storage to be used for seldom-accessed snapshot space.
2  About PS Series compression

The PS Series architecture is built on virtualization software that utilizes the underlying hardware efficiently. One fundamental component of this software architecture is the PS Series page structure. All data stored within a PS Series group is contained within PS Series pages. Pages may have different states of access. For instance, pages of a volume connected to a host with high I/O would be considered frequently accessed, while offline snapshot or replica pages whose parent volume is not changing would be considered infrequently accessed. PS Series compression compresses the pages of data that are least used within snapshots or replicas.

The PS Series takes advantage of efficient compression algorithms which analyze the data for repeat patterns and then represent those patterns more concisely. For instance, a pattern of 1,000 zeroes may be represented as a single notation as opposed to actually storing 1,000 zeroes. Compressed data may be decompressed and the PS Series software ensures that no data is lost during the compression or decompression process.

2.1  Compression policy

The overall goal of PS Series compression is to increase the free space of the pool without degrading performance. Compression only runs when a substantial period of time is reached for infrequently accessed data, however there is a modest performance cost when compressing and decompressing pages. The PS Series compresses cold pages that are seldom used, while leaving active or hot pages decompressed for faster access. Pages marked for compression will be automatically moved as needed to a compression-capable PS Series member in the pool. These considerations allow for data to be compressed with little impact on production workloads.

2.2  Compression process

For PS Series arrays, the software compression engine determines which snapshot and replica pages will be marked for compression. When a pool includes a PS6210 or PS6610 member, the identified pages are sent to a compression-capable member to be compressed. The PS6210 or PS6610 then compresses the pages received from other members in that pool, as well as any compressible pages from volumes that it is supporting, and stores the compressed data. The pages are compressed in the background when I/O is occurring to minimize the performance impact.

As shown in Figure 1, both compression-capable and non-compression-capable arrays are present in the same pool. The least-active snapshot data is sent to the compression-capable member and then compressed and stored on that PS Series member.
2.3 Compression criteria

Compression occurs on pages after they have not been accessed in at least 4.5 hours. In addition, compression may occur during array optimization tasks such as internal load balancing.

In general, a page is selected for compression if the following conditions are met:

- The page is owned exclusively by a snapshot or a replica snapshot (for example, the page is not actively accessed by the base volume).
- All of the snapshots (snaps) referencing the shared page are marked as compression eligible.
- The page is cold based on inactivity (approximately 4.5 hours without access).
3 Considerations for compression

All members in the group must be running PS Series firmware version 8 or higher. See the firmware release notes on eqlsupport.dell.com (requires login) for a list of models that are supported by version 8 firmware.

Compression will only be attempted by a compression-capable array if all of these conditions are met:

- The array has compression-capable hardware.
- Compression has been enabled on the array.
- The compression-capable-array capacity limit has not been exceeded (over 50 percent of the member capacity used by compressed data).

3.1 Compression status

Compression is disabled by default and must be enabled individually on each array as desired. Only compression-capable members such as the PS6210 or PS6610 may be enabled.

The compression status of the array is classified as follows:

**Non-compression array:** An array that has never been configured for compression. This category includes arrays without compression-capable hardware as well as arrays that are capable but have never been enabled for compression.

**Compression-enabled array:** An array that is enabled for compression. An array can only be enabled by a user if it has compression-capable hardware. Once a compression-enabled array reaches its capacity limits and can no longer service compression requests, it becomes a compression-paused array.

**Compression-paused array (suspend):** An array that has been enabled for compression but has been paused, or its compression capacity limits have been reached and it is no longer actively compressing pages. There may or may not be compressed pages stored on this array because pausing compression does not cause compressed pages to be decompressed.
Figure 2 shows a pool with different compression states. In this example, the PS6110 may participate in a pool which has compression enabled, however the member itself will not perform or store compressed data. This example also shows that one PS6210 is enabled while the other is paused, and the PS6210 with compression enabled will hold any new compressed pages.

Compression can be enabled on some or all of the compression-capable arrays in a given pool. A compression-enabled array will compress, decompress, and store compressed data with its local compression engine. Also, a compression-paused array is capable of decompressing its compressed pages. It is important to note that non-compression arrays and compression-paused arrays can still have eligible pages moved to the compression-enabled arrays within the pool.

**Note:** Compression may be enabled on compression-capable arrays when the RAID status is “OK” or “verifying”.

If compression is suspended on an array, no new pages will be sent to this array to be compressed, but the compressed pages currently residing on the array will remain compressed until decompression triggers are invoked on a page-by-page basis. These triggers may include writes to any compressed page or the discarding of data caused by the deletion of all snapshots or replicas that refer to the page. Decompressed pages on paused arrays can still be selected to be compressed on other compression-enabled arrays in the pool.
3.2 Capacity gain limitations: 50-percent rule
Once the member has stored compressed pages up to 50 percent of its total usable capacity, additional new pages can no longer be compressed. This is a safeguard to ensure that the member can continue to provide normal volume services and that enough space exists to decompress the compressed data.

The rule assumes a 2:1 compression ratio, and an array can gain up to 50 percent of its total capacity to be used in storing compressed snapshot or replica pages. For example, an array with a physical capacity of 4TB can achieve up to 6TB of usable capacity. The additional 2TB of virtual space is utilized as in-use snapshot storage, allowing more snapshots to be stored in a given snapshot reserve space.

3.3 Enabling compression on PS Series arrays
Compression for PS Series arrays is disabled by default, but it may be enabled on each compression-capable member (with firmware version 8) in the pool. In addition, if the array is upgraded to firmware 8 or higher, the default is to have compression off.

**Note:** For compression to be enabled in the pool, the pool must include a PS6210 or PS6610 array which are designed to accommodate the processor and memory overhead required for compression.
Use the following steps to enable compression:

1. In the Group Manager interface, expand the Members menu and select the member(s) you wish to start compression.
2. Click **Start compression**. The option to start compression is available at initial startup (off by default).

![Starting the compression process](image)

**Figure 3** Starting the compression process
3. When the Compression settings window appears with a warning message, click **Continue**.

The warning message shown in Figure 4 indicates that once compression is enabled, the only operation available will be to suspend compression ("suspended" as indicated in the warning).

![Compression warning message](image)

**Figure 4** Compression warning message

Compression will now start. You will notice that the only activity available at this point is to suspend compression, which will only suspend compression for new snapshot and replica pages. Also, the Group Manager interface shows the results of compression for each participating member under the Status tab for the member. This will start the compression of cold snapshot or replica data.

**Note:** Snapshots will remain compressed until they are brought online, in which case they will be decompressed.
Demonstrating compression

The compression examples shown below were performed with different data types as represented in the Silesia Corpus dataset. The steps are outlined as follows:

1. Create and copy the appropriate data to the test volume for compression.
2. Create a snapshot of that volume after the data has been added. Note the size of the snapshot for later comparison.
3. Start compression on the appropriate members in the pool. See section 3.3 for steps to enable compression.
4. Delete the data on the volume. This will require the array to copy the original data to the snapshot which will increase the size of the in-use snapshot space.
5. After compression completes, review the space results. See Figure 5 and Figure 6.

Figure 5 shows the volume status view in the Group Manager before compression has been started.

![Figure 5](image_url)

**Figure 5** In-use space of snapshots before compression
Once compression has started, only the Suspend compression action will be available in the Group Manager interface.

Figure 6  Space savings, compressed size, and expanded size shown after compression has completed

**Note:** Compression may take some time to complete depending on the size and inactivity of the in-use snapshot space.
4.1 Suspending compression

Compression on the member may be suspended. This will suspend future compression operations on new snapshots. The existing compressed data will remain compressed.

In the Group Manager interface, select the member for which you would like compression to be suspended. Then, under the Activities section, click **Suspend compression**.

![Figure 7 Suspending compression on a compression-capable member](image-url)
4.2 Resuming compression

To resume compression, click **Resume compression** under the Activities section for the member as indicated in Figure 8.

![Figure 8](image_url)  
Resuming compression on a member which is suspended
4.3 Snapshot decompression policy

Decompression is the rehydration of compressed snapshot pages to their expanded size. This may occur during any of the following scenarios:

- Volume movement between pools: Data is decompressed at the source array but may become compressed again after the movement to the new pool (if a compression-capable array is present in the new pool).
- Member move or delete (vacate): This causes decompression of pages that are moved to a new member. These pages may be recompressed if a compression-capable member exists in the pool after the removed member has transferred all of its data to other members in the pool.
- Reads involving the compressed page: This results in decompression for the duration of the read.
- Writes which involve the compressed page: This will result in decompression until the pages become inactive for the appropriate period of time.

The operations involved to decompress snapshot pages include:

1. Read the snapshot pages as decompressed data.
2. Move the decompressed data page to another array. In the case of a single-member group, data access to the pages may cause decompression.
3. After move completion is verified, delete the original compressed data pages.

**Note:** Decompression is enforced on a page-by-page basis, and not a volume basis. Accessing a non-compressed page of a snapshot containing compressed pages will not trigger decompression of the entire snapshot.
Additional considerations for replicas

In addition to snapshots, the PS Series will also compress replicas utilizing compression-capable arrays at the target site. When enabling replication on a volume, a thin provisioned volume is created on the remote partner. Every replica set is composed of both a base volume and a series of replicas which are effectively snapshots. With each subsequent replica that is sent, only the changed data is transferred to the target site. The PS Series software reconstructs a new base volume as it existed at the time of the initiation of the replica by combining the pages that are unchanged with the new pages, while the previous oldest replica now effectively becomes a snapshot. As older replicas become eligible for deletion, the unique pages that they reference are returned to the replica reserve for that volume.

View replica (delegated) space compression

Replicas on PS Series arrays are represented by the amount of space available to replication, also known as delegated space. Since this space may have inactive replica pages, the space may also be eligible for compression.

Delegated space utilization will be shown on the secondary system and will indicate the compression savings for incoming replication.

Figure 9  Inbound replicas showing compression space savings in the delegated space area

Note: The source group will indicate the outbound volume replication, however compression savings will only be displayed in the Group Manager interface of the secondary group.

Suspending compression on the replication partner

Compression may be suspended on the replication partner and will stop compression of new replica pages in the same manner as with snapshots.
5.3 Decompression of replicas

The same policy for decompression of snapshots is followed for replicas. Data for a replica page will be decompressed when access involves writing, which occurs when a replica set volume is promoted or the replica set is moved to the delegated space in a different pool.
6 Performance considerations
One factor that is inherent to compression is the processing required to determine if the data is compressible. The overhead needed to perform compression has been minimized in the implementation of compression in PS Series arrays. Compression, like page movement during load balancing, is a low-priority process and will be throttled as user I/O takes precedence.

6.1 Compression rate: A background process
PS Series compression is designed to provide the greatest amount of free space possible while having minimal impact on user I/O performance. PS6210 or PS6610 models with firmware 8 are required for compression because these systems have faster processors and greater memory capacity than previous-generation storage arrays, allowing them to minimize the performance impact from compressing or decompressing data. Also, compression is a background process that is designed to adapt to the compression rate, and help throttle the compression speed to minimize the degradation of user I/O.

6.2 Decompression: Only on access
The decompression process may occur through the array page-movement process or by a host accessing a compressed snapshot. If a compressed snapshot is written to, the page is first read into the PS Series cache of the member holding the compressed page, and is then written as decompressed data to that member. For this reason, decompressing pages requires overhead from the processor and memory of the compression-capable members in the pool.

6.3 Compression efficiency: Data dependent
Different data types exhibit varying levels of compressibility. For instance, a large dataset with many repeating or null values will typically have a large percentage of pages compressed and therefore a higher compression ratio. Other data that is already optimized, such as JPEG files, often is not highly compressible. The compression ratio is expressed as a percentage of space saved in PS Series management tools such as Group Manager or SAN Headquarters.
Monitoring compression

Compression may be monitored through the Group Manager or through SAN Headquarters v3.1.

7.1 Group Manager

The Group Manager shows the space savings as a percentage of the total for snapshot and replica set compression. In the event of decompression, the capacity needed for expansion is indicated as shown in Figure 10.

Figure 10 A pool showing compressed size, space savings, and resulting expanded size (after decompression)
The compression details may be obtained at the pool, member, and volume level as shown in Figure 11.

![Figure 11: Status tab displaying general volume information, compression usage, and space savings](image-url)
7.2 SAN Headquarters

Beginning with version 3.1, SAN Headquarters shows compression details on several interface panels. As shown in Figure 12, compression savings and usage are displayed across all groups monitored.

![SAN Headquarters showing compression savings for all groups](image-url)

<table>
<thead>
<tr>
<th>Group</th>
<th>Volume</th>
<th>Total Capacity</th>
<th>Allocated (TB)</th>
<th>Used (TB)</th>
<th>Total Snapshot Size</th>
<th>Exp. Size</th>
<th>Compressed Size</th>
<th>Calories</th>
<th>GB</th>
<th>GB</th>
<th>GB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default Group</td>
<td>All Groups</td>
<td>10.07 GB</td>
<td>8.06 GB</td>
<td>7.97 GB</td>
<td>1.09 GB</td>
<td>0.83 GB</td>
<td>0.79 GB</td>
<td>0.05 GB</td>
<td>15.10</td>
<td>15.10</td>
<td>15.10</td>
</tr>
<tr>
<td>Default Group</td>
<td>All Groups</td>
<td>100.00 GB</td>
<td>80.00 GB</td>
<td>79.99 GB</td>
<td>10.01 GB</td>
<td>8.00 GB</td>
<td>7.98 GB</td>
<td>0.12 GB</td>
<td>150.10</td>
<td>150.10</td>
<td>150.10</td>
</tr>
</tbody>
</table>

Figure 12  SAN Headquarters showing compression savings for all groups
The compression ratio is also displayed for each member by pool, as shown in Figure 13.

Figure 13  Space savings shown for all group members
Replica set compression savings is also easily viewed through SAN Headquarters for inbound replicas on the target group as shown in Figure 14.

Figure 14  Compression information on replica reserve for the inbound replicas on the replication target
Conclusion

With the introduction of firmware 8, Dell PS Series arrays add block-level compression to a long list of enhanced features. Compression allows users to maximize the cost advantage of larger-capacity drives for storing recovery data while retaining the performance and flexibility that is expected from PS Series storage. Also, with the simple addition of a compression-enabled PS6210 or PS6610, legacy PS Series pools can obtain relief from capacity challenges and optimize the capacity used by colder data, driving further efficiencies in the data center.
A  Additional resources

A.1  Technical support

Dell offers PS Series support with online and telephone-based support and service options. Availability varies by country and product, and some services might not be available in your area.

For general Dell support, visit Dell.com/support or call 800-945-3355 (United States and Canada).

A.2  Dell online resources

Visit the Dell EqualLogic TechCenter site to learn more about Dell PS Series products and new releases being planned. Or visit the EqualLogic Technical Content page for articles, demos, technical documentation, and more details about PS Series storage.

You can find compatibility information for PS Series products in the Dell Storage Compatibility Matrix.

To learn more about Dell products and services, visit Dell.com or the URL specified in your Dell product information. Use the locale menu or click the link that specifies your country or region.

A.3  Feedback

We encourage readers of this publication to provide feedback on the quality and usefulness of this information by sending an email to StorageSolutionsFeedback@dell.com.