Technical Report

# Reallocate Best Practices Guide

Chris Wilson, NetApp
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## SUMMARY

The reallocate and read reallocate toolsets offer functionality to improve the performance of NetApp® storage systems running Data ONTAP®. This paper introduces the basic functionality and best practices associated with using the reallocate toolset.

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# 1 INTRODUCTION

Data ONTAP provides a set of tools to help customers optimize the layout of data on disk for sequential read access. This guide introduces the reallocate tools in Data ONTAP, including **reallocate** and the volume option, **read reallocate**. This guide also describes some best practices for using reallocate. The *System Administration Guide* for the appropriate version of Data ONTAP may answer any additional questions not covered in this guide.

# 2 HOW REALLOCATE WORKS

Use reallocate to optimize the layout of data on disk. It works on volumes, LUNs, individual files, and in a special case, aggregates.

Reallocate internally uses the following process:

1. Reallocate measures the current layout and produces an optimization score. If the optimization score is greater than the threshold, proceed to step 2. If the optimization score is less than the threshold, reallocation is not needed. For information about thresholds and measurements, see section 3.1, "When to Use Reallocate."
2. Perform data reallocation by using traditional or physical reallocation.
3. Recheck the current layout and repeat the process until the layout is optimal.

## 2.1 TRADITIONAL REALLOCATION

The reallocation process progresses through the file system and moves data blocks by rewriting them when Data ONTAP determines that the layout can be improved. If no improvement is predicted, no data is moved. NetApp Snapshot® data is not moved even when active file system data has been moved to new, optimized locations. Because data is rewritten to disk, if Snapshot copies are used, additional space is required to maintain the copies. The impacts of using reallocate are discussed in section 4, "System and Feature Interactions."

## 2.2 PHYSICAL REALLOCATION

The reallocate tool also provides a physical reallocation option. Physical reallocation follows the same process as traditional reallocation; however, instead of completely rewriting data to the disks, the data blocks are moved by changing the physical block location while maintaining the logical block location within the FlexVol® volume. The benefit of using physical reallocation is that no additional space for is required for Snapshot copies, compared to using traditional reallocation. The implications of using physical reallocation are discussed in section 4, "System and Feature Interactions."

| Best Practice |
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| When possible, use physical reallocation, to reduce the space requirements of Snapshot copies. |

# 3 USING REALLOCATE

Reallocate can be started, quieced, stopped, and scheduled from the command line interface (CLI) by using the `reallocate` command. You can also use the same command to check the status of the reallocation and measure the current layout optimization. The following sections describe when and how to execute `reallocate` with the correct options.

## 3.1 WHEN TO USE REALLOCATE

Reallocate optimizes sequential read performance. The workload that most benefits from the use of reallocate is sequential reads after random writes; however, other workloads may also show some improvement, and vary depending on the workload characteristics.

Typical applications that see the most benefit from using reallocate include:

- Online transaction processing databases that have large table scans
- E-mail systems that use database storage with verification processes
- Host-side backup of LUNs

If the workload isn't well known, it may be difficult to determine whether a reallocation is necessary. Reallocate includes measurement functionality to help users quantify the degree to which the current layout is optimal. The `reallocate measure` command provides insight into the current layout by providing a current optimization value. The output values can be used to determine whether on-disk layout is a potential cause of decreased performance. The following command shows how to measure the layout of a volume:

```
toaster> reallocate measure -o /vol/volX
```

**Note**: Use the `-o` flag to measure layout only and not run the data reallocation.

You can use this optimization value as a threshold setting for reallocate. The default threshold that reallocate uses is 4; you can change this default by using the `-t` flag when executing a `reallocate start` or `reallocate measure` command. Valid threshold values are between 3 and 10 (not optimal).

```
toaster> reallocate start -t 5 /vol/volX
```

or

```
toaster> reallocate measure -t 5 /vol/volX
```

It is also possible to skip the scanning portion of reallocate by using the `-n` option. This option ignores any thresholds and simply begins data reallocation.

```
toaster> reallocate start -n /vol/volX
```

## 3.2 REALLOCATE OPTIONS

You can execute and schedule reallocate by using the Data ONTAP CLI. Table 1 describes the available options.

**Table 1) `reallocate start` execution options.**

| Option | Description |
|---|---|
| -p | Executes reallocate by using physical reallocation. Generally recommended. For more information, see section 3.3, "Execution Requirements". |
| -f | Executes a forced reallocation. Generally not recommended. For more information, see section 3.4, "Forced Reallocation." |
| -o | Executes reallocation one time only. |
| -n | Executes reallocation without measuring the layout first. |
| -t | Forces reallocate to use a custom threshold. |

## 3.3 EXECUTION REQUIREMENTS

To run reallocate, you must meet various requirements. The following list can help determine why reallocate might not run:.

- The object to be reallocated must be writable (no SnapMirror® destinations).
- More than 5% of a volume must be free.
- Free Snapshot space must be greater than 10% of the Snapshot reserve or more than 5% of the volume size, whichever is less. This requirement does not apply to physical reallocation.
- Full reallocation requires the physical reallocate option (`-p`) if Snapshot copies are present.
- Physical reallocate can be executed only on data in FlexVol volumes.
- Physical reallocate cannot be executed on FlexClone® volumes.
- Physical reallocate (and aggregate reallocate) cannot be run on data stored in mirrored aggregates.
- The underlying aggregate must not be RAID 0.
- Physical reallocate cannot be run on aggregates created with Data ONTAP 7.0 or 7.1.

## 3.4 FORCED REALLOCATION

A forced reallocation scan rewrites all the data in the volume, LUN, or file *regardless of current optimization.*

| Best Practice |
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| Use forced reallocation after adding disks to an aggregate so that existing data is spread onto the new disks, reducing the time required to balance the load across all the disks. |

Forced reallocation ignores the optimization thresholds and completely rewrites the data to disk, unlike the normal reallocation process. Although this improves the layout, routine use of reallocate `-f` is not a best practice. Also, because all of the data is optimized, forced reallocation cannot be run against volumes that have existing Snapshot copies unless the physical reallocation method (`-p`) is also used.

## 3.5 DEVELOPING A REALLOCATE SCHEDULE

Reallocate is most effective when it is executed regularly. With regular reallocation, the amount of work that reallocate must complete during each iteration can potentially be reduced, and consistently better performance can be achieved. Developing a schedule for reallocate depends on the reallocation method, the time required to reallocate, and the workload applied to the system. A daily reallocation scan may be most effective in most situations.

When using the traditional reallocation method, it's important to consider the additional Snapshot reserve space that will be required. Using physical reallocate eliminates this consideration.

By default, executing `reallocate start` without any parameters causes reallocate to run once daily. To change this default, use the `reallocate schedule` command after a reallocation scan has been created; or use the `-i` flag when creating the reallocate scan. The `reallocate schedule` command can be used only on reallocation scans that have already been created. A schedule in the form of "minute hour day_of_month day_of_week" is required as a parameter for the command. An asterisk (*) is a valid value that represents "any." The following example creates a weekly reallocate schedule (every Saturday at midnight) for volX:

```
toaster> reallocate schedule "0 0 * 6" /vol/volX
```

To create a scan with a weekly interval at creation time, use the `-i` flag:

```
toaster> reallocate start -i 7d /vol/volX
```

To delete a reallocate job, use the `-d` flag:

```
toaster> reallocate schedule -d /vol/volX
```

To stop and delete a job, use the `reallocate stop` command:

```
toaster> reallocate stop /vol/volX
```

### 3.6 AGGREGATE REALLOCATION

An additional option, `-A`, is available at the aggregate abstraction. This reallocation method reallocates blocks within an aggregate to improve contiguous free space. The `-A` option does not reallocate all of the data in the aggregate following the normal reallocation method. It should not be used to improve sequential read performance. Because aggregate reallocation uses the physical reallocation method to move blocks to create contiguous free space, the impacts of using physical reallocate still apply.

| Best Practice |
| --- |
| Use reallocate `-A` only if directed by NetApp to improve contiguous free space. |

## 4 SYSTEM AND FEATURE INTERACTIONS

### 4.1 OVERALL SYSTEM PERFORMANCE

By design, reallocate has a minimal impact on system performance. If a system is heavily loaded, reallocate is treated as a low-priority operation and should not significantly slow users' access to data. However, a heavily loaded system also causes reallocate to take longer to complete.

| Best Practice |
| --- |
| When possible, schedule reallocate runs during off-peak hours. |

### 4.2 VOLUME SNAPSHOT AND SNAPMIRROR

Both the traditional and physical reallocation methods affect existing Snapshot copies in some way. The following two subsections describe how Snapshot copies and SnapMirror are affected by both methods.

#### TRADITIONAL REALLOCATE

As previously described, the traditional reallocation method rewrites the data in the active file system to improve layout on disk. Snapshot copies do not require any additional space unless a block in the active file system is altered or removed. Because reallocate rewrites data to improve layout, a non-optimal file system layout requires many blocks to be rewritten. WAFL® (Write Anywhere File Layout) improves the layout by moving the blocks, but the original block remains in Snapshot copies, thus increasing the required Snapshot space. Administrators must plan for this additional capacity utilization when running reallocate. The additional utilization lasts only as long as the life of the Snapshot copies.

SnapMirror hinges off of Snapshot technology to create point-in-time mirroring. When using the traditional reallocation method against a SnapMirror source, SnapMirror flags any reallocated data as data that needs to be sent during the next update, regardless of whether the contents have actually changed. Therefore, if a large amount of data was reallocated, SnapMirror will require a large update on the next sync.

#### PHYSICAL REALLOCATE

The physical reallocation method does not have the same impact on Snapshot copies as the traditional reallocation method. Because physical reallocation does not follow the complete rewrite process, but rather moves data blocks at a lower level without altering the logical location, Data ONTAP Snapshot technology does not notice any changes. This low-level movement does not cause the copies to occupy any additional capacity.

Using physical reallocate can introduce a read performance impact to existing Snapshot copies. This performance impact is due to additional operations that must be completed to locate Snapshot data after a reallocation completes. After a block is read from a Snapshot copy, subsequent accesses to that block does not require additional lookups. Physical reallocation does not affect the performance of copies created after reallocate completes.

Physical reallocate does not cause the active file system to diverge from existing Snapshot copies. Unlike the traditional reallocation method, SnapMirror does not identify any data that was reallocated as data that must be sent during the next sync.

### 4.3 FLEXCLONE VOLUMES

FlexClone volumes also hinge off of Snapshot technology, so executing reallocate has similar implications. Running reallocate against a parent causes any data that is reallocated to be maintained in the Snapshot copy for the clones, using additional Snapshot reserve space. If the clone is reallocated, it diverges from the parent and uses additional space in the aggregate. The parent remains in the same, unoptimized state.

If physical reallocate is used against a parent of FlexClone volumes, the parent is reallocated as expected; however, the clones may exhibit some read performance degradation during the first access of data due to additional location lookups. Physical reallocate and space_optimized read reallocation against a clone are not allowed.

### 4.4 DEDUPLICATION AND COMPRESSION

Currently, reallocate does not support deduplicated data and is not recommended with compressed data. Reallocate and read reallocate do not attempt to move deduplicated or compressed blocks. Deduplicated data cannot be reallocated because the reallocate functionality cannot determine the best way to reallocate a shared block.

## 5 READ REALLOCATE

### 5.1 OVERVIEW

Read reallocate is a volume option that performs opportunistic reallocation on data to improve performance. Read reallocation uses the normal workload reads along with the read-ahead engine to determine the current layout optimization. If the read was less than optimal, the data will be reallocated to improve the next read of this data. Read reallocate offers both the traditional and physical reallocation

methods associated with the `reallocate` command. Also, because read reallocate uses the existing read workload, it does not require additional scanning or scheduling.

### 5.2 ENABLING READ REALLOCATION

Read reallocate is a volume option that is enabled by using one of the following CLI commands:

```
toaster> vol options volX read_realloc on
```

or

```
toaster> vol options volX read_realloc space_optimized
```

Simply enabling read reallocation by using the "on" function tells Data ONTAP to use the traditional reallocation method. This has the same side effects as traditional reallocate. The `space_optimized` option is synonymous with the physical reallocation method. It does not introduce the Snapshot space requirements associated with the traditional reallocation method. The `space_optimized` method does, however, introduce the Snapshot read performance impact, similar to physical reallocation.

### 5.3 READ REALLOCATION AND REALLOCATE

Reallocate and read reallocation are complementary. Both features can be employed together to accomplish the same goal of improving spatial layout. Read reallocate can help reallocate by reducing the amount of work that reallocate needs to do in each iteration, depending on the workload applied to the system.

An example of when to employ both is in a database system with weekly large table scans. Enabling read reallocate maintains an optimal layout of frequently accessed data, while a scheduled reallocate execution prior to the large table scan may help improve the table scan speed.

| Best Practice |
| --- |
| Use read reallocate and regular reallocate scans together to reduce the time that reallocate must run and to maintain the optimal layout. |

## 6 CONCLUSION

The reallocate tools in Data ONTAP enable administrators to optimize the layout of data on disk to improve system performance. To get more information about using reallocate, read reallocate, or any other NetApp feature, see the Data ONTAP documentation on the NetApp Support site.

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