ABSTRACT
This technical note explains TimeFinder with HYPERMAX OS, Solutions Enabler, and Unisphere for VMAX.

May, 2017
# TABLE OF CONTENTS

## EXECUTIVE SUMMARY

- Audience .......................................................... 5

## OVERVIEW

- Terminology ................................................................ 5
- Creating Snapshots .................................................. 6
- Generation Numbers ................................................ 7
- Time-to-Live (TTL) .................................................. 7
- Host Writes to Source .............................................. 8
- Redirect-On-Write ................................................... 8
- Replication Cache ................................................... 9
- Shared Allocations ................................................... 12
- Linking Target Volumes to Snapshots ........................ 12
- Relinking ................................................................. 13
- Unlinking ................................................................. 13
- Defining State .......................................................... 13
- Linking Larger Target .............................................. 14
- Source Volumes / Linked Targets SRP Relationships .... 14
- Restore Operations .................................................. 15
- Cascading Snapshots .............................................. 15
- Reserved Capacity ................................................... 16
- Interoperability ......................................................... 16
- Storage Group Operations ....................................... 17
- Secure Snaps .......................................................... 18

## IMPLEMENTING TIMEFINDER SNAPVX

- Creating Snapshots .................................................. 20
- Linking, relinking, unlinking .................................... 21
- Restoring from snapshots ........................................ 23

## EMULATION SUPPORT FOR TIMEFINDER MIRROR, CLONE, AND VP SNAP

- TimeFinder VP Snap Emulation ................................ 24
- TimeFinder Snap Deprecation .................................... 24
CONCLUSION ........................................................................................................... 24
REFERENCES ......................................................................................................... 25
APPENDICES ......................................................................................................... 26
Appendix A .............................................................................................................. 26
TimeFinder SnapVX State Table ............................................................................. 26
Appendix B .............................................................................................................. 27
Geometry Compatibility Mode (GCM) ................................................................. 27
Appendix C .............................................................................................................. 28
Monitoring the Copy Process ................................................................................... 28
Appendix D .............................................................................................................. 28
Nocopy Linked Target Functionality ....................................................................... 28
Appendix E .............................................................................................................. 29
Scheduling Snapshots with Unisphere for VMAX ................................................. 29
EXECUTIVE SUMMARY

TimeFinder® software delivers point-in-time copies of volumes that can be used for backups, decision support, data warehouse refreshes, or any other process that requires parallel access to production data.

Previous VMAX™ families provide several different TimeFinder offerings, each with their own characteristics and ideal use cases. These offerings also have several similarities, the main one being that each requires a target volume to retain snapshot or clone data.

TimeFinder in HYPERMAX OS 5977 introduced TimeFinder SnapVX which combines the best aspects of the previous TimeFinder offerings, adds some new ease-of-use features, and increases scalability.

SnapVX provides very low impact snapshots and clones for VMAX LUNs. SnapVX supports up to 256 snapshots per source volume, which are tracked as versions with less overhead and simple relationship tracking. Users can assign names to identify their snapshots, and can set automatic expiration dates on each snapshot.

SnapVX provides the ability to manage consistent point-in-time copies for storage groups with a single operation. Up to 1024 target volumes can be linked per source volume, providing read/write access as pointers or full-copy clones.

TimeFinder in HYPERMAX OS also provides compatibility modes for users who rely on their TimeFinder Mirror, Clone, or VP Snap command scripts. This allows users to leverage their existing scripts while learning how to take advantage of the new features of SnapVX.

This document describes TimeFinder features for business continuance and implementation guidelines, including restrictions and limitations for this product. The features discussed are valid for HYPERMAX OS 5977 on VMAX™ All Flash and VMAX3™ Series arrays.

AUDIENCE

This technical note is intended for storage administrators, database administrators, and technologists who have an interest in understanding the concepts surrounding Local Replication in VMAX All Flash and VMAX3 Family storage arrays.

OVERVIEW

Local replication with SnapVX starts out as efficient as possible by creating a snapshot, a pointer based structure that preserves a point-in-time view of a source volume. Snapshots do not require target volumes, share back-end allocations with the source volume and other snapshots of the source volume, and only consume additional space when the source volume is changed. A single source volume can have up to 256 snapshots.

Each snapshot has a user-defined name and can optionally have an expiration date, both of which can be modified later. New management interfaces enable the user to take a snapshot of an entire Storage Group with a single command.

A point-in-time snapshot can be accessed by linking it to a host accessible volume referred to as a target. The target volumes are standard Thin LUNs. Up to 1024 target volumes can be linked to the snapshot(s) of a single source volume. This limit can be achieved either by linking all 1024 target volumes to the same snapshot from the source volume, or by linking multiple target volumes to multiple snapshots from the same source volume. However, a target volume may only be linked to a single snapshot at a time.

By default, targets are linked in a nocopy mode, but can be linked in a copy mode to create full-copy clones. Snapshots can be cascaded from linked targets, and targets can be linked to snapshots of linked targets. There is no limit to the levels of cascading and the cascade can be broken at any point, with limitations that are discussed later.

TERMINOLOGY

The following are explanations of terms that are commonly used throughout the paper:

**Storage Resource Pool (SRP):** A collection of data pools which provide physical storage for thin devices. SRPs are managed by Fully Automated Storage Tiering (FAST).

**Source Volume:** A LUN that has SnapVX snapshots from it, either with or without linked targets.
**Snapshot**: A preserved point-in-time image of a source volume. A snapshot uses pointers in cache to indicate which version of a track is applicable to the specific point-in-time; either a track that resides on the source volume, or a snapshot delta.

**Snapshot Delta**: A point-in-time version of a source volume track that was preserved during a host write to a source volume that had an active snapshot.

**Linked Target Volume**: A LUN that is linked to a SnapVX snapshot in order to make the point-in-time of the snapshot accessible to the host. Linked targets can have one of two modes:

- **Nocopy Mode**: Does not copy data to the linked target volume but still makes the point-in-time accessible via pointers to the snapshot. The point-in-time image will not be available after the target is unlinked because some target data may no longer be associated with the point-in-time.

- **Copy Mode**: Copies all relevant tracks from the snapshot’s point-in-time to the linked target volume to create a complete copy of the point-in-time that will remain available after the target is unlinked.

1Please see Appendix D for changes to the nocopy target functionality beginning in the HYPERMAX OS Q1 2016 Service Release.

**CREATING SNAPSHOTs**

TimeFinder SnapVX allows snapshots to be taken without the use of a target volume. The snapshots are made as efficient as possible by sharing point-in-time tracks, which are called snapshot deltas. The snapshot deltas are stored directly in the Storage Resource Pool (SRP) where the source volume resides. Each snapshot will use pointers to reference snapshot deltas appropriate for the specific point-in-time image.

SnapVX Snapshots are created with the `symsnapvx establish` command. As part of the establish command the user defines a name for the snapshot. The name has up to 32 characters and can include alpha and numeric characters, dash and underscores. The name is not case sensitive. Figure 1 depicts a volume with three targetless snapshots.

![Production Volume with three targetless snapshots](image)

Figure 1: Production volume with three targetless snapshots

Solutions Enabler and Unisphere for VMAX both report the snapshot allocated usage of an SRP as shown in Figure 2 and Figure 3:

```
PS C:\Users\Administrators> symcfg -sid list -demand -srp -type sl

STORAGE RESOURCE POOLS
Symmetrix ID : 0001970000
Name : SP2.1
Usable Capacity (GB) : 15/40.2
SRDF DSE Allocated (GB) : 0.0
Snapshots Allocated (GB) : 0.6
```

Figure 2: `symcfg list -demand -srp -type sl`
GENERATION NUMBERS

It is possible to have multiple snapshots with the same name for the same set of source volumes, and generation numbers identify the different snapshots. It is important to understand how generation numbers are applied when deciding to either reuse snapshot names or to use unique names for each snapshot. Generation numbers are relative to existing snapshots at the time of creating or displaying snapshots, and they change as snapshots are created and terminated.

When a snapshot name is reused, the new session becomes Generation 0 and all previous sessions with the same name have their generation numbers incremented by one. Similarly, if a more recent snapshot is terminated, all older snapshots have their generation numbers decreased by one. The most recent snapshot always has a generation number of 0. This is advantageous because after creating a new snapshot, the user knows that it is Generation 0 and does not have to search for the specific snapshot.

For example, if a user creates a snapshot called hourly_backup at 1PM, this snapshot would be Generation 0. Then at 2PM they create another snapshot and reuse the name hourly_backup. At this point, the 1PM snapshot would become Generation 1 and the 2PM snapshot would be Generation 0. Similarly, at this point if the 2PM snapshot (Generation 0) was terminated, the 1PM snapshot would again become Generation 0.

Reusing snapshot names and employing generation numbers can be very useful. A user could create a certain amount of generations for a specific snapshot, and then every day, create a new one and terminate the oldest, using the same commands each day and making scripting simple.

However, the user must recognize that the generation numbers are dynamic; creating or terminating snapshots may cause generation numbers of other snapshots to change. This could be problematic in situations where multiple users create snapshots on the same set of volumes, especially in situations where a single volume is in multiple groups (Storage Groups, Device Groups, Composite Groups, and so on). As with any other feature or option, the user must make the best choice for their environment.

TIME-TO-LIVE (TTL)

The user can also define a Time-To-Live (TTL) value on each snapshot, which acts as an expiration date. Snapshots automatically terminate when the TTL expires, assuming the snapshot does not have any linked targets. If a snapshot has linked targets and the time-to-live has expired, the snapshot terminates when the last target is unlinked.

TTL values can either be set to a specific date (\texttt{-absolute}) or a specified number of days (\texttt{-delta}). When a user sets a TTL value to a specific date, Solutions Enabler internally uses a delta that is calculated from the specified date and the current host time. This internal conversion eliminates the need for users to synchronize clocks or calculate times between servers and the storage array. Time-to-Live values can be specified when the snapshot is established, and can also be set or changed on existing snapshots.

Expiration can be specified by days and/or hours beginning with Solutions Enabler 8.4, Unisphere for VMAX 8.4, and REST API 8.4. Expiration is available in one day increments in earlier releases.
Hours can be specified with both the **-absolute** and the **-delta** options. The maximum value allowed is 23 hours. Specifying hours is optional when setting the expiration date and can be omitted. Scripts that were created with previous versions of Solutions Enabler and do not specify hours continue to function after upgrading to Solutions Enabler 8.4.

- Examples of the CLI format of the **-ttl** option are:
  - Expire snapshot in 1 day: `-ttl -delta 1`
  - Expire snapshot in 1 day and 12 hours: `-ttl -delta 1:12`
  - Expire snapshot in 12 hours: `-ttl -delta 0:12`
  - Expire snapshot on March 1, 2018 at 1pm: `-ttl -absolute 03/1/2018:13`

Figure 4 is an example of the Unisphere for VMAX wizard:

![Create Snapshot Wizard](image)

**Figure 4: Create Snapshot Wizard**

### HOST WRITES TO SOURCE

Host writes to source volumes create snapshot deltas in the SRP. Snapshot deltas are the original point-in-time version of each track that has been updated since a snapshot was established. Multiple snapshots can share a single snapshot delta if all are active at the time a source track was updated. So, if a source track that is being updated needs to be preserved by multiple snapshots, only one snapshot delta is needed. This sharing allows the snapshots to be as space-efficient as possible.

The output of command `symsnapvx list -detail` and other commands report the amount of deltas for each snapshot. The `symsnapvx list -detail` output also has a “Non-Shared Tracks” field that provides the number of tracks uniquely allocated to each snapshot. This information is valuable because it can be used to determine which snapshots are using the most non-shared space and are most beneficial to terminate in the event of needing to free some space in the SRP. Only non-shared space is freed from the SRP when a snapshot is terminated.

### REDIRECT-ON-WRITE

SnapVX introduces Redirect-On-Write (ROW) technology to TimeFinder. When a source track is written to and the original data needs to be preserved for a snapshot(s), the new write is accepted and asynchronously written to a new location in the Storage Resource Pool (SRP). The source volume now points to the new data while the snapshot(s) continue to point to the original data (the snapshot delta) in its original location.

Redirect-On-Write is illustrated in the following figures. Figure 5 shows the source volume and snapshot both pointing to the same location in the pool before the track is updated.
SnapVX uses Asynchronous Copy on First Write (ACOFW) rather than ROW in certain situations, specifically to prevent the new write from being directed to a lower tier. For example, if the original track resides on the Flash Drive tier, it may be copied to a lower technology drive to allow the new write to be applied to the original location on the Flash tier. In all flash SRPs ROW is most likely to be used exclusively.

**REPLICATION CACHE**

A portion of the metadata in cache is dedicated for Replication Data Pointers (RDP) which keep track of the snapshot deltas in the SRP. This portion of metadata is called Replication Cache. If Replication Cache is exhausted, snapshots may begin to fail.

Replication Cache is used by SnapVX snapshots and VP Snap Emulation sessions. Replication Cache usage increases as SnapVX and VP Snap source devices are written to, as there is more point-in-time data to manage. SnapVX Linked Targets and Clone Emulation sessions do not have an effect on Replication Cache usage.

It is important to understand that Replication Cache resources are not immediately released upon snapshot termination. The process may take some time as it is designed as a background process so to not take away processing resources from other higher priority operations within the array. Therefore, current Replication Cache usage should be checked before creating new snapshots immediately after terminating existing snapshots.

All systems follow the same algorithm to determine the percentage of metadata to dedicate to Replication Cache. Systems that have very high snapshot usage may be candidates to have the Replication Cache portion of metadata increased. However, this is not a typical use case. In the large majority of systems, the standard algorithm provides enough Replication Cache for the environment. Contact your local Dell EMC Service Representative if you feel your environment requires increased Replication Cache.

**MONITORING REPLICATION CACHE USAGE**

Solutions Enabler 8.2 and Unisphere for VMAX 8.2 introduced tools to monitor Replication Cache Usage. These tools are only available when used with systems running the HYPERMAX OS 2016 Q1 Service Release or later. The information described below is also available in REST API beginning with version 8.3.

The `symcfg list -v` output has a field that shows the current Replication Cache usage, as shown in Figure 7:
Figure 7: `symcfg list -v`

Solutions Enabler 8.2 also provides a new alert ID 1222 to report when Replication Cache usage has exceeded the specified thresholds. The default threshold values are the same as the default values for other Solutions Enabler thresholds alerts. The user also has the ability to specify other values. However, the alerts are not enabled by default, and need to be enabled by the user. The default threshold values are as follows:

- **FATAL severity = 100%**
- **CRITICAL severity >= 80%**
- **MAJOR severity >= 70%**
- **MINOR severity >= 65%**
- **WARNING severity >= 60%**

Unisphere for VMAX reports Replication Cache usage on the summary page of the Data Protection Dashboard as shown in Figure 8:

Alerts are also available in Unisphere for VMAX 8.2. The System Alerts have the following threshold values and are enabled by default:

- **FATAL severity = 100%**
- **CRITICAL severity >= 80%**
- **Warning severity >= 60%**
Users can also create custom alerts with their own threshold values:

Beginning with Unisphere for VMAX 8.4 the Performance Dashboard gives a graphical view of Replication Meta Data Usage as shown in Figure 11.
SHARED ALLOCATIONS

VP Snap in Enginuity 5876 introduced back-end allocation sharing between VP Snap target volumes; multiple snapshots from a source volume can share point-in-time versions of a track. A back-end allocation could be shared by up to 16 VP Snaps. Allowing multiple targets to reference the same shared copy provides cost-effective space savings. Shared track values on thin pools could be seen with Solutions Enabler and Unisphere for VMAX.

SnapVX in HYPERMAX OS 5977 greatly enhances this shared allocation capability. A snapshot delta can be shared between snapshots and shared with target volumes, and a source allocation can be shared with target volumes. And there is no limit to the amount of volumes that can share a particular allocation.

Sharing of a snapshot delta between snapshots is similar to that of VP Snap in Enginuity 5876; when a source write arrives and the original track needs to be preserved as a snapshot delta for multiple snapshots, only a single snapshot delta needs creating.

However, nocopy linked targets begin to share tracks with the source volume and/or share snapshot deltas for the specific point-in-time as part of the defining process, which is discussed on page 12. The targets are added to sharing at the time of link, independent of source track updates.

If a source track that is being shared with a target (or multiple targets) is updated, the existing track is preserved as a snapshot delta and continues to be shared with the target(s).

Writes to a target are applied only to the specific target. If the write is to a track that is being shared then the track for the specific target is split from the shared group, and any other snapshots and/or targets continue to share the original shared track.

Reporting of shared track counts on pools or SRPs by Solutions Enabler or Unisphere for VMAX is not applicable in HYPERMAX OS 5977. However, some Solutions Enabler displays report shared track counts on pools for backwards compatibility with older arrays.

Solutions Enabler instances and Unisphere for VMAX report the non-shared track count on each snapshot. The non-shared count is the most important value because non-shared snapshot deltas are discarded when the snapshot is terminated, which frees space in the SRP.

Note: See Appendix D for changes to the nocopy target functionality beginning in the HYPERMAX OS Q1 2016 Service Release.

LINKING TARGET VOLUMES TO SNAPSHOTS

A target volume can be linked to a snapshot when a user wants to present a point-in-time copy to a host. Multiple targets can be linked to a single snapshot. Writing to a linked target does not affect the point-in-time of the snapshot; should the data on the linked target be corrupted by the user activity the target can be relinked to the original snapshot. Figure 12 depicts a source volume with three snapshots, and a target linked to the 3rd snapshot.

Figure 12: Production volume with three targetless snapshots and one Linked Target
Targets can be linked in either copy mode to create full-volume copies that remain available even after a snapshot is terminated, or in nocopy mode to create space-saving copies that only allocate space due to host writes to the target. Host writes to a source volume that has a snapshot with a target linked in nocopy mode only preserve point-in-time tracks as snapshot deltas, and do not cause any tracks to be copied to the linked target. The linked targets access the preserved point-in-time by sharing the snapshot delta allocation.

Snapshots that have linked targets cannot be terminated. The user needs to unlink the target first and then terminate the snapshot.

Linked targets can be SRDF R1 volumes, as long as the link command is in copy mode.

RELINKING
The relink command provides the capability to perform incremental refreshes of linked targets. The relink command can also be used to link a target to a different snapshot of the same source volume. The relink command can be issued to both copy and nocopy mode linked targets. This functionality provides an easy way for users to check different points-in-time if they are unsure which one is the best for them to access.

Note: Just like the link command, relink is in nocopy mode by default unless the user specifies -copy, regardless of the mode of the original link.

UNLINKING
The unlink command breaks the relationship between a snapshot and a linked target. Copy mode linked targets can be unlinked once copying is complete and retain a full, useable point-in-time copy of the source volume.

After a nocopy linked target has been unlinked, the target data should not be considered valid since a considerable amount of the data may not be associated with the point-in-time\(^1\). However, the unlink operation does not deallocate any data on the target. This includes data that was copied during the link operation as well as data that was directly written to the target. Therefore, an unlink operation does not return any free capacity to the SRP.

If the user wants to deallocate the data on the target(s) after unlink, they can do so by issuing the symdev free -all command to the target volume.

Please note that this is a powerful command that completely deallocates all data on the volumes that it is issued against. Extreme care must be taken when using this command. As a safety mechanism, the free -all command requires the device to be not ready or unmapped.

\(^1\)See Appendix D for changes to the nocopy target functionality beginning in the HYPERMAX OS Q1 2016 Service Release.

A target volume that has cascaded snapshots can only be unlinked once the target has completely copied. In the case of a nocopy linked target that has cascaded snapshot(s), the user needs to set mode to copy, then unlink after copy has completed\(^2\). Cascaded snapshots are discussed further on page 14.

\(^2\)Note: This restriction has been removed in the HYPERMAX OS Q1 2016 Service Release. Beginning with this version of HYPERMAX OS and going forward, users can unlink nocopy targets that have dependent/cascaded snapshots.

DEFINING STATE
SnapVX introduces a new concept of a “defined” state for linked target tracks. Defining may aid performance of host access of target tracks that have not yet been copied to target by presenting data directly from the SRP and eliminating the need for a redirect to source or snapshot.

The point-in-time of a snapshot is immediately available through the target volume as soon as it is linked. However, its track tables still point to its old track locations and all tracks are considered “undefined.” Shortly after linking, a background defining process changes the pointers of each track to reflect the location of the appropriate track version for the specific point-in-time. The defining process is what creates shared allocations between the target and tracks on source and/or snapshot deltas.

Figure 13 illustrates the defining process. The target is linked to snapshot 2. The first two tracks on the linked target volume have been defined and point directly to the data in the SRP. The last two tracks on the linked target volume have not yet been defined and are still pointing to the snapshot.
Note: An undefined track could point to a track on source rather than snapshot if that is the appropriate version of the track for the specific point-in-time represented by that snapshot.

Figure 13: Defined and undefined track states

Defining applies to both copy mode and nocopy mode linked targets. In the case of copy mode linked targets the defining process and copy process run concurrently on the linked target but each track will be defined before copying.

The point-in-time of the snapshot is immediately available when the target is linked. The user does not need to wait for the target volume to be defined before accessing the point-in-time. A write to an undefined target track will invoke the defining process for the track. And a read to an undefined target track will be redirected to the appropriate point-in-time version of the track via either the snapshot or the source volume.

The user can check for the defined state of a linked target with the following command:

symsnapvx -sid verify -sg -snapshot_name -linked -defined

LINKING LARGER TARGET

A target volume that is larger than the source volume can be linked to the snapshot in either copy or nocopy mode. This functionality is enabled by default. There is an environmental variable SYMCLI_SNAPVX_LARGER_TGT that can be set to prevent larger targets from being used.

SOURCE VOLUMES / LINKED TARGETS SRP RELATIONSHIPS

Source volumes and linked targets can be associated either to the same or separate SRPs. Single SRP systems are recommended because they are easier to manage and performance may be better when spreading workloads across all available resources in the array. Also, the Reserved Capacity setting in HYPERMAX OS (described on Page 15) allows the user to limit the amount of storage in the SRP that the replicas can consume, eliminating the need to physically separate production volumes and their replicas (snaps and clones).

Note: SRP count and configuration need to be specified during the system ordering process.

Snapshot deltas will always be stored in the source volume’s SRP. There is no advantage to having nocopy linked targets in a separate SRP because writes to a source volume will only create snapshot deltas and will not initiate a copy to target.

If opting for a separate SRP for copy mode linked targets, the target SRP must have enough disks to support the expected capacity and performance requirements of the target volumes.

A single snapshot can have both copy and nocopy linked targets. All linked targets from a single snapshot do not need to be in the same SRP. Source volumes and linked targets (copy and nocopy modes) can be moved between SRPs while TimeFinder sessions are active; FAST will move allocations accordingly.
RESTORE OPERATIONS

Snapshots can be restored directly to the source volume(s) via the `symsnapvx restore` command or via Unisphere for VMAX. The `symsnapvx terminate -restored` command will terminate the restored session only and will not break the source-to-snapshot relationship. Restoring from a snapshot to source will not affect the point-in-time of any other snapshots or linked targets.

Restoring from a linked target back to a source is functionally possible although it is not done with a restore command. Instead, the user would take a snapshot of a linked target, which will essentially create a cascaded scenario, discussed further in the following section. The user could then use the original source volume as a linked target to the cascaded snapshot. Cascaded snapshots are discussed further in the following section.

CASCADING SNAPSHOTS

Cascading refers to taking a snapshot of a linked target, and also to linking a target to a snapshot of a linked target. All tracks on a target volume must be defined before a snapshot can be taken of the target volume.

Figure 14 illustrates one example of cascaded SnapVX sessions.

![Cascading snapshots and linked targets](image)

The cascading capabilities of SnapVX are very robust. However, it is important to note that some historical reasons for cascading clone or snap sessions may not exist with SnapVX.

Since point-in-time data for SnapVX snapshots is stored in the SRP and cannot be directly accessed by the host, the point-in-time of the snapshot is always pristine, and there is no need to make a “Gold Copy” clone to cascade from. Even if a target is linked to the snapshot and written to, the point-in-time of the snapshot will not change. This reduces the amount of full volume copies that are required in most use cases making SnapVX very space efficient.

Furthermore, the defining mechanism allows reads to tracks that do not reside on the target volume to be serviced directly from the SRP and not redirected to the source volume as would be the case with traditional snaps or clones. This not only improves performance of the read but also reduces the possibility of target reads affecting performance of the source volume.

Cascaded SnapVX sessions are supported with the following considerations:

- There is no limit on the amount of cascaded hops that are allowed.
- A snapshot of a linked target is only allowed once the linked target is in either the defined or copied state.
- A cascaded snapshot can only restore to a linked target that is in copy mode and has fully copied.
- The cascaded chain can be broken at any point by unlinking the target from the snapshot with the following rules:
- A snapshot that has a linked target cannot be terminated.
- A linked target that has a cascaded snapshot must be in copy mode and fully copied before it can be unlinked.

Note: This restriction has been removed in the HYPERMAX OS Q1 2016 Service Release. Beginning with this version of HYPERMAX OS and going forward, users can unlink nocopy targets that have dependent/cascaded snapshots.

**RESERVED CAPACITY**

Reserved Capacity is a percentage of the SRP that can only be consumed by new host writes. Existing and new snapshots will be affected if the Free Capacity of the SRP falls below the set Reserved Capacity. The following commands can be used to view and change the values:

- `symcfg list -srp -v`
- `symconfigure -sid <sid> -cmd "set srp <srp_name> resv_cap=<value>";" commit`

Valid values for Reserved Capacity percentage are from 1% to 80%, and NONE.

As an example, if the reserved capacity on an SRP is set to 10% and the SRP becomes 90% full with volume allocations, snapshot deltas, and SRDF Delta Set Extension allocations, then only new host writes can consume the last free 10% of the SRP.

When only Reserved Capacity is available in an SRP, a snapshot will fail at the next attempt to create a new snapshot delta, and the snapshot will need to be terminated. VP Snap and Clone Nocopy Emulation Mode sessions will also fail at the next write that requires a source track to be copied to target.

Copy to targets will halt and will not be able to complete. This includes SnapVX linked targets, Clone copy mode sessions, and TimeFinder Mirror BCVs. Copy will resume if free space is made available in the SRP, or if the Reserved Capacity value is lowered to a sufficient value.

The Reserved Capacity only affects the TimeFinder copy process. Host reads and writes to the targets will still be possible.

**INTEROPERABILITY**

TimeFinder SnapVX is interoperable with other HYPERMAX OS features under the following conditions:

**SRDF**
- Snapshots can be taken from R1 and R2 volumes in all SRDF modes (SRDF/S, SRDF/A, and SRDF/Metro)
- Write-pacing is not required when taking snapshots from SRDF/A R2 volumes
- Linked targets in copy mode can be SRDF source volumes

**FAST**
- Allocations owned by a source volume will be managed by the Service Level Objective of the source volumes Storage Group
- Allocations owned by a target volume will be managed by the Service Level Objective of the target volumes Storage Group
- Snapshot deltas will be managed by the Optimized Service Level Objective
- Read miss I/Os to target tracks that are owned by the source volume will increment the FAST metrics for the source volume, not the target volume, and may contribute to the extent being promoted
- Source and target volumes can be moved across SRPs while TimeFinder sessions are active

**ZERO SPACE RECLAIM**
- Zero space reclaim is supported on SnapVX source and target volumes.
PERSISTENT ALLOCATIONS
Persistent Allocations are tracks that are unaffected by a standard reclaim operation. The user can mark and unmark tracks as persistent with the Solutions Enabler symdev or symsg commands, and with Unisphere for VMAX.

The considerations for Persistent Allocations with SnapVX are as follows:

- Snapshots can be taken of a volume that has Persistent Allocations. However, restores from a snapshot will be blocked if the source volume has any Persistent Allocations. The user will need to remove the Persistent Allocations from the entire volume in order to allow the restore operation. Persistent Allocations can be reset on the source volume once the restore session is terminated.

- Volumes with persistent allocations cannot be used as linked targets. Likewise, persistent allocations cannot be set on linked targets.

NON-DISRUPTIVE MIGRATION
Non-disruptive Migration was introduced in the HYPERMAX OS Q3 2016 Service Release. For more in-depth info, please see the VMAX Non-Disruptive Migration Configuration and Best Practices Technical Notes, available on EMC.com

- Existing TimeFinder sessions from an NDM device can remain in place during the migration.

- New replication from an NDM device can be configured during a specific point in the migration process.

- An NDM device, source or target, cannot be the target of a TimeFinder session.

- The TimeFinder session cannot restore data back to the NDM device at any time during the migration session.

INLINE COMPRESSION
Inline Compression was introduced in the HYPERMAX OS Q3 2016 Service Release. For more in-depth info on Compression please see the Compression Tech Note available on EMC.com

Nocopy Sessions (SnapVX, VP Snap)
Uncompressed source data will remain uncompressed when becoming snapshot data, and may be compressed later as it becomes less active. However, read activity to a snapshot through a linked target may prevent uncompressed snapshot data from being compressed. Similarly, compressed source data will remain compressed when becoming snapshot data. However, read activity to a snapshot through a linked target may cause compressed snapshot data to be decompressed.

The compression setting of a linked target will only affect data written directly to the linked target and will not affect the snapshot data.

Copy Sessions (SnapVX Full Copy Linked Targets, Clone, Mirror)
The compression settings for both the source and the target are taken into account for copy sessions.

When compression is enabled on the source the data will be decompressed before copying to the target. When compression is enabled on the target the data will be compressed before allocation for the target. Likewise, when compression is enabled on both the source and the target the data will be decompressed before the copy and then compressed again to allocate for target.

Copy times may vary due to decompression and compression of the data. It is not recommended to change the compression settings in between differential operations (i.e. disabling compression before each differential operation and then enabling again after the copy completes) as this will cause data to go through needless compression/decompression cycles.

STORAGE GROUP OPERATIONS
SnapVX has the ability to perform operations on entire Storage Groups (SGs). This reduces complexity by eliminating the need for users to create separate device files, device groups or composite groups for replication. Those options are still available in Solutions Enabler. The storage group option is the only option for SnapVX in Unisphere for VMAX. This document will focus on the storage group option in the following implementation section.
When creating snapshots with the `symsnapvx establish` command, the `-sg` switch is used to specify the source SG, and one snapshot of the same name will be created for each volume in the SG. If for some reason a snapshot cannot be created for one of the volumes in the SG, the entire operation will fail and no snapshots will be created.

When linking target volumes to a snapshot with the `symsnapvx link` command, the `-lns` switch is used to specify the entire target SG to link. Similar to the `establish` command, if any volume in the SG cannot be linked for some reason, the entire operation will fail and no volumes will be linked. Unisphere for VMAX also has an option that will create a new SG and appropriate volumes for the user, which will be shown later.

In the case of cascaded storage groups, a `symsnapvx` command issued to a parent storage group will be applied to all child storage groups.

Note: Solutions Enabler continues support of Composite Groups (-cg), Device Groups (-g) and Device Files (-f) options.

Composite Groups provide the ability to take consistent snapshots across a set of devices that span multiple arrays.

SnapVX also introduces the `-devs` option, a new method to specify device range within the command line.

**EXPANDING STORAGE GROUPS WITH ACTIVE SNAPSHOTS**

SnapVX is designed to replicate entire applications that are configured on volumes contained in an entire SG. It is possible to add volumes to an SG that has active snapshots. The new volumes will be included the next time a snapshot is taken. However, the volumes will not be included in previously existing snapshots.

If an SG is restored from snapshots that do not include the new volumes, the SG will be taken back to a point-in-time when the new volumes did not exist. Therefore, these new volumes in the SG should not be presented to the application and will be set to Not Ready. The volumes will remain Not Ready after the restored session is terminated and the user will need to determine the best course of action to reintroduce the new volumes to the SG. The volumes will automatically become ready again if the user decides to restore from snapshots that include these volumes.

Similar action is taken for using SGs that have been expanded as linked targets. If the SG that is being used as the linked target contains more volumes than are included in the specified snapshot, the extra volumes will be set to Not Ready and will not be included in the point-in-time image. The user will need to determine the best course of action to remove or reintroduce the extra volumes. And if the SG is linked to another snapshot that contains all of the volumes in the SG, the volumes will automatically be made ready and will be included in the session.

**SECURE SNAPS**

Secure snaps is an optional setting for SnapVX targetless snapshots that prevent a user from deleting snapshots accidentally or intentionally. Secure snaps are available beginning with the HYPERMAX OS Q2 2017 Release using Solutions Enabler 8.4, Unisphere for VMAX 8.4, and REST API 8.4.

Secure snaps allow the user to set a retention period on snapshots. No user will be allowed to terminate the secure snap during the retention period. Attempts to terminate a secure snap prior to the retention date will be rejected. When the retention time is reached the snapshot is automatically terminated.

Users may extend a retention period in situations where a snapshot is needed longer than originally planned, but reducing a retention period is not allowed. A traditional snapshot may be converted to a secure snap, but a secure snap may not be converted to a traditional snapshot. All SnapVX operations and rules for traditional snapshots regarding restores, linked target operations, and automatic expiration also apply to secure snaps. If a secure snap has any linked targets or restored sessions when the expiration date is reached the snapshot will not terminate until the targets are unlinked and/or the restored session is terminated.

When implementing secure snaps a user should determine how many snapshots on an array must be secure. Users should consider using secure snaps only on certain critical volumes, or only on a subset of the snapshots to capture particular points-in-time that are critical to the business, and for how long the secure snaps should be retained. As always, proper planning and system sizing is crucial, no matter the types or number of snapshots that will exist in an environment.

The CLI format of the retention period is the same as that of the traditional expiration date. The traditional expiration date and secure retention period cannot be used together on a single snapshot.
The following is the Solutions Enabler command structure along with an example of setting a snapshot to secure for one day and 12 hours:

```
symsnapvx -sg <sg> -name <snapshot_name> establish -secure <-delta | absolute>
symsnapvx -sg prod_sg -name daily_8am_snap establish -secure -delta 1:12
```

Figure 15 shows how to create secure snaps with the Unisphere for VMAX snapshot wizard:

![Figure 15: Creating secure snaps in Unisphere for VMAX](image)

**SECURE SNAP COMPARISONS TO TRADITIONAL SNAPSHECTS**

Secure snaps are intended for use in environments where protecting specific point-in-time images are considered the highest priority and therefore exhibit several behavioral differences compared to traditional snapshots. For example, if the system is reaching Replication Cache or SRP resource limits the user will not be able to terminate secure snaps to help remediate the situation as can be done with traditional snapshots.

Secure snaps are also unique in the handling of host writes and snapshots when SRP or Replication Cache limits are reached. When Reserved Capacity of an SRP is reached and a host write to a source volume requires a new allocation in the SRP an existing traditional snapshot will be placed into a failed state. However, secure snaps will be allowed to grow past the Reserved Capacity limit of the SRP. New secure snaps cannot be created once Reserved Capacity is reached.

Preserving the secure snaps will also take priority over host writes to those source volumes in the event the entire SRP runs out of available capacity. This is the intent of the feature. For example, if there is an intentional attack or a runaway application on a system that consuming all of the available capacity, preserving the secure snaps allows the user to restore from the secure snaps once the situation is resolved.

Note: Secure snapshots may only be terminated after they expire or by customer-authorized EMC support. Please refer to Dell EMC Knowledgebase article 498316 for additional information: [https://support.emc.com/kb/498316](https://support.emc.com/kb/498316)
IMPLEMENTING TIMEFINDER SNAPVX

CREATING SNAPSHOTS

```bash
$ symsnapvx -sid XYZ -nop -sg snapsource establish -name hourlysnap -ttl -delta 2
```

Establish operation execution is in progress for the storage group snapsource. Please wait.

Polling for Establish .................................................. Started.
Polling for Establish .................................................. Done.
Polling for Activate .................................................... Started.
Polling for Activate .................................................... Done.

Establish operation successfully executed for the storage group snapsource.

Creating a snapshot called hourlysnap and keeping for 2 days

Figure 16: Creating snapshots with Solutions Enabler

![Creating snapshots with Solutions Enabler](image)

Figure 17: Creating snapshot with Unisphere for VMAX

![Creating snapshot with Unisphere for VMAX](image)

Figure 18 shows there are 4 generations of snap from the storage group snapsource, and Figure 19 shows a more detailed view giving more information including the each snapshot was taken and expiration date if one was set on creation.

```bash
$ symsnapvx -sid XYZ list -sg snapsource
```

<table>
<thead>
<tr>
<th>Storage Group</th>
<th>Capacity (GB)</th>
<th>Snapshots</th>
<th>Last Creation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>snapsource</td>
<td>500</td>
<td>5</td>
<td>5 Sep 29, 2014 10:09:04 AM</td>
</tr>
</tbody>
</table>

![Snapshots](image)

Flgs:
(F)ailed : X = Failed, . = No Failure
(L)ink : X = Link Exists, . = No Link Exists
(R)estore : X = Restore Active, . = No Restore Active
(G)CM : X = GCM, . = Non-GCM

Figure 18: symsnapvx list -sg <sg_name>
### Figure 19: `symsnapvx -sid XYZ list -sg snapsource -detail`

<table>
<thead>
<tr>
<th>Sym</th>
<th>Dev</th>
<th>Snapshot Name</th>
<th>Gen</th>
<th>FLRG</th>
<th>Snapshot Timestamp</th>
<th>Total Deltas (Tracks)</th>
<th>Non-Shared Deltas (Tracks)</th>
<th>Expiration Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>00040</td>
<td>hourlysnap</td>
<td>0 .... Mon Sep 29 11:00:00 2014</td>
<td>62371</td>
<td>25848</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00041</td>
<td>hourlysnap</td>
<td>1 .... Mon Sep 29 10:00:00 2014</td>
<td>62389</td>
<td>25866</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00042</td>
<td>hourlysnap</td>
<td>2 .... Mon Sep 29 09:00:00 2014</td>
<td>62389</td>
<td>5120 Thu Oct 31 10:13:55 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00043</td>
<td>hourlysnap</td>
<td>3 .... Mon Sep 29 08:00:00 2014</td>
<td>62389</td>
<td>5120 Wed Oct 22 10:11:58 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00041</td>
<td>hourlysnap</td>
<td>0 .... Mon Sep 29 11:00:00 2014</td>
<td>62379</td>
<td>25866</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00042</td>
<td>hourlysnap</td>
<td>1 .... Mon Sep 29 10:00:00 2014</td>
<td>62389</td>
<td>25866</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00043</td>
<td>hourlysnap</td>
<td>2 .... Mon Sep 29 09:00:00 2014</td>
<td>62389</td>
<td>5120 Thu Oct 31 10:13:55 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00044</td>
<td>hourlysnap</td>
<td>3 .... Mon Sep 29 08:00:00 2014</td>
<td>62389</td>
<td>5120 Wed Oct 22 10:11:58 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- **(F)**ailed: X = Failed, . = No Failure
- **(L)**ink: X = Link Exists, . = No Link Exists
- **(R)**estore: X = Restore Active, . = No Restore Active
- **(G)**CM: X = GCM, . = Non-GCM

**Note:** See Appendix B for information on the GCM Flag

---

**Figure 20: Viewing snapshots with Unisphere for VMAX**

**LINKING, RELINKING, UNLINKING**

To access a point in time copy, a host mapped target volume is linked to the snapshot data. The links may be created in Copy mode for a permanent copy of the target volume, or in Nocopy mode for temporary use.

Copy mode links create full-volume clones of the data. Nocopy mode links are space saving snapshots that only consume space when host data is written directly to the target volume. Both modes are allowed to be in either the same or separate SRP as the source volume.
Figure 21 shows the CLI commands for linking to a snapshot, note that a generation number was specified. If no generation is specified the most recent snapshot for the snapshot name provided will automatically be selected.

Note: Please see Appendix C for information on monitoring the copy process to copy mode linked targets.

When linking snapshots via Unisphere for VMAX, the user is presented with existing SGs to select for the targets. Unisphere for VMAX can also create a new SG with the appropriate volumes and perform the link operation from one simple wizard, as seen in Figure 22.

Should the user need to transition to a different snapshot copy using the same set of source and target volumes a relink operation can be performed linking to a different snapshot or a different generation of the same snapshot. Users should unmount any target volumes from the mount host and remount after relink to ensure that the data the host sees is correct. Figure 23 shows the relink process with Solutions Enabler and Figure 24 shows the relink process in Unisphere for VMAX.
HYPERMAX OS supports up to 1,024 linked targets per source volume.

At any time the target volume can be unlinked from the snap copy, if the link was created with the copy mode and state transitioned to a copied state the target volumes will be an independent copy of the source.

Independent copies that are no longer required can be reused as linked targets in the future providing there are no snapshots cascaded off these volumes. If the space used by linked copies needs to be returned to the SRP the user can run the ‘symdev free –all’ command to return this space to the system for global use.

Note: It is important to understand that the ‘symdev free –all’ command provides the user with the ability to wipe a volume of all data. The command should be used with caution and only by knowledgeable administrators.

RESTORING FROM SNAPS

It is possible to restore from any point in time snapshot that is available in the array. Figure 25 shows how to restore from a snapshot to the production volume using the CLI commands. It is recommended to unmount the production volume prior to issuing the restore operation and remount after to ensure that the host sees the correct data. Users can determine which snapshot to use by verifying the data through a linked target with the link/relink commands.

Note that Figure 25 above shows the command line option restoring from generation 2 of a snapshot to the source volume.
EMULATION SUPPORT FOR TIMEFINDER MIRROR, CLONE, AND VP SNAP

SnapVX provides emulation modes for TimeFinder Mirror, Clone, and VP Snap. This allows the user to issue legacy TimeFinder commands when in reality SnapVX sessions are created in the background. The sessions will appear to be legacy TimeFinder sessions to the user. A single source volume cannot have both SnapVX and Emulation sessions at the same time.

Solutions Enabler and Unisphere for VMAX steps to create sessions are exactly the same as in the latest versions of Enginuity 5876, and the sessions will follow all feature restrictions from Enginuity 5876, including session counts, cascaded hop limits, and requiring source-target pairing. Emulation sessions cannot take advantage of Storage Group operations (–sg option). Emulation sessions will copy data directly from source to target without using snapshot deltas.

Emulation mode target volumes can be moved between SRPs while sessions are active.

TIMEFINDER VP SNAP EMULATION

VP Snap control commands at 5977 are exactly the same as 5876, enabling users to use their existing VMAX VP Snap scripts on HYPERMAX OS. However, there are several behavioral differences that need to be understood when preparing volumes and monitoring sessions. The following behaviors apply to VP Snap in HYPERMAX OS:

- All VP Snap target volumes from a specific source do not need to be associated to the same SRP.
- VP Snap target volumes can be moved across SRPs while sessions are active. Non-shared allocations will be moved.
- As source tracks are updated, the Protected Track counts will not decrement.
- As source tracks are updated when the session is active, the preserved point-in-time tracks for the VP Snap emulation sessions will be stored in the SRP of the source volume, even if the target volume is in a different SRP. Only changed tracks on the target volume are stored in the target SRP.
- Shared allocation counts in Solution Enabler and Unisphere for VMAX do not apply due to the way that shared allocations are handled in HYPERMAX OS. These counters will always show zero.
- VP Snap target volumes will not be deallocated when the sessions are terminated. If the target volume is in a separate SRP from the source volume, any allocations that reside in the source SRP after terminate will be relocated to the target SRP by a FAST compliance move.

Note: See Appendix C for information on monitoring the copy process of Mirror and Clone emulation sessions.

TIMEFINDER SNAP DEPRECIATION

TimeFinder Snap is not available with HYPERMAX OS for open systems. Dell EMC offers services for TimeFinder Snap users that would like help converting to SnapVX on HYPERMAX OS. Please contact your local account team for more information.

CONCLUSION

TimeFinder SnapVX provides new functionality and combines the benefits of the TimeFinder Clone, Mirror, and VP Snap into one easy-to-use software feature.

SnapVX allows the user to create snapshots without the need for a target volume. Snapshots can then be used to link to target volumes in either full-copy or nocopy mode which can then be presented to the host server. SnapVX allows for far greater scalability than previous TimeFinder offerings, with up to 256 snapshots per source volume and 1024 linked target volumes per source volume. SnapVX also introduces the ability to take snapshots on a Storage Group level, and uses advanced redirect-on-write technology.

SnapVX is compatible with many other HYPERMAX OS features. And along with all of the new functionality that is provided, users can also run emulations of TimeFinder Mirror, Clone, and VP Snap which will use SnapVX technology in the background, completely transparent to the user until ready to make the switch and take full advantage of SnapVX.
REFERENCES
Reference information and product documentation can be found at support.EMC.com including:

- Dell EMC VMAX All Flash Product Guide for VMAX 450F, 450FX, 850F, 850FX, 950F, 950FX with HYPERMAX OS
- Dell EMC VMAX3 Family with HYPERMAX OS Product Guide
- Dell EMC Solutions Enabler TimeFinder SnapVX CLI User Guide
- Dell EMC Solutions Enabler TimeFinder Family CLI User Guide
- Dell EMC VMAX3 Family Feature Overview
- Dell EMC VMAX3 Service Level Provisioning with Fully Automated Storage Tiering (FAST)
- VMAX Non-Disruptive Migration Configuration and Best Practices Technical Notes
## TIMEFINDER SNAPVX STATE TABLE

Table 1 describes prerequisites, transient states, and final states for all controls:

<table>
<thead>
<tr>
<th>Action</th>
<th>Prerequisite</th>
<th>Transient State</th>
<th>Final State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish</td>
<td>None</td>
<td>Establish In Progress</td>
<td>Established</td>
</tr>
<tr>
<td>Restore</td>
<td>Established</td>
<td>Restore In Progress</td>
<td>Restored</td>
</tr>
<tr>
<td></td>
<td>If the source device is a link target, must be fully copied.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminate</td>
<td>Established</td>
<td>Terminate In Progress</td>
<td>NA</td>
</tr>
<tr>
<td>Terminate with FLAG1_RESTORED</td>
<td>Restored</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Setmode Copy</td>
<td>Linked NoCopy</td>
<td>Link Copy In Progress</td>
<td>Link Copied</td>
</tr>
<tr>
<td>Setmode NoCopy</td>
<td>Link Copy In Progress or Link Copied</td>
<td>NA</td>
<td>Linked</td>
</tr>
<tr>
<td>Set TTL</td>
<td>Established with no links or restores.</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Link</td>
<td>Established</td>
<td>NA</td>
<td>Linked</td>
</tr>
<tr>
<td>Link with FLAG1_COPY</td>
<td>Established</td>
<td>Link Copy In Progress</td>
<td>Link Copied</td>
</tr>
<tr>
<td>Unlink</td>
<td>Linked or Link Copied</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>If the target is the source of another snapshot, the link must be fully copied.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relink</td>
<td>Linked or Link Copied</td>
<td>NA</td>
<td>Linked</td>
</tr>
<tr>
<td>Relink with FLAG1_COPY</td>
<td>Linked or Link Copied</td>
<td>Link Copy In Progress</td>
<td>Link Copied</td>
</tr>
<tr>
<td>Rename</td>
<td>Established</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
APPENDIX B

GEOMETRY COMPATIBILITY MODE (GCM)

One of the architectural changes in HYPERMAX OS 5977 compared to Enginuity 5876 is the doubling of track size, from 64K to 128K. Therefore, an array running HYPERMAX OS cannot create a device that is exactly the same size as a device with an odd number of cylinders on an array running Enginuity 5876. In order to support the full functionality, SRDF requires that R1 and R2 devices in a device pair be same size and TimeFinder requires that source and target devices are the same size.

HYPERMAX OS introduces a new device attribute, Geometry Compatible Mode (GCM). A device with GCM set is treated as half a cylinder smaller than its true configured size so the device will be treated as the same size as an Enginuity 5876 device with an odd number of cylinders, thus enabling full functionality between HYPERMAX OS and Enginuity 5876 for SRDF, TimeFinder SnapVX, and TimeFinder emulations, and ORS.

The GCM attribute can only be set for devices on arrays running HYPERMAX OS. The attribute can be set manually or automatically as part of an operation that creates a local or remote replication relationship.

- The `symdev set/unset, symdg set/unset, symcg set/unset, and symsg set/unset` commands have been enhanced with a new option `-gcm` to set and unset GCM for a device or group.

- The `symdev show, symdev list -v, symdg show ld, symdg list ld -v, sympd show, and sympd list -v` commands have been enhanced to report the GCM attribute.

- The `symrdf createpair` command has been enhanced to transparently set/unset the GCM attribute as part of the create pair operation, as follows:
  - Set the GCM attribute for a target device that is configured ½ a cylinder larger. The source of the copy can be:
    - A device on an array running Enginuity 5876 with an odd number of cylinders and capacity that matches the GCM size of the device.
    - A GCM device on an array running HYPERMAX OS.
  - Unset the GCM attribute for a target device that is configured the exact same size as the source of the copy. The source of the copy can be:
    - A device on an array running Enginuity 5876 with even number of the cylinders and capacity that matches the size of the device on the array running HYPERMAX OS.
    - A device on the array running HYPERMAX OS without the GCM attribute.

OPEN REPLICATOR FOR SYMMETRIX (ORS)

The ORS create operation will be modified to use the GCM size when establishing a push or pull session to the remote target.

TIMEFINDER SNAPVX

If a SnapVX snapshot is created from a GCM device, then the resulting snapshot will also be given the GCM attribute and this will be reported as an attribute of the snapshot.

A SnapVX link operation will change the GCM attribute on the link target device to match the GCM setting of the snapshot.

TIMEFINDER CLONE AND VP SNAP

Create, full establish, or full restore operations between a GCM device and a non-GCM device will result in the device that is the target of the data copy having it’s GCM attribute changed to match the GCM attribute setting of the device that is the source of the data copy.

When the source and target devices are the same physical size, and the source of a clone session is a GCM device and the target device is not, then the Clone to Larger Target rules will be enforced.
**TIMEFINDER MIRROR**

Full establish and full restore operations between a GCM device and a non-GCM device will result in the device that is the target of the data copy having it’s GCM attribute changed to match the GCM attribute setting of the device that is the source of the data copy.

**APPENDIX C**

**MONITORING THE COPY PROCESS**

When monitoring the copy process to a full copy linked target, the number of tracks remaining to copy are determined by a sum of multiple internal counters, capped at the maximum size of the volume. If the sum of these values exceeds the size of the device, then it may appear that the copy has not started or is stuck when querying the session from Solutions Enabler or Unisphere for VMAX, even though the copy has actually begun. See the following example:

```
$ symsnapvx -sid XYZ list -sg snapsource -linked -detail
```

<table>
<thead>
<tr>
<th>Dev</th>
<th>Snapshot Name</th>
<th>Gen</th>
<th>Dev</th>
<th>FCMD Snapshot</th>
<th>Timestamp</th>
<th>Remaining (Tracks)</th>
<th>Done (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00040</td>
<td>hourlysnap</td>
<td>2</td>
<td>0003D...I Mon Sep 29 14:01:59 2014</td>
<td>18510</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00041</td>
<td>hourlysnap</td>
<td>2</td>
<td>0003E...I Mon Sep 29 14:01:59 2014</td>
<td>18510</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00042</td>
<td>hourlysnap</td>
<td>2</td>
<td>0003F...I Mon Sep 29 14:01:59 2014</td>
<td>18510</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00043</td>
<td>hourlysnap</td>
<td>2</td>
<td>00040...I Mon Sep 29 14:01:59 2014</td>
<td>18510</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flgs:**
- (F)ailed : F = Force Failed, X = Failed, . = No Failure
- (C)opy : I = CopyInProg, C = Copied, D = Copied/Destaged, . = NoCopy Link
- (M)odified : X = Modified Target Data, . = Not Modified
- (D)efined : X = All Tracks Defined, . = Define in progress

The user may be able to notice usage increase on the target volumes or SRPs. This does not slow down the actual copy, just the way that the copy is reported. Once the internal counters drop below a certain threshold the number of tracks reported to the user will drop dramatically.

Another effect of this is that incremental relink operations may appear as full operations because the internal counters add up to the full size of the volume. Both of these behaviors will be more noticeable on larger volumes.

This behavior also applies to monitoring the copy process of TimeFinder Mirror and Clone emulation sessions, which use SnapVX in the background.

This behavior is also documented in Dell EMC Knowledgebase article 196700 [https://support.emc.com/kb/196700](https://support.emc.com/kb/196700)

**APPENDIX D**

**NOCOPY LINKED TARGET FUNCTIONALITY**

Beginning with the HYPERMAX OS Q1 2016 Service Release, users can continue to access the data on fully-defined nocopy targets after having been unlinked. This functionality is possible through the shared allocations. As discussed earlier, the defining process creates the shared allocations between the target volume and source/snapshot deltas.

When a target is unlinked, the allocation sharing remains in place. In other words, unlinking will not “unshare” the allocations. Even after unlinked, termination of a snapshot will result in the target owning the snapshot delta. And an updated write to the source track will result in the target owning the original track. The target will also take ownership of any shared source tracks if the source is deallocated after unlink.
This enhanced functionality allows the user to continue to access the target data after unlink in the same way that previously required full copy targets, but without duplicating the entire back-end data from the point-in-time to the target.

There are a few important aspects to understand about this behavior:

- Nocopy target data will only be valid if the target is fully defined before unlink. The following commands will help the user determine if defined process has completed on target(s):
  
  o `symsnapvx -<sourcedevs> -snapshot_name list -linked`
  
  o `symsnapvx -<targetdevs> -snapshot_name verify -linked -defined -by_tgt`

- The unlink operation will not cause any data on the target to be deallocated. This includes data that was copied during the link operation as well as data that was directly written to the target. Therefore, an unlink operation will not return any free capacity to the SRP.

- If the user wants to deallocate the data on the target(s) after unlink, they can do so by issuing the `symdev free -all` command to the target volume.

  Please note that this is a powerful command that will completely deallocate all data on the volumes that it is issued against. Extreme care must be taken when using this command. As a safety mechanism, the free -all command requires the device to be not ready or unmapped.

- Similarly, after terminating a snapshot, users may not see as much capacity returned available to the SRP as expected because the previous target that was sharing the snapshot deltas has taken ownership of them.

- Also, if that target happens to be in a separate SRP from the source/snapshot, the data will be copied across SRPs as the target takes ownership.

- The underlying behavior exists in earlier versions of HYPERMAX OS, but the data verification testing was not completed to qualify the feature until the HYPERMAX OS Q1 2016 Service Release.

  This means that at earlier versions of HYPERMAX OS, users may observe the behavior described in the previous bullets. But the validity of the data on the nocopy targets after unlink cannot be guaranteed.

- In regards to performance, this feature should be considered to perform as well as accessing linked nocopy targets.

APPENDIX E

SCHEDULING SNAPSHOTs WITH UNISPhERE FOR VMAX

Unisphere for VMAX 8.3 introduced the ability for users to schedule automated recurring snapshots.

This functionality provides the user with the ability to configure a snapshot to be created at specific time(s) and day(s) of the week. This is configured by adding the task to the Job List in Unisphere as shown in the example below

Once the schedule is set-up, it will run. To discontinue a scheduled job, delete the entry from the Job List.

Automatic termination of snapshots is performed by the Time-to-Live option as normal, not by the scheduler. Use of the Days to Live option is strongly recommended for recurring snapshots. The automatic expiration of snapshots that are no longer needed will maximize the efficiency of SnapVX on system resources. The Days to Live option is found under the Advanced options in the Create Snapshot Wizard.

Process:

1. Open the Create Snapshot Wizard from the Protection Dashboard.
   a. Go to Data Protection > Protection Dashboard.
b. Select the Storage Group you want to schedule snapshots for and Click Protect.

2. Once all options are specified (SnapVX, Snapshot Name, Days to Live, etc) select “Add to Job List”
3. Click View Job List.

Figure 29: Unisphere for VMAX Protection Wizard snapshot completion window

4. Select the Created Job for the SnapVX Establish and Click View Details.

Figure 30: Unisphere for VMAX Job List

5. Click the calendar icon or schedule button to launch the schedule dialog.

Figure 31: Unisphere for VMAX snapshot job
6. Select the time of day for the first job to run, and then select either Run Once, Hourly or Daily from the dropdown box.

![Figure 32: Unisphere for VMAX snapshot scheduler window](image)

- Run Once allows you to schedule the creation time for the single snapshot, but is not for scheduling recurring snapshots.
- Hourly will create a new snapshot every hour every day of the week.
- Daily will create a new snapshot at the same time of day on the specified days of the week. The days of the week are selected by check boxes.

![Figure 33: Unisphere for VMAX snapshot scheduler window](image)

7. After specifying day(s) and time, click OK to save the schedule.

Note: The hour, minutes, and am/pm fields are set independently. Changing one field will not cause the others to adjust. For example, if the displayed time is set to 11:59 am, increasing the minute field will change the time to 11:00 am, not 12:00 pm.

8. The Job List will now show the job as Scheduled and Recurring
Helpful Notes

- Be sure to monitor resources used by the snapshots as discussed earlier in this document, such as used / available back-end capacity, Snapshot Deltas and Replication Cache / Replication Data Pointers (RDP), using threshold alerts as applicable.

- Also as mentioned earlier in the document, proper planning is critical to ensure that the system is configured with enough resources to support your snapshot requirements. And just as with any other application, as requirements change and grow, resources may need to be added to the system.

- Unscheduled snapshot jobs can be grouped together and then a single recurring schedule can be applied to that group. This can be helpful in coordinating snapshots for multiple Storage Groups.

However, please be aware that the snapshot for each Storage Group is performed individually and may have slightly differing timestamps. If the same timestamp is required, the user may want to consider creating a separate, larger Storage Group specifically for the snapshots.

Please be sure to remember to set up the day/time schedule after the jobs have been grouped.

- If execution of a snapshot at a specific time fails for any reason, an alert will be created. The job will remain active and will attempt to create another snapshot at the next scheduled time.
- Editing a scheduled job is currently not supported. If a snapshot schedule needs to be modified, the existing job will need to be deleted, and then a new one created.

- The scheduler runs within Unisphere for VMAX and may be affected if there is a problem with the host where it is installed, or if Unisphere needs to be uninstalled.
  
  o Embedded Management (eManagement) provides high-availability. In this case the schedule will continue to run on the secondary instance if the primary fails.