Supplement: DP-VOL Expansion in GAD Pairs for VSP 5000 Series

Contents

MK-24RD9036-00, December 2024

About this document

This document (MK-24RD9036-00, December 2024) provides information about the DP-VOL expansion feature of Hitachi Virtual Storage Platform (VSP) 5000 series.

Intended audience

This document is intended for customers and Hitachi Vantara partners who license and use VSP 5000 series storage systems.

Getting help

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Required microcode and firmware versions

The following microcode and firmware versions are required for DP-VOL expansion:

- **Microcode:** DKCMAIN 90-09-26-00/00 or later
- **SVP firmware:** 90-09-26/00 or later

(1) Expanding DP-VOL capacity in a GAD pair

There are two different procedures for expanding the capacity of a DP-VOL used in a GAD pair, depending on whether the GAD pair shares a volume with other software (for example, Thin Image). The procedures in this section describe expanding DP-VOL capacity when the GAD pair does not share a volume with other software.

There are also two ways to expand volume capacity regardless of whether the GAD pair shares a volume with other software: you can suspend the GAD pair before you expand volume capacity, or you can keep the GAD pair in PAIR status when you expand volume capacity. The procedures differ slightly depending on whether the GAD pair shares a volume with other software and which software it is.

Note: If you want to expand volume capacity while keeping the GAD pair in PAIR status, you must satisfy the conditions in "Prerequisites" in Expanding volume capacity with the GAD pair in PAIR status in addition to the general conditions in "Prerequisites" in each procedure.

Note: Only the assigned page capacity out of the DP-VOL capacity is counted as the GAD license capacity.

Note: If a failure occurs after the capacity of one volume of a GAD pair was expanded, the create, resync, swap resync, and horctakeover operations for the GAD pair cannot be performed because the capacity of both volumes is not the same. Expand the capacity of the other volume so that the capacity of both volumes is the same, and then retry the operation.

Prerequisites

Ensure that the following conditions are met:

- The V-VOL to be expanded must not be an external volume.
- The LDEV format is not being performed on a V-VOL to be expanded.
- The pool containing the V-VOL to be expanded must meet at least one of the following conditions:
  - Normal condition
  - The pool is not being shrunk.
- The V-VOL to be expanded must have been created on a valid storage system. For details, see *Expansion of DP-VOL capacity while keeping pair status* in the *Global-Active Device User Guide*.
- There must be enough GAD license capacity for the page capacity assigned to the expanded volume capacity before the expansion.

MK-24RD9036-00, December 2024

Expanding volume capacity after suspending the GAD pair

Procedure

1) Verify that both the P-VOL and S-VOL of a GAD pair meet the prerequisites.
2) Display the detailed information about the GAD pair on CCI.
3) If the capacity of each volume of the GAD pair is 4 TB or greater, go to step 5. If the capacity of the GAD pair volume is less than 4 TB, verify whether the current differential data management method is shared memory (SM) difference management or hierarchical difference management by a drive. The **DM** column displayed by the `pairdisplay` command shows whether shared memory (**S**) difference management or hierarchical (**D**) difference management is applied.

```
# pairdisplay -g oradb -fe

Group PairVol(L/R) (Port#,TID, LU),Seq#, LDEV#.P/S,Status,Fence,Seq#,P-LDEV# M
CTG JID AP EM E-Seq# E-LDEV# R/W QM DM P
oradb dev1(L) (CL5-A-0,30, 0) 64568 301.P-VOL PAIR ASYNC,64568 303 - 0 2 1 - -
- -/- AA S N
oradb dev1(R) (CL5-A-0,30, 2) 64568 303.S-VOL PAIR ASYNC,----- 301 - 0 4 1 - -
- -/- AA S N
oradb dev2(L) (CL5-A-0,30, 1) 64568 302.P-VOL PAIR ASYNC,64568 304 - 0 3 1 - -
- -/- AA D N
oradb dev2(R) (CL1-A-0,30, 3) 64568 304.S-VOL PAIR ASYNC,----- 302 - 0 5 1 - -
- -/- AA D N
```

   - If SM difference management is applied, go to step 4 to temporarily change to hierarchical difference management.
   - If hierarchical difference management is applied, go to step 5.
   - If using HDvM - SN, verify the advanced system settings No. 5 and No. 6 in the **Edit Advanced System Settings** window.
   - If both the advanced system settings No. 5 and No. 6 are set to **Disable**, SM difference management is applied. Go to step 4.
   - If either or both the advanced system settings No. 5 and No.6 are set to **Enable**, hierarchical difference management is applied. Go to step 5.

4) Change the differential data management method to hierarchical difference management.
   a) Change system settings for hierarchical difference management as follows.
      – If using CCI, set the system option mode (SOM) 1198 to ON and 1199 to OFF by using the `raidcom modify system_opt` command.

      Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode enable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode disable
```

- If using HDvM - SN, set the advanced system settings No. 5 to **Enable** and No.6 to **Disable** in the **Edit Advanced System Settings** window. For details about the procedure, see the *System Administrator Guide*.

b) Suspend the GAD pair.

c) Resynchronize the GAD pair.

d) Display the detailed information about the GAD pair on CCI.

e) Verify that the current differential data management method is hierarchical difference management.

5) Suspend the GAD pair.

6) Expand the S-VOL capacity in the GAD pair.

   - If using CCI, add the `-request_id auto` option to the `raidcom extend ldev` command to specify the asynchronous command processing.

     Command example:

     The following command expands the capacity of LDEV#44:44 by 10 GB.

```
raidcom extend ldev -ldev_id 0x4444 -capacity 10G -request_id auto -IH1
```

   - If using HDvM - SN, expand the capacity in the **Expand V-VOLs** window.

7) Verify that expanding the S-VOL capacity in the GAD pair is finished.

   - If using CCI, use the `raidcom get command_status` command to verify that the `raidcom extend ldev` command is finished processing.

     Command example:

```
raidcom get command_status -IH1
```

     Verify the expanded LDEV capacity using the `raidcom get ldev` command.

```
raidcom get ldev -ldev_id 0x4444 -fx -IH1
```

   - If using HDvM - SN, select Logical devices from the Storage Systems tree, and then display the **LDEV** tab. Verify that the capacity with the target LDEV number is correct.

8) Expand the P-VOL capacity in the GAD pair in the same way as the S-VOL capacity. If the P-VOL capacity in the GAD pair cannot be expanded, see (3) Recovering from failure when the capacity of one GAD volume cannot be expanded.

9) Verify that expanding the P-VOL capacity in the GAD pair is complete in the same way as the S-VOL capacity.

10) Resynchronize the GAD pair. If the resync operation in the GAD pair cannot be performed, see (3) Recovering from failure when the capacity of one GAD volume cannot be expanded.

11) Verify that the pair statuses of both the P-VOL and S-VOL in the GAD pair have changed to PAIR (Mirror(RL)), and that the volume capacity is not being expanded.

- If using CCI, check that the **P** column of the `pairdisplay` command output displays **N**.

```
# pairdisplay -g oradb -fe

Group PairVol(L/R) (Port#,TID, LU),Seq#, LDEV#.P/S,Status,Fence,Seq#, P-LDEV# M
CTG JID AP EM E-Seq# E-LDEV# R/W QM DM P
oradb dev1(L) (CL5-A-0,30, 0) 64568 301.P-VOL PAIR ASYNC,64568 303 - 0 2 1 - -
- L/M AA S N
oradb dev1(R) (CL5-A-0,30, 2) 64568 303.S-VOL PAIR ASYNC,----- 301 - 0 4 1 - -
- L/M AA S N
oradb dev2(L) (CL5-A-0,30, 1) 64568 302.P-VOL PAIR ASYNC,64568 304 - 0 3 1 - -
- L/M AA D N
oradb dev2(R) (CL1-A-0,30, 3) 64568 304.S-VOL PAIR ASYNC,----- 302 - 0 5 1 - -
- L/M AA D N
```

  The **P** column in the `pairdisplay` command output displays the status that the volume capacity is being expanded. An **N** indicates that the volume capacity is not being expanded, and an **E** indicates that the volume capacity is being expanded.

  The **E** status is displayed after expanding the P-VOL or S-VOL capacity in the GAD pair, and before performing the pair resync operation. This status changes to **N** after the resync operation completes.

- If using HDvM - SN, check if the **Processing Status** field in the **Remote Replication** window is blank. **Expanding** is displayed if the volume capacity is being expanded.

12) If you temporarily changed the differential data management method from SM difference to hierarchical difference (step 3), restore to SM difference management.

a) Restore to SM difference management as follows.

- If using CCI, set the system option mode (SOM) 1198 to OFF and 1199 to ON by using the `raidcom modify system_opt` command.

  Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode disable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode enable
```

- If using HDvM - SN, set the advanced system settings No. 5 to **Disable** and No.6 to **Disable** in the **Edit Advanced System Settings** window. For details about the procedure, see the *System Administrator Guide*.

b) Suspend the GAD pair.

c) Resynchronize the GAD pair.

d) Display the detailed information about the GAD pair on CCI.

e) Verify that the current differential data management method is SM difference management.

f) If using CCI and the settings of SOMs 1198 and 1199 have been changed, set SOM 1198 to OFF and 1199 to OFF by using the `raidcom modify system_opt` command.

Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode disable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode disable
```

Expanding volume capacity with the GAD pair in PAIR status

If you expand the capacity of the S-VOL of a GAD pair while the pair is in PAIR status, the capacity of the P-VOL is also expanded automatically. Check the capacity of the pool used by the P-VOL and S-VOL before you expand the GAD S-VOL.

Prerequisites

Ensure that the following conditions are met:

- The storage systems at both the primary and secondary sites for the GAD pair must be VSP 5000 series with microcode and firmware version 90-09-26-xx/xx or later.
- The differential data management method for the P-VOL and S-VOL of the GAD pair must be hierarchical difference management.
- The P-VOL or S-VOL of the GAD pair must not be shared with another GAD pair.

To check the differential data management method, see step 3 in Expanding volume capacity after suspending the GAD pair.

If you are using SM difference management, perform step 4 in Expanding volume capacity after suspending the GAD pair to change the differential data management method to hierarchical difference management.

Note: To change the differential data management method from SM difference management to hierarchical difference management, you need to suspend the GAD pair first.

Procedure

1) Verify that both the P-VOL and S-VOL of the GAD pair meet all prerequisites including the general prerequisites in "Prerequisites" in (1) Expanding DP-VOL capacity in a GAD pair.
2) Verify that the GAD pair is in PAIR status.

3) Expand the capacity of the GAD S-VOL.

   As the size of a single expansion, set 32 TB or less per volume. If you use HDvM - SN to expand the capacity of multiple volumes simultaneously, set 1 PB or less for the total size of expansion. If you set a greater value (more than 32 TB for one volume and more than 1 PB for multiple volumes), the GAD pair might be suspended by failure during capacity expansion.

   Do not suspend the target GAD pair until the capacity expansion of the S-VOL is finished. If you do, suspension of the GAD pair might fail or take a long a time to complete, temporarily stopping host I/O to the GAD pair.

   - If using CCI, add the `-request_id auto` option to the `raidcom extend ldev` command to specify the asynchronous command processing.

     Command example:

     The following command expands the capacity of LDEV#44:44 by 10 GB.

```
raidcom extend ldev -ldev_id 0x4444 -capacity 10G -request_id auto -IH1
```

   - If using HDvM - SN, expand the capacity in the **Expand V-VOLs** window.

   Note: When you expand the capacity of the GAD S-VOL, the capacity of the P-VOL is simultaneously expanded.

4) Verify that expanding the capacity of the S-VOL and P-VOL in the GAD pair is finished.

   - If using CCI, use the `raidcom get command_status` command to verify that the `raidcom extend ldev` command is finished processing.

     Command example:

```
raidcom get command_status -IH1
```

     Verify the expanded LDEV capacity using the `raidcom get ldev` command.

```
raidcom get ldev -ldev_id 0x4444 -fx -IH1
```

   - If using HDvM - SN, select Logical devices from the Storage Systems tree, and then display the **LDEV** tab. Verify that the capacity of the S-VOL and P-VOL of the GAD pair with the target LDEV numbers is expanded as specified.

   Note: If a failure occurs during volume expansion for a GAD pair, the GAD pair might be suspended by failure. In that case, verify that the capacity of the P-VOL and the capacity of the S-VOL match, and then resynchronize the GAD pair. If either P-VOL or S-VOL alone is expanded and the capacities of the two volumes do not match, expand the unexpanded volume by specifying the same capacity. Make sure that the capacity of the P-VOL and the capacity of the S-VOL match. Then resynchronize the GAD pair.

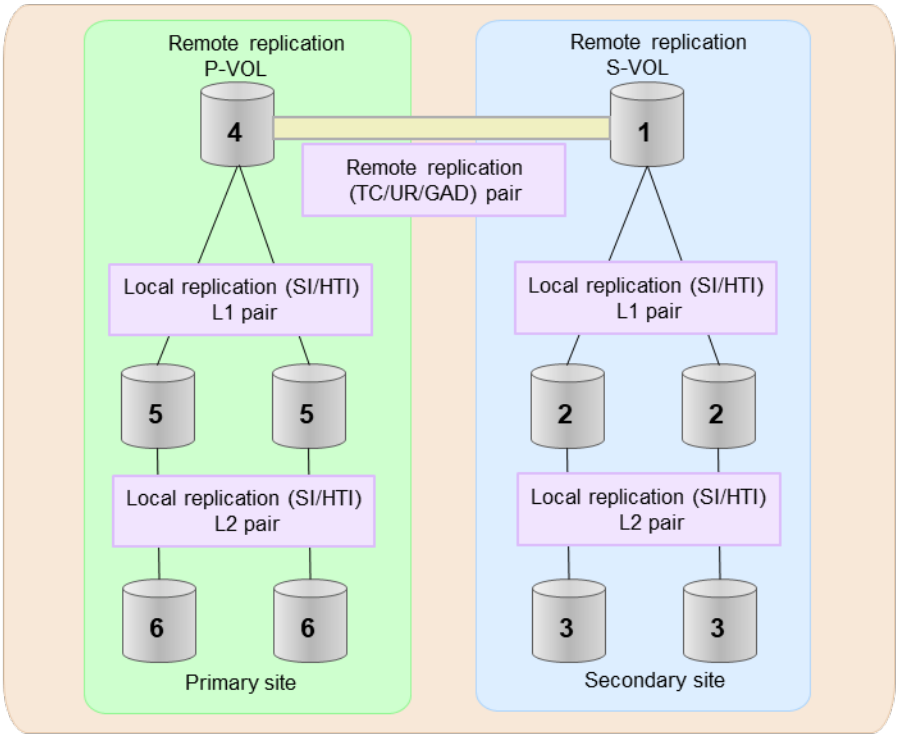
5) Verify that the GAD pair is in PAIR status.

(2) Expanding DP-VOL capacity when a GAD pair shares volumes with other software

You can expand the capacity of DP-VOLs used in GAD pairs and in other volume pairs when a GAD pair shares the same volumes with UR, SI, HTI, and HTIA.

When a GAD pair shares the same volumes with other software, the order in which you expand the DP-VOL capacity consists of the following two expansion orders:

- Expansion order in a point-to-point configuration of the GAD pair
- Expansion order in a point-to-point configuration of each software product



Legend
TC: TrueCopy
UR: Universal Replicator
GAD: Global-active device
SI: ShadowImage
HTI: Thin Image or Thin Image Advanced

- When a remote replication (TC/UR/GAD) is included, first expand the S-VOL capacity on the end of the remote replication, and then expand the P-VOL capacity. For more information about the specific expansion procedure, see Expanding DP-VOL capacity when a GAD pair is used with Universal Replicator.
- When a remote replication pair (TC/UR/GAD) shares a volume with a local replication pair (SI/HTI/HTIA), first expand the capacity of the S-VOL group in the remote replication pair. The S-VOL group consists of the S-VOL in the remote replication and all volumes in the local replication with which the S-VOL shares the same volume. After expanding the capacity of the S-VOL group in the remote

replication, expand the capacity of the P-VOL group in the remote replication. The P-VOL group consists of the P-VOL in the remote replication and all volumes in the local replication with which the P-VOL shares the same volume.

The expansion order in each group follows the expansion order in the local replication. For more information about the specific expansion procedures, see Expanding DP-VOL capacity when a GAD pair is used with ShadowImage and Expanding DP-VOL capacity when a GAD pair is used with Thin Image or Thin Image Advanced.

- In the local replication pair (SI/HTI/HTIA), expand the capacity from the highest layer to the lowest. The expansion order is not specified for the volumes in the same layer.

Note: If a failure occurs after the capacity of one volume of a GAD pair was expanded, the create, resync, swap resync, and horctakeover operations for the GAD pair cannot be performed because the capacity of both volumes is not the same. Expand the capacity of the other volume so that the capacity of both volumes is the same, and then retry the operation.

Expanding DP-VOL capacity when a GAD pair is used with Universal Replicator

You can expand the capacity of DP-VOLs when pairs are created in a 3DC delta resync configuration with GAD and UR. For the detailed procedures for verifying the differential data management method, expanding the capacity, and verifying the expansion during the following procedures, see (1) Expanding DP-VOL capacity in a GAD pair.

There are two ways to expand volume capacity. One is to suspend the GAD pair before you expand volume capacity. The other is to keep the GAD pair in PAIR status (not suspend the GAD pair) when you expand volume capacity.

Note: If you want to expand volume capacity while keeping the GAD pair in PAIR status, you must satisfy the conditions in "Prerequisites" in Expanding volume capacity with the GAD pair in PAIR status in addition to the conditions in "Prerequisites" for each relevant section.

Prerequisites

- The V-VOL to be expanded must not be an external volume.
- The LDEV format is not being performed on a V-VOL to be expanded.
- The pool containing the V-VOL to be expanded must meet at least one of the following conditions:
  - Normal condition
  - The pool is not being shrunk.
- When using GAD, TC, or UR, there must be enough software license capacity for the page capacity assigned to the expanded volume capacity before the expansion.

- The V-VOL to be expanded must have been created on a valid storage system. For details, see *Expansion of DP-VOL capacity while keeping pair status* in the *Global-Active Device User Guide*.

Expanding volume capacity after suspending the GAD pair (UR)

Procedure

1) Verify that each volume of the P-VOLs and S-VOLs in a GAD pair and UR pairs with which the GAD pair shares the same volumes meets the prerequisites.
2) Display the detailed information about the GAD pair, UR pair, and UR delta resync pair on CCI by using the `pairdisplay` command.
3) If the capacity of each of the P-VOLs and S-VOLs of the GAD pair and the UR pairs with which the GAD pair shares the same volumes is 4 TB or greater, proceed to step 5. If the capacity of a P-VOL or S-VOL is less than 4 TB, verify whether the current differential data management method is SM difference management or hierarchical difference management by a drive.
   - If SM difference management is applied, proceed to step 4.
   - If hierarchical difference management is applied, proceed to step 5.
   - If using HDvM - SN, verify the advanced system settings No. 5 and No. 6 in the **Edit Advanced System Settings** window.

   If both the advanced system settings No. 5 and No. 6 are set to **Disable**, SM difference management is applied. Proceed to step 4.

   If either or both the advanced system settings No. 5 and No. 6 are set to **Enable**, hierarchical difference management is applied. Proceed to step 5.
4) Change the differential data management method to hierarchical difference management.
   a) Change system settings for hierarchical difference management as follows.

   If using CCI, set the system option mode (SOM) 1198 to ON and 1199 to OFF by using the `raidcom modify system_opt` command.

   Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode enable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode disable
```

   If using HDvM - SN, set the advanced system settings No. 5 to **Enable** and No. 6 to **Disable** in the **Edit Advanced System Settings** window. For details about the procedure, see the *System Administrator Guide*.

   b) Swap suspend the GAD pair. The delta resync operation can be performed automatically.

c) Verify the pair statuses of the GAD pair, UR pair, and UR delta resync pair, and that the delta resync operation is complete correctly.

d) Swap suspend the GAD pair again. The delta resync operation can be performed automatically.

e) Verify the pair statuses of the GAD pair, UR pair, and UR delta resync pair, and that the delta resync operation is complete correctly.

f) Display the detailed information about the GAD pair, UR pair, and UR delta resync pair on CCI.

g) Verify that the current differential data management method is hierarchical difference management.

5) Suspend the GAD pair and UR pairs.

6) Expand each volume capacity, and then verify that the expansion is complete in the following expansion order:

a) Expand the S-VOL in the UR pair (S-VOL in the UR delta resync pair). If you fail in expanding the S-VOL capacity in the UR pair, expanding the P-VOL capacity in the GAD pair, or resynchronizing the GAD pair or UR pair, make sure to perform the recovery procedure described in (3) Recovering from failure when the capacity of one GAD volume cannot be expanded.

b) Expand the S-VOL in the GAD pair.

c) Expand the P-VOL in the GAD pair.

7) Resynchronize the GAD pair and UR pair.

8) Verify that both the pair statuses of the P-VOL and S-VOL in each pair of the GAD pair have changed to PAIR(Mirror(RL)) and in each pair of the UR pair have changed to PAIR.

In addition, verify that each volume capacity in the GAD pair, UR pair, and UR delta resync pair is not being expanded.

The following table shows how the expansion process is displayed.

Expansion status	**CCI**	**HDvM - SN**
	P column in the pairdisplay command output	**Processing Status field in the Remote Replication window**
Not being expanded	N	Blank
Being expanded	E*	Expanding*
* These statuses are displayed after expanding the P-VOL or S-VOL capacity in the GAD pair or the UR pair, and before performing the pair resync operation. After the resync operation is complete, the status is migrated to the Not being expanded status. In the UR delta resync pair, the Being expanded status will not be displayed on CCI or HDvM - SN because the expansion in the UR delta resync pair is complete concurrently with the GAD pair and the UR pair.		

9) In step 3, if the differential data management method is SM difference management, restore to SM difference management using the following procedure:

   a) Restore to the SM difference management as follows.

   If using CCI, set the system option mode (SOM) 1198 to OFF and 1199 to ON by using the `raidcom modify system_opt` command.

   Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode disable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode enable
```

   If using HDvM - SN, set the advanced system settings No. 5 to **Disable** and No. 6 to **Disable** in the **Edit Advanced System Settings** window. For details about the procedure, see the *System Administrator Guide*.

   b) Swap suspend the GAD pair. The delta resync operation can be performed automatically.

   c) Verify the pair statuses of the GAD pair, UR pair, and UR delta resync pair, and that the delta resync operation is complete correctly.

   d) Swap suspend the GAD pair again. The delta resync operation can be performed automatically.

   e) Verify the pair statuses of the GAD pair, UR pair, and UR delta resync pair, and that the delta resync operation is complete correctly.

   f) Display the detailed information about the GAD pair, UR pair, and UR delta resync pair on CCI.

   g) Verify that the current differential data management method is SM difference management.

   h) If using CCI, and the settings of SOMs 1198 and 1199 have been changed, set SOM 1198 to OFF and 1199 to OFF by using the `raidcom modify system_opt` command.

   Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode disable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode disable
```

Expanding volume capacity with the GAD pair in PAIR status (UR)

If you expand the capacity of the S-VOL of a GAD pair while the pair is in PAIR status, the capacity of the P-VOL is also expanded automatically. Check the capacity of the pool used by the P-VOL and S-VOL before you expand the GAD S-VOL.

Prerequisites

Ensure that the following conditions are met:

- The storage systems at both the primary and secondary sites for the GAD pair must be VSP 5000 series with microcode version or firmware version 90-09-26-xx/xx or later.
- The differential data management method for the P-VOLs and S-VOLs of the GAD pair, UR pair, and UR delta resync pair must be hierarchical difference management.
- The P-VOL or S-VOL of the GAD pair must not be shared with another GAD pair.

To check the differential data management method, see step 3 in Expanding volume capacity after suspending the GAD pair (UR).

If you are using SM difference management, perform step 4 in Expanding volume capacity after suspending the GAD pair (UR). to change the differential data management method to hierarchical difference management.

Note:

- To change the differential data management method from SM difference management to hierarchical difference management, you need to suspend the target pair first.
- You cannot expand the capacity of the volumes of the UR pair with which the GAD pair shares the same volume while keeping the UR pair in PAIR status.

Procedure

1) Verify that each of the P-VOLs and S-VOLs of the GAD pair and the UR pair with which the GAD pair shares the same volume meets the general prerequisites in "Prerequisites" in Expanding DP-VOL capacity when a GAD pair is used with Universal Replicator.
2) Verify that both the P-VOL and S-VOL of the GAD pair meet all prerequisites including the general prerequisites in "Prerequisites" in (1) Expanding DP-VOL capacity in a GAD pair.
3) Suspend the UR pair.
4) Verify that the GAD pair is in PAIR status.
5) Expand the capacity of the following volumes.

   As the size of a single expansion, set 32 TB or less per volume. If you use HDvM - SN to expand the capacity of multiple volumes simultaneously, set 1 PB or less for

the total size of expansion. If you set a greater value (more than 32 TB for one volume and more than 1 PB for multiple volumes), the GAD pair might be suspended by failure during capacity expansion.

- S-VOL of the UR pair (S-VOL of the UR delta resync pair)
- S-VOL of the GAD pair

Do not suspend the target GAD pair until the capacity expansion of the S-VOL is finished. If you do, suspension of the GAD pair might fail or take a long a time to complete, temporarily stopping host I/O to the GAD pair.

Note: When you expand the capacity of the GAD S-VOL, the capacity of the P-VOL is simultaneously expanded.

6) Verify that expanding the capacity of the P-VOL and S-VOL is finished.

   Note: If a failure occurs during volume expansion for a GAD pair, the GAD pair might be suspended by failure. In that case, verify that the capacity of the P-VOL and the capacity of the S-VOL match, and then resynchronize the GAD pair. If either P-VOL or S-VOL alone is expanded and the capacities of the two volumes do not match, expand the unexpanded volume by specifying the same capacity. Make sure that the capacity of the P-VOL and the capacity of the S-VOL match. Then resynchronize the GAD pair.

7) Resynchronize the UR pair.
8) Verify that the GAD pair is in PAIR status and the pair status of the UR pair has changed to PAIR.
9) Verify that volume expansion is not being performed for the GAD pair, UR pair, and UR delta resync pair.

   The following table shows how the expansion process is displayed.

Expansion status	CCI	HDvM - SN
	P column in the pairdisplay command output	Processing Status field in the Remote Replication window
Not being expanded	N	Blank
Being expanded	E*	Expanding*
* This status continues to be displayed after expanding the P-VOL or S-VOL capacity in the GAD pair or the UR pair, and before performing the pair resync operation. After the resync operation is complete, the status changes to "Not being expanded". For the UR delta resync pair, the Being expanded status will not be displayed on CCI or HDvM - SN because the expansion in the UR delta resync pair is complete concurrently with the GAD pair and the UR pair.		

Expanding DP-VOL capacity when a GAD pair is used with ShadowImage

You can expand the capacity of DP-VOLs used as pair volumes when a GAD pair is used with SI. The procedures provide examples for expanding the DP-VOL capacity in a configuration where the SI L1 pair and L2 pair are created for each volume of the P-VOL and S-VOL in the GAD pair. For the detailed procedures for verifying the differential data management method, expanding the capacity, and verifying the expansion during the following procedures, see (1) Expanding DP-VOL capacity in a GAD pair.

There are two ways to expand volume capacity. One is to suspend the GAD pair before you expand volume capacity. The other is to keep the GAD pair in PAIR status (not suspend the GAD pair) when you expand volume capacity.

Note: If you want to expand volume capacity while keeping the GAD pair in PAIR status, you must satisfy the conditions in "Prerequisites" in Expanding volume capacity with the GAD pair in PAIR status in addition to the general conditions in "Prerequisites" in each relevant section.

Prerequisites

- The V-VOL to be expanded must not be an external volume.
- The LDEV format is not being performed on a V-VOL to be expanded.
- The pool containing the V-VOL to be expanded must meet at least one of the following conditions:
  - Normal condition
  - The pool is not being shrunk.
- When using GAD, TC, or UR, there must be enough software license capacity for the page capacity assigned to the expanded volume capacity before the expansion.
- The V-VOL to be expanded must have been created on a valid storage system. For details, see *Expansion of DP-VOL capacity while keeping pair status* in the *Global-Active Device User Guide*.
- The numbers of differential tables and pair tables required after the expansion must not exceed the maximum number allowed on the storage system. For information about calculating the number of tables, see Calculating the numbers of differential and pair tables for each pair.

Procedure

1) Verify that each volume of the P-VOLs and S-VOLs in a GAD pair and SI pairs with which the GAD pair shares the same volumes meets the prerequisites.
2) Display the detailed information about the GAD pair on CCI by using the `pairdisplay` command.
3) If the capacity of each volume of the GAD pair is 4 TB or greater, proceed to step 5. If the capacity of a GAD pair volume is less than 4 TB, verify whether the current differential data management method is SM difference management or hierarchical difference management by a drive.
   - If SM difference management is applied, proceed to step 4.
   - If hierarchical difference management is applied, proceed to step 5.
   - If using HDvM - SN, verify the advanced system settings No. 5 and No. 6 in the **Edit Advanced System Settings** window.
   - If both the advanced system settings No. 5 and No. 6 are set to **Disable**, SM difference management is applied. Proceed to step 4.
   - If either or both the advanced system settings No. 5 and No. 6 are set to **Enable**, hierarchical difference management is applied. Proceed to step 5.
4) Change the differential data management method to hierarchical difference management.
   a) Change system settings for hierarchical difference management as follows.

   If using CCI, set the system option mode (SOM) 1198 to ON and 1199 to OFF by using the `raidcom modify system_opt` command.

   Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode enable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode disable
```

   If using HDvM - SN, set the advanced system settings No. 5 to **Enable** and No. 6 to **Disable** in the **Edit Advanced System Settings** window. For details about the procedure, see the *System Administrator Guide*.

   b) Suspend the GAD pair.
   c) Resynchronize the GAD pair.
   d) Display the detailed information about the GAD pair on CCI.
   e) Verify that the current differential data management method is hierarchical difference management.
5) Suspend the GAD pair and all SI pairs.

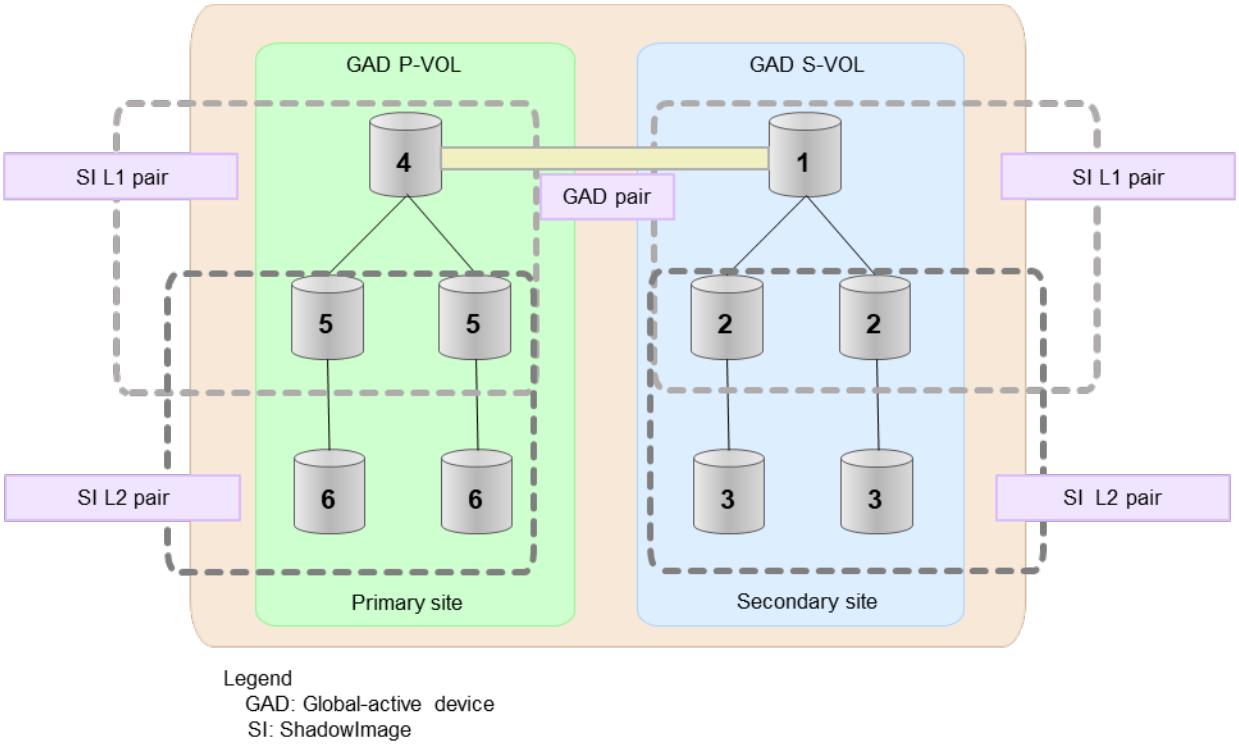
6) Verify the pair statuses of the SI pairs.

   The SI pair volume capacity can be expanded when the SI pairs are in the PSUS or PSUE status. Verify the current pair statuses of the SI pairs.

   a) If the pair statuses are not PSUS or PSUE, perform the pair operations.

   b) Ensure that the pair statuses are migrated to PSUS or PSUE.

7) Expand each volume capacity, and then verify that the expansion is complete in the expansion order shown in the following figure.



   After expanding the first volume capacity (S-VOL in the GAD pair), if you cannot expand the DP-VOL capacity in the SI pair, you cannot expand the P-VOL capacity in the GAD pair, or you cannot resynchronize the GAD pair, make sure to perform the recovery procedure described in (3) Recovering from failure when the capacity of one GAD volume cannot be expanded.

8) Resynchronize the GAD pair.

9) Verify that both the pair statuses of the P-VOL and S-VOL in each pair of the GAD pair have changed to PAIR(Mirror(RL)).

   In addition, verify that each volume capacity in the GAD pair and SI pair is not being expanded.

   The following table shows how the expansion process is displayed.

Expansion status	CCI	HDvM - SN
	P column in the pairdisplay command output	Processing Status field in the Remote Replication or Local Replication window
Not being expanded	N	Blank
Being expanded	E*	Expanding*
* These statuses have been displayed after expanding the P-VOL or S-VOL capacity in the GAD pair, and before performing the pair resync operation. After the resync operation is complete, the status is migrated to the Not being expanded status. In the SI pair, the Being expanded status is displayed for a while (30 seconds or so) after the expansion of the P-VOL and S-VOL capacity is complete. After that, the status is migrated to the Not being expanded status.		

10) In step 3, if the differential data management method is SM difference management, restore to SM difference management using the following procedure:

    a) Restore to SM difference management as follows.

        – If using CCI, set the system option mode (SOM) 1198 to OFF and 1199 to ON by using the `raidcom modify system_opt` command.

    Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -mode
disable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode enable
```

        – If using HDvM - SN, set the advanced system settings No. 5 to **Disable** and No. 6 to **Disable** in the **Edit Advanced System Settings** window. For details about the procedure, see the *System Administrator Guide*.

    b) Suspend the GAD pair.

    c) Resynchronize the GAD pair.

    d) Display the detailed information about the GAD pair on CCI.

    e) Verify that the current differential data management method is SM difference management.

    f) If using CCI, and the settings of SOMs 1198 and 1199 have been changed, set SOM 1198 to OFF and 1199 to OFF by using the `raidcom modify system_opt` command.

    Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode disable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode disable
```

Expanding volume capacity with the GAD pair in PAIR status (SI)

If you expand the capacity of the S-VOL of a GAD pair while the pair is in PAIR status, the capacity of the P-VOL is also expanded automatically. Check the capacity of the pool used by the P-VOL and S-VOL before you expand the GAD S-VOL.

Prerequisites

Ensure that the following conditions are met:

- The storage systems at both the primary and secondary sites for the GAD pair must be VSP 5000 series with microcode version or firmware version 90-09-26-xx/xx or later.
- The differential data management method for the P-VOL and S-VOL of the GAD pair must be hierarchical difference management.
- The P-VOL or S-VOL of the GAD pair must not be shared with another GAD pair.

To check the differential data management method, see step 3 in Expanding volume capacity after suspending the GAD pair (SI).

If you are using SM difference management, perform step 4 in Expanding volume capacity after suspending the GAD pair (SI) to change the differential data management method to hierarchical difference management.

Note:

- To change the differential data management method from SM difference management to hierarchical difference management, you need to suspend the target GAD pair first.
- You cannot expand the capacity of the volumes of the SI pair with which the GAD pair shares the same volume while keeping the SI pair in PAIR status.

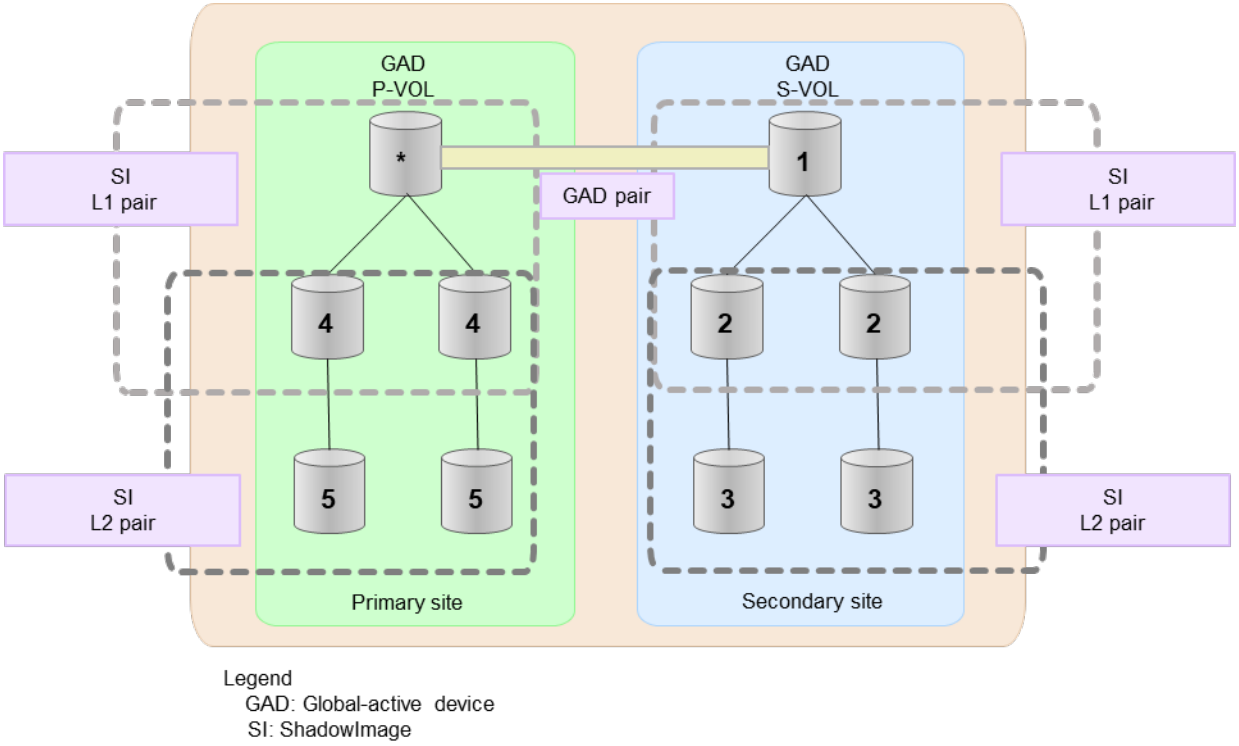
Procedure

1) Verify that each of the P-VOLs and S-VOLs of the GAD pair and the SI pair with which the GAD pair shares the same volume meets the general prerequisites in "Prerequisites" in Expanding DP-VOL capacity when a GAD pair is used with ShadowImage.
2) Verify that both the P-VOL and S-VOL of the GAD pair meet all prerequisites including the general prerequisites in "Prerequisites" in (1) Expanding DP-VOL capacity in a GAD pair.
3) Suspend the SI pair.
4) Verify that the GAD pair is in PAIR status.
5) Verify the pair status of the SI pair.

The volumes of the SI pair can be expanded when the pair status is PSUS or PSUE. If the pair status is other than PSUS or PSUE, perform appropriate pair operations to change the status to PSUS or PSUE.

6) Expand the capacity of the volumes and verify the completion of volume expansion in the sequence shown in the following figure.

   As the size of a single expansion, set 32 TB or less per volume. If you use HDvM - SN to expand the capacity of multiple volumes simultaneously, set 1 PB or less for the total size of expansion. If you set a greater value (more than 32 TB for one volume and more than 1 PB for multiple volumes), the GAD pair might be suspended by failure during capacity expansion.



* When you expand the capacity of the GAD S-VOL, the capacity of the P-VOL is simultaneously expanded. For this reason, verify the completion of P-VOL expansion as well.

Do not suspend the target GAD pair until the capacity expansion of the S-VOL is finished. If you do, suspension of the GAD pair might fail or take a long a time to complete, temporarily stopping host I/O to the GAD pair.

Note:

- If a failure occurs during volume expansion for a GAD pair, the GAD pair might be suspended by failure. In that case, verify that the capacity of the P-VOL and the capacity of the S-VOL match, and then resynchronize the GAD pair. If either P-VOL or S-VOL alone is expanded and the capacities of the two volumes do not match, expand the unexpanded volume by specifying the same capacity. Make sure that the capacity of the P-VOL and the capacity of the S-VOL match. Then resynchronize the GAD pair.

- If you cannot expand the volumes of the SI pair after you expand the volumes of the GAD pair, see (3) Recovering from failure when the capacity of one GAD volume cannot be expanded.

7) Verify that the GAD pair is in PAIR status.
8) Verify that volume expansion is not being performed for the GAD pair and all SI pairs.

   The following table shows how the expansion process is displayed.

Expansion status	CCI	HDvM - SN
	P column in the pairdisplay command output	Processing Status field in the Remote Replication or Local Replication window
Not being expanded	N	Blank
Being expanded	E*	Expanding*
* This status continues to be displayed after expanding the P-VOL or S-VOL capacity in the GAD pair, and before performing the pair resync operation. After the resync operation is complete, the status changes to "Not being expanded". For the SI pair, the Being expanded status is displayed for a while (30 seconds or so) after the expansion of the P-VOL or S-VOL capacity is complete. After that, the status changes to "Not being expanded".		

Expanding DP-VOL capacity when a GAD pair is used with Thin Image or Thin Image Advanced

You can expand the capacity of DP-VOLs used as pair volumes when a GAD pair is used with HTI or HTIA. The procedures are the same for HTI and HTIA. The procedures provide examples for expanding the DP-VOL capacity in a configuration where the HTI L1 pair and L2 pair are created for each volume of the P-VOL and S-VOL in the GAD pair. For the detailed procedures for verifying the differential data management method, expanding the capacity, and verifying the expansion during the following procedures, see (1) Expanding DP-VOL capacity in a GAD pair.

There are two ways to expand volume capacity. One is to suspend the GAD pair before you expand volume capacity. The other is to keep the GAD pair in PAIR status (not suspend the GAD pair) when you expand volume capacity.

Note: If you want to expand volume capacity while keeping the GAD pair in PAIR status, you must satisfy the conditions in "Prerequisites" in Expanding volume capacity with the GAD pair in PAIR status in addition to the general conditions in "Prerequisites" in each relevant section.

Prerequisites

- The V-VOL to be expanded must not be an external volume.
- The LDEV format is not being performed on a V-VOL to be expanded.
- The pool containing the V-VOL to be expanded must meet at least one of the following conditions:
  - Normal condition
  - The pool is not being shrunk.
- When using GAD, TC, or UR, there must be enough software license capacity for the page capacity assigned to the expanded volume capacity before the expansion.
- The V-VOL to be expanded must have been created on a valid storage system. For details, see *Expansion of DP-VOL capacity while keeping pair status* in the *Global-Active Device User Guide*.
- (Thin Image only) The V-VOL to be expanded must not be used in a pair with the clone attribute.
- (Thin Image only) The following numbers required after the expansion must not exceed the maximum number allowed on the storage system:
  - Snapshot estimated manageable capacity
  - Number of cache management devices
  - Subscription limit of the V-VOL capacity

For information about calculating these numbers, see Calculating the snapshot estimated manageable capacity, the numbers of cache management devices, and the subscription limit of the V-VOL capacity.

- (Thin Image Advanced only) If the GAD pair is used with Thin Image Advanced, ensure that the following numbers do not exceed the maximum number allowed on the storage system:
  - Estimated Configurable in the **Pools** window
  - Number of cache management devices

Expanding volume capacity after suspending the GAD pair (HTI/HTIA)

Procedure

1) Verify that each volume of the P-VOLs and S-VOLs in a GAD pair and HTI/HTIA pairs with which the GAD pair shares the same volumes meets the prerequisites.
2) Display the detailed information about the GAD pair on CCI by using the `pairdisplay` command.

3) If the capacity of each volume of the GAD pair is 4 TB or greater, proceed to step 5. If the capacity of a GAD pair volume is less than 4 TB, verify whether the current differential data management method is SM difference management or hierarchical difference management by a drive.
   - If SM difference management is applied, proceed to step 4.
   - If hierarchical difference management is applied, proceed to step 5.
   - If using HDvM - SN, verify the advanced system settings No. 5 and No. 6 in the **Edit Advanced System Settings** window.
     - If both the advanced system settings No. 5 and No. 6 are set to **Disable**, SM difference management is applied. Proceed to step 4.
     - If either or both the advanced system settings No. 5 and No. 6 are set to **Enable**, hierarchical difference management is applied. Proceed to step 5.
4) Change the differential data management method to hierarchical difference management.
   a) Change system settings for hierarchical difference management as follows.
      - If using CCI, set the system option mode (SOM) 1198 to ON and 1199 to OFF by using the `raidcom modify system_opt` command.

   Command example:

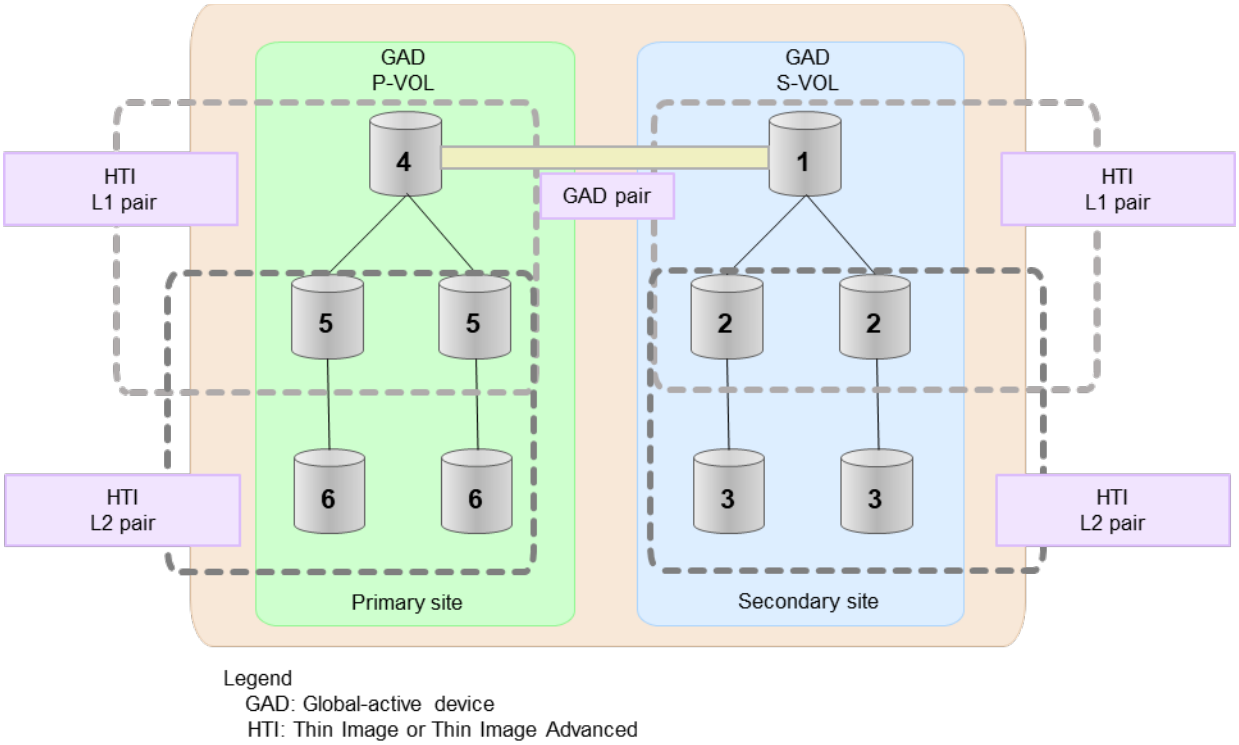
```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode enable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode disable
```

      - If using HDvM - SN, set the advanced system settings No. 5 to **Enable** and No. 6 to **Disable** in the **Edit Advanced System Settings** window. For details about the procedure, see the *System Administrator Guide*.

   b) Suspend the GAD pair.
   c) Resynchronize the GAD pair.
   d) Display the detailed information about the GAD pair on CCI.
   e) Verify that the current differential data management method is hierarchical difference management.
5) Suspend the GAD pair.
6) Verify the pair statuses of the HTI/HTIA pairs.

   The HTI/HTIA pair volume capacity can be expanded when the HTI/HTIA pairs are in the PAIR, PSUS, or PSUE status. Verify the current pair statuses of the HTI/HTIA pairs. If the pair statuses are not PAIR, PSUS, or PSUE, perform pair operations to change the pair statuses to PAIR or PSUS.
7) Expand each volume capacity, and then verify that the expansion is complete in the expansion order shown in the following figure.



After expanding the first volume capacity (S-VOL in the GAD pair), if you cannot expand the DP-VOL capacity in the HTI/HTIA pair, you cannot expand the P-VOL capacity in the GAD pair, or you cannot resynchronize the GAD pair, make sure to perform the recovery procedure described in (3) Recovering from failure when the capacity of one GAD volume cannot be expanded.

8) Resynchronize the GAD pair.

9) Verify that both the pair statuses of the P-VOL and S-VOL in each pair of the GAD pair have changed to PAIR(Mirror(RL)).

   In addition, verify that each volume capacity in the GAD pair and HTI/HTIA pair is not being expanded. The following table shows how the expansion process is displayed.

Expansion status	CCI	HDvM - SN
	P column in the pairdisplay or raidcom get snapshot command output	**Processing Status field in the Remote Replication or HTI/HTIA Pairs window**
Not being expanded	N	Blank
Being expanded	E*	Expanding*
* These statuses have been displayed after expanding the P-VOL or S-VOL capacity in the GAD pair, and before performing the pair resync operation. After the resync operation is complete, the status is migrated to the Not being expanded status. In the HTI/HTIA pair, the Being expanded status is displayed for a while (30 seconds or so) after the expansion of the P-VOL and S-VOL capacity is complete. After that, the status is migrated to the Not being expanded status.		

10) In step 3, if the differential data management method is SM difference management, restore to SM difference management using the following procedure:

a) Restore to SM difference management as follows.

- If using CCI, set the system option mode (SOM) 1198 to OFF and 1199 to ON by using the `raidcom modify system_opt` command.

Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode disable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode enable
```

- If using HDvM - SN, set the advanced system settings No. 5 to **Disable** and No. 6 to **Disable** in the **Edit Advanced System Settings** window. For details about the procedure, see the *System Administrator Guide*.

b) Suspend the GAD pair.

c) Resynchronize the GAD pair.

d) Display the detailed information about the GAD pair on CCI.

e) Verify that the current differential data management method is SM difference management.

f) If using CCI, and the settings of SOMs 1198 and 1199 have been changed, set SOM 1198 to OFF and 1199 to OFF by using the `raidcom modify system_opt` command.

Command example:

```
raidcom modify system_opt -system_option_mode system -mode_id 1198 -
mode disable

raidcom modify system_opt -system_option_mode system -mode_id 1199 -
mode disable
```

Expanding volume capacity with the GAD pair in PAIR status (HTI/HTIA)

If you expand the capacity of the S-VOL of a GAD pair while the pair is in PAIR status, the capacity of the P-VOL is also expanded automatically. Check the capacity of the pool used by the P-VOL and S-VOL before you expand the GAD S-VOL.

Prerequisites

Ensure that the following conditions are met:

- The storage systems at both the primary and secondary sites for the GAD pair must be VSP 5000 series with microcode version or firmware version 90-09-26-xx/xx or later.

- The differential data management method for the P-VOL and S-VOL of the GAD pair must be hierarchical difference management.
- The P-VOL or S-VOL of the GAD pair must not be shared with another GAD pair.

To check the differential data management method, see step 3 in Expanding volume capacity after suspending the GAD pair (HTI/HTIA).

If you are using SM difference management, perform step 4 in Expanding volume capacity after suspending the GAD pair (HTI/HTIA) to change the differential data management method to hierarchical difference management.

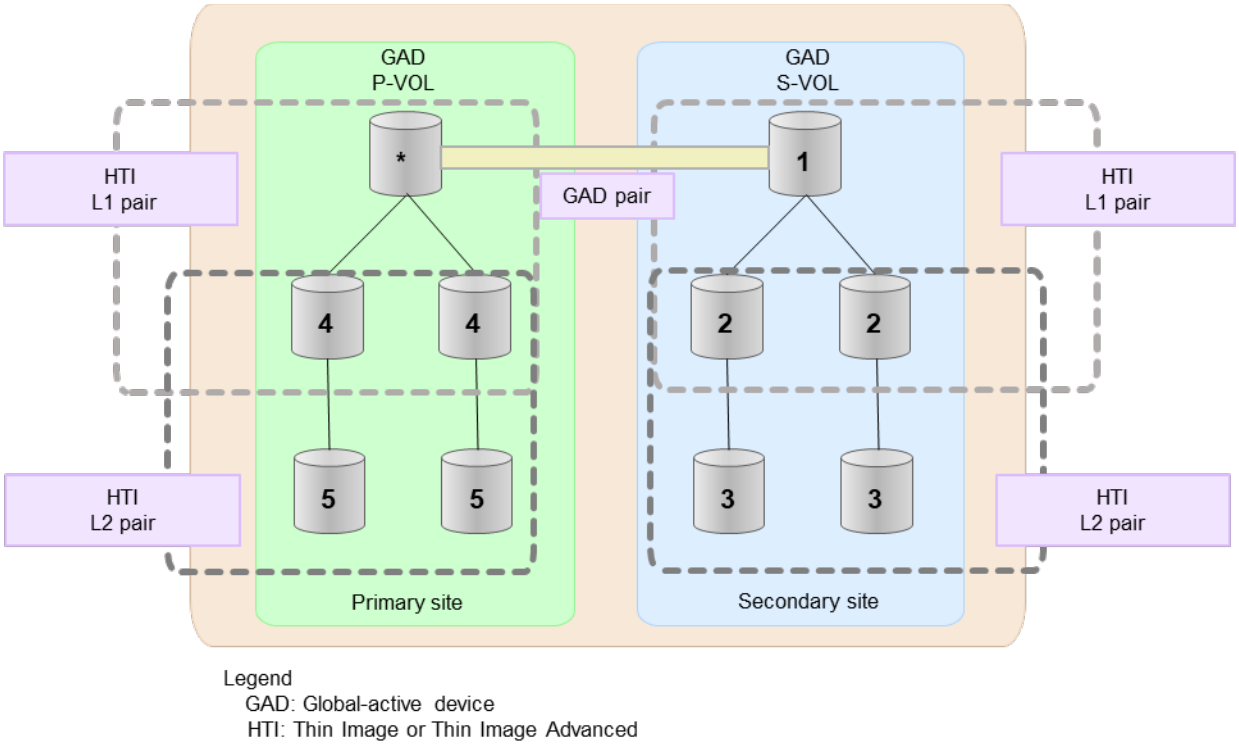
Note: To change the differential data management method from SM difference management to hierarchical difference management, you need to suspend the target GAD pair first.

Procedure

1) Verify that each of the P-VOLs and S-VOLs of the GAD pair and the HTI/HTIA pair with which the GAD pair shares the same volume meets the general prerequisites in "Prerequisites" in Expanding DP-VOL capacity when a GAD pair is used with Thin Image or Thin Image Advanced.
2) Verify that both the P-VOL and S-VOL of the GAD pair meet all prerequisites including the general prerequisites in "Prerequisites" in (1) Expanding DP-VOL capacity in a GAD pair.
3) Verify that the GAD pair is in PAIR status.
4) Verify the pair status of the HTI/HTIA pair.

   The volumes of the HTI/HTIA pair can be expanded when the pair status is PAIR, PSUS, or PSUE. If the pair status is other than PAIR, PSUS, or PSUE, perform appropriate pair operations to change the pair status to PAIR or PSUS.
5) Expand the capacity of the volumes and verify the completion of volume expansion in the sequence shown in the following figure.

   As the size of a single expansion, set 32 TB or less per volume. If you use HDvM - SN to expand the capacity of multiple volumes simultaneously, set 1 PB or less for the total size of expansion. If you set a greater value (more than 32 TB for one volume and more than 1 PB for multiple volumes), the GAD pair might be suspended by failure during capacity expansion.



* When you expand the capacity of the GAD S-VOL, the capacity of the P-VOL is simultaneously expanded. For this reason, verify the completion of P-VOL expansion as well.

Do not suspend the target GAD pair until the capacity expansion of the S-VOL is finished. If you do, suspension of the GAD pair might fail or take a long a time to complete, temporarily stopping host I/O to the GAD pair.

Note:

- If a failure occurs during volume expansion for a GAD pair, the GAD pair might be suspended by failure. In that case, verify that the capacity of the P-VOL and the capacity of the S-VOL match, and then resynchronize the GAD pair. If either P-VOL or S-VOL alone is expanded and the capacities of the two volumes do not match, expand the unexpanded volume by specifying the same capacity. Make sure that the capacity of the P-VOL and the capacity of the S-VOL match. Then resynchronize the GAD pair.
- If you cannot expand the volumes of the HTI/HTIA pair after you expand the volumes of the GAD pair, see (3) Recovering from failure when the capacity of one GAD volume cannot be expanded.

6) Verify that the GAD pair is in PAIR status.

7) Verify that volume expansion is not being performed for the GAD pair and all HTI/HTIA pairs.

   The following table shows how the expansion process is displayed.

Expansion status	CCI	HDvM - SN
	P column in the pairdisplay or raidcom get snapshot command output	Processing Status field in the Remote Replication or HTI/HTIA Pairs window
Not being expanded	N	Blank
Being expanded	E*	Expanding*
* This status continues to be displayed after expanding the P-VOL or S-VOL capacity in the GAD pair, and before performing the pair resync operation. After the resync operation is complete, the status changes to "Not being expanded". For the HTI/HTIA pair, the Being expanded status is displayed for a while (30 seconds or so) after the expansion of the P-VOL or S-VOL capacity is complete. After that, the status changes to "Not being expanded".		

Calculating the numbers of differential and pair tables for each pair

If a DP-VOL exceeds 4 TB, the differential tables are placed in the hierarchy memory instead of the shared memory, and the differential tables in the shared memory are not used. Therefore, it is not necessary to calculate the number of differential tables for DP-VOLs over 4 TB.

Procedure

1) Calculate how many differential tables are required for each pair.

   Use the following formulas:

```
(number-of-differential-tables-for-expansion) = (number-of-differential-tables-after-expansion) - (number-of-differential-tables-before-expansion)

(number-of-differential-tables-per-pair) = ceiling ((volume-capacity [KB] / 256) / 20,448)
```

   Ensure that the ceiling value enclosed in the parentheses () is rounded up to the next integer.

2) Calculate how many pair tables are required for each pair.

   Use the following formulas:

```
(number-of-pair-tables-for-expansion) = (number-of-pair-tables-after-expansion) - (number-of-pair-tables-before-expansion)

(number-of-pair-tables-per-pair) = ceiling ((number-of-pair-tables-per-pair / 36)
```

   Ensure that the ceiling value enclosed in the parentheses () is rounded up to the next integer.

3) Verify that the following numbers do not exceed the maximum number allowed on the storage system.
   - The total numbers of current pair tables and pair tables required for expanding the capacity
   - The total numbers of current differential tables and differential tables required for expanding the capacity

   You can check the numbers of differential and pair tables in the **Local Replication** window.

Calculating the snapshot estimated manageable capacity, the numbers of cache management devices, and the subscription limit of the V-VOL capacity

Procedure

1) Calculate the snapshot estimated manageable capacity required for expanding the capacity of an HTI/HTIA root volume.

   To expand the capacity of an HTI/HTIA root volume, verify that the snapshot estimated manageable capacity is available. Use the following formulas:

```
(Snapshot-estimated-manageable-capacity-for-root-volume-expansion) = (Snapshot-estimated-manageable-capacity-after-root-volume-expansion) - (Snapshot-estimated-manageable-capacity-before-root-volume-expansion)

(Snapshot-estimated-manageable-capacity) = (Root-volume-capacity [TB] / 2.6 [TB]) × 3,024 [GB] + (168 [GB] × 2 (consumed-shared-memory [GB]))
```

Expanding the volumes other than a root volume does not consume the snapshot estimated manageable capacity. You can check the snapshot estimated manageable capacity in the **Local Replication** window.

2) Calculate the maximum number of cache management devices required for expanding the capacity of an HTI/HTIA root volume.

   To expand the capacity of an HTI/HTIA root volume, verify that the cache management devices are available.

   Use the following formula:

```
(number-of-cache-management-devices-for-root-volume-expansion) =
ceiling ((Root-volume-capacity-after-expansion [TB] / 2.6 [TB])) - ceiling
((Root-volume-capacity-before-expansion [TB] / 2.6 [TB]))
```

   Ensure that the ceiling value enclosed in the parentheses () is rounded up to the next integer.

   Expanding the volumes other than a root volume does not consume the cache management devices. The formula for calculating the maximum number of cache management devices differs for Thin Image Advanced. See the *Thin Image Advanced User Guide*.

3) Calculate the V-VOL capacity to be added by expanding the capacity of an HTI/HTIA root volume.

   To expand the capacity of an HTI/HTIA root volume, verify that the capacity after the expansion does not exceed the subscription limit of the V-VOL capacity contained in a DP pool.

   Use the following formula:

```
(V-VOL-capacity-added-by-root-volume-expansion) = (HTI/HTIA-pair-capacity-
calculated-based-on-root-volume-capacity-after-expansion) - (HTI/HTIA-pair-
capacity-calculated-based-on-root-volume-capacity-before-expansion)

(HTI/HTIA-pair-capacity) = Σ ceiling ((Root-volume-capacity [MB] × number-of-
pairs* × 2 / 42 [MB])) × 42 [MB]+ Σ ceiling ((Root-volume-capacity [MB] ×
number-of-pairs* × 2 / 2,921,688 [MB])) × 175,434 [MB]
```

   * Use the maximum number of HTI/HTIA pairs to be created in the applicable snapshot tree as number-of-pairs instead of the number of pairs currently created in the applicable snapshot tree because the allocated pages are not released if you delete some pairs.

   Ensure that the ceiling value enclosed in the parentheses () is rounded up to the next integer.

   Expanding volumes other than a root volume does not add the V-VOL capacity contained in the DP pool in Thin Image/Thin Image Advanced.

(3) Recovering from failure when the capacity of one GAD volume cannot be expanded

If the capacity of only one volume in a GAD pair is expanded, the create, resync, swap resync, and horctakeover operations for the GAD pair cannot be performed because the capacity of both volumes is not the same.

If a GAD pair shares volumes with UR, SI, HTI, or HTIA and the capacity of a shared volume fails to expand, it causes an invalid state in which the expansion of the entire volume capacity is not complete.

Perform the following operation to recover from this invalid state.

For more information about the I/O operations of the P-VOL and S-VOL in a GAD pair when the resync operation in a GAD pair cannot be performed, see the information about I/O modes in the *Global-Active Device User Guide*.

Procedure

1) Verify that all prerequisites are met.
   a) Verify that both the P-VOL and S-VOL in a GAD pair meet the prerequisites for expanding the DP-VOL capacity. See (1) Expanding DP-VOL capacity in a GAD pair.
   b) Verify that all volumes meet the prerequisites for expanding the capacity in each of the software products. If a GAD pair is used with UR, SI, HTI, or HTIA, the capacity of the P-VOLs and S-VOLs in all used software products must be expanded.

   If the prerequisites are not met, proceed to step 4.
2) When the prerequisites for expanding the DP-VOL capacity are met, retry the expansion and make sure that the capacity of the P-VOL and S-VOL in the GAD pair is the same.
   a) If there is not enough free space, increase the free space, and then expand the DP-VOL capacity.
   b) If a GAD pair is used with UR, SI, HTI, or HTIA, retry the expansion and make sure that the capacity of the P-VOL and S-VOL in each of the software products is the same.
      - If you can expand the capacity, go to step 3.
      - If you cannot expand the capacity, go to step 4.
3) Resynchronize the GAD pair if it is suspended.

   When a GAD pair is used with UR, resynchronize the UR pair. As a result, the recovery procedure from the failure is complete.

4) Delete the GAD pair, expand the volume capacity in the SMPL status, and then re-create the GAD pair.
    - If you want to restore to the conditions before the expansion due to a capacity input error and others, delete the GAD pair, and then re-create the LDEV with the correct capacity. After that, re-create the GAD pair.
    - If a GAD pair is used with UR, delete all pairs, expand the volume capacity in the SMPL status, and then restore the configurations by following the procedure for creating the configurations.

    If you want to restore to the conditions before the expansion due to a capacity input error and others, delete all pairs, and then re-create the LDEV with the correct capacity. After that, restore the configurations by following the procedure for creating the configurations.
    - If a GAD pair is used with SI, HTI, or HTIA and the capacity of the P-VOL and S-VOL in an SI, HTI, or HTIA pair is not the same, you can only delete the SI, HTI, or HTIA pair. You can read the S-VOL data in the SI, HTI, or HTIA pair before the expansion.

    If you want to use the data before the expansion, delete all pairs after the data reading is complete. Expand the volume capacity in the SMPL status, and then restore the configurations by following the procedure for creating the configurations.

    If you want to restore to the conditions before the expansion due to a capacity input error and others, delete all pairs, and then re-create the LDEV with the correct capacity. After that, restore the configurations.

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