Table 81 Number of differential tables used in OPEN-V (continued)

Capacity[1]	Differential Tables	Capacity[1]	Differential Tables	Capacity[1]	Differential Tables
Up to 1,915.9GB	128	Up to 2,409.9GB	161		
Up to 1,930.9GB	129	Up to 2,424.9GB	162		

1. 1 GB = 10243 Byte

If you intend to create pairs with volumes of different emulation types, the maximum number of pairs you can create depends on the following conditions.

- If an LU consists of one volume (when LUSE is not used):

    The maximum number of pairs you can create is the largest number that meets the equation, $\Sigma(\alpha) \leq \beta$, where:

    $\Sigma\alpha$ is total number of differential tables per pair (see Table 81)

    β is number of differential tables in the disk array

    β = 13,652 when additional shared memory for differential tables is not installed

    β = 30,718 when additional shared memory for differential tables is installed

    For example, if you create 10 pairs of OPEN-3 volumes and 20 pairs of OPEN-L volumes in a disk array that does not have additional shared memory for differential tables, use the following equation to calculate, $\Sigma\alpha$:

    (1 x 10) + (13 x 20) = 270

    Because 270 is smaller than 13,652, it meets the equation, $\Sigma(\alpha) \leq \beta$, ensuring that 10 pairs of OPEN-3 volumes and 20 pairs of OPEN-L volumes can be created.

- If an LU consists of more than one volume (when LUSE volumes are used):

    The maximum number of pairs you can create is the largest number that meets the equation, $\Sigma(\Sigma\alpha) \leq \beta$, where:

    $\Sigma\alpha$ is total number of differential tables used by each volume constituting a LUSE volume. Every volume constituting a LUSE volume shares the same differential tables with the other volume in the same pair.

    β is number of differential tables available in the disk array.

    For example, if you create 10 pairs of LUSE volumes consisting respectively of three OPEN-3 volumes and one OPEN-E volume (that is, not a customized volume), and 20 pairs of LUSE volumes consisting respectively of five OPEN-L, use the following equation to calculate $\Sigma\Sigma\alpha$:

    ((1 x 3) + (5 x 1)) x 10 + (13 x 5 x 20) = 1,380

    Because 1,380 is smaller than 13,652, it meets the equation, $\Sigma(\Sigma\alpha) \leq \beta$, ensuring that 10 pairs of LUSE volumes consisting respectively of three OPEN-3 volumes and 20 pairs of LUSE volumes consisting respectively of five OPEN-L volumes (33.9GB) can be created.

BC operations

Set reserve attribute operation

This operation reserves a volume so it can be used as a BC S-VOL. Reserved volumes can only be used as BC S-VOLs. The disk array rejects all write operations to reserved volumes (unless in split (PSUS) status).

You can reserve up to 4,095 volumes in one disk array. Use the Set Reserve Attribute window (see "Setting reserve attributes" on page 459) to reserve volumes for use as BC S-VOLs.

A volume might be reserved for BC to ensure that a server does not mount it before BC can use it in a pair. BC cannot use a volume as an S-VOL if it is being used by a server.

NOTE: BC leaf volumes (L2 cascade pair) also function as S-VOLs and must be reserved prior to being assigned to an L2 cascade pair.

Reset reserve attribute operation

This operation unreserves a volume so it can be mounted and accessed by all hosts. After you reset the reserve attribute, the disk array accepts all subsequent I/O operations to the volume. Use the Reset Reserve Attribute window (see "Resetting reserve attributes" on page 460) to unreserve volumes.

Paircreate operation

This operation establishes the new BC pair(s). The volume that will be the P-VOL must be in the SMPL (simplex) state, and the volume that will be the S-VOL must be in the SMPL state before being added to a BC pair.

NOTE: You can reserve the S-VOL before creating a pair, but you can also create a pair with an unreserved S-VOL. Use the Paircreate window (see "Creating BC pairs (Paircreate)" on page 461) to create new BC volume pairs.

Initial copy operation

This operation occurs when you create a new volume pair (see Figure 235). The BC initial copy operation copies all data on the P-VOL to the associated S-VOL. The P-VOL remains available to all hosts for read and write I/Os throughout the initial copy operation. After the initial copy is complete, the update copy operation duplicates write operations performed on the P-VOL during the initial copy operation at the S-VOL.

Before the initial copy operation, the status of a pair is SMPL. The status of the pair is COPY(PD) (PD = pending) while the initial copy operation is in progress. The status changes to PAIR when the initial copy is complete. Write operations performed on the P-VOL during the initial copy operation are duplicated at the S-VOL by update copy operations after the initial copy is complete.
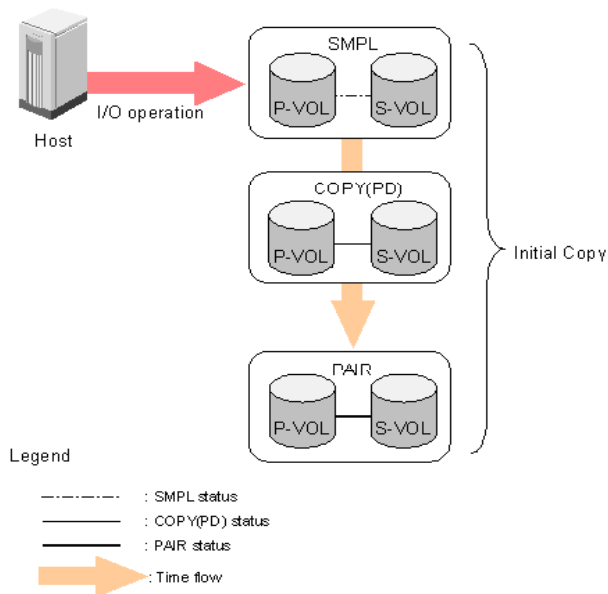
Figure 235 Adding a pair in BC

Update copy operation

This operation updates the S-VOL of a BC pair after the initial copy operation is complete. Since a P-VOL remains available to all hosts for read and write I/Os during the initial copy operation, the P-VOL might be updated during the operation. Therefore, when the status of the pair changes to PAIR after the initial copy operation is complete, the update copy operation takes place and the P-VOL's differential data is copied to the S-VOL. Update copy operations take place only for duplex pairs (status = PAIR). As write I/Os are performed on a duplex P-VOL, the disk array stores a map of the P-VOL's differential data, and performs update copy operations periodically based on the amount of differential data present on the P-VOL and the elapsed time between update copy operations. Figure 236 illustrates an update copy operation in a BC pair with only one S-VOL.

📝 NOTE:

- Update copy operations are not performed for pairs with the following status: COPY(PD) (pending duplex), COPY(SP) (steady split pending), PSUS(SP) (quick split pending), PSUS (split), COPY(RS) (resync), COPY(RS-R) (resync-reverse), and PSUE (suspended).

- Update copy operations do not occur every time a host issues a write I/O operation to the P-VOL of a BC pair. BC update copy operations are performed asynchronously according to the differential bitmap, which is stored in shared memory.

- If shared memory is lost (for example, offline micro exchange or volatile PS on), the differential bitmap is also lost. In this case, the disk array treats the entire BC P-VOL (S-VOL for COPY(RS) pairs) as difference data and recopies all data to the S-VOL (P-VOL for COPY(RS) pairs) to ensure proper pair resynchronization. For pairs with COPY(SP) or PSUS(SP) status, the disk array changes the status to

PSUE due to the loss of the differential bitmap, also ensuring proper resynchronization of these pairs. If shared memory is lost, allow extra time for BC operations.
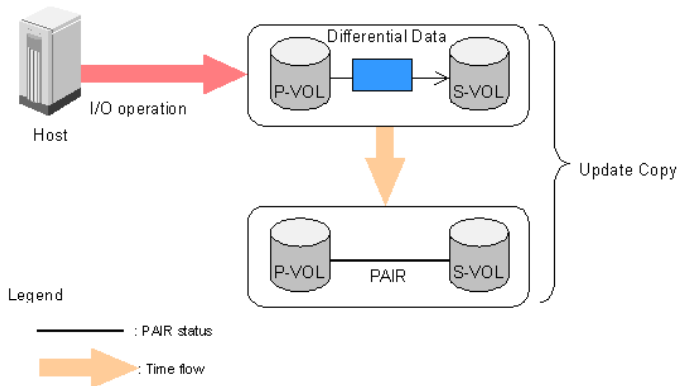

Figure 236 Update copy operation

Cascade function

This function creates a second layer of BC volume pairs (L2) underneath the first layer of BC pairs (L1). Cascade pairs are created by clicking Cascade instead of Set in the Paircreate window (see "Creating BC pairs (Paircreate)" on page 461). This cascade layering scheme creates up to nine copies of one BC P-VOL. See "Cascade function" on page 436 for further information on cascade pairs and the cascade function.

Pairsplit operation

The BC split capability provides point-in-time backup of data, and facilitates real data testing by making the BC copies (S-VOLs) available for host access. The BC pairsplit operation performs all pending S-VOL updates (those issued prior to the split command and recorded in the P-VOL track map) to make the S-VOL identical to the state of the P-VOL when the split command was issued, and then provides full read/write access to the split S-VOL. You can split existing pairs as needed. You can also use the pairsplit operation to create and split pairs in one step.

Use the Pairsplit window (see "Splitting BC pairs (Pairsplit)" on page 465) to split existing BC pairs or to add and split new BC pairs in one step. When the split operation is complete, the pair status changes to PSUS, and you have full read/write access to the split S-VOL (even though it is still reserved). While the pair is split, the disk array establishes a track map for the split P-VOL and S-VOL, and records all updates to both volumes. The P-VOL remains fully accessible during the pairsplit operation. Pairsplit operations cannot be performed on suspended (PSUE) pairs.

- When splitting pairs, you can select the pace for the pending update copy operation: Slower, Medium, and Faster. The slower pace minimizes the impact of BC operations on disk array I/O performance, while the faster pace splits the pairs as quickly as possible.

- When splitting pairs, you can also select the split type: Quick Split or Steady Split.

  - When quick split operations start, the pair status changes to PSUS(SP), and the S-VOL is available immediately for read and write I/Os (even though it is still reserved). The disk array performs all pending update copy operations to the S-VOL in the background. When the quick split is complete, the pair status changes to PSUS.

  - When steady split operations start, the pair status changes to COPY(SP), and the disk array performs all pending update copy operations to the S-VOL. When the Steady Split operation is complete, the pair status changes to PSUS, and you have full read/write access to the split S-VOL (even though it is still reserved).

Pairresync operations

To change the status of the pairs from PSUS to PAIR, or from PSUE to PAIR, you must resynchronize the pairs. BC can perform the following types of pairresync operations according to the speed and direction of the resynchronization:

- Normal Copy

- Quick Resync

- Reverse Copy

- Quick Restore

Use the Pairresync panel to resynchronize split and suspended BC pairs. When the pairresync operation starts, the pair status changes to COPY(RS) or COPY(RS-R). When the pairresync is complete, the pair status changes to PAIR. The local disk array resumes BC update copy operations after the pair status changes to PAIR. The P-VOL remains fully accessible during a normal pairresync operation, but is inaccessible to all hosts during a reverse or quick restore pairresync operation. This ensures that data on the P-VOL is identical to data on the S-VOL when the reverse or quick restore pairresync operation completes.

NOTE: You can use BC to perform normal or quick pairresync operations on split and suspended pairs, but you can perform reverse or quick restore pairresync operations only on split pairs.

Forward pairresync operation

A forward pairresync operation resynchronizes pairs by copying data on P-VOLs to S-VOLs. The following are the types of forward pairresync operations:

- Normal. This operation (see Figure 237) resynchronizes the S-VOL with the P-VOL. The copy direction for a normal pairresync operation is P-VOL to S-VOL. The pair status during a normal resync operation is COPY(RS), and the P-VOL remains accessible to all hosts for read and write operations during a normal pairresync.

- Quick. This operation speeds up the normal pairresync operation without copying the P-VOL data to the S-VOL. The P-VOL and S-VOL are resynchronized when update copy operations are performed for duplex pairs (status = PAIR). The pair status during a quick pairresync operation is PSUS(SP) until the

differential map is copied, and the P-VOL remains accessible to all hosts for read and write operations. The S-VOL becomes inaccessible to all hosts during a quick pairresync operation.
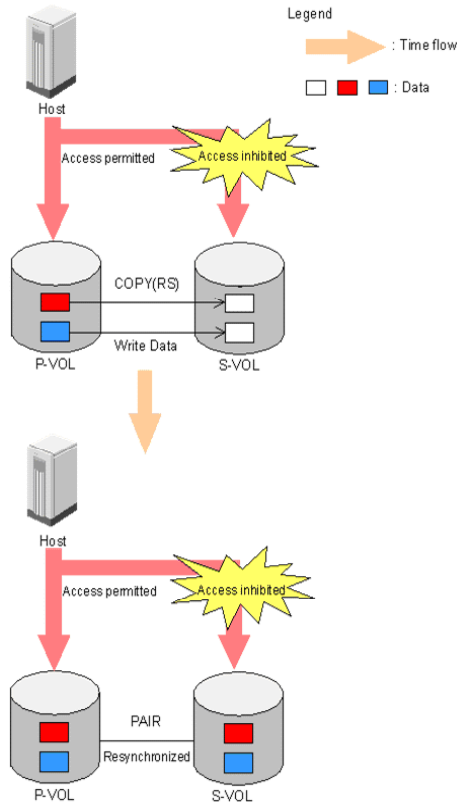

Figure 237 Normal and quick pairresync operations

Backward pairresync operation

A backward pairresync operation resynchronizes pairs by copying data on S-VOLs to P-VOLs. The following are the types of backward pairresync operations:

- Reverse. This operation (see Figure 238) synchronizes the P-VOL with the S-VOL. The copy direction for a reverse pairresync operation is S-VOL to P-VOL. Table 82 lists operational requirements for the reverse pairresync operation. The pair status during a reverse resync operation is COPY(RS-R), and the P-VOL and S-VOL become inaccessible to all hosts for write operations during a reverse pairresync operation. When the reverse pairresync is complete, the P-VOL becomes accessible. The reverse pairresync operation can only be performed on split pairs, not on suspended pairs. The reverse pairresync operation cannot be performed on L2 cascade pairs.

NOTE: The P-VOL remains read-enabled during the reverse pairresync operation only to enable the host to recognize the volume. Data on the P-VOL is not guaranteed until the reverse pairresync operation is complete and the status changes to PAIR.

- Quick Restore. This operation (Figure 238) speeds up reverse resync by changing the volume map in the disk array to swap the contents of the P-VOL and S-VOL without copying the S-VOL data to the P-VOL. The P-VOL and S-VOL are resynchronized when update copy operations are performed for pairs in PAIR status. The pair status during a quick restore operation is COPY(RS-R) until the volume map change is complete. The P-VOL and S-VOL become inaccessible to all hosts for write operations during

a quick restore operation. Quick restore cannot be performed on L2 cascade pairs. Table 82 lists operational requirements for the quick restore operation.
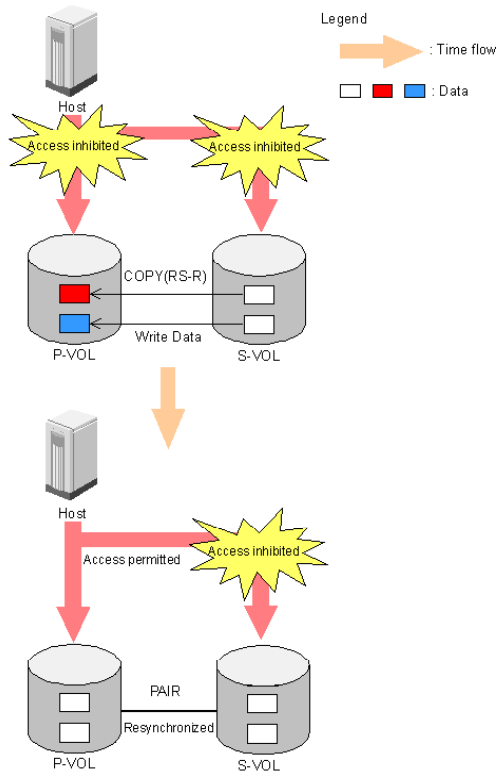

Figure 238 Reverse and quick restore pair operations

📝 NOTE: The P-VOL remains read-enabled during the quick restore operation only to enable the host to recognize the volume. Data on the P-VOL is not guaranteed until the quick restore operation is complete and the status changes to PAIR.

📝 NOTE: When a quick restore operation is in progress, the array management user interface may display old configuration information. To update the information in the user interface, wait for the quick restore operation to finish, and click Refresh.

⚠ CAUTION: During a quick restore operation, the RAID levels, HDD types, and Cache LUN settings of the P-VOL and S-VOL are exchanged. For example, if the P-VOL has a RAID-1 level and the S-VOL has a RAID-5 level, the quick restore operation changes the P-VOL to RAID-5 and the S-VOL to RAID-1.

To avoid any performance impact due to the quick restore operation

1. Ensure that the P-VOL and S-VOL have the same RAID level and HDD type before performing the quick restore operation. To restore the original RAID levels after a quick restore, stop host I/Os to the pair, split the pair, perform the quick restore operation for that pair again, and restart host I/Os to the pair.

2. Because Cache LUN settings are exchanged during a quick restore operation, you must perform one of the following operations. If you do not, the change of location of cache residence areas may cause I/O performance to the Cache LUN data to be down.

- Set the same Cache LUN settings (locations) for the P-VOL and S-VOL before performing the quick restore operation.

- Release the Cache LUN settings of the P-VOL and S-VOL before the quick restore operation, and reset the Cache LUN settings of the P-VOL and S-VOL after the pair changes to PAIR status as a result of the quick restore operation.

⚠ CAUTION: If you do not want the P-VOL and S-VOL to be resynchronized after the quick restore operation, set the Swap&Freeze option before performing the quick restore operation (see "Swap&Freeze option" on page 435 and "Setting BC options" on page 477).

Table 82   BC pairresync parameter requirements

Parameter	Requirement(s)
Pair status.	The specified pair must be in the PSUS state. If not, the reverse or quick restore pairresync command will be rejected. All other pairs sharing the same P-VOL as the specified pair must also be in the PSUS or PSUE state. If not, the reverse or quick restore pairresync command will be rejected.
Effect on other pairs sharing the P-VOL.	• If the BC P-VOL is also a CA P-VOL and the pair is in PAIR status, the reverse and quick restore pairresync operations cannot be performed. (The command will be rejected.) If the pair is in PSUS (suspended) status, the reverse and quick restore pairresync operations can be performed. • If the BC P-VOL is also a CA S-VOL and the pair is in PAIR status, the reverse and quick restore pairresync operations cannot be performed. (The command will be rejected.) If the pair is in PSUS (suspended) status, the reverse and quick restore pairresync operations can be performed. • If the BC S-VOL is also a CA P-VOL, the reverse and quick restore pairresync operations cannot be performed. (The command will be rejected.) • During the reverse or quick restore pairresync operation, a CA pair cannot be created. The CA paircreate command will be rejected when the BC pair status is COPY(RS-R). • For XP12000 only, if the BC P-VOL forms a pair with a CA S-VOL and an external S-VOL, the quick restore pairresync operation cannot be performed. • For XP12000 only, if the BC P-VOL forms a pair with an external S-VOL and a shared CA S-VOL, the quick restore pairresync operation cannot be performed. • For XP12000 only, if the BC S-VOL forms a pair with an external P-VOl and a shared CA P-VOL, the quick restore pairresync operation cannot be performed.

Table 82 BC pairresync parameter requirements (continued)

Parameter	Requirement(s)
Reverse or quick restore pairresync command issued to a shared BC/CA volume.	If the reverse or quick restore pairresync operation is performed on one BC pair in a 1-to-n BC configuration (n>1), the P-VOL and the other S-VOLs are no longer synchronized. While this reverse or quick restore pairresync is in progress, you cannot perform paircreate, pairsplit, or pairresync operations for any other pair sharing the same P-VOL (pairsplit-S and pairsplit-E are allowed). During the reverse or quick restore pairresync operation, you cannot create a CA pair or CA Journaling pair. The CA paircreate command and CA Journaling paircreate command will be rejected when the BC pair status is COPY(RS-R). When the shared BC or CA volume is paired with an external volume shown in Figure 239, Figure 240, or Figure 241, the quick restore pairresync operation cannot be performed. Also, when the shared BC or CA Journaling volume is paired with an external volume shown Figure 242 and Figure 243, the quick restore pairresync operation cannot be performed. In Figure 239, Figure 240, Figure 241, Figure 242, and Figure 243, a colored volume is an internal volume, and a volume without color is an external volume.
Reverse or quick restore resync ends abnormally; OR, Pairsplit-E (PSUE) is requested during reverse or quick restore resync.	1. The pair status changes to PSUE. 2. The P-VOL of the PSUE pair is read- and write-enabled for all hosts; however, data on the P-VOL is not guaranteed. The S-VOL of the PSUE pair remains write-disabled (read-only); however, data on the S-VOL is not guaranteed. 3. The status of other BC pairs sharing the same P-VOL does not change.
Reverse or quick restore pairresync command issued to a shared BC or CA Journaling volume.	If the BC and CA Journaling pairs share the same volume, and the CA Journaling pair is not suspended, the reverse and quick restore pairresync operations cannot be performed. (The command will be rejected.)

NOTE: A P-VOL of CA Journaling means a primary data volume of CA Journaling. An S-VOL of CA Journaling means a secondary data volume of CA Journaling.

CAUTION: If a reverse or quick restore resync operation ends abnormally, or a Pairsplit-E (PSUE) is requested during reverse or quick restore resync operation, the status of other BC pairs that share the same P-VOL does not change.

NOTE: When a reverse or quick restore pairresync is in progress, you cannot perform paircreate, pairsplit, or pairresync operations for any other pair that shares the same P-VOL (parisplit-S and pairsplit-E are allowed).
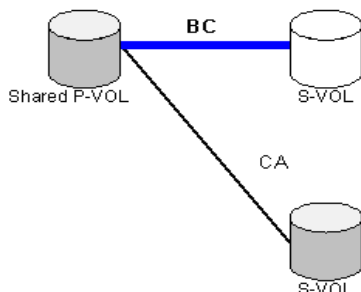

Figure 239 BC P-VOL forming pair with CA S-VOL and external S-VOL, respectively
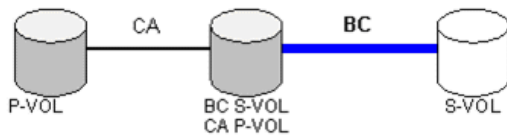
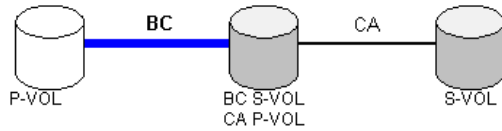Figure 240 BC P-VOL forming pair with external S-VOL and shared as CA S-VOL

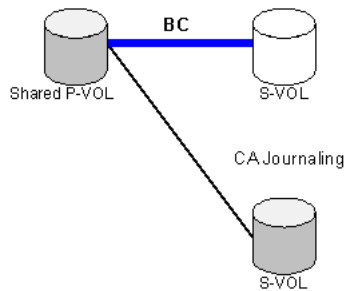Figure 241 BC S-VOL forming pair with external P-VOL and shared as CA P-VOL

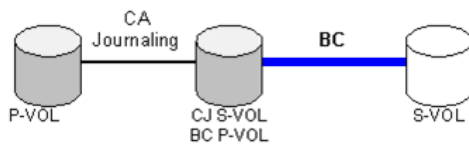Figure 242 BC P0VOL forming pair with CA Journaling S-VOL and External S-VOL, respectively

Figure 243 BC P-VOL forming pair with external S-VOL and shared as CA Journaling S-VOL

Use the Pairresync window (see "Resynchronizing BC pairs (Pairresync)" on page 470) to resynchronize split and suspended BC pairs. When the pairresync operation starts, the pair status changes to COPY(RS) or COPY(RS-R). When the pairresync is complete, the pair status changes to PAIR. The disk array resumes BC update copy operations after the pair status changes to PAIR. The P-VOL remains fully accessible during a normal pairresync operation, but becomes inaccessible to all hosts during a reverse or quick restore pairresync operation. This ensures that data on the P-VOL is identical to data on the S-VOL when the reverse or quick restore pairresync operation completes.

Pair status and time required for pairresync

The pairresync operation can be performed on a split pair or suspended pair. This section describes the relationship between the pair status and the time required for pairresync operations.

- Pairresync for split pair. When a normal/quick pairresync operation is performed on a split pair (status = PSUS), the disk array copies all flagged tracks from the P-VOL to the S-VOL. When a reverse or quick restore pairresync operation is performed on a split pair, the disk array copies all flagged tracks from the S-VOL to the P-VOL. This ensures that the P-VOL and S-VOL are properly resynchronized in the desired direction, and greatly reduces the time needed to resynchronize the pair.

- Pairresync for suspended pair. When a normal/quick pairresync operation is performed on a suspended pair (status = PSUE), the disk array copies all data on the P-VOL to the S-VOL, because all P-VOL tracks were flagged as difference data when the pair was suspended. Reverse and quick restore

pairresync operations cannot be performed on suspended pairs. The normal pairresync operation for suspended pairs is equivalent to and takes as long as the BC initial copy operation.

> ⚠️ **CAUTION:** When resynchronizing pairs, you can select the pace for the pairresync operation: slower, medium, or faster. The slower pace minimizes the impact of BC operations on subsystem I/O performance. The faster pace resynchronizes the pairs as quickly as possible, but it may affect the disk array's I/O performance.

Pairsplit-E operation (suspend)

This operation suspends the BC copy operations to the S-VOL of the pair. You can suspend a BC pair at any time. When a BC pair is suspended (status = PSUE), the disk array stops performing BC copy operations to the S-VOL, continues accepting write I/O operations to the P-VOL, and marks the entire P-VOL track as difference data. When a pairresync operation is performed on a suspended pair, the entire P-VOL is copied to the S-VOL. While the pairresync operation for a split BC pair can be very fast, the pairresync operation for a suspended pair takes as long as the initial copy operation. The reverse and quick restore pairresync operations cannot be performed on suspended pairs.

The disk array automatically suspends a BC pair when it cannot keep the pair mirrored for any reason. When the disk array suspends a pair, sense information is generated to notify the host. The disk array automatically suspends a pair under the following conditions:

- When the volume pair has been suspended (PSUE) or deleted (SMPL) from an open system host using the RAID Manager command line interface.

- When the disk array detects an error condition related to an initial copy operation. When a volume pair with COPY(PD) status is suspended (PSUE), the disk array aborts the initial copy operation, changes the status of the P-VOL and S-VOL to SMPL, accepts all subsequent write I/Os to the S-VOL, and does not keep track of updates.

- When the disk array detects an error condition related to an update copy operation.

- When the P-VOL and/or S-VOL track map in shared memory is lost (for example, due to offline microprogram exchange). This applies to COPY(SP) and PSUS(SP) pairs only. For PAIR, PSUS, COPY(RS), or COPY(RS-R) pairs, the pair is not suspended, but the entire P-VOL (S-VOL for reverse or quick restore pairresync) is marked as difference data.

Use the Pairsplit-E window (see "Suspending BC pairs (Pairsplit-E)" on page 473) to suspend BC pairs. When a pair is suspended, the status changes to PSUE. When the pairresync operation starts, the pair status changes to COPY(RS). The P-VOL remains fully accessible while suspended and during the pairresync operation.

Pairsplit-S operation (delete)

This operation stops BC copy operations to the S-VOL of the pair and changes the pair status of both volumes to SMPL. The volumes are not deleted. A BC pair can be deleted at any time except during the quick pairsplit operation (or any status except SMPL status and PSUS(SP) status). After you delete a BC pair, the S-VOL is still not available for write operations until the reserve attribute is reset.

Use the Pairsplit-S window (see "Deleting BC pairs (Pairsplit-S)" on page 474) to delete BC pairs. When a BC pair is deleted, pending update copy operations for the pair are discarded, and the status of the P-VOL and S-VOL is changed to SMPL.

> ⚠️ **CAUTION:** The S-VOL of a duplex pair (PAIR status) may not be identical to its P-VOL due to the asynchronous BC update copy operations. See "Deleting BC pairs (Pairsplit-S)" on page 474 for instructions on synchronizing the volumes before deleting the pair.

BC options

Use the BC options to extend standard BC operations such as the paircreate and pairresync operations. The following table lists the options that are currently available.

Table 83   BC options types and requirements

No.	Option Type	Requirement
1	Swap&Freeze	The BC quick restore operation can be performed on the disk array. If the disk array setting disables the quick restore operation, change the setting (that is, enable the quick restore operation in the disk array) before using the Swap&Freeze option. See "Swap&Freeze option" on page 435.
2	Host I/O Performance	See "Host I/O Performance option" on page 436.
3 - 32	Reserved (Currently unavailable)	-

NOTE: The number of available option types depends on the disk array's settings.

Swap&Freeze option

This option allows the S-VOLs of a BC pair to remain unchanged after the quick restore operation. If the quick restore operation is performed on a BC pair with the Swap&Freeze option, update copy operations are suppressed for pairs in PAIR status after the quick restore operation. If the quick restore operation is performed without the Swap&Freeze option, the P-VOL and S-VOL are resynchronized when update copy operations are performed for pairs in PAIR status.

The following figure shows the state of the S-VOL after the quick restore operation with or without the Swap&Freeze option.
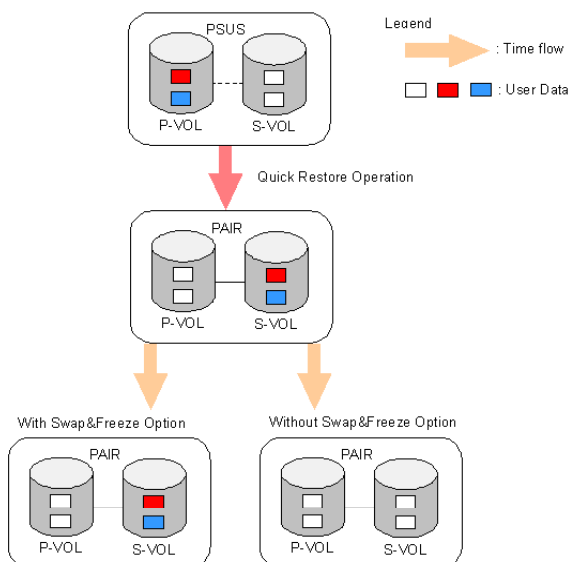

Figure 244 Quick Restore operation with or without Swap&Freeze option

The Quick Restore pairresync operation on a pair with status of PSUS exchanges data in the pair's P-VOL and S-VOL. If you use the Swap&Freeze option when performing the Quick Restore pairresync operation, the update copy operation will not take place after the Quick Restore pairresync operation is complete. Therefore, data on the P-VOL and S-VOL is kept exchanged. If you do not use the Swap&Freeze option when performing the Quick Restore pairresync operation, the update copy operation will take place after the Quick Restore pairresync operation is complete, and data on the P-VOL overwrites data on the S-VOL.

Host I/O Performance option

This option improves host I/O responses over ShadowImage SI390/ShadowImage for z/OS (SI390 and z/OS) copying processing time. When the Host I/O Performance option is used, the disk array suppresses execution of SI390/z/OS copying processing, and consequently host I/O responses improve.

When SI390/z/OS copying processing is suppressed, the time taken for copying increases. Also, if BC pairs exist, host I/O responses might not be faster. In this case, set the Host I/O Performance option for BC as well.

Ý¿–½¿¼»

Cascade function

This function creates a second layer of volume pairs underneath the first layer of BC pair(s). Pairs created in the first and second layer are called cascaded pairs. Figure 245 illustrates cascaded BC volume pairs. The first cascade layer (L1) is the original BC pair, consisting of one P-VOL (root volume) and up to three S-VOLs (node volumes). In the second cascade layer (L2), the S-VOLs of the original BC pair function as the P-VOLs of the L2 pairs, and each L2 P-VOL can have up to two S-VOLs (leaf volumes). This layering scheme can create up to nine copies of one BC primary volume (P-VOL).

Every volume can have up to three Mirror Unit (MU) numbers associated with it. The MU number designates a pair for which the volume is a member. The MU number is not the number of the pair, but the number of the volume. A pair is made up of two volumes of which each pair member could have the same or different MU numbers.

- MU=0 is the number of a volume for its first pair.

- MU=1 is the number of the same volume for its next pair.

- MU=2 is the number of the same volume for its third pair.

- The MU number of an S-VOL is always MU=0.

For Level 1 (L1) pairs, the root volume could have MU=0, MU=1, and MU=2. For L1 pairs, the associated S-VOLs all have MU=0 because this is the first pair of which they are a member.

For the Level 2 (L2) pairs, the L1 S-VOLs are now all acting as L2 P-VOLs. Because they are already a member of one pair, the next MU number for each of them is MU=1 for their first L2 pair and MU=2 for

their second L2 pair. For the S-VOLs associated with each of these pairs, the MU number is once again MU=0 because this is the first pair of which they are a member.
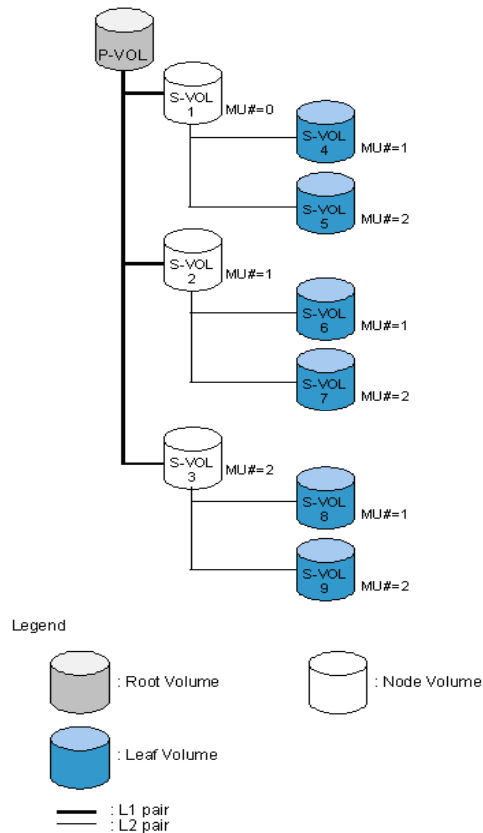

Figure 245 Cascade pairs

When L1 and L2 cascade pairs are created, the P-VOLs and S-VOLs of the cascade pairs are classified using the following terms (as shown in the previous figure):

- The root volume is the P-VOL of the L1 pair, which is the original BC pair. You can add up to three S-VOLs (node volumes) to a root volume.

- The node volume is the S-VOL (reserved) of an L1 pair and the P-VOL of an L2 pair. You can add up to two S-VOLs (leaf volumes) to a node volume.

- The leaf volume is the S-VOL (reserved) of an L2 cascade pair.

Table 84 shows the relationship between L1 pair status and availability of BC pair operations on the associated L2 pairs. To split an L2 pair, you must first split the L1 pair (L1 status = PSUS). The reverse and quick restore pairresync operations cannot be used for L2 pairs. Table 85 shows the relationship between L2 pair status and availability of pair operations on the associated L1 pairs. (CMD RJT = command rejected.) If you delete an L1 pair containing an L2 pair, the L2 pair becomes the L1 pair.

NOTE:

- Combining L1 and L2 pairs with CA volumes is allowed; however, CA considers node and leaf volumes as secondary volumes (S-VOLs).

- When a P-VOL is paired with more than one S-VOL, the disk array assumes there are the same number of virtual P-VOLs. For example, when a P-VOL is paired with three S-VOLs, there is only one real P-VOL, but the disk array assumes there are three virtual P-VOLs. A Virtual P-VOL is called an MU (Mirror Unit).

- "MU#" in Figure 245 means MU number, which identifies each MU. MU#=1 under S-VOL1 means the MU number of the P-VOL that is paired with the S-VOL1 is 1.

Table 84   Relationship between L1 pair status and L2 pair operations

L1 Pair Status	L2 Pair Operations					
	Paircreate	Pairsplit	Pairresync	Reverse/ Quick Restore	Pairsplit-E	Pairsplit-S
COPY(PD)	OK	NO (CMD RJT)	OK	NO (CMD RJT)	OK	OK
PAIR	OK	NO (CMD RJT)	OK	NO (CMD RJT)	OK	OK
COPY(SP)	OK	NO (CMD RJT)	OK	NO (CMD RJT)	OK	OK
PSUS(SP)	OK	NO (CMD RJT)	OK	NO (CMD RJT)	OK	OK
PSUS	OK	OK	OK	NO (CMD RJT)	OK	OK
COPY(RS)	OK	NO (CMD RJT)	OK	NO (CMD RJT)	OK	OK
COPY(RS-R)	OK	NO (CMD RJT)	OK	NO (CMD RJT)	OK	OK
PSUE	OK	NO (CMD RJT)	OK	NO (CMD RJT)	OK	OK

Table 85 shows the relationship between the L2 pair status and availability of pair operations on the associated L1 pairs. (CMD RJT = command rejected.) If you delete an L1 pair containing an L2 pair, the L2 pair becomes the L1 pair.

Table 85   Relationship between L2 pair status and L1 pair operations

L2 Pair Status	L1 Pair Operations					
	Paircreate	Pairsplit	Pairresync	Reverse/ Quick Restore	Pairsplit-E	Pairsplit-S
COPY(PD)	OK[1,2]	OK	OK	OK	OK	OK
PAIR	OK[1,2]	OK	OK	OK	OK	OK
COPY(SP)	NO[2] (CMD RJT)	NO[2] (CMD RJT)	NO (CMD RJT)	NO (CMD RJT)	OK	OK
PSUS(SP)	NO[2] (CMD RJT)	NO[2] (CMD RJT)	NO (CMD RJT)	NO (CMD RJT)	OK	OK
PSUS	OK[1,2]	OK	OK	OK	OK	OK
COPY(RS)	OK[1,2]	OK	OK	OK	OK	OK

Table 85 Relationship between L2 pair status and L1 pair operations (continued)

L2 Pair Status	L1 Pair Operations					
	Paircreate	Pairsplit	Pairresync	Reverse/ Quick Restore	Pairsplit-E	Pairsplit-S
COPY(RS-R)[3]	NO[2] (CMD RJT)	NO[2] (CMD RJT)	--	--	--	--
PSUE	OK[1,2]	OK	OK	OK	OK	OK

1. MU# of L2 node pair member must be 1 or 2.
2. XP12000: Not displayed by the array management interface.
3. XP12000 only.

The read/write operation to each volume (root, node, or leaf) from the host is enabled or disabled depending on the status of L1/L2 pairs. The read/write operation from the host can always be performed to the root volume regardless of the status of L1/L2 pairs. Table 86 shows the relationship between read/write operations from host to node volume and status of L1/L2 pairs. Table 87 shows the relationship between read/write operations from host to leaf volume and L2 pair status.

Table 86 Read/write operation (host to the node volume) and L1/L2 pair status

L1 Pair Status	L2 Pair Status					
	COPY(PD)	PAIR	COPY(SP)	PSUS(SP)/ PSUS	COPY(RS)	PSUE
COPY(PD)	Read Only	Read Only	Read Only	Read Only	Read Only	Read Only
PAIR	Read Only	Read Only	Read Only	Read Only	Read Only	Read Only
COPY(SP)	Read Only	Read Only	Read Only	Read Only	Read Only	Read Only
PSUS(SP)/ PSUS	Read/ Write	Read/ Write	Read/ Write	Read/ Write	Read/ Write	Read/ Write
COPY(RS)	Read Only	Read Only	Read Only	Read Only	Read Only	Read Only
COPY(RS-R)	Read Only	Read Only	Read Only	Read Only	Read Only	Read Only
PSUE	Read Only	Read Only	Read Only	Read Only	Read Only	Read Only

Table 87 indicates the relationship between the read/write operation from the host to the leaf volume and the L2 pair status.

Table 87 Read/write operation (host to the leaf volume) and L2 pair status

COPY	L2 Pair Status				
	PAIR	COPY(SP)	PSUS(SP)/PSUS	COPY(RS)	PSUE
Read Only	Read Only	Read Only	Read/Write	Read Only	Read Only

At-Time Split function

In the past, a BC pair group split each LUN pair in the group at a slightly different time. If the application data spanned multiple LUNs in the group, there was the chance of data corruption unless the application was stopped before the split. With the At-Time Split function, LUN pairs are split at the same time within the group, which keeps data consistent without having to stop the application.

At this time, the At-Time Split operation is performed using RAID Manager on the UNIX/PC server host. You can use Command View to perform BC pair operations for At-Time Split pairs created by RAID Manager. However, the At-Time Split option in Command View is disabled.

A BC consistency group is a user-defined set of BC volume pairs used for the At-Time Split function. This function creates S-VOLs of all P-VOLs in the same consistency group when the pairsplit command is executed.

BC consistency groups and the At-Time Split function have the following restrictions:

- You can configure up to 128 consistency groups in a disk array, including BC consistency groups.

- A number (0–127) is assigned to each consistency group. You can specify a consistency group number when you create BC pairs. If you do not specify a number, the disk array assigns a number automatically.

- You can define up to 1,024 BC pairs in a consistency group. However, for LUSE volumes containing n LDEVs, you should count as n volumes. For more information about LUSE volumes, see "Volume Management for the XP128/XP1024/XP12000" on page 241.

- BC pairs and ShadowImage pairs cannot co-exist in the same consistency group.

- To configure BC consistency groups, use the RAID Manager software. However, to confirm the BC consistency group numbers, use BC (see "Volume list" on page 453).

When the At-Time Split function is enabled, data in all P-VOLs in the same consistency group is copied to the corresponding S-VOLs when the disk array receives the pairsplit request from the host server. The following figure shows an overview of the At-Time Split function.
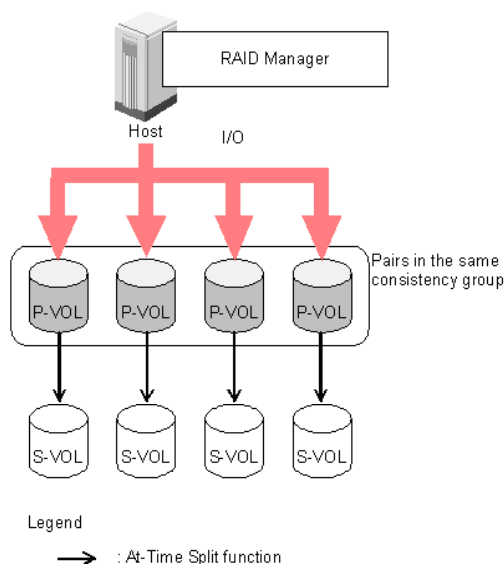

Figure 246 Overview of At-Time Split function

Enabling the At-Time Split function using RAID Manager

1. Create BC At-Time Split pairs as follows:

   a. Define a consistency group for BC pairs. You cannot define L1 and L2 cascade pairs (see "Cascade function" on page 436) sharing the same node volume in a consistency group. If you specify such pairs in the same consistency group, the paircreate command will be rejected.

   b. Specify the At-Time Split option.

   c. Execute the paircreate command.

2. Execute the pairsplit command on the new BC At-Time Split pairs.

   The At-Time Split option is enabled, and data in all P-VOLs in the same consistency group is copied to the corresponding S-VOLs when the disk array receives the pairsplit request.

📝 **NOTE:**

- You can perform BC pair operations (see "Performing BC operations" on page 459) from the Command View XP management station on the BC At-Time Split pairs created by RAID Manager; however, the At-Time Split option is disabled (the pairsplit operation does not ensure creating S VOLs of the P-VOLs in the same consistency groups).

- When the RAID Manager pairsplit operation ends abnormally, all BC pairs in the same consistency group are suspended (status = PSUE).

- When the host server is down or has failed, a consistency group with no BC pairs can be defined. If you execute the paircreate command with the At-Time Split option (-m) under these conditions, the paircreate command might be rejected. In this case, first find a consistency group number that is not used by any pairs on the BC main screen by sorting the CTG column (see "Volume list" on page 453). Next, specify the consistency group number explicitly, and execute the paircreate command with the At-Time Split option using RAID Manager on the host server.

- Do not mix pairs created with the At-Time Split option and pairs not created with the At-Time Split option in the same group defined in the RAID Manager configuration file. If you mix these two types of pairs, the pairsplit operation might terminate abnormally, or the S-VOLs of the P-VOLs in the same consistency group might not be created correctly when the pairsplit request is received.

📝 **NOTE:** After the pairsplit, response time of the first I/O to each logical unit (LU) can be up to approximately five seconds in the worst case. This worst case should be in a one-to-three BC pair situation and 36 LDEV LUSE configuration.

Pair status

The BC remote console software displays the pair status of all BC volumes (LUs) on the specified port of the connected disk array. The following figure shows the BC pair status transitions and the relationship between pair status and BC operations.
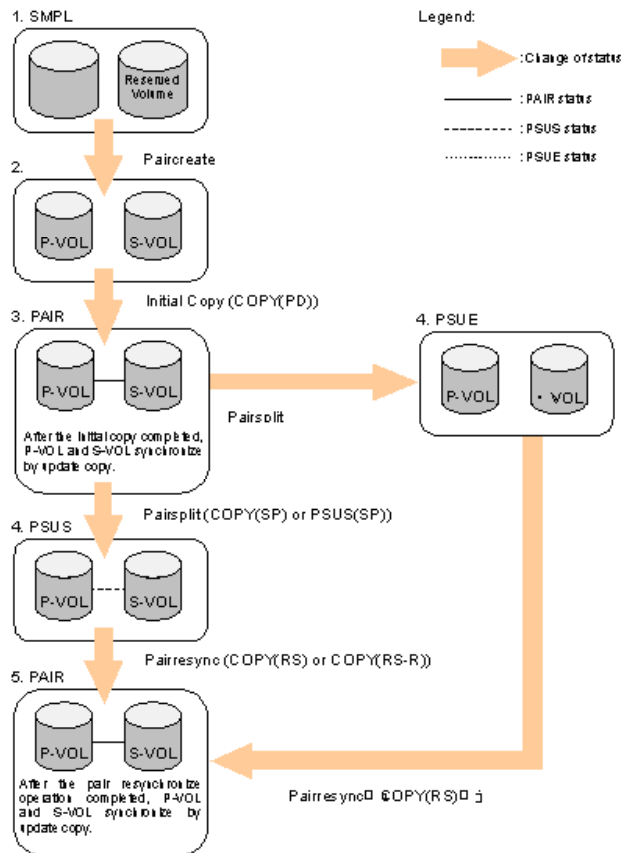

Figure 247 BC pair status transitions

The following describes BC pair status conditions:

1. If a volume is not assigned to a BC pair, its status is SMPL.

2. Select the SMPL volumes for the P-VOL and S-VOL to create a BC pair. When you create a BC pair, the initial copy operation starts. During the initial copy operation, the status of the P-VOL and S-VOL changes to COPY(PD).

3. When the initial copy operation is complete, the pair status becomes PAIR. When the pair status is PAIR, the P-VOL and S-VOL have the same data. If the P-VOL is updated after the initial copy operation, the update copy operation takes place and synchronizes the P-VOL and S-VOL.

4. The following are the types of pair status (PSUS and PSUE) when the pair is not synchronized:

   • When you split a pair (pairsplit), the pair status changes to COPY(SP) or PSUS(SP) for quick pairsplit. During the pairsplit process, the pair status becomes COPY(SP). If you specify Quick Split pairsplit, the pair status becomes PSUS(SP) during the process. When the pairsplit operation is complete, the pair status changes to PSUS and you can access the split S-VOL. The update copy operation is not performed on pairs with status of PSUS.

   • If the disk array cannot maintain PAIR status for any reason or if you suspend the pair (pairsplit-E), the pair status changes to PSUE.

NOTE:

- When you specify reverse or quick restore mode for a pairresync operation, the pair status changes to COPY(RS-R) (data is copied in the reverse direction from the S-VOL to the P-VOL). For more information about pairresync operation settings, see "Pairresync operations" on page 428.

- When you delete a pair (pairsplit-S), the pair status changes to SMPL. You cannot delete a pair with status of PSUS(SP).

5. When you start a pairresync operation, the pair status changes to COPY(RS) or COPY(RS-R). When the pairresync operation is complete, the pair status changes to PAIR.

Table 88   BC pair status conditions

Pair Status	Description	S-VOL Access
SMPL	The volume is not assigned to a BC pair. The disk array accepts read and write I/Os for all SMPL volumes that are not reserved.	N/A (there is no S-VOL yet).
COPY(PD)	The initial copy operation is in progress. The disk array continues to accept read and write operations for the P-VOL, but stops accepting write operations for the S-VOL. No update copy operations are performed.	Read only.
PAIR	The initial copy operation is complete, and the disk array performs asynchronous update copy operations from the P-VOL to the S-VOL as needed. The P-VOL and S-VOL of a duplex pair (PAIR status) may not be identical. The disk array rejects all write I/Os for S-VOLs with status PAIR.	Read only.
COPY(SP)	The status becomes COPY(SP) when the steady split mode is selected for the pairsplit operation. All P-VOL updates prior to the pairsplit command are copied to the S-VOL. When these updates are complete, the split S-VOL is identical to the state of the P-VOL when the split started. The disk array rejects all write I/Os for COPY(SP) S-VOLs.	Read only.
PSUS(SP)	The status becomes PSUS(SP) when the quick split mode is selected for the pairsplit operation. Only the P-VOL differential data is copied to the S-VOL in the background. The disk array accepts writes for PSUS(SP) S-VOLs. PSUS(SP) pairs cannot be deleted.	Read and write. The S-VOL can be mounted.
PSUS	The disk array stops update copy operations for PSUS (split) pairs, and starts accepting write I/Os for PSUS S-VOLs. The disk array keeps track of all updates to the split P-VOL and S-VOL, so the pair can be resynchronized quickly.	Read and write. The S-VOL can be mounted.
COPY(RS)	The disk array does not accept write I/Os for COPY(RS) S-VOLs. When a split pair is resynchronized in normal mode, the disk array copies only the P-VOL differential data to the S-VOL. When a PSUE (suspended) pair is resynchronized, the disk array copies the entire P-VOL to the S-VOL. No update copy operations are performed during the pairresync operation.	Read only.

BC pair status conditions (continued)

Pair Status	Description	S-VOL Access
COPY(RS-R)	The disk array does not accept write I/Os for COPY(RS-R) S-VOLs. When a split pair is resynchronized in reverse or quick restore mode, the disk array copies only the S-VOL differential data to the P-VOL. No update copy operations are performed during the reverse or quick restore pairresync operation.	Read only.
PSUE	The disk array continues accepting read and write I/Os for a PSUE (suspended) P-VOL, but does not perform update copy operations for a PSUE S-VOL. The disk array marks the entire P-VOL track map as difference data, so the entire P-VOL is copied to the S-VOL when the PSUE pair is resumed. Use the pairresync command to resume a PSUE pair.	Read only.

Cautions on switching off the power supply

To switch off the power supply of the disk array during BC operations, make sure to:

- Complete copying for the BC pair in COPY(SP) or PSUS(SP) status first to change the pair status from COPY(SP) or PSUS(SP) to PSUS, and then switch off the power supply. If shared memory is volatilized when you switch on the power supply again, the pair in COPY(SP) or PSUS(SP) status changes to PSUE.

- Establish a timetable for BC copying operations. If shared memory is volatilized when you switch on the power supply again, the following conditions occur:

  - If the BC pair was in COPY(PD) or COPY(SP) status, data already copied becomes target data to be copied after the power supply is switched back on. Even if there is no host I/O, the data consistency rate does not reach 100% when the BC pair status changes to PAIR. When the BC pair status changes to PAIR, target data is copied to the secondary volume.

  - If the BC pair was in PAIR status, data already copied becomes target data to be copied after the power supply is switched back on. In this case, the data consistency rate is 0%, and target data is copied to the S-VOL.

  - If the BC pair was in PSUS status, the entire volume becomes differential data. In this case, the data consistency rate is 0%, and the entire volume is copied to the secondary volume when you perform the pairresync operation.

Preparing for BC operations

System requirements

BC operations involve the disk array containing the primary and secondary volumes and the licensed BC feature enabled on the Command View management station. System requirements for BC are:

- Disk array hardware, microcode, and software required for BC operations must be installed and enabled.

- Command View management station (user-supplied Windows-based PC).

- BC license key installed.

Preparing for BC operations

To ensure that you and your disk array(s) are ready for BC operations, perform the following tasks:

• BC operations affect I/O performance of the disk array because of copy operations to the S-VOLs. If you have not already done so, consider the relative importance of the disk array's I/O performance and the BC backup copies. For example, assigning three S-VOLs to each P-VOL takes more resources than assigning one or two. You can also use the copy pace option to control the impact of BC initial copy operations. Using a slower copy pace minimizes the impact of BC operations on I/O performance, while a faster copy pace produces copies more quickly, but may affect I/O performance.

• If you are using more than one disk array data management feature (such as BC, CA, or Cache LUN) at the same time in the same disk array, contact your HP account support representative to ensure that your disk array is optimized for your configuration of concurrent operations. Each disk array feature can affect disk array performance and/or operation of other features. For example, BC and CA operations both involve initial copy and update copy operations to secondary/remote volumes in addition to host I/O workload.

• Identify the volumes (LUs) you will use for BC operations. For each volume, write down the full SCSI path (port, target ID (TID), and LUN), whether the volume will be a P-VOL or S-VOL, and the other volume(s) in its pair (see Table 89 for a sample). LUN Management displays this information. Volumes that will be P-VOLs remain fully accessible to all hosts throughout normal BC operations, but volumes that will be S-VOLs must be unmounted before being reserved for BC operations.

Table 89 Identifying the volumes for BC operations

CU	Port	TID: LUN	L1 P-VOL	Assoc. L1 S-VOL(s)	L1 S-VOL	Assoc. L1 P-VOL	L2 P-VOL	Assoc. L2 S-VOL(s)	L2 S-VOL	Assoc. L2 P-VOL
0	1A	0:00	Yes	1B-0:00, 2A-0:00, 2B-0:00	No	--	No	--	No	--
0	1A	0:01	Yes	1B-0:01, 2A-0:01, 2B-0:01	No	--	No	--	No	--
etc.										
0	1B	0:00	No	--	Yes	1A-0:00	Yes	3A-0:00, 3A-0:01	No	--
0	1B	0:01	No	--	Yes	1A-0:01	Yes	3B-0:00, 3B-0:01	No	--
etc.										
0	2A	0:00	No	--	Yes	1A-0:00	Yes	4A-0:00, 3B-0:01	No	--
0	2A	0:01	No	--	Yes	1A-0:01	Yes	4B-0:00, 3B-0:01	No	--
etc.										
0	3A	0:00	No	--	No	--	No	--	Yes	1B-0:00
0	3A	0:01	No	--	No	--	No	--	Yes	1B-0:00

Combining BC with other data management operations

BC supports concurrent operations with the following data management functions:

- LU Size Expansion (LUSE). LUSE volumes can be assigned to BC pairs if the P-VOL and S-VOL have the same LU type and number of LDEVs (same size). If you must perform LUSE operations on an existing BC P-VOL or S-VOL, delete the pair first to return the volume to SMPL status.

- VSC. VSC volumes can be assigned to BC pairs if the S-VOL has the same capacity as the P-VOL. If you must perform VSC operations on an existing BC P-VOL or S-VOL, delete the pair first to return the volume to SMPL status.

- LUN Security. LUN Security operations do not affect BC operations. Volumes under secure ports and/or assigned to World Wide Name (WWN) groups and/or LUN groups can also be assigned to BC pairs. Volumes assigned to BC pairs can also be assigned to secure ports, WWN groups, and/or LUN groups for LUN Security.

NOTE: BC S-VOLs cannot be accessed by any host except when the pair is split.

- Cache LUN. Cache LUN volumes can be assigned to BC pairs. Cache LUN operations can be performed on BC P-VOLs and S-VOLs.

- CA Journaling. CA Journaling volumes can be assigned to BC pairs, and BC volumes can be assigned to CA Journaling pairs.

CAUTION: See "Pairresync operations" on page 428 for important information on performing quick restore operations on Cache LUN volumes.

- CA. CA volumes can be assigned to BC pairs, and BC volumes can be assigned to CA pairs. See "Combining BC and CA operations" on page 448 for important information on BC and CA shared volume configurations.

- Auto LUN. BC can be assigned to Auto LUN migration volumes. However, if the BC P-VOL is already paired with three S-VOLs, delete the BC pairs before migrating the volumes. Also, to assign BC volumes to destination migration volumes or reserve BC volumes for Auto LUN, delete the BC volumes or unreserve the BC volumes before using them with Auto LUN. If you assign a BC P-VOL that is already paired with three S-VOLs to Auto LUN migration volumes, or assign BC volumes to Auto LUN volumes other than migration volumes, the command will be rejected.

  If you split the BC pair assigned to Auto LUN migration volumes, migration of those volumes will be canceled.

NOTE: You cannot use Auto LUN migration, destination, and reserved volumes for BC pair operations (the command will be rejected). To use Auto LUN volumes for BC pair operations, use Auto LUN to release the volumes.

- External Storage XP. BC operations can be performed with External Storage XP operations to create pairs with the external volumes.

Combining BC and CA Journaling operations

CA Journaling volumes can be assigned to BC pairs, and BC volumes can be assigned to CA Journaling pairs.