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Ensuring Business Continuity: Policy-Based Replication and Policy-Based High Availability for IBM Storage Virtualize Systems

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Preface

In today's digital age, downtime is not an option. Businesses rely on constant access to critical data to maintain productivity and ensure customer satisfaction. IBM® Storage Virtualize offers functionalities to safeguard your data against various threats. Policy-based replication and policy-based HA (policy-based-HA) protect against site failures by automatically failing over to a secondary site, helping ensure business continuity.

This IBM Redbooks® delves into the powerful tools of IBM policy-based replication and IBM policy-based high availability, empowering you to create a robust disaster recovery plan that minimizes downtime and maximizes data protection.

Whether you are a seasoned IT professional or just starting to explore business continuity solutions, this book provides a comprehensive guide to navigating these essential technologies and building a resilient IT infrastructure.

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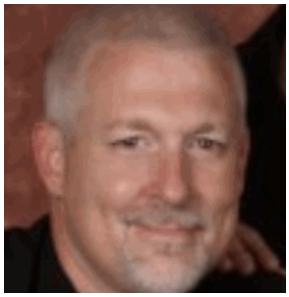

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1

Introduction

Business continuity ensures that an organization can deliver services even during disruptions. Although some applications might tolerate temporary outages, major disasters can cause significant downtime and data loss, leading to immense costs for recovery. Organizations should minimize data loss and downtime to lessen business impact and financial strain.

From a storage perspective, business continuity involves maintaining data consistency and availability for uninterrupted application access. Two key concepts contribute to this: Disaster recovery (DR) and high availability (HA). DR focuses on replicating data to remote locations for recovery, and HA prioritizes continuous data accessibility.

Disasters can range from entire site outages to data corruption or theft. Data protection typically involves local or remote data backups. IBM Storage Virtualize offers functionalities to safeguard your data against various threats. Policy-based replication and policy-based HA protect against site failures by automatically failing over to a secondary site, helping ensure business continuity. Although not covered in this book, Storage Virtualize offers additional features like Snapshots and Safeguarded Snapshots to protect against data corruption or cyberattacks.

This chapter has the following sections:

1.1 Recovery Time Objectives and Recovery Point Objectives

After a disastrous event, the priority is to recover the business-critical applications as quickly as possible and to use the most recent data available.

In a disaster recovery environment, where a production site runs the applications and replicates on a recovery site, depending on the replication mode, the data on the recovery site can be older than the one on the production site. The time gap between these two versions represents the amount of data potentially lost in case there is a disaster. It is referred to as the *Recovery Point Objective* (RPO).

The time needed to recover to access the latest available data is the *Recovery Time Objective* (RTO). It is typically the time needed to reload the latest available data and to mount volumes to servers on the recovery site; it corresponds to the application downtime.

When cycle-based asynchronous replication is used, the cycle period defines the recovery point. See Figure 1-1.

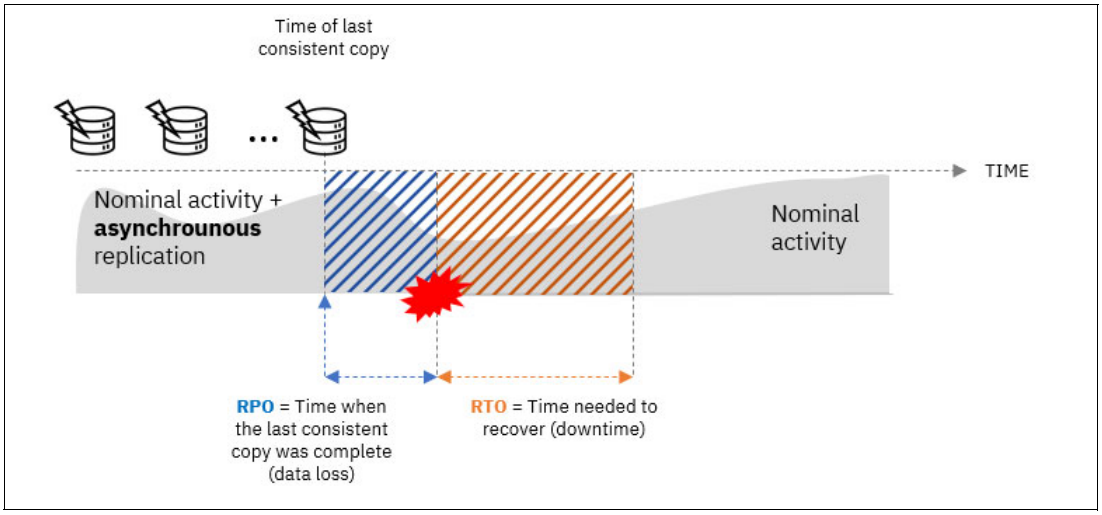

Figure 1-1 Non-zero RPO and non-zero RTO

When synchronous replication is used, the recovery point is reduced to zero because the available version of data on the recovery site is equivalent to the latest on production site. There is no data loss in the event of a disaster. See Figure 1-2 on page 3.

Policy-based replication is an adaptive replication solution. When conditions are optimal, policy-based replication is a near-synchronous replication, the recovery point is very small (several milliseconds to a few seconds).

The RTO is not related to the type of replication between production and recovery sites. Whenever a disaster occurs, even with a synchronous replication, recovered data still needs to be presented to servers on the recovery site. The recovery time can be reduced when servers are pre-attached to the recovery system, but the servers must still mount the recovered data. This is generally done manually or scripted, and there is still a downtime for business-critical applications.

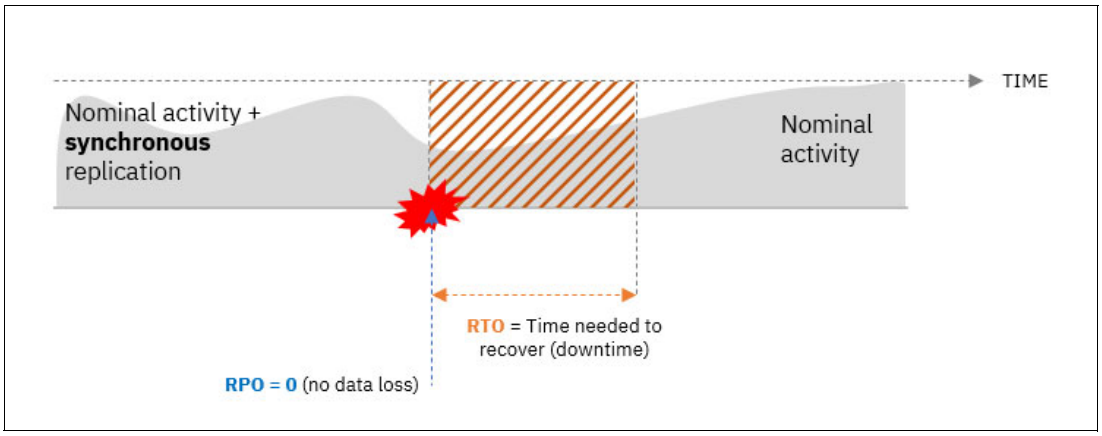

Figure 1-2 Zero RPO and non-zero RTO

With policy-based HA, servers are pre-mapped to volumes that are instantly accessible. If there is a disaster, they automatically failover to the surviving site to access the data. The recovery time in that case is reduced to zero as there is no downtime. See Figure 1-3.

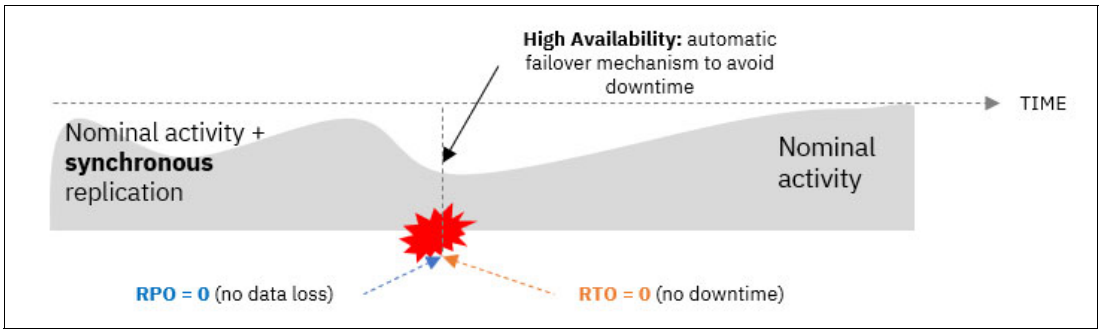

Figure 1-3 Zero RPO and zero RTO

1.2 Synchronous, asynchronous, and policy-based replication

In a storage infrastructure, disaster recovery (DR) is the ability to return some data from a system after a disaster occurred. DR is implemented by replicating data, locally or remotely, depending on the nature of the risks, the localization of systems, and the amount of data that clients are ready to lose.

A typical DR implementation involves a production site where applications run and access local data. Additionally, a secondary or recovery site stores copies of this production data. This helps ensure that even if the primary site becomes unavailable, you can access and restore critical data from the secondary location.

1.2.1 Synchronous replication

Synchronous replication prioritizes data equivalence between the production and recovery sites. In this approach, every write operation to the production system is first copied to the recovery system. The write operation is acknowledged only after successful confirmation of the copy operation.

This method helps ensure that both production and recovery systems maintain identical data copies. However, there are tradeoffs:

- Increased write response times. Because writes involve sending data to the recovery site and waiting for confirmation, application performance can be impacted.
- Impact of round-trip time (RTT). The longer the distance between the production and recovery sites (measured in milliseconds or ms), the higher the write response times because of the additional data travel and confirmation cycle.

Therefore, synchronous replication is best suited for scenarios with very low RTT, ideally less than 1 millisecond to minimize performance drawbacks.

See Figure 1-4.

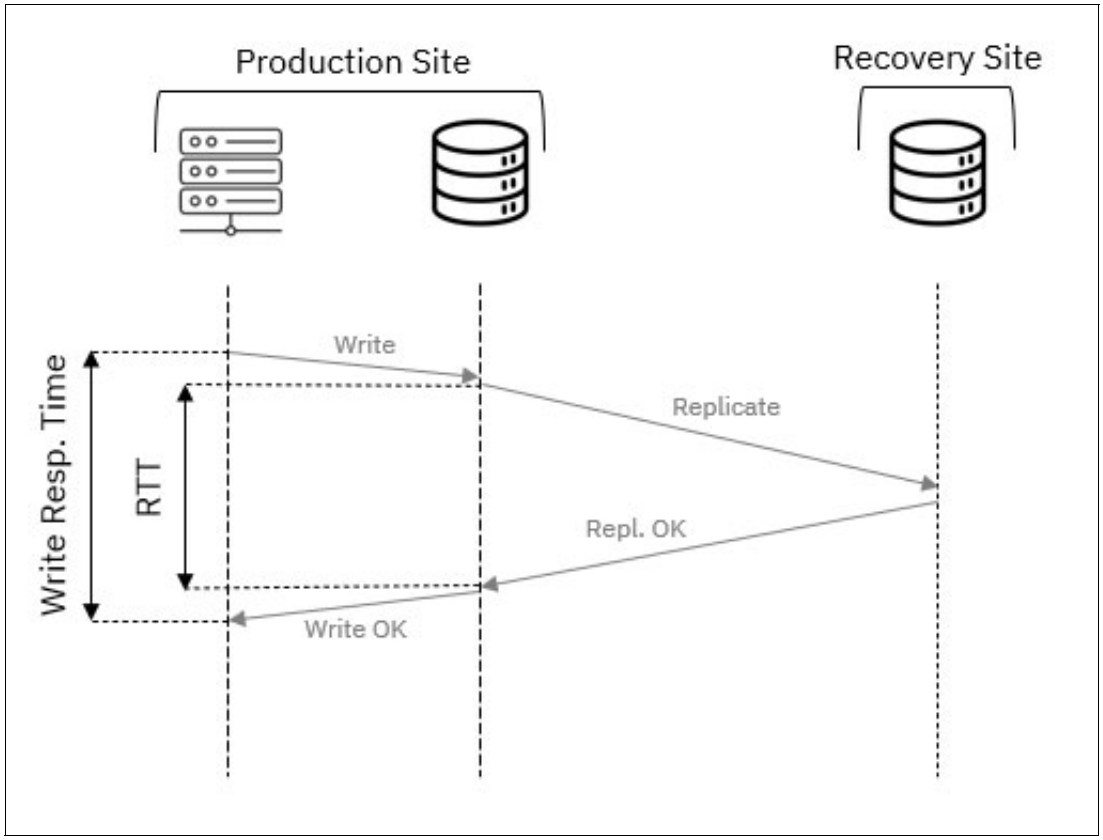

Figure 1-4 Synchronous replication and RTT impact

In earlier versions of IBM Storage Virtualize, synchronous replication was facilitated by the Metro Mirror remote copy service. However, for geographically dispersed sites where distance creates high RTT, synchronous replication becomes impractical. The other option is asynchronous replication.

1.2.2 Asynchronous replication

Asynchronous replication consists in dissociating replication processing from hosts writes. Unlike synchronous replication, hosts do not have to wait for write operation completion on the recovery storage system.

This approach demands sufficient bandwidth between the production and recovery sites. The bandwidth needs to be able to handle the write throughput of the production system to minimize the amount of data waiting to be replicated.

Additionally, because the hosts do not wait for the replication to finish on the recovery site, there might be a gap between data in production and in recovery sites if a disaster occurs and the replication is not finished.

Asynchronous replication was managed by Global Mirror on previous versions of Storage Virtualize.

1.2.3 Asynchronous replication with snapshots

To optimize the bandwidth usage, asynchronous replication with cycling mode (snapshots) can be used. This type of asynchronous replication captures periodic snapshots of the production data. Only the changes that occur between these snapshots are copied to the recovery site, which reduces the amount of data transferred.

By dissociating application server activity and data replication, this method optimizes overall system efficiency. Applications and replication operate independently, minimizing performance bottlenecks. See Figure 1-5.

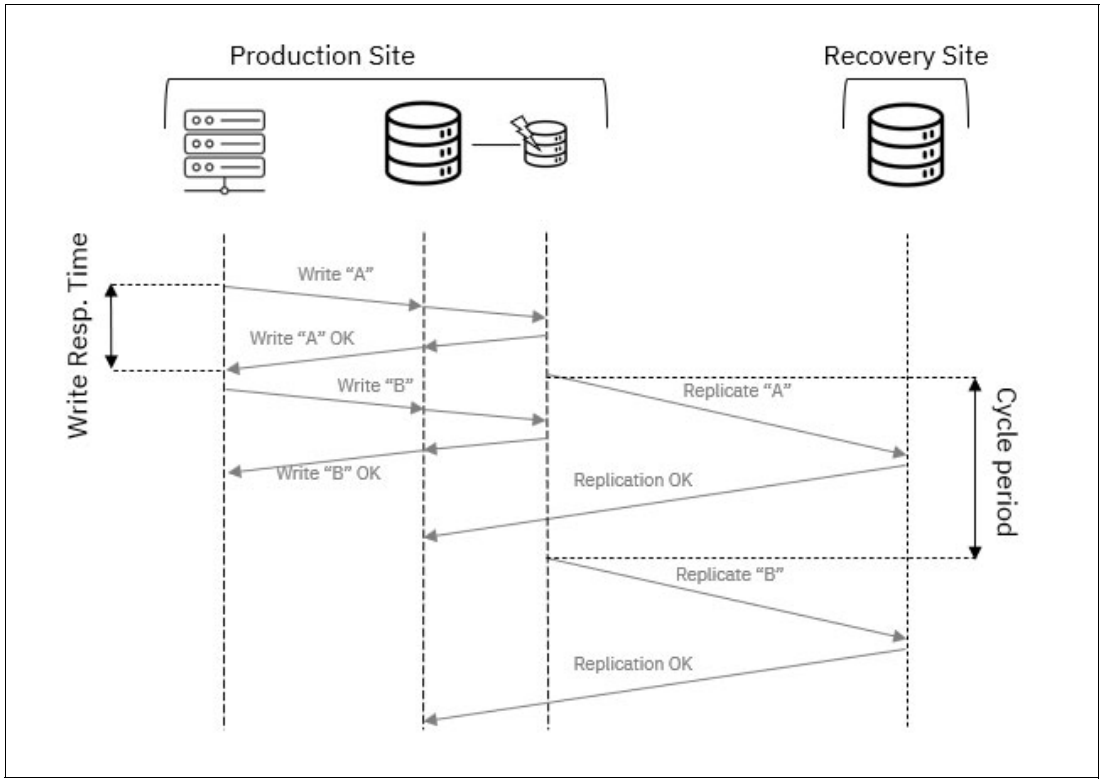

Figure 1-5 Cycle-based asynchronous replication

In this mode, replicated data on the recovery site can be older than the production one because data is likely to change since the last completed cycle. In the preceding example, Recovery Site started receiving "A" while "B" was being written on Production. Recovery site will receive "B" on next cycle.

It is the write change rate on data that determines the size of the snapshots and therefore the amount of data to be replicated. Some areas of data volumes can change several times between cycles, but only the latest are replicated, which reduces the amount of data to be replicated.

The frequency of the cycles dictates the age of the latest available copy on the recovery site. The frequency of the cycles should be high to minimize the time gap between a disaster event and the latest completed cycle.

In earlier versions of IBM Storage Virtualize, asynchronous replication was managed by two primary remote copy services:

- Global Mirror. This service facilitated basic asynchronous replication.
- Global Mirror with Change Volumes (cycling-mode). This advanced version offered asynchronous replication with snapshots, similar to the functionality described in this section.

1.2.4 IBM policy-based replication

IBM policy-based replication employs a single algorithm that incorporates both asynchronous snapshot-based and full data replication methods. This intelligent approach automatically switches between these modes (cycling mode and journaling mode) based on the available replication bandwidth, helping ensure efficient data transfer.

Therefore, the system always strives to provide the best possible recovery point based on the current workload and available bandwidth. With journaling mode, this is achieved by using a journal to record every write operation on the production volumes. The system monitors this journal and triggers replication operations dynamically, eliminating the need for predefined replication cycles.

Journals are used in journaling mode and snapshots are used in cycling mode, maintaining consistency at all times. To help ensure consistent data on the recovery site, the system automatically creates a snapshot before it initiates the resynchronization process. This snapshot guarantees that the order of writes on the recovery site mirrors the production site, maintaining data integrity.

To achieve a high frequency replication and maintain the most recent data on the recovery site, the bandwidth between the two sites must be sufficient to handle the write throughput of the production site.

Policy-based replication has three operation modes:

- A *Change Recording* mode that tracks the changes on the production site without replicating to the recovery site.
- A *Journaling* mode which tracks and replicates in order the changes that are made on production environment.
- A *Cycling* mode where new host writes are tracked and periodically replicated from a snapshot of the production volume.

Journaling mode is the preferred replication method because it offers a lower RPO. However, the system might switch to cycling mode if it cannot sustain the write volume required for journaling because of bandwidth limitations. In cycling mode, the system captures periodic snapshots of the production volume and replicates only the changes since the last snapshot. This reduces the amount of transferred data but increases the potential recovery point.

The frequency of these cycles in cycling mode is determined by the acceptable recovery point objective. More frequent cycles minimize data loss but require more bandwidth. The system automatically balances these factors to meet the RPO for the volumes. The administrator can use different replication policies with different RPOs to prioritize replication between different applications.

See Figure 1-6.

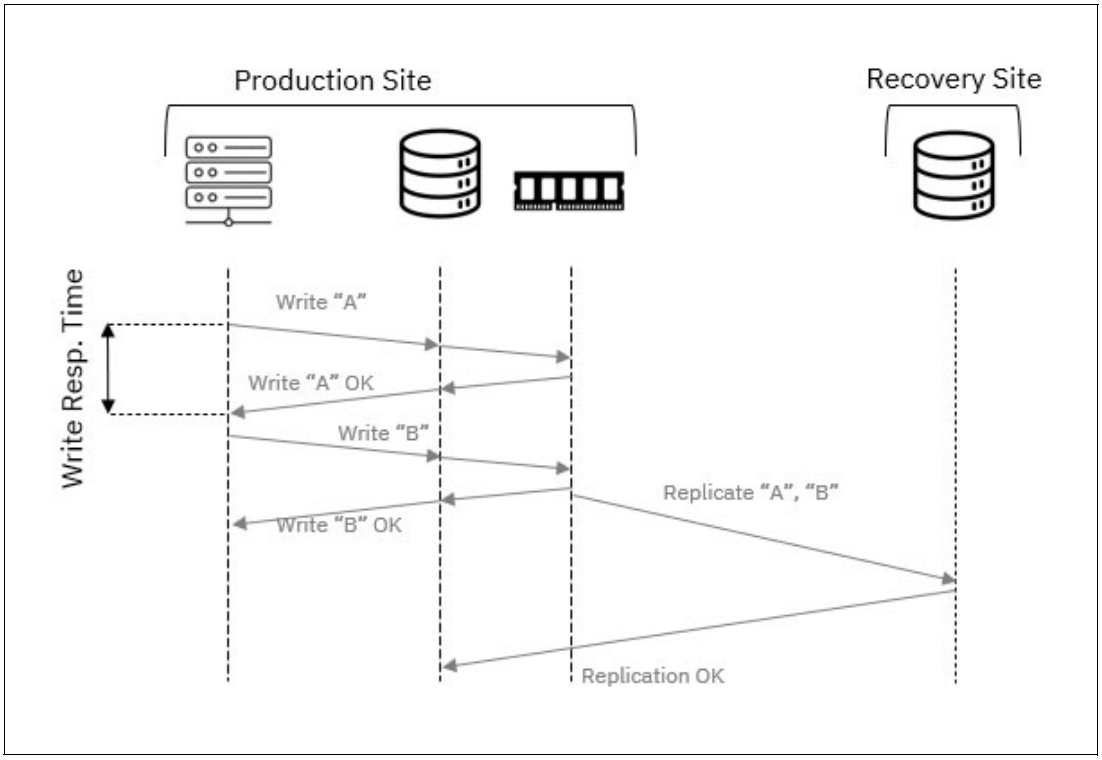

Figure 1-6 Policy-based replication with journaling

1.3 Data consistency

Regardless of the replication method that is used between two systems, it is essential for business continuity to help ensure the integrity of the data replicated on the recovery site. Consistent data on the recovery site means it can be read by an application or operating system if there is a failover.

Data consistency applies within each volume and across volumes. Some applications need blocks from different volumes to assemble exploitable data, so consistency needs to be maintained between volumes that are associated to the same application.

The order in which data changes are applied on the recovery site whether within a volume or across volumes of a volume group is crucial to maintain data consistency. IBM Storage Virtualize policy-based replication uses an in-memory journal while in journaling mode. The journal tracks the changes that are made on volumes within the volume groups in sequence. The journal in journaling mode acts as a buffer for write I/Os on the production site. This allows data to be written locally without waiting for the entire replication process to finish. Hosts can continue operations without delays caused by replication.

In cycling mode, to help ensure data consistency during resynchronization, the system automatically creates a snapshot of the volumes before initiating the process. This snapshot provides a known, consistent state of the data. If the resynchronization fails, the system can revert to this snapshot, guaranteeing data integrity on the recovery site.

1.4 Policy-based HA

In storage infrastructure, high availability (HA) helps ensure that applications on hosts can access their data continuously even if there is a failure in the primary storage system. This solution is achieved by maintaining a full copy of the data and synchronization on a peer system that allows for application access through either system, so that data access is maintained even during a disaster.

Policy-based HA (PBHA) is an active/active high availability solution. Both copies of the volume are accessible while HA is established where the hosts can submit I/O to either copy and synchronization is maintained between the copies.

Policy-based HA uses a synchronous replication to help ensure data equivalence between production volumes copies. Volume groups are used to manage the consistency across volumes, which are application interdependent. In an HA solution, the hosts from all sites must have access to the same set of production data. To facilitate this behavior, IBM

Storage Virtualize introduces a concept of Storage Partitions. Storage partitions are a collection of related volume groups, hosts and mappings. See Figure 1-7.

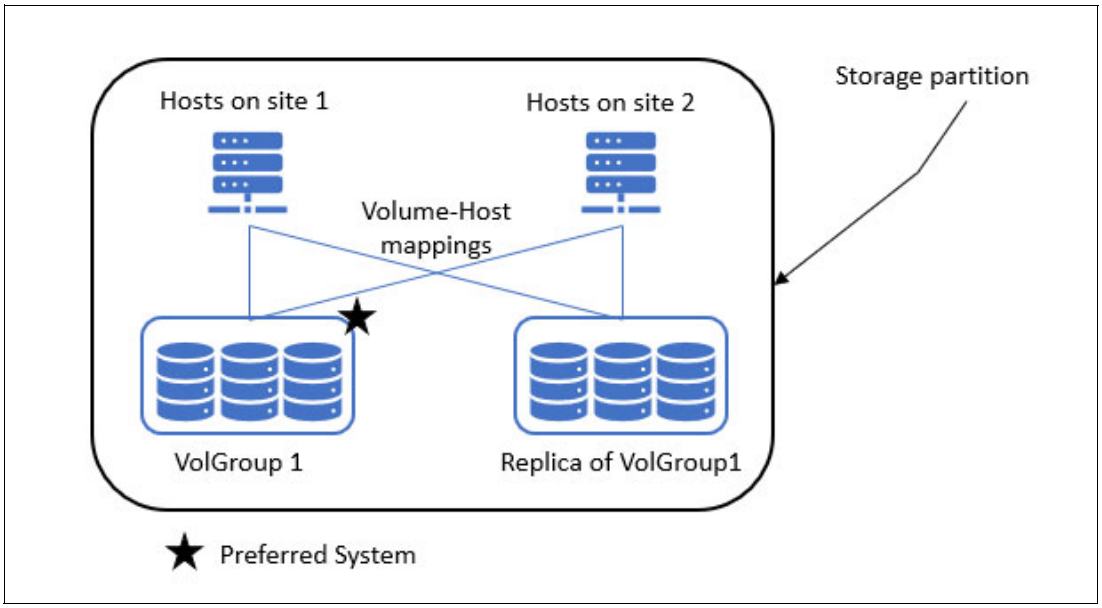

Figure 1-7 Storage partitions

With storage partitions, users do not have to worry about manually mapping the hosts to the volume groups copy, as it is already prepared on both systems. They do not have to worry either about volumes recognition by the hosts, because the UID is the same.

To ensure complete consistency, HA replicates not only data but also the configuration of the storage partition (including host definitions and mappings) to the remote site whenever changes occur. This configuration information is typically managed on a *preferred system* for the selected partition and stored on both systems.

In HA configurations, a *preferred management system* is designated per storage partition. The preferred management system is typically the system where the partition is managed. It is the system that is preferred for the storage partition to continue to be accessible and managed through in the event of a disconnect between systems. If host locations are not set, hosts access the volumes through this system while HA is established.

When the location is explicitly set for hosts, read and write operations are *localized*. This means hosts at a specific site access the copy of the data available on the storage system at the same site, assuming that the host location is configured correctly.

Additionally, management of the volume groups, storage partitions, and the policy are centralized on an *active management system*. The active management system is usually the preferred management location.

If an outage or other failure happens on the current active management system, the active management system automatically fails over to the other system.

In a system failure on a local site, hosts from the local site automatically switch to the system on the remote site to access the data, by using their ALUA-compliant multipath policy.

1.5 Summary of storage business continuity strategies

A business continuity strategy involves many factors. First, not all applications, hosts, and volumes need the same level of protection or continuity. The standard approach is to determine what RPO and RTO is required for a given set of data. Costs, ease of management, and administrators' knowledge are also factors to consider.

From a storage infrastructure perspective, IBM Storage Virtualize policy-based replication protects your business from data loss on a production site by replicating the data on a recovery site. The RPO is optimized to a minimum value and is tracked so you can control or avoid data loss. Policy-based HA adds a different layer of protection for your business by avoiding downtime with automatic fail-over from a production site to a recovery site. See Table 1-1.

Table 1-1 Business continuity options

Replication and HA technique	RPO	RTO	Constraints
Legacy Metro Mirror	0	> 0 (not HA)	Short distance and low RTT
Legacy GM/GMCV	Seconds to hours	> 0 (not HA)	Dependent on link quality and bandwidth
Legacy HyperSwap®	0	0	No storage partitioning (system-centric solution)
Policy-based Replication	Adaptive: from near-zero to hours or days	> 0 (not HA)	Adaptive RPO and must be monitored
Policy-based HA	0	0	Short distance and low RTT

1.6 IBM Flash Grid

IBM Storage Virtualize, with the adoption of storage partitions and volume groups, dissociates the business continuity requirements (HA, replication) from hardware systems and moves further toward the creation of multiple software-defined virtual storage systems within a single FlashSystem deployment.

By using the Flash Grid approach, users can create federated and scalable clusters of independent storage devices and failure domains. From an application angle, through the use of storage partitions, users can add HA and DR resilience to applications through manual or automated nondisruptive data movement. The Flash Grid approach also enables easier device migration and consolidation and rebalancing of storage capacity and performance over several systems.

Clients can aggregate IBM FlashSystem or SVC systems and manage them as a single scalable storage grid, which is engineered for high availability, replication, and non-disruptive application data migration. Systems that are involved in replication and HA can participate on the same Flash Grid.

The historical approach of clustering nodes with IBM Storage Virtualize was a “per I/O group” one. Pairs of nodes were the bricks of a cluster solution design that was more “scale-up” oriented. With the introduction of IBM Flash Grid, the clustering granularity is slightly different. It is now the systems themselves that can scale-out and form a single solution with a single point of management. There are fewer requirements for hardware compatibility and the performance and capacity can scale linearly.

After storage partitions are configured, they can be moved from one system to another, manually balanced by users over several systems and sites. They can also be stretched over two sites for high availability. See Figure 1-8 on page 11.

At the time of this writing, Flash Grid features (partitions mobility) are manageable with IBM Storage Insights Pro only.

It is possible to use the CLI to create a Flash Grid and add or remove systems in a Flash Grid.

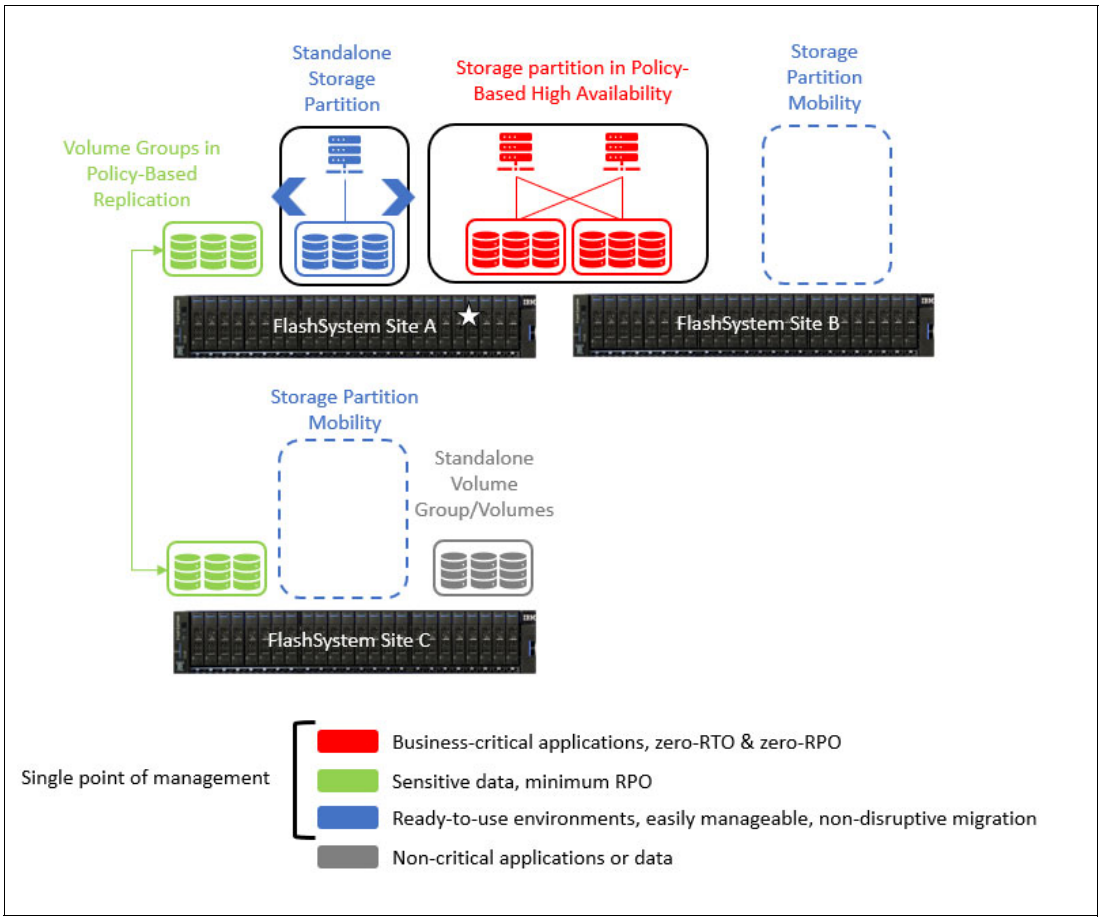

Figure 1-8 IBM Flash Grid concept

2

Policy-based replication

IBM policy-based replication is a significant advancement in managing data replication for FlashSystem and SVC storage and can help to make it easier and faster to achieve data protection and improve storage efficiency. This chapter discusses policy-based replication and has the following sections:

2.1 Introduction

Policy-based replication is the method by which IBM Storage Virtualize provides replication services. Policy-based replication was introduced into Storage Virtualize 8.5.2 and is a replacement for Remote Copy in previous versions of code. It is a *ground up implementation of code* that uses the most recent coding advancements and techniques. Policy-based replication offers many performance and automation advantages over Remote Copy.

This solution uses policies, such as provisioning and replication policies, to define the overall replication behavior. Volume groups serve as the smallest unit, and the assigned replication policy dictates how data is replicated. The replication policy states what systems to replicate between and the desired recovery point objective (RPO). Different volume groups can have differing policies to allow an organization to replicate to a maximum of 3 DR systems and prioritize the value of sets of data. This prioritization occurs only if resources are restricted. If no restriction exists, all volume groups are treated with equal value. Because the volumes are in a volume group, the system maintains consistency between them.

Policy-based replication is designed to free a system administrator from having to manually configure and maintain replication. With legacy Remote Copy, an administrator manually configured and maintained remote replication targets, relationships, consistency groups, and change volumes. By using policy-based replication, all these manual steps are automated, freeing system administrators to focus on higher value tasks.

Note: Currently, policy-based replication is asynchronous only.

2.2 Policy-based replication - Asynchronous

Asynchronous policy-based replication is a direct replacement for the Remote Copy Services: Global Mirror, Global Mirror with Consistency Protection and Global Mirror with Change Volumes. In the past, each of these modes was chosen manually, and if the mode needed to change, this was also a manual intervention. Policy-based replication combines all three of these methodologies and automatically switches between methodologies on a volume group by volume group basis if necessary. It uses the RPO designated on the policy to use QoS to try to keep all volume groups within their stated RPO.

The bandwidth limit on the partnership that is used for asynchronous policy-based replication dictates how much data can be sent between systems. The bandwidth limit helps ensure that a particular system does not overload the shared inter-site WAN link. The bandwidth limit value does not take into consideration data compression, so if the data is being compressed by native IP-based replication or FCIP-based replication, set the limit accordingly. The bandwidth limit is per I/O group on a multi-I/O group system.

There are generally two types of methodologies for asynchronous replication that will be explored in more depth in the following sections. These methods are journaling, which is used by Global Mirror/Global Mirror with Consistency Protection, and cycling, which is used by Global Mirror with Change Volumes.

2.2.1 Asynchronous replication - Journaling

Journaling is a method that captures frames in a journal or buffer, sequences them, and sends them in order. When a write from a host comes into the system, an acknowledgment is sent to the host and then the write is sent to a journal in either memory or on disk where it is

stored until it can be sent across the link to the remote site. Assuming no constraints, this method can produce a very low RPO. With policy-based replication, this can be as low as one half the round-trip time to the secondary site. The disadvantage to this method is that when the amount of data overruns the link or if the link has problems, the journal can run out of space and potentially slow down or stop replication. Policy-based replication monitors journal resources proactively and takes action to prevent journaling from slowing down or stopping replication.

In IBM Storage Virtualize the journaling is implemented, as shown in Figure 2-1. In IBM's DR systems, each controller or node employs a non-volatile bitmap and a volatile journal. A volume is divided into fixed-size regions called *grains*, where each grain is a contiguous 128 KiB segment. Each bit in the bitmap represents the status of a corresponding grain.

When a write request arrives at a controller or node, it is mirrored to the other node. The bitmap for the affected grains is marked as *dirty*, indicating a pending write operation. This updated bitmap is then synchronized with the other controller or node. Subsequently, the write is sequenced, assigned a unique identifier, and acknowledged back to the host system.

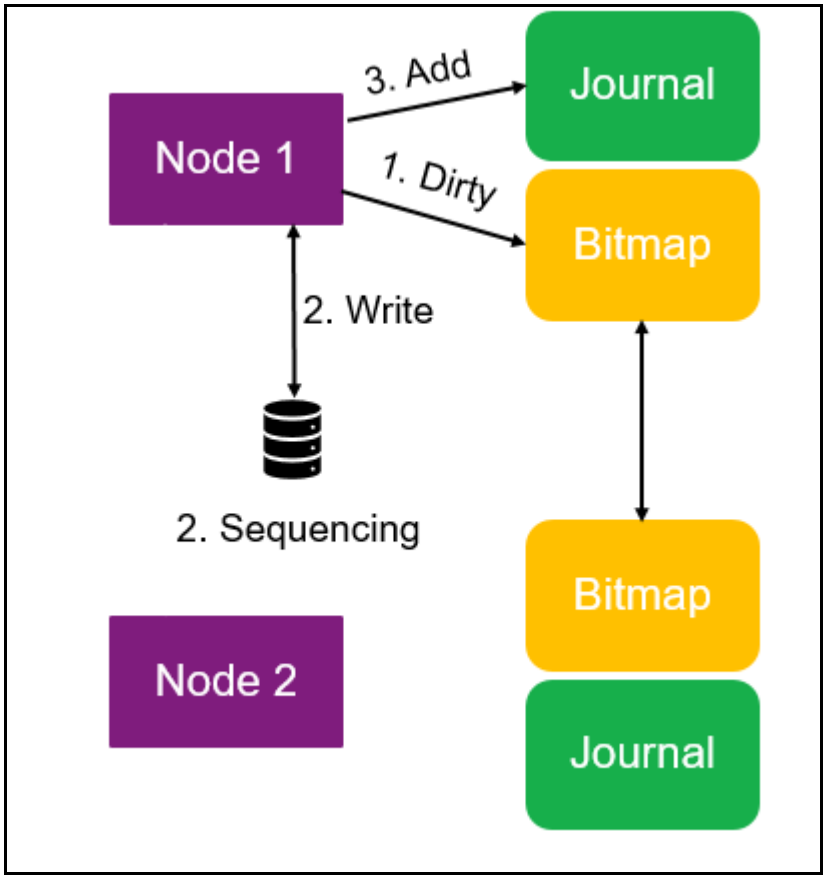

Figure 2-1 Journaling methodology

Note: IBM FlashSystem storage systems implement a dual-controller architecture where there is a control enclosure, and each controller is known as a node. For SAN Volume Controller, each appliance is a node, and nodes are deployed in pairs.

Asynchronously, the write data is written to the volatile journal. This journal acts as a temporary buffer, holding the write data until it is transmitted across the network connection to the remote system for redundancy.

DR systems use sequence numbers to maintain data integrity during replication to ensure that data is written to remote storage in the correct order. This guarantees a consistent point-in-time reflection of the data at the recovery site though it might not be the most up-to-date version. The journal can be volatile. However, the bitmap effectively tracks what data was sent. So, if the journal is corrupted, the bitmap can be used to enable recovery. The bitmap uses fewer resources than the journal and minimizes network traffic between nodes.

In IBM's DR systems, maintaining a consistent point-in-time copy at the recovery site relies on sending data sequentially. However, if the link fails or replication stops, restarting requires the bitmap to identify which data needs transmission.

Because the journal might be unavailable during this interruption, the order of transactions and potentially some data might be lost. In such scenarios, change volumes are used to create a potentially outdated recovery point on the target site while resynchronization occurs. This ensures a recoverable state until data synchronization is complete.

Change volumes are always used during resynchronization, so include space for them when designing policy-based replication.

Tip: As a rule, change volumes can use up to 10% of the storage capacity on both the production and recovery systems.

Although not visible through the GUI, change volumes can be accessed using the **`lsvdisk -showhidden`** command or the **`lsfcmap -showhidden`** command.

2.2.2 Asynchronous replication - Cycling

The other method of asynchronous replication deploys a recurring cycle, which involves the following steps:

- Take a point-in-time snapshot at the primary site.
- Send the changes to the secondary site.
- When the changes are at the secondary site, take a point-in-time snapshot at the secondary site to have a consistent point to recover from if necessary.
- Repeat the cycle.

The change volumes that are associated with the relationship are used for the point-in-time snapshots.

The advantage to this method is that it tolerates low-bandwidth links and problems with site connectivity. The disadvantage to this method is that it is hard to maintain a very low RPO. See Figure 2-2 on page 35.

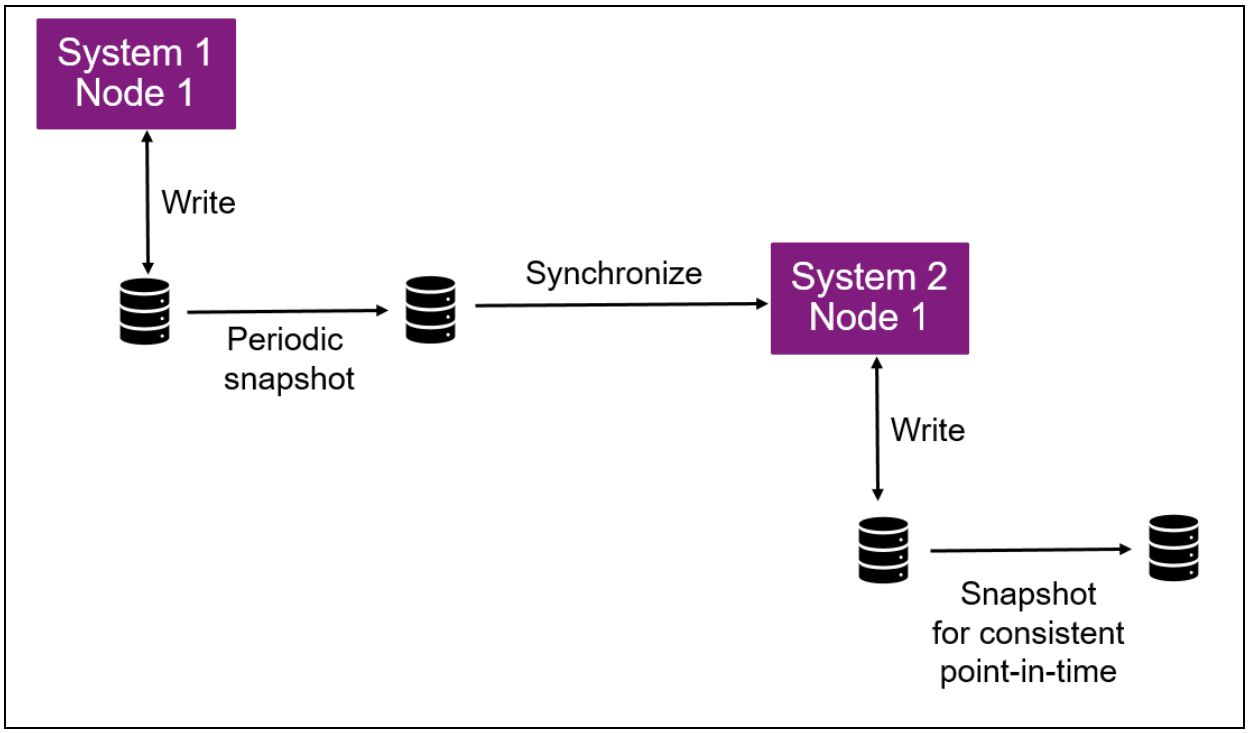

Figure 2-2 Cycling methodology

2.2.3 Quality of service

Unlike remote copy, policy-based replication offers quality of service (QoS) based on the RPO alert on the replication policy attached to specified volume groups. This allows the system to prioritize some traffic over other traffic. The RPO alert on a replication policy can be set from 1 minute to 1440 minutes (24 hours). The system always attempts to keep all volume groups within the RPO alert stated on their replication policy.

Barring constraints, policy-based replication *always* prefers journaling mode regardless of the stated RPO on the policy. This keeps all volume groups at the lowest possible RPO.

If constraints appear on the system or connections, policy-based replication might convert some or all of the volume groups into cycling mode and base that decision on the stated RPO alert on the policy. If the constraint no longer exists, the system converts some or all of the volume groups back to journaling mode. The end user does not control whether policy-based replication is using journaling or cycling.

For example, take a system with two replication policies to the same target system. One policy has an RPO alert of 5 minutes and the other has an RPO alert of 60 minutes. In this example, the client has a peak workload in the evening that overloads their connection bandwidth between the two sites. When constraints appear on the system, it can convert some or all of the volume groups with the 60-minute RPO policy to cycling mode. The change keeps them within their 60-minute RPO, so it can dedicate more bandwidth to the volume groups with the stated 5-minute RPO and keep them in journaling mode. When the constraint no longer exists, the system converts the affected volume groups from cycling mode back into journaling mode.

2.3 Recovery and testing

When performing replication between sites, it is sometimes necessary to recover to the recovery site and perform intermittent testing to prove the recovery mechanisms work and can provide the specified level of recovery. Enabling independent access at the recovery site provides the ability to recover or test. The downside to enabling access at the recovery site is that replication is suspended and the recovery point increases while testing occurs. To mitigate this, some choose to take a snapshot of the volume group on the recovery site and then create a thin clone to test with. Although this provides a testing mechanism, it does not prove that the actual target volumes are recoverable. A third method is to start a recovery test on the volume group in question. This method allows the target volumes to come online and be tested while replication continues. The recovery test function was released in Storage Virtualize 8.6.2. These methods are explored in more depth.

2.3.1 Enabling access

Target volumes in a policy-based replication volume group are offline and therefore inaccessible to the servers. To bring them online and mount them to a server, access must be enabled. Enabling access at the target site *must* be done from that site. The command cannot be issued from the production storage device or site. Enabling access creates two independent copies of the data. Both copies are tracked for changes so that replication can be started in either direction. Only the deltas are copied across the link. Changes can be forced from site 1 to site 2 if that is to be the primary copy or changes can be forced from site 2 to site 1, if necessary. *Replication must be restarted from the storage device that is to be the primary copy.* For example, if a real disaster was declared and production starts running on site 2 instead of site 1, when replication is restarted, it must be started from site 2 so that changes are replicated from site 2 to site 1. See Figure 2-3 on page 37.

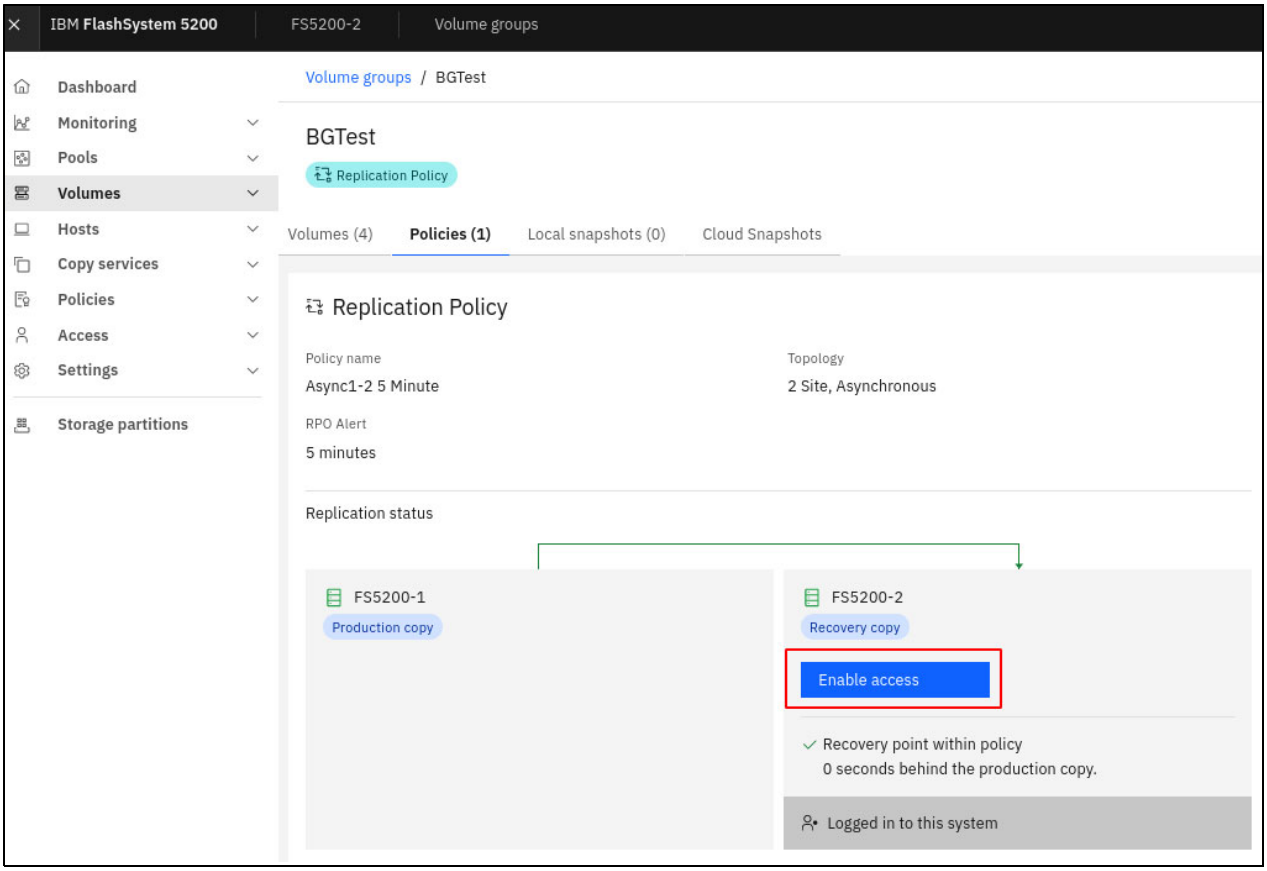

Figure 2-3 Enable access 1

Enabling access is the means for disaster recovery and a means of testing also. However, if testing is the primary function, one of the other two methods is better suited. See Figure 2-4 and Figure 2-5 on page 38.

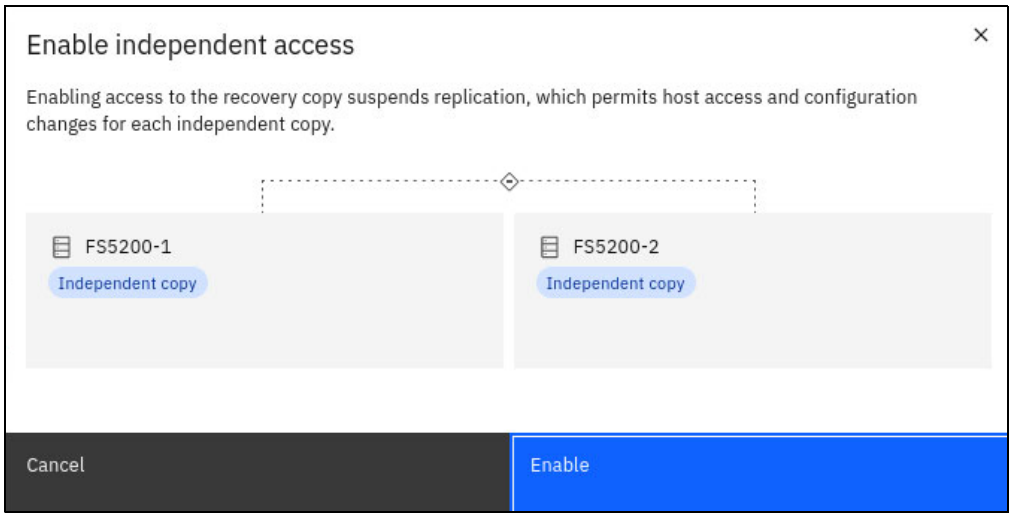

Figure 2-4 Enable access 2

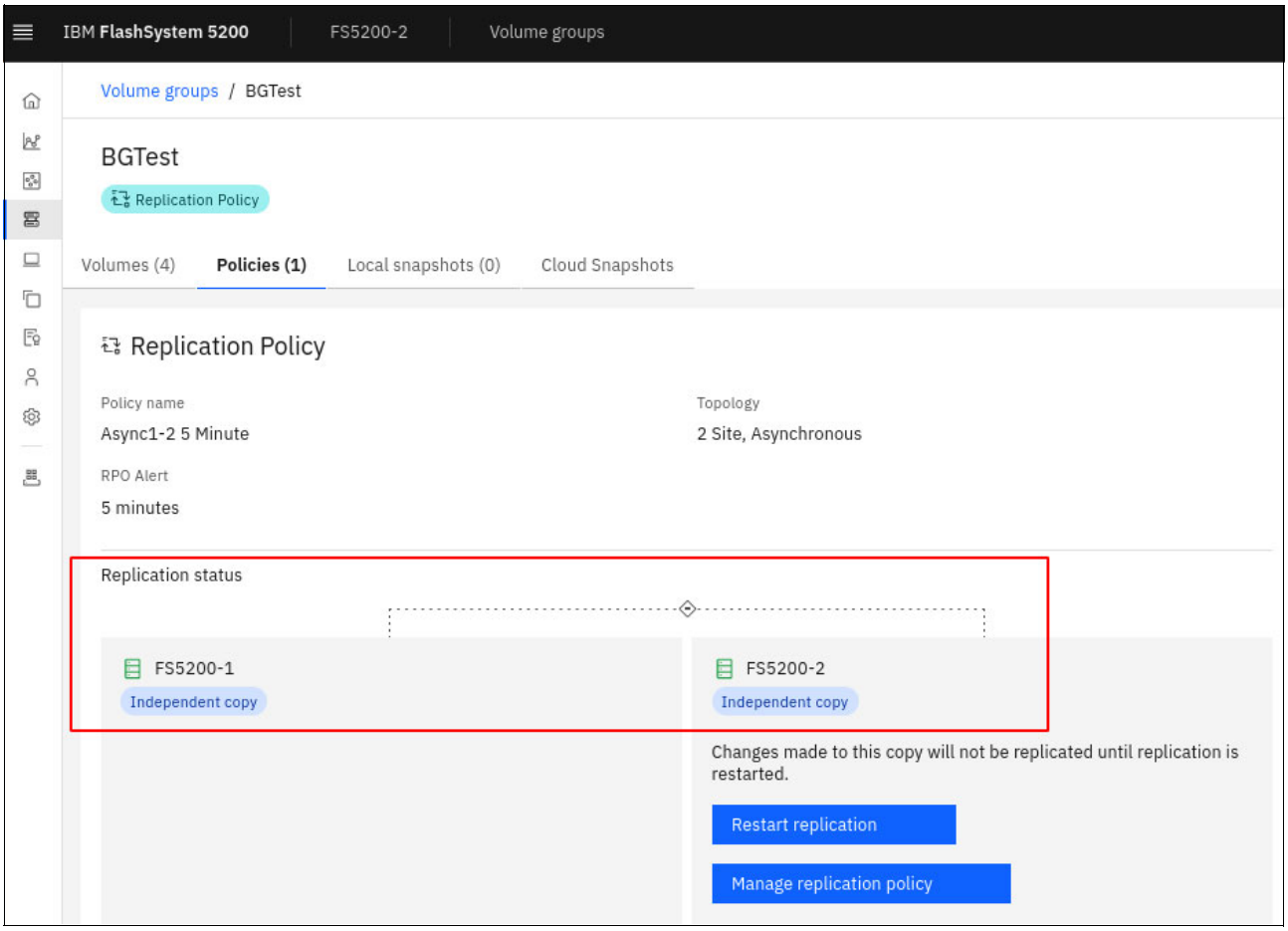

Figure 2-5 Enable access 3

2.3.2 Snapshot and thin clone

Enabling access allows for testing but also stops replication. If testing is the primary objective, a snapshot and thin clone can be used for testing at the secondary site. This requires taking a snapshot of the secondary volume group and creating a thin clone to mount to servers for testing. After testing is completed, the thin clone volumes, volume group, and snapshot can be deleted. Although this method works, it might not be adequate for some because the actual secondary volumes are not tested.

2.3.3 Recovery test

Starting with Storage Virtualize code 8.6.2 there is an option for a recovery test in which the target volumes come online and are mounted to a server while replication continues in the background. This allows for the actual target volumes to be tested, proving that they can be used for recovery in a disaster. This option is only available from the command line and must be issued on the target storage array.

To initiate a recovery test on a volume group named BGTest, enter the following command on the command-line interface (CLI) or REST API:

```
chvolumegroupreplication -startrecoverytest BGTest
```

Figure 2-6 shows that the recovery test is in progress.

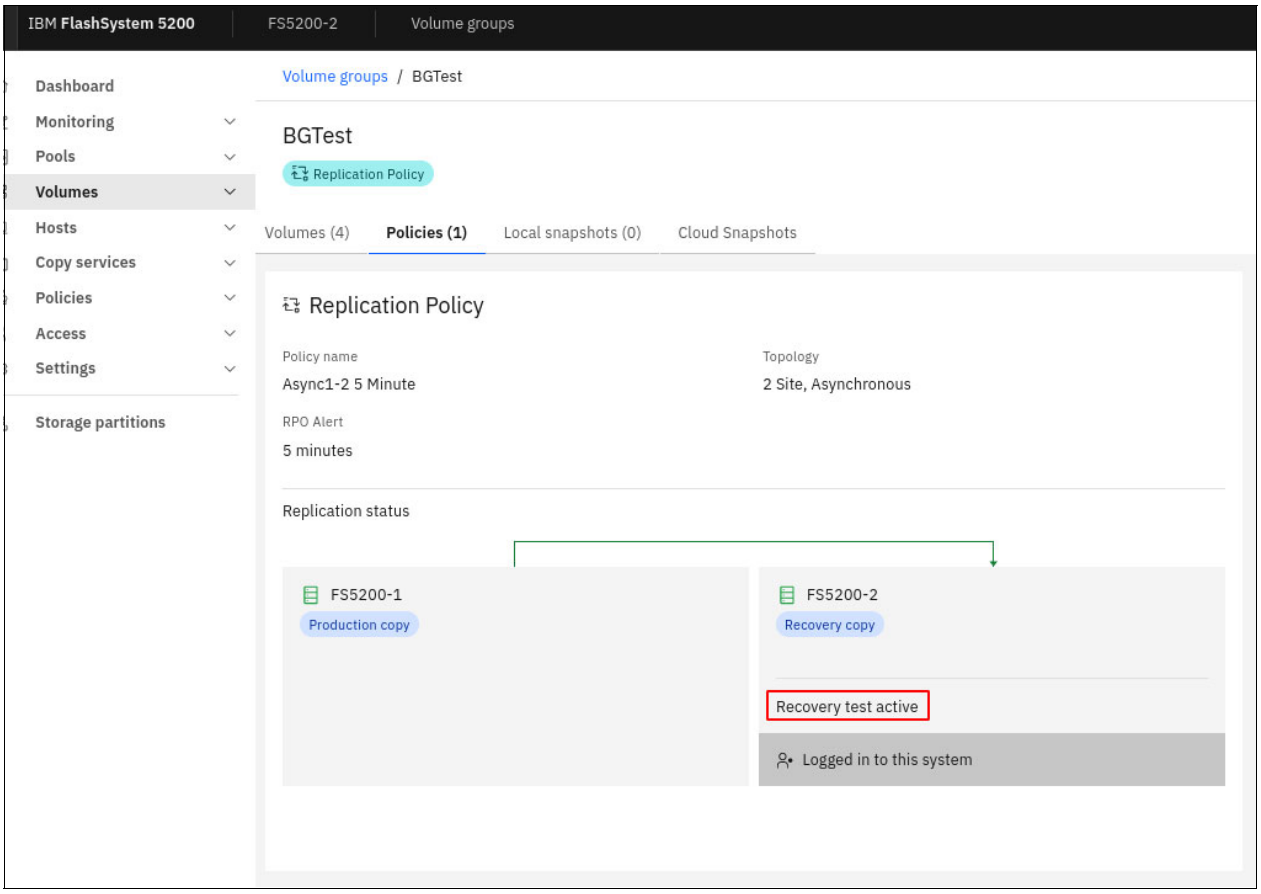

Figure 2-6 Recovery test In progress

Recovery volumes are offline, but when a recovery test is initiated, these volumes come online and can be mounted to a server with read/write access for testing. See Figure 2-7 on page 40.

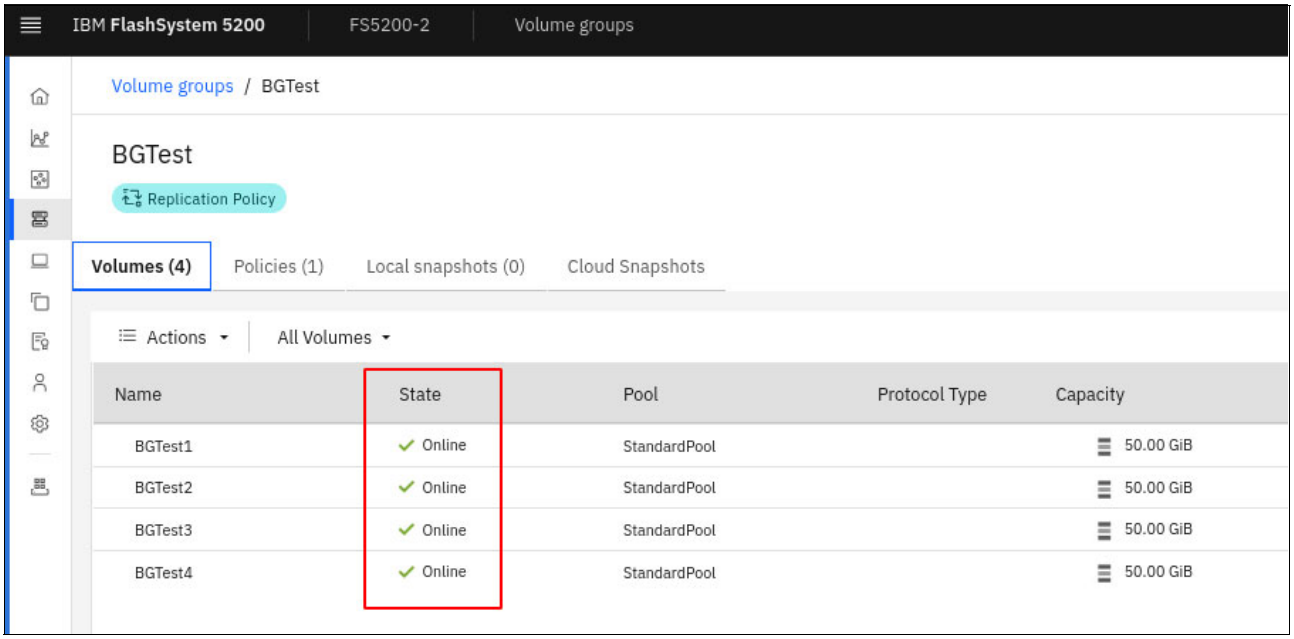

Figure 2-7 Recovery volumes online

When the recovery test is terminated, all changes to the volumes in the recovery volume group are overwritten by what has changed on the source and the recovery volumes are offline again. To stop the recovery test on a volume group named BGTest, enter the following command:

```
chvolumegroupreplication -stoprecoverytest BGTest
```

By using the recovery test method, you can test on the target volumes and when the test is done, less data needs to be updated when compared to the enable access method.

Recommendation: Take a snapshot of the target volume group before the recovery test is initiated.

For more information, see *Policy-Based Replication with IBM Storage FlashSystem, IBM SAN Volume Controller and IBM Storage Virtualize*, REDP-5704.

3

Policy-based high availability

This chapter includes a discussion of policy-based high availability (policy-based HA). This chapter has the following sections:

3.1 Introduction

IBM is modernizing FlashSystem and SVC management to achieve a more efficient and scalable storage infrastructure. The first step involved implementing policy-based management, introduced in 2022. This approach streamlines storage provisioning and simplifies overall management tasks.

In Storage Virtualize version 8.6.1, IBM introduced storage partitions. This critical step laid the groundwork for Flash Grid architecture, offering greater flexibility and scalability of storage. For more information, see Chapter 1, “Introduction” on page 1.

3.1.1 Driving forces behind the development of a new policy-based HA solution

The emergence of policy-based HA can be attributed to several key factors:

- Evolution® of hardware

  Traditional solutions like HyperSwap are designed for older hardware environments with limited processing power, such as systems with a maximum of 8 cores. Policy-based HA is designed to use the capabilities of modern, multi-core processors for improved scalability and performance.

- Integration with policy-based management

  A core tenet of modern storage management is automation and ease of use. Policy-based HA seeks to seamlessly integrate with policy-based management tools, allowing for streamlined configuration and ongoing management of high availability solutions.

- Addressing HyperSwap and stretched cluster limitations

  HyperSwap and stretched cluster have served as a reliable high availability solutions for many years, but they have some limitations that policy-based HA is designed to address:

  – Limited configuration flexibility

    In HyperSwap, all HA volumes must have their targets in the same cluster. Policy-based HA offers more granular control. Users can selectively replicate specific volumes based on their needs.

  – Split brain requires half the cluster to stop

    In split-brain scenarios where communication between systems is lost, then HyperSwap and stretched cluster require shutting down half the system to maintain data integrity. Only one site stays online. Also local volumes can go offline by a decision. Policy-based HA can potentially introduce improved split-brain handling mechanisms to minimize downtime.

  – Performance constraints

    Users might have performance limitations in certain configurations. Policy-based HA can be designed to use modern hardware for improved replication performance.

  – Hardware and software restrictions

    HyperSwap and stretched cluster might require identical hardware at both sites because of clustering support. Also, the software level must be the same in a cluster. So, software upgrades must be done across the cluster at the same time. Policy-based HA might offer more flexibility in hardware configurations and potentially introduce rolling software updates to minimize disruption.

Note: Storage Virtualize 8.7.0.x is the final release to support HyperSwap.

3.1.2 Simplifying storage with IBM Flash Grid and policy-based HA

IBM is revolutionizing storage management with two key advancements that are designed to simplify your operations, optimize performance, and minimize disruptions:

- IBM Flash Grid technology

  IBM Flash Grid allows clients to manage storage systems as a highly available and independently scalable environment, from a single control window, with the ability to move workloads between FlashSystem devices.

  Policy-based HA fits into the Flash Grid architecture and is ready for the future.

- Policy-based HA

  Flash Grid builds upon the foundation of policy-based HA to deliver an HA solution with flexibility and ease of use and includes the following advantages:

  - Simplified management

    Simplified management by using policies to configure entire storage partitions to be highly available, and the system manages the HA for the user.

  - Modular design

    Policy-based HA introduces storage partitions for granular and simplified management. These partitions act as building blocks, so you can group hosts, host-to-volume mappings, volume groups, and volumes. Grouping the related storage resources helps to simplify management where HA is scoped to only the resources within the partition. This modular design allows you to manage these resources as a single entity.

  - Increased fault tolerance

    An issue on one FlashSystem or SVC, whether hardware or software related, remains isolated and does not impact the other systems. This eliminates downtime by providing an HA solution where the volumes are always available.

  - Flexibility in hardware and software versions

    Policy-based HA allows for mixed hardware and software versions across FlashSystem units or SVC in an HA relationship. This provides greater flexibility during upgrades or maintenance cycles because you can upgrade systems independently without affecting high availability.

  - Enhanced performance

    Policy-based HA delivers significant improvements in performance, with a maximum of a 4x increase in throughput and a reduction in latency compared to HyperSwap.

  - Zero impact on non-HA volumes

    HA operations do not disrupt non-critical workloads running on the same system.

  - Increased scalability

    Policy-based HA supports a higher maximum of HA volumes compared to both HyperSwap and stretched cluster.

  - Automated HA configuration

    Assign an HA policy to a partition, and policy-based HA automatically configures everything within it for high availability. This includes remote provisioning, which can eliminate the need for a complex manual setup.

– Isolated recovery

  Storage partitions can be configured to prefer to continue running on different systems in the event of a split brain. This isolated recovery approach minimizes downtime for critical applications and ensures non-HA volumes on the same system remain unaffected.

See 3.3, “Behavior examples of policy-based HA” on page 47 for some examples.

Limits and restrictions: For more information about configuration limits and restrictions, see V8.7.0.x Configuration Limits for IBM FlashSystem and SAN Volume Controller.

Statement of general direction: In the second half of 2024, IBM intends to further enhance these features to support highly available storage with replication to a third system.

All statements regarding future enhancements are subject to change.

3.2 Policy-based HA concepts

Policy-based HA is an active/active high availability solution.

- Volumes in the storage partition are highly-available in an active/active manner while HA is established. When HA is not established, access is only through the active system.
- Writes to the preferred system for a storage partition might have shorter response times because there is only one round trip over the ISL for writes. Writes to the non-preferred system involve an additional round trip, but data traverses the inter-site link once to reduce network traffic. The preferred system can be changed at any time. Reads are processed by the local system.
- Policy-based HA uses host location awareness. When a host location is defined, volumes automatically report preferred access to the storage system in the same location as the host. This optimizes performance by minimizing ISL traffic and latency for geographically distributed deployments.
- All volumes and volume groups within a storage partition do have the same copy direction. The active partition management system always acts as a copy source system. Changing the active management system to the other site changes the copy direction for all volumes within this partition.
- Because policy-based HA is based on the new grid architecture, it can be implemented between only two single I/O group systems.

3.2.1 Simplified management with storage partitions

Policy-based HA introduces storage partitions to manage your HA storage. Partitions offer a modular approach:

- Logical grouping. Create custom partitions that logically group your hosts, host-to-volume mappings, volume groups, and volumes so that you can manage these resources as a single entity.

- Efficient management. Keep resources self-contained so that HA can be configured, and it can be guaranteed that the storage configures HA on all objects that the user wants as HA.
- Volume group requirement. All volumes within a partition must belong to a volume group. This helps ensure proper organization and management of your storage resources.

Figure 3-1 shows a storage partition.

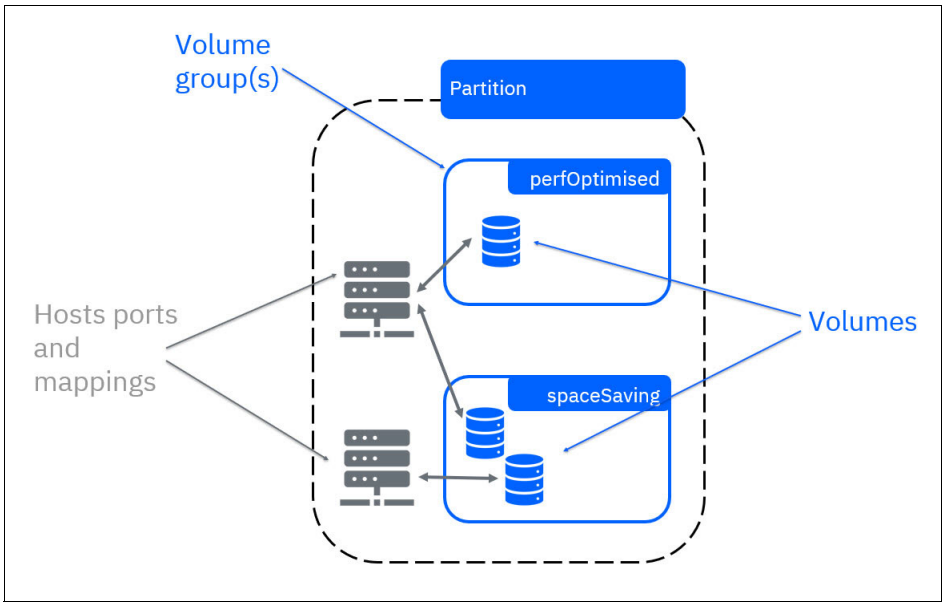

Figure 3-1 Storage partition

Currently, a maximum of four storage partitions are supported per FlashSystem. However, there is no limit on the number of volumes, volume groups, hosts, and host-to-volume mappings you can configure within a partition. You can add more resources as needed, either to existing partitions or by creating new ones. It is possible to merge partitions, if they have the same replication policy. A partition cannot be split into separate partitions.

Figure 3-2 shows a FlashSystem example with a single IO group with 2 partitions and other local volumes.

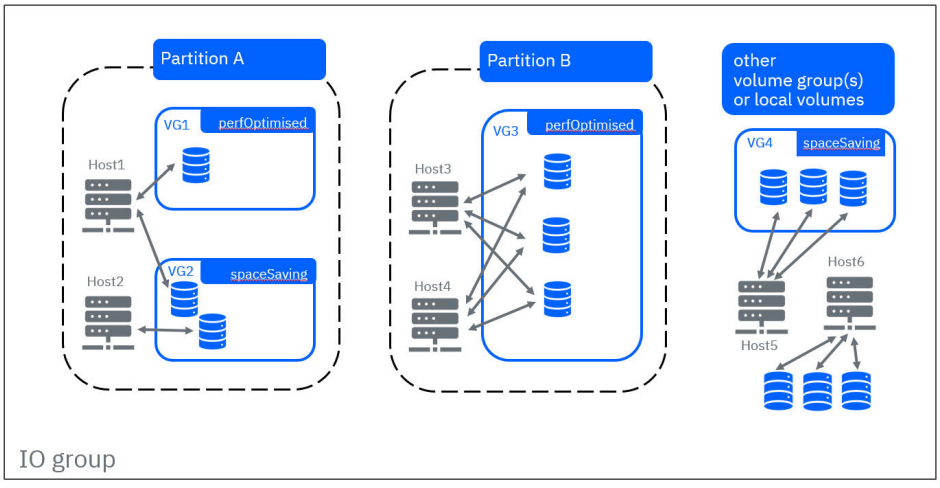

Figure 3-2 FlashSystem example - single IO group with two partitions and other local volumes

3.2.2 Draft partition

With policy-based HA, you can create a new storage partition and specify existing volume groups. The GUI guides you through this process. A draft partition has no effect until it is published. For more information, see Storage partitions.

3.2.3 Making partitions highly available

Policy-based HA uses familiar connection infrastructure, replicating data between sites by using either Fibre Channel SCSI or High-Speed Ethernet (iWARP with RDMA).

- Configuration steps for high availability:
  - Partnership, pools, and policies. Set up the foundation for HA by configuring partnerships between your FlashSystem units, storage pools, pool links, and provisioning policies.
  - 2-Site-HA topology. Apply a "2-site-HA" topology to a specific partition to enable high availability between your two independent FlashSystem units or SVC.
- Partition management:
  - Active versus preferred management system. Each partition that is associated with an HA replication policy has two properties, the *preferred management system* and the *active management system*. All configuration actions on a storage partition must be performed on the active management system. The storage partition can be monitored on either system.

    The preferred management system is the system that you want to be the active management system under ideal conditions. If the active management system and the preferred management system are not the same system, the system automatically fails over the active management system back to the preferred management system when it is able. The preferred management system can be changed by the user.
  - Dynamic partition configuration. You can create or delete volumes, volume groups, hosts, and host-to-volume mappings within a partition at any time. A volume removal from a partition requires a replication policy unassignment. A partition must include all volumes mapped to any hosts within it. The assigned HA policy automatically configures all hosts and volumes within the partition for high availability. Policy-based HA uses an IP quorum application to determine the active management system and prevent split-brain scenarios in which both systems are managing the same partition.

Best practice: Configure a second IP quorum as a backup for situations where the primary quorum fails or requires maintenance.

SAN zoning: SAN zoning to isolate traffic must be configured manually. It is not automated by policy-based HA.

Figure 3-3 shows a highly available storage partition.

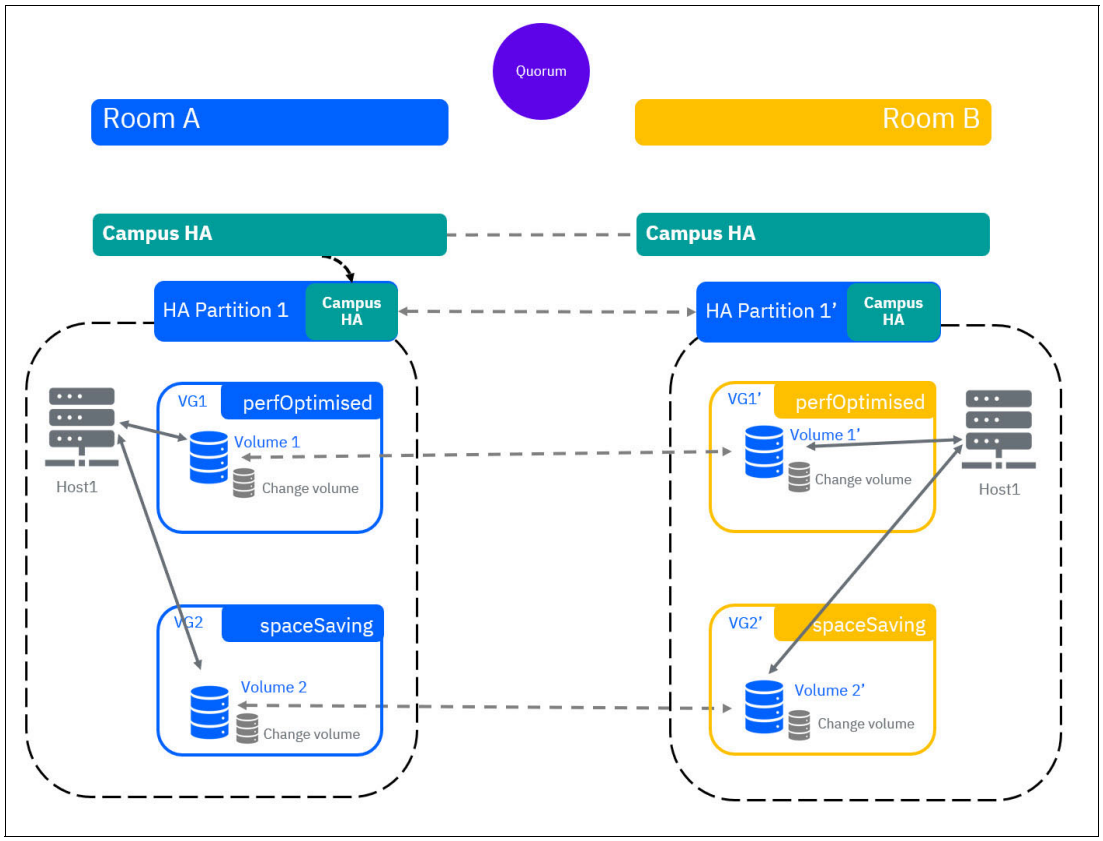

Figure 3-3 Highly available storage partition

In summary, policy-based HA offers a simplified and automated approach to setting up and managing high availability. With familiar connection infrastructure, predefined configuration steps, and automatic failover mechanisms, policy-based HA helps ensure continuous data access and simplifies storage management.

To summarize: Policy-based HA offers a simplified and automated approach to setting up and managing high availability. With familiar connection infrastructure, pre-defined configuration steps, and automatic failover mechanisms, policy-based HA helps ensure continuous data access and simplifies storage management.

3.3 Behavior examples of policy-based HA

Policy-based HA delivers robust high availability with active/active access and site affinity for your storage systems. This means applications can access data simultaneously from either FlashSystem, preventing disruptions during failures.

Policy-based HA uses site awareness. Host site awareness is the (optional) ability to set a location for each host such that when HA is established the I/Os are directed to the storage system in the same location as the host.

3.3.1 Effects of not configuring site affinity

Without site affinity configured, all hosts prioritize the preferred partition, potentially causing brief disruptions during a failover as the multipathing driver reconfigures paths. Also, all traffic from hosts at the non-preferred site to the active management system traverses the public SAN. Therefore, it is crucial to consider the required bandwidth when sizing the public SAN to avoid bottlenecks. Figure 3-4 shows an HA configuration without host locations.

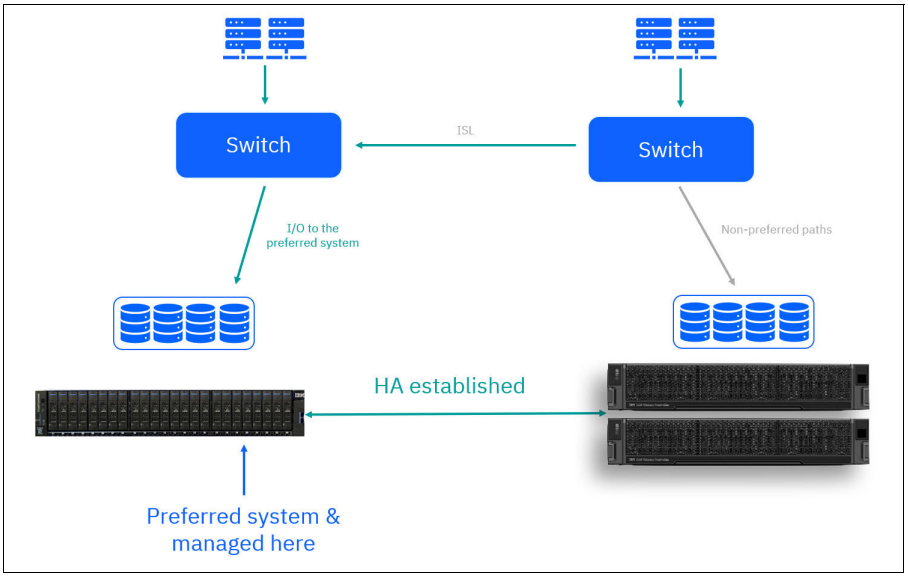

Figure 3-4 HA without host locations

Recommendation: For optimal performance and efficient high availability, assign site attributes to all your hosts. This configuration step unlocks benefits for your applications and simplifies storage management.

The site attribute is the name of the IBM FlashSystem or SVC. Figure 3-5 shows the data flow, if site attributes are used.

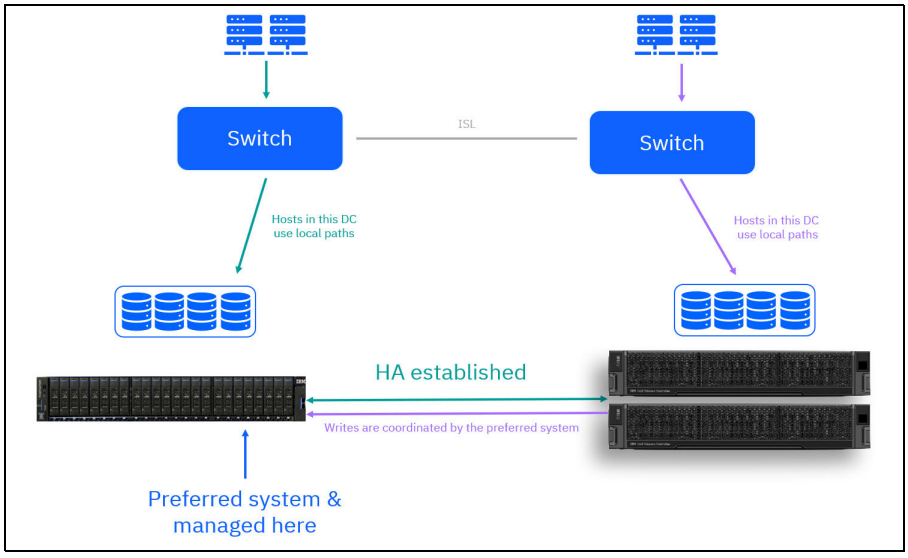

Figure 3-5 HA with host locations

Figure 3-6 shows that the host multipath driver is directing I/O to the one surviving system.

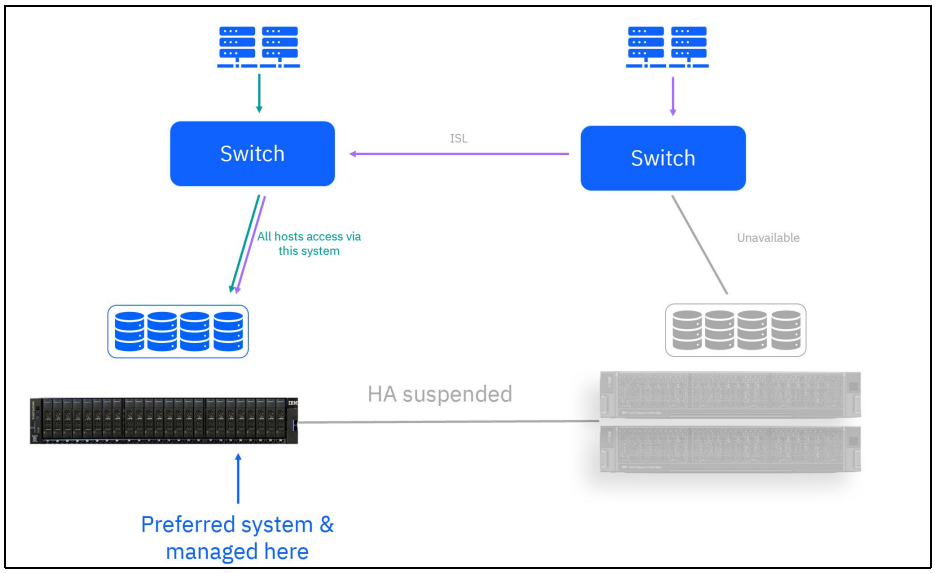

Figure 3-6 HA with host locations - Storage failure

3.3.2 Split-brain scenario

In a split-brain scenario because of lost communication between sites, each policy-based HA partition uses its own IP quorum to determine the active management system. If the preferred site is available and has the majority of quorum votes within a partition, that partition likely remains managed by the preferred site. However, quorum votes ultimately dictate the active management system, not just the preferred designation.

The `preferred management system` attribute is defined on a per-partition basis. The system-wide "preferred quorum" parameter has minimal influence on policy-based HA behavior, so you can typically leave it at its default setting. See Figure 3-7.

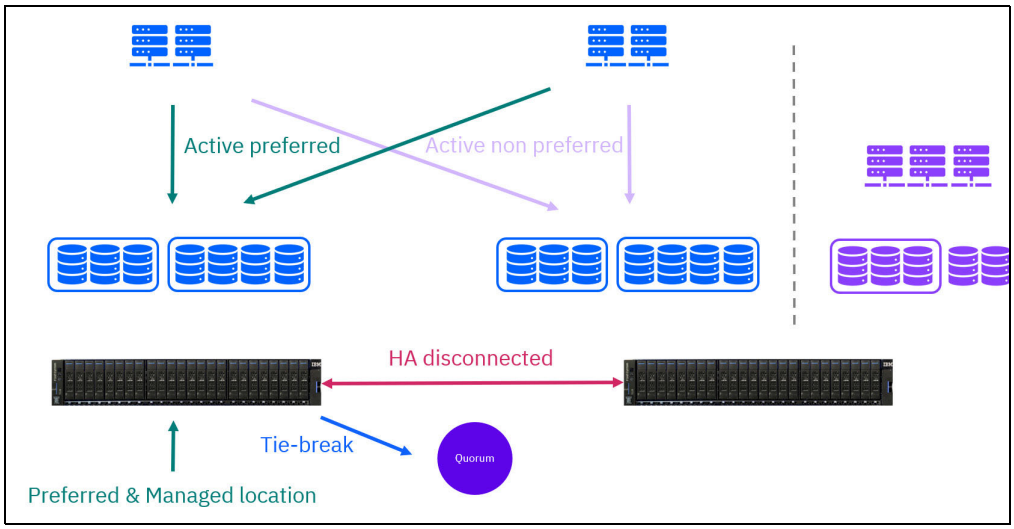

Figure 3-7 HA storage partitions - split brain scenario 1

In a split-brain scenario, only the affected partition on the secondary site and its access paths become unavailable with policy-based HA. Local non-HA volumes on the secondary site

critically remain accessible. This is a significant advantage over HyperSwap, where an entire secondary site goes offline during a split-brain scenario, which might impact all data that is stored there. See Figure 3-8.

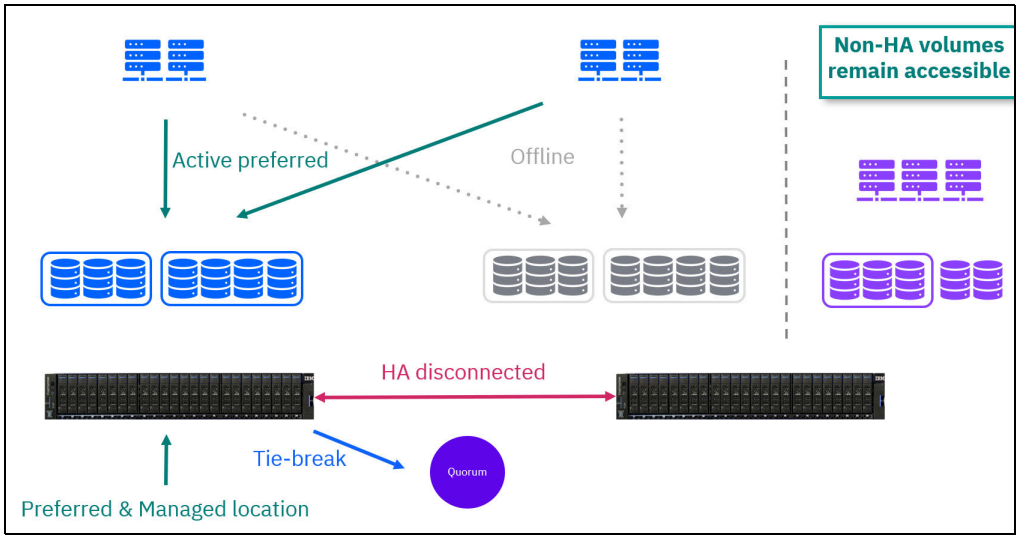

Figure 3-8 HA storage partitions - split brain scenario 2

During a failover event in policy-based HA, the multipathing driver on the host automatically switches the paths to the active partition from the secondary site to the preferred site. To ensure optimal performance during a failover, the public SAN must have sufficient bandwidth to handle the additional workload from the non-preferred site. See Figure 3-9.

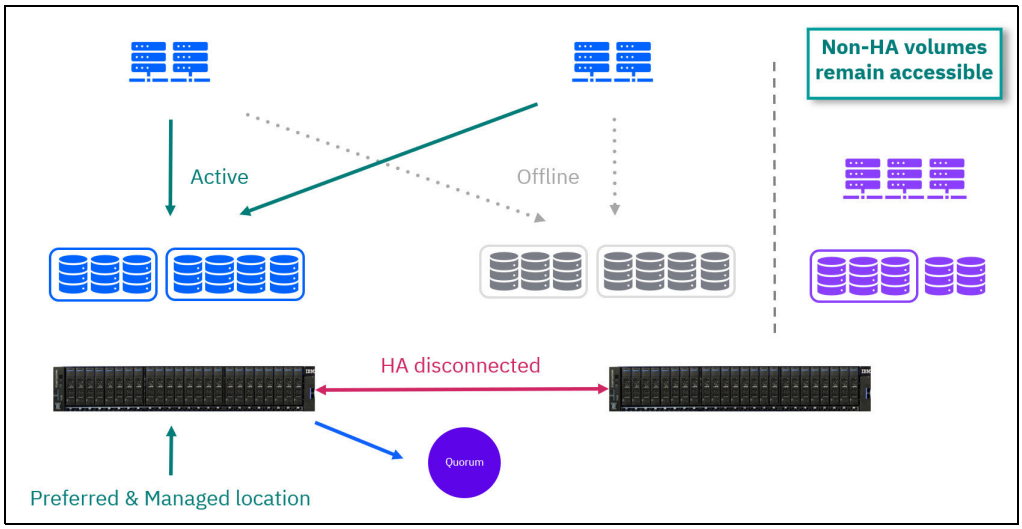

Figure 3-9 HA storage partitions - split brain scenario 3

If the connection between sites is reestablished, resynchronization automatically begins. Change volumes are used automatically during synchronization to maintain a consistent data copy at the secondary site.

In case of cascading failures, where HA was not fully reestablished, disaster recovery-like access can be enabled to the most recently synchronized copy of volumes within the partition. HA is only established when all volumes in the partition are synchronized. HA becomes available after synchronization finishes for all volume groups, and the partition

reaches the established state. This typically occurs immediately after synchronization finishes.

Management of the partition follows the active management system, which might or might not be the same as the preferred system depending on the failure scenario. After a failure, management and data access is routed through only one of the FlashSystem units until HA is reestablished.

Note: If policy-based HA detects issues that might compromise high availability, it automatically suspends the affected partnership for 15 minutes. This 15-minute window allows the systems and network links to stabilize before attempting to reestablish HA. After the 15-minute suspension, a resynchronization process occurs to ensure data consistency before resumptions of the HA configuration.

Although automatic restart occurs after 15 minutes, you can manually initiate the partnership restart on both FlashSystem units to expedite HA reestablishment.

3.3.3 HA storage partitions - with preferred workload in different locations

In scenarios with two data centers and active workloads on each site, defining different partitions for each site is considered best practice for policy-based HA. See Figure 3-10.

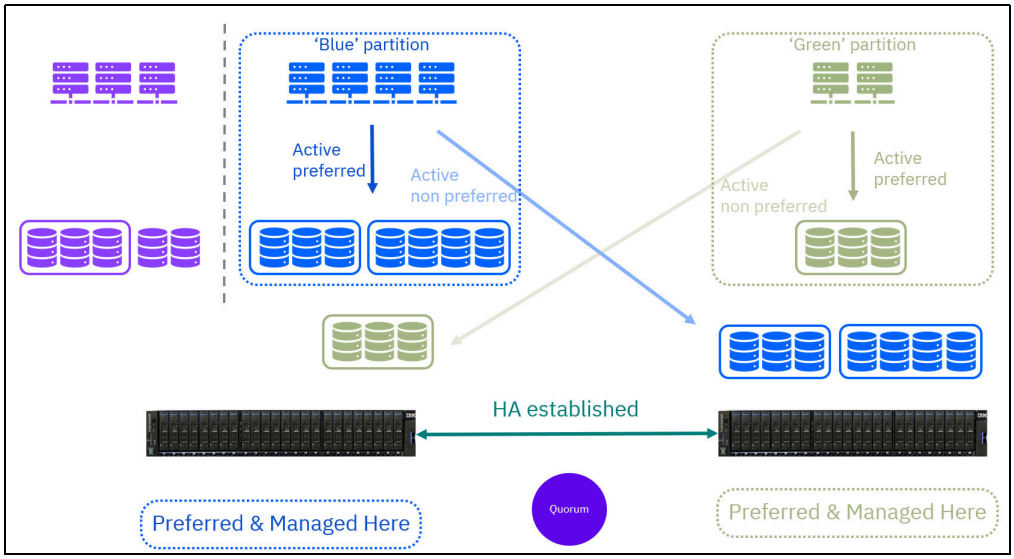

Figure 3-10 HA storage partitions - normal running, asymmetric preferences

3.3.4 Split brain scenario with preferred workload in different locations

Policy-based HA offers a significant advantage over HyperSwap when the connection between HA systems is lost, especially with preferred partitions defined:

- Per-partition quorum decisions. Unlike HyperSwap, policy-based HA relies on per-partition quorums. Each partition independently determines its active management system based on quorum votes within itself.
- Preferred site advantage. If the connection is lost and the preferred site for a partition is available with a majority of quorum votes, that partition remains managed by the preferred site. This avoids unnecessary failovers and keeps data accessible from the preferred location.

- Remote partition handling. Partitions associated with the unavailable site are likely to go offline because of the lack of communication and quorum.
- Non-HA disk accessibility. Even during a connection loss, non-HA volumes on the available FlashSystem typically remain accessible, ensuring continued access to critical data not part of an HA policy.

  See Figure 3-11.

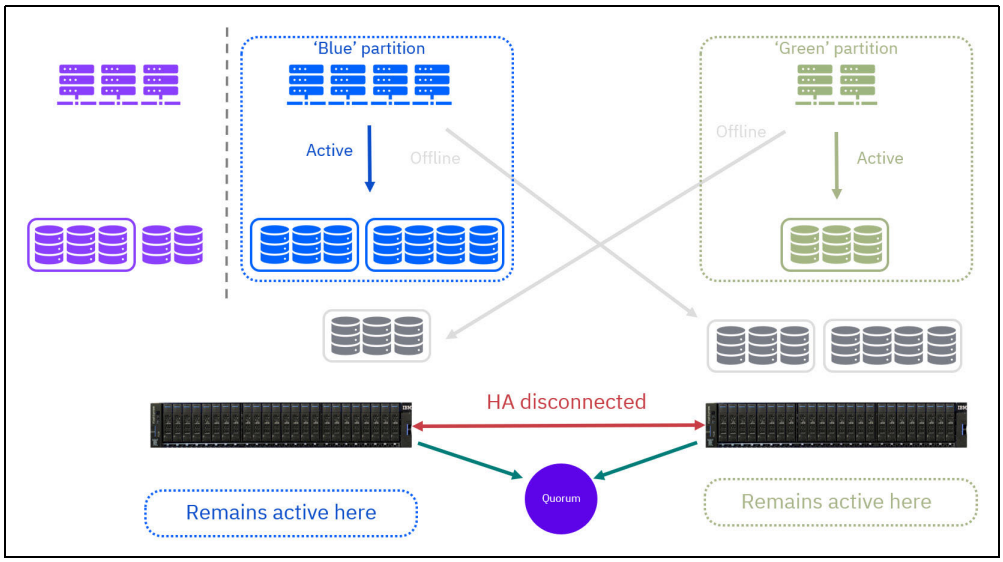

Figure 3-11 HA storage partitions - quorum decision per partition

3.3.5 HA disconnected - System 1 cannot get to the quorum

This section describes what happens in policy-based HA if the preferred site loses connection to the quorum, a critical decision-making component for high availability. See Figure 3-12.

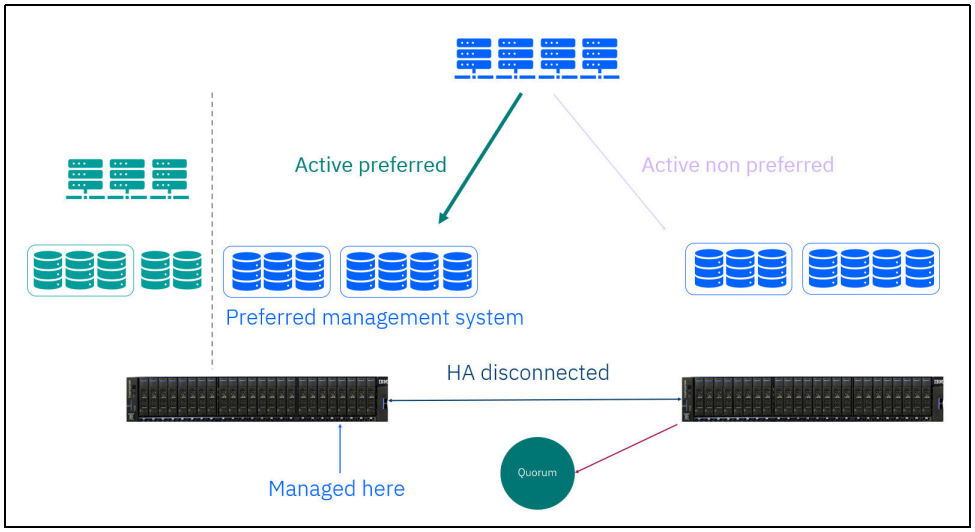

Figure 3-12 HA disconnected - System 1 cannot get to the quorum

1. In the event of a failure at the primary (preferred) site, policy-based HA automatically initiates a failover in the following manner:

– Secondary site takes over. The designated secondary site assumes control, ensuring minimal disruption to your applications and data access.
– Preferred site goes offline. The primary site is brought offline to prevent potential data inconsistencies during the failover process. See Figure 3-13.

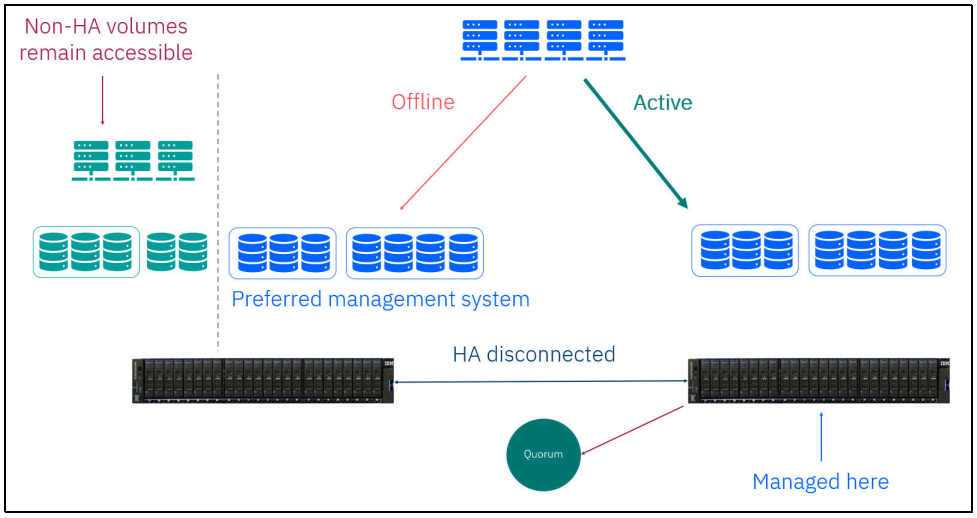

Figure 3-13 Operation while in fault state

Upon reconnection, policy-based HA captures a snapshot of the *change volume*. which is a temporary storage area that holds modifications during the outage. By using the change volume snapshot, policy-based HA performs an efficient resynchronization to ensure that both sites are back in sync. When resynchronization is complete, policy-based HA reestablishes high availability to ensure your data remains protected.

See Figure 3-14.

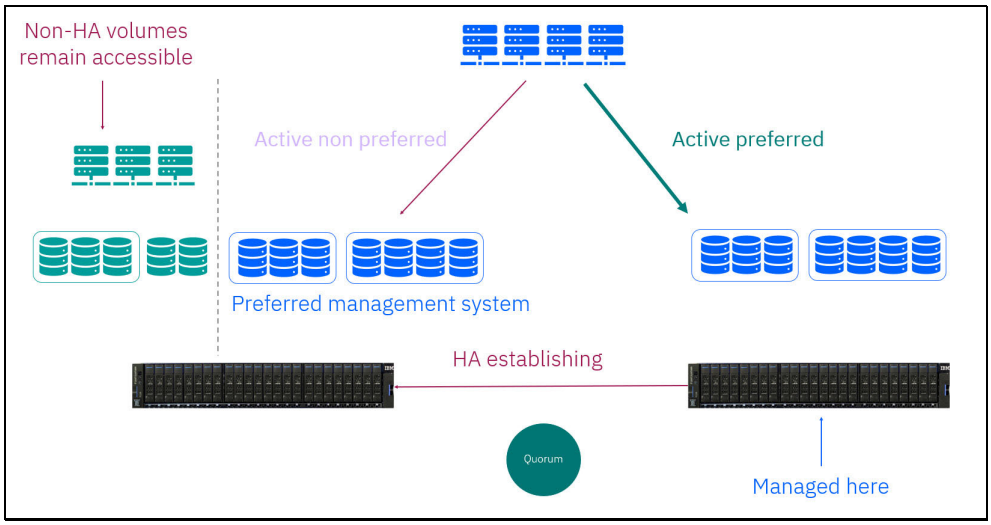

Figure 3-14 Problem fixed - Resynchronization

2. After HA is reestablished, the paths fail back to the preferred site. See Figure 3-15 on page 54.

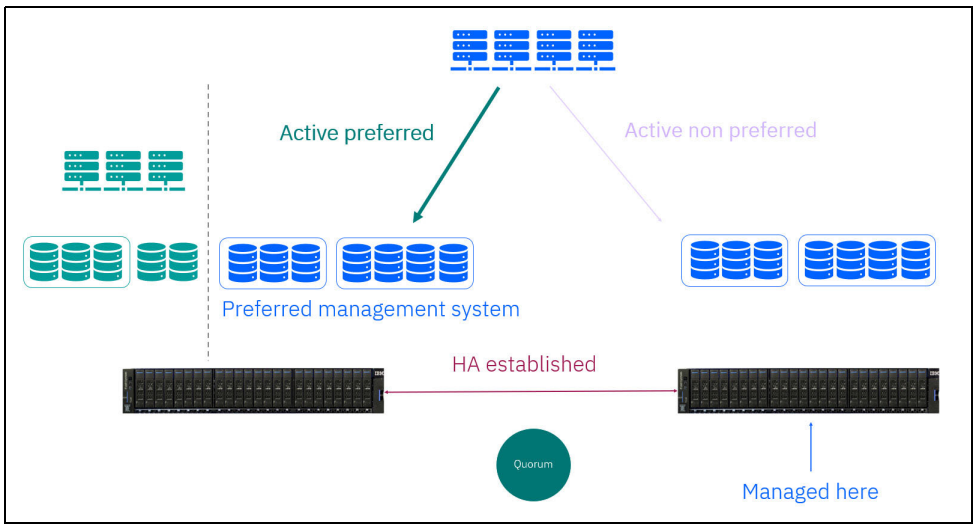

Figure 3-15 Paths return to normal

3. Also, the management fails back to the preferred site. See Figure 3-16.

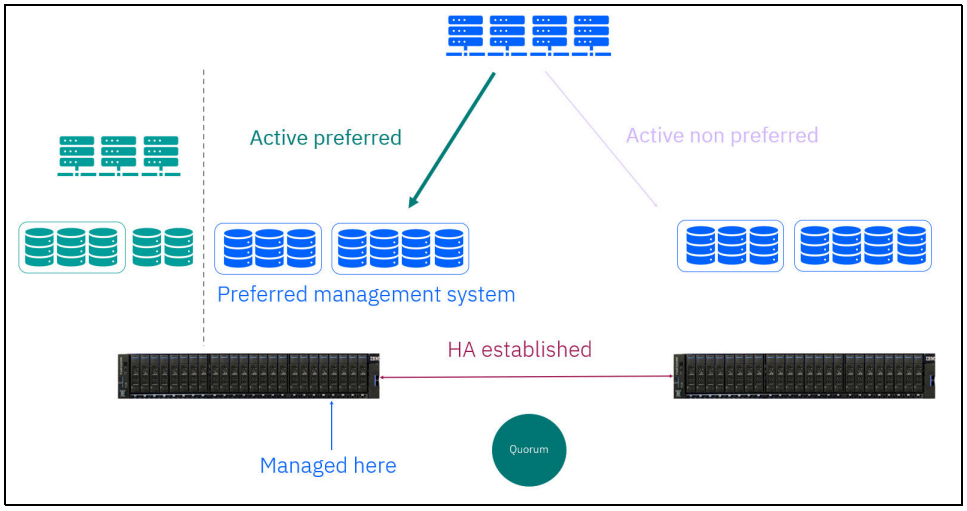

Figure 3-16 Management returns to normal

4. The system returns to the preferred HA configuration.

3.4 Comparison of policy-based HA with SVC stretched cluster and HyperSwap

This document focuses on the current capabilities of policy-based HA. Although some limitations exist in this initial version, continuous development is underway to address them and introduce more advanced features. Table 3-1 on page 55 compares policy-based HA with SVC stretched cluster and HyperSwap.

Table 3-1 Comparing policy-based HA with SVC stretched cluster and HyperSwap

	Policy-based HA	HyperSwap	Enhanced Stretched Cluster
Supported on	SVC and NVMe products. 1 I/O group systems	2 or more I/O group systems	2 or more I/O group SVC only
Maximum HA capacity	Up to 4 PiB	Up to 2 PiB per pair of I/O groups, 4 PiB per system	40 PiB per I/O group (SV3), 1 PiB (SV2, SA2)
Maximum HA volume count	32,500	2,000	7,932
Non-HA volumes	Unaffected by HA problems	Link problems cause offline volumes	Link problems cause offline volumes
Protects against outage of entire system	Yes	No	No
Protects (mutual) consistency during resynchronization	Yes	Yes (mutual consistency with consistency groups)	No
Host interoperability support	Limited. See Planning high availability.	Full	Full
HA snapshots (including Safeguarded)	No*	No*	Yes
3-site support	Statement of direction	Yes - externally orchestrated asynchronous	Synchronous with Metro Mirror, asynchronous with policy-based replication
Volume resize support	No	Expand thin volumes	Expand and shrink
Quorum	IP quorum app only, preferred-site behavior per storage partition	IP quorum app or controller, default/preferred/winner per system	App or controller, default/preferred/winner per system
Maximum nodes per site	2 (1 I/O group)	4 (2 I/O groups)	4 (half of each I/O group)
Mixed hardware models	Yes, unrestricted	Limited (must cluster)	Limited (must cluster)
Mixed software levels	Yes (scheduled for future)	No	No
Licensing	Remote Copy, included in LMC	Remote copy, included in LMC	Base

* Volume Group Snapshots would be taken on both sides rather than making the snapshots HA.

4

Implementing policy-based replication

This chapter includes a description of how to implement policy-based replication for the Storage Virtualize 8.7 solutions and how to stop and reverse the mirror direction during a failure of the production system.

This chapter has the following sections:

4.1 Implementing policy-based replication

Policy-based replication (PBR) can help the setup, administration, and oversight of replication by employing volume groups and replication policies. This approach offers a simplified means of configuring, managing, and monitoring replication between two systems.

4.1.1 Advantages of PBR

PBR brings several key advantages to asynchronous replication:

- PBR uses volume groups so that all volumes are replicated based on the assigned policy.
- By eliminating the need to manage relationships and change volumes manually, policy-based replication can help simplify the overall administration process.
- The feature automatically manages provisioning on the remote system, reducing the administrative burden.
- During a site failover, policy-based replication can enable easier visualization of the replication process, which can facilitate effective management and decision-making.
- IBM Storage Virtualize version 8.5.2 and later provides asynchronous replication over Fibre Channel and IP partnerships.
- Automatic notifications are generated when the recovery point objective exceeds the specified threshold, ensuring timely awareness of any deviations.
- Policy-based replication provides status updates and alerts regarding the overall health of the replication process, enhancing monitoring and troubleshooting capabilities.

4.1.2 Configuring policy-based replication by using the GUI

To demonstrate the full functionality and capabilities of policy-based replication, this section shows the roles of the storage architect and the storage administrator.

Figure 4-1 shows the topology for the systems and the example configuration.

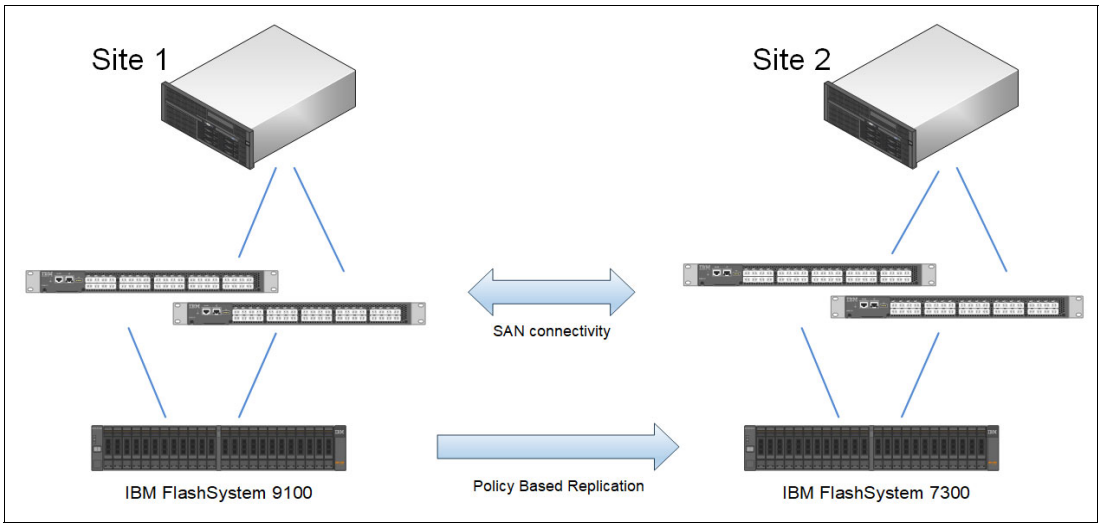

Figure 4-1 Topology for our policy-based replication setup

All aspects of replication can be managed using the GUI.

When you create the first partnership for policy-based replication, the management GUI guides you through the following main steps:

1. Completing the partnership setup by creating the partnership from the remote system.
2. Linking pools between systems, optionally using provisioning policies on each pool.
3. Creating a replication policy.
4. Creating a volume group and assigning a replication policy to the group.
5. Creating new volumes or adding existing volumes to the group.

You can monitor and manage replication from the Volume Groups page.

Note: In the following example, the setup of policy-based replication is on two connected FlashSystem systems. Policy-based replication can also be configured on SAN Volume Controller (SVC).

In the example, the systems are SAN-zoned together with dedicated ports for node-to-node communication. Other connectivity options include high speed Ethernet networking.

Check code levels on both connecting systems

To ensure compatibility for policy-based replication, use the GUI to verify that for replication both systems have the preferred Storage Virtualize code version. In the example, the systems must be updated from version 8.7.0.0. Go to **Settings**, and select **Update System**, as shown in Figure 4-2.

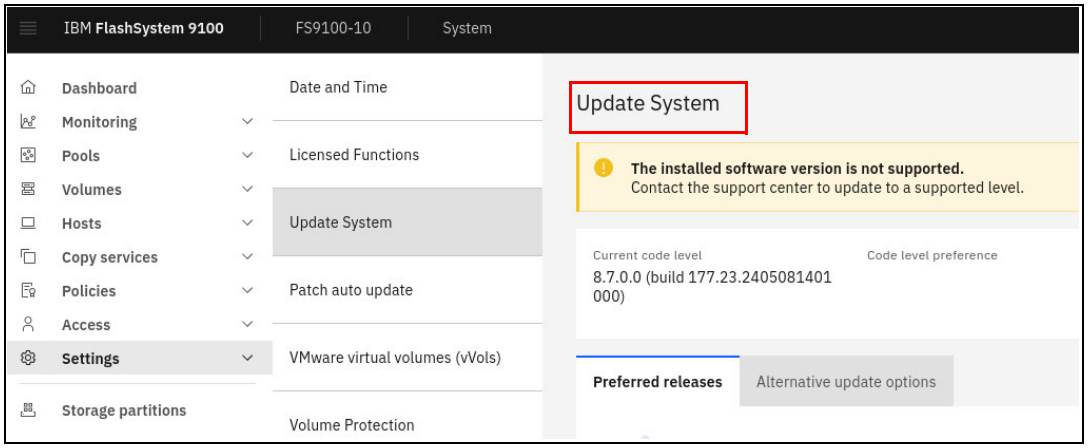

Figure 4-2 Verify software version

Define partnership for replication

Before starting the configuration process, it is important to ensure that a partnership is established between the two FlashSystem boxes. This partnership is used for data replication and synchronization. To initiate the partnership, perform the initial system setup on both systems to be partners. This setup involves establishing a partnership between the systems by using either FC or IP connectivity.

Also, as part of the partnership setup, a certificate exchange must be performed. This exchange ensures that each system has the necessary configuration access to the other system by using the REST API.

Note: A prerequisite for creating a partnership through SAN-zoning is that the two systems are correctly zoned together with dedicated ISL-links for node-to-node traffic.

Creating a partnership

To create the partnership between systems, complete these steps:

1. On the first system, select **Copy Services** and then **Partnerships**.
2. Click **Create Partnership**.
3. Enter the type of partnership (FCP, IP TCP, or IP RDMA).
4. Select the remote system.
5. Ensure that the Use **Policy-Based Replication** checkbox is selected.
6. Enter the value, in megabits per second (Mbps), for the total bandwidth available between the two systems that can be used for replication. If all the bandwidth is available for policy-based replication, ensure the background copy rate (%) is set to 100.
7. Click **Create**. The Create Partnership wizard is shown in Figure 4-3.

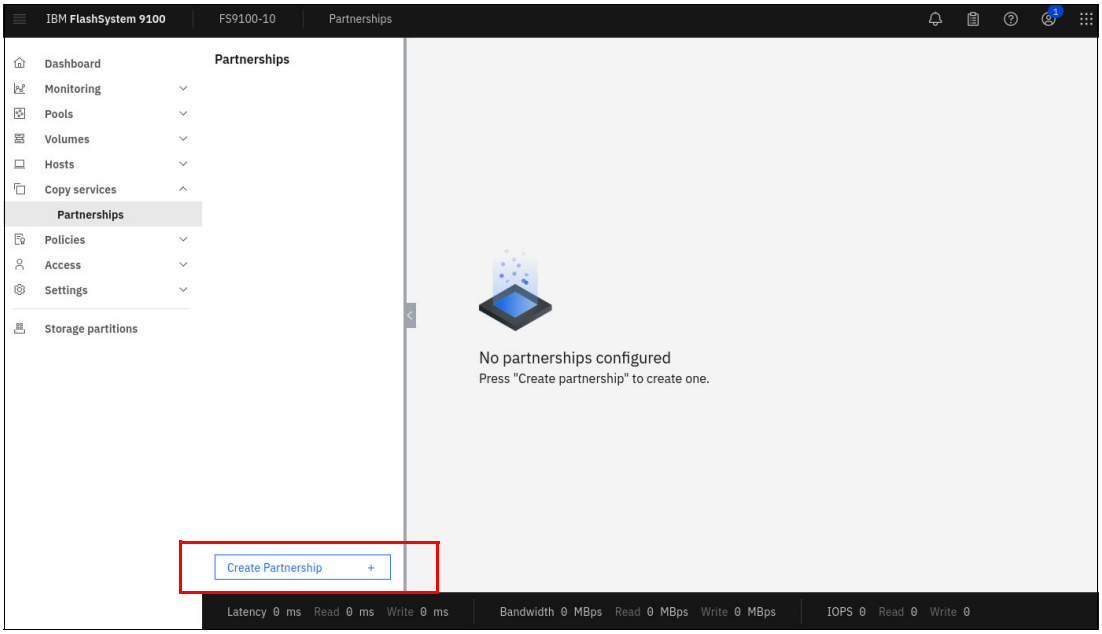

Figure 4-3 Create partnership

8. The Create Partnership wizard options are shown in Figure 4-4 on page 61 and include selection of Fibre Channel, the selection of the Partner system name, and selecting the checkbox Use policy-based replication. Also, the bandwidth and background copy rate are specified.

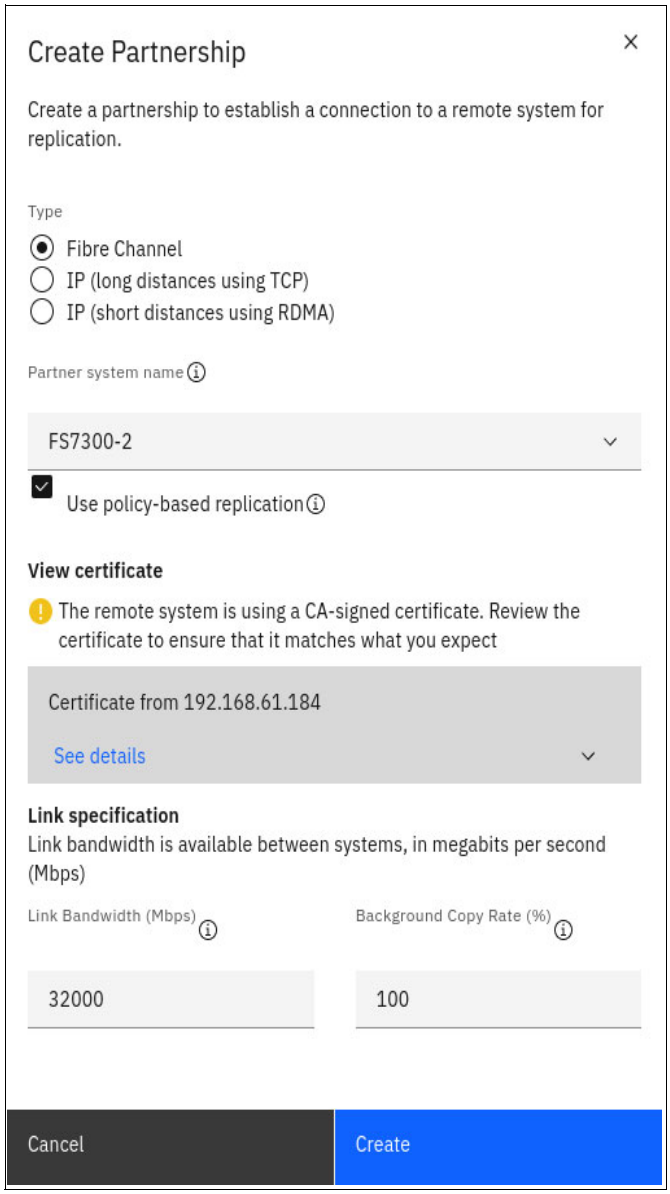

Figure 4-4 Create Partnership window

The partnership must be created from both the production and recovery systems.

9. After the partnership is created, the **CopyServices** → **Partnership** menu looks like the system in Figure 4-5 on page 62.

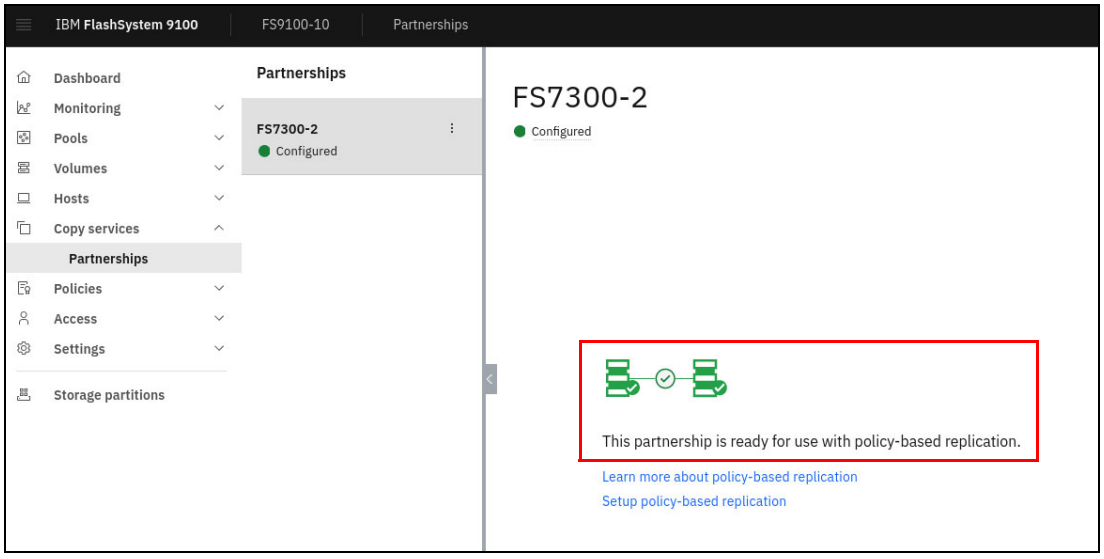

Figure 4-5 Partnership ready for policy-based replication

Because the two systems are partners, the Partnerships panel on each system looks like Figure 4-5.

Setup policy-based replication wizard

Select **Copy Services** → **Partnerships** and click **Setup Policy-based replication**. The resulting window, after the partnership are created, looks like Figure 4-6.

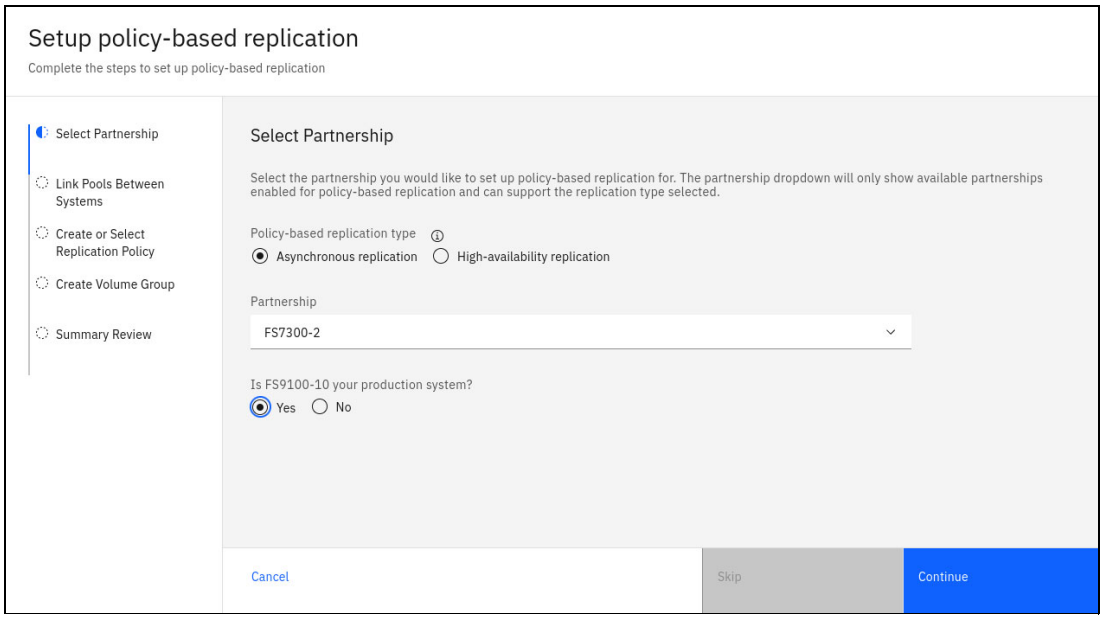

Figure 4-6 Setup policy-based replication

In the Setup policy-based replication window define the partnership:

1. Select **Asynchronous** replication.
2. Select the system to replicate with, in this example it is **FS7300-2**.

3. Confirm that this system is your production system. That is, confirm you are mirroring from this system to the recovery system. If you select **No**, you are prompted to make the changes from the partner system instead.
4. Click **Continue**.

Link storage pools together

To establish a linked pool in policy-based replication, the storage pool links determine where the recovery copy of a volume is stored on the recovery system based on the production volume pool. It is necessary to have links between the pools on the production and recovery systems when using policy-based replication.

At least one linked pool is required on each system for policy-based replication to function properly. There are two approaches to creating linked pools. The first option involves creating pools on each storage system and then linking them together manually.

Alternatively, the wizard to Setup policy-based replication in Figure 4-7 guides you through the processes involved.

Select the storage pools to link together. Our lab configuration has only a single pool to select on each system as shown in Figure 4-7. Click **Link Pools** to proceed.

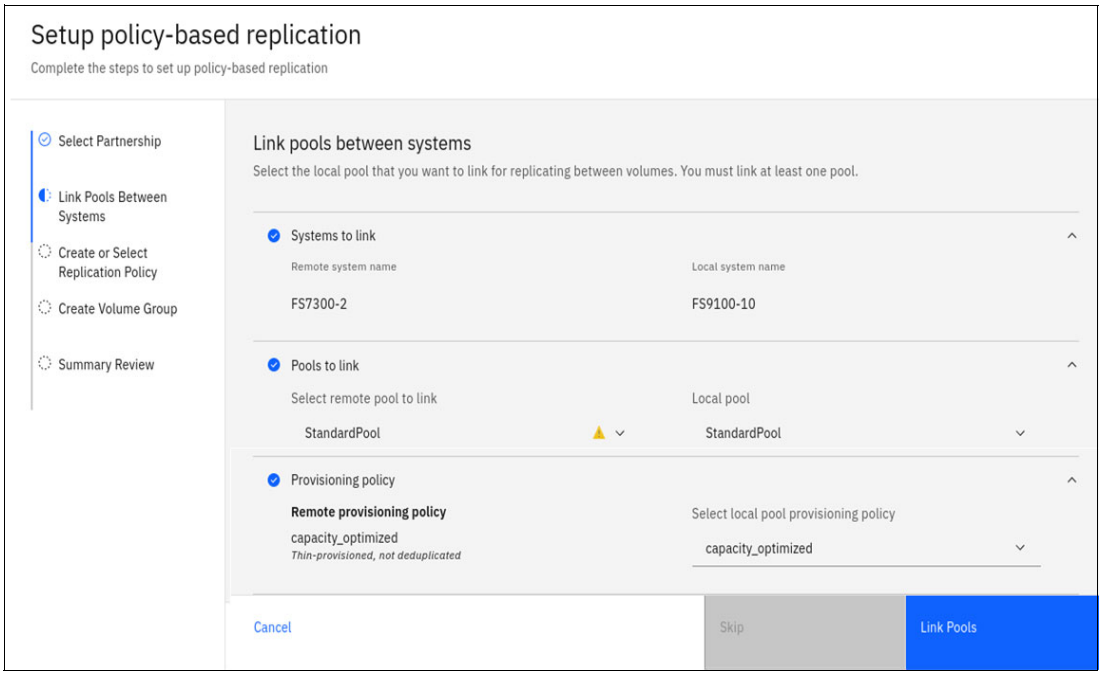

Figure 4-7 Set up policy-based replication - Link pools

The wizard prompts the user for the following information:

1. Systems to link. In the example, select the local system **FS9100-10** and the remote system **FS7300-2**.
2. Pools to link:
   - Select the single available pools on each system.
   - The system posts a warning because only one system has its storage pool encrypted, which is not recommended. Encryption should be enabled on both or none.

3. Provisioning policy:
   - Apply a provisioning policy to the storage pools. Select **capacity optimized** to configure thin provisioning.
   - The wizard directs the user to the remote system to enable a provisioning policy to the remote system's storage pool.

The Link Pools Between systems wizard in Figure 4-7 on page 63 initially provides a link to the recovery system on which you are directed to the Pools menu. You can then right-click the pool and select **Add Pool Link for Replication**. Figure 4-8 shows how to add or remove pool links directly on the target system.

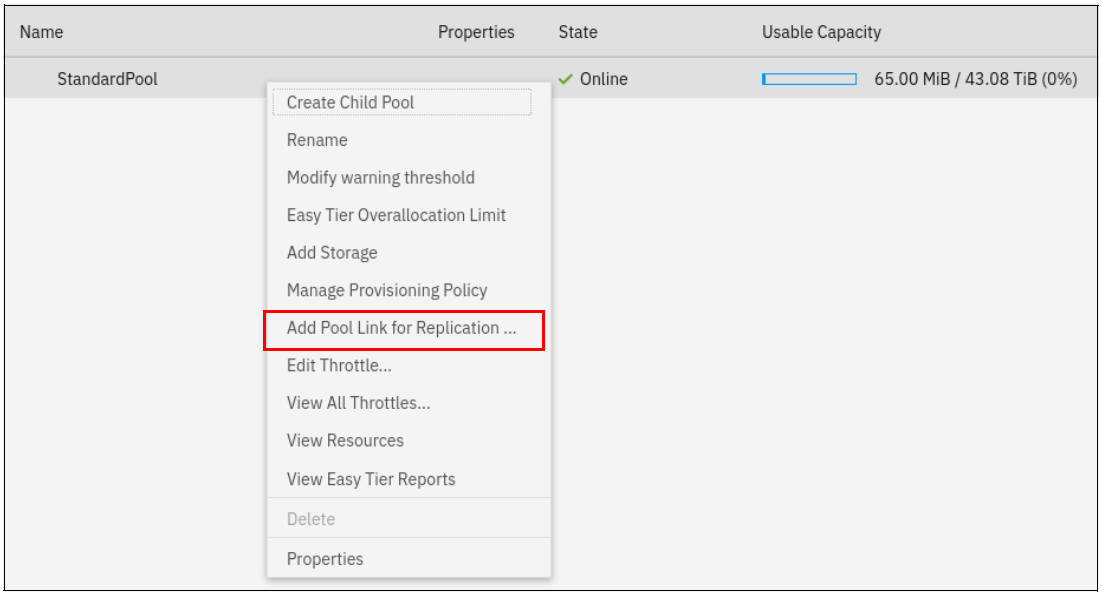

Figure 4-8 Link pools on the recovery system

When the replication is active, the pool links cannot be modified.

Creating a replication policy

Replication policies play a crucial role in PBR because they define the configuration of replication between I/O groups in partnered systems and define how to apply it to volume groups and their associated volumes. These policies are established between two fully configured and partnered systems that are capable of policy-based replication.

A replication policy can be linked to multiple volume groups. However, each volume group can have a maximum of one replication policy associated with it.

Figure 4-9 on page 65 shows the Create replication policy panel in which you can perform the following steps:

1. Select **Create new policy**.
2. Enter a name in the Name field.
3. In the Topology field, select **2 Site, Asynchronous**.
4. Select the systems in the Location 1 and Location 2 fields.
5. Define how old the data on the recovery site can be before an alert is sent.
6. Click **Create replication policy** to proceed.

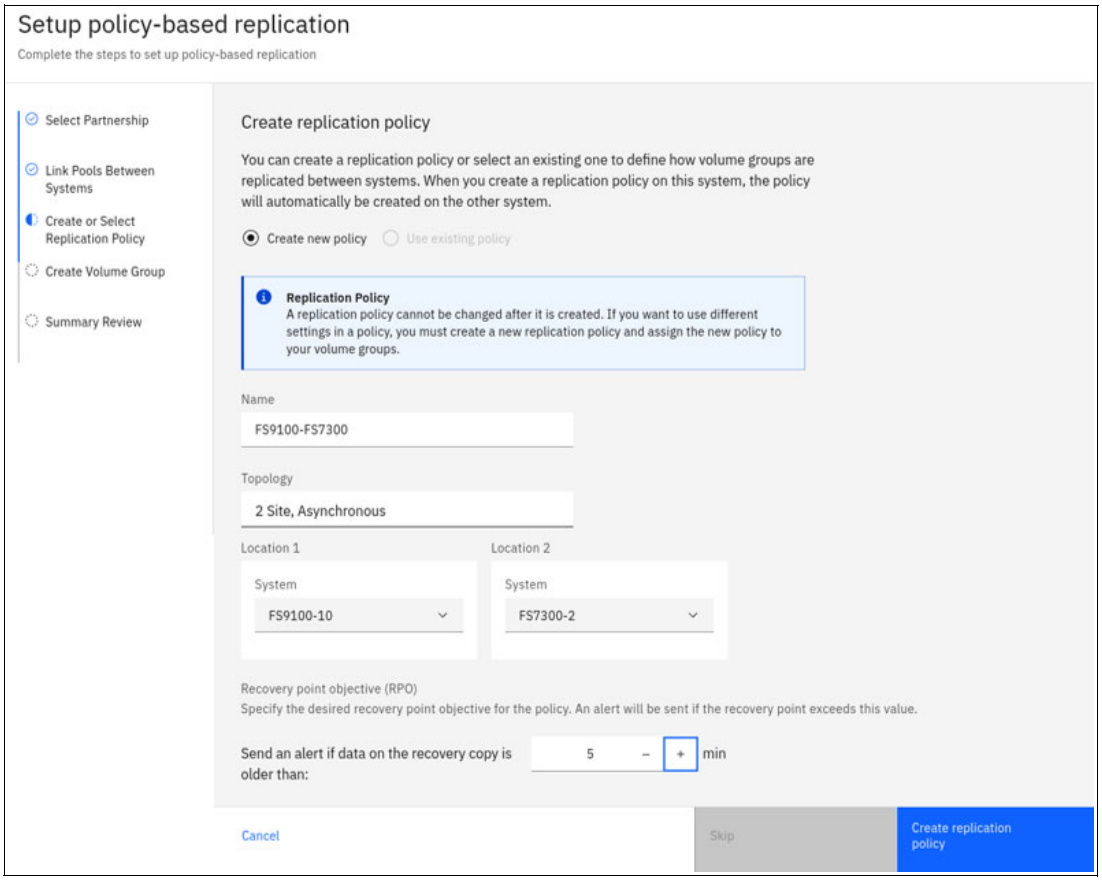

Figure 4-9 Create replication policy

Creating a volume group

To deploy and manage replications in policy-based replication, use volume groups and replication policies. After a replication policy is created, the wizard prompts you to create a volume group. This process helps ensure consistent replication by replicating the source volumes as a group to the recovery system.

The recovery copies of volume groups are immutable, meaning they cannot be modified or altered. Policy-based replication greatly simplifies the configuration, management, and monitoring of replication between two systems.

To create a volume group, the Create Policy-Based Replication wizard prompts you to enter a volume group name as shown in Figure 4-10 on page 66. Enter the name and click **Create Volume Group** to proceed.

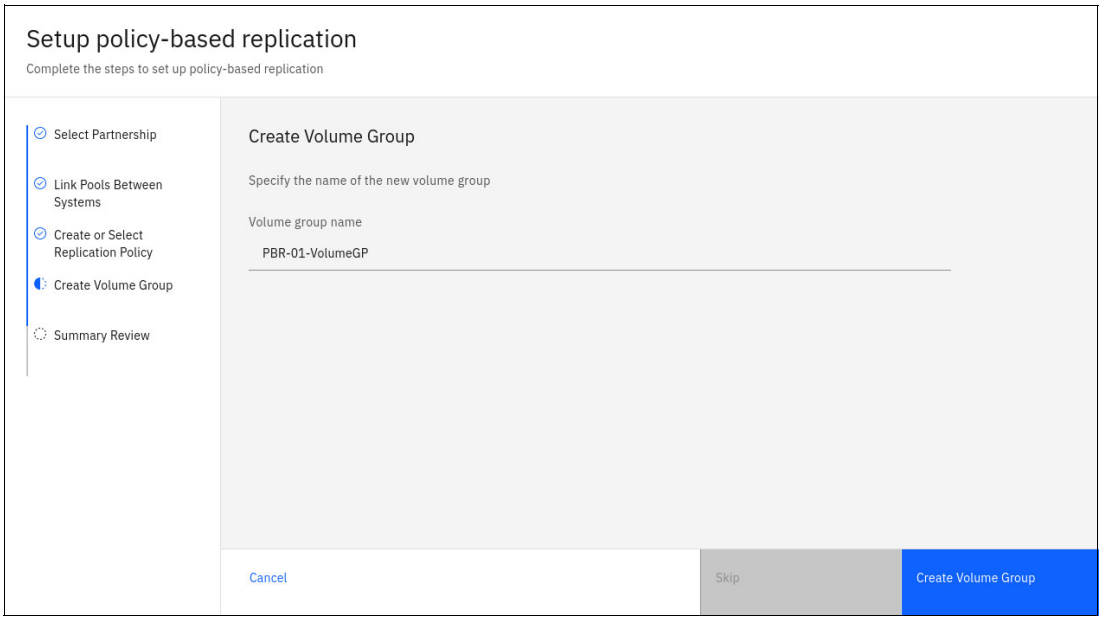

Figure 4-10 Create Volume Group

The Setup Policy-Based Replication wizard shows a Summary review as shown in Figure 4-11. Click **Go to Volumes** to proceed.

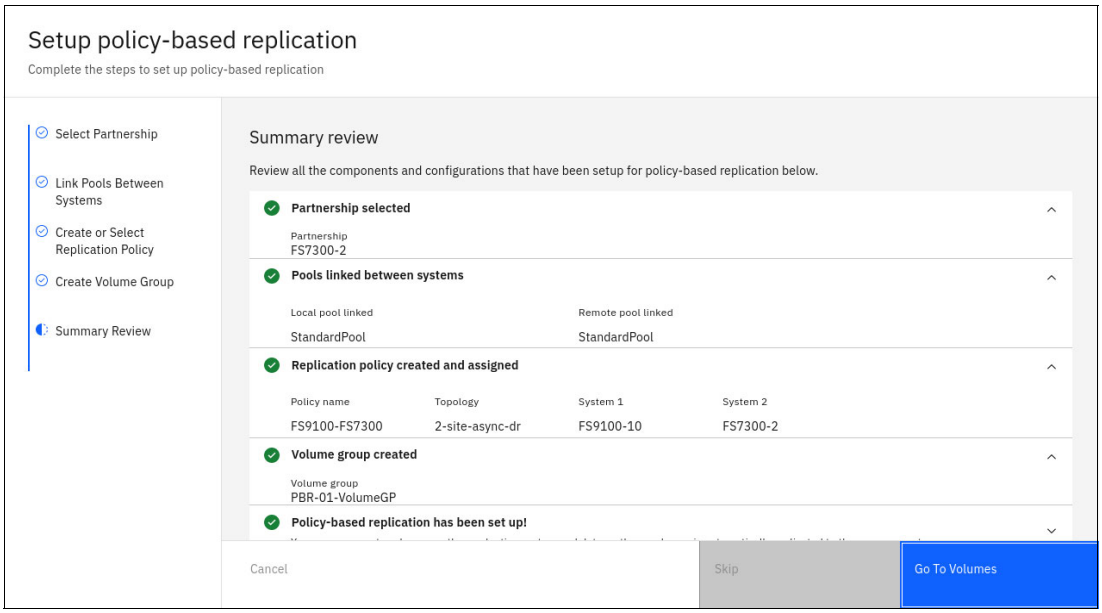

Figure 4-11 Policy-based replication create summary

The Setup Policy-Based Replication wizard is finished. Select Go to Volumes to add volumes to the volume group.

Adding volumes to a volume group

The next step is to create volumes or add existing volumes to the volume group. Figure 4-12 on page 67 shows the newly created volume group, which is empty.

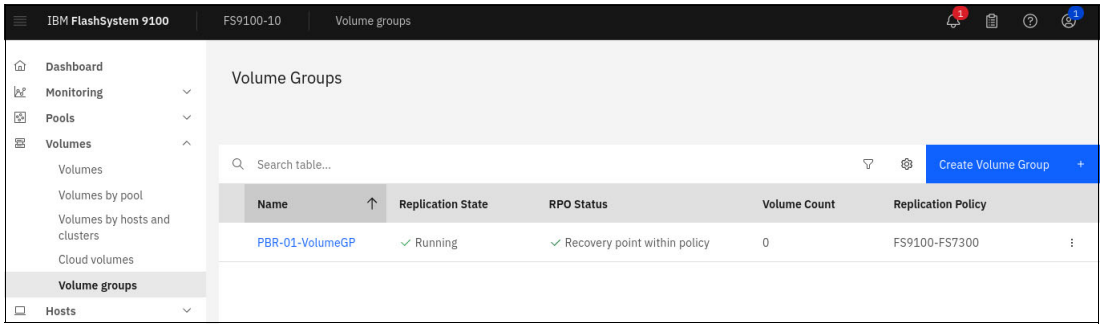

Figure 4-12 Volume Group created including no volumes

Follow the steps to add volumes to the volume group.

1. Click the newly created Volume Group and click **Actions** → **Create New Volumes** or **Add Existing Volumes**.
2. In this example, **Create New Volumes** is selected as shown in Figure 4-13.

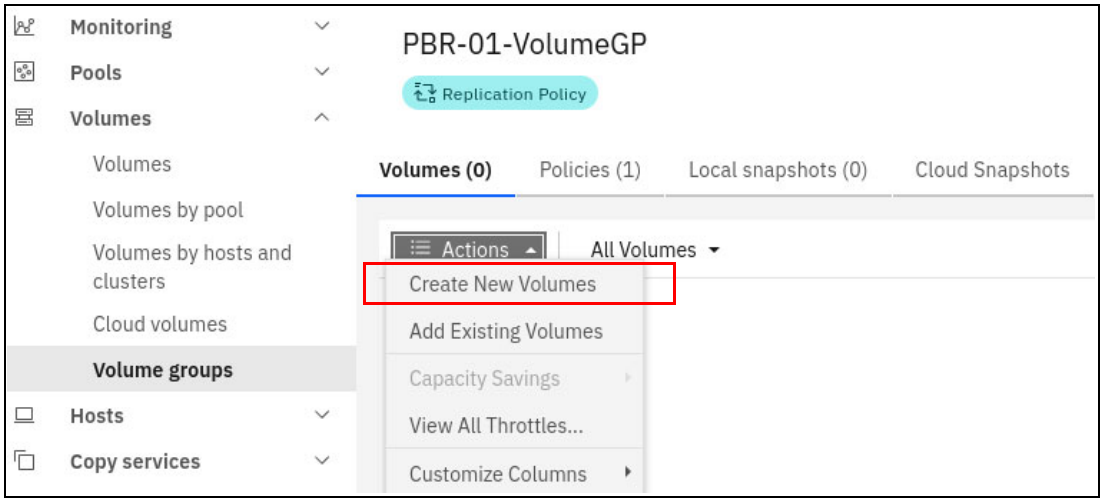

Figure 4-13 Create new volumes within Volume Group

3. The Create Volumes window opens. Select the storage pool for the new volumes. The only pool is **StandardPool**. Figure 4-14 shows the Create Volumes wizard. Select the pool and click **Define Volume Properties**.

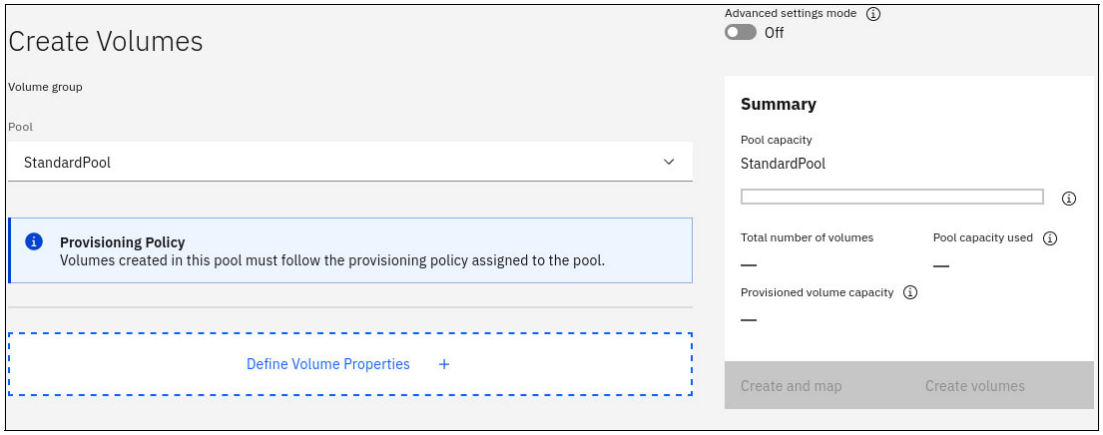

Figure 4-14 Create Volumes wizard begins

4. For this demonstration, create four small 50 GB volumes.
   a. Enter **4** in the Quantity field.
   b. Enter a Name.
   c. Define the Capacity and Unit.
   d. Accept or change the Suffix Range.
   e. The provisioning policy Capacity Optimized is active on the storage pool, so all volumes that are created in this storage pool are thin provisioned.
5. Figure 4-15 shows the completed Define Volume Properties page. Click **Save** to continue.

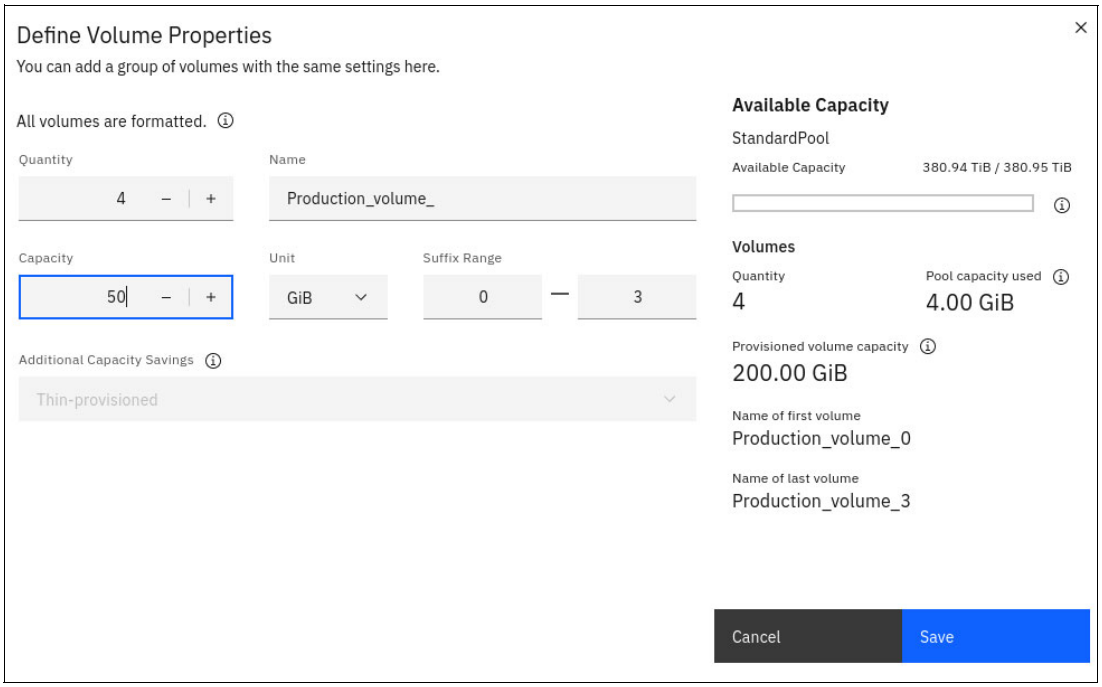

Figure 4-15 Create four volumes each 50 GB

Four volumes active are defined in the volume group, and these are replicating to the recovery system.

The content of the volume group is shown in Figure 4-16.

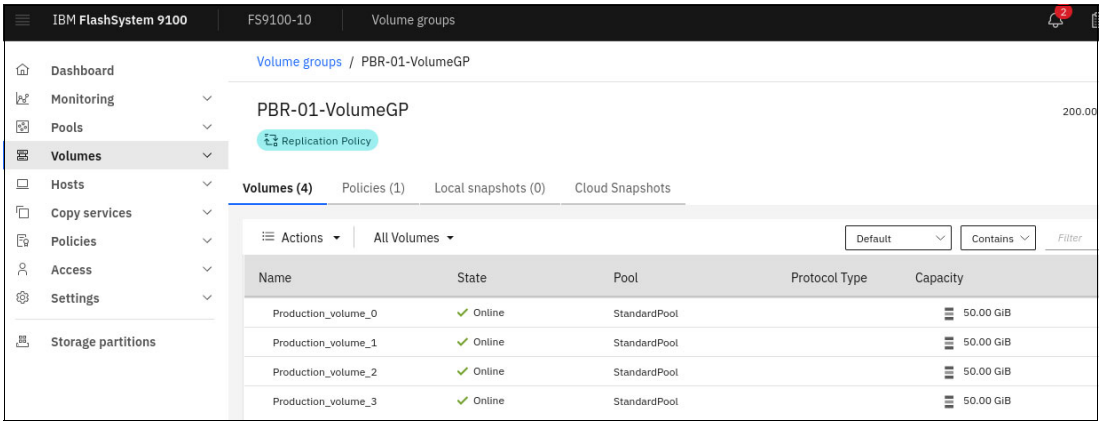

Figure 4-16 Four volumes created and added to the Volume group

The configuration is completed, and volumes within the volume group PBR-01-VolumeGP are copying from FS9100 to FS7300.

6. To check the status on the recovery system go to the window **Volumes** → **Volume Groups** to verify that the volume group on the production system is replicated to the remote system. During initial replication, you can monitor the progress as shown in Figure 4-17.

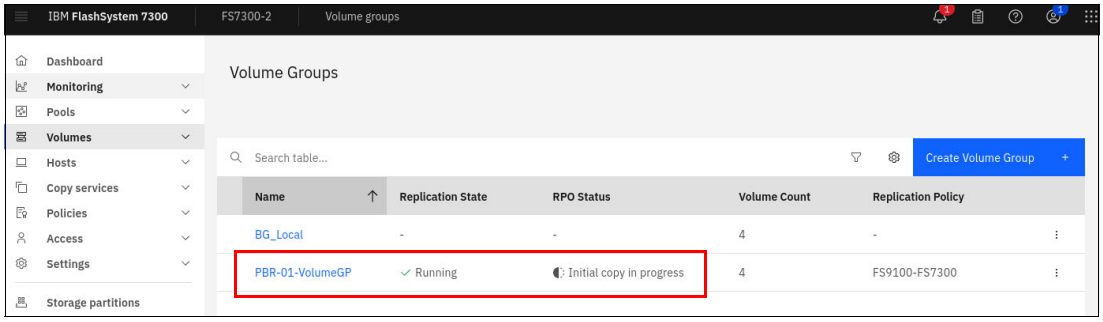

Figure 4-17 Initial copy ongoing

7. By entering the defined volume group and clicking the tab **Policies**, you can view the status of the current replication policy as shown in Figure 4-18.

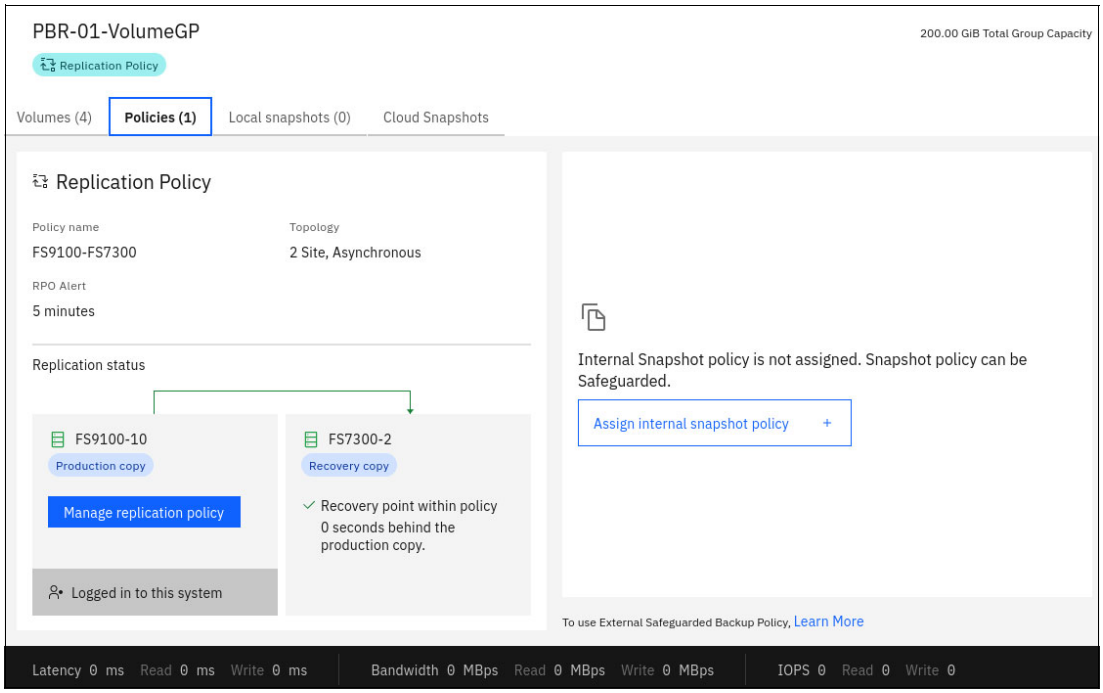

Figure 4-18 Volume group policy status

8. You now have the option to click **Manage replication policy** where you can remove the replication policy if needed.

   If you are on the recovery system, the **Manage replication policy** window lists the option to enable access to the recovery volumes.

Note: The newly created volumes can be mapped to one or more hosts from the Volumes menu.

Using targets of replicated volumes

Although the volumes on the recovery system can be mapped to hosts, it is important to note that these volumes remain in an offline state during the replication relation. However, there is an option to **Enable independent access** from the secondary site. This can be done in the Policy tab of the volume group in the secondary site, as shown in Figure 4-19.

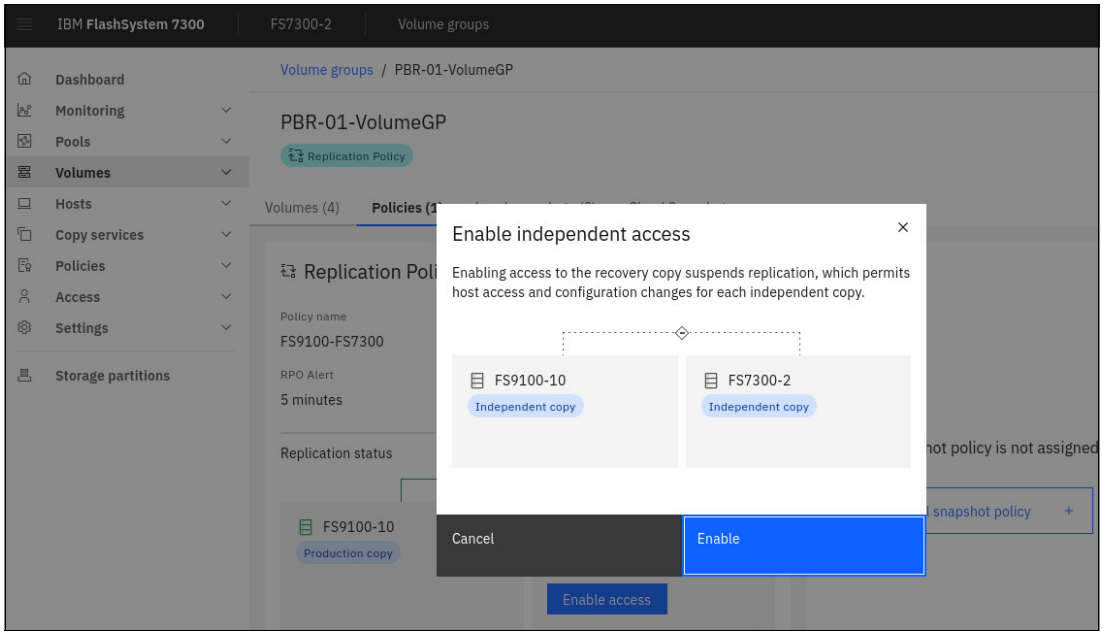

Figure 4-19 Enable volume access from recovery system

Enable access to the recovery copy suspends replication, which permits host access and configuration changes for each independent copy.

Notice that you can select **Restart replication** and that the changes that are made to this copy are not replicated until replication is restarted. The replication status is shown in Figure 4-20 on page 71.

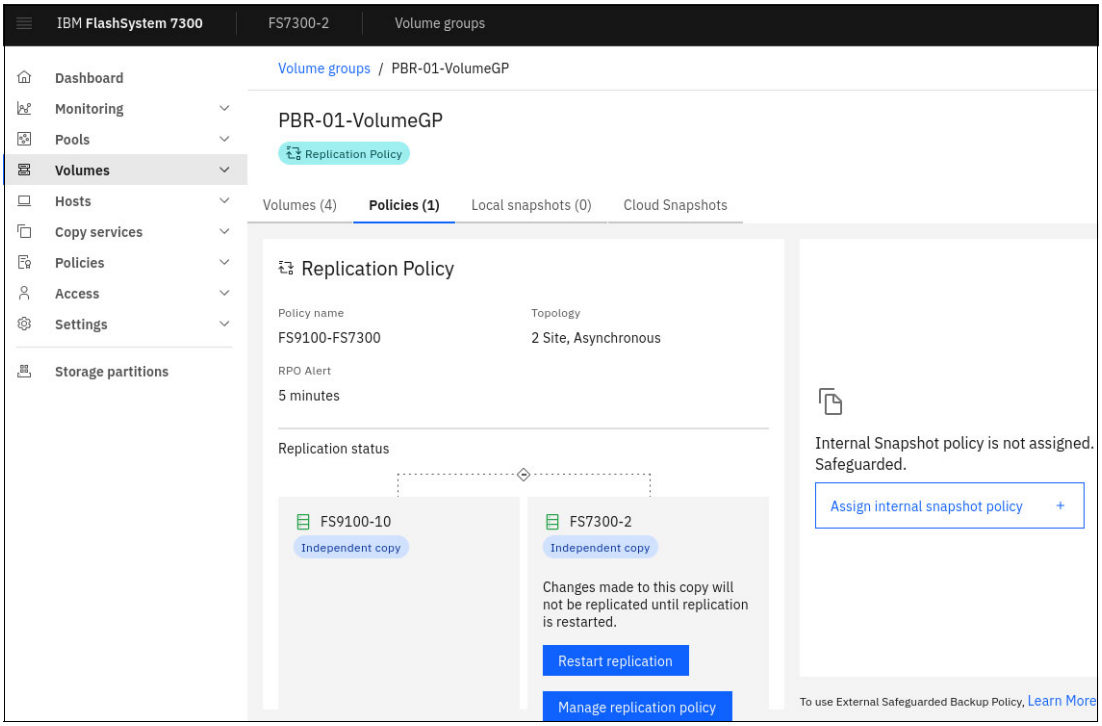

Figure 4-20 Replication stopped and access enabled to recovery volumes

Restarting or reversing replication

After you enable access on the recovery system and suspend the replication, you can restart the replication and select the direction for the relation.

Click **Restart replication** to proceed as shown in Figure 4-20.

Whether you want to restart the replication from the production site or want to reverse the replication from the recovery site, which might be the current production site, depends on from which system you restart the replication.

Figure 4-21 on page 72 shows how you can restart the replication in which the recovery site is the production system.

The action overwrites the volumes on the FS9100-10 system, which was the production system. However, the situation might be that this system has been down for some time and that the volumes on it are no longer current because the recovery system is now functioning as the production system.

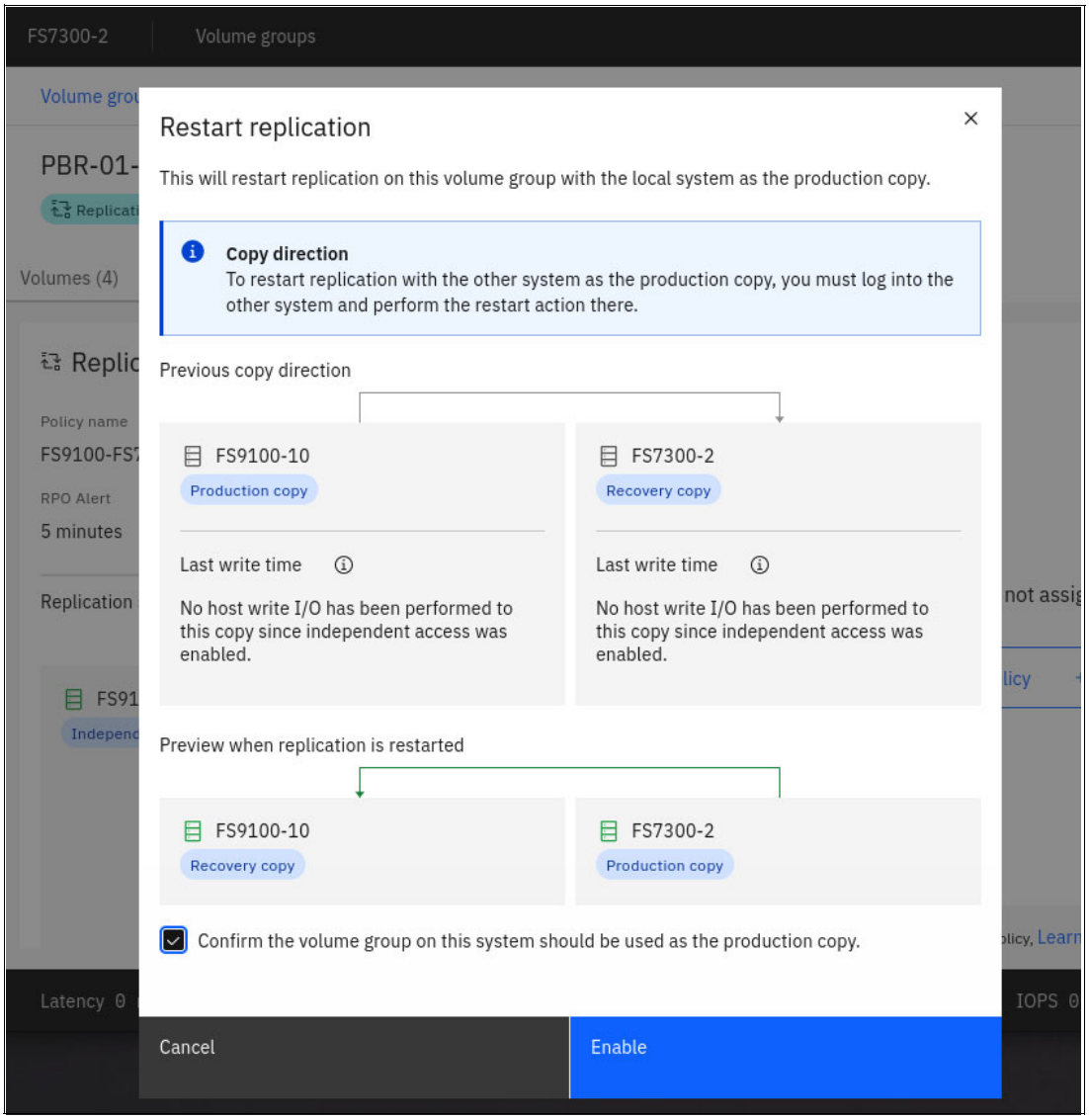

Figure 4-21 Restarting replication in reverse direction

Figure 4-22 on page 73 shows that initial copy is ongoing from the FS7300-2 to the FS9100-10.

In the preceding scenario, initial replication was from a FlashSystem 9100 to a FlashSystem 7300. In a failover situation, you might have to switch back to FS9100-10 being the primary because FS9100-10 is the normal production location.

Switching the direction of replication back to the FlashSystem 9100 requires the same actions as before, which is to log on to the FS9100-10 and click **Enable Access** on the Volume Group policy tab as shown in Figure 4-19 on page 70.

To switch copy direction in a safe way requires that the hosts accessing the volumes be shut down when you reverse the copy direction back to FS9100-10. So you can expect a few minutes of downtime when you switch the copy direction.

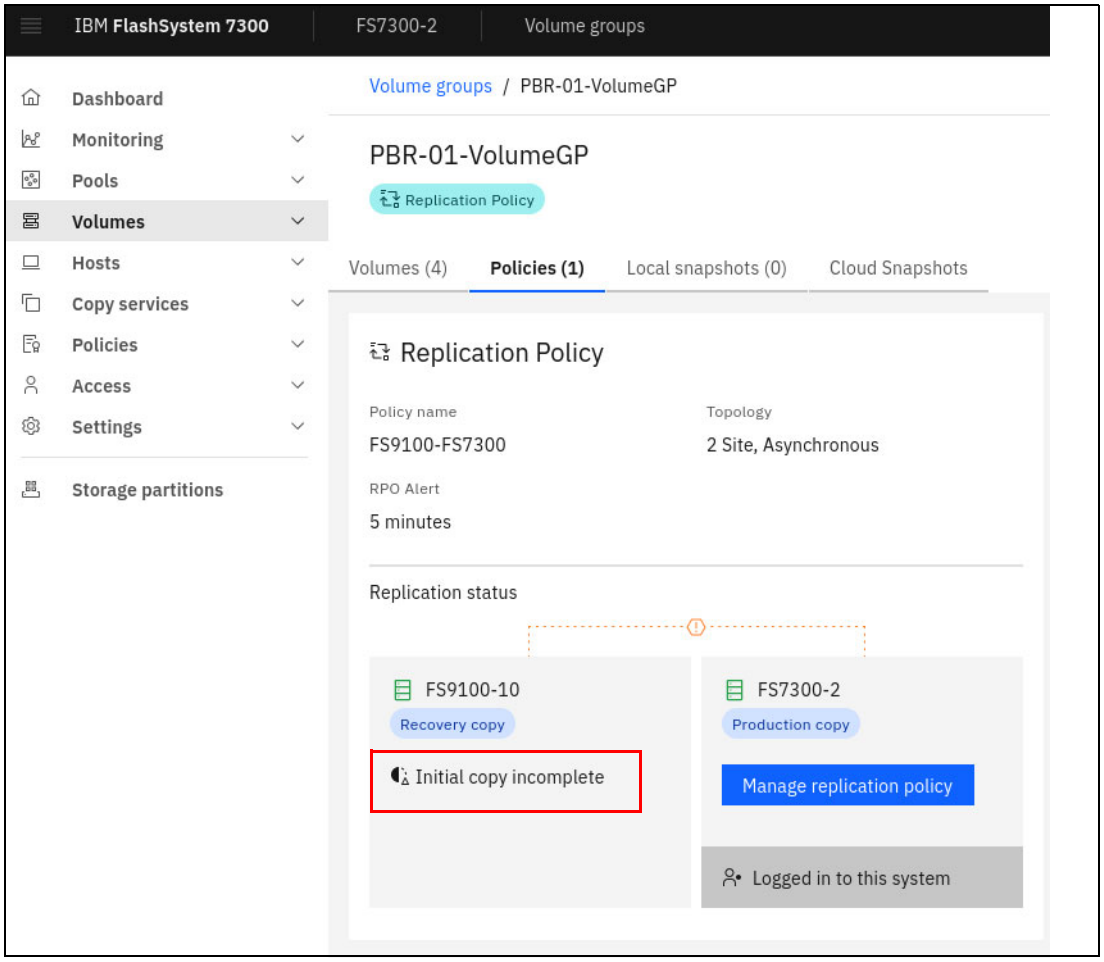

Figure 4-22 Copy direction reversed - initial copy ongoing

4.2 Converting Global Mirror to policy-based replication

For IBM Storage Virtualize version 8.6.0 and 8.7.0, if you use Global Mirror for data replication between two partnered systems, it is possible to convert the existing setup to policy-based replication. During this conversion process, the remote-copy configuration can be retained for a volume to ensure that a synchronized copy remains available on the disaster recovery (DR) system without any downtime.

Ensure that the following prerequisites are met before you configure a volume that is part of a Global Mirror relationship to use policy-based replication:

- The relationship must be either Metro Mirror or Global Mirror.
- The volume being migrated must be the primary volume within the Metro Mirror or Global Mirror relationship.
- Volumes that use Global Mirror can be manually migrated to use policy-based replication.
- Remote Copy features such as 3-site partnerships cannot be directly migrated to policy-based replication due to their more complex configuration requirements.
- No associated change volumes can be linked to the primary volume.

- During the migration process, do not change the direction of the remote-copy relationship or transform it into a secondary relationship.
- The primary volume cannot be designated as a recovery volume for policy-based replication.
- A volume within a Metro Mirror or Global Mirror relationship can have policy-based replication configured only if it belongs to the same I/O group specified in the replication policy. If it does not match, you can move the volume to the appropriate I/O group using the **movevdisk** command.
- If you keep a disaster recovery copy, ensure that you have enough resources available on the recovery system to accommodate both sets of copies.

Before running the **movevdisk** command to transfer a volume between I/O groups, several conditions must be satisfied:

- If the relationship is part of a consistency group, the volume cannot move between I/O groups when the policy-based replication is defined. Use the movevdisk command to move the volume as needed.
- The relationship state must be `consistent_synchronized`. The data in the source and target volumes of the relationship must be fully synchronized and consistent. Resolve any pending changes or discrepancies before proceeding with the volume movement.
- The relationship cannot be in a consistency group. Consistency groups are a collection of relationships that need to maintain data consistency as a group. If the relationship is part of a consistency group, it cannot be moved independently. Restrict the volume movement to relationships that are not associated with any consistency group.
- The relationship type must be Metro Mirror or Global Mirror. The **movevdisk** command is designed specifically for volumes that are involved in Metro Mirror or Global Mirror relationships. These relationship types enable synchronous or asynchronous replication of data between primary and secondary volumes. Only volumes that are associated with these types of relationships are eligible for the move operation.
- The relationship must not have a change volume associated with the primary volume. In some replication scenarios, a change volume is used to track modifications made to the primary volume. If the relationship has an active change volume associated with the primary volume, the move operation cannot proceed. Remove or detach the change volume before you start the volume transfer.
- The volume being moved must be the primary volume in the Metro Mirror or Global Mirror relationship. When you move a volume, the volume must be the primary volume in the Metro Mirror or Global Mirror relationship. The primary volume is the source volume where the original data resides, and the secondary volume is the target for replication. Moving the primary volume ensures the appropriate replication of data to the new I/O group.

Convert Global Mirror to policy-based replication

To convert from Global Mirror (GM) replication to policy-based replication, follow these steps:

1. Enable policy-based replication on the partnership:
   - Establish a mutual SSL certificate exchange between systems to enable REST API access.
   - Use the GUI for configuration of the existing partnership for policy-based replication.
2. Establish linked pools between systems and assign necessary provisioning policies:
   - Linked pools can be established from either system.
   - The GUI provides a method for configuring pool links and assigning provisioning policies.

3. Create replication policies:
   - Depending on the current configuration, it might be necessary to create multiple replication policies. For instance, if Global Mirror with Change Volumes (GMCV) is used with different cycling times, different recovery point objectives can be specified for various sets of volumes.
4. Create volume groups and assign replication policies:
   - Ensure that each consistency group has a corresponding volume group.
   - For policy-based replication, volumes must be placed within volume groups, so one or more volume groups must be created for any previously independent relationships.
5. Move volumes into volume groups:
   - Before you move volumes into a volume group with a replication policy, remove the Remote Copy configuration from the volumes.
   - Move volumes into volume groups and allow sufficient time for the initial synchronization process to complete.

The preceding steps can be done manually or by using the Setup Policy-Based Replication wizard as shown in Figure 4-26 on page 77.

Converting Global Mirror to policy-based replication by using the GUI

To convert from Global Mirror replication to policy-based replication for replicated volumes by using the GUI, follow these steps:

1. Update the existing partnership to support policy-based replication. Access the local system's management interface and navigate to **Copy Services** → **Partnerships and Remote Copy**, as shown in Figure 4-23.

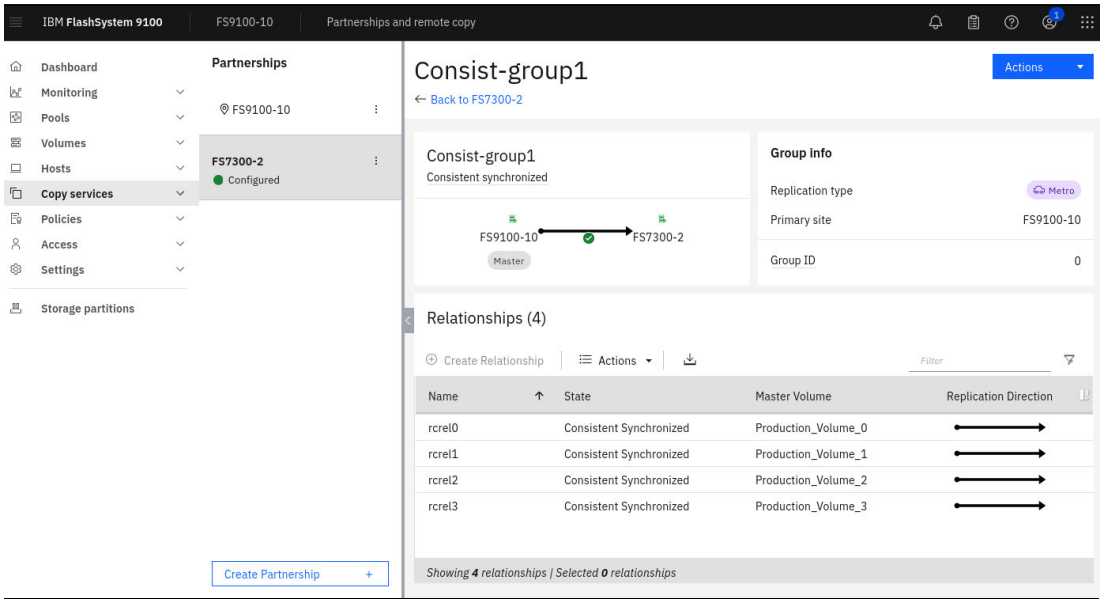

Figure 4-23 Update the existing partnership

2. Choose the current Remote Copy partnership from the left navigation and select **Actions** → **Partnership Properties**, as shown in Figure 4-24 on page 76.

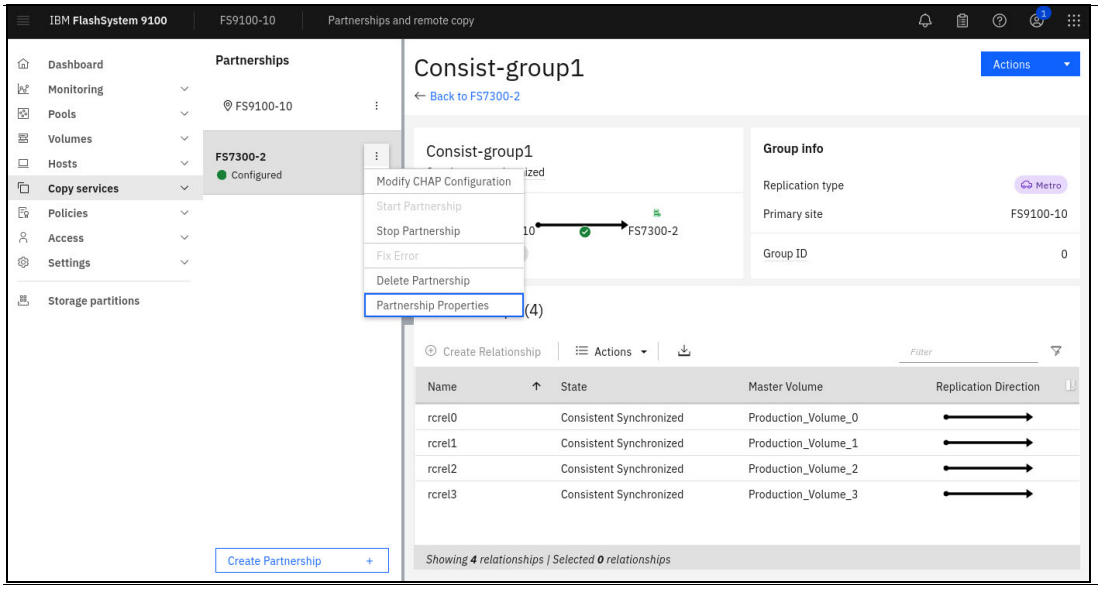

Figure 4-24 Partnership properties

a. On the **Partnership Properties** page, enable policy-based replication to retrieve the certificate from the remote system. The management interface automatically creates a truststore on the local system to store the remote system's certificate.

b. View the remote system certificate to verify it.

c. Save the changes.

3. Repeat steps 1 and 2 on the remote system within the partnership:

   a. Enable policy-based replication on the remote system as well.

   b. Create a truststore for each system in the partnership if you use the command-line interface.

4. After the remote system is enabled for policy-based replication, confirm that the partnership can be configured to use policy-based replication.

   a. On either of the systems, go to **Copy Services** → **Partnerships and Remote Copy** and select the respective partnership from the left navigation.

   b. Verify the message `This partnership is ready for use with policy-based replication` to ensure configuration is successful.

   c. Verify that the Global Mirror replication relationship is correctly converted to policy-based replication, as shown in Figure 4-25 on page 77.

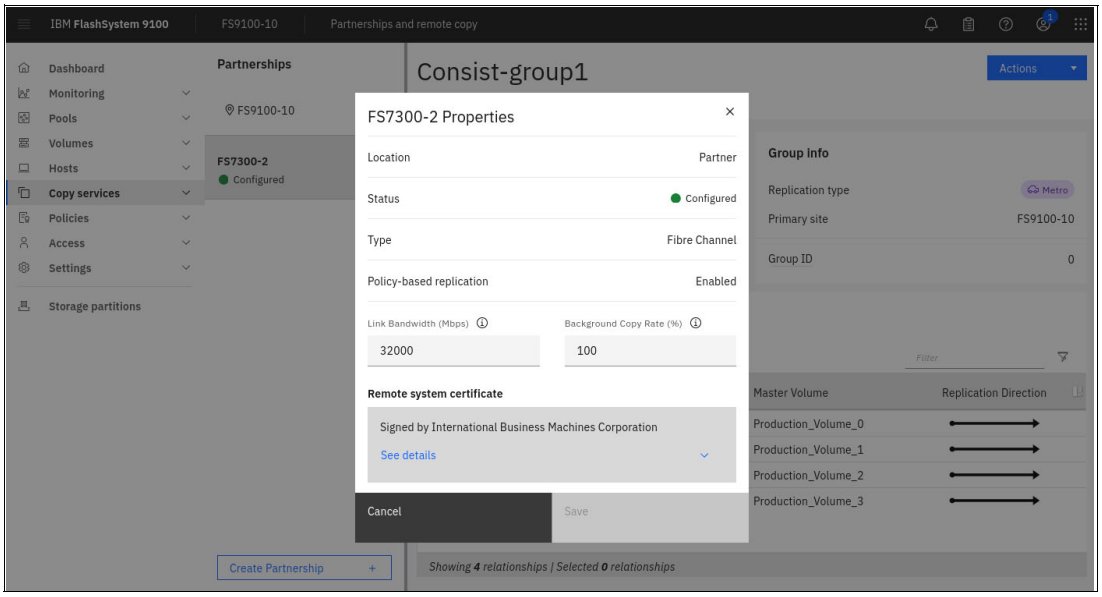

Figure 4-25 Verify that the partnership is ready for policy-based replication enabled

5. Configure a provisioning policy for each linked pool, create one or more replication policies, create an empty volume group for each consistency group and independent relationships and assign a replication policy as described in section “Setup policy-based replication wizard” on page 62. This Setup Policy-Based Replication wizard can be reached from menu **Copy Services** → **Partnerships** and Remote Copy, as shown in Figure 4-26

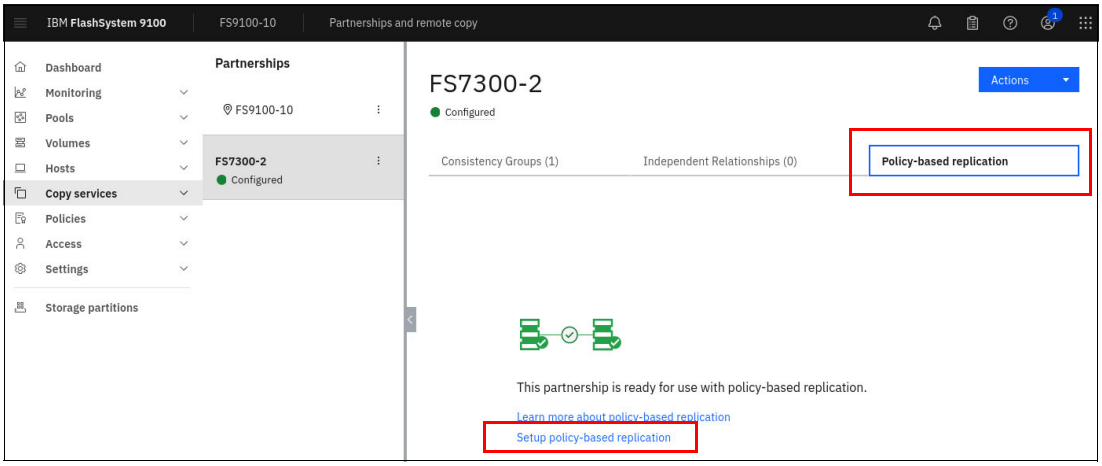

Figure 4-26 Setup policy-based replication wizard

Note: To convert Remote Copy volumes to policy-based replication, no associated change volumes can be linked to the primary volume. If you try to move volumes with change volumes for a Remote Copy relationship into a PBR-enabled volume group, you get an error. Instead, delete change volumes for existing relationships that might have such.

When the policy-based replication setup has completed, open the recovery system menu **Volumes** → **Volumes** to verify that there are two copies of the replicated production volumes as shown in Figure 4-27 on page 78

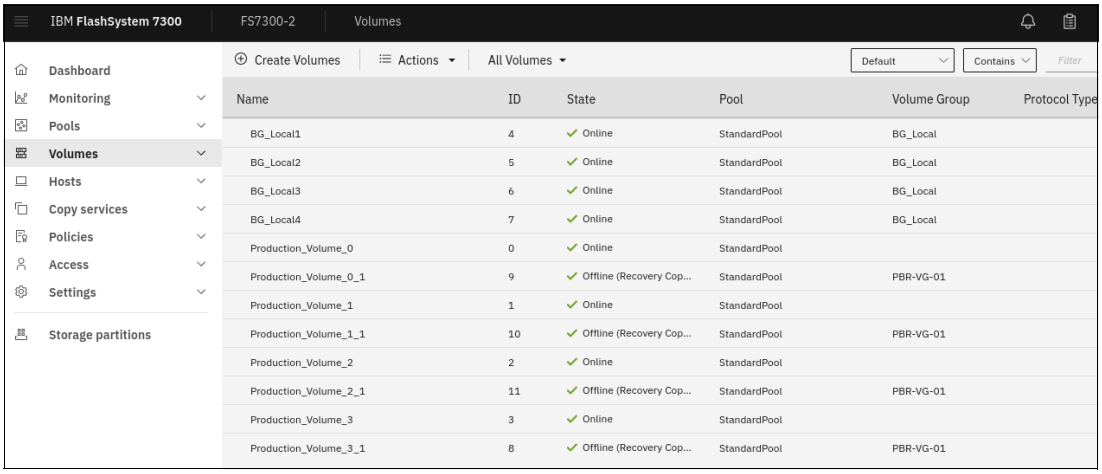

Figure 4-27 Volumes exist for Remote Copy and for policy-based replication

Remove Remote Copy configuration

When policy-based replication is enabled on a Remote Copy configuration, two copies of the target volumes exist on the recovery system, one for policy-based replication and one for Remote Copy. The policy-based replication volumes can be identified because they belong to a volume group. There might not be enough space on the recovery system for two copies. The following instructions describe how to remove the Remote Copy configuration and volumes.

Removing a Remote Copy configuration by using the GUI

To remove the Remote Copy configuration, consider the following points and determine whether you want to retain existing secondary volumes as a point-in-time copy for disaster recovery while establishing the new recovery copy with policy-based replication.

If you choose to keep the disaster recovery copy, ensure that sufficient capacity is available on the recovery system to accommodate both sets of copies.

Retaining existing volumes provides data protection in case of an outage, and you can verify replicated data on the recovery system after configuring policy-based replication.

To remove the Remote Copy configuration, follow these steps:

1. Access the primary system's management interface and navigate to **Copy Services** → **Partnerships and Remote Copy.**
2. Select the **Consistency Groups** tab and verify that the current state of the consistency group is `Consistent Synchronized` for a Global Mirror consistency group or `Consistency Copying` for a Global Mirror consistency group with change volumes, as shown in Figure 4-28 on page 79.

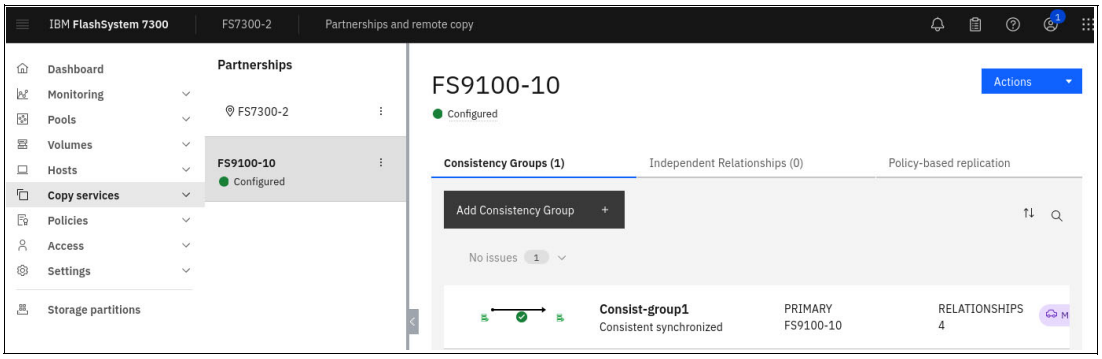

Figure 4-28 Verify the current state of the consistency group

3. Select **Actions** → **Stop Group.** On the **Stop Remote-Copy Consistency Group** page, choose the option **Allow secondary read/write access** to retain the secondary volumes as a disaster recovery copy, as shown in Figure 4-29.

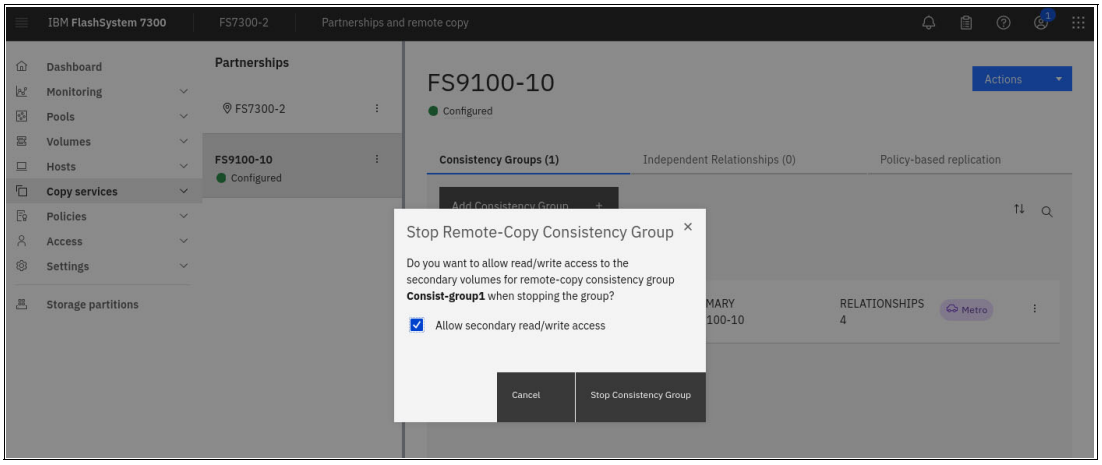

Figure 4-29 Stop Remote-Copy consistency group

4. Click **Stop Consistency Group**. The state of the consistency group changes to `Idling`, as shown in Figure 4-30.

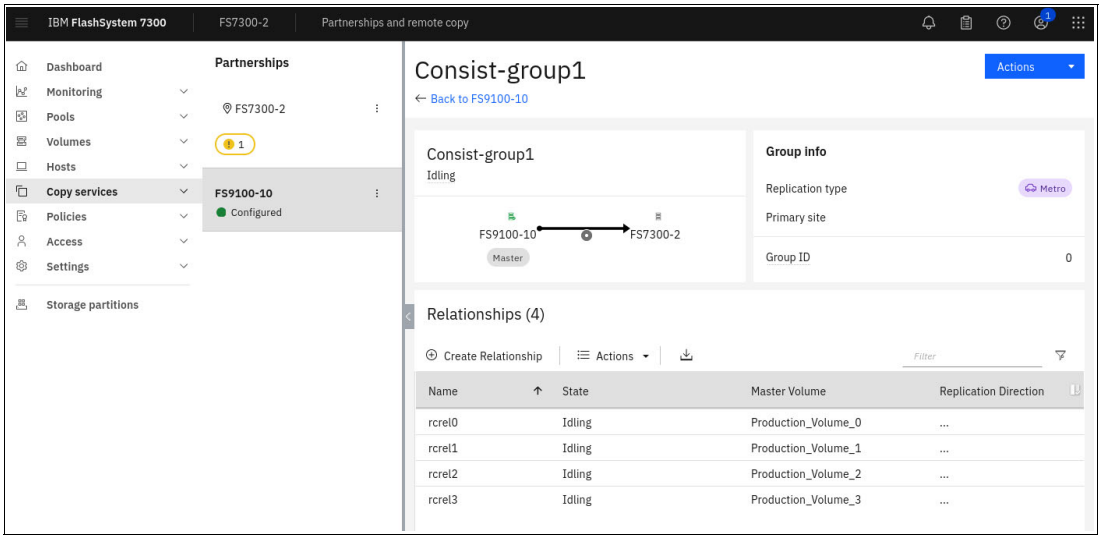

Figure 4-30 State of the consistency group to Idling

5. In the **Relationships** section, select all the relationships within the consistency group.
6. Right-click the selected relationships and choose **Delete**, as shown in Figure 4-31.

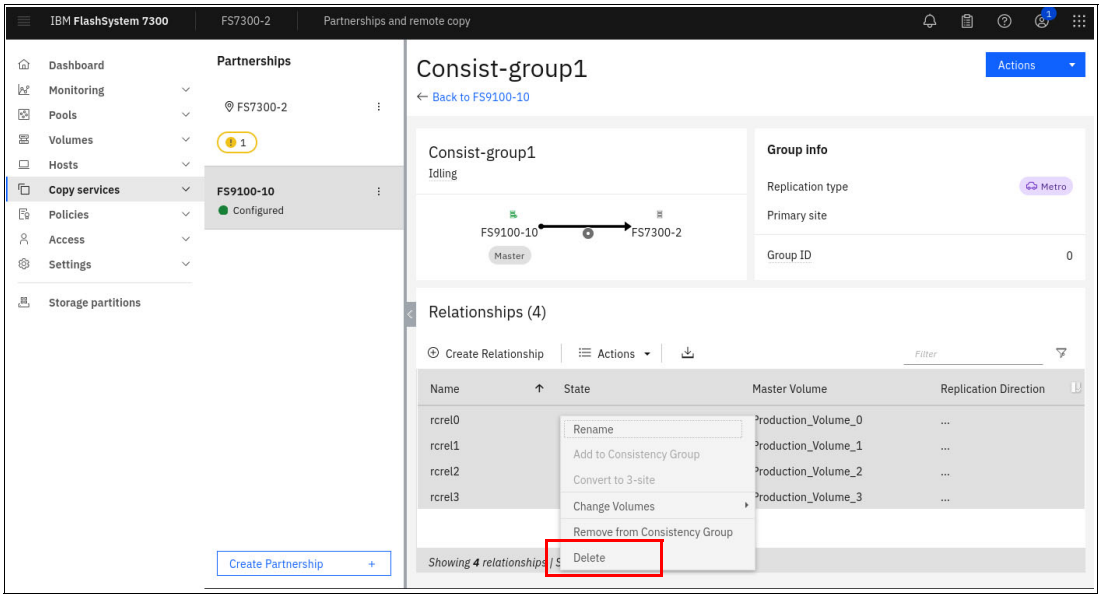

Figure 4-31 Delete relationship

7. On the **Delete Relationship** page, verify the number of relationships being deleted. Verify that the checkbox **Delete the relationship even when the data on the target system is not consistent** is cleared. This cleared checkbox allows the secondary volumes to be retained for disaster recovery until a new recovery point is established using policy-based replication, as shown in Figure 4-32.

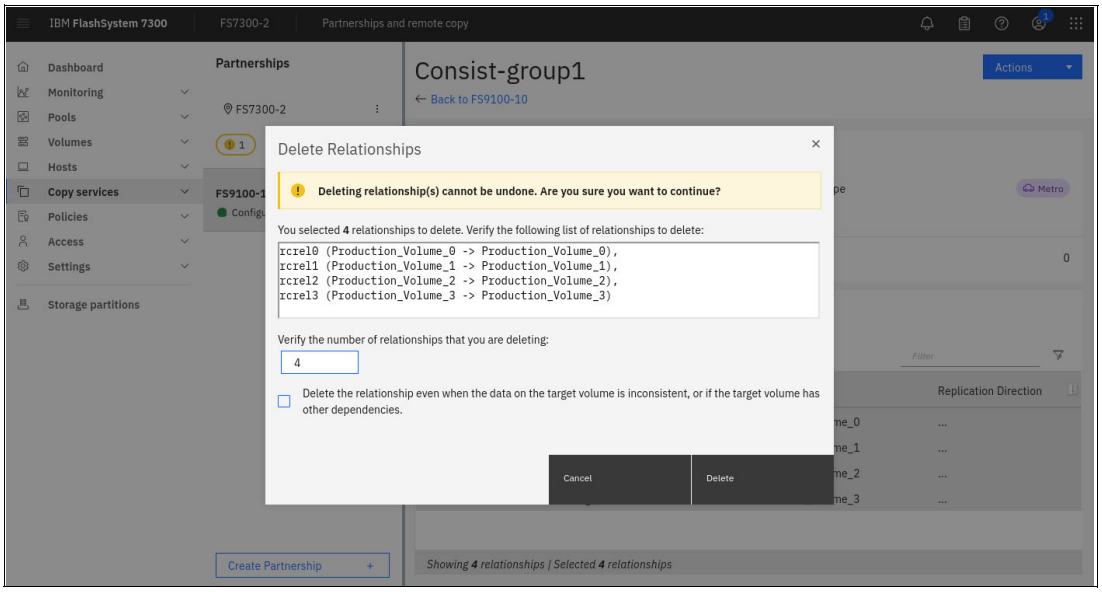

Figure 4-32 Confirm relationship deletion

8. Click **Delete**. After the relationships are deleted from the consistency group, select **Actions** → **Delete Group** to complete the removal process, as shown in Figure 4-33 on page 81.

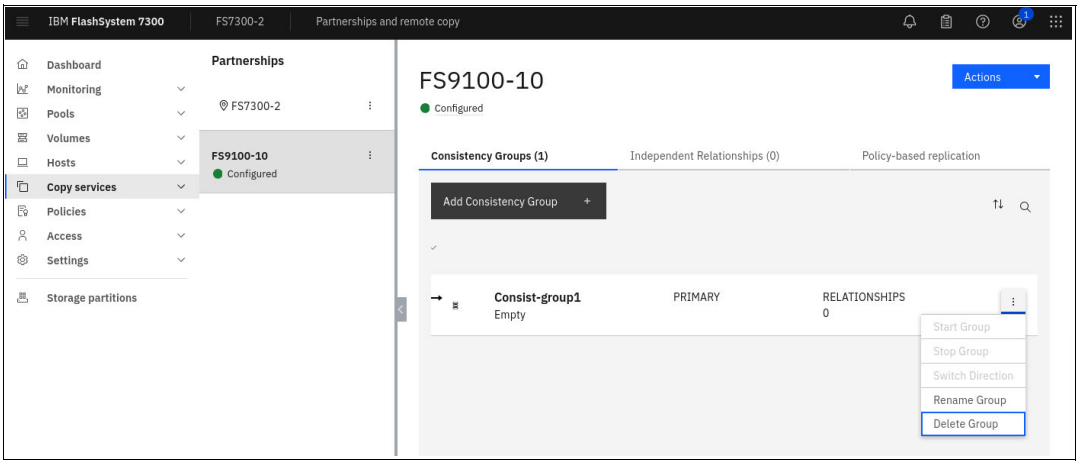

Figure 4-33 Delete group

The Remote Copy configuration is now deleted. The volumes from the Remote Copy relationship exist and are available for host mapping, or they can be deleted. Both copies Remote Copy and PBR volumes requires space, which requires free space in the storage pool.

The GUI continues to show the Remote Copy features. This can be disabled from the menu **Settings** → **GUI Preferences** → **GUI Features** → **Remote Copy Functions in copy services**, as shown in Figure 4-34.

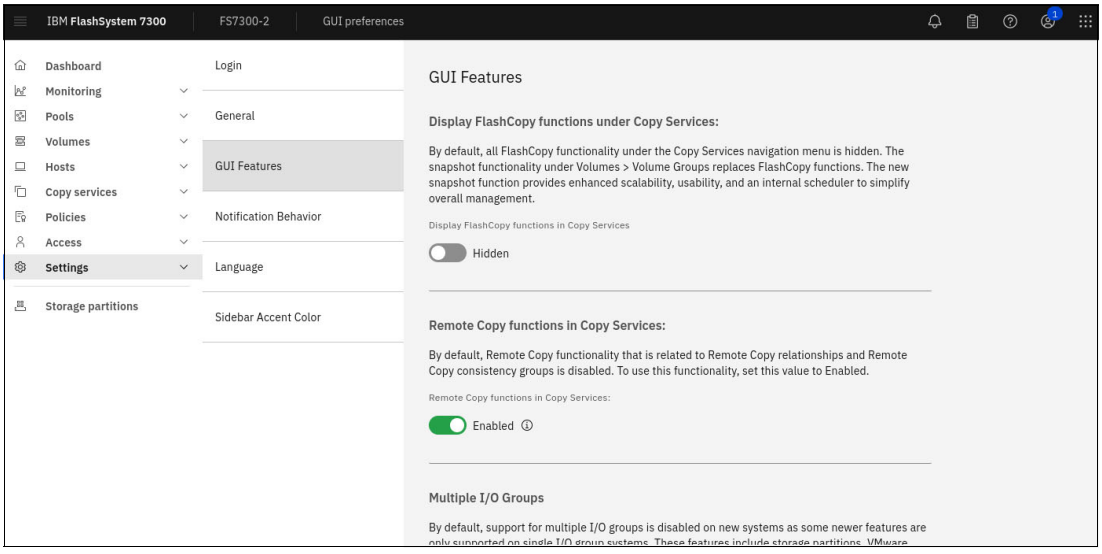

Figure 4-34 GUI preferences - remove Remote Copy features

Ransomware and cyberattacks

In parallel to replicating from one system to another, which helps in case of hardware or accessibility issues, the organization and the storage administrator may also want to implement a Safeguarded Copy environment. Safeguarded copies are immutable snapshots or cyber-resilient point-in-time copies of volumes that cannot be changed or deleted through user errors

For more information about Safeguarded Copy, see the Redpaper *Data Resiliency Designs: A Deep Dive into IBM Storage Safeguarded Copy,* REDP-5737.

5

Managing policy-based replication

Managing policy-based replication is not limited to replication policies, but also partnerships, pool links, volume groups, and policies.

Monitoring the recovery point objective (RPO) is a crucial aspect of business continuity. Storage Virtualize provides several ways of verifying whether the objective of recovery points are reached and provides ways to receive alerts if the RPO is not met.

This chapter covers the following topics:

5.1 Managing partnerships by using the GUI

When you replicate volumes or volume groups, a partnership between systems must exist. The partnership defines the link between the systems, which includes the type of network and bandwidth. To learn how to create partnerships, see Chapter 1, “Introduction” on page 1.

5.1.1 Viewing a partnership

To manage existing partnerships in the management GUI, from the production system select **Copy Services** → **Partnerships**. See Figure 5-1.

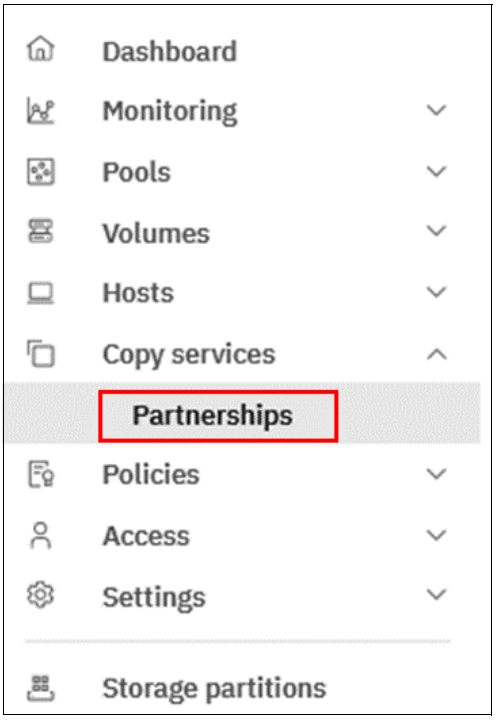

Figure 5-1 Partnerships menu

When partnerships are created on all systems, they appear as “Configured”. It is possible to create a policy for replication, if not already done, from that screen. See Figure 5-2 on page 85.

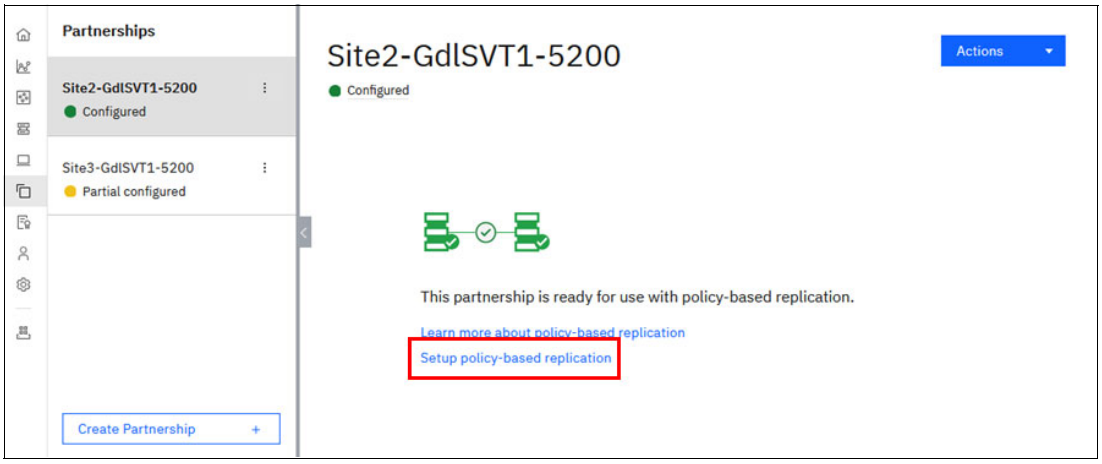

Figure 5-2 Fully configures partnership

Only one partnership can be defined between two systems, but a system can have multiple partnerships. A system can be a partner with up to three remote systems. No more than four systems can be in the same connected set. See Figure 5-3.

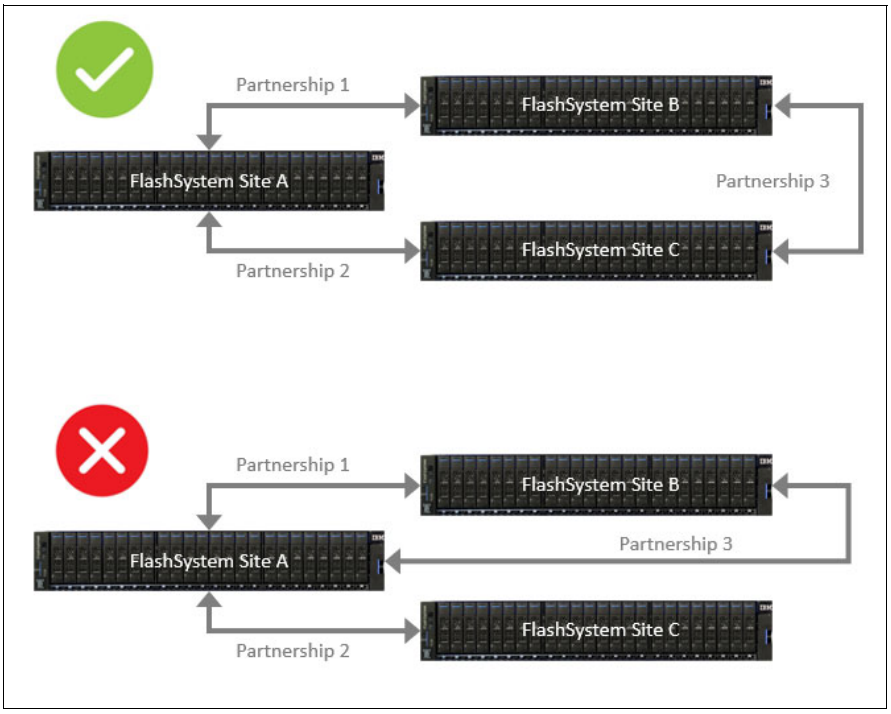

Figure 5-3 Supported multiple partnerships

5.1.2 Stopping a partnership

A partnership can be stopped from the partnership's actions menu. When stopped from either a production or recovery system, a partnership appears as “Local stopped” on the system where the action was taken and “Remote stopped” on the other system. It can be restarted only from the system where it was stopped. See Figure 5-4 on page 86.

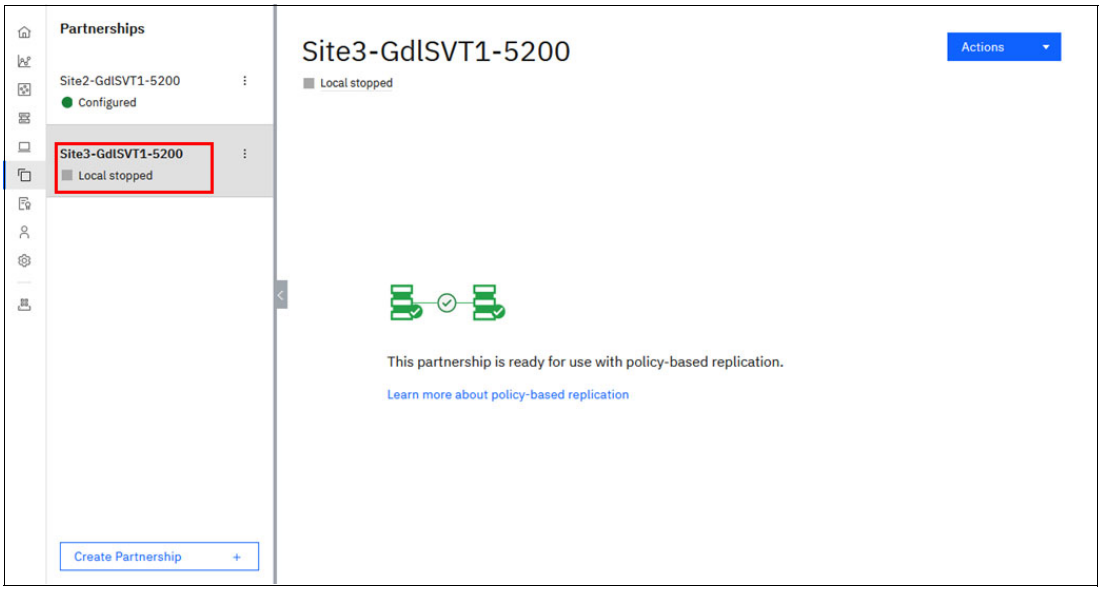

Figure 5-4 Stopping a partnership

When a partnership is stopped, all the replicating volume groups that use this partnership are suspended. The replications status is listed as a disconnected system in the Volume Group page under the Policies tab. See Figure 5-5 on page 87.

You can stop a partnership to simulate an interruption of communication between the production system and the recovery system. On the recovery system, in the Volume Groups page, the last recovery point is given. Based on the RPO defined in the replication policy, the recovery volume group can be within or out of the RPO.

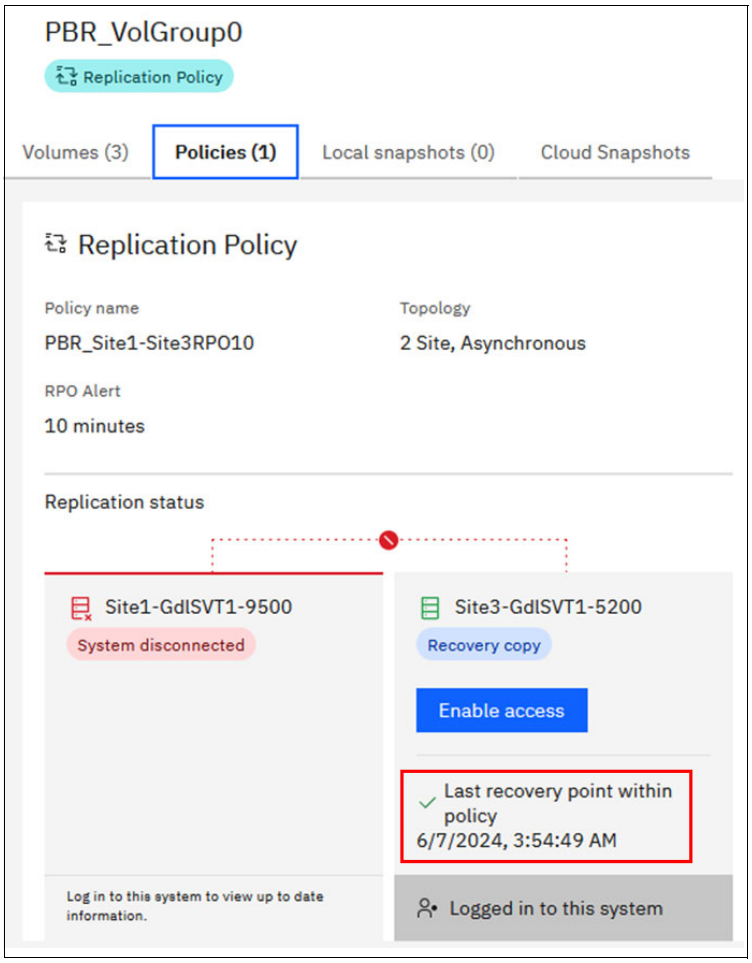

Figure 5-5 Last recovery point on stopped partnership

5.2 Managing pool links

Storage pool linking provides a mechanism to define which storage pool or child pool the system uses to create copies of a volume.

Use the Pools page in the management GUI to manage storage pools, and pool links between production and disaster recovery locations by navigating to **Pools** → **Pools** page. See Figure 5-6 on page 88.

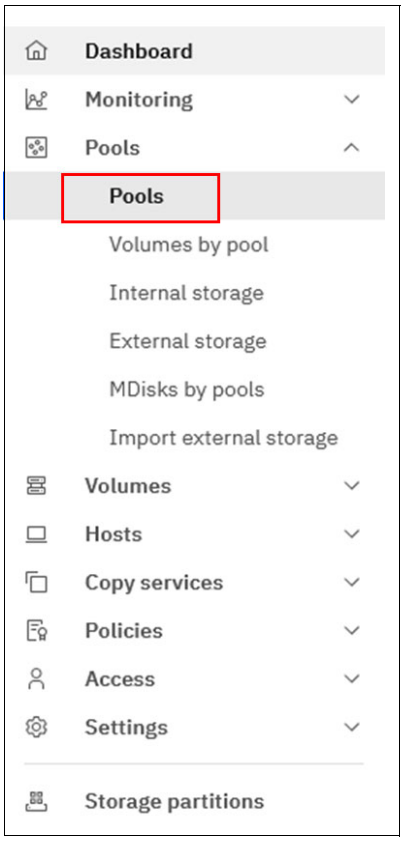

Figure 5-6 Pools management menu

If the storage pools exist on the production and recovery systems, you can add a link between the pools from either system. If a pool on one of the systems has existing links to another partnered system, you must add the link from the unlinked system. The existing link between pools for other partnerships is not affected. Alternatively, if child pools currently exist on the production system only, you can use the management GUI on the recovery system to create and link a child pool in a single step. The management GUI simplifies the process of creating a linked pool on the recovery system. The management GUI automatically displays the properties such as name, capacity, and provisioning policy from the production system. You can use these values to create the new linked child pool on the recovery system without logging in to the other system.

To create a link between storage pools from the production system, right-click the pool to link and select **Add Pool Link for Replication**. The Add Pool Link page opens. See Figure 5-7 on page 89.

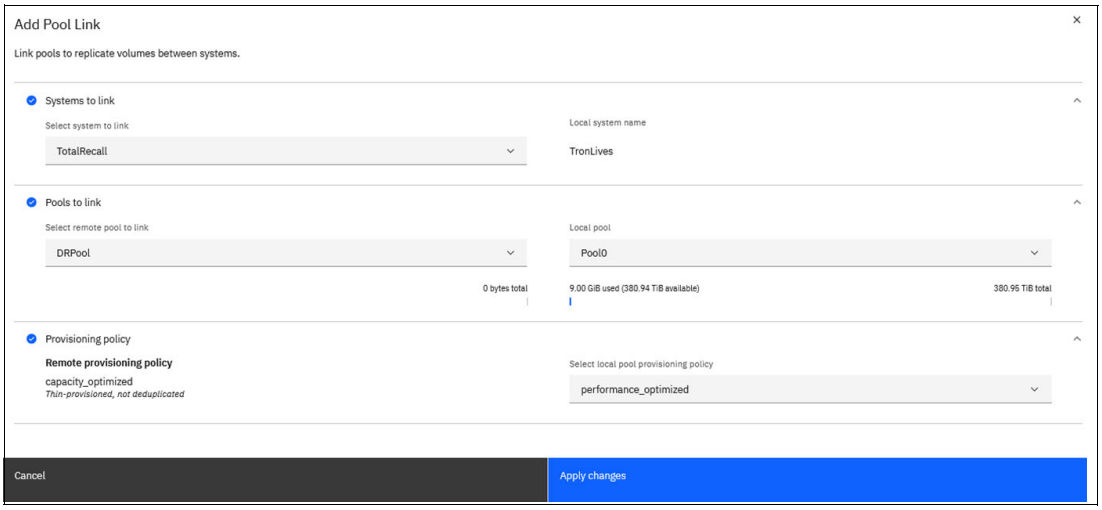

Figure 5-7 Adding a pool link

The Add Pool Link page displays options for the remote system on the left side of the page. Local system details are displayed on the right.

From each drop-down menu, select the remote system to link, the remote pool to link, and the local pool to link. Also, determine whether the provisioning policy is assigned to the remote pool. If a provisioning policy is already assigned to the remote pool, then select the local pool provisioning policy from the drop-down menu.

To modify pool links between pools in production and disaster recovery locations, use the management GUI and select **Pools** → **Pools**, right-click the pool and select M**odify Pool Links for Replication**. On the Modify pool link page, select whether you want to unlink the selected pool from remote systems or move all links from the pool to another pool. See Figure 5-8.

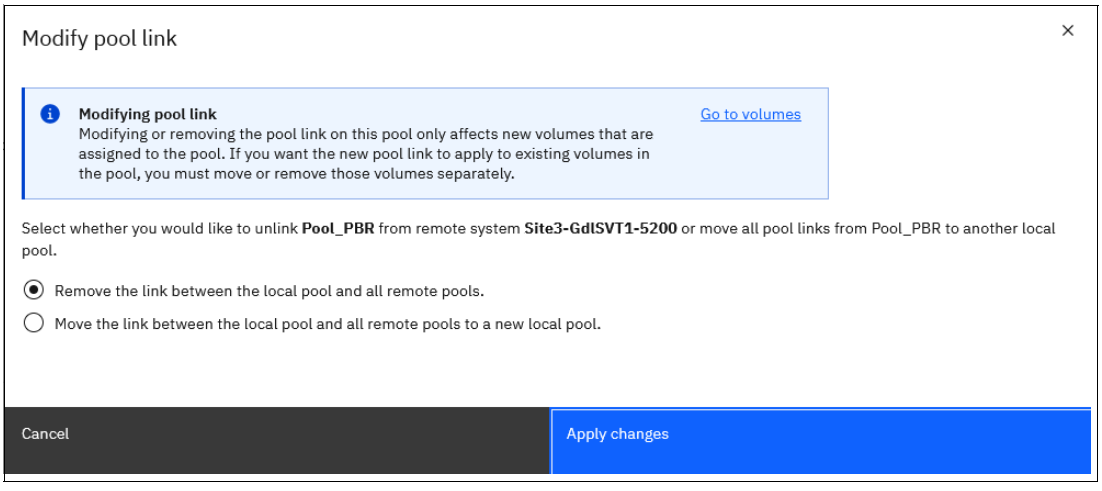

Figure 5-8 Modifying a pool link

5.3 Managing volume groups using the GUI

Volume groups provide a method for grouping volumes that are used by an application.

Replication policies apply to volume groups (and not stand-alone volumes).

To view existing volume groups in the management GUI, from the production system or the recovery system, select **Volumes** → **Volume Groups**. See Figure 5-9.

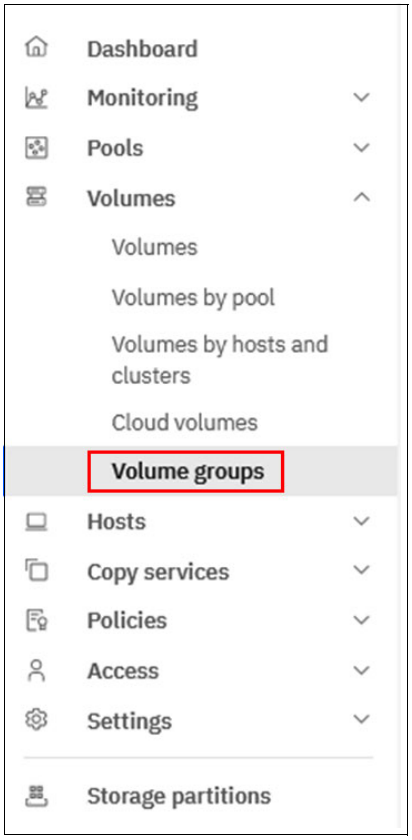

Figure 5-9 Volume Groups menu

Volume groups have multiple attributes among which the following can be changed:

- Name
- Volumes
- Optional replication policy
- Optional snapshot policy

The available actions on a volume group are renaming it, deleting it, adding or removing volumes, changing the replication policy, changing the snapshot policy, and manage local and cloud snapshots.

The name of a volume group cannot be changed while a replication policy is assigned and cannot be changed while the volume is in a volume group with a replication policy assigned.

Volume groups can have only a single replication policy. A system can host multiple volume groups, each of them using a different replication policy, but a volume group cannot have multiple replication policies assigned. See Figure 5-10 on page 91 and Figure 5-11 on page 91.

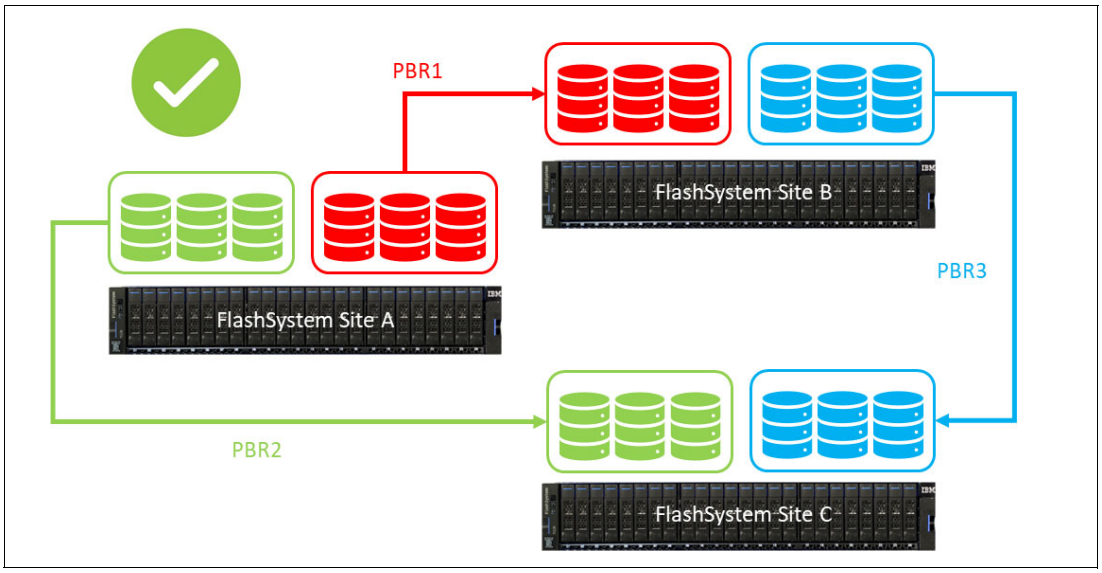

Figure 5-10 Supported multiple replication policies

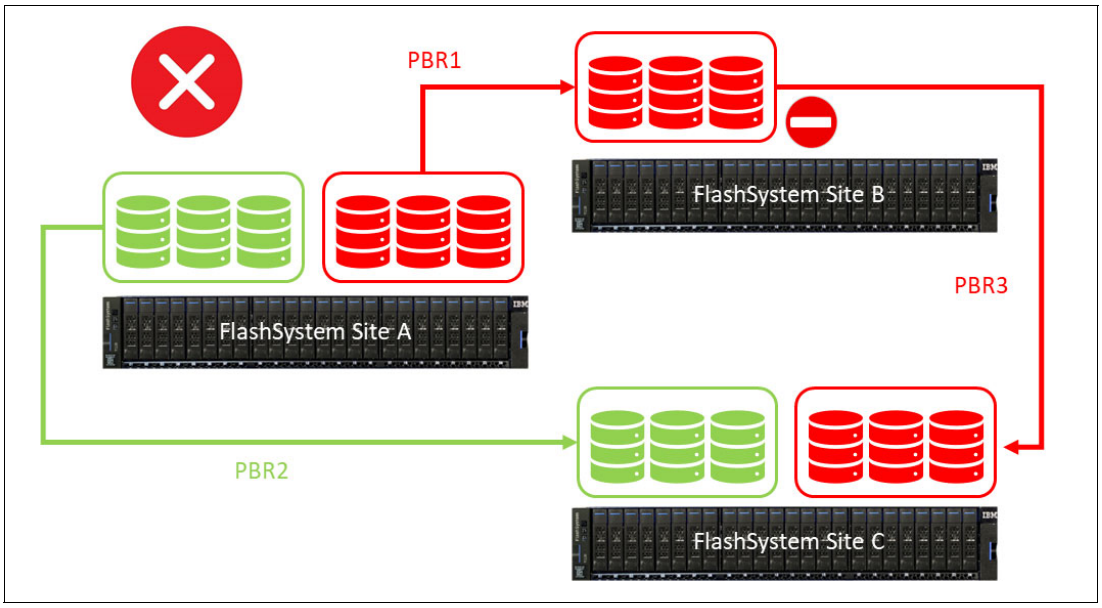

Figure 5-11 Unsupported multiple replication policies

The following actions cannot be performed on a volume while the volume is in a volume group with a replication policy assigned:

- Resize (expand or shrink)
- Migrate to image mode or add an image mode copy
- Move to a different I/O group

5.3.1 Adding volumes to a volume group

To add volumes in an existing volume group, select the **Volumes** → **Volumes** menu. In the list of volumes, right-click the ones to be added, then select **Add to Volume Group** and choose the volume group where to add the volume. **Ctrl** and **Shift** keys can be used for selection.

Volumes that already belong to a volume group cannot be added to another volume group. See Figure 5-12.

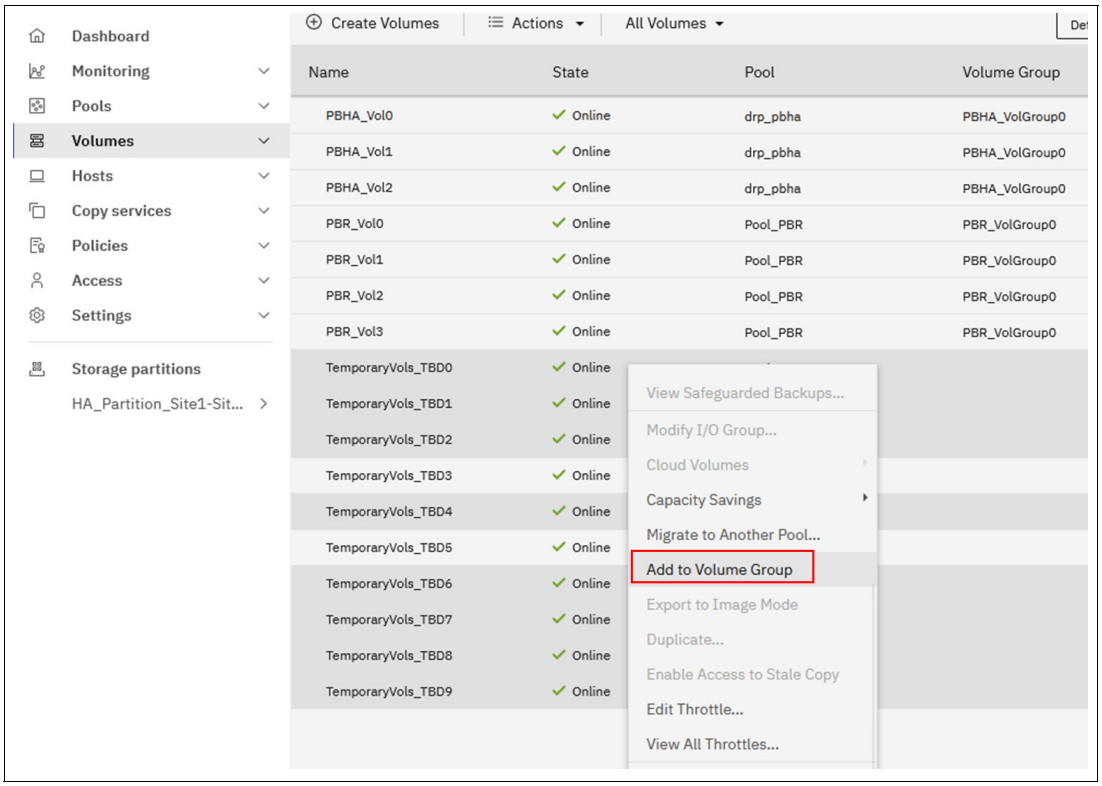

Figure 5-12 Adding volumes to a Volume group

Volume groups are not used exclusively for replication and can be managed on a stand-alone system for local copies, for instance. Volumes from a volume group that are *not* associated with a replication policy can be moved to another volume group. To move volumes from one volume group to another, select the Volumes menu and in the list of volumes, right-click the ones that you want to move. Then, select **Move to Volume Group** and choose the volume group where you want to add the volume.

5.3.2 Removing volumes from a volume group

To remove volumes from a volume group, navigate to **Volumes** → **Volume Groups**, select the volume group you want to remove volumes from, then select the volumes to be removed, right-click, and select **Remove from Volume Group** action. See Figure 5-13 on page 93.

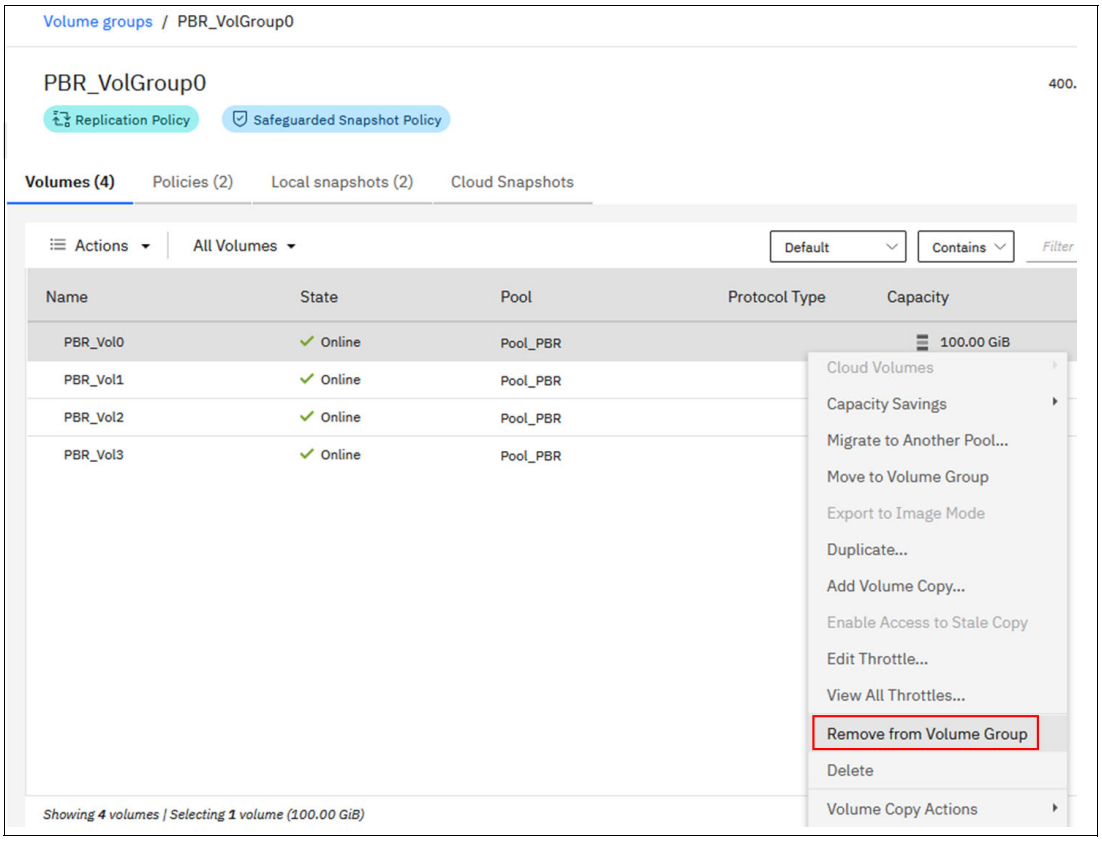

Figure 5-13 Removing volumes from a volume group

Removing a volume from a volume group is a configuration change and is done only on the production system. The change is reflected on the recovery system where the volume is also deleted from the volume group when it is no longer part of the recovery point.

If a local snapshot was taken for the volume group from which the volumes are deleted, before the deletion, it cannot be restored as the number of volumes are not the same anymore. However, a clone of the volume group can be made to restore the volumes.

Deleting a volume in a volume group is again a configuration change and reflects on the recovery system.

5.3.3 Taking snapshots of volume groups

Volume groups can be copied on local systems by taking snapshots. Snapshots of Volume groups can be made instantly or can be scheduled for regular copies.

To take an instant snapshot of a volume group using the GUI, navigate to **Volumes** → **Volume Groups**, select the volume group to be copied, select the **Local Snapshots** tab, and click **Take Snapshot**. Instant snapshots cannot be safeguarded. They have no expiration date and can be restored, cloned, or deleted anytime. See Figure 5-14 on page 94.

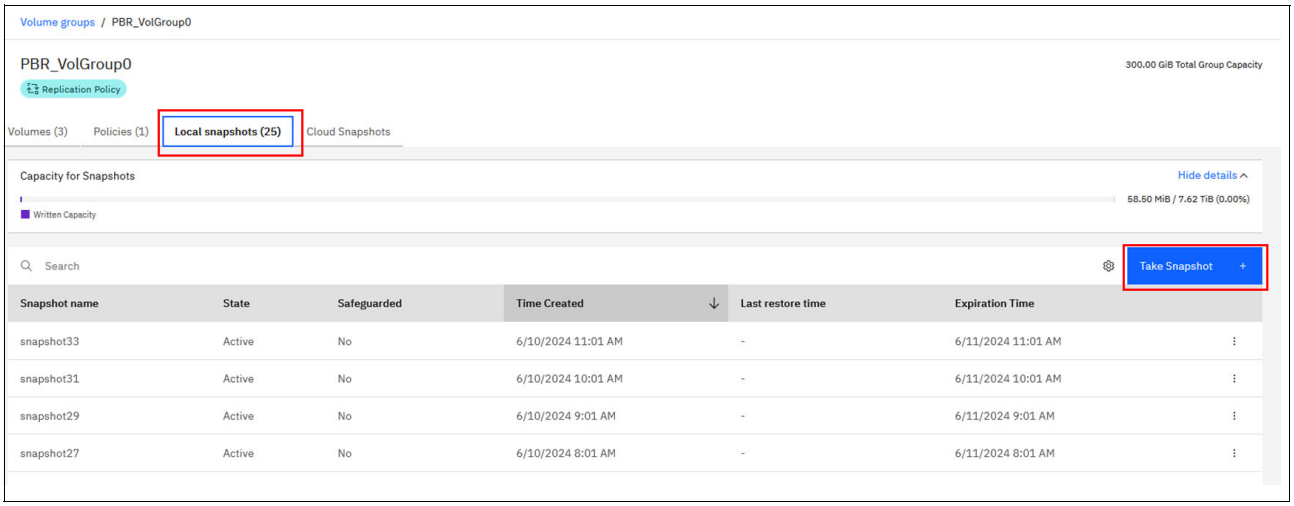

Figure 5-14 Taking volume groups snapshot

A snapshot policy can be assigned to a volume group. To manage snapshot policies, navigate to **Policies** → **Snapshot Policies**. To define a snapshot policy, specify a frequency, time, day of the week, day of the month, and retention period for snapshots.

To assign a policy to a volume group by using the management GUI, select **Volumes** → **Volume Groups**, select the volume group for which to assign a policy, and click the **Assign internal snapshot policy** button. See Figure 5-15.

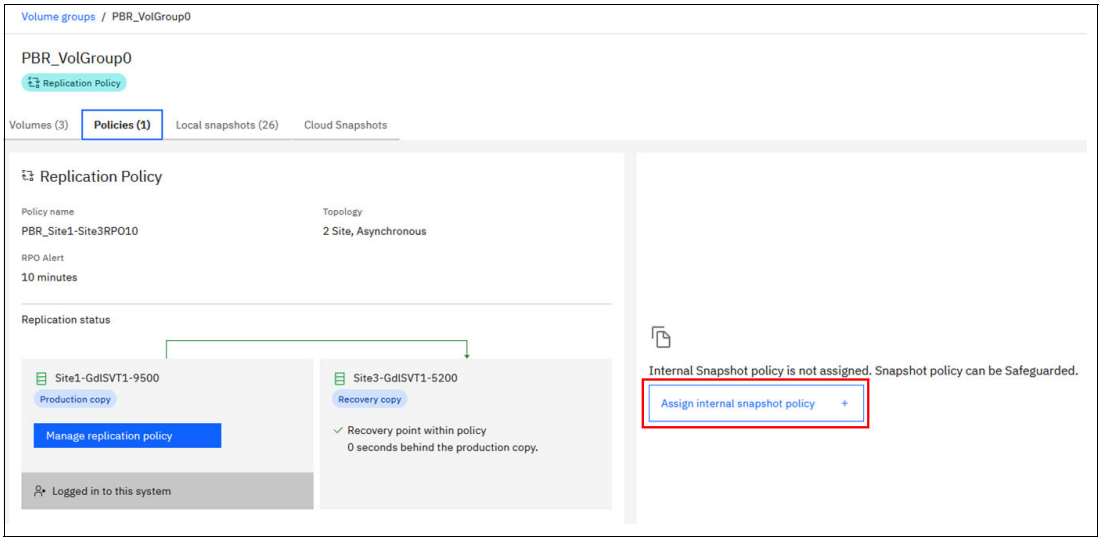

Figure 5-15 Assigning an internal snapshot policy to a volume group

Select the policy to assign to the volume group and specify the start date and time. You can make Safeguarded snapshots of the volume group. Safeguarded snapshots that are created from the selected volume group are backups that cannot be changed or assigned to hosts. See Figure 5-16 on page 95.

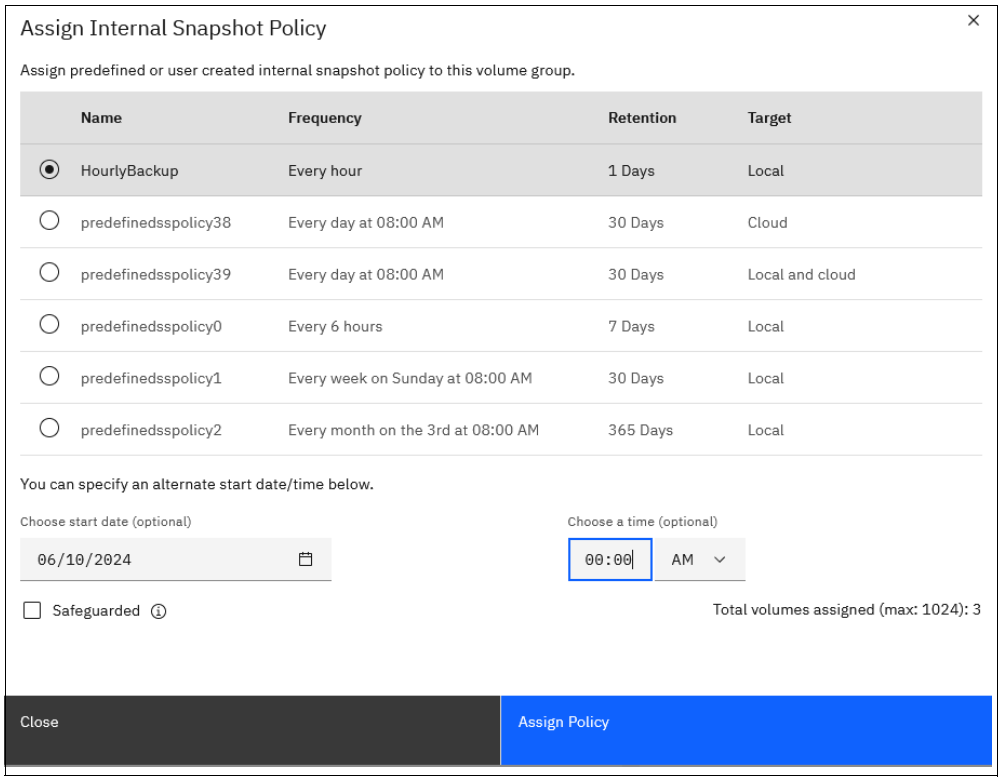

Figure 5-16 Selecting a snapshot policy for a volume group

You can assign only one local snapshot policy to a volume group. You can assign a local snapshot policy and a replication policy to a volume group.

It is possible to orchestrate the snapshots of volume groups through an external tool (like IBM Storage Copy Data Management (CDM) or IBM Copy Services Manager (CSM) to make Safeguarded Copies. If the option to assign an external policy is not visible in the Volume Group page, it might be hidden by the system GUI settings. Go to the **Settings** → **GUI preferences** → **GUI Features** page. Select the switch labeled Display Safeguarded Backup policy tile and External Schedule application settings to make the option visible. See Figure 5-17 on page 96.

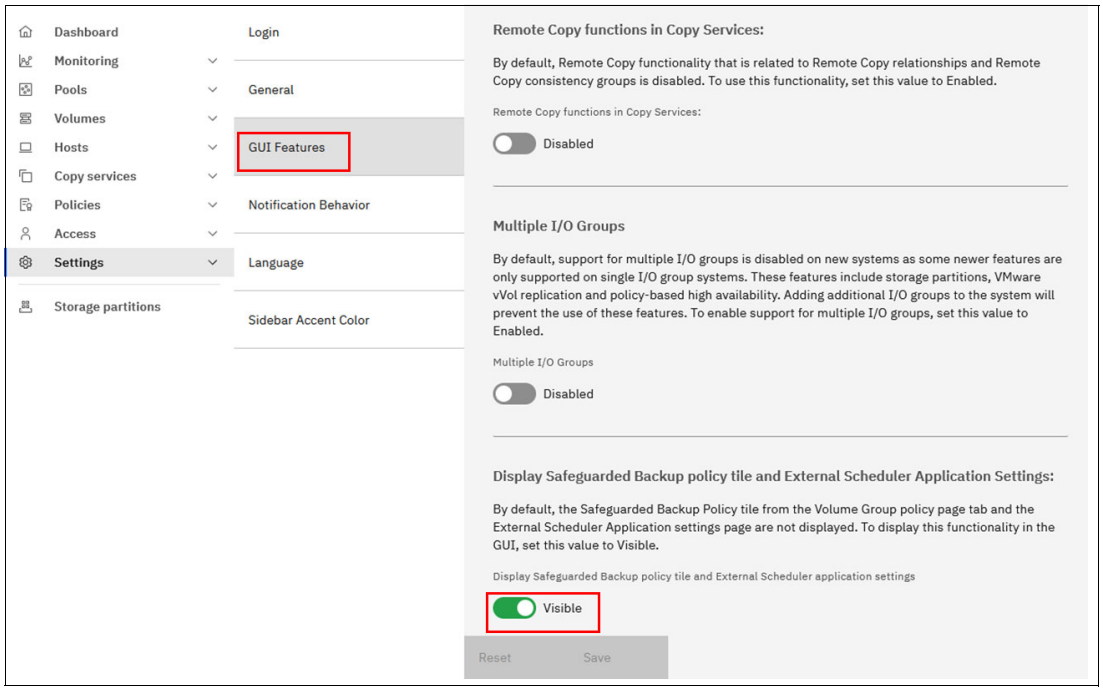

Figure 5-17 Displaying external Safeguarded backup policy in volume groups

A new panel is then available in the volume group properties. See Figure 5-18.

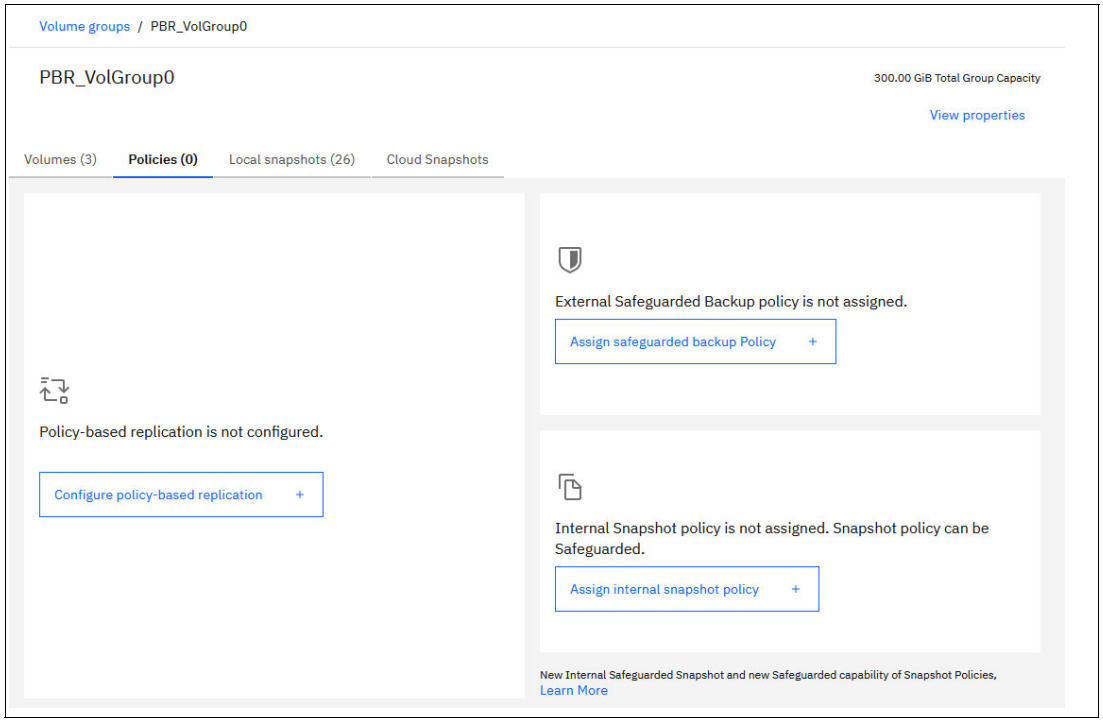

Figure 5-18 A Volume Group page with external Safeguarded backup policies available

5.3.4 Restoring a volume group from snapshots

Volume groups can be restored from one of their snapshots.

To restore a volume group from snapshots, the following requirements must be met:

- When you initiate a restore operation, the volume group that is specified by the volume group parameter must be the same parent group from which the snapshot was originally created.
- The composition of the volume group must be the same at the time of the restore as it was at the time the snapshot was taken.
- If volumes are added to or removed from the volume group in the time between the snapshot being taken and the restore being requested, then the restore fails. Those volumes must be removed from or added back into the volume group before the restore can be performed.

  Note: If the volume group on FlashSystem Site B is not mapped to any host, then data on that volume group is unchanged. Therefore, the last replicated state from FlashSystem Site A before enabling independent access (last recovery point) is restored.

- If a volume is deleted after the snapshot is taken, it is removed from the volume group and is in the deleting state. By requesting a snapshot restore, assuming that all other prerequisites have been met and the restore operation proceeds, the volume is added back to the volume group and put into the active state.
- If the volumes are expanded between the time that the snapshot is taken and when the restore is requested, then the restore fails. Shrink the parent volumes back to the size they were when the snapshot was taken before a restore can proceed.

  This has implications if new snapshots were taken after a volume was expanded because you cannot shrink the parent volumes without cleaning out any new snapshots and their dependent volume groups.

To restore a volume group from snapshots, perform the following steps:

1. Open the **Volumes** → **Volume Groups** panel in the management GUI.
2. Select the volume group to associate with the snapshots.
3. Under the Snapshots tab, select the **Restore** option on the overflow menu for the snapshot being used for the restore.
4. There is an option to either restore the entire volume group or a subset of volumes within that group. Select the applicable option and the subset of volumes if applicable and select **Restore**. See Figure 5-19 on page 98.

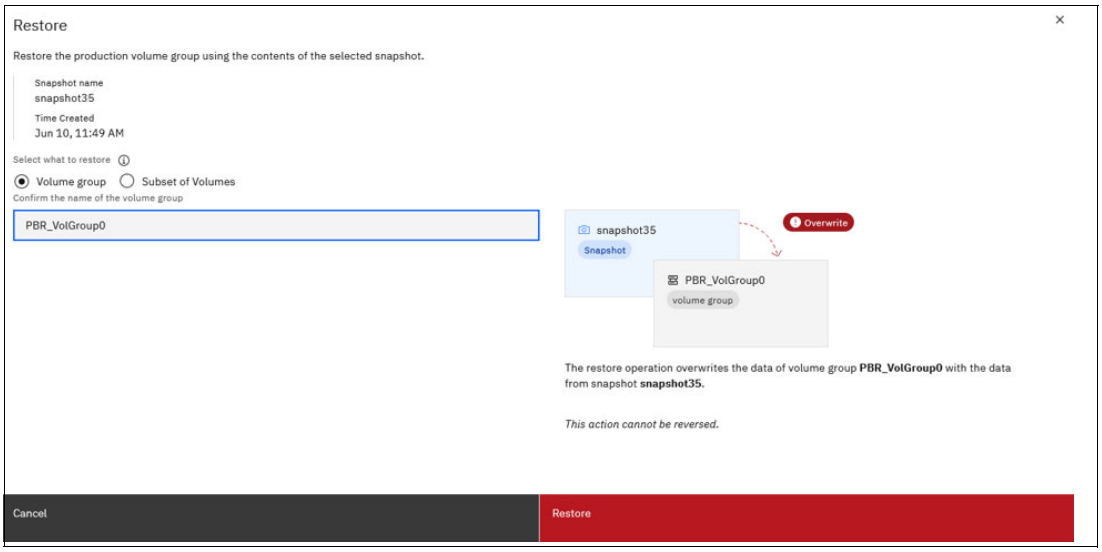

Figure 5-19 Restoring a volume group snapshot

A snapshot restore overwrites the data on the target volume group. Be sure to identify the correct snapshot to restore and the correct target of the restoration.

A volume group in an active replication policy cannot be restored from a snapshot. the replication policy must first be unassigned from the volume group.

To see when a volume group was last restored from a snapshot, go to the **Properties** option on the **Volumes** → **Volume Groups** panel.

5.4 Managing replication policies by using the GUI

To manage replication policies in the management GUI, select **Policies** → **Replication policies**. See Figure 5-20 on page 99.

Any existing policies are displayed in a table. The table lists the existing replication policies with their name, Location 1 system, Location 2 system, and the number of volume groups that use the policy.

To create a new policy, use the following instructions:

1. Click the **Create replication policy** button.
2. Enter the following information:
   - Name of the new policy
   - Requested RPO (the minimum RPO is 1 minute). See Figure 5-21 on page 100.

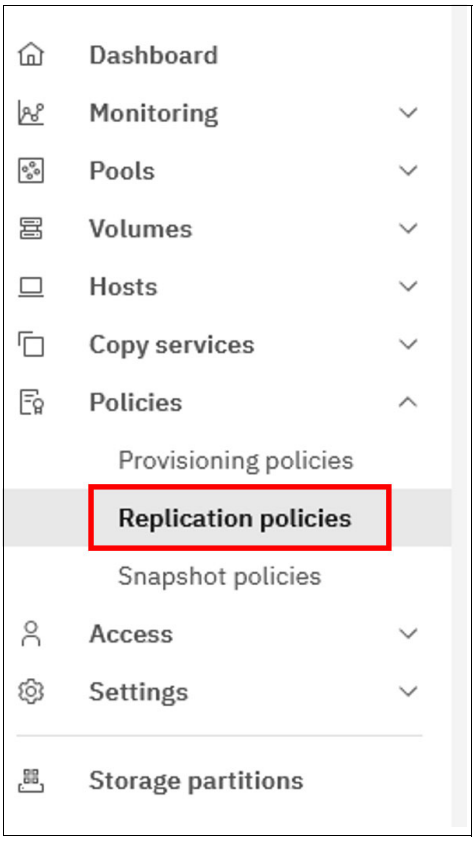

Figure 5-20 Replication policies menu

Note: As of this writing, Storage Virtualize version 8.7 supports only two-site configurations for replication that uses both asynchronous technology and high availability (HA). This means you can select only two locations, which are designated as location 1 and location 2.

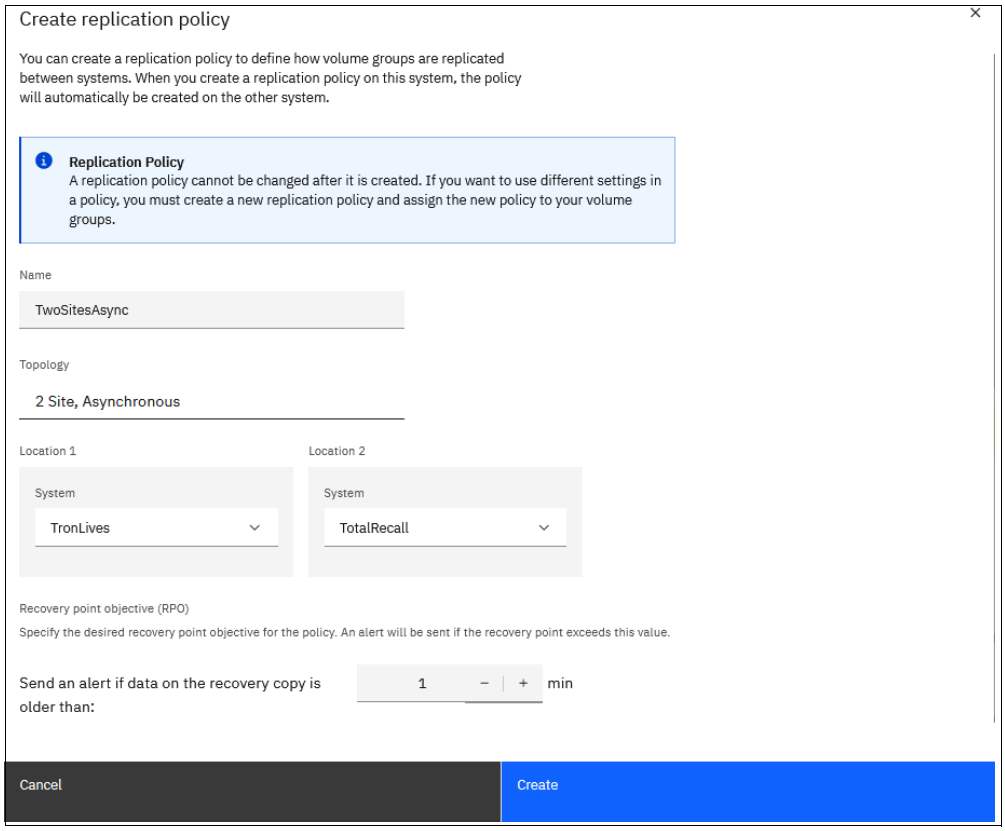

Figure 5-21 Creating a replication policy

When the replication policy is created, you can assign volume groups to it by clicking the **Overflow** menu, which consists of three vertical dots, and selecting **Assign to volume groups**. See Figure 5-22.

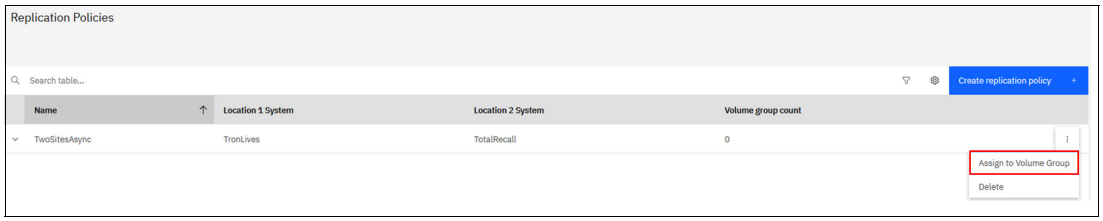

Figure 5-22 Assigning a replication policy to a volume group

The system where the policy is assigned is the production system, and the other system in the policy is the recovery system for the volume group. See Figure 5-23 on page 101.

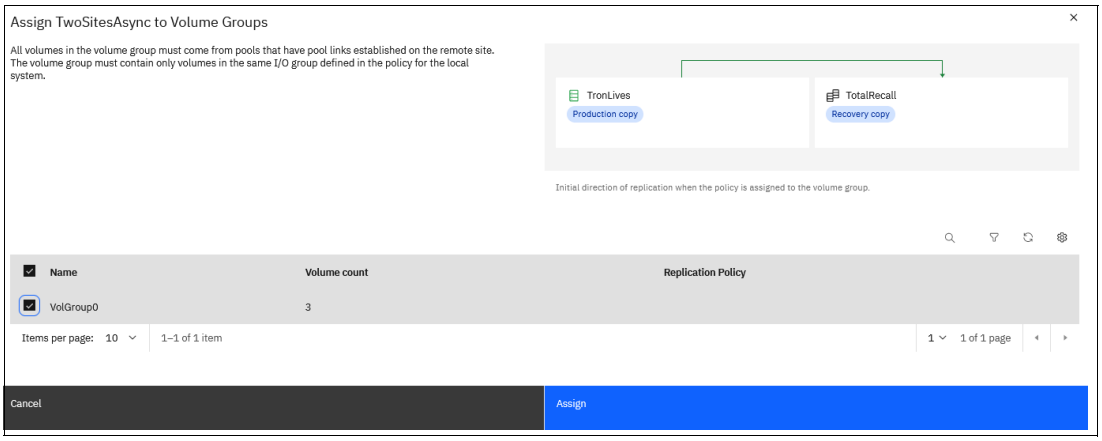

Figure 5-23 Assigning a replication policy to a volume group

Note that if a volume group is already associated to a replication policy, it does not appear in the list of available volume groups.

When a volume group is associated with a replication policy, the synchronization of the volumes starts. The system creates the recovery copy of the volume group and volumes on the remote system automatically. There is no need to create them on the remote system.

The first synchronization of the volumes is done at the speed of the available partnership's link bandwidth. The background copy rate setting for that partnership is not used if there is only policy-based replication.

To manage replication policies in the management GUI that are assigned to existing volume groups, select **Volumes** → **Volume Groups**. Select the volume group and select **Policies**.

5.5 Checking the RPO and the status of policy-based replication

To ensure business continuity, it is crucial to regularly monitor the RPO and status of your FlashSystem replication. An alert is automatically triggered when a replication falls outside its defined RPO or if the status of the replication link changes. For advanced monitoring needs, some users might prefer to use third-party tools that use RESTful APIs to track RPO and replication status within their FlashSystem environment.

5.5.1 Checking the RPO and status by using the management GUI

To view the replication status for a volume group do the following steps:

1. Navigate to the **Policies** tab within the management GUI.
2. In the Volumes section, select **Volume Groups** and choose the specific group that you want to monitor.
3. On the Volume Groups page, click the **Policies** tab. The RPO status is listed under the Recovery copy illustration. See Figure 5-24 on page 102.

.

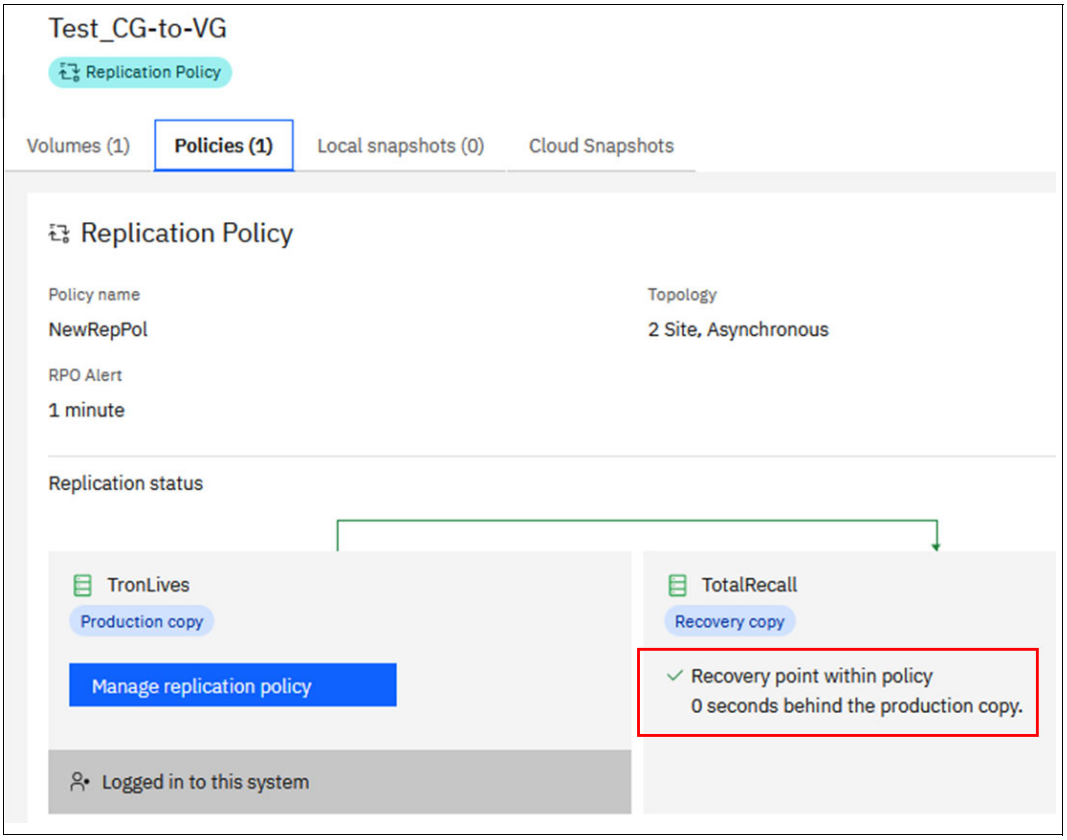

Figure 5-24 Volume group RPO and status

In the Volume Groups list page, the RPO is also listed for every replicating volume group. See Figure 5-25.

Figure 5-25 Volume groups and their RPO

Table 5-1 lists the possible status of an RPO.

Table 5-1 RPO status

RPO status	Description
Within policy's RPO	Replication is within the RPO value set in the policy.
Outside policy's RPO	Data on the recovery copy is outside the RPO value set in the policy.
Initial copy in progress	Replication is in progress for the first time.
Initial copy incomplete	Replication is incomplete, and replication is suspended.

If the recovery point exceeds the policy's definition, then an alert is triggered and is posted in the event log. It is automatically fixed when the recovery point returns within the policy's definition. See Figure 5-26.

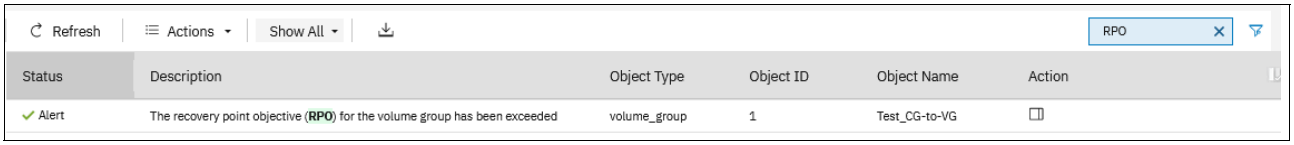

Figure 5-26 An outside policy RPO alert

The replication status is also displayed and illustrated between the production and recovery copies. Table 5-2 lists the possible states of Replication.

Table 5-2 Replication status

Replication state	Description	Action required
Replication running	Data is currently being replicated between systems.	No action required
Independent access	Replication is stopped and each copy of the volume group is accessible for I/O.	To resume replication, choose the system that you would like to use the data and configuration from. Make this system the production copy.
Replication suspended	Replication is suspended due to an error on one of the systems. Replication automatically resumes when all errors are resolved.	Review the event log and address errors.
System disconnected	Connection between systems is unavailable.	Restore connectivity between the systems.

5.5.2 Checking the RPO and status by using REST APIs

You can check the RPO status of replicating volume groups by using a tool that can communicate with the RESTful API server of FlashSystem.

The HTTPS server requires authentication of a valid username and password for each API session. The /auth endpoint uses the POST method for the authentication request. See Example 5-1.

Example 5-1 Authenticating and getting a token

```
curl --location --request POST 'https://<your_flashsystem_ip>:7443/rest/v1/auth' \
--header 'X-Auth-Username: <your_userID>' \
--header 'X-Auth-Password: <your_password>' \
-d ''
```

In the preceding example, replace `<your_flashsystem_ip>` with your FlashSystem's IP address, replace `<your_userID>` with your user ID and replace `<your_password>` with your password.

The response to this request is a token (a string) which must be used for further requests. It is referenced in the next example as `<your_token>`.

When the authentication is successful with a response status of 200 and when you have stored the token, use the command **lsvolumegroupreplication**.

In Example 5-2, the token that was returned in the previous authentication request is used.

Example 5-2 Requesting volume groups' replication status

```
curl --location --request POST
'https://<your_flashsystem_ip>:7443/rest/v1/lsvolumegroupreplication' \
--header 'X-Auth-Token: <your_token>' \
--data ''
```

If a successful response is returned with a status of 200, it can be used by the third-party tool. Example 5-3 is the response to a previous request. It lists the status of the two volume groups that are defined on our lab system.

Example 5-3 Viewing the volume groups and their replication status

```
{
        "id": "1",
        "name": "Test_CG-to-VG",
        "replication_policy_id": "0",
        "replication_policy_name": "NewRepPol",
        "ha_replication_policy_id": "",
        "ha_replication_policy_name": "",
        "location1_system_name": "TronLives",
        "location1_replication_mode": "production",
        "location1_within_rpo": "",
        "location2_system_name": "TotalRecall",
        "location2_replication_mode": "recovery",
        "location2_within_rpo": "yes",
        "link1_status": "running",
        "partition_id": "",
        "partition_name": "",
        "recovery_test_active": "no",
        "draft_partition_id": "",
        "draft_partition_name": ""
    }
```

The attributes `location1_within_rpo` or `location2_within_rpo`, depending on the direction of the copy, indicate whether the replication is within the RPO or not. In the preceding example, the volume group with `id` 1 has a recovery point within the policy.

More details are listed if the `id` of the volume group is specified in the request. For example, Example 5-4 shows the response for the following request:

`https://<your_flashsystem_ip>:7443/rest/v1/lsvolumegroupreplication/1.`

Example 5-4 Details of the replication status for a given volume group

```
{
    "id": "1",
    "name": "Test_CG-to-VG",
    "replication_policy_id": "0",
    "replication_policy_name": "NewRepPol",
```

```
    "ha_replication_policy_id": "",
    "ha_replication_policy_name": "",
    "local_location": "1",
    "location1_system_id": "0000020421A086D8",
    "location1_system_name": "TronLives",
    "location1_replication_mode": "production",
    "location1_status": "healthy",
    "location1_running_recovery_point": "",
    "location1_fixed_recovery_point": "",
    "location1_within_rpo": "",
    "location1_volumegroup_id": "1",
    "location1_sync_required": "",
    "location1_sync_remaining": "",
    "location1_previous_replication_mode": "",
    "location1_last_write_time": "",
    "location2_system_id": "0000020420C082FA",
    "location2_system_name": "TotalRecall",
    "location2_replication_mode": "recovery",
    "location2_status": "healthy",
    "location2_running_recovery_point": "0",
    "location2_fixed_recovery_point": "",
    "location2_within_rpo": "yes",
    "location2_volumegroup_id": "0",
    "location2_sync_required": "",
    "location2_sync_remaining": "",
    "location2_previous_replication_mode": "",
    "location2_last_write_time": "",
    "link1_status": "running",
    "partition_id": "",
    "partition_name": "",
    "checkpoint_achieved": "yes",
    "recovery_test_active": "no",
    "draft_partition_id": "",
    "draft_partition_name": ""
}
```

You can also view the event log for exceeding RPO events. In Example 5-5, after authentication is successful and a token is retrieved, you can list the alerts from the event log. Event ID 052004 means “The recovery point objective (RPO) for the volume group has been exceeded”.

Example 5-5 Requesting RPO alerts list from the event log

```
curl --location 'https://<your_flashsystem_ip>:7443/rest/lseventlog' \
--header 'X-Auth-Token: <your_token>' \
--header 'Content-Type: application/json' \
--data '{
    "filtervalue": "event_id=052004",
    "fixed": "yes",
    "order": "severity"
    }'
```

The response to this request provides a list of all alerts that are related to the event “The recovery point objective (RPO) for the volume group has been exceeded.” Each alert

includes the latest timestamp, the name and ID of the affected volume group, and a sequence number for future reference if you want to retrieve more details about the event. See Example 5-6.

Example 5-6 Eventlog with exceeded RPO events only

```
{
        "sequence_number": "208",
        "last_timestamp": "240527051415",
        "object_type": "volume_group",
        "object_id": "1",
        "object_name": "Test_CG-to-VG",
        "copy_id": "",
        "status": "alert",
        "fixed": "yes",
        "event_id": "052004",
        "error_code": "",
        "description": "The recovery point objective (RPO) for the volume group
has been exceeded"
    },
    {
        "sequence_number": "212",
        "last_timestamp": "240529102925",
        "object_type": "volume_group",
        "object_id": "1",
        "object_name": "Test_CG-to-VG",
        "copy_id": "",
        "status": "alert",
        "fixed": "yes",
        "event_id": "052004",
        "error_code": "",
        "description": "The recovery point objective (RPO) for the volume group
has been exceeded"
    }
```

You can list more details for a specific event by specifying the sequence number in the request URL. Example 5-7, shows a request for more details for the sequence number 208. The sequence number is provided from a previous response.

Example 5-7 Example of specific event details

```
curl --location --request POST
'https://<your_flashsytem_ip>:7443/rest/lseventlog/208' \
--header 'X-Auth-Token: <your_token>' \
--data ''
```

The returned response provides details on the event, which can be used for further optimization such as number of occurrences, duration of the event, and so on. See Example 5-8.

Example 5-8 Example of details for a specific exceeded RPO alert

```
{
    "sequence_number": "208",
    "first_timestamp": "240527051415",
```

```
    "first_timestamp_epoch": "1716801255",
    "last_timestamp": "240527051415",
    "last_timestamp_epoch": "1716801255",
    "object_type": "volume_group",
    "object_id": "1",
    "object_name": "Test_CG-to-VG",
    "copy_id": "",
    "reporting_node_id": "1",
    "reporting_node_name": "node1",
    "root_sequence_number": "",
    "event_count": "1",
    "status": "alert",
    "fixed": "yes",
    "auto_fixed": "yes",
    "notification_type": "warning",
    "event_id": "052004",
    "event_id_text": "The recovery point objective (RPO) for the volume group has
been exceeded",
    "error_code": "",
    "error_code_text": "",
    "machine_type": "9846AG8",
    "serial_number": "78E316M",
    "FRU": "None , None , None , None ",
    "fixed_timestamp": "240527051415",
    "fixed_timestamp_epoch": "1716801255",
    "callhome_type": "none",
    "sense1": "00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00",
    "sense2": "00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00",
    "sense3": "00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00",
    "sense4": "00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00",
    "sense5": "00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00",
    "sense6": "00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00",
    "sense7": "00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00",
    "sense8": "00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00"
}
```

6

Implementing policy-based HA

This chapter guides you through implementing policy-based high availability (policy-based-HA) for IBM Storage Virtualize 8.7.

Before you implement policy-based HA, ensure your environment meets the requirements for it and that you understand the concepts of the solution. For more information, see Planning high availability.

This guide explains how to configure a policy-based HA solution. You can set up policy-based HA using the management GUI or the CLI.

This chapter has the following sections:

6.1 Storage partitions

Storage partitions are vital components in policy-based HA. Storage partitions are associated with an HA replication policy and can be used in the following ways:

- As management units that contain volumes groups, volumes, host ports, and volume-to-host mappings
- To implement policy-based HA available since V8.6.1
- To implement Storage Partition Mobility available since V8.6.3
- To implemented Flash Grid, which is a feature in V8.7.0

Within a storage partition, all volumes are in volume groups, and host mappings can be created only between volumes and hosts in the same partition.

In storage partitions configured for HA replication, there are two important properties: the preferred management system and the active management system.

The preferred management system is configured and changed by the storage administrator. Certain error situations can trigger a failover of the management system to the HA-partner. When the system recovers, control automatically returns to the preferred management system. The administrator can also change the preferred management system.

All configuration actions on a storage partition must be performed on the active management system. The storage partition can be monitored on either system.

You can configure additional volumes, volume groups, hosts, and host-to-volume mappings at any time, either by adding to an existing partition or by creating a new one. A partition must include all volumes that are mapped to any hosts included in the partition.

6.2 Policy-based HA versus HyperSwap

Policy-based HA replaces HyperSwap as the HA solution for Storage Virtualize. The software on existing systems with HyperSwap can be updated to version 8.7 but cannot be updated to a later version. HyperSwap can be created on compatible systems on code version 8.7, but policy-based HA provides several advantages over HyperSwap:

- Simplified management
- Better performance
- Migration options
- Non-mirrored volumes remain accessible in the case of connectivity issues
- Hardware on the two sites does not need to be compatible

6.3 Migrating from HyperSwap to policy-based HA

One significant difference when you migrate from HyperSwap to policy-based HA is that with HyperSwap, two storage enclosures are clustered together as a two-IO-group system and are acting as a single managed entity. For policy-based HA, the two storage enclosures are individual enclosures not clustered together. High availability is managed through hosts and volumes in storage partitions that span two individual storage enclosures.

The following steps are involved in converting a two-storage-enclosure HyperSwap configuration to a policy-based HA setup:

1. Unmirror HA-volumes

   Convert all HyperSwap volumes to basic volumes and leave a volume copy on only the remaining enclosure (IO-group).

2. Migrate non-HA-volumes

   Migrate all non-HA volumes to the remaining enclosure (IO-group).

3. Unconfigure HyperSwap

   Change topology to standard.

4. Remove enclosure

   If IO-group 0 is the remaining enclosure, then remove the nodes from I/O group 1. The nodes in IO-group 1 change to state Candidate.

5. Initialize a new system

   Create a new system by using the nodes from I/O group 1.

6. Configure policy-based HA

   When you have two independent storage systems defined, you can configure policy-based HA between them.

   On the original system, follow instructions in 6.4, “Configuring policy-based HA” on page 111 to create a new storage partition and configure policy-based HA.

Important: There is currently no method to migrate from HyperSwap to policy-based HA while maintaining high availability during migration.

6.4 Configuring policy-based HA

The environment consists of a FlashSystem 9100 and a FlashSystem 7300 connected through SAN switches. These switches employ dedicated Inter-Switch Link (ISL) connections, with one dedicated ISL per switch fabric:

- Public traffic ISL. Carries data traffic between the storage systems and the hosts.
- Private traffic ISL. Facilitates communication between the storage system nodes for node to node operations.

Figure 6-1 on page 112 shows the topology for the systems to be configured.

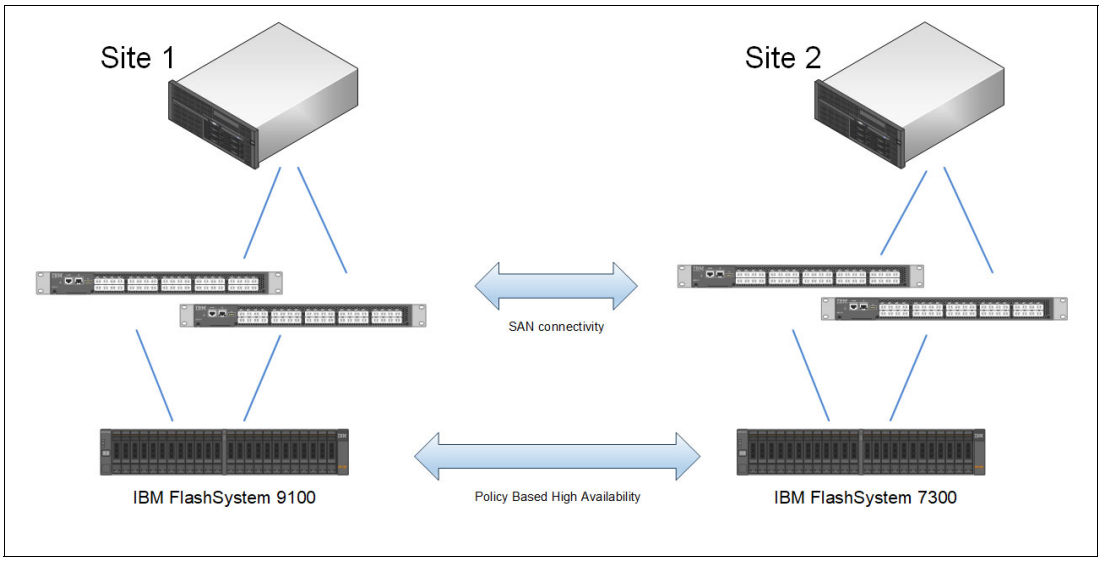

Figure 6-1 The topology of the systems to be configured

Creating policy-based HA using GUI

In the management GUI, select **Storage Partitions** or **Copy Services** → **Partnerships** to configure HA.

Follow these steps to configure policy-based HA by using the management GUI:

1. Verify code levels on both connecting systems. Use the GUI to verify that you have Storage Virtualize version 8.7.0 or later on both systems. This is shown in “Check code levels on both connecting systems” on page 59
2. If you do not already have a partnership, create a partnership with the HA-partner. This is shown in “Define partnership for replication” on page 59.
3. From the panel **Copy Services** → **Partnerships:**
   a. Select a partnership that is ready for use with policy-based replication.
   b. Select **Setup policy-based replication.** This starts the Setup policy-based replication wizard.
   c. Select the **HA-partner** and choose **High-availability replication** as shown in Figure 6-2 on page 113.
   d. Click **Continue** to proceed.

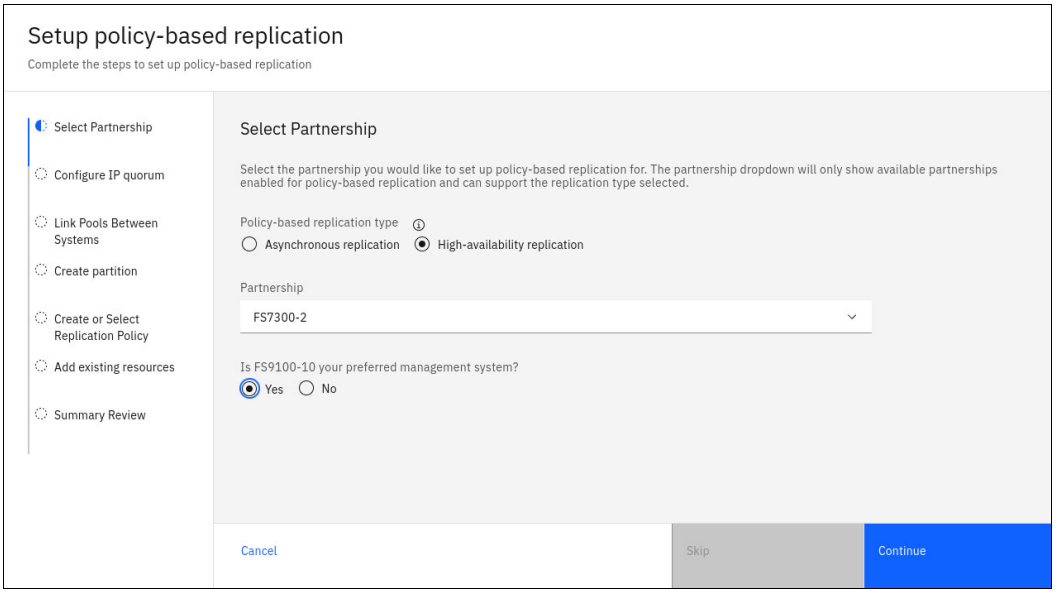

Figure 6-2 The Setup policy-based replication wizard begins

4. Configure an IP quorum application:
   a. Click **Download IPv4 Application** as shown in Figure 6-3.
   b. When the IP quorum application downloads to the local system, you can run it locally or distributed to a host dedicated to running IP-quorum.
   c. Click **Continue** to proceed.

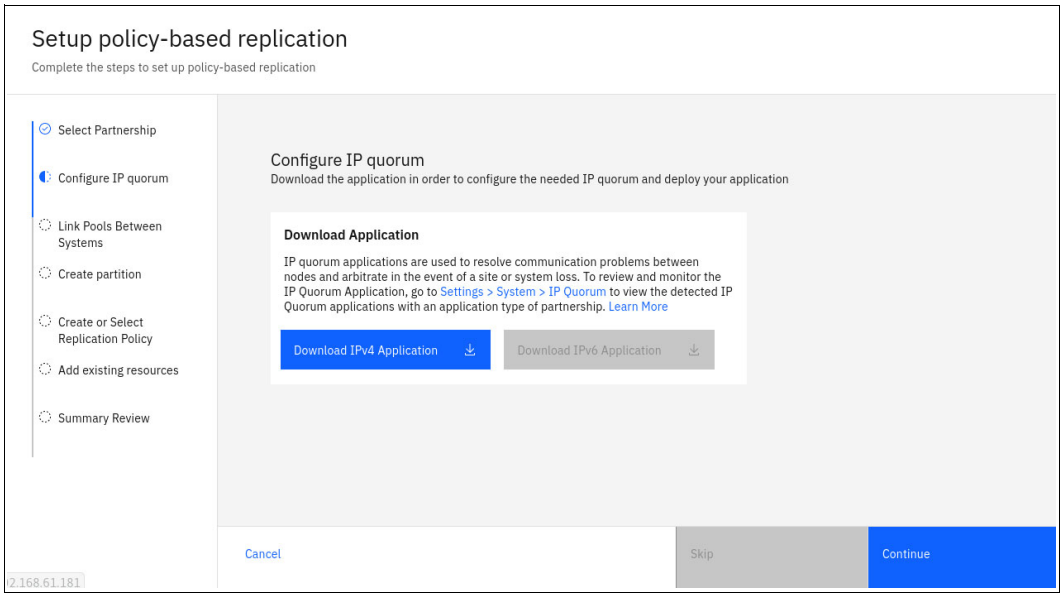

Figure 6-3 Download IP quorum

Note: You must have connectivity from all the servers that are running an IP quorum application to the service IP addresses of all the nodes or node canisters.

For a full list of IP quorum requirements, see IBM Storage Virtualize IP quorum application requirements.

For more information about how to use IP quorum, see IP quorum application web page.

5. Link the two systems and storage pools. See Figure 6-4.
   a. Select the storage pools to link on the two systems.
   b. Select a pool on both systems. The example shows StandardPool.
   c. Select a provisioning policy for both systems. The example shows **capacity_optimized** to use thin provisioning for the volumes in these pools.
   d. Click **Link Pools**.

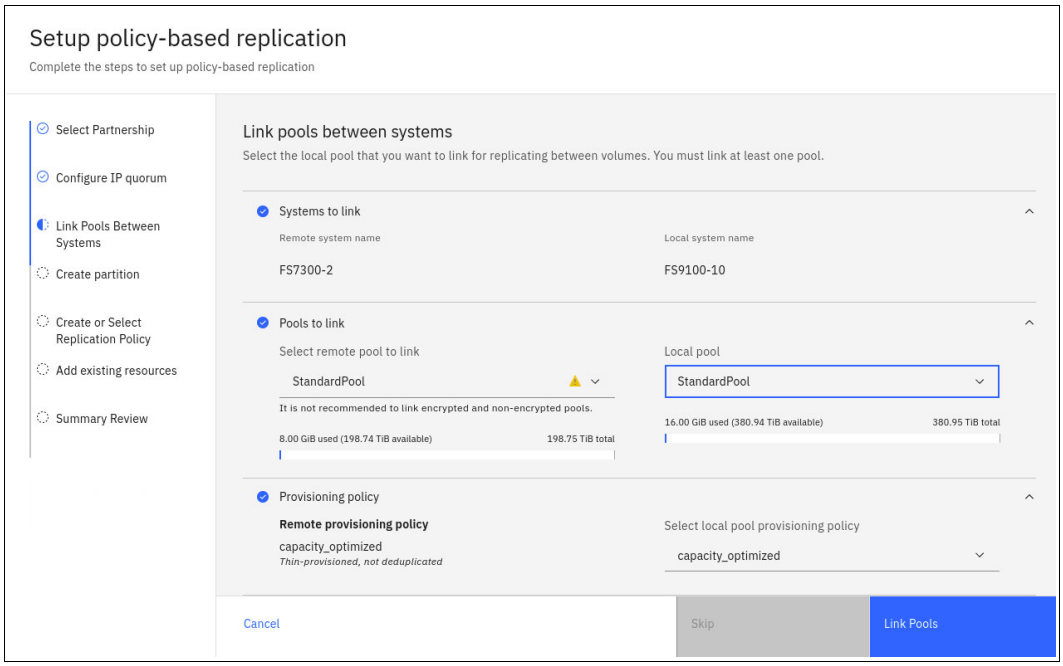

Figure 6-4 Link pools between systems

6. Create a storage partition and give it a name. Click **Create partition** to proceed. See Figure 6-5 on page 115.
7. Create an HA replication policy and give it a name. In the example, the partition is named FS9100-FS7300-HA. Click **Create replication policy**. See Figure 6-6 on page 115.

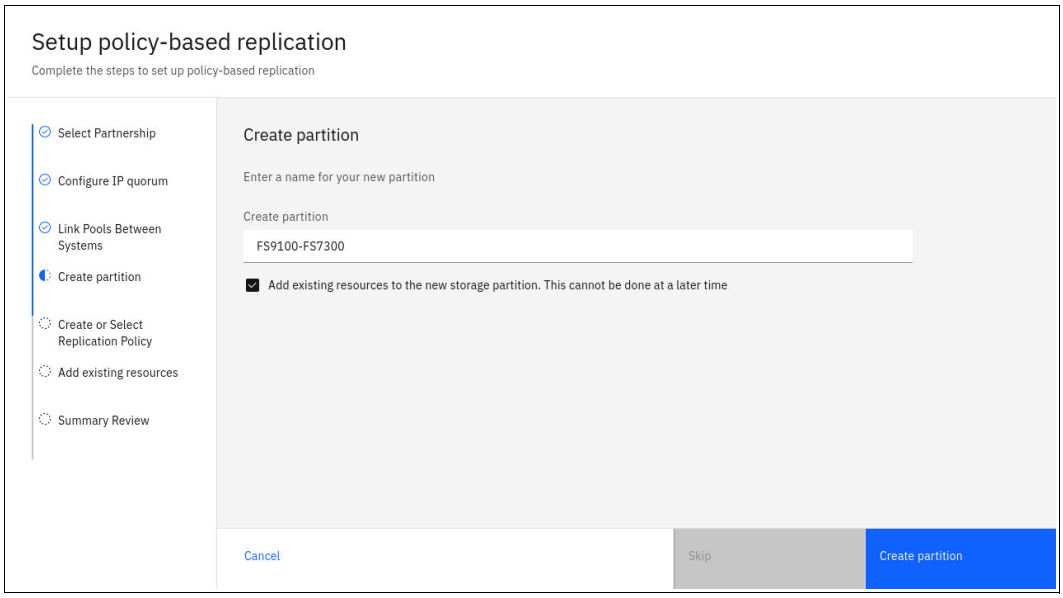

Figure 6-5 Create partition

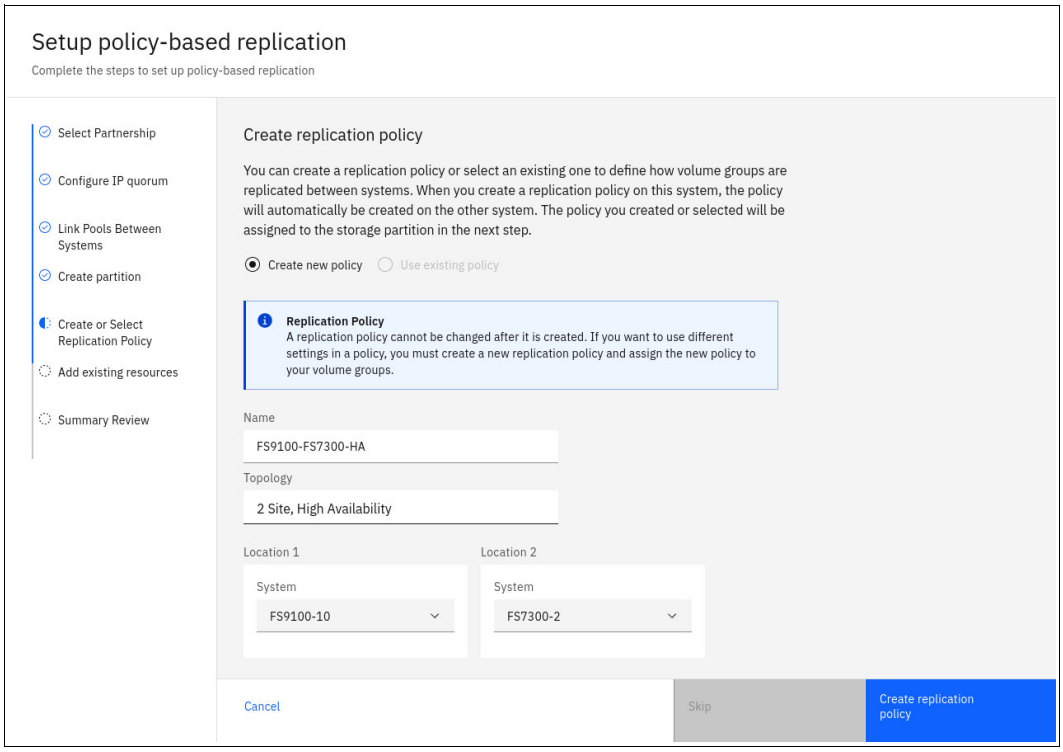

Figure 6-6 Create replication policy

8. The Setup policy-based replication wizard prompts for selecting volume groups to add to the newly created storage partition. Volumes in the volume group being selected are synchronously mirrored between the two partnered systems. You can select the volume group or groups from a list of previously created volume groups, or you can skip this step. Click **Select volume groups**. See Figure 6-7.

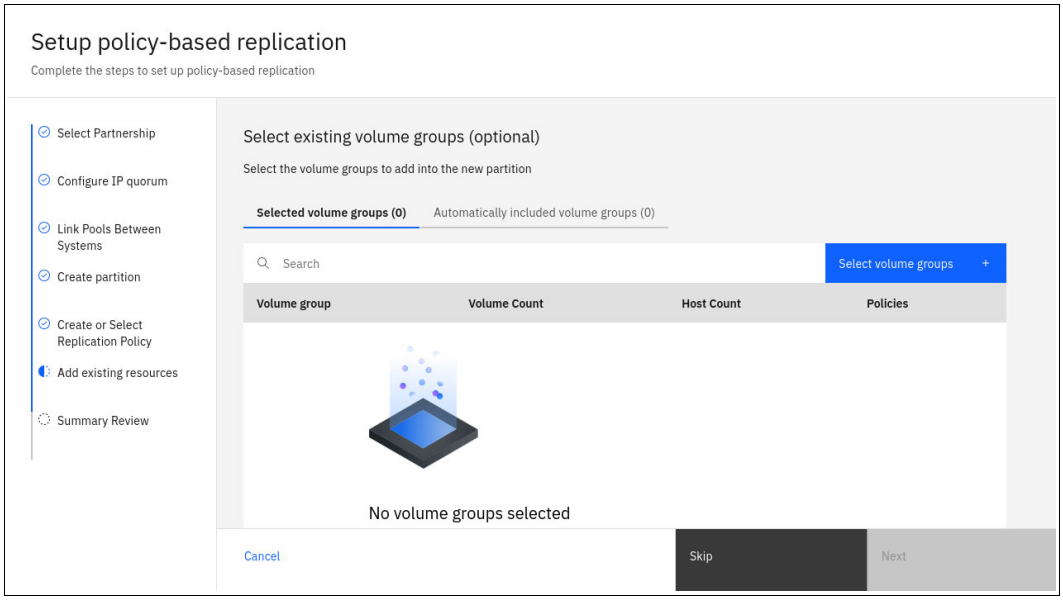

Figure 6-7 Select volume groups

9. Select an existing volume group, which contains four volumes. The resulting window displaying this selection is shown in Figure 6-8. Click **Next** to proceed.

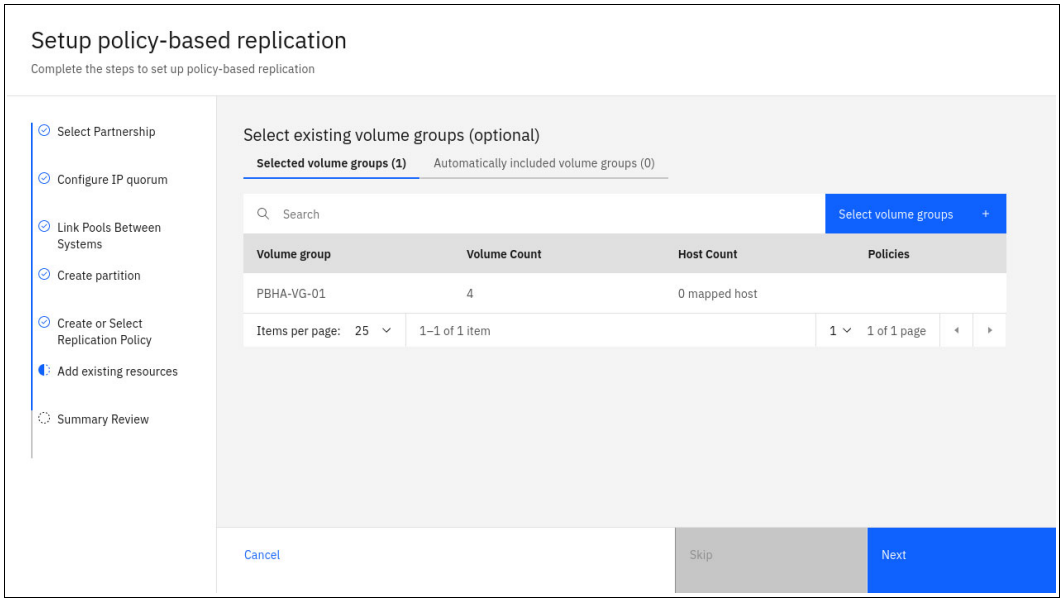

Figure 6-8 Volume group selected

Note: Volumes are configured, but no hosts are added yet. Host creation and configuration are discussed in “Creating hosts in policy-based HA and mapping volumes” on page 121.

10. The Setup policy-based replication wizard finalizes and shows the Summary Review page. The warning message states that the IP quorum is not configured. Policy-based HA can be enabled without an IP quorum, but it is a best practice to enable the quorum before you use the system for production. Click **Close** to exit as shown in Figure 6-9.

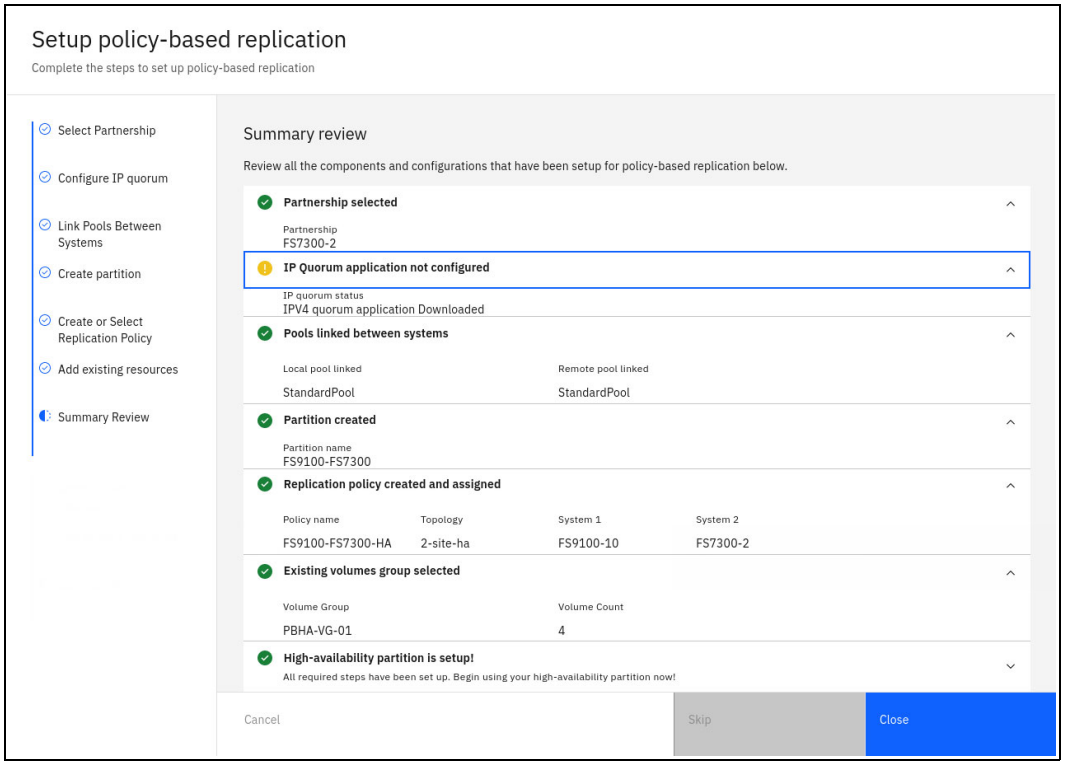

Figure 6-9 Summary review

11. The wizard exits to the Storage Partition view, as shown in Figure 6-10.

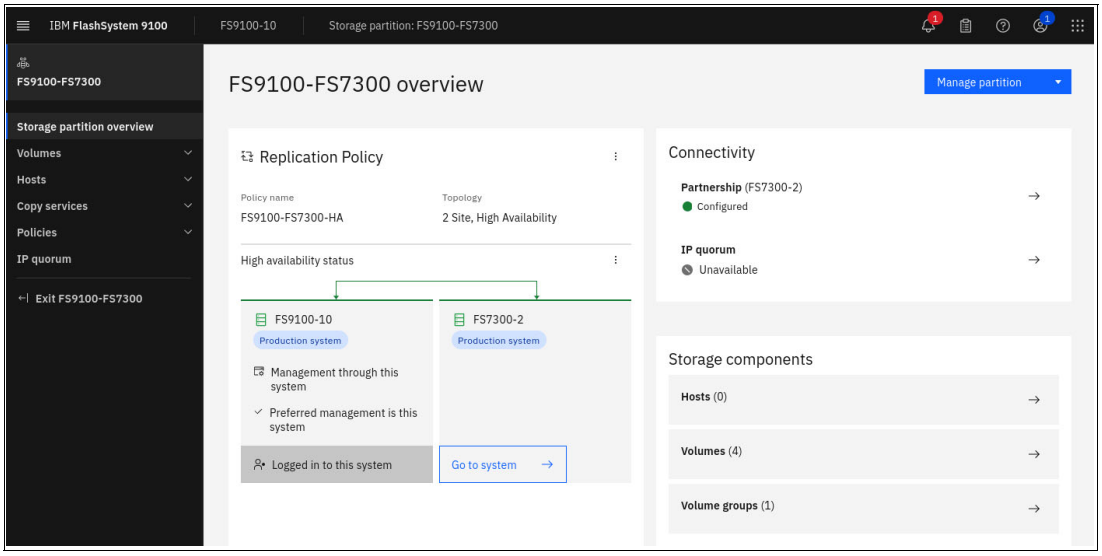

Figure 6-10 Storage Partition view

The Storage Partition overview shows that the FS9100-10 and FS7300-2 are active in a highly available relationship where the FS9100-10 is the preferred management system.

In the previous scenario, a FlashSystem 9100 and a FlashSystem 7300 are in an HA relationship together. Ensure that the smaller system can manage the workload, which is a best practice.

The next step involves creating new components on both FlashSystem storage systems:

- New hosts. Define new hosts in the management software.
- Volume groups. Create volume groups to manage related volumes for easier administration.
- Host-to-volume mappings. Establish mappings between the newly created hosts and the volumes that they must access.

During host creation, the storage administrator can specify a location preference. This ensures that local FlashSystem volumes on the same site as the host are prioritized for access. This approach optimizes performance and minimizes network traffic.

Use the Storage Partition Overview panel to monitor connectivity between the two systems and the IP quorum applications, and the health of the hosts and volumes associated with the partition.

Creating volumes in policy-based HA

In the previous example, the storage partition includes existing volumes from a volume group. The next example demonstrates how to create new volumes within this storage partition.

These new volumes are created on the primary management system, which is the FlashSystem 9100 (FS9100) in this policy-based HA configuration. Because of the replication policy applied to the storage partition, any volumes that are created in the partition are automatically mirrored to the partner system, which ensures data redundancy and high availability.

Follow these steps to configure volumes to be used for storage partitions in policy-based HA:

1. From the Volumes menu within the storage partition, click **Create Volumes** as shown in Figure 6-11

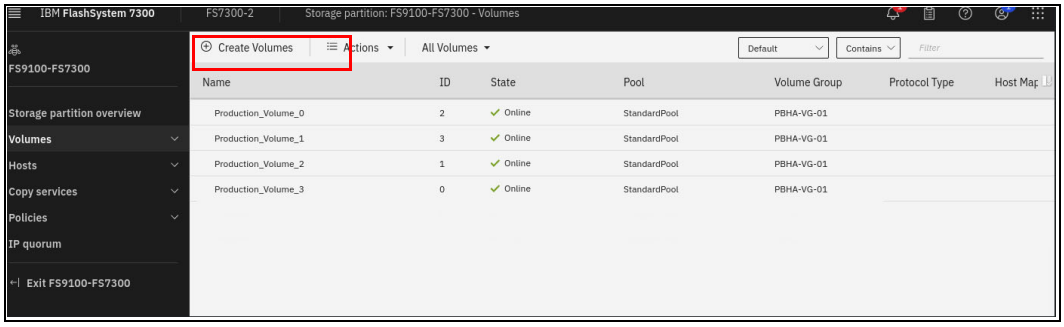

Figure 6-11 Create volumes from within the storage partition

2. When the window opens, click **Define Volume Properties** to open the Define volume properties window. Enter a name and capacity for the new volumes and click **Save** as shown in Figure 6-12

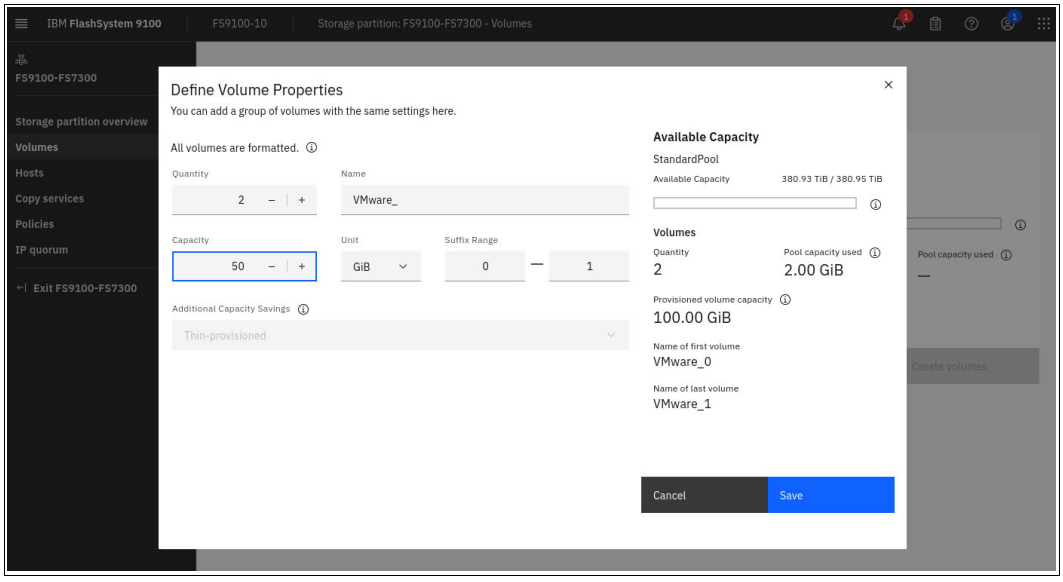

Figure 6-12 Define volume properties

3. The Create Volumes menu lists a summary of changes. Click **Create volumes** to proceed. See Figure 6-13

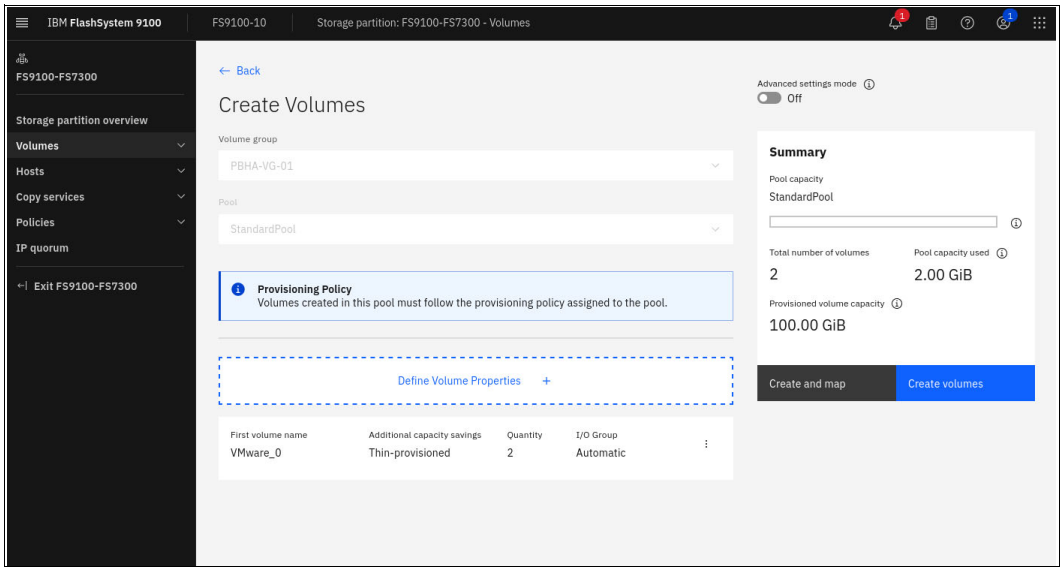

Figure 6-13 Create volumes wizard

4. On the primary management system, which is the FS9100, the new volumes are listed, and they belong to a volume group to which a replication policy is enabled, as shown in Figure 6-14. These volumes are replicating to the FS7300.

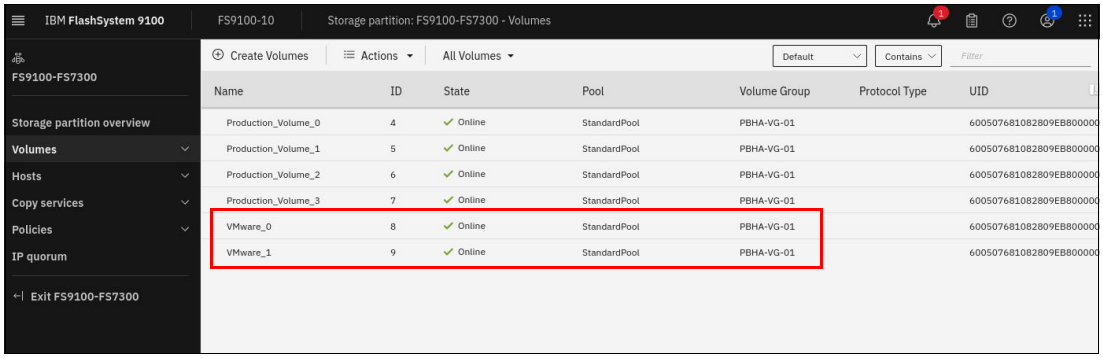

Figure 6-14 Volumes in the storage partition of the FS9100 and FS7300

Note: Volumes that are not required to be mirrored in a policy-based HA relationship can be created in the **Volumes** → **Volumes** window outside of the Storage partition section of the GUI.

Open the **Volumes** → **Volumes** window on the FS7300 HA-partner to verify that the new replicated volumes also exist on the FS7300 as shown in Figure 6-15.

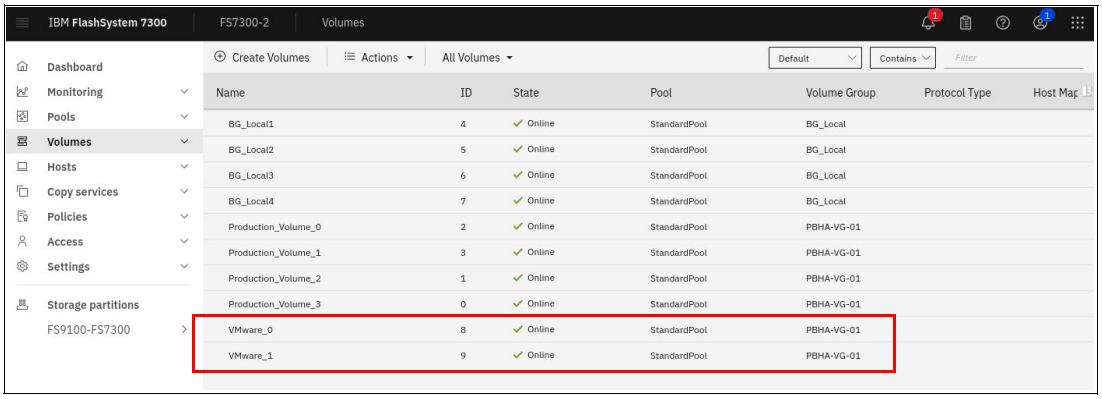

Figure 6-15 Volumes on the FS7300

The volumes in Figure 6-15 are accessible from outside the Storage Partitions menu or within the Storage Partitions menu.

Because these volumes belong to a volume group with an enabled replication policy, they are mirrored to the HA partner system for redundancy and failover capabilities. This helps ensure that data remains available if the primary system encounters an issue.

Note: You cannot create volumes that are attached to the replicating volume group from the FS7300 because it is not the preferred management system. You can create non-replicated volumes outside of the Storage Partitions menu on the FS7300 system.

Creating hosts in policy-based HA and mapping volumes

The following section describes how to create hosts and map volumes to it.

Creating hosts

Follow these steps to add to hosts in policy-based HA:

1. Enter the storage partition FS9100-FS7300.
2. Select **Hosts** as shown in Figure 6-16. No hosts are listed.
3. Click **Add Host** to proceed.

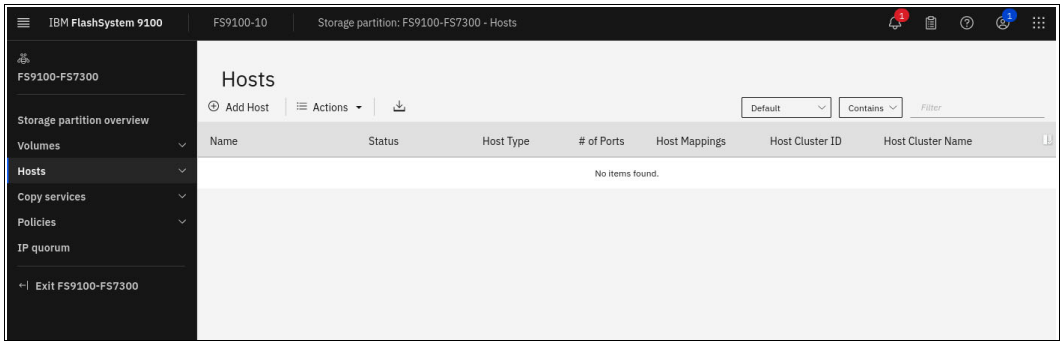

Figure 6-16 Hosts menu in policy-based HA

4. The Add Host wizard opens. Ensure that the **Assign location** checkbox is checked.
5. Select the preferred location of the host as shown in Figure 6-17. Select the location name from the list of storage devices.

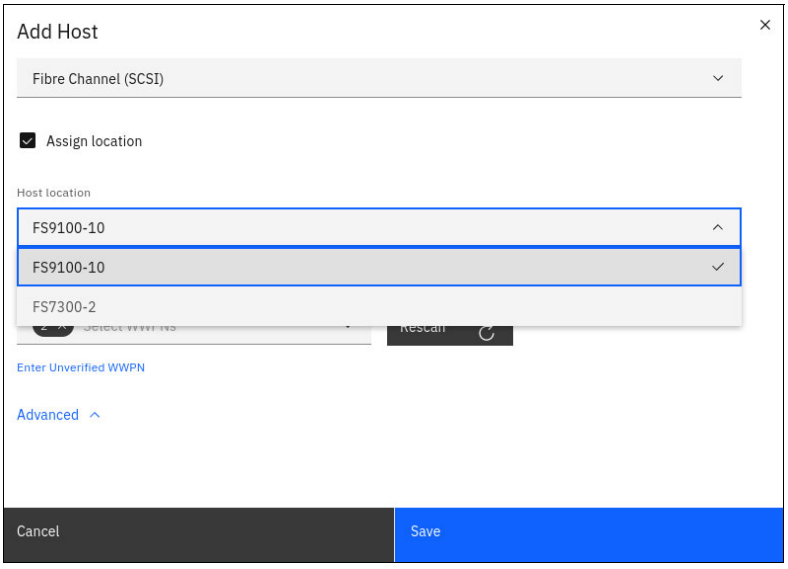

Figure 6-17 Select host location

6. Open the Host port (WWPN) menu to select the WWPNs that belong to the host being added as shown in Figure 6-18.

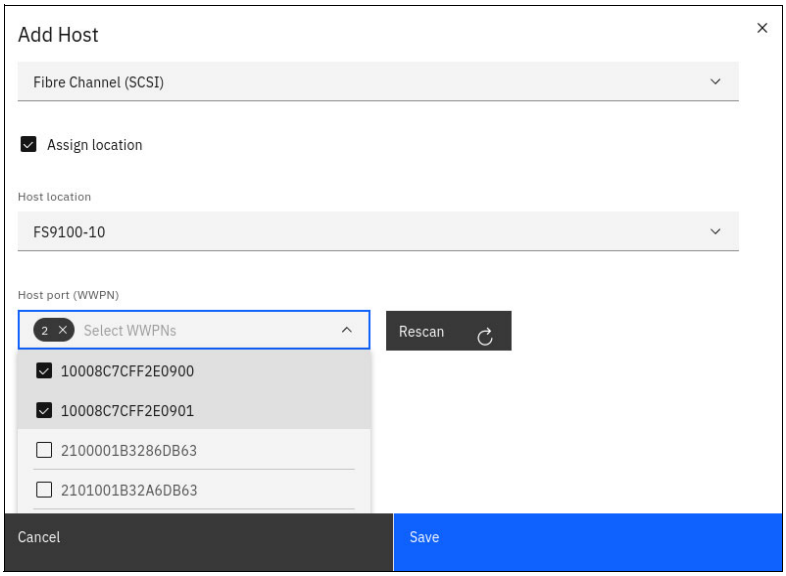

Figure 6-18 Select host WWNs

7. Review the settings and click **Save** to proceed. See Figure 6-19.

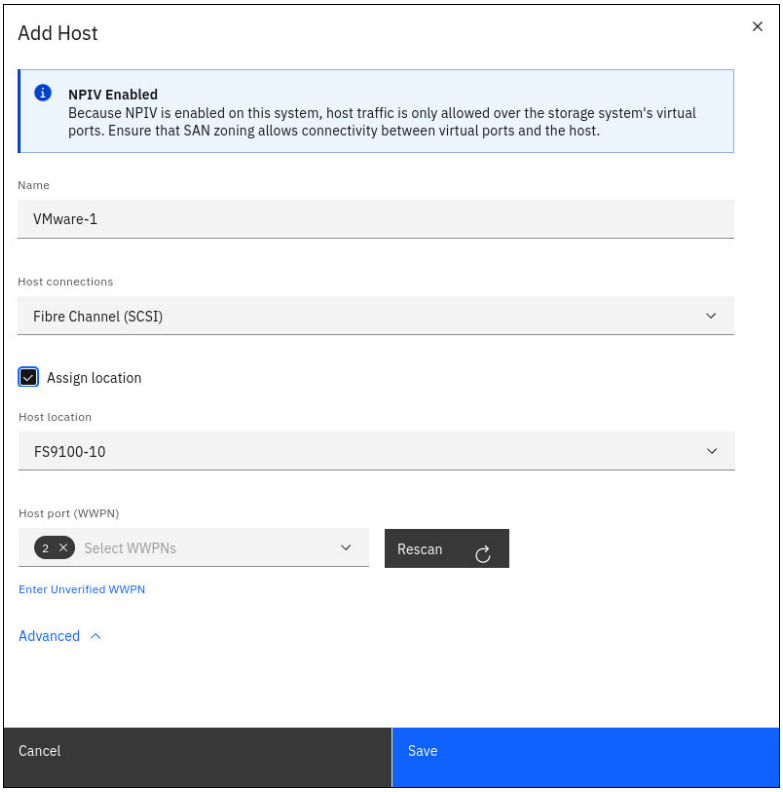

Figure 6-19 Review hosts settings

8. The host is listed as shown in Figure 6-20.

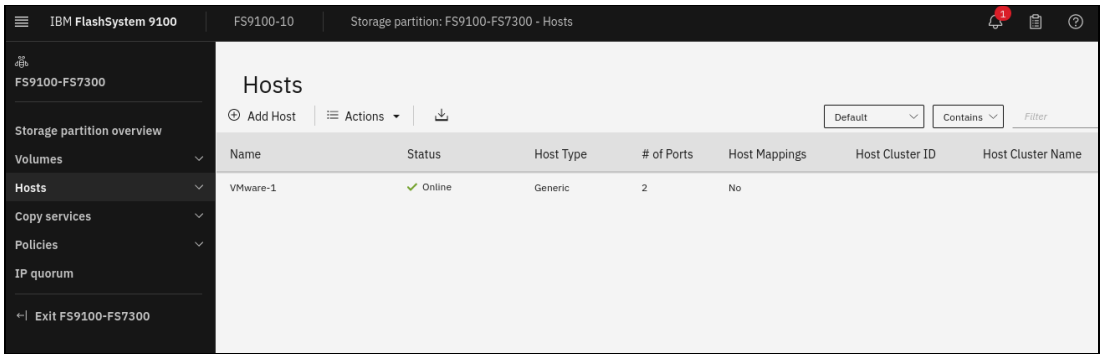

Figure 6-20 Host created

Mapping volumes to a host

After the host is created, define volume mappings.

1. From the Volumes menu, select the volumes that you are mapping to hosts and right-click.
2. Click **Map to Host or Host Cluster** as shown in Figure 6-21.

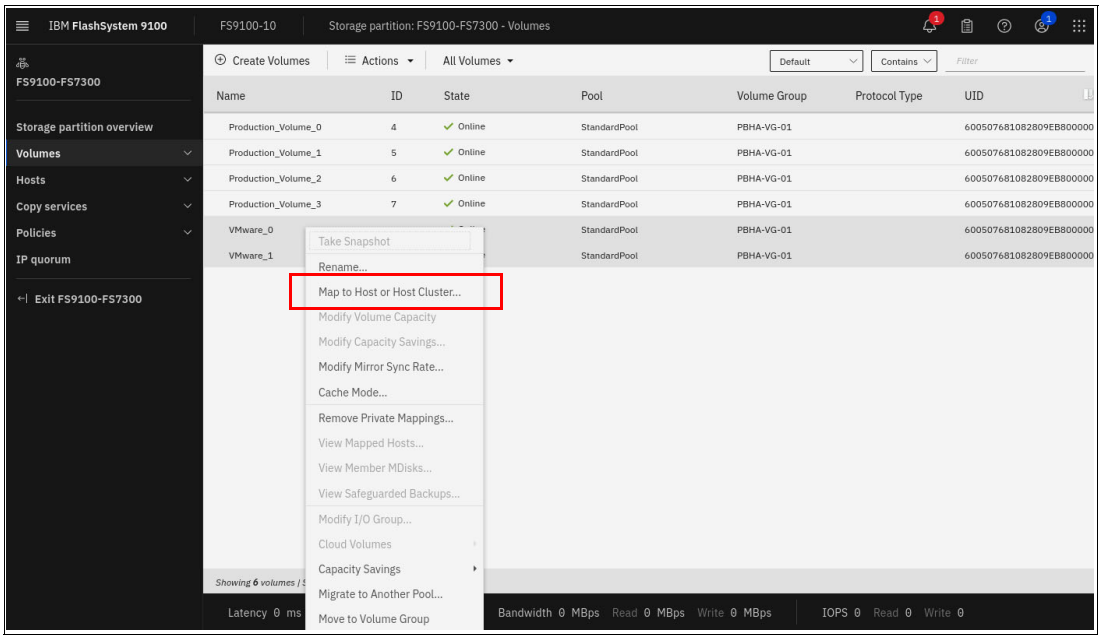

Figure 6-21 Create volume mappings to host

3. The Create mapping wizard opens. Select your preferred options and the host or host cluster to which you are mapping volumes and click **Next** as shown in Figure 6-22.

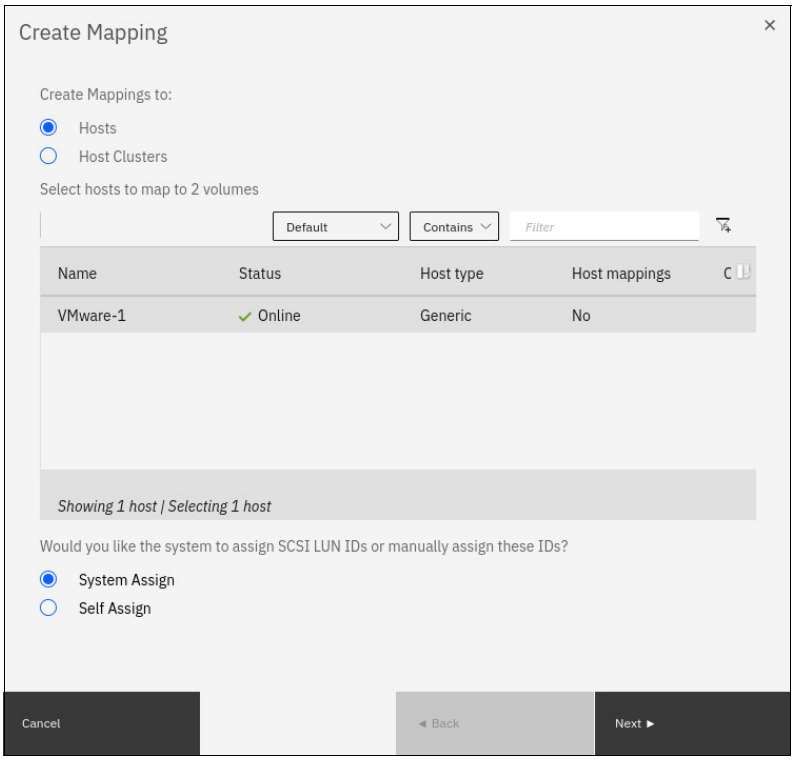

Figure 6-22 Create mapping wizard

4. Review the volumes to be mapped and click **Map Volumes** as shown in Figure 6-23.

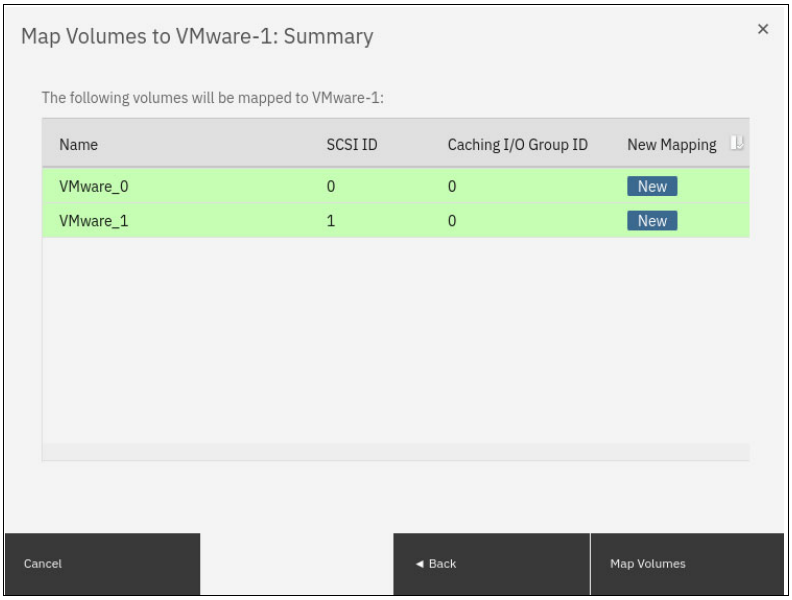

Figure 6-23 Select volumes to map

5. The Storage Partition overview page shows hosts online as shown in Figure 6-24

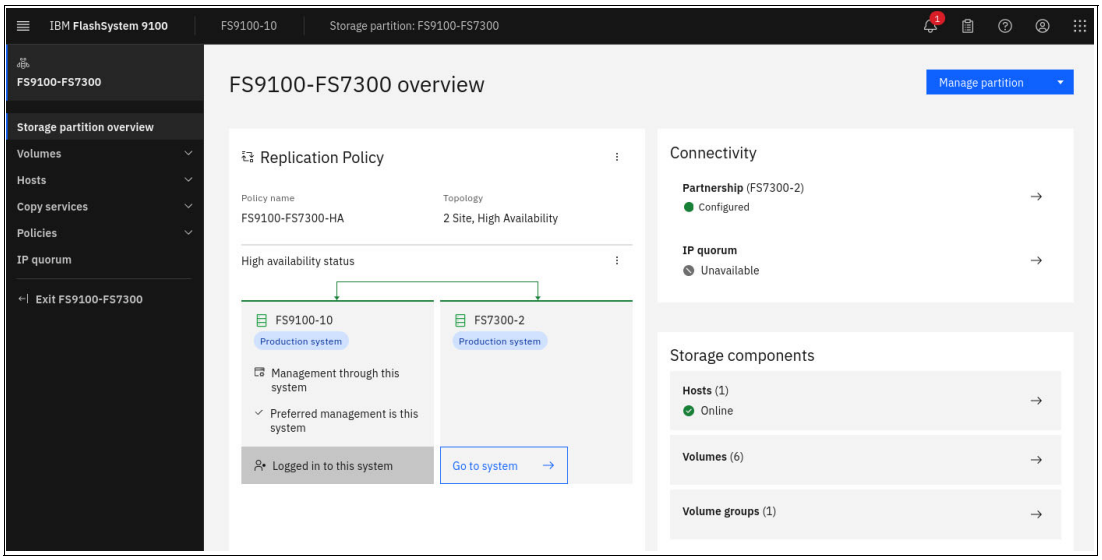

Figure 6-24 Storage Partition overview page

6.5 Migrating storage partitions between systems

IBM Storage Virtualize supports the non-disruptive migration of storage partitions between systems. This enables a partition to be migrated from one Storage Virtualize system to another without any application downtime. Migrating a storage partition requires both Fibre Channel and IP connectivity between the source and target storage systems.

Storage partitions bring a new level of flexibility to Storage Virtualize by enabling the migration of both the frontend and backend storage components. With a single command, you can migrate all underlying storage and associated hosts, volumes, and host-to-volume mappings to a new system.

This process involves updating storage paths for attached hosts. Fortunately, multipathing drivers handle this automatically and can provide a non-disruptive migration with no impact on applications or users. This can simplify the decommissioning of old equipment.

Note: Migrating storage partitions requires appropriate SAN-zoning between systems to be migrated.

Storage partition migration use cases

The following are examples of use cases of storage partition migration:

- Nondisruptive upgrade of system hardware from older systems to newer regardless of model. For example, upgrading from FS5200 to FS7300.
- Balancing the load by migrating storage partitions from overloaded systems to other systems.

Migration process overview

Migrating a storage partition is a two-step process:

1. Exchange certificates between the two systems and create storage pool links
2. Run a single command to change the partition to the new system.

The CLI **`svctask chpartition`** command is the sole CLI-command that is used to start a migration. This helps to make the migration simpler and more direct.

Storage Virtualize provides event-driven confirmation steps when user validation is needed during migration. These events are provided on the migration source and on the migration target system during the migration process and can includethe following examples:

- Check multipath on hosts before final path switch.
- Confirm deletion of original copy.

When data synchronization is complete, the hosts see a new set of paths to identical volumes on a different storage system.

CLI procedure to migrate storage partitions

Flash Grid is new in Storage Virtualize version 8.7.0. However, Storage Virtualize version 8.6.3 and later support storage partitions and migration of storage partitions.

For Storage Virtualize version 8.7.0, partitions can be migrated between systems that are members of the same Flash Grid, or can be migrated between systems that are not configured in a Flash Grid. Migration of storage partitions in 8.7.0 is supported only on systems that support Flash Grid.

Migration enables relocation of storage partitions from a source system to a different system location, and as a consequence, the following flow of events occurs:

- All the objects that are associated with the storage partition are moved to the migration target storage system.
- Host I/O is served from the migration target storage system after the migration is done.
- At the end of the migration process, the storage partition and all of its objects are removed from the source system.

Note: The initial release of Storage Virtualize 8.7 does not include Storage Partition Migration functionality within the graphical user interface (GUI). This feature is expected to be available in an update. You can still use CLI for migration tasks.

Prerequisites

Before you can use nondisruptive Storage Partition Migration function, ensure that the following prerequisites are met:

- Review the HA requirements to ensure that the storage partition supports migration and the host operating systems support this feature. For more information, see Planning high availability.
- Confirm that both systems are members of the same Flash Grid, or that neither system is a member of a Flash Grid, and that both systems meet the requirements for Flash Grid.
- Use the **`lspartnershipcandidate`** command and make sure that both source and target systems are correctly zoned and are visible to each other. For more information, see lspartnershipcandidate.

- SAN-zoning requirements are the same as for HyperSwap configurations, which require dedicated ISL-connections for public traffic, which provides hosts communication, and for private traffic, which provides node-to-node communication.
- Although the systems are visible to each other, a partner system can have multiple storage pools that can host the migrated storage partition. In that case, establish suitable storage pools between systems on the source and target systems. For more information, see chmdisk.
- Use the **lspartnership** command to verify that the source and a system are already in partnership. For more information, see lspartnership.
- Make sure that both systems have their certificates added to the truststore of each other, with the REST API usage enabled. For more information, see mktruststore.

Limits and restrictions

Refer to IBM Documentation for the current limits and restrictions for automated storage partition migrations.

Procedure

Perform the following steps:

1. Run the **chpartition** command with the **-location** option to migrate the storage partition to its required system location. For more information, see chpartition.
2. The following example initiates a migration of storage partition to the designated location system:

   ```
   chpartition -location <remote_system> mypartition1
   ```

3. To check the migration status, run the **lspartition** command. For more information, see lspartition.
4. After you successfully migrate the storage partition's data and configuration to the target system, an event is posted for the storage administrator. This event verifies that the affected hosts established new paths to the volumes on the target system. After you confirm this by fixing the event, host I/O operations for the storage partition automatically switch to using the paths on the target storage system. This event is raised and fixed at the source storage system.
5. To finalize the migration process, another event prompts the storage administrator to remove the copy of the data and configuration from the source storage system.

   Important: Before confirming this event by fixing it, it is crucial to verify the performance of the storage partition on the target system. This ensures a smooth transition and optimal performance after migration. This event is raised and fixed at the target storage system.

6. An informational event on the target storage system marks the completion of the storage partition migration.

You can monitor the progress of the migration, including the amount of data remaining to be copied by using the **lsvolumegreopureplication** command. For more information, see lsvolumegroupreplication.

You can monitor the migration by using the `migration_status` field that is shown by the **lspartition** command indicating that there is no migration activity active or queued for that storage partition. For more information, see lspartition.

Use the **chpartition** command to automate the procedure of migration of storage partitions. The command automates intermediate steps, such as setting up Fibre Channel partnerships between the systems. For more information, see chpartition.

An ongoing storage partition migration can be stopped by specifying a new migration location that uses the **-override** option. The migration to the new location is queued behind any existing queued migrations. For more information about the storage partition migration procedure, see Migrating storage partitions between systems.

7

Managing policy-based high availability

The contents of this chapter describe how to manage and monitor a policy-based HA environment.

The discussion includes an examination of a pre-existing policy-based HA configuration to gain insights into the available settings and current replication status. Also included is a discussion of common operations for volumes, hosts (including optimized data path management for long distances), and partition management. Various migration options are described, such as migrating existing data to a policy-based HA environment or migrating policy-based HA protected data to a different storage system. Another topic includes the considerations for snapshots within a policy-based HA environment.

This chapter has the following sections:

7.1 Evaluating the status of policy-based HA

To gain a preliminary understanding of which policy-based replication services are configured on your system, you can use either the GUI or CLI interface. Both options are presented in this section.

7.1.1 Evaluating the environment by using the GUI

Replication partnerships define the relationships between this storage system and others. To view these partnerships, navigate to **Copy Services** → **Partnerships** on the storage system. This displays all existing replication partnerships for this particular system. Figure 7-1 depicts a single configured partnership with an FS9100 system.

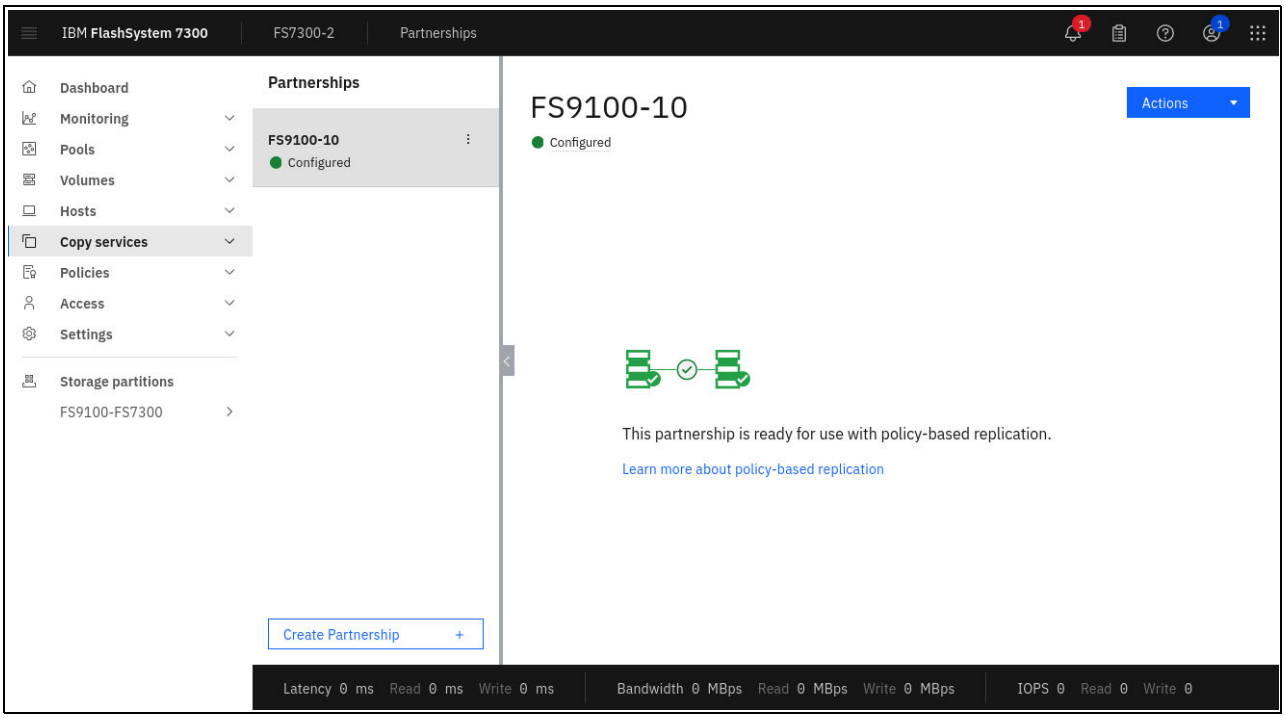

Figure 7-1 Replication partnership

Replication policies define replication details, including source and target system IDs, location names and IDs, RPO alerts (if any), IO group selections, and the replication topology.

These policies can be verified by opening **Policies** → **Replication Policies** as shown in Figure 7-2 on page 131.

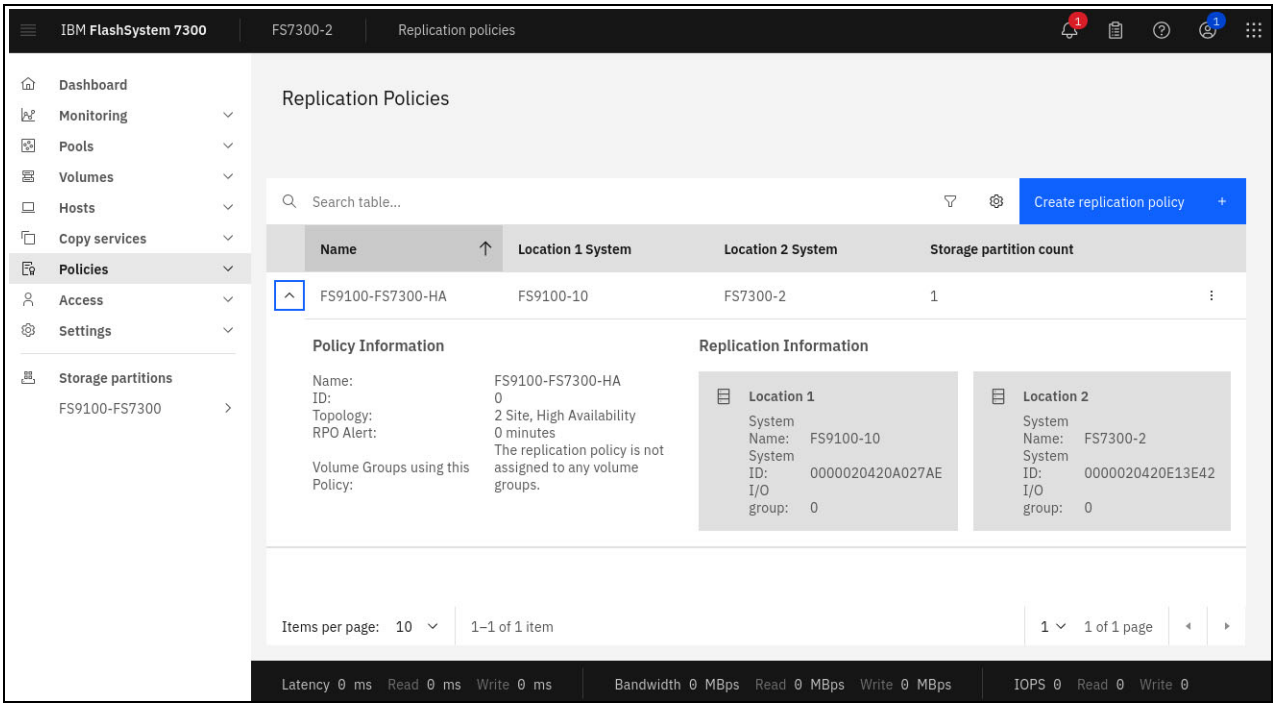

Figure 7-2 Replication policy for 2-site high availability (policy-based HA)

Partitions are used in policy-based HA to set a common management environment for hosts, volumes, volume groups, and related snapshots. Partitions are available under the **Storage partitions** menu item as shown in Figure 7-3.

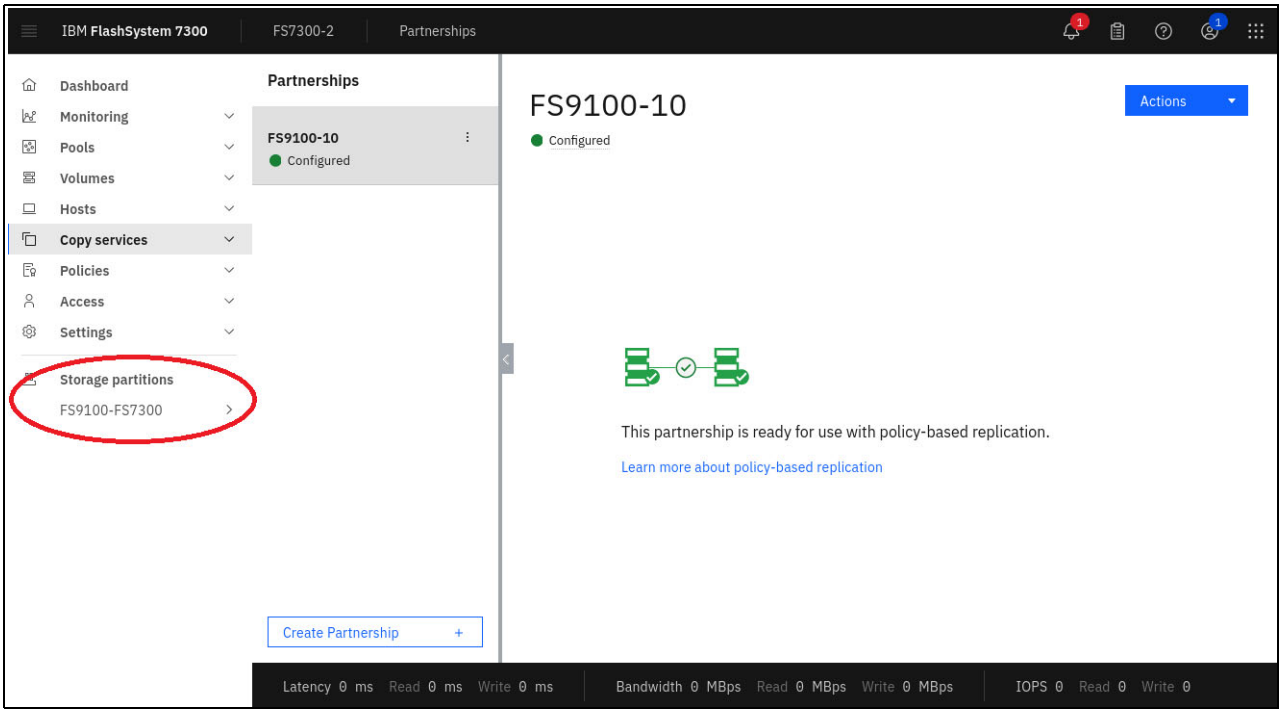

Figure 7-3 Configuration entry point for partitions

Partition details shown in Figure 1-4 on page 6 include the following information:

- Assigned replication policy
- Current replication status
- Active management system, which sets the current copy direction
- Hosts and volumes
- Quorum device status

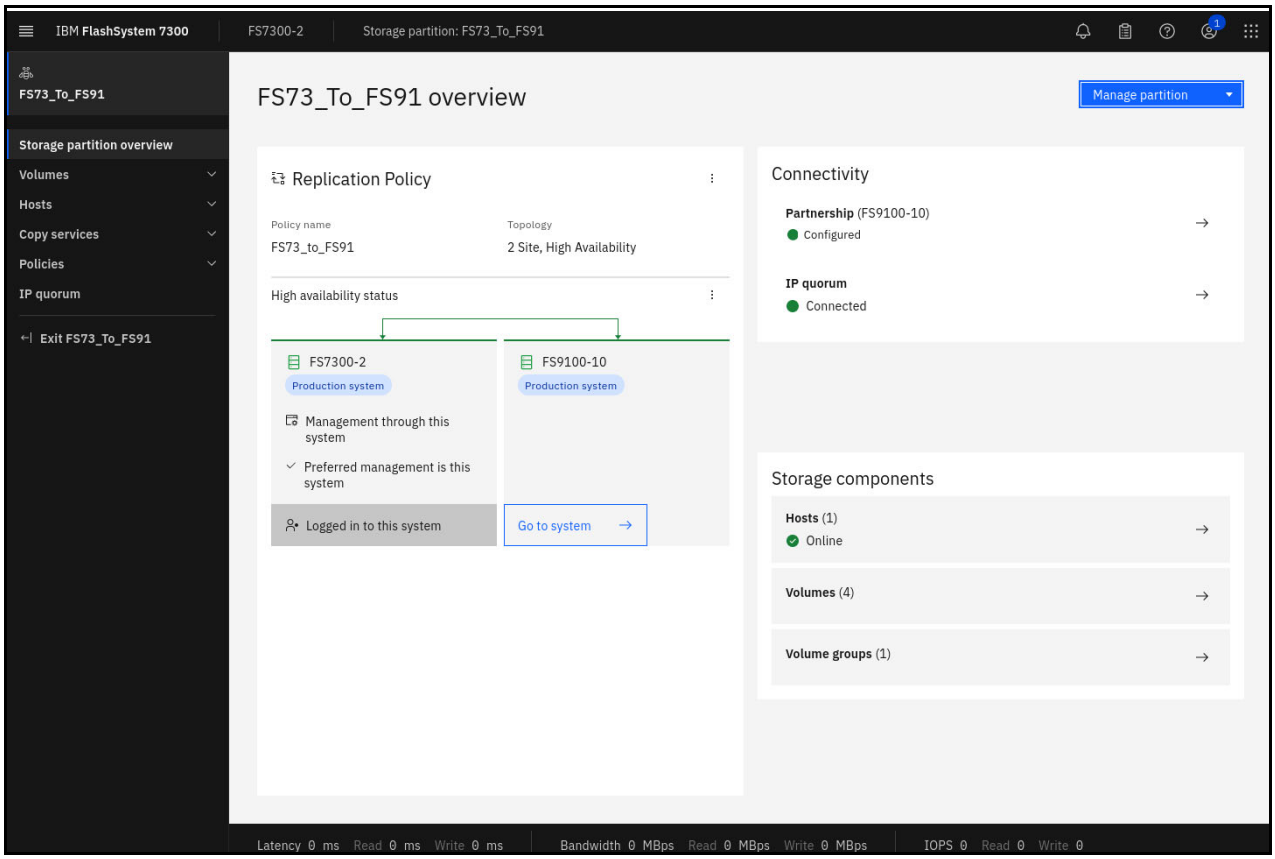

Figure 7-4 Partition configuration: Overview

For all partition configuration tasks, use the **Storage Partitions** menu item on the left panel.

7.1.2 Evaluate the current environment using CLI

Use the **lspartnership** command to determine the status of the partnership between the storage systems and verify that the partnership is fully configured as shown in Example 7-1.

Example 7-1 Verify remote copy partnerships

```
BM_FlashSystem:FS7300-2:Team4>lspartnership
id                 name      location partnership      type cluster_ip
event_log_sequence link1 link2 link1_ip_id link2_ip_id
0000020420E13E42 FS7300-2 local
0000020420A027AE FS9100-10 remote   fully_configured fc
```

All policy-based replication activities require a policy, which defines the general replication settings. Identify the existing policies and check for the number of partitions that are associated with each policy as shown in Example 7-2 on page 133.

Example 7-2 List available replication policies

```
IBM_FlashSystem:FS7300-2:Team4>lsreplicationpolicy
id name         rpo_alert topology volume_group_count location1_system_name
location1_iogrp_id location2_system_name location2_iogrp_id partition_count
0  FS73_to_FS91 0       2-site-ha 0              FS7300-2           0
FS9100-10             0                  1
```

The definition for source and target systems, the topology, and the number of partitions that use this policy are shown in the policy details in Example 7-3.

Example 7-3 Replication policy in detail

```
IBM_FlashSystem:FS7300-2:Team4>lsreplicationpolicy 0
id 0
name FS73_to_FS91
rpo_alert 0
topology 2-site-ha
volume_group_count 0
location1_system_id 0000020420E13E42
location1_system_name FS7300-2
location1_iogrp_id 0
location2_system_id 0000020420A027AE
location2_system_name FS9100-10
location2_iogrp_id 0
partition_count 1
IBM_FlashSystem:FS7300-2:Team4>
```

The partitions are managed by the policies. To verify this, check the policies used and the status of the partitions as shown in Example 7-4. Note the setting for the active management system. This system coordinates policy-based HA replication within the partition. In Example 7-4, the FS7300-2 is the active management system.

Example 7-4 List of partition and one partition in detail

```
IBM_FlashSystem:FS7300-2:Team4>lspartition
id name            preferred_management_system_name active_management_system_name
replication_policy_id replication_policy_name location1_system_name
location1_status location2_system_name location2_status host_count
volume_group_count ha_status   link_status  desired_location_system_name
migration_status draft draft_volume_group_count draft_host_count uuid
0  FS73_To_FS91     FS7300-2                          FS7300-2
0                    FS73_to_FS91           FS7300-2             healthy
FS9100-10             healthy          1          1                  established
synchronized                                        no    0
0                476A7EFA-25B1-573E-92F0-5A01FD73841F
1 Non-HA_Partition
1        1
no    0                         0
D6C0672B-4141-5CC9-B9E3-A443A17D8E74
IBM_FlashSystem:FS7300-2:Team4>lspartition 0
id 0
name FS73_To_FS91
preferred_management_system_id 0000020420E13E42
preferred_management_system_name FS7300-2
active_management_system_id 0000020420E13E42
```

```
active_management_system_name FS7300-2
replication_policy_id 0
replication_policy_name FS73_to_FS91
location1_system_id 0000020420E13E42
location1_system_name FS7300-2
location1_status healthy
location2_system_id 0000020420A027AE
location2_system_name FS9100-10
location2_status healthy
host_count 1
host_offline_count 0
volume_group_count 1
volume_group_synchronized_count 1
volume_group_synchronizing_count 0
volume_group_stopped_count 0
ha_status established
link_status synchronized
desired_location_system_id
desired_location_system_name
migration_status
draft no
draft_volume_group_count 0
draft_host_count 0
location1_total_object_count 6
location2_total_object_count 6
merge_target_partition_id
merge_source_partition_id
uuid 476A7EFA-25B1-573E-92F0-5A01FD73841F
user_action_sequence_number
user_action_type
IBM_FlashSystem:FS7300-2:Team4>
```

Optimized data path management for long distances relies on host location settings. If host locations are not defined, the replication is originated from the system that receives the write from the host, and all host traffic (read and write) is managed by the active management system. In this scenario, the copy source volumes reside at the same site as the active management system. As shown in Example 7-5, the FS7300-2 is the default access point for all hosts without a location setting within this partition.

Example 7-5 Partition: Identification of active management system

```
IBM_FlashSystem:FS7300-2:Team4>lspartition 0 | grep active_management
active_management_system_id 0000020420E13E42
active_management_system_name FS7300-2
IBM_FlashSystem:FS7300-2:Team4>
```

Changing the active management system immediately reverses the copy direction between the storage systems and designates the new system as the default storage system for host access, as illustrated in Example 7-6.

Example 7-6 Partition: Change active management system

```
IBM_FlashSystem:FS7300-2:Team4>chpartition -preferredmanagementsystem FS9100-10 0
IBM_FlashSystem:FS7300-2:Team4>lspartition 0 | grep active_management
active_management_system_id 0000020420A027AE
active_management_system_name FS9100-10
```

```
IBM_FlashSystem:FS7300-2:Team4>
```

Policy-based HA configurations use optimized data paths through host-level location settings. In the absence of a location setting, a host always accesses the active management system for this partition, regardless of its physical location, for all read and write I/O. Changing the active management system impacts both the copy direction for all partition volumes and the default access point for hosts without a location setting. Public ISLs are used for this redirected traffic.

With a defined host location, read and write I/O are performed, when possible, directly with the storage system assigned to the defined location. Local reads and writes are performed directly with the assigned storage and data is asynchronously replicated to the remote site. The active management system ensures data consistency by acknowledging both copies. This approach minimizes data traffic by eliminating unnecessary network transfers and uses the private ISL for efficient replication.

Use the **lshost** command to list the host configuration and the location parameter as shown in Example 7-7.

Example 7-7 Identify the storage location and verify the host location

```
IBM_FlashSystem:FS9100-10:Team4>lshost
id name    port_count iogrp_count status site_id site_name host_cluster_id
host_cluster_name protocol owner_id owner_name portset_id portset_name
partition_id partition_name draft_partition_id draft_partition_name
ungrouped_volume_mapping location_system_name
0  PB_HA_1 1         4          online
scsi               64     portset64  0       FS9100-FS7300
no                        FS9100-10
1  PB_HA_2 1         4          online
scsi               64     portset64  0       FS9100-FS7300
no                        FS7300-2
IBM_FlashSystem:FS9100-10:Team4>lshost 0 | grep location
location_system_name FS9100-10
IBM_FlashSystem:FS9100-10:Team4>
```

7.2 Volume management

This section describes how to manage volumes.

7.2.1 Create a new volume in a partition

You can create new, empty volumes within a partition. The system automatically creates corresponding policy-based HA volumes at the remote site, including all host assignments. Create a new volume with the following steps:

1. Within your partition, select **Volumes** → **Volumes**.
2. Click the **Create Volumes** button.
3. Use the wizard to create one or multiple volumes according to your needs. Be sure to select the appropriate volume group.
4. In a second step, assign the host mapping for your newly created volumes.

The same steps are also available in the CLI. In Example 7-8, a single new volume is created and assigned to the appropriate volume group.

Example 7-8 Create new policy-based HA volume

```
IBM_2145:SVC_SA2:superuser>svctask mkvolume -name PB_HA_Add_12 -pool 0 -size
42949672960 -unit b -volumegroup 0
```

As previously discussed, you must assign the new volume to both appropriate hosts. See Example 7-9.

Example 7-9 Assign policy-based HA volume to both hosts

```
IBM_2145:SVC_SA2:superuser>svctask mkvdiskhostmap -force -host 2 4
IBM_2145:SVC_SA2:superuser>svctask mkvdiskhostmap -force -host 3 4
```

7.2.2 Delete a volume in a partition

Deleting a policy-based HA volume permanently removes the volume definition and all associated data on both storage systems. This action also removes any host mappings that are assigned to the volume. The process for deleting a policy-based HA volume is similar to deleting a traditional volume within the partition as shown in Figure 7-5.

Note: A volume deletion for a volume with active snapshots is not physically removed from the storage system if a dependent snapshot exists.

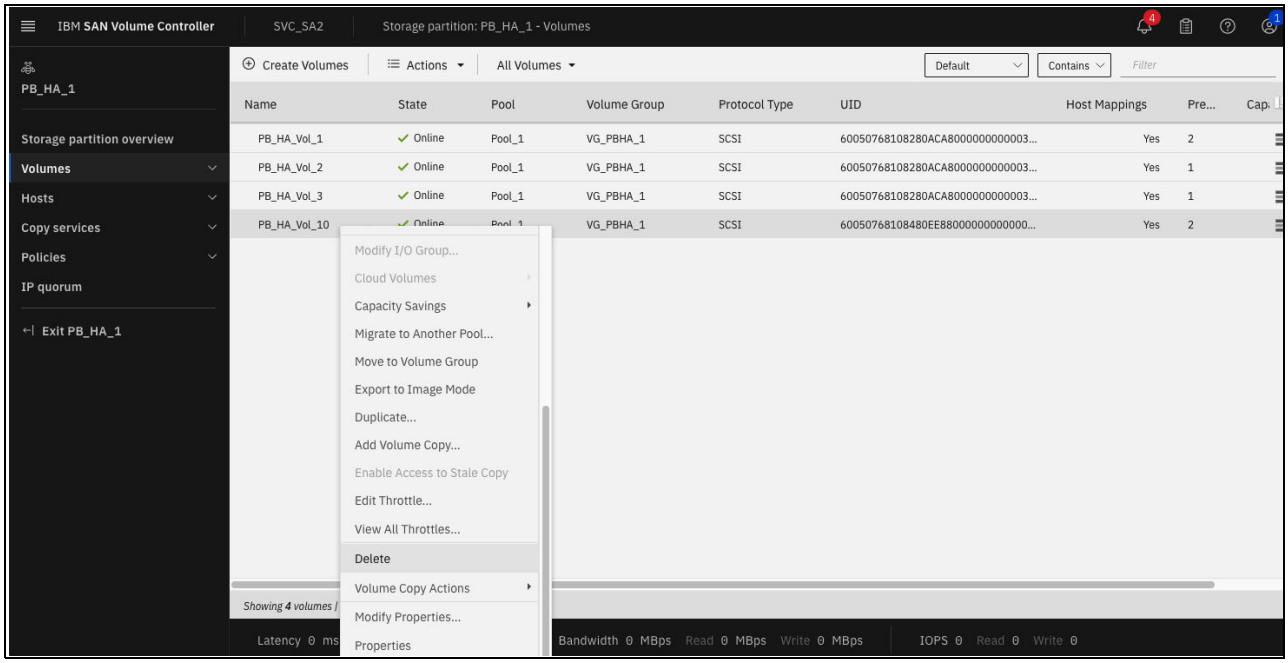

Figure 7-5 Delete a policy-based HA volume

Follow the deletion process and select the removal although there are already host assignments in place as shown in Figure 7-6 on page 137.

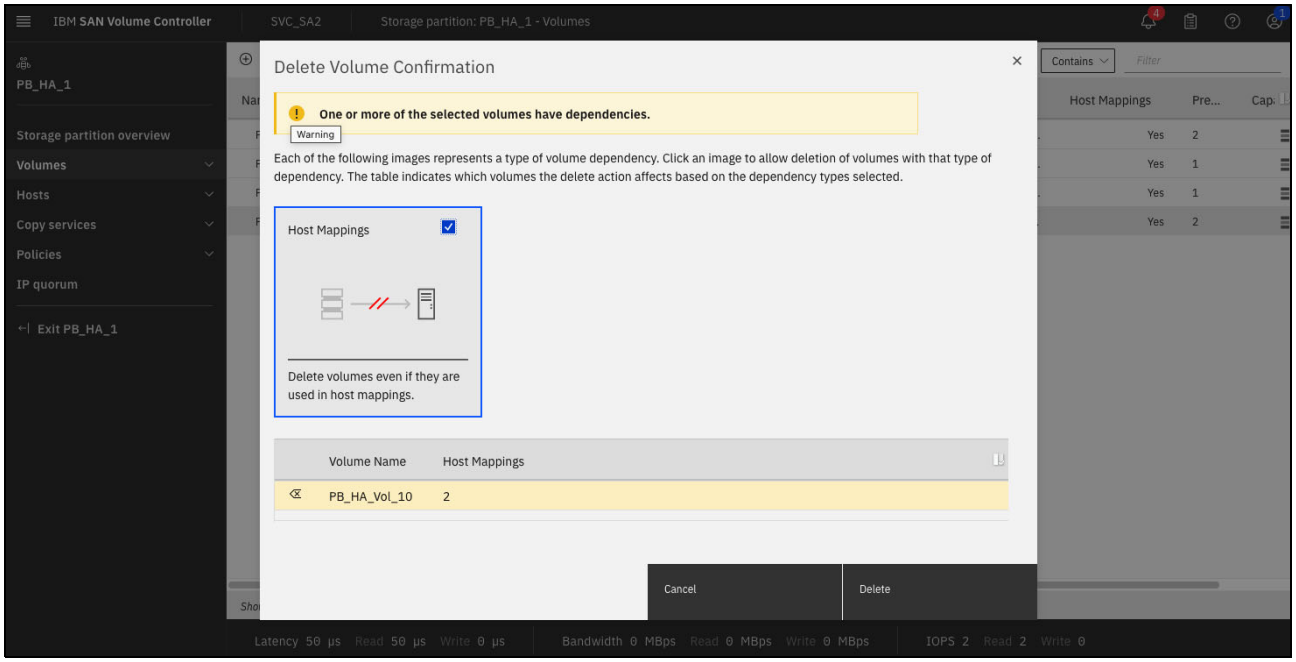

Figure 7-6 Delete a policy-based HA volume and confirm host mapping removal

The volume and data deletion and the host unassignment are run on both storage systems without additional checks.

You can also use the CLI to delete the volume as shown in Example 7-10.

Example 7-10 Policy-based HA volume deletion

```
IBM_2145:SVC_SA2:superuser>lsvdisk | grep VG_PBHA_Add
0  PB_HA_Vol_10 0           io_grp0       online   0           Pool_1
40.00GB  striped many  many              60050768108480EE8800000000000028 2
...
4  PB_HA_Vol_12 0           io_grp0       online   0           Pool_1
40.00GB  striped many  many              60050768108480EE8800000000000033 2
1         not_empty       1           no       0                  0
Pool_1                                    no         no      4
PB_HA_Vol_12      0         VG_PBHA_Add     scsi   no      0
no                        0                          no
IBM_2145:SVC_SA2:superuser>rmvolume -removehostmappings 4
```

The single command successfully removed all host definitions, all host mappings, and all data for this volume at both sites.

7.2.3 Add data volumes to a partition and merge partitions

Adding volumes with existing data to an already existing partition is a multi-step approach. The process is supported by a GUI wizard, which can make it easier to perform the initial process.

Note: It is important that the volumes to be added must first be migrated to a temporary partition with identical properties as the target partition. This helps to ensure a smooth merge by using the partition merging feature.

The existing volumes must be summarized in a temporary partition by using the same properties as the existing partition. The partition merge combines volume groups and hosts from both partitions into a single entity. Importantly, existing volumes, their assignments within volume groups, host definitions, and host-volume access remain unchanged during the merge process.

There are multiple prerequisites:

- The appropriate zoning must be configured correctly for both partitions.
- Volume and host names can be used in only one partition.

In this example, only the GUI method is used because the GUI significantly simplifies the overall process.

The existing partition is a single policy-based HA partition with three volumes and two hosts as shown in Figure 7-7. All data is replicated to the remote site.

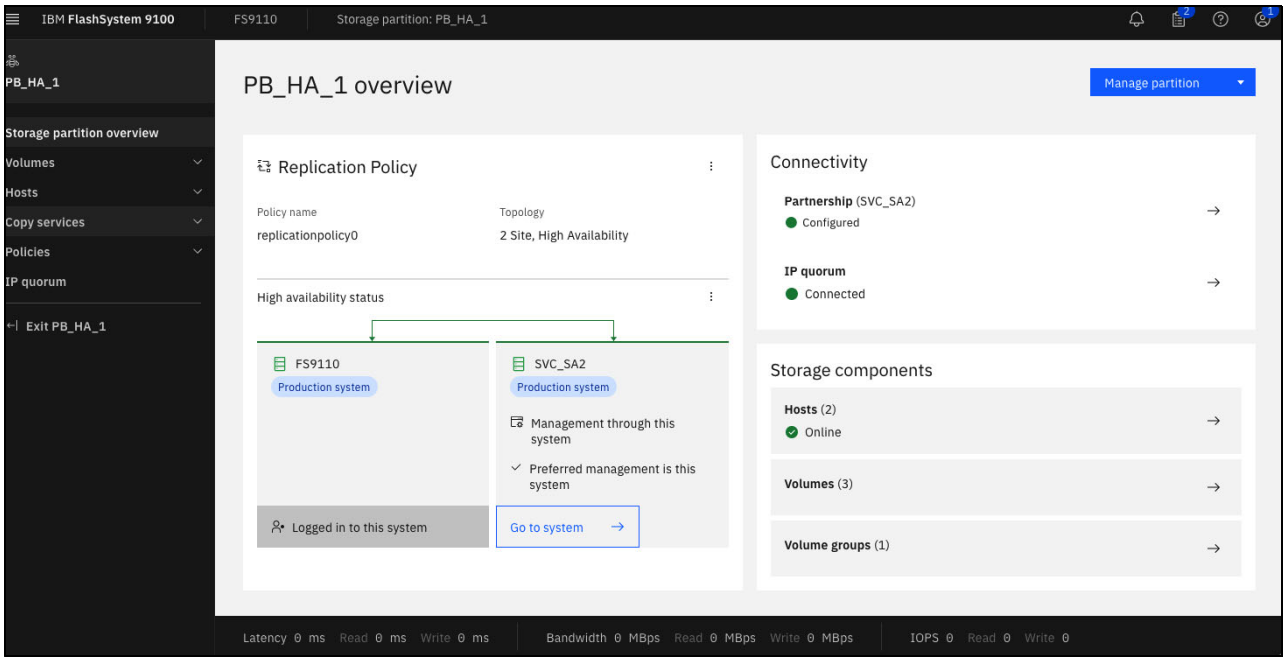

Figure 7-7 Original storage partition, replicated to the remote site

There are three active volumes, already replicated to the remote site as shown in Figure 7-8 on page 139.

The following example describes how to add two existing volumes with data to the existing policy-based HA partition named `PB_HA_1` and includes the following steps:

- Volume group preparation to create a new, common volume group for the two existing volumes
- Temporary partition creation to establish a new partition and assign the newly created volume group during this process.

Creating the temporary partition

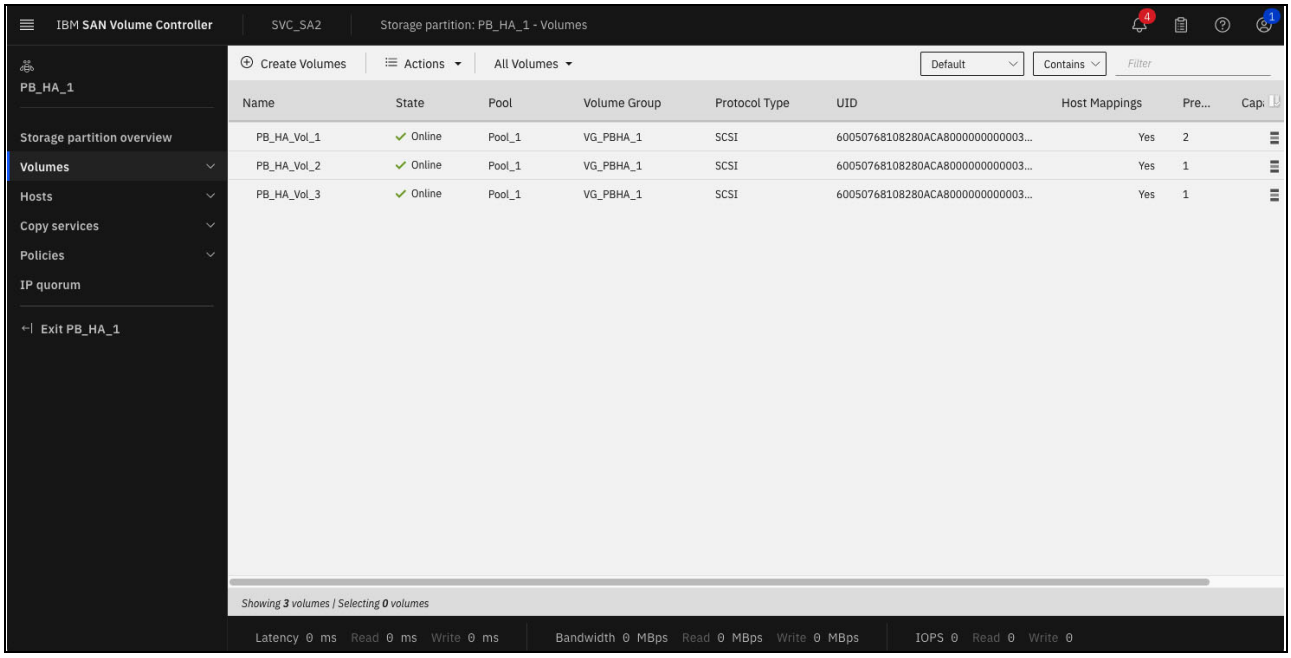

Figure 7-8 Check current policy-based HA volume status

See Figure 7-9 for a visual guide to create a new storage partition

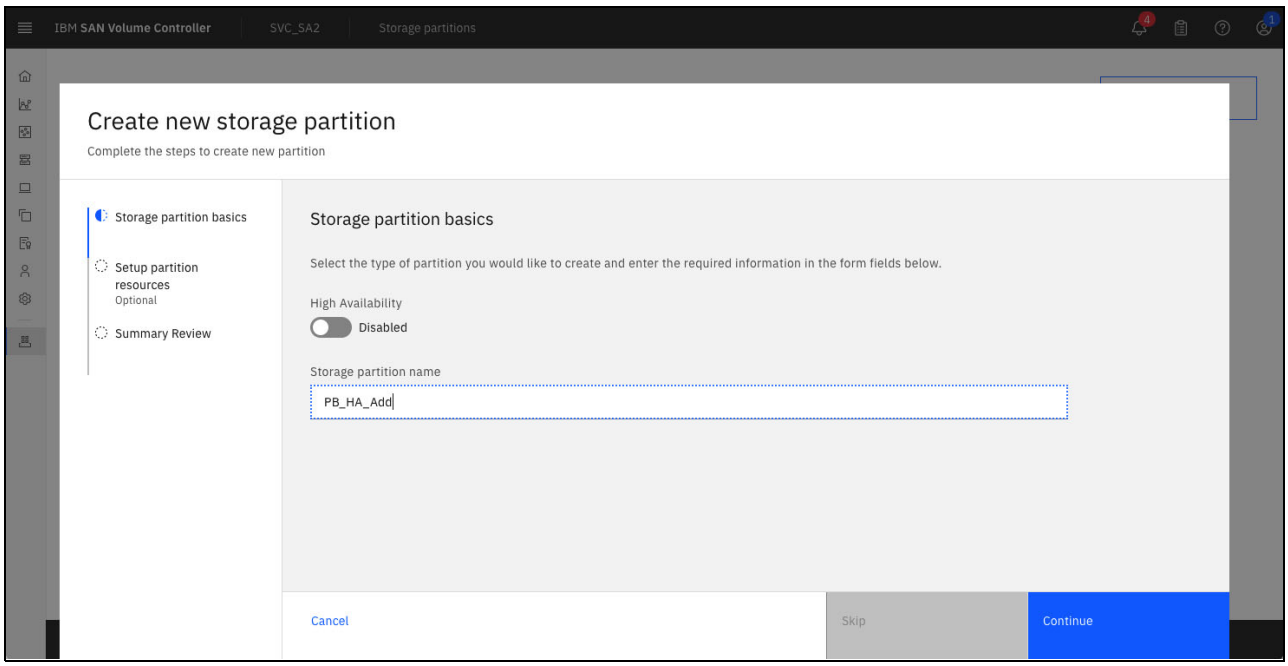

Figure 7-9 Create a new storage partition

To create a new storage part

1. Click **Select existing volume groups** as shown in Figure 7-10 on page 140.
2. Click **Continue**.

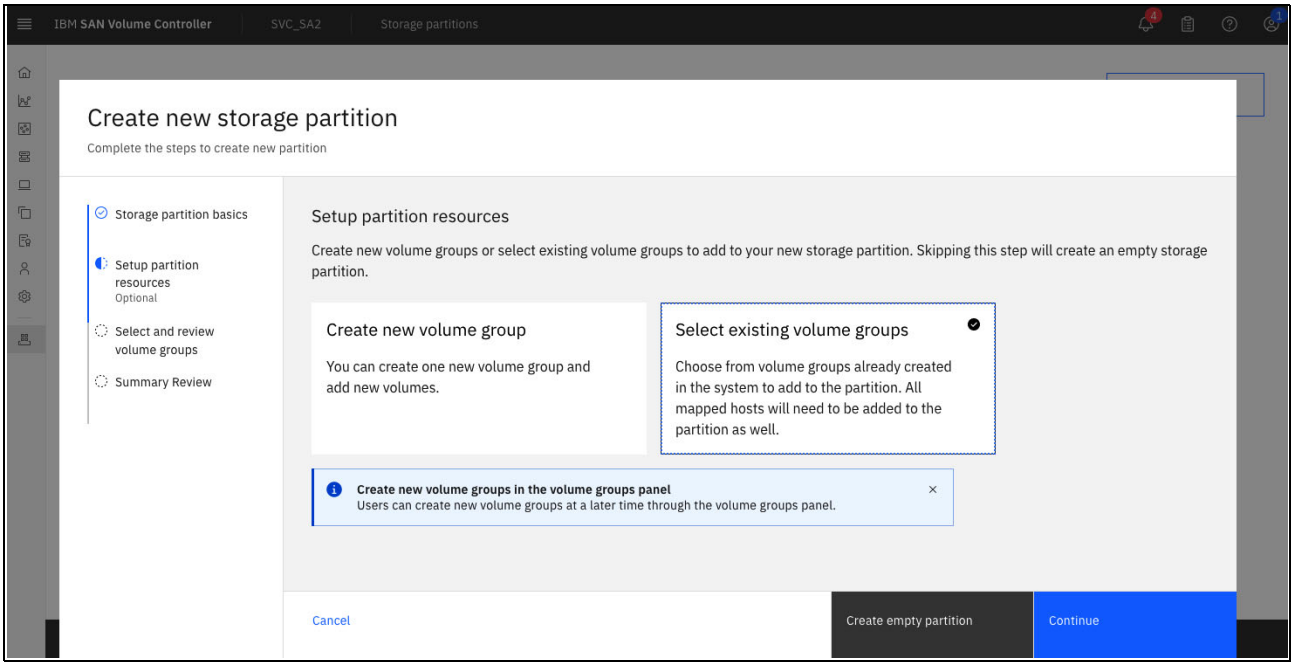

Figure 7-10 Create new storage partition and select volume group

3. Click **Select volume groups** as shown in Figure 7-11 and click **Continue**.

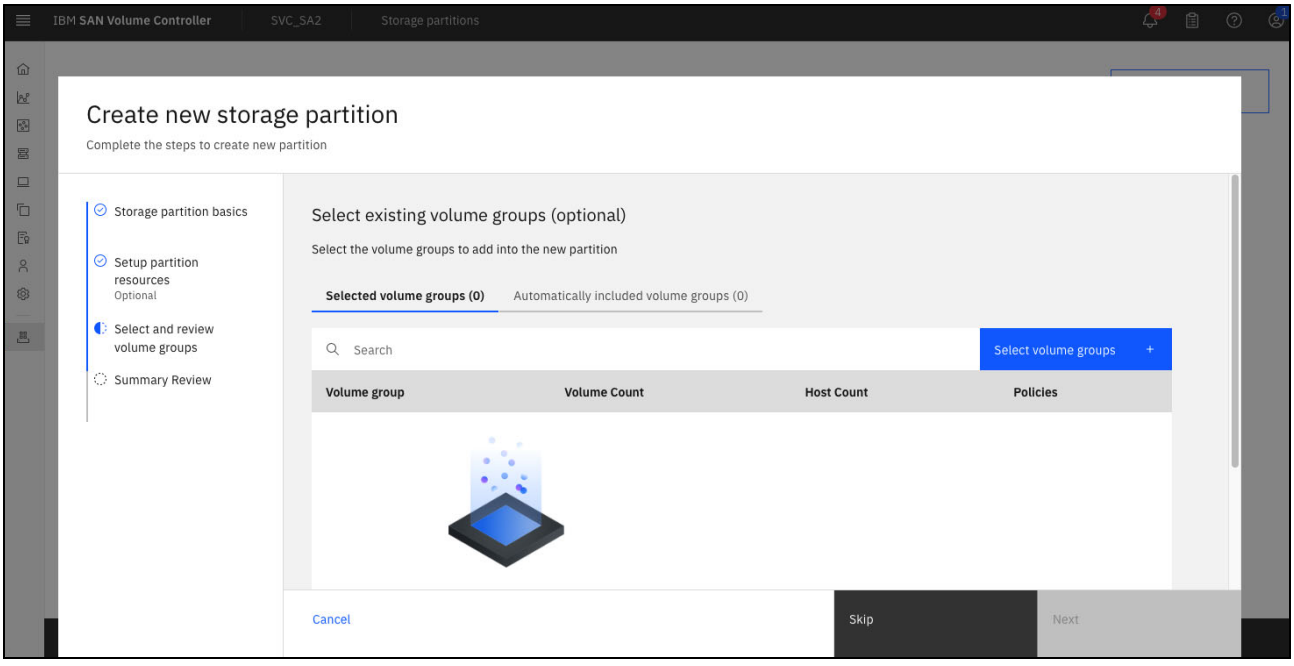

Figure 7-11 Create a new storage partition and select volume group

4. Select the appropriate volume group or groups as shown in Figure 7-12 on page 141 and follow the prompts provided by the GUI wizard.

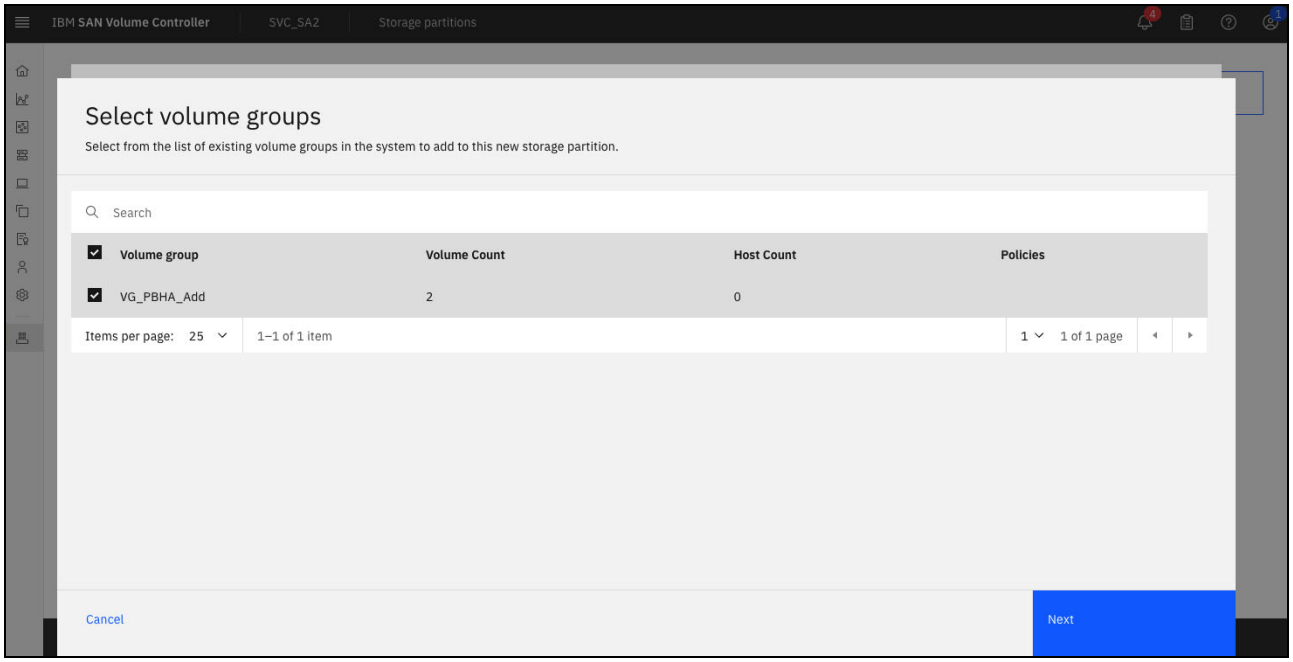

Figure 7-12 Create a new storage partition and select volume group finish

5. The new partition has two volumes and two hosts as shown in Figure 7-13.

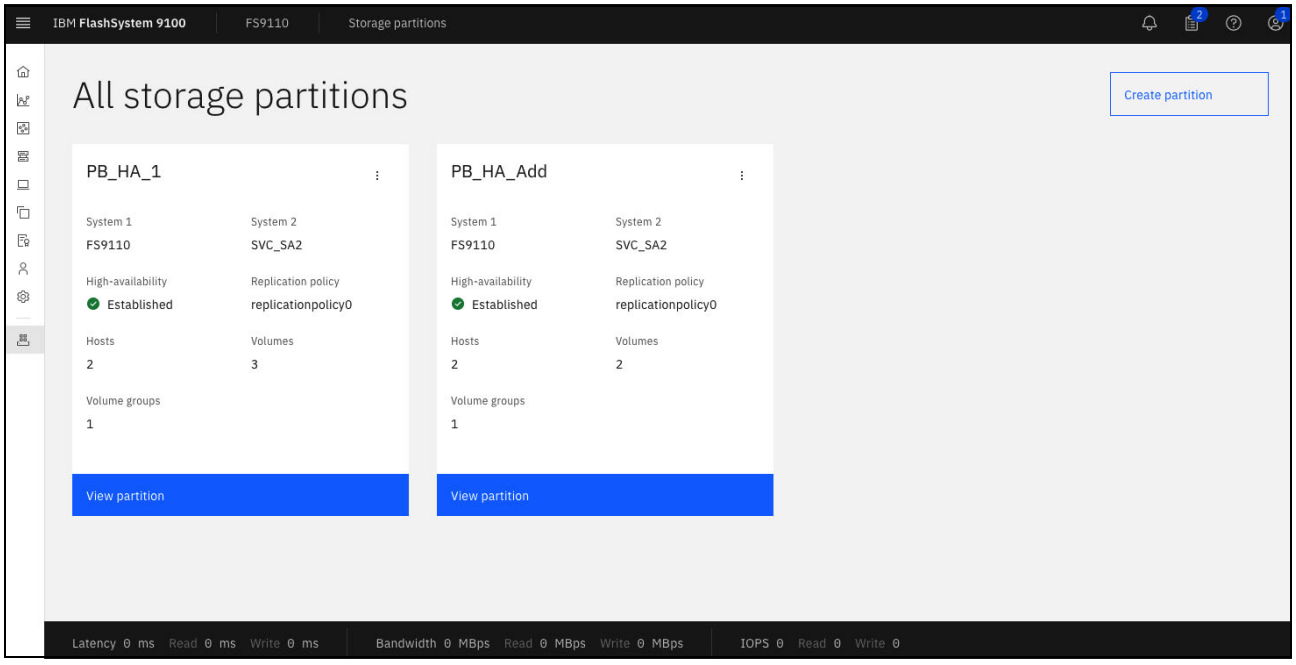

Figure 7-13 Check all storage partitions

The data volume is now managed by the newly created partition. To merge the two partitions, both partitions must have the same properties. The original partition is running a 2-site high available configuration, but the newly created partition is running without the additional 2-site protection. Assigning the appropriate policy-based HA policy eliminates this difference and automatically creates the required volume copies on the recovery site.

6. Open the newly created partition and click **Select high availability replication** as shown in Figure 7-14.

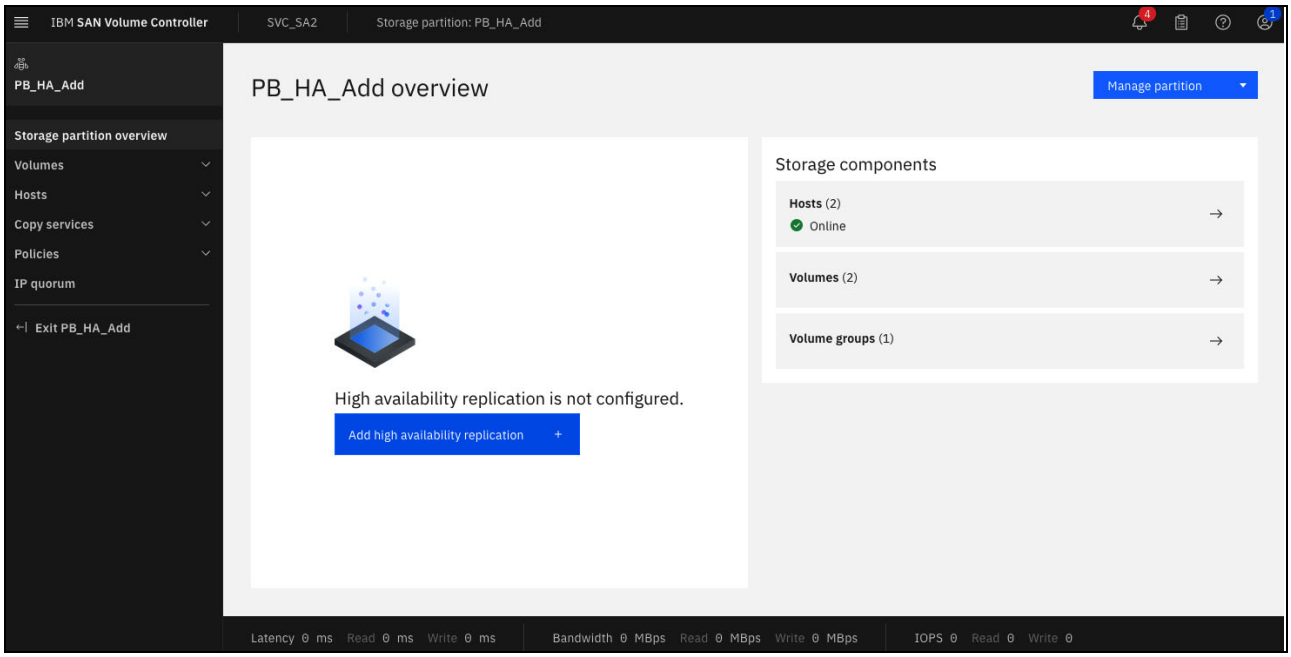

Figure 7-14 Partition: Check for details for the new partition

7. Follow the process and select the appropriate policy, set your preferred management system, and download the IP Quorum application (if not already done), link the pools. As shown in Figure 7-15, select the appropriate replication policy to activate the configured settings.

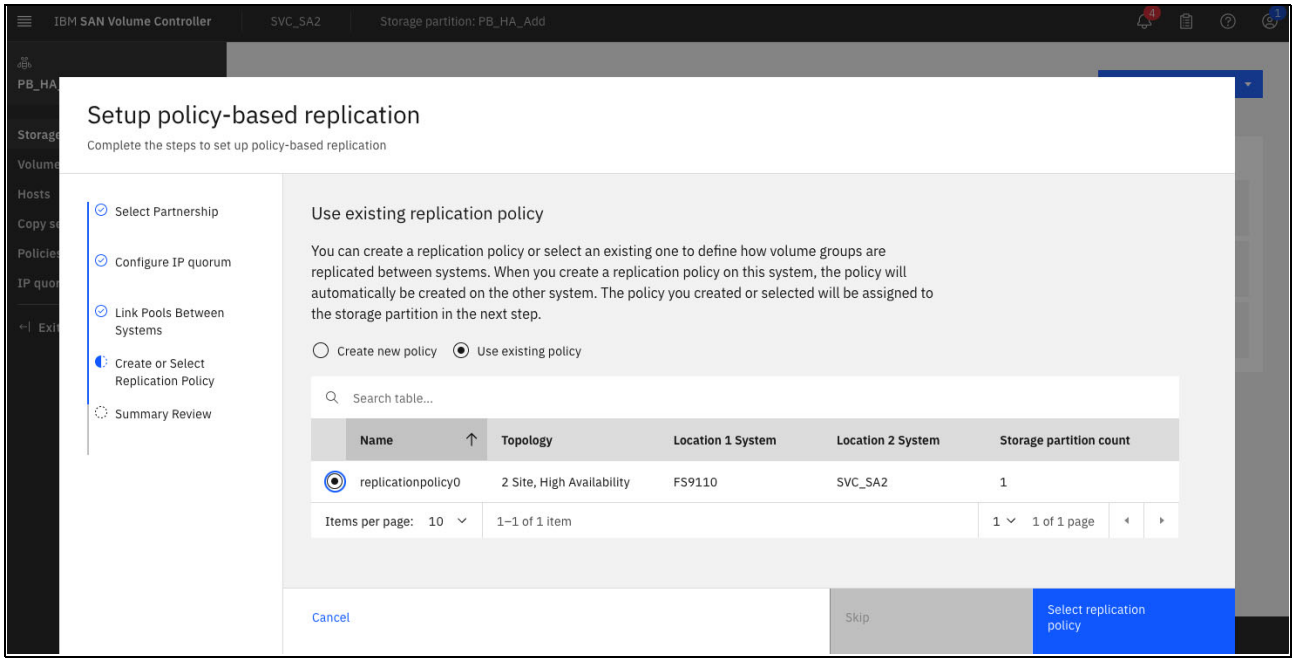

Figure 7-15 Partition: Select replication policy

8. Finalize the wizard and verify the new settings as shown in Figure 7-16.

Note: The configuration must be identical for both partitions.

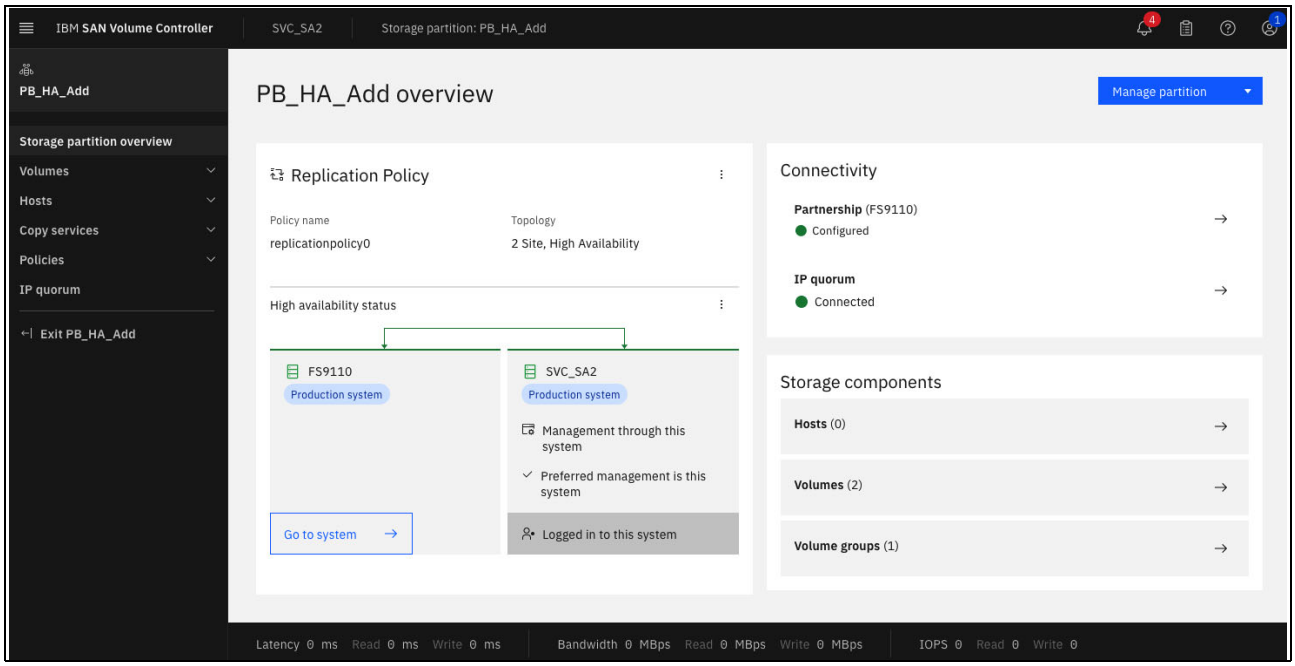

Figure 7-16 Partition: Review and finalize partition changes

Merging the two partitions

1. Because both partitions are identical, you can initiate the partition merge. On the storage partition to be merged, in this example “PB_HA_Add”, click the **Manage partition** button and select **Merge partition**, as shown in Figure 7-17.

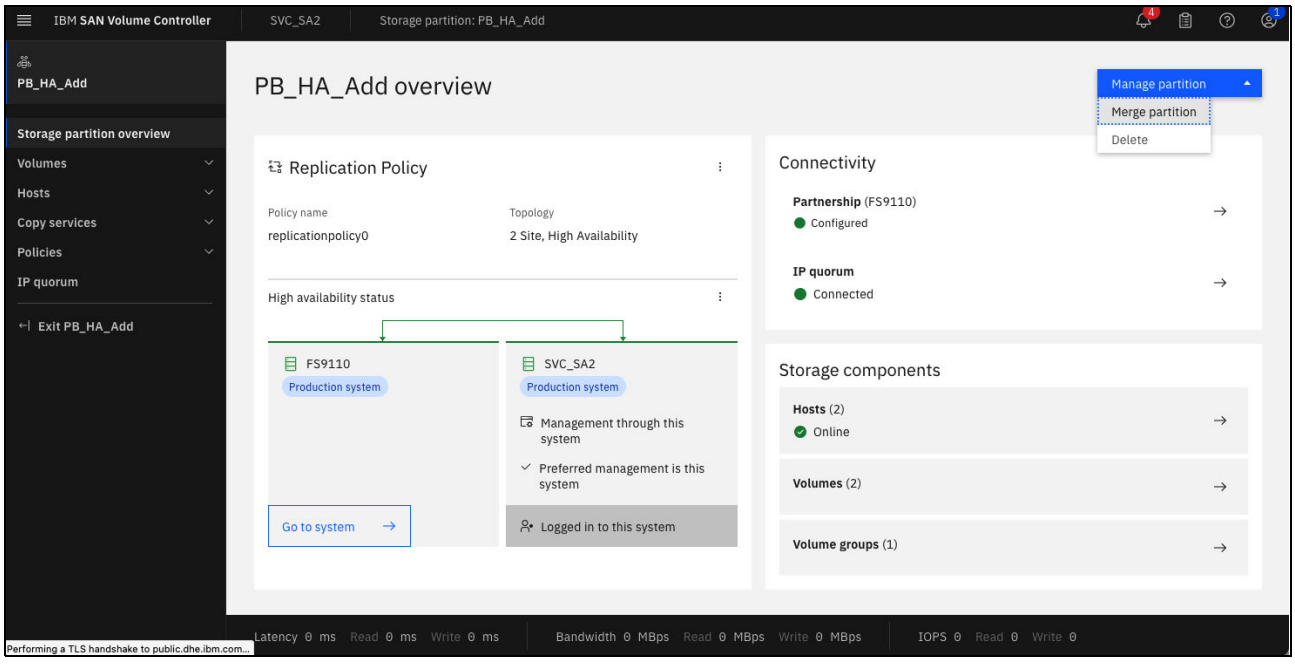

Figure 7-17 Start partition merge process

2. Follow the process and select the target partition as shown in Figure 7-18.

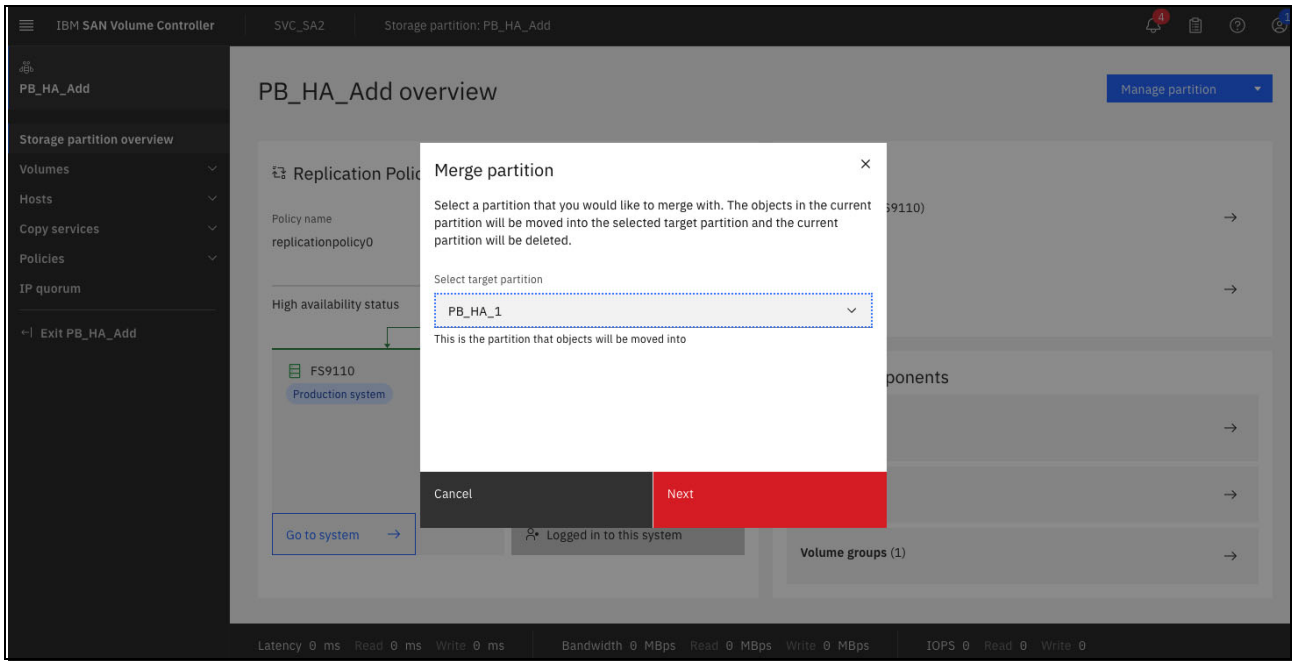

Figure 7-18 Set options for partition merge

3. Review the Merge configuration, as shown in Figure 7-19, to make sure that the configuration meets your requirements.

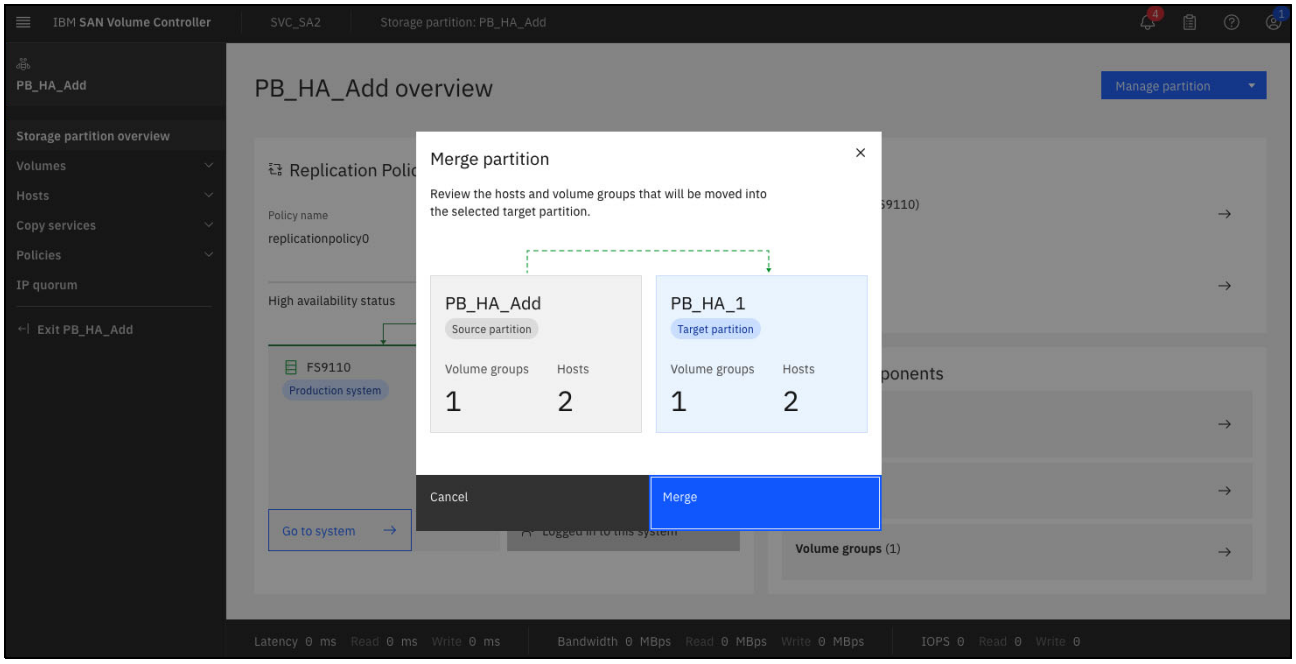

Figure 7-19 Review the partition merge settings and start the merge process

4. Verify the new configuration. The partition now manages five volumes, four hosts. All volumes and hosts are available at both sites as shown in Figure 7-20 on page 145.

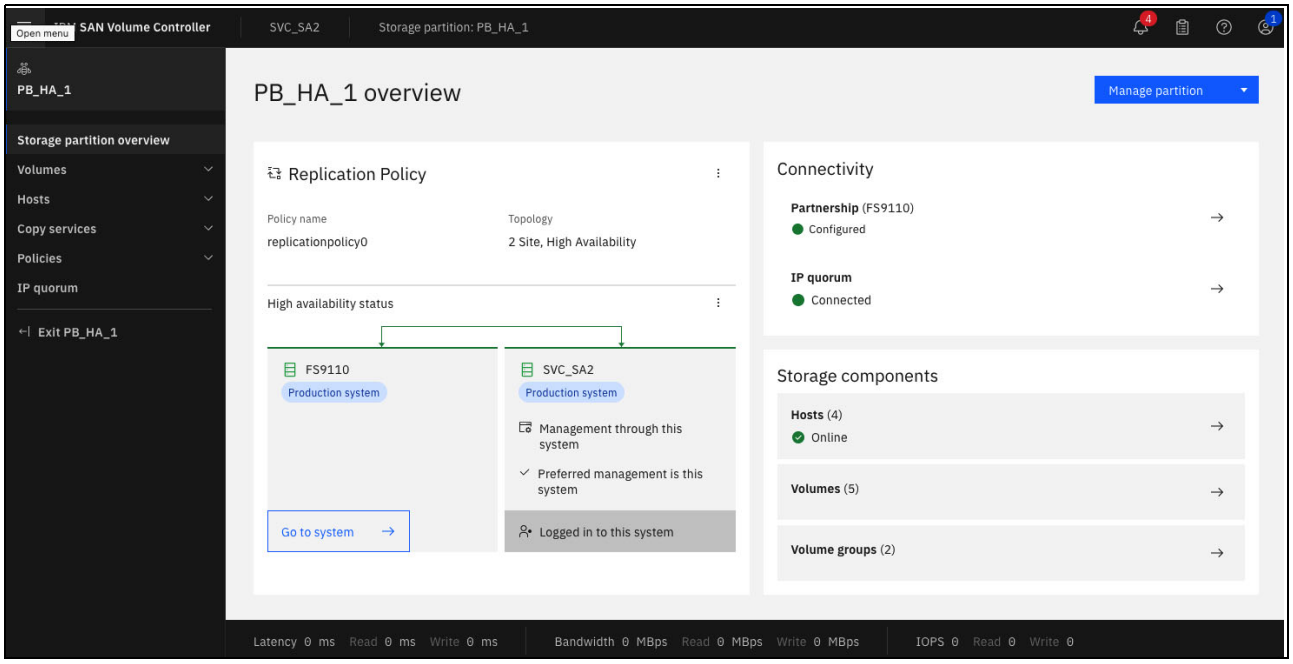

Figure 7-20 Verify the partition after merge

5. Verify the details such as volume or host settings as shown in Figure 7-21.

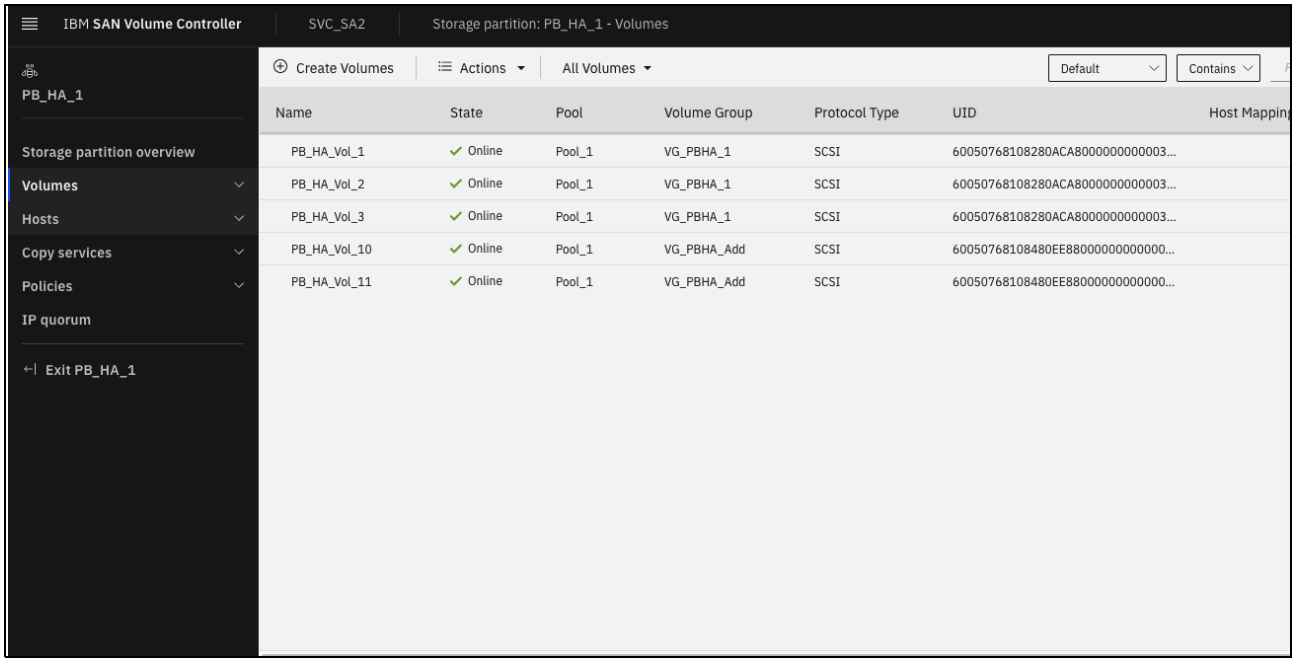

Figure 7-21 Check for policy-based HA volumes in detail after the merge

Two existing volumes are assigned to an existing policy-based HA partition by using the merge process. The system automatically created the required host definitions and volumes at the target site. It merged all volumes, volume groups, and hosts from two independent partitions in a single partition.

7.3 Host management

The appropriate host configuration might have an impact on the overall performance because it defines the data path usage between both sites. If the host location is not defined, the host uses the active management system for this partition for read and write access.

Setting the host location parameter to the local storage system optimizes the data flow and ensures always local read and write access at each site, which significantly reduces the long-distance traffic between both sites.

You can use the host location setting to optimize data paths for geographically distant locations by using the following steps:

- Identify storage system names. Locate the name of the storage system on which you are currently working and the name of the remote storage system within your established partnership.
- Set host location. Based on the storage system names that you identified, assign the appropriate location setting to your host.

Example 7-11 lists two storage systems. Their names, which also serve as location identifiers, are `SVC_SA2` and `FS9110`.

Example 7-11 Identify storage locations - optional needed for host definition

```
IBM_2145:SVC_SA2:superuser>lssystem | grep name
name SVC_SA2
...
IBM_2145:SVC_SA2:superuser>lspartnership
id               name    location partnership      type cluster_ip
event_log_sequence link1 link2 link1_ip_id link2_ip_id
0000020421203BA2 SVC_SA2 local
000002042OA02B2A FS9110  remote   fully_configured fc
```

In this example, the local system is SVC_SA2; the remote system is FS9110. Those names can be used when you define the location during the host creation or modification process.

7.3.1 Add hosts to partition

Create a new host within your storage partition by selecting **Hosts** → **Hosts**. Start the wizard by selecting the **Add Host** button. When you have successfully created new hosts, you can proceed with assigning appropriate volumes to them. The following examples demonstrate the process of creating new volumes with location definitions and assigning them to your newly created hosts.

1. Create the new hosts as shown in Example 7-12.

Example 7-12 Create new hosts with location settings

```
svctask mkhost -fcwwpn 100000109B55XXXX -force -name SR650_111 -partition 0
-protocol fcscsi -location FS9110
svctask mkhost -fcwwpn 100000109B55YYYY -force -name SR650_112 -partition 0
-protocol fcscsi -location SVC_SA2
```

2. Assign the newly created volumes to the host or host cluster. See Example 7-13 on page 147.

Example 7-13 Assign the volume to the hosts

```
svctask mkvdiskhostmap -force -host 3 -scsi 1 4
svctask mkvdiskhostmap -force -host 4 -scsi 1 4
```

7.3.2 Optimize policy-based HA internal data flow: Assign host location

Assigning the host location can make a significant performance difference in a policy-based HA configuration.

Note: Only hosts with a location setting use the optimized data path management. You can modify existing host objects and assign the appropriate location to the host. In your partition select **Hosts** → **Hosts**, and select the host and modify the location.

The host location can be modified by using the CLI. See Example 7-14.

Example 7-14 Change host location setting

```
svctask chhost -location FS9110 3
```

7.3.3 Remove host from partition

A host removal is similar to legacy host management. Select **Hosts** → **Hosts**, right click the host you want to delete and select **Remove host**. Follow the process and the system removes the host including all volume mappings from both policy-based HA systems.

The host can also be removed using the CLI. See Example 7-15.

Example 7-15 Host removal

```
svctask rmhost -force 3
```

7.4 Partition management

This section discusses partition management, which includes changing and deleting a partition.

7.4.1 Change replication policy

Only a single replication policy can be active on each partition at any given time. Changing a replication policy can change the overall behavior of the replication, depending on the specific policy settings. Replacing an existing policy with a similar one that has only different timeout settings is possible. However, minor changes can impact replication behavior. See Example 7-15.

Example 7-16 Assign a different replication policy to a partition

```
IBM_2145:SVC_SA2:superuser>chpartition -replicationpolicy  1 0
```

Replacing an existing policy with a new topology requires a policy removal first. Before you change a topology from policy-based replication to policy-based HA, you must remove the existing disaster recovery policy from the partition.

Removing an existing policy permanently removes the following information:

- All replicated data on the remote site.
- All volume and host settings that are associated with the policy.

After you remove the policy, you can assign a new policy-based HA policy to the partition, which creates all volumes and hosts and initiates an initial data copy to the remote system.

Recommendation: Before proceeding, ensure that you have a comprehensive backup plan in place, as the initial data copy to the remote site can take significant time, depending on data volume.

7.4.2 Delete partition

Deleting a partition is permanent and removes all associated data. Before you delete a partition, you must first ensure there are no active replication policies linked to the partition.

Use the following steps to delete a partition:

1. Within your partition, select **Storage partition overview**.
2. Click the three dots beside **Replication Policy.**
3. Select **Remove Replication Policy** as shown in Figure 7-22 and follow the wizard. Note that removing the replication policy deletes all remote volumes and their data and removes host objects related to this partition.

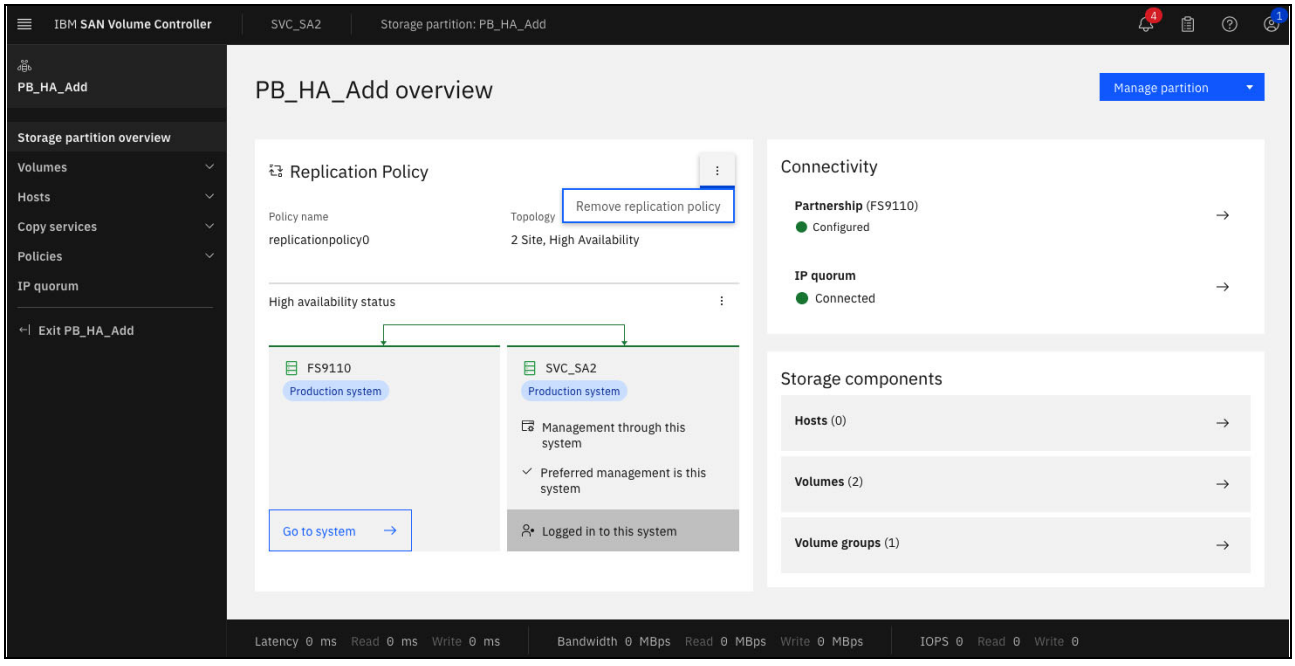

Figure 7-22 Remove replication policy

4. After the replication policy is removed, the partition can be removed. Click **Manage partition** and **Delete** as shown in Figure 7-23 on page 149.

5. Follow the wizard, enter the partition name you want to remove and click **Delete storage partition**.

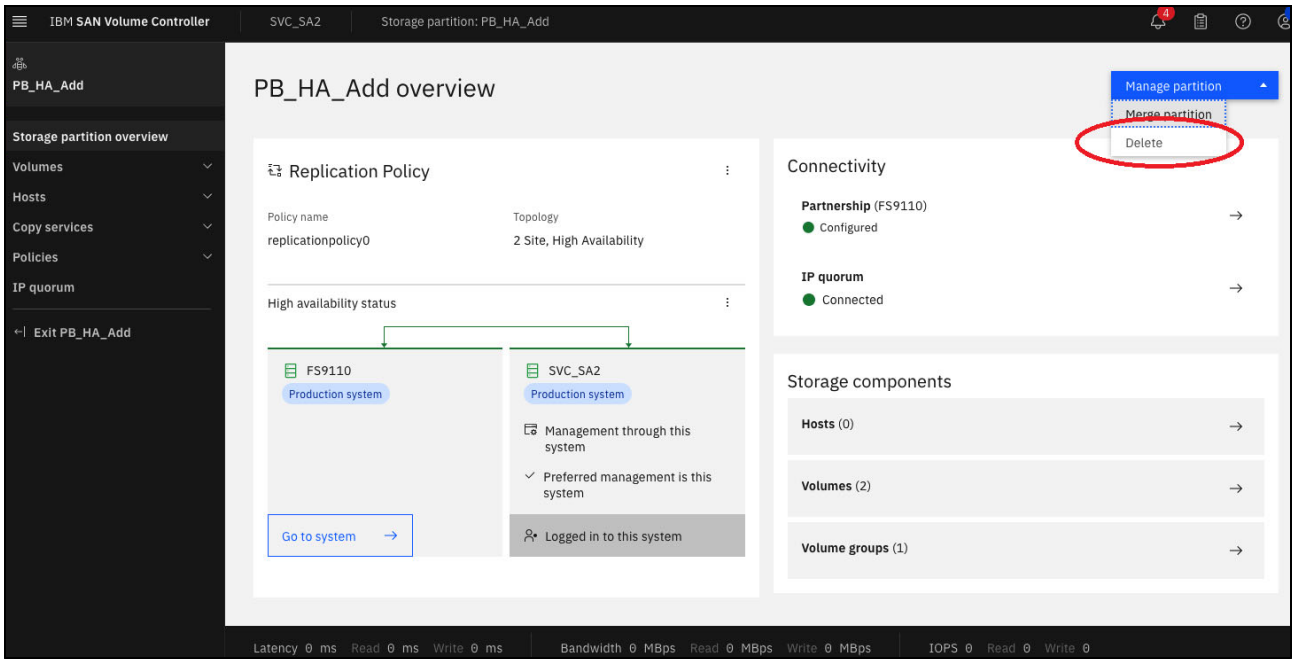

Figure 7-23 Delete the storage partition

Those actions can be performed from the CLI as well.

1. Remove the replication policy from the partition. See Example 7-17.

Example 7-17 Remove replication policy

```
IBM_2145:SVC_SA2:superuser>lspartition
id name    preferred_management_system_name active_management_system_name
replication_policy_id replication_policy_name location1_system_name
location1_status location2_system_name location2_status host_count
volume_group_count ha_status   link_status  desired_location_system_name
migration_status draft draft_volume_group_count draft_host_count
0  PB_HA_1 SVC_SA2                     SVC_SA2                   1
Test_PB_HA             FS9110               healthy          SVC_SA2
healthy          4          2                  established synchronized
IBM_2145:SVC_SA2:superuser>chpartition -noreplicationpolicy PB_HA_1
```

2. Delete the partition. See Example 7-18.

Example 7-18 Delete the partition

```
IBM_2145:SVC_SA2:superuser>svctask rmpartition 0
IBM_2145:SVC_SA2:superuser>lspartition
IBM_2145:SVC_SA2:superuser>
```

If there is no replication required anymore on the system, you might want to remove the storage system partnership to the remote storage system as well.

Note: Before you delete the partnership, remove all active replication policies that are using this particular partnership from the system. Also, before you delete a partition, have a comprehensive backup plan in place because any data stored within the partition is permanently erased.

7.5 Migration options for policy-based HA partitions

Partitions can be migrated nondisruptively between storage systems. The source and target must be in a partnership together. Those migrations can be done for standard partitions without an active policy-based remote copy relationship like policy-based HA or policy-based replication.

Important: The required zoning changes between the storage systems and to the host systems are not part of the migration process and must be completed before the migration.

If the partition is already in a policy-based remote copy relationship, the partition migration cannot be done by using the same method. There are multiple options available, which are discussed in the following sections.

7.5.1 Migration of policy-based HA data by temporary HA protection removal

Perform the following steps for partition migration:

1. Define the copy direction by setting the migration target system as an active management system.
2. Remove the existing policy-based HA policy from the storage partition. This step removes all volume and host definitions and deletes the data from the old policy-based HA partner site.
3. Assign a new policy-based HA policy to the storage partition for the target site. This automatically creates necessary volumes, hosts, and initiates data replication.
4. Verify the new configuration.

7.5.2 Migration of policy-based HA data to a third site by keeping the policy-based HA protection

Expanding your replication to a third site that uses policy-based replication is not currently supported. However, you can achieve migration by using host-based mirroring to the storage system at the third, independent site. This approach replicates your data directly at the host level, keeping your current storage configuration unchanged and allowing you to implement the third-site protection without losing your existing 2-site HA functionality.

7.5.3 Migration of policy-based HA or policy-based replication data to a third site

The existing policy-based HA solution or the policy-based replication solution should be migrated to a different system at a third site.

At the time of writing, 3-site configurations are not supported. IBM has released statements that it is planning policy-based HA plus policy-based replication to achieve replication to a third site in the second half of 2024.

7.6 Snapshots and policy-based HA

All policy-based HA volumes are managed by the storage partition. You can assign snapshot policies to any volume group, regardless of whether they are stand-alone or managed by a partition. This assignment can be done independently on each storage system, allowing for different scheduling if needed.

7.6.1 Key differences from the previous snapshot solutions

The following aspects are key differences from the previous snapshot solutions:

- Cloning flexibility. You can create clones and thin clones of these volumes to existing volumes or newly created volume groups outside the partition.
- Policy removal impact. Removing the replication policy from the partition causes the associated volumes and data to be deleted on the remote site. Additionally, the associated snapshots are also removed when they expire.

8

Configuring FlashSystem and SVC partnerships over high-speed Ethernet

This chapter discusses how to configure FlashSystem and SVC partnerships over high-speed Ethernet to be used for policy-based replication and policy-based-HA. The focus is on the deployment of short-distance partnerships that use Remote Direct Memory Access (RDMA).

The following key aspects are discussed:

- High-speed replication portset setup. Learn how to configure high-speed replication portsets for optimal performance.
- IP address assignment. Discover the process for assigning IP addresses to these portsets.
- Partnership creation. Explore methods for creating partnerships between storage systems, by using both the command-line interface (CLI) and graphical user interface (GUI).
- Deployment guidelines. Gain valuable insights into the recommended practices for deploying short-distance partnerships that use RDMA for efficient data replication.

Note: This chapter is based on the white paper Configure policy-based replication over high-speed Ethernet transport on IBM FlashSystem authored by Abhishek Jaiswal, Aakanksha Mathur, Akshada Thorat, Akash Shah and Santosh Yadav from IBM India.

This chapter has the following sections:

8.1 Introduction to replication over high-speed Ethernet

IBM Storage Virtualize V8.6.2 introduced support for configuring replication over high-speed Ethernet by using the RDMA protocol, which enables disaster recovery (DR) with high bandwidth over short distances. This capability enables customers with Ethernet infrastructure to implement DR with performance close to Fibre Channel (FC).

This chapter guides you through configuring a DR solution by using high-speed Ethernet partnerships between two systems. It details the prerequisites and setup considerations for establishing these partnerships and provides a comprehensive procedure that incorporates RDMA technology. Visual aids such as topology diagrams and step-by-step instructions through both GUI and CLI interfaces are included to facilitate the setup process.

To maintain real-time data copies at the remote DR site, this chapter explores the use of policy-based replication and remote copy technologies. In this setup, one system acts as the production system where hosts access the data, and the other system serves as the DR system at a distant location. Visual aids such as topology diagrams and step-by-step instructions through both GUI and CLI interfaces are included to facilitate the setup process.

Policy-based replication offers asynchronous data replication with a variable recovery point greater than zero, aiming to achieve an optimal recovery point considering business needs. In contrast to remote copy, it provides higher throughput and reduced latency between systems. Notably, it eliminates complex configuration requirements at the DR site, saving user time and ensuring streamlined failover procedures in DR scenarios.

8.2 Short-distance partnership using RDMA

IBM introduced replication over high-speed Ethernet, also known as short-distance partnership using the RDMA technology, for data transfer over replication links. RDMA offloads data transfer from CPUs and operating systems, resulting in low latency and high throughput. This is ideal for reliable, short-distance connections with low round-trip time (RTT), enabling superior performance.

8.3 Setup considerations

This section explains the setup considerations for configuring replication over high-speed Ethernet by using RDMA.

8.3.1 Initial setup considerations

It is possible to configure a short-distance partnership by using RDMA between two systems. Ensure that both the production and recovery systems are in either the replication or the storage layer.

You can use the **`svcinfo lssystem`** command to find the layer in which the system is. For more information, see lssystem.

You can use the **`svctask chsystem`** command to change the layer of the system. There can be up to two redundant fabrics established between the two systems. For more information, see chsystem.

Hardware considerations

Short-distance partnership by using RDMA is supported on IBM FlashSystem 9xx0, FlashSystem 7x00, FlashSystem 5x00, and IBM System Storage SAN Volume Controller platforms.

Note: The system must contain RDMA-capable Ethernet adapters for establishing short-distance partnership using RDMA. The adapter part number of the supported adapter is 01LJ587.

Software considerations

Make a note of the following software considerations to establish a short-distance partnership using RDMA:

- Short-distance partnerships that use RDMA is supported in IBM FlashSystem 8.6.2.0 and later versions. Ensure that both the systems have version 8.6.2.0 or later.
- Systems where IBM HyperSwap solution is already deployed in an Ethernet environment cannot be a part of a short-distance partnership that uses RDMA.
- The candidate systems participating in the partnership must not be visible to each other over FC connections. You can check this using the command **`svcinfo lspartnershipcandidate`**.

8.3.2 Network requirements

For HA purposes, there are two replication links that are supported for short-distance replication using RDMA. These links can be either routed or direct-attached.

Short-distance partnerships that use RDMA are supported on both layer 2 and layer 3 networks, as shown in Figure 8-1.

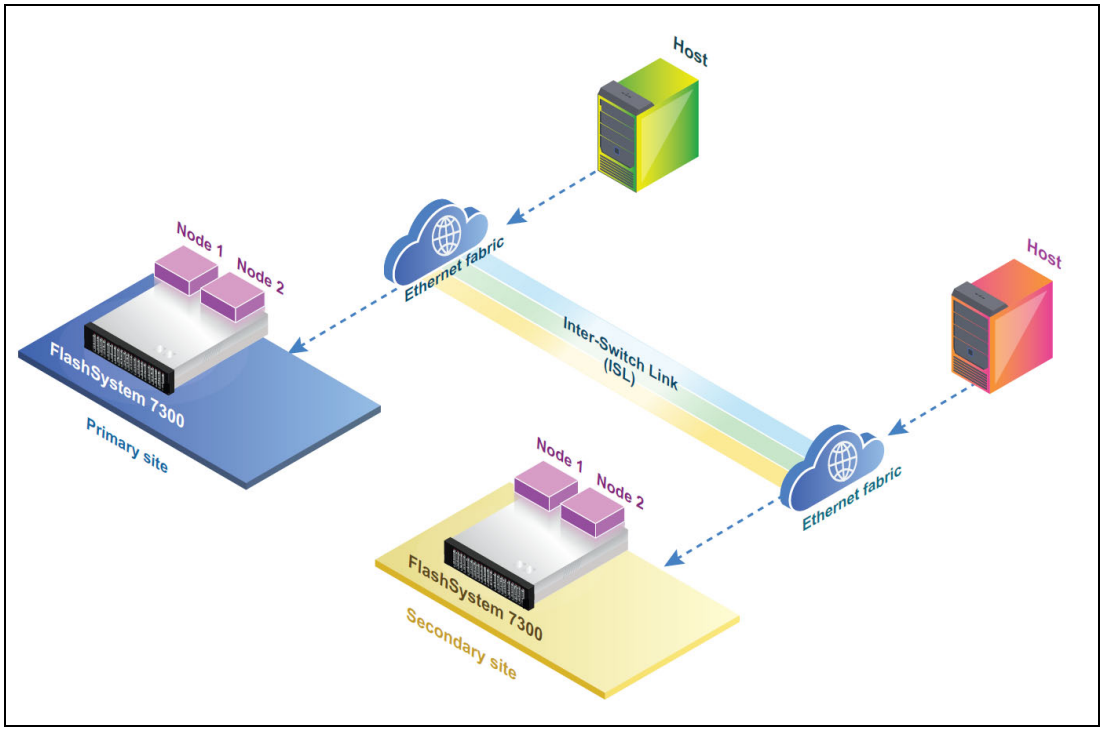

Figure 8-1 Configuration topology for short-distance partnership that uses RDMA

8.3.3 Deployment of short-distance partnership using RDMA

To establish a short-distance RDMA partnership between two systems, you must first configure them. Each partnership can have up to two links, each associated with a single highspeedreplication portset. Use the **-link1** or **-link2** attribute in the **mkippartnership** command to specify the high-speed replication portset for each link. For partnerships with dual links, both **-link1** and **-link2** attributes must be used, along with their corresponding high-speed replication portsets.

If there is a single ISL, either **–link1** or **–link2** replication parameter can be used. If there are two ISLs, both the parameters **-link1** and **–link2** can be used.

All the adapters in the configuration are RDMA-capable Ethernet adapters. To avoid network congestion, provision the ISL between the two systems so that it can accommodate all the traffic passing through it. See Figure 8-2

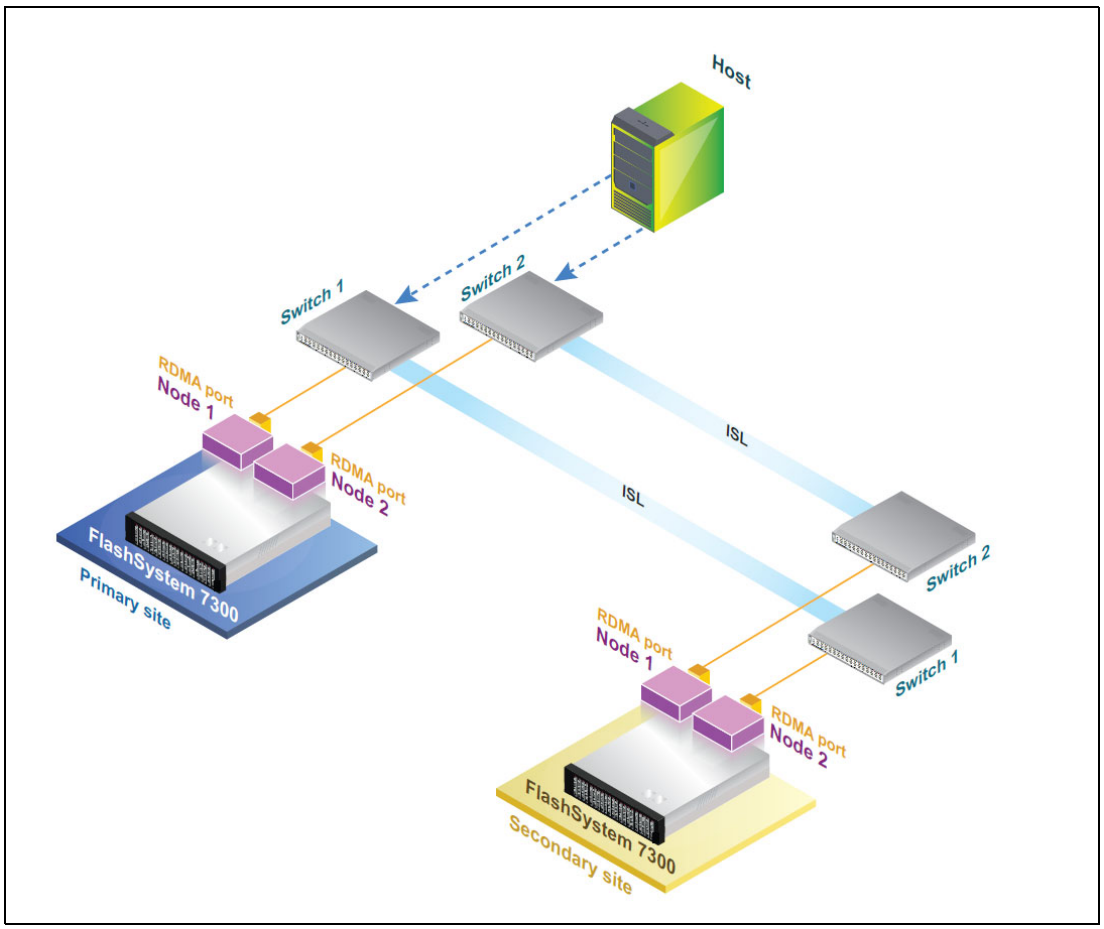

Figure 8-2 Configuration of a short-distance partnership using RDMA over ISL

You can configure the partnership by directly connecting the ports of the two systems, as shown in Figure 8-3 on page 157.

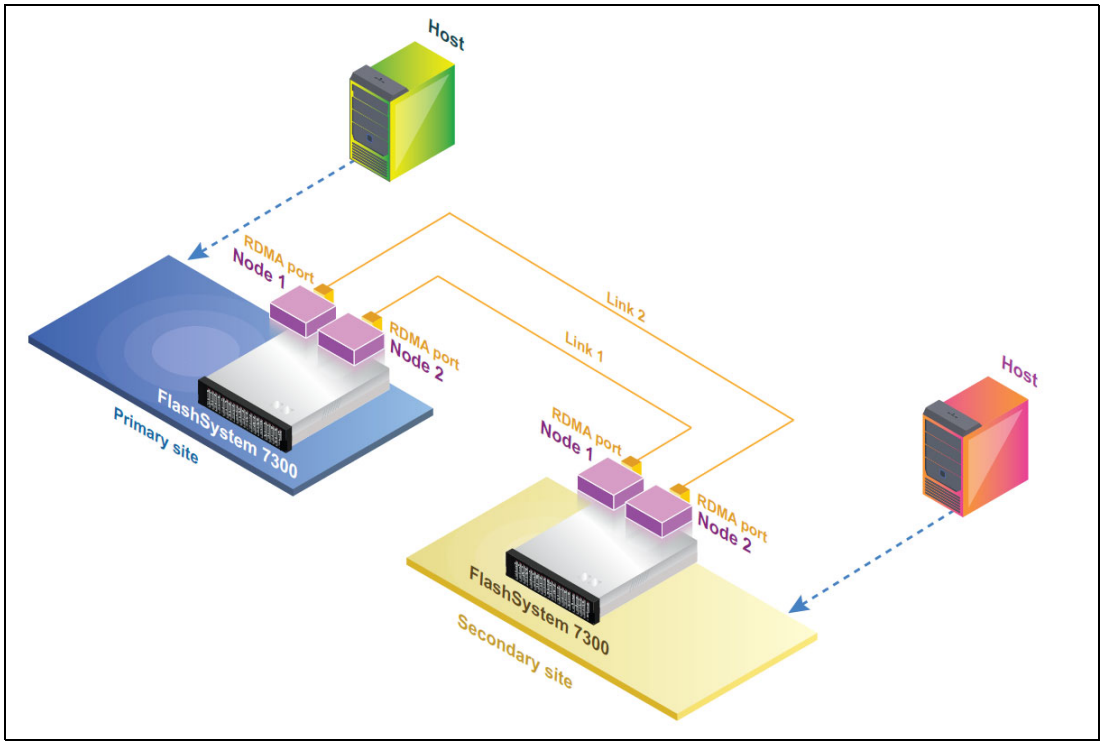

Figure 8-3 Configuration of a short-distance partnership that uses RDMA using direct-attach connections

8.3.4 Configuring a short-distance partnership using RDMA

The configuration task includes the following steps:

1. Identify the systems that participate in the partnership.
2. Identify the RDMA ports on each system that are a part of the partnership links and have connectivity between them.
3. Create high-speed replication portsets on each setup.
4. Configure these RDMA ports with IP addresses and map them to the respective high-speed replication portset.
5. Establish the partnership between both the systems.

The following section takes you through detailed configuration steps using GUI and CLI.

Configuration using the GUI

The procedures and screen captures in this section describe a walkthrough of the IBM Storage Virtualize GUI and explain the steps to create and configure a high-speed replication portset.

Creating high-speed replication portsets

Perform the following steps to create a high-speed replication portset:

1. In the IBM FlashSystem GUI, click **Settings** → **Network** → **Portsets**. Then click **Create Portset**, as shown in Figure 8-4 on page 158.

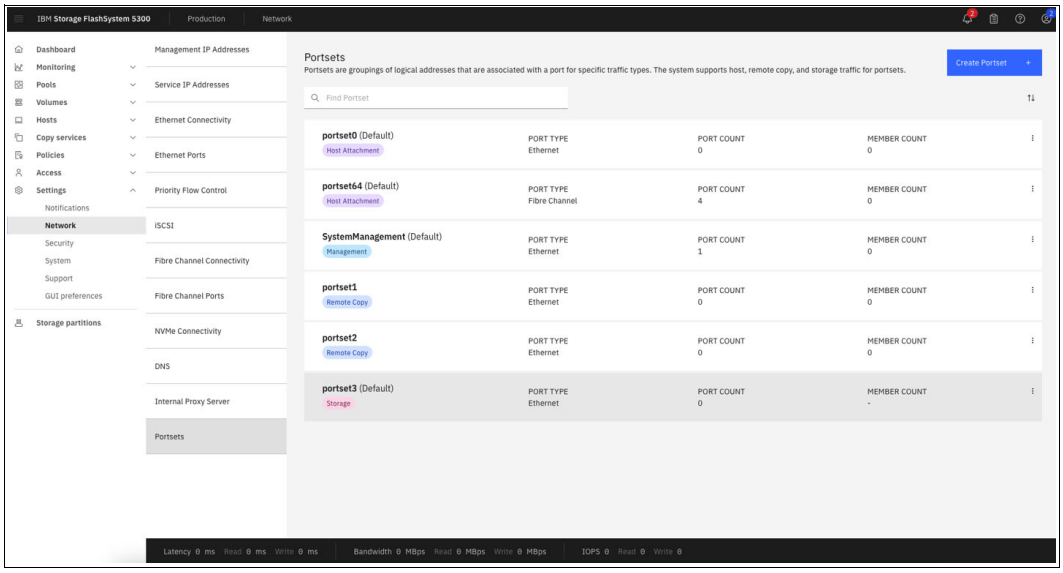

Figure 8-4 Creating a portset

2. In the **Create Portset** dialog, enter a name for the portset (for example, **portset4**, in this instance). Portset name is a user-defined variable and you can give any name to the portset.
3. Select the portset type as **High speed replication**.
4. In the **Port Type** section, select Ethernet and then click **Create**. See Figure 8-5.

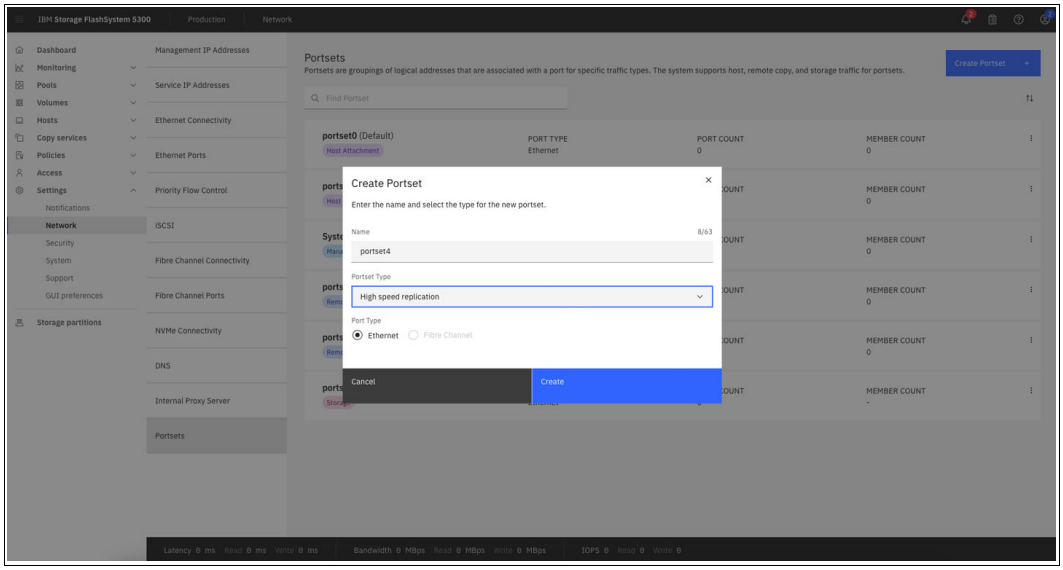

Figure 8-5 Specify portset name and type

5. To create another portset named "portset5," simply repeat the previous steps. After they are created, both portset4 and portset5 are listed on the Portsets page. See Figure 8-6.

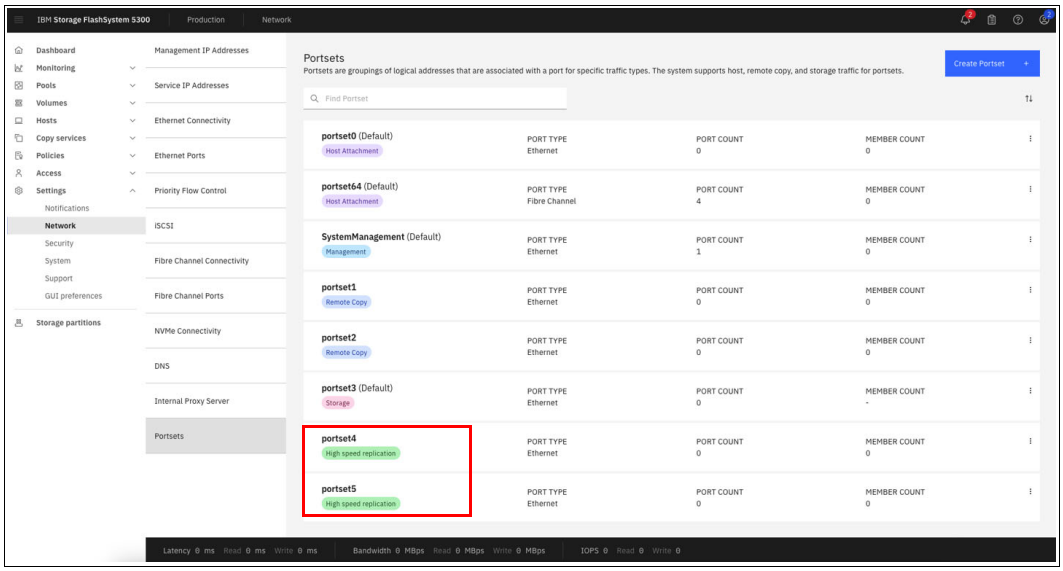

Figure 8-6 Listing of portsets

Assigning IP addresses to the portsets

After the creation of high-speed replication portsets, you can assign IP addresses to them by performing the following steps:

1. Click **Settings** → **Network** → **Ethernet Ports**.
2. On the Ethernet Ports page, right-click the port to which you need to assign an IP address and click **Manage IP Addresses**, as shown in Figure 8-7.

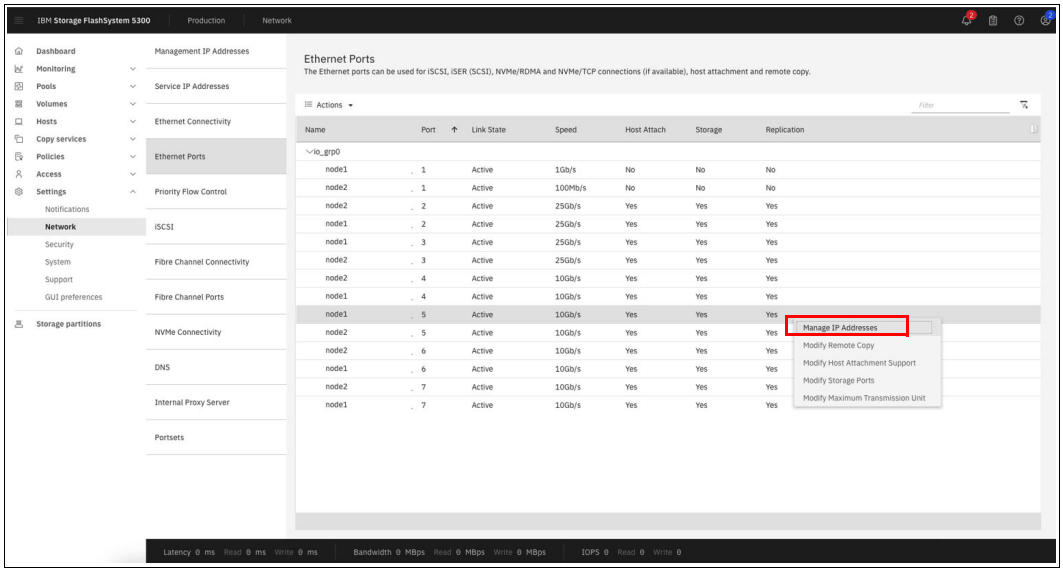

Figure 8-7 Right-click RDMA port

3. Click **Add IP Address**. See Figure 8-8

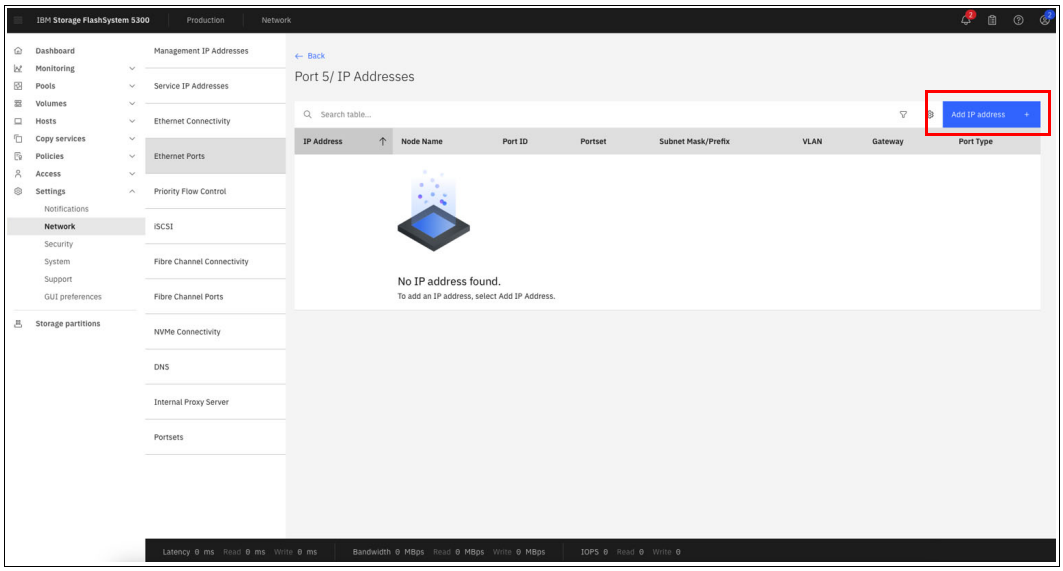

Figure 8-8 Add IP address

4. Enter the information as shown in Figure 8-9 for the IP address that you are adding to the selected port: IP address, subnet mask, VLAN, and gateway. Specify IPv4 as the type.

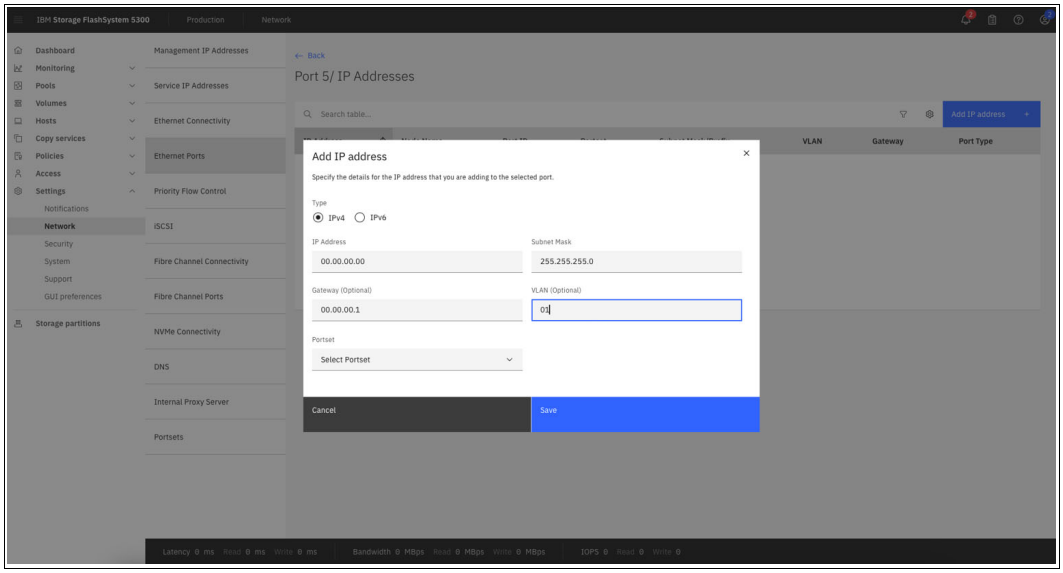

Figure 8-9 Enter IP address, subnet mask, VLAN, and gateway

5. Select the name of the portset and ensure that the portset type matches the specified traffic type. See Figure 8-10.

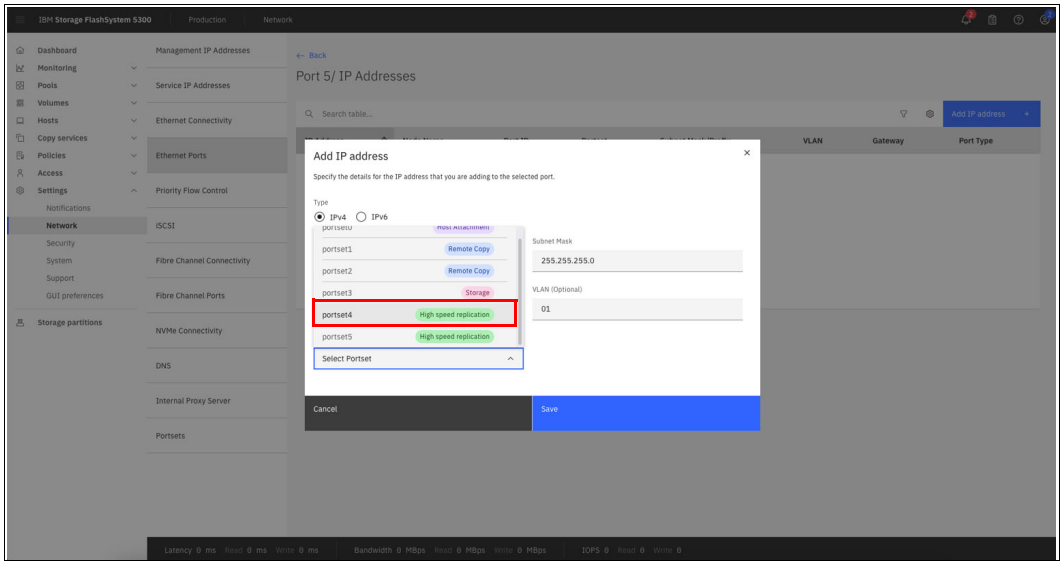

Figure 8-10 Select a portset

6. After selecting the portset (portset4), click **Save**. The IP address is assigned to the portset as shown in Figure 8-11.

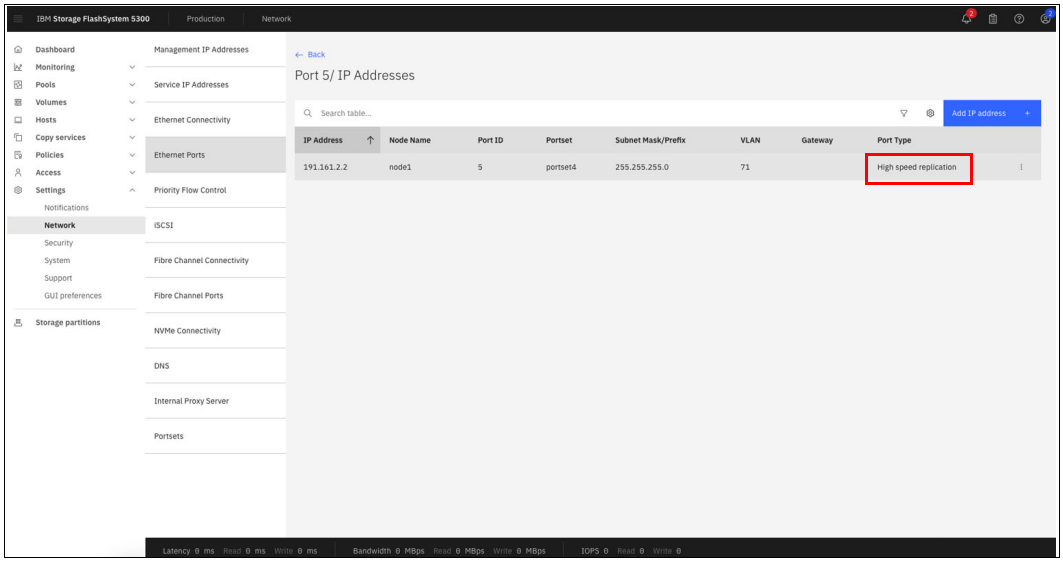

Figure 8-11 IP address of RDMA port

7. Repeat the same procedure for assigning IP to another portset (portset5).

Creating a partnership

After assigning the IP addresses, perform the following steps to create a partnership.

1. Click **Copy Service** → **Partnership and remote copy** → **Create Partnership**.
2. Select **2-site partnership** then click **Continue**, as shown in Figure 8-12.

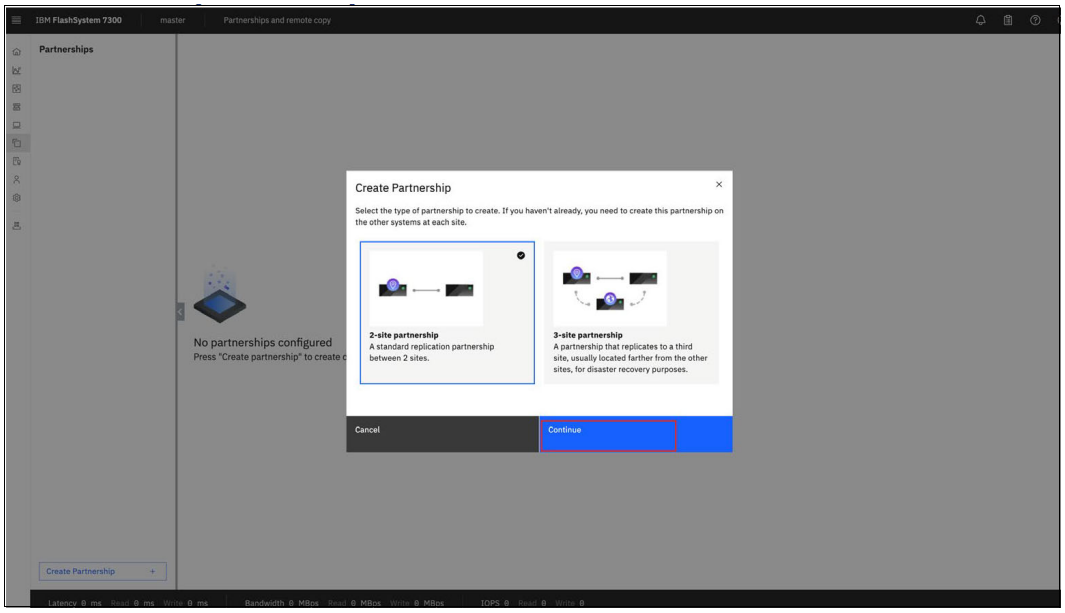

Figure 8-12 Creating a partnership

3. Select **IP (short distances using RDMA)** as the partnership type, enter the partner cluster IP address, and click **Test Connection**. See Figure 8-13.

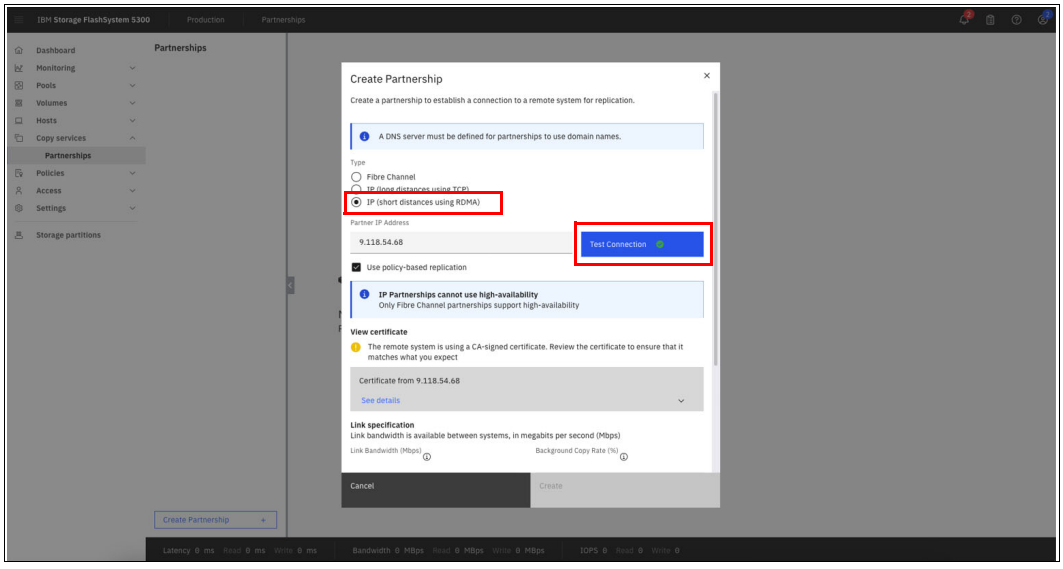

Figure 8-13 Select a short-distance partnership using RDMA

4. After testing the connection, select a policy-based replication based on your requirement. See Figure 8-14.

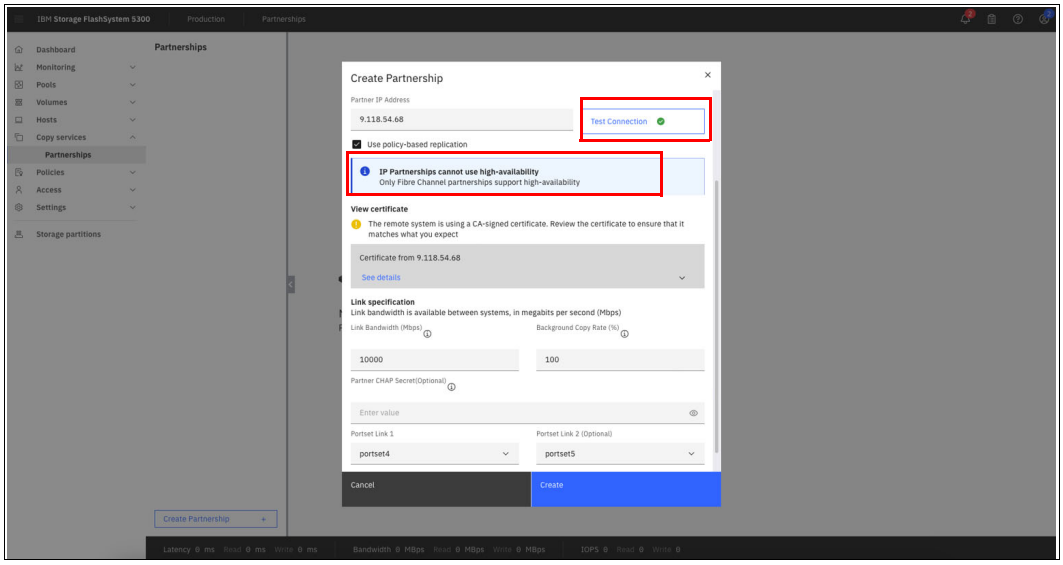

Figure 8-14 Test a connection for partnership

5. Enter link bandwidth and background copy rate. Then select the high-speed replication portsets for Portset Link1 and Portset Link2. In this example, **portset4** is selected for Portset Link1 and **portset5** is selected for Portset Link2 as shown in Figure 8-15.
6. Click **Create**.

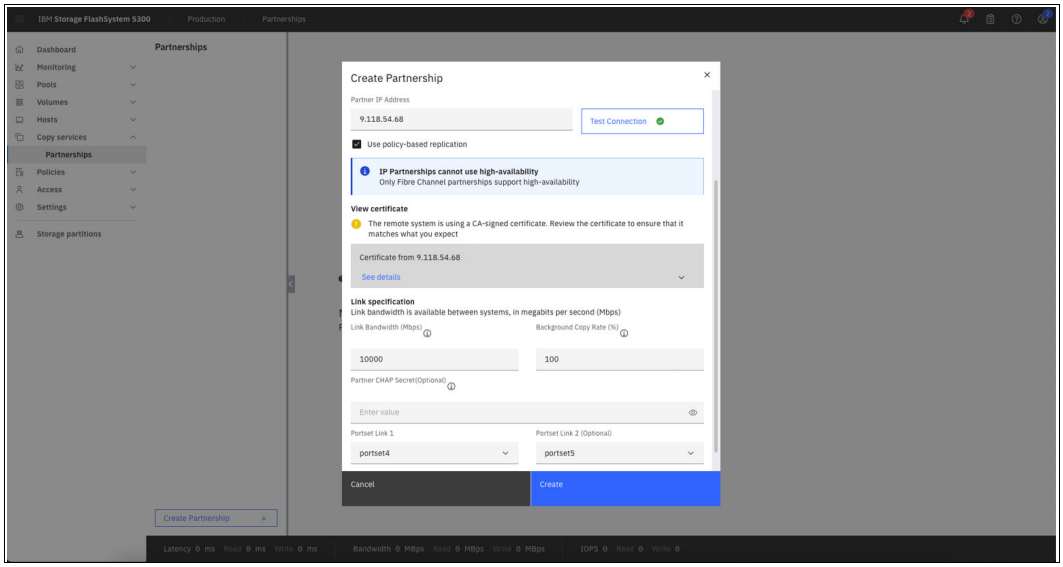

Figure 8-15 Select Portset Link1 and Portset Link2

7. Notice that the partially configured partnership is created, as shown in Figure 8-16.

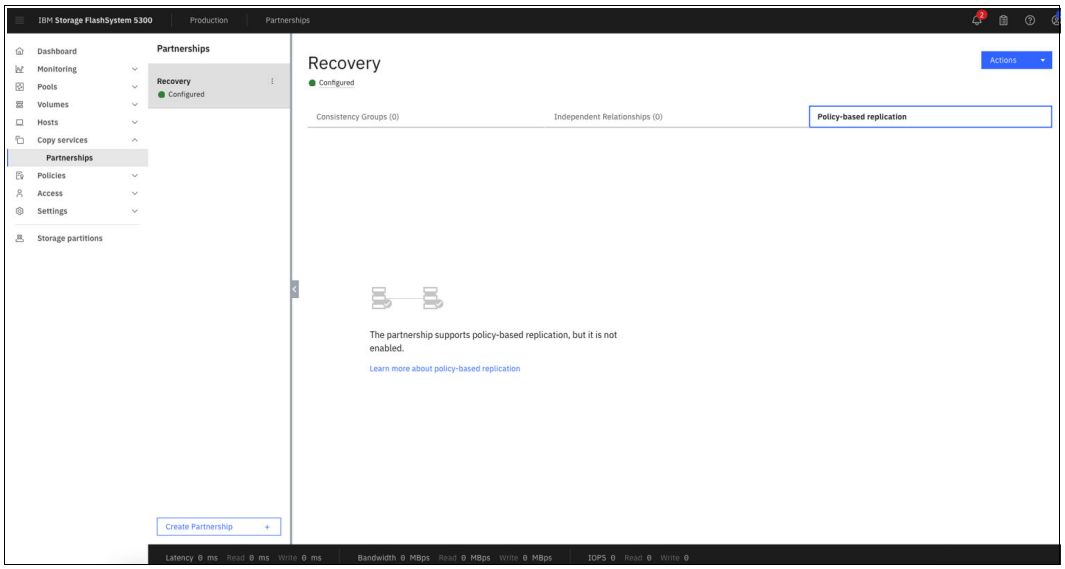

Figure 8-16 Partially configured partnership

You can follow the preceding steps on the remote cluster to change the partnership status to fully configured state.

8. After completing the steps for the remote cluster, notice that the partnership status shows **Configured**. See Figure 8-17.

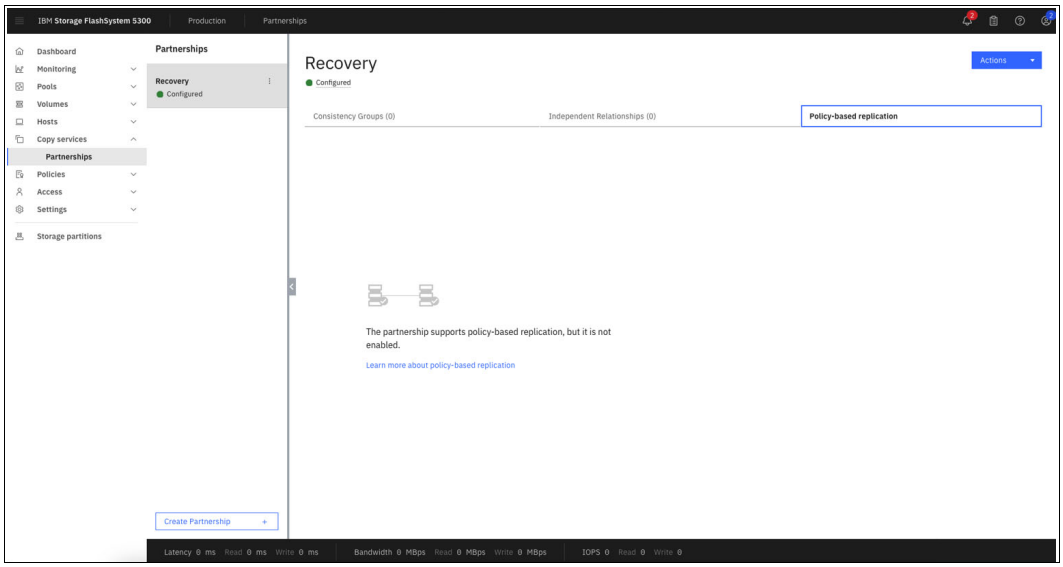

Figure 8-17 Configured partnership

9. After the partnership is configured click the **Overflow** menu and then select **Partnership Properties**, as shown in Figure 8-18.

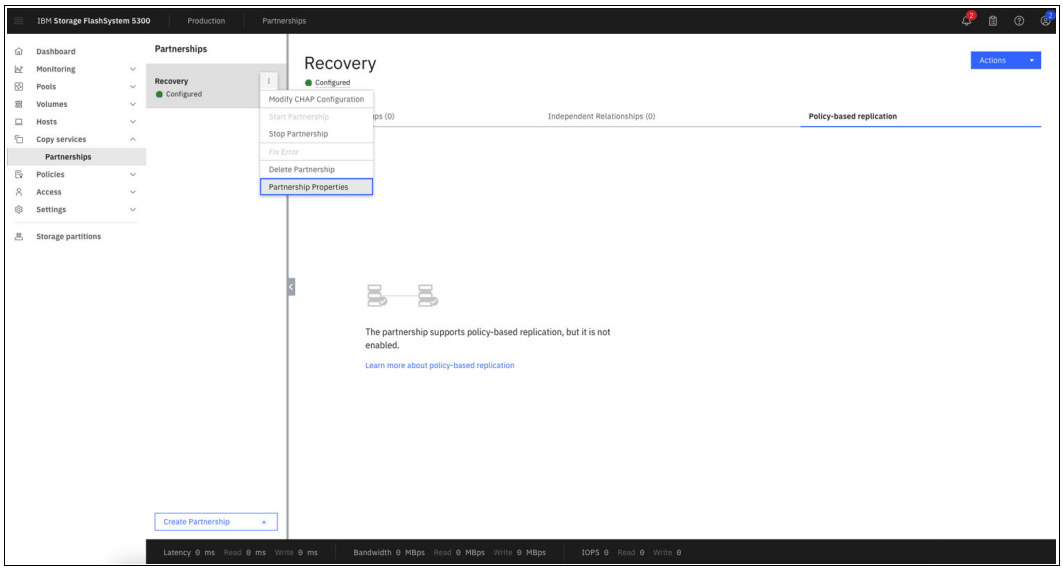

Figure 8-18 Select partnership properties

In the Properties dialog, notice that you can see a detailed view of partnerships, such as links, configuration status, type (short distance using RDMA), and so on. See Figure 8-19.

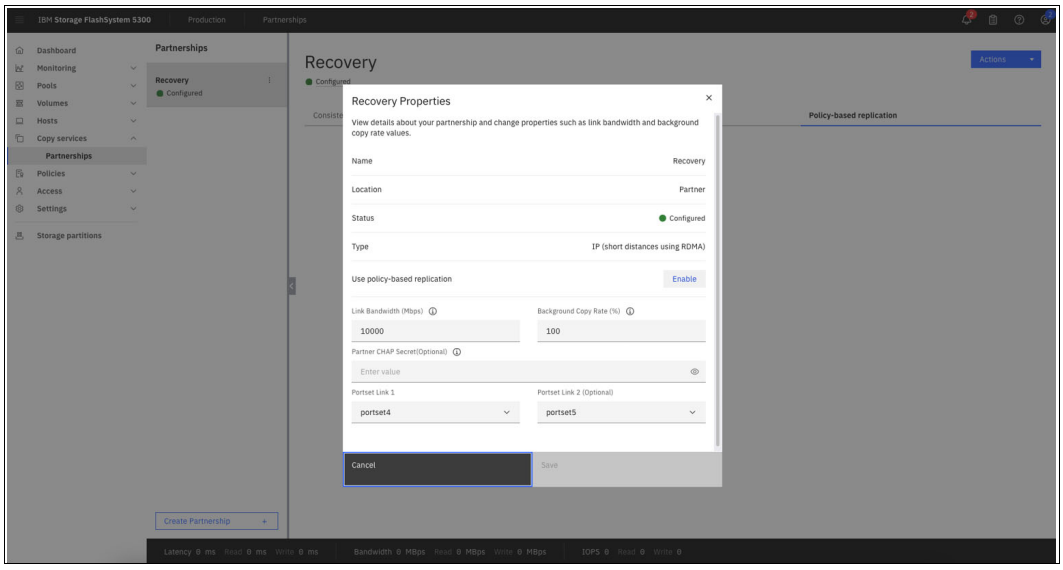

Figure 8-19 Partnership properties

Configuration using the CLI

This section takes you through the configuration of a short-distance partnership using RDMA using the CLI.

Creating a portset of type highspeedreplication

You can create the newly introduced high-speed replication portset by using the **`mkportset`** command with type **`highspeedreplication`**. The portsets that are created that use the **`mkportset`** command are listed under the **`lsportset`** command, as shown in Figure 8-20 on page 166.

```
IBM_FlashSystem:master:superuser>svctask mkportset -type highspeedreplication
Portset, id [4], successfully created
IBM_FlashSystem:master:superuser>svctask mkportset -type highspeedreplication
Portset, id [5], successfully created
IBM_FlashSystem:master:superuser>lsportset
id name             type                port_count host_count lossless owner_id owner_name port_type is_default
0  portset0         host                0          0                                      ethernet  yes
1  portset1         replication         0          0                                      ethernet  no
2  portset2         replication         0          0                                      ethernet  no
3  portset3         storage             0          0                                      ethernet  no
4  portset4         highspeedreplication 0         0                                      ethernet  no
5  portset5         highspeedreplication 0         0                                      ethernet  no
64 portset64        host                4          69         yes                         fc        yes
72 SystemManagement management          1          0          no                          ethernet  yes
```

Figure 8-20 mkportset and lsportset command output

In Figure 8-20, there are two high-speed replication portsets with default names as `portset4` and `portset5`. Portset name is a user-defined attribute. The **`mkportset`** command has the following syntax:

```
mkportset -type <portset_type>
```

Assigning IP addresses

You can assign IP addresses to the defined portsets by using the **`mkip`** command. Select only the RDMA port for configuring IP addresses and mapping those to the high-speed replication portsets. In the following screenshot, RDMA port 5 of node1 and node2 are selected for configuring IP addresses. See Figure 8-21.

```
IBM_FlashSystem:master:superuser>lsportethernet
port_id node_id node_name MAC               duplex speed  link_state dcbx_state  rdma_type adapter_location adapter_port_id host storage replication eth_clustering management
1       1       node1     0c:48:c6:7f:85:9a Full   10Gb/s active     unsupported          0                1              yes  yes     yes         no             yes
2       1       node1     0c:48:c6:7f:85:9b              inactive                         0                2              yes  yes     yes         no             yes
3       1       node1     0c:48:c6:7f:85:9c              inactive                         0                3              yes  yes     yes         no             no
4       1       node1     0c:48:c6:7f:85:9d              inactive                         0                4              yes  yes     yes         no             no
5       1       node1     00:07:43:5a:9d:58 Full   25Gb/s active     disabled    iWARP     1                1              yes  yes     yes         no             no
6       1       node1     00:07:43:5a:9d:50 Full   25Gb/s active     disabled    iWARP     1                2              yes  yes     yes         no             no
7       1       node1     b8:59:9f:d9:cc:81 Full   25Gb/s active     enabled     RoCE      2                1              yes  yes     yes         no             no
8       1       node1     b8:59:9f:d9:cc:80 Full   25Gb/s active     enabled     RoCE      2                2              yes  yes     yes         no             no
1       2       node2     0c:48:c6:7f:86:76 Full   10Gb/s active     unsupported          0                1              yes  yes     yes         no             yes
2       2       node2     0c:48:c6:7f:86:77              inactive                         0                2              yes  yes     yes         no             yes
3       2       node2     0c:48:c6:7f:86:78              inactive                         0                3              yes  yes     yes         no             no
4       2       node2     0c:48:c6:7f:86:79              inactive                         0                4              yes  yes     yes         no             no
5       2       node2     00:07:43:48:4c:d8 Full   25Gb/s active     disabled    iWARP     1                1              yes  yes     yes         no             no
6       2       node2     00:07:43:48:4c:d0 Full   25Gb/s active     disabled    iWARP     1                2              yes  yes     yes         no             no
7       2       node2     b8:59:9f:fc:61:4d Full   25Gb/s active     enabled     RoCE      2                1              yes  yes     yes         no             no
8       2       node2     b8:59:9f:fc:61:4c Full   25Gb/s active     enabled     RoCE      2                2              yes  yes     yes         no             no
```

Figure 8-21 lsportethernet command output

When you assign the IP address, you can either provide the high-speed replication portset name or the portset ID. In the following example, the **`mkip`** command is used to assign an IP address and map it to a high-speed replication portset. See Figure 8-22. For more information, see mkip.

```
IBM_FlashSystem:master:superuser>mkip -node node1 -port 5 -portset portset4 -ip xx.xx.xx.xx  -prefix xx -vlan xx
IP Address, id [1], successfully created
IBM_FlashSystem:master:superuser>mkip -node node2 -port 5 -portset portset5 -ip xx.xx.xx.xx  -prefix xx -vlan xx
IP Address, id [2], successfully created
IBM_FlashSystem:master:superuser>lsip
id node_id node_name port_id portset_id portset_name     IP_address    prefix vlan gateway     owner_id owner_name
0                    1       72         SystemManagement xx.xx.xx.xx   xx          xx.xx.xx.xx
1  1       node1     5       4          portset4         xx.xx.xx.xx   xx     xx
2  2       node2     5       5          portset5         xx.xx.xx.xx   xx     xx
```

Figure 8-22 mkip and lsip command output

The assigned IP addresses are listed by using the **`lsip`** command.

Note: Use the RDMA port for short distance partnership using the RDMA type. The same port which has been used for partnership cannot be used for host attachment, storage attachment, replication, or Ethernet clustering. Also, the same IP address cannot be assigned to two different RDMA ports.

Creating a partnership

Establishing a short-distance partnership between production and recovery systems can be done using the **mkippartnership** command. The command takes two options **-link1** and **-link2**. Users should provide an individual portset to each of these two options. Users can provide a maximum of two links per partnership. For more information, see mkippartnership.

It is advisable to provide two portsets corresponding to each of the link options. A partnership can also be created with a single link option, but users can use both the replication links for redundancy purposes.

The example in Figure 8-23 shows a short-distance partnership creation with high-speed replication portsets (as created in earlier steps). Users can provide either a high-speed replication portset ID or a portset name while creating a partnership.

In Figure 8-23, the partnership status is `partially_configured_local`.

```
IBM_FlashSystem:master:superuser>svctask mkippartnership -clusterip xx.xx.xx.xx -linkbandwidthmbits 25000 -backgroundcopyrate 100 -link1 portset4 -link2 portset5
IBM_FlashSystem:master:superuser>lspartnership
id               name         location partnership               type cluster_ip    event_log_sequence link1    link2    link1_ip_id link2_ip_id
000002043BE16280 master       local
0000020437415F70 aux          remote   partially_configured_local ipv4 xx.xx.xx.xx                 portset4 portset5
```

Figure 8-23 mkippartnership and lspartnership command output

The created partnership is listed by using the **lspartnership** command. For more information, see lspartnership.

To create a fully configured partnership, repeat the **mkippartnership** command on the remote system. You can verify the partnership status by using the **lspartnership** command on each system, as shown in Figure 8-24.

```
IBM_FlashSystem:master:superuser>lspartnership
id               name    location partnership        type cluster_ip    event_log_sequence link1    link2    link1_ip_id link2_ip_id
000002043BE162B0 master  local
0000020437415F70 aux     remote   fully_configured   ipv4 xx.xx.xx.xx                    portset4 portset5
```

Figure 8-24 lspartnership command output

For short distance partnerships, run the **sainfo lsnodeipconnectivity** command to observe RDMA connectivity. Figure 8-25 shows that the status is connected for both the links of the fully configured partnership created in “Creating a partnership” on page 162.

```
IBM_FlashSystem:master:superuser>sainfo lsnodeipconnectivity 01-1
status          local_port_id local_vlan local_rdma_type local_ip_addr remote_port_id remote_vlan remote_rdma_type remote_ip_addr remote_wwnn      remote_panel_name cluster_id     error_data
Connected:iWARP 5             xx         iWARP          xx.xx.xx.xx   5              xx          iWARP           xx.xx.xx.xx    500507681000B184 01-1              000002043BE16280

IBM_FlashSystem:master:superuser>sainfo lsnodeipconnectivity 01-2
status          local_port_id local_vlan local_rdma_type local_ip_addr remote_port_id remote_vlan remote_rdma_type remote_ip_addr remote_wwnn      remote_panel_name cluster_id     error_data
Connected:iWARP 5             xx         iWARP          xx.xx.xx.xx   5              xx          iWARP           xx.xx.xx.xx    500507681000B158 01-2              000002043BE16280
```

Figure 8-25 sainfo lsnodeipconnectivity command output

Note: The native IP replication can be done by using a replication type portset, and the short-distance partnership using RDMA is possible only with portsets of type **`highspeedreplication`**. Compression and secured IP partnerships are not supported with short-distance partnerships that use RDMA portsets.

Changing attributes by using the chpartnership command

The **`chpartnership`** command can be used for changing the attributes of an already created partnership. For more information, see chpartnership.

8.3.5 Bandwidth usage

For 100% write workload, IBM FlashSystem achieves maximum throughput with policy-based replication and by using high-speed Ethernet. The built-in performance monitor shows fully saturated links and maximum bandwidth usage when using IBM FlashSystem with high-speed replication over Ethernet. The graph in Figure 8-26 illustrates this, showing fully saturated links and maximum bandwidth usage with IBM FlashSystem using high-speed replication over Ethernet.

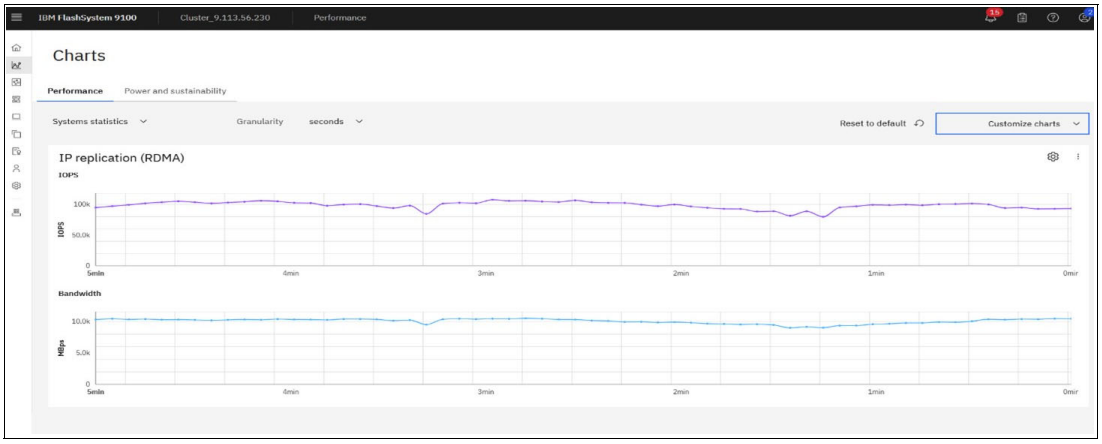

Figure 8-26 Throughput versus time

When the connection between the two near DR sites uses reliable links, replication performance reaches its optimal level. Because iWARP uses TCP, performance remains relatively stable even during temporary link issues.

The graph data is for informational purposes only and does not reflect benchmark results.

8.3.6 Policy-based replication configuration checklist

Do the following steps to configure policy-based replication:

1. Define a mutual Transport Layer Security (mTLS) between the systems.
2. Configure the partnership at both the sites.
3. Link the pools between the systems. For more information, see Pool links. The linked page is for FlashSystem 7x00, but the information applies to all supported Storage Virtualize systems.
4. Create a replication policy of topology, 2-site-async-dr.
5. Create a volume group and assign the newly created replication policy to the group.

6. Create new volumes or add existing volumes to the volume group.

Refer to Chapter 4, “Implementing policy-based replication” on page 57 for more details.

8.3.7 General guidelines

Guidelines for creating a high-speed replication portset:

- Use only RDMA ports for short-distance partnerships using RDMA and the port cannot be used for any other traffic such as host attachment, storage attachment, replication, or Ethernet clustering.
- Up to two RDMA ports can be assigned per high-speed replication portset per node.
- You can define a maximum of six high-speed replication portsets per system.
- You can assign IPV4 and IPV6 addresses to a high-speed replication portset.

Guidelines for creating a short-distance partnership:

- Ethernet-based RDMA clustering and short-distance partnership using RDMA cannot coexist.
- Partnerships can be created using a single replication link or a dual replication link.
- You can view the partnership status using the **`lspartnership`** command. Ideally, it should be fully configured. If partnership status is not present, then use the instructions in 8.3.8, “Troubleshooting” on page 169 to fix it.

8.3.8 Troubleshooting

This section lists a few troubleshooting tips to validate the configuration.

1. Validate the partnership status:
   a. In the GUI, click **Copy Service** → **Partnership and remote copy** → **Partnerships**. Notice that the status is displayed as **Configured**, as shown in Figure 8-27.

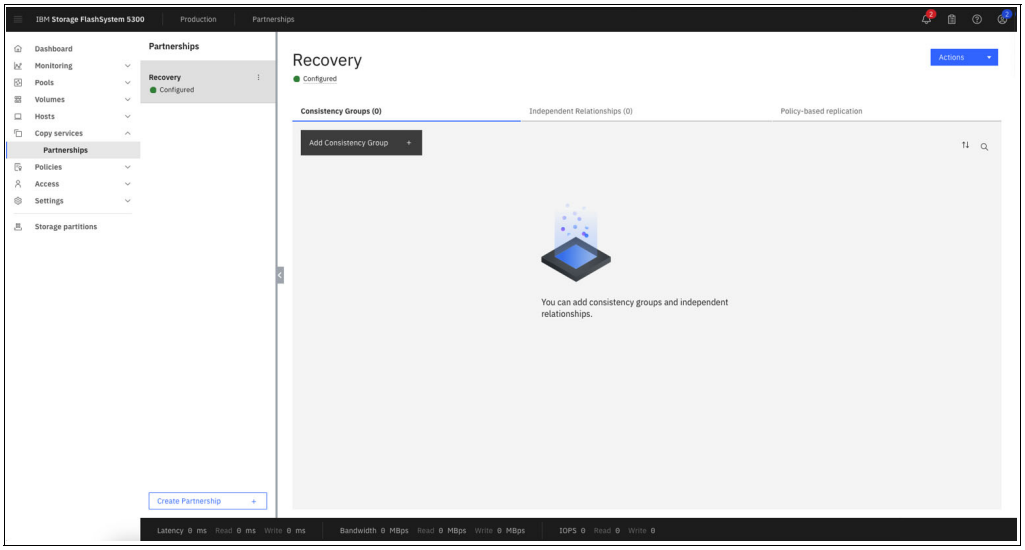

Figure 8-27 View the configuration status in GUI

b. In the CLI, run the **lspartnership** command and check if the output shows the partnership status as `fully_configured` with the other partnership attributes, as shown in Figure 8-28.

```
IBM_FlashSystem:master:superuser>lspartnership
id                 name    location partnership       type cluster_ip    event_log_sequence link1    link2    link1_ip_id link2_ip_id
000002043BE162B0 master  local
0000020437415F70 aux     remote   fully_configured  ipv4 xx.xx.xx.xx                      portset4 portset5
```

Figure 8-28 View the configuration status in CLI

2. Ensure connectivity between links. Ensure that all IP addresses associated with the link1 and link2 portsets on the production IBM FlashSystem storage system are connected with all IP addresses associated with the link1 and link2 portsets on the recovery IBM FlashSystem storage system. The same can be validated by using the following methods:

   a. In the GUI, click **Settings** → **Network** → **Ethernet Connectivity**, as shown in Figure 8-29.

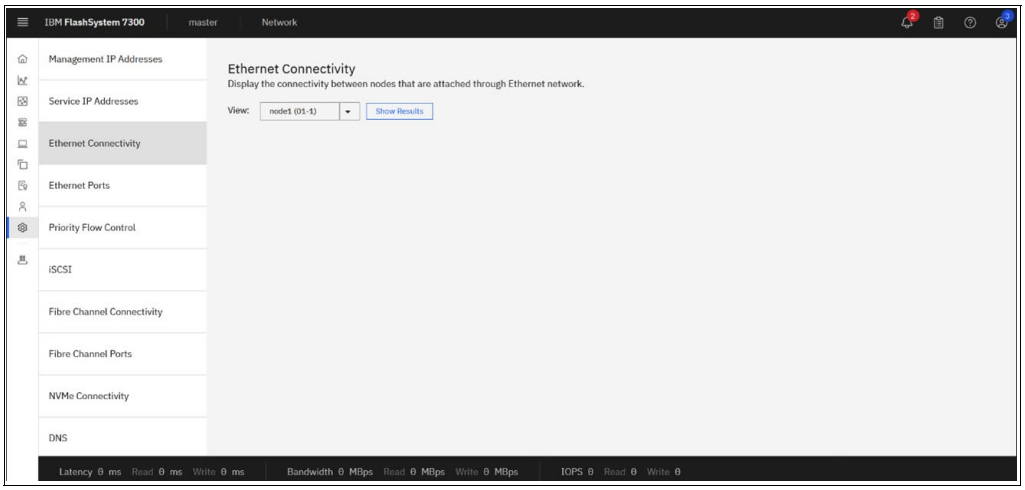

Figure 8-29 Ethernet Connectivity page

   b. Select the node and click **Show Results**, as in Figure 8-30.

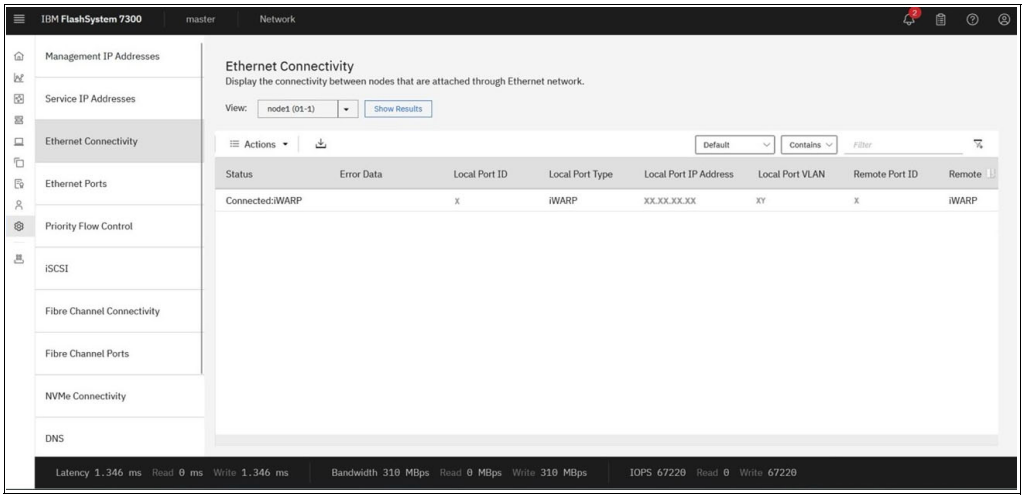

Figure 8-30 Displaying connectivity between nodes attached through Ethernet network

c. In the CLI, run the **sainfo lsnodeipconnectivity** command on all the nodes of the system, as shown in Figure 8-31.

Figure 8-31 IP addresses configured on the ports

3. For a more resilient configuration to have maximum redundancy, ensure that the IP addresses configured on the ports for both the links are from different nodes.
4. If the partnership status is something other than `fully_configured`, then further troubleshooting is required to understand why the partnership is not reflecting the required ideal state, which is `fully_configured`.
   a. Partnership is in the `not_present` state. An IP partnership can change to the `not_present` state for multiple reasons, and it means that the replication services are stopped. Check for alerts, warnings, or errors associated with partnership. In the CLI, run the **lseventlog** command, or in the GUI click **Monitoring** and then view the list in the Events tab in the GUI to find the events pertaining to the changes occurred in the system.
   b. In the CLI, run the **sainfo lsnodeipconnectivity** command on all the nodes of the system to understand if there are any issues with the sessions established. Ideally, the session status is `Connected`, but other states can be `Protocol mismatch`, `Degraded`, and `Unreachable`.
5. Although reference of event logs and directed maintenance procedures (DMPs) from the GUI are the recommended ways to resolve any issue pertaining to the IBM FlashSystem, you can also examine the connectivity to the remote system.
   a. Check the connectivity to the remote cluster by using the **svctask ping** command: For IPv4 and IPv6 use these commands:

      ```
      svctask ping -srcip4 <source_ip> <destination_ip>
      ```

      ```
      svctask ping6 -srcip6 <source_ip> <destination_ip>
      ```
6. If you see the error codes 2021 or 2023 in the event logs, use the following links to help determine the cause and determine the action to take to resolve the issue:
   – Error code 2021: IBM Documentation for error code 2021
   – Error code 2023: IBM Documentation for error code 2023

In the GUI, follow the Directed Maintenance Procedure (DMP) from the menu **Monitoring** → **Events** to troubleshoot the issue. If you followed the DMP and the issue is still not resolved, then another option is to open a support ticket with IBM for further assistance.

Abbreviations and acronyms

CDM	Copy Data Management
CLI	Command Line Interface
CSM	Copy Services Manager
DMP	Directed Maintenance Procedure
DR	Disaster Recovery
FC	Fibre Channel
FS9100	FlashSystem 9100
GM	Global Mirror
GMCV	Global Mirror with Change Volumes
GUI	Graphical User Interface
HA	High Availability
IBM	International Business Machines Corporation
ISL	Inter-Switch Link
Mbps	megabits per second
PBHA	Policy-based HA
PBR	Policy-based replication
QoS	Quality of Service
RDMA	Remote Direct Memory Access
RPO	Recovery Point Objective
RTO	Recovery Time Objective
RTT	round-trip time
SVC	SAN Volume Controller
mTLS	mutual Transport Layer Security

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks

The following IBM Redbooks publications provide additional information about the topic in this document. Note that some publications referenced in this list might be available in softcopy only.

- *Policy-Based Replication with IBM Storage FlashSystem, IBM SAN Volume Controller and IBM Storage Virtualize*, REDP-5704
- *Unleash the Power of Flash: Getting Started with IBM Storage Virtualize Version 8.7 on IBM Storage FlashSystem and IBM SAN Volume Controller*, SG24-8561

You can search for, view, download or order these documents and other Redbooks, Redpapers, Web Docs, draft and additional materials, at the following website:

ibm.com/redbooks

Online resources

These websites are also relevant as further information sources:

- *Configure policy-based replication over high-speed Ethernet transport on IBM FlashSystem* whitepaper:

  https://www.ibm.com/downloads/cas/NP4RWMKX

Help from IBM

IBM Support and downloads

ibm.com/support

IBM Global Services

ibm.com/services

Redbooks

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