Dell Technologies

Technical White Paper

Dell EMC PowerFlex: Introduction to Replication

Overview and basic configuration of PowerFlex replication

Abstract

Dell EMC™ PowerFlex™ software-defined storage (formerly VxFlex OS) version 3.5 adds native asynchronous replication. This paper provides an overview of PowerFlex replication technology along with deployment and configuration details as well as design considerations for replicating PowerFlex clusters.

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Executive summary

As PowerFlex continues to evolve, the 3.5 release adds a variety of core features including asynchronous replication. Customers require disaster recovery and replication features to meet business and compliance requirements. Replication can be leveraged for other use cases such as offloading demanding workloads like analytics, isolating them from mission-critical workloads such as ERP, MRP, or other business-critical systems. Another requirement is the need for more than two copies of certain data sets. This paper covers:

- Key features of PowerFlex Release 3.5
- The core design principles of PowerFlex replication
- Configuration requirements for pairing storage clusters
- Configuration requirements of Replication Consistency Groups
- Networking Considerations
- Replication use cases

Images of the PowerFlex replication architecture will be shared along with screenshots of the new Web User Interface (WebUI) to assist in clearly communicating all the essential elements of replication.

1 Introduction

PowerFlex is a software-defined storage platform designed to significantly reduce operational and infrastructure complexity empowering organizations to move faster by delivering flexibility, elasticity, and simplicity with predictable performance and resiliency at scale. The PowerFlex family provides a foundation that combines compute as well as high performance storage resources in a managed unified fabric. Flexibility is offered as it comes in multiple hardware deployment options such as integrated rack, appliance or ready nodes, all of which provide Server SAN, HCI and storage only architectures.

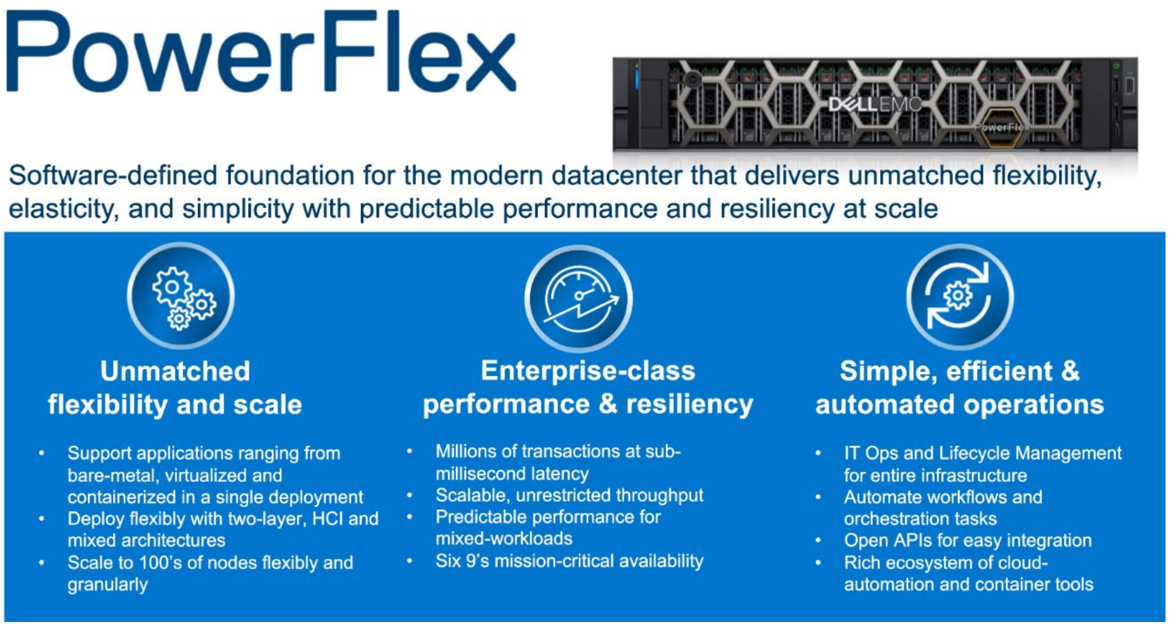


Figure 1 PowerFlex overview

PowerFlex provides the flexibility and scale demanded by a range of application deployments, whether they are on bare metal, virtualized, or containerized.

It provides the performance and resiliency required by the most demanding enterprises, demonstrating six 9s or greater of mission-critical availability with stable and predictable latency.

Easily providing millions of IOPs at sub-millisecond latency, PowerFlex is ideal for both high performance applications and for private clouds that desire a flexible foundation with synergies into public and hybrid cloud. It is also great for organizations consolidating heterogeneous assets into a single system with a flexible, scalable architecture that provides the automation to manage both storage and compute infrastructure.

2 PowerFlex 3.5 new features

There is much more than replication in this release, so it is worth mentioning some additional features.

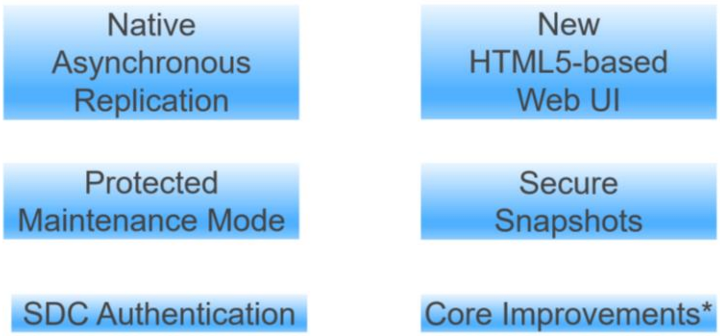


Figure 2 New features

2.1 Native asynchronous replication

This much anticipated feature is the key subject of this paper and will be covered in detail.

2.2 Protected Maintenance Mode

Protected Maintenance Mode, or PMM, offers better data protection over Instant Maintenance Mode. While Instant Maintenance Mode, or IMM, offered the ability to perform node maintenance very quickly, there was some exposure to potential data unavailability or loss should an additional device or node experience failure. PMM creates a temporary third copy of the node’s data throughout the system spare capacity during the maintenance period. When maintenance is complete, the deltas are synced back to the maintained node. While it takes longer to perform than IMM, it preserves full data protection throughout the maintenance period and vastly reduces concern for data loss and availability.

2.3 SDC authentication

Authentication of SDCs is better secured with CHAP, or Challenge-Handshake Authentication Protocol. It allows the MDM to validate the authenticity of each SDC when it is first attached and to establish secrets between the SDCs and SDSs to regulate access to volumes. The MDM regularly refreshes the secrets, forcing the SDCs and SDSs to re-authenticate on a regular basis.

2.4 New WebUI

The PowerFlex 3.5 release offers a new, streamlined HTML5-based user interface which is consistent with other Dell Technologies™ product solutions.

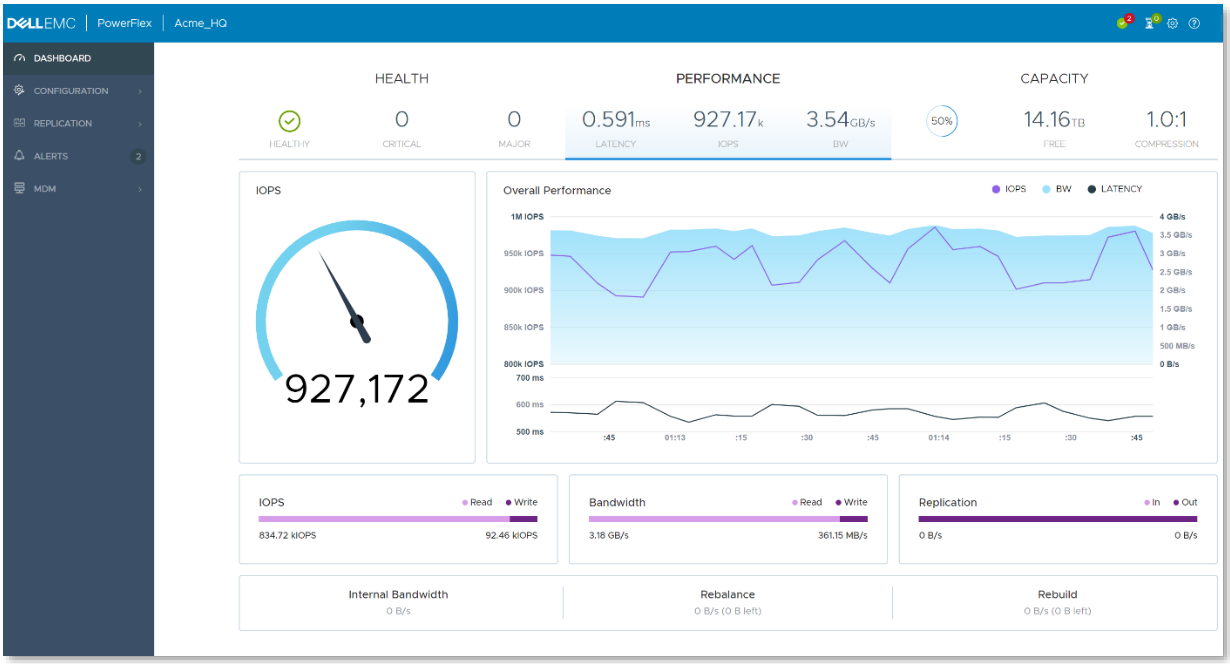


Figure 3 This primary dashboard view displays the majority of system activity at a single glance while also preserving the ability to drill into all PowerFlex elements to view or manage them.

2.5 Secure snapshots

Secure snapshots were added to meet customer business and statutory requirements for data retention.

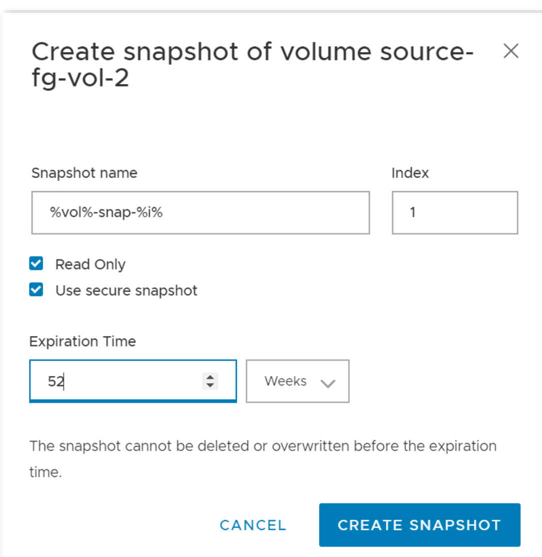


Figure 4 Secure snapshot with 1 year expiration time.

Once a snapshot is created with the secure option, it cannot be deleted until the assigned expiration time is reached. For cases where secure snapshots are created by mistake, or must be removed for other reasons, there is a formal process integrated with Dell support that must be followed to delete them. Note also that in 3.5, snapshots now can be created with read-only access, whether they are secure or not.

2.6 Core improvements

There are several core improvements in 3.5, but a few merit special mentions. Release 3.5 adds a Fine Granularity Metadata cache which eliminates the two-step metadata lookup required for FG volume read I/Os. Up to 32GB of FG pool metadata can be cached per SDS. The cache is not persistent and resides in DRAM. It is updated either on new reads after an SDS reboots or upon a cache-miss. This dramatically improves FG read performance for recent and frequently read IOs.

Data resiliency has been improved with two new features. Persistent checksum is now available for data residing on Medium Granularity storage pools, and this is enabled by default on volumes created after the upgrade to 3.5. Additionally, new Partial Disk Error handling prevents immediate media ejections and rebuild of entire drives when only a few sectors fail. This provides a longer useful life of your storage media.

For more information on the PowerFlex 3.5 release, refer to the *Getting to Know* document in the product documentation bundle found on the Dell EMC support site.

3 PowerFlex asynchronous replication architecture

To understand how replication works, we must first consider the basic architecture of PowerFlex itself.

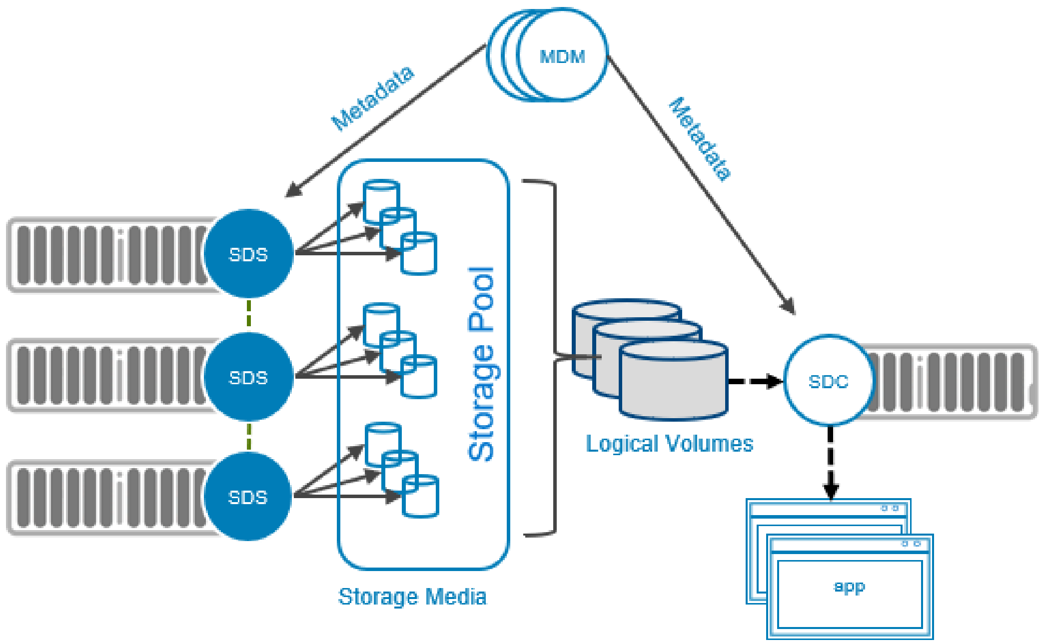


Figure 5 PowerFlex basic architecture diagram

Servers contributing media to a storage cluster run the Storage Data Server (SDS) software element which allows PowerFlex to aggregate the media while sharing these resources as one or more unified pools on which logical volumes are created.

Servers consuming storage run the Storage Data Client (SDC) which provides access to the logical volumes via the host SCSI layer. Note that iSCSI is not used, but instead, a resilient load-managing, load-balancing network service which runs on TCP/IP storage networks.

The Metadata Manager (MDM) controls the flow of data through the system but is not in the data path. Instead, it creates and maintains information about volume distribution across the SDS cluster and distributes the mapping to the SDC informing it where to place and retrieve data for each part of the address space.

These three base elements comprise the fundamental parts of best software-defined storage solution today, one that scales linearly to hundreds of SDS nodes.

When considering architectural options for replication, maintaining the scalability and resiliency of PowerFlex was critical. The replication architecture in PowerFlex is a natural extension of the fundamentals just described.

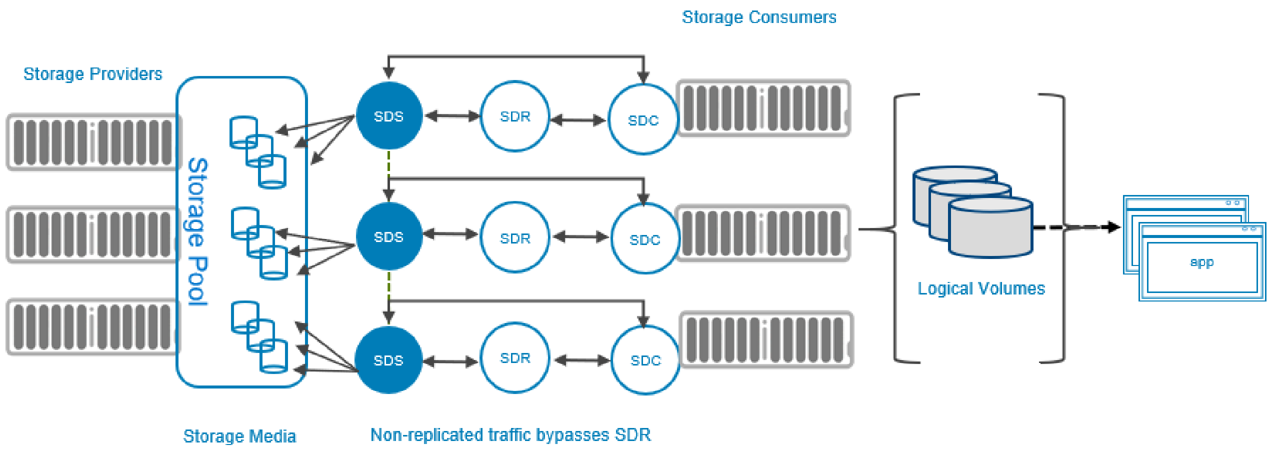


Figure 6 PowerFlex basic replication architecture

PowerFlex 3.5 introduces a new storage software component called the Storage Data Replicator. Figure 6 depicts where it fits into the overall PowerFlex architecture. Its role is to proxy the I/O of replicated volumes between the SDC and the SDSs where data is ultimately stored. It splits write I/Os sending one copy on to the SDSs and another to a replication journal volume. As it sits between the SDS and SDC, from the point-of-view of the SDS, the SDR appears as, and behaves as, an SDC sending writes. Conversely, to the SDC, the SDR appears as, and behaves as, an SDS to which writes can be sent.

The SDR only mediates the flow of traffic for replicated volumes, and as always, the MDM instructs each of these elements where to read and write data. Writes related to non-replicated volumes passes directly from the SDC to the SDSs, as always. This is facilitated by the volume mapping presented to the SDC by the MDM, determining which volume's data is sent directly to the SDSs, and which volume's data is routed through the SDR and then to the SDS.

3.1 Journaling and snapshotting

There are two schools of thought concerning how replication is implemented. Many storage solutions leverage a snapshot approach. With snapshots, it is easy to identify the block change delta between two points in time. However, as Recovery Point Objectives get smaller, the number of snapshots increase dramatically, which places hard limits on how small RPOs can be. Instead, PowerFlex uses a journaling-based approach.

Journaling provides the possibility of very small RPOs, and, importantly, it is not constrained by the maximum number of available snapshots in the system, or on a given volume.

Checkpoints are maintained in journals, and those journals live as volumes in a storage pool. The journal volumes resize dynamically as writes ebb and flow, so the overall size of the journal buffer will vary over time.

3.2 Journaling space reservations

The reservation size of the journal volume is set by the user and is measured as a percentage of the storage pool in which it is contained. For cluster installations that do not require replication, no journal space reservations are made. This brings up our first system design consideration concerning replication. **We need space in one or more storage SSD or NVMe pools to provide a home for journal files**. To determine how much space, account for all the write I/O of your replicated volumes including the aggregated write size and rate. Add a margin of safety of 15% for the volume overhead, journal write timestamps, and the journal-related handshaking. Consider also that you should always maintain enough free space reserves to sustain a complete SDS node ejection. These additional node ejection reserves should be proportionate to the percentage of storage space contributed by a single node, or multiple nodes for cases where Protected Maintenance Mode may be used simultaneously on multiple nodes. Consider snapshots as well. If writes have been issued to writable snapshots, that should be accounted for in your free space reservations.

When sizing the journal volume reservation, also consider the possibility of a **communications failure** to the remote site. If the journals are unable to transmit, the journals will fill the buffer, potentially filling it altogether. So, you must consider the maximum cumulative writes that might occur in that time. If the journal buffer space fills completely, the replica-pair volumes will require re-initialization.

For an example, we determine that an application generates 890MB/s of writes. Adding 15% overhead (plus an allowance for node ejection), we have 890MB/s x 1.15, which is 1.0235GB/s. Next, we have decided we wish to balance availability with storage conservation and allow a maximum of two hours of network failure between the two storage clusters. This translates to 1.0235GB/s * 7200 seconds which is 7.3693TB of data. Since the journaling reservation is expressed as a percentage, we divide our 7.3692TB of buffer space by the size of our storage pool which is 204TB. The space reservation for this app is then 3.6%. Repeat this for each application being replicated. If this is the only application being replicated, round the figure to 4%.

3.3 Journal management

Each cluster can be both a replication source and a target. This allows customers to split applications between clusters while protecting application availability for both.

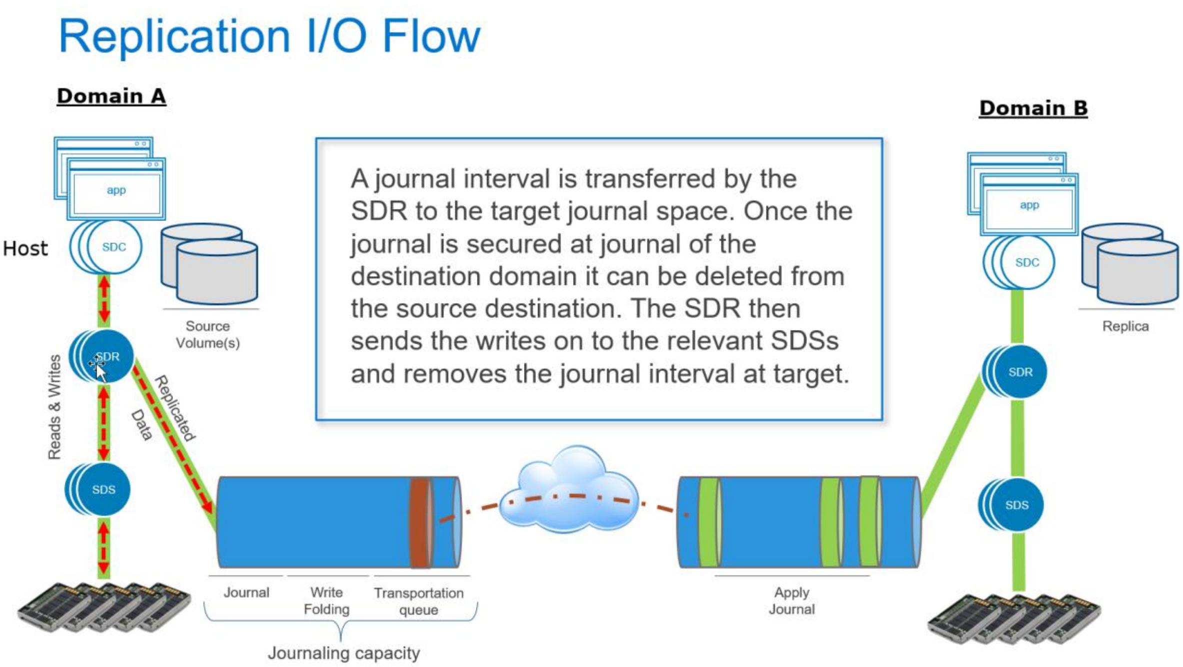


Figure 7 PowerFlex simplified replication I/O flow

The volume mapping on the source SDC sends writes for replicated data to the SDR, which duplicates the write and forwards it. The local SDSs process those writes normally, while the SDR assembles the journal files which contain checkpoints to preserve write order.

Journals are batched in the journal buffer on the source system. As they near the head of the queue they are scanned, and duplicate block writes are consolidated (folded) to minimize the volume of data being sent over the wire.

The journals are sent to the remote target journal buffer by the SDR over dedicated subnets on local or external networks assigned to replication and, once acknowledged, are removed.

On the target system, the journals are processed by the SDR, passing the writes on to the relevant SDSs. Remember, the SDS thinks the I/O is coming from an SDC, so the SDS manages the primary and secondary copy writes as usual. This addresses a commonly asked question: *How is compression affected?* Because the SDR is a mediator between the SDC and the SDS, it plays no role in compression. Compression occurs in the same way it did with the release of PowerFlex 3.0, with the SDS handling all aspects of compression. This means that data sent over the wire is not compressed.

Once the target SDR receives acknowledgment from the target SDS, it proceeds to the next write contained in the journal interval being processed. When the last write in a journal interval is processed and acknowledged, the interval space in the journal is made available for reuse.

There are a variety of other SDR processes working together to protect the integrity of your data, but this description covers all the fundamentals.

There is one limitation worthy of mention related to volume migration. It is not possible to migrate replicated volumes from one Protection Domain to another. This is due to the fact that the replication journals to not span Protection Domains.

4 Deploying and configuring PowerFlex clusters for replication

Proper system and storage sizing must be performed before deploying any new PowerFlex clusters. Replication adds additional sizing concerns. Your Dell Technologies technical sales resources have access to a system sizing utility which not only requires that your workload information is collected, profiled, and characterized, but also your replication footprint, and network design and infrastructure are accounted for.

There are additional cluster setup requirements to consider when adding asynchronous replication. We need

- A way for the clusters participating in replication to communicate securely.
- To group volume pairs together into consistency groups.
- Methods of testing failure, or even distributing workload without impacting the primary application.
- Configuring the physical WAN network for replicating externally when the target cluster is in another data center
- Additional IP addresses for replication activity

We will cover all these topics in this chapter.

4.1 Deployment and configuration

When deploying cluster pairs to be used with replication, there are a few required configuration steps.

4.1.1 The exchange of storage cluster Certificate Authority root certificates

CA root certificates must be exchanged between replicating clusters to protect from possible security attacks. Since this is a security-sensitive issue, this step is performed using the PowerFlex command line interface. On each system, a certificate is created and sent to the other host in the replicated pair. The command:

```
scli –extract_root_ca –certificate_file /tmp/sys0.cert
```

extracts the certificate from the cluster. The certificate is then manually copied to the partner cluster.

To import the certificate, on the partner system, we use a command of the following form:

```
scli –add_trusted_ca –certificate_file /tmp/sys0.cert –comment Acme_HQ
```

Once the certificates are generated, exchanged, and imported on both systems, the certificate step is complete.

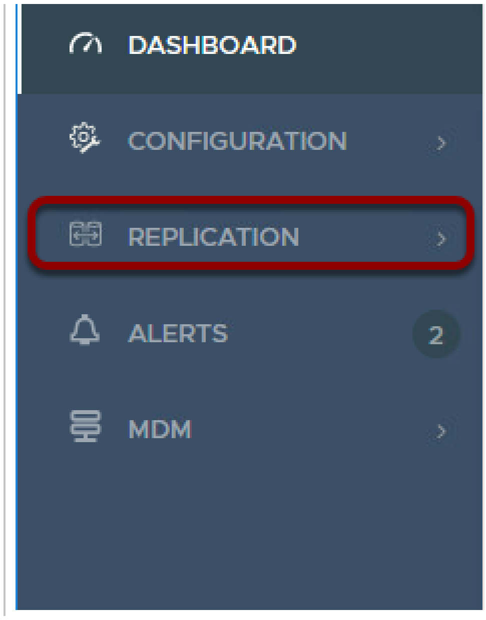
4.1.2 Peering storage clusters

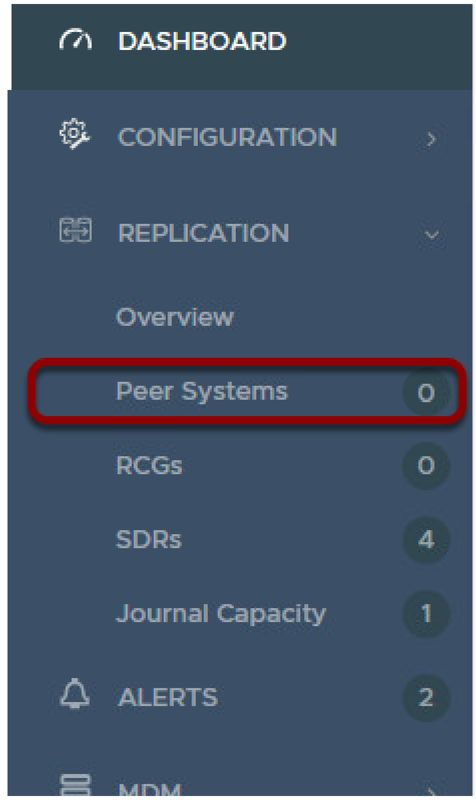
The next step required before configuring replicated volume pairs is Peering. Peering establishes the data paths between the systems. This can be done using the new PowerFlex HTML5-based WebUI, but there is one piece of critical information we will need first. We will use the PowerFlex CLI to capture the MDM System IDs for both storage clusters by logging into the PowerFlex CLI. The act of authenticating to the cluster will reveal the required cluster IDs. You will need the IDs from both the source and the target systems.

```
[root@primary1 scripts]# scli --login --username admin --password
Logged in. User role is SuperUser. System ID is 0c7d77bf6161800f
[root@primary1 scripts]#
```

Figure 8 Capturing a PowerFlex system ID

To begin peering, navigate to the REPLICATION tab in the PowerFlex WebUI and expand it by clicking on it.





From there, select the **Peer Systems** tab.

- To add the system peer, click the **ADD** button.

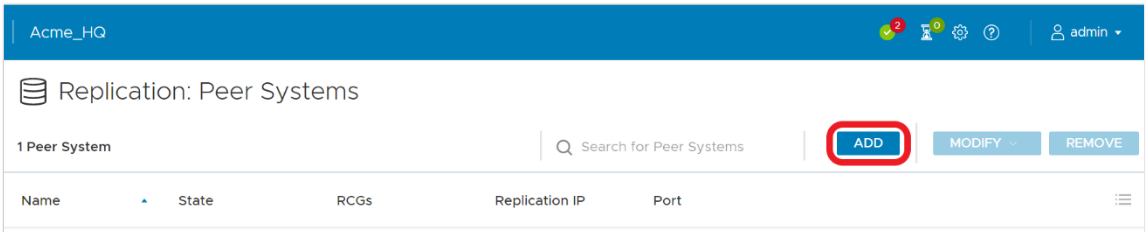


Figure 9 Add peer

- And lastly, complete the form by clicking **Add Peer**.

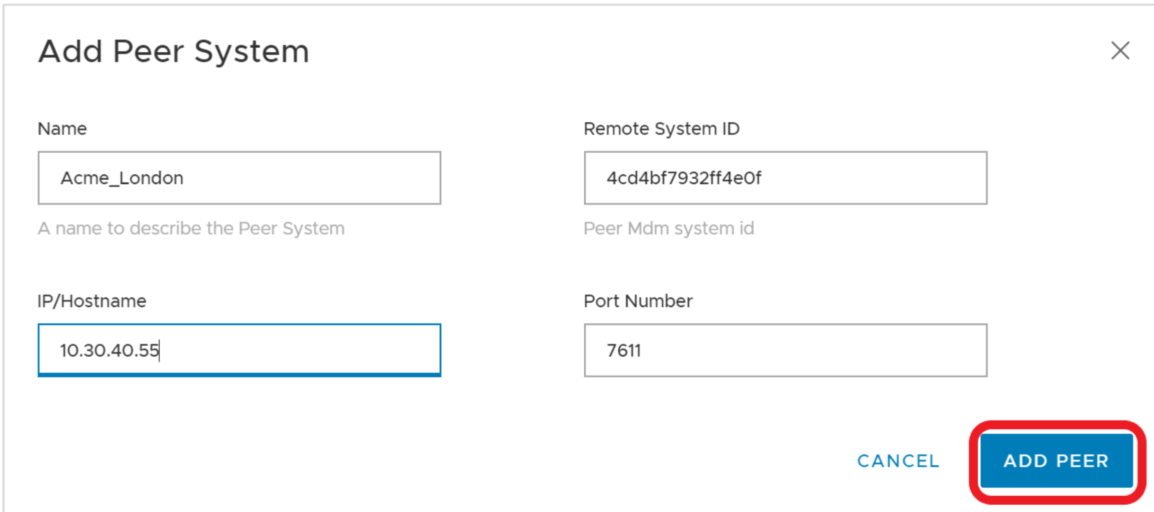


Figure 10 Add peer system

- Once you add the peer, repeat the process on the target storage cluster using the same steps, entering the remote system ID of the primary cluster. Once that is complete, the systems are peered in both directions, and you are ready to start pairing your replicated volumes.

4.2 Replication Consistency Groups

Replication Consistency Groups, or RCGs, establish the attributes and behavior of the replication of one or more volume pairs. One such attribute is the target replication storage cluster. While a given RCG can replicate to only one target cluster, in principle other RCGs may replicate to other clusters provided they have exchanged certificates and have been peered. In the initial release of PowerFlex native asynchronous replication, however, a source site may only be peered with one other site. Future releases will permit additional replication topologies.

Before creating RCGs, our replication volumes must exist on both the source and target systems, and they must be of the same size. But are not required to reside in a storage pool of the same type (MG vs. FG.), nor must they have the same properties (thick vs. thin, compressed vs. non-compressed). If there comes a time when a volume needs to be resized, the target volume should be expanded first. Expanding the volumes in this manner prevents any disruptions in replication. This means it is mandatory to know what volumes are being replicated, so that this practice is followed when data outgrows the volume.

RCGs are very flexible. For some use cases, you might assign all volumes associated with an application to a single RCG. For larger applications, you might create multiple RCGs based on data retention, data type, or related application quiescing procedures to enable read-consistent snapshots when needed. In general, RCGs are crash-consistent. Snapshots can be made read-consistent if application quiescing rules were followed when they were created. This places no special requirements on the storage platform, but generally requires scripting with the application.

Concerning Recovery Point Objectives specified in the RCG configuration, you will see in Figure 13 below, that they can be set between 30 seconds and 60 minutes. PowerFlex release 3.5, offers the smallest RPO of 30 seconds. Over time, this lower limit will be reduced as lower RPOs are validated for production use.

To create an RCG, log into the new WebUI and navigate **to REPLICATION->RCGs->ADD**.

This first step in creating an RCG involves providing:

- A name for the RCG
- The desired RPO
- The source Protection Domain
- The target system
- The target Protection Domain

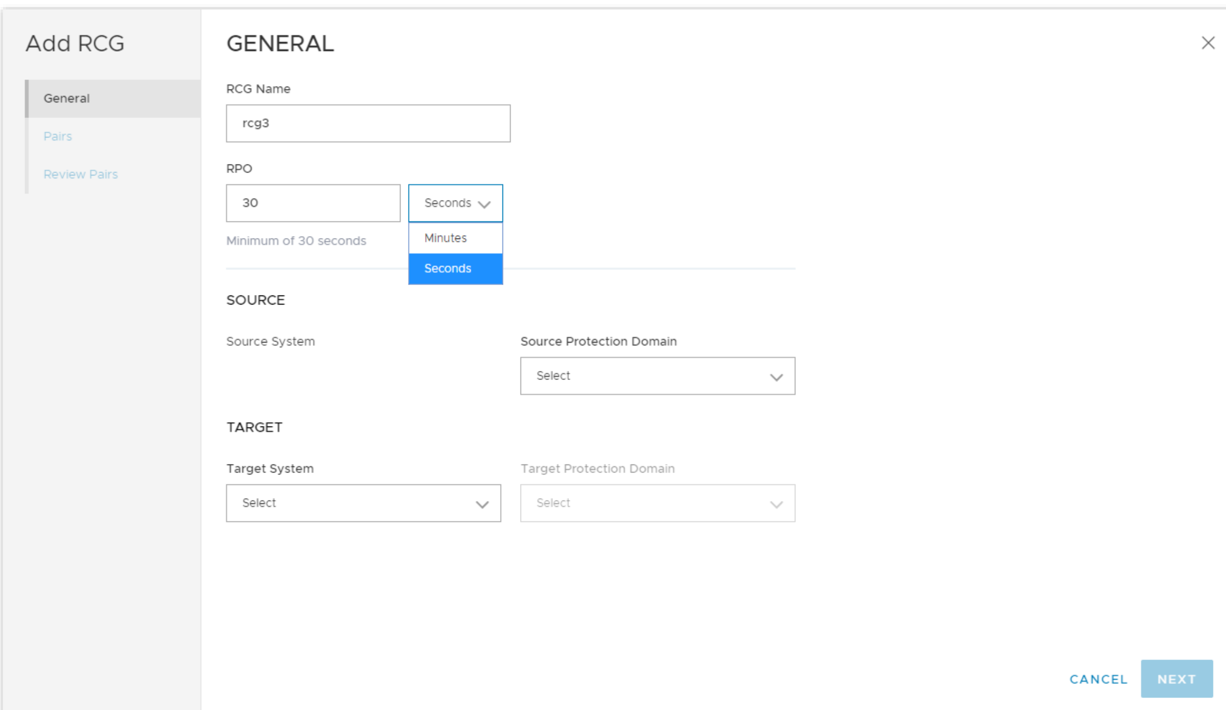


Figure 11   Add RCG > set RPO

To complete the operation, we will first match up the source and target volumes.

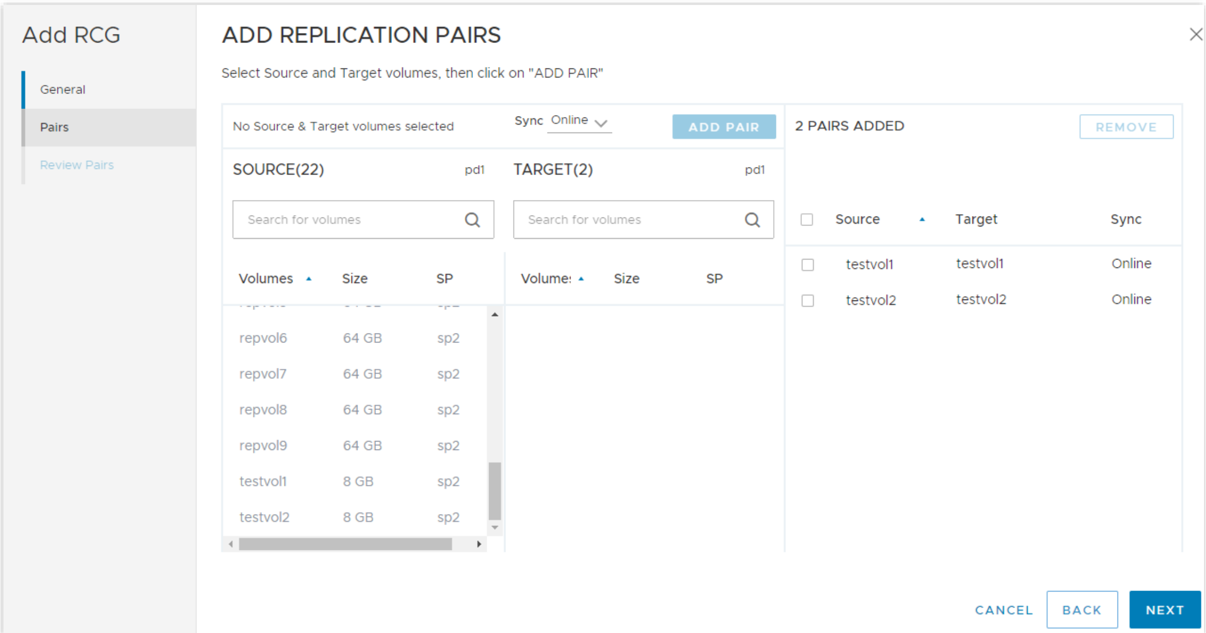


Figure 12 Add RCG > match source and target volumes

- Unpaired volumes appear in the source and target lists in dark text. When a source volume is selected, un-paired target volumes are highlighted provided they have the same capacity as the selected volume. Once the two volumes have been selected, the **ADD PAIR** button is selected, moving the volume pair into the list appearing on the right. Once all volumes have been added, proceed by clicking the **NEXT** button.
- A summary is then displayed where you can select pairs and remove them if needed.

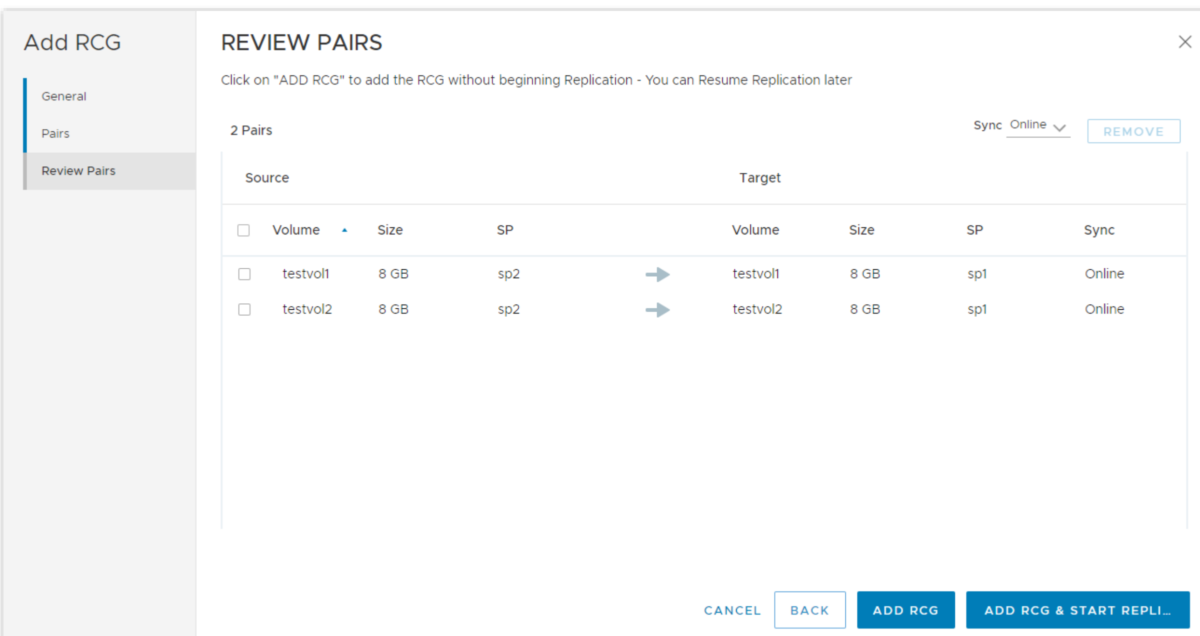


Figure 13 Add RCG > review pairs

- The final mouse click gives us the option of creating the RCG and initiating the volume synchronization immediately or deferring the synchronization when there might be concern of workload interference in production environments during periods of peak load.
- You do have the ability to add or remove volumes from an RCG at any time. Out of concern for excessive I/O and based on the size of the volumes you may elect to add only single volume pairs at a time to the RCG when it is first created, but this is usually not necessary.

5 Replication monitoring and configuration

5.1 The replication dashboard

The **REPLICATION > Overview** tab gives us a dashboard to determine the overall health of replication.

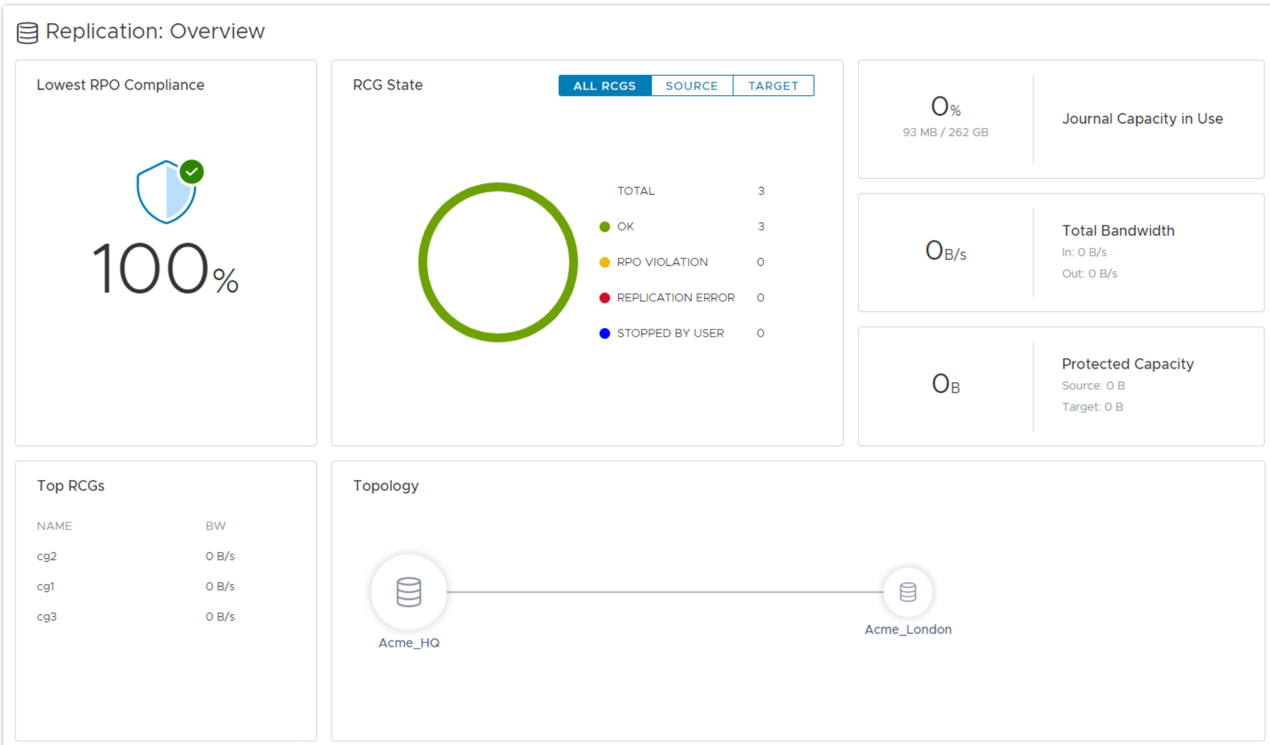


Figure 14 Replication overview

5.2 The Replication Consistency Group tab

- The **REPLICATION > RCGs** tab in the WebUI allows us to monitor the health and status of the individual Replication Consistency groups or add new ones.

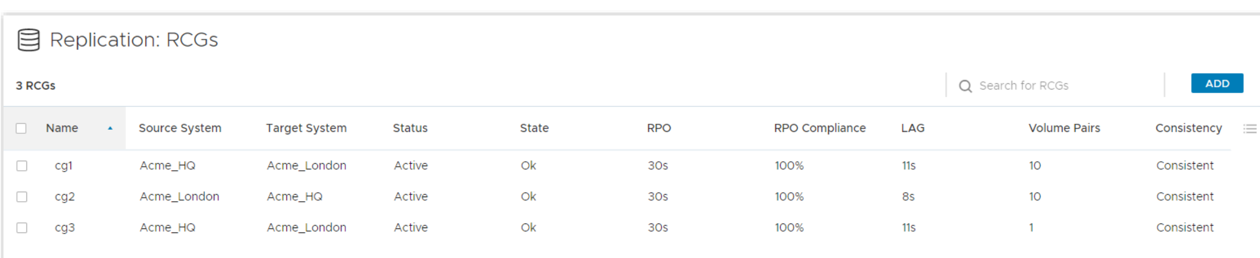


Figure 15 RCG overview

You can select any RCG by clicking on its checkbox, and once you do, there are management commands available to you.

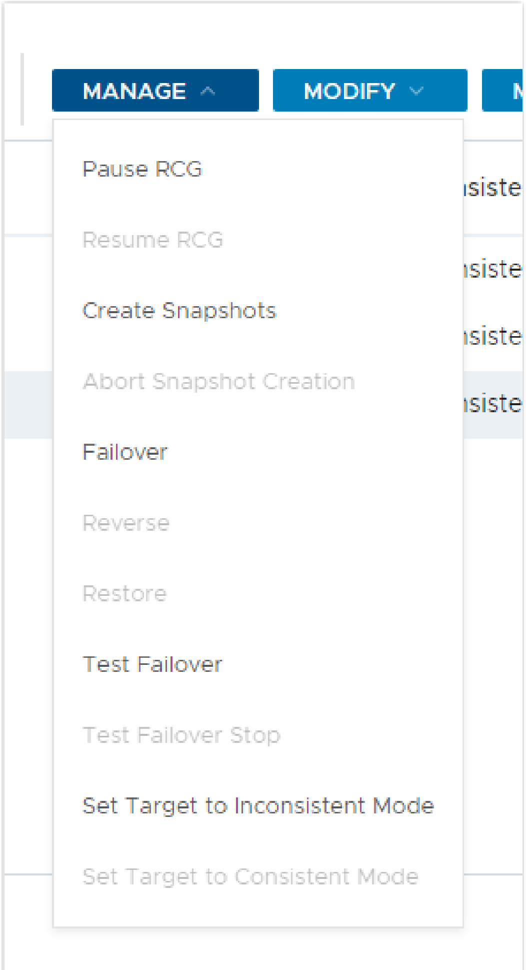


Figure 16 RCG management options

Pause: Pauses replication of writes. This prevents journals from being shipped to the target cluster until replication is resumed again.

Create Snapshots: Generates snapshots of each volume in the RCG on the target system. This can be useful for remotely testing an application or DR activity. There is no facility to delete the snapshots, so they will have to be unmapped and deleted manually on the target system.

Failover: Forces a failover event, passing primary ownership of the volumes within the RCG to the target system. Once this is done, for planned failovers, you can also select the **Reverse** command to keep the original source volumes in sync.

Test Failover: This automatically creates a snapshot on the target system and replaces the original target volume mapping with a mapping to the snapshot. Using this command, you can perform write testing to the volume while preventing the source volume from being corrupted by the test activity.

5.3 Volume access

There are some replication-related commands that can be performed in both the WebUI and the CLI, and in fact, most of them can be performed in the WebUI. These include

- Creating Volumes
- Mapping volumes for read-write access
- Creating Replication Consistency Groups

Other commands must be performed using the CLI or REST API, including

- Performing the Certificate Authority certificate exchange
- Mapping volumes for read-only
- Setting the target volume access mode for the RCG

Due to security concerns, the default behavior of a newly created Replication Consistency Group prevents the target system from reading the target volume. The access modes are defined as:

- no_access (default behavior)
- read_only

For RCGs created with the WebUI, one can grant target read_only volume access with the following command after logging into the PowerFlex CLI on the source system:

```
[root@primary1 scripts]# scli --modify_replication_consistency_group_target_volume_access_mode \
>       --replication_consistency_group_name cg1 \
>       --target_volume_access_mode read_only
Successfully modified Replication Consistency Group cg1's target volume access mode to read_only
[root@primary1 scripts]#
```

Once this command is issued, we can access all volumes included in the RCG on the target storage cluster.

5.3.1 Access mode for mapping the target volume

We are already familiar with mapping volumes and by default, volumes are mapped with **read_write** access. This creates a conflict with the mapping of target volumes. Since we have set the remote access mode of the Replication Consistency Group point-of-view to **read_only**, this is incompatible with the default mapping access mode of **read_write** volume mapping offered by the WebUI. Therefore, we must log onto the target system and manually map all volumes in the RCG to the target system using this command:

```
[root@secondary1 scripts]# scli --map_volume_to_sdc --volume_name testvol2 --sdc_name sdc1 --access_mode read_only
Successfully mapped volume testvol2 to SDC sdc1
[root@secondary1 scripts]#
```

Once this is done, you will be able to proceed with failover-related replication commands.

5.3.2 Test failover behavior

In Section 3.2, we discussed the Test Failover command which is found in the RCG command menu. Once the remote volume access and secondary cluster volume mapping tasks are completed, we can test the RCG failover, and attach our volumes to our application or filesystem. The act of issuing the Test Failover command will:

- Create a snapshot on the target system for all volumes attached to the RCG
- Replace the pointer used by the volume mapping for each volume with a pointer to its snapshot
- Change the access mode of the volume mapping of each volume on the target system to **read_write**

These steps all happen in milliseconds, making the volumes immediately write-accessible to the Storage Data Client. This means that you can do whatever you wish with the volumes, whether it is using them for opening a database, an application, or mounting a filesystem. Since they are snapshots, you can freely test your application, and if the storage pool is of the same type as the source system, your application will perform equally well. In some cases, you might use compression with fine granularity volumes on the primary, while your target volume might reside on medium granularity volumes. In this case, the application may perform better than in the production environment. This feature provides a few additional benefits:

- Enables you to perform resource-intensive operations on secondary storage without impacting production
- Test application upgrades on the target system without production impact
- Ability to attach different, and higher-performing compute systems or media in the target environment
- Ability to attach systems with different hardware attributes such as GPUs in the target domain
- Ability to run analytics on the data without impeding your operational systems
- Perform what-if actions on the data because that data will not be written back to prod
- Eliminates many manual storage tasks because the test is fully automated along with the snapshots

In summary, replication testing can be leveraged to reduce impact and risk.

5.3.3 Failover behavior

When the RCG Failover command is issued, the access mode of the original source volumes switches to **read_only**. This means that in the case of planned fail-over, you are required to shut your applications down. The access mode of the target volumes switches to **read_write**. There is nothing else to do, and the behavior is the same if the failover is issued from the command line interface or REST API. If the failover is of a planned nature such compute node maintenance, but the original storage cluster continues functioning, you have the option of initiating the RCG command to **reverse** replication. This keeps the volume pairs in sync. If you will be shutting down the primary system for a prolonged period, you will likely have to re-initialize your volume pairs.

One thing to bear in mind is that each PowerFlex storage system creates unique volume and SCSI IDs, so they will be different for the source and target systems.

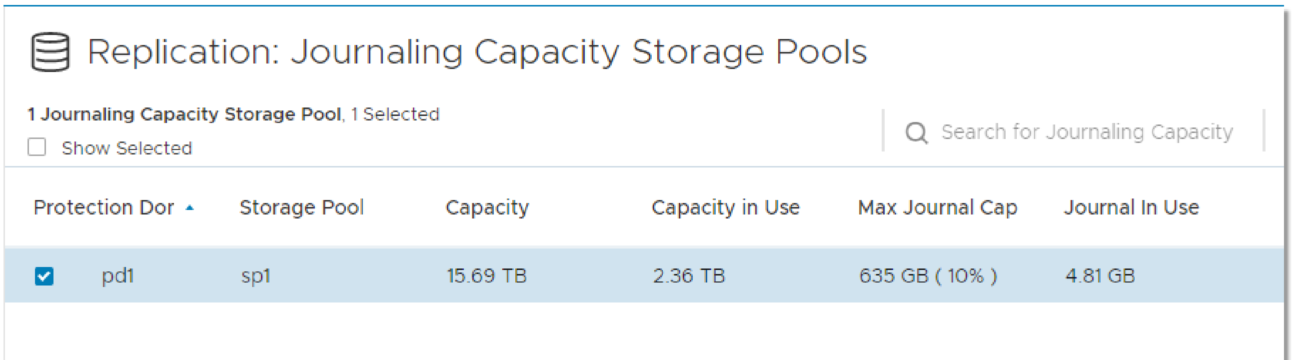
5.3.4 Create snapshots behavior

This RCG command creates snapshots for all volumes attached to the RCG on the target side, but it does not manage the snapshots any further. Consuming the snapshots is done separately. From there, to test your applications, you would need to:

1. Map the volumes to a target SDC compute system(s)
2. Use the volumes as needed
3. Un-map the volumes when they are no longer needed
4. Delete the snapshots

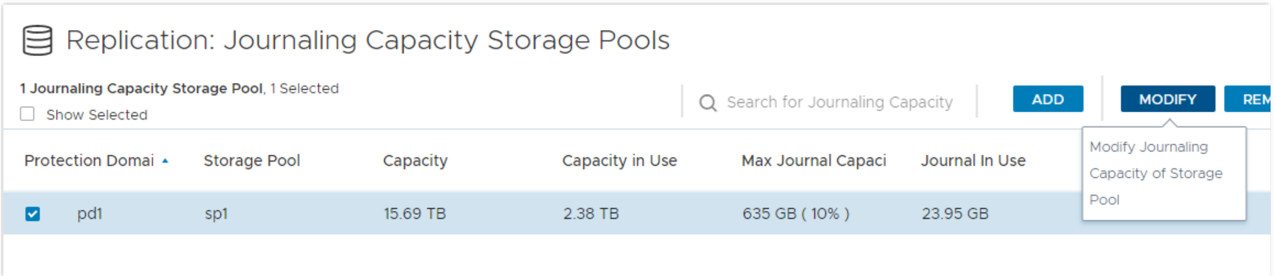
5.3.5 Monitoring journal capacity and health

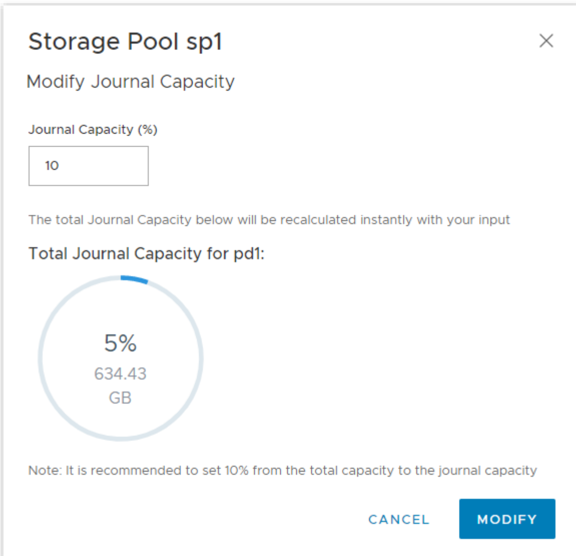
By logging onto the WebUI and navigating to REPLICATION > Journal Capacity you can track the utilization of your Journal space reservation(s).



Here, we see that we have reserved 10% or 636GB of Storage Pool sp1 for journaling, and we currently have 4.8GB of journal content in use. If there is concern that the space reservation is too small or large, you can change it at any time.

Just click on the storage pool checkbox and click on the Modify command. You can now change the reservation if you wish.





6 PowerFlex 3.5 networking considerations

All networking topologies, availability, and load balancing options previously recommended remain fully supported. However, PowerFlex replication adds a possible wrinkle in the network fabric that we need to account for. There is some network overhead (~15%) associated with replication and related journaling activity.

6.1 TCP/IP port considerations

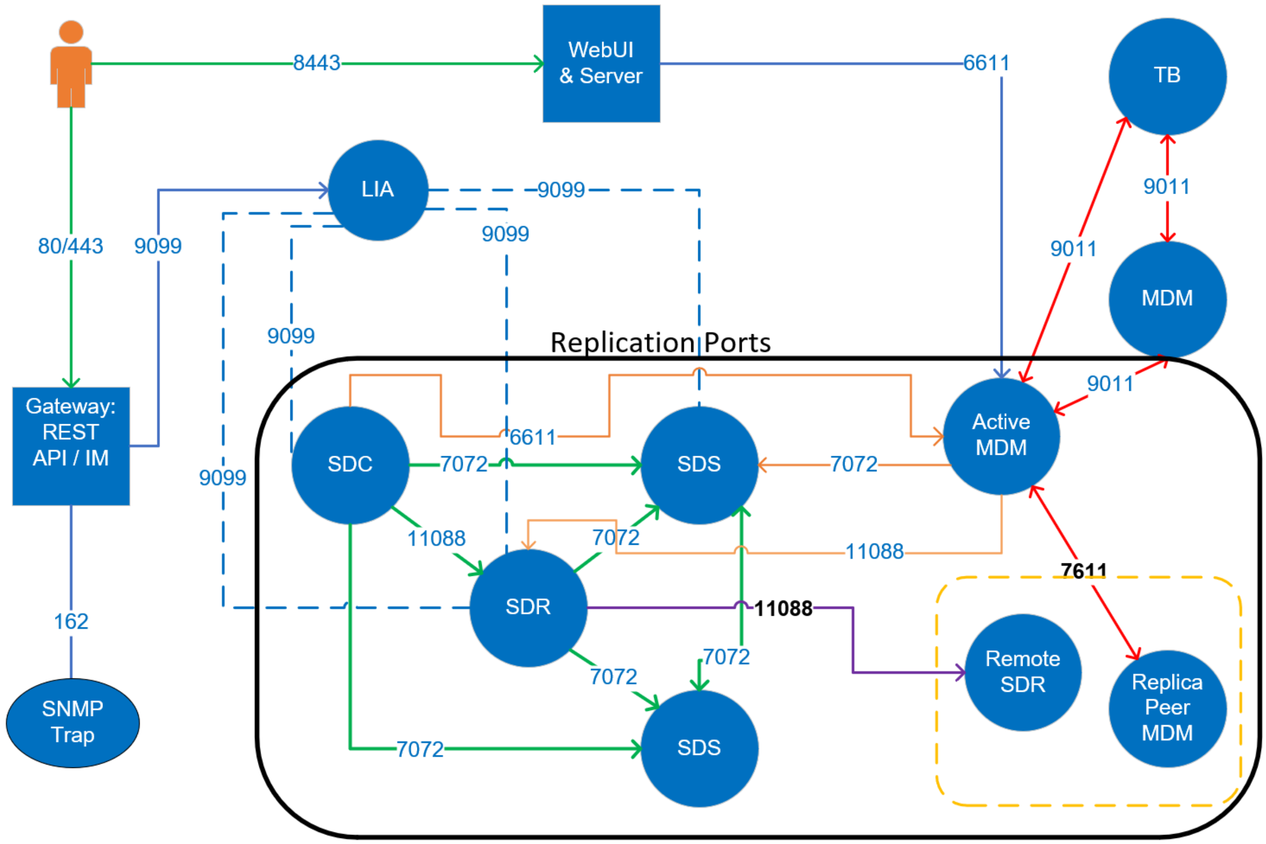


Figure 17 PowerFlex port and traffic overview

This diagram above provides us with a representation of all the logical software components of PowerFlex as well as the TCP/IP ports used by those components. We see the ports which must be associated with firewall rules on our PowerFlex server hosts. We can also see, the ports related specifically to remote replication which include:

1. Port 11088 which links the SDC and MDM to the SDR and also links the SDR to the remote SDR.
2. Port 7611 which allows MDM communications between two replicating clusters.

6.2 Network bandwidth considerations

First, there are general considerations for communications between replicating clusters. **The volume of writes cannot exceed the networking bandwidth of the intra-cluster networks**. Also **factor in 15% for the overhead of replication processing**. Plan that at least one path in the intra-cluster network will fail and make certain the expected write bandwidth can be sustained with latencies falling within the requirements of your applications and service levels. Customers with newly deployed 25GbE networks, like those deploying the PowerFlex rack or appliance with four data networks are likely not effected.

6.3 Native PowerFlex 3.5 IP load balancing

Release 3.5 offers a transformative change. SDC network path failover time prior to this new release was greater than 15 seconds, causing issues for some highly I/O-sensitive applications. In 3.5, the path failover for native load balancing has now fallen to three seconds. Those customers who previously chose to deploy LACP for that reason can now revert to native networking if they choose to do so.

6.4 Remote replication networking

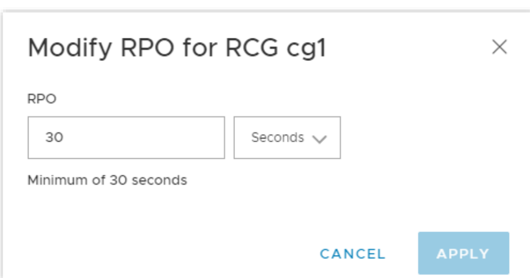
For networking configurations where access to the remote cluster passes through a static routed WAN, or where the networking baseline latency is greater than 50ms, the greatest concern is latency. For any configuration, there is a latency limit of 200ms, which is a potential issue for remote clusters. For network paths exceeding 200ms, it is likely a path approaching from the other side of the Earth will perform better. This configuration will require at least two subnets connected to the target system, and with the higher latency, bandwidth can become an issue, so thoroughly test the latency and throughput limits of your links and keep the replication bandwidth under your known thresholds!

For planning purposes, in addition to the 15% replication overhead, leave a 20% margin of safety for replication traffic over a WAN.

Cross-site traffic must be considered to greater extent here since the traffic passes over the WAN to the cluster at the remote site.

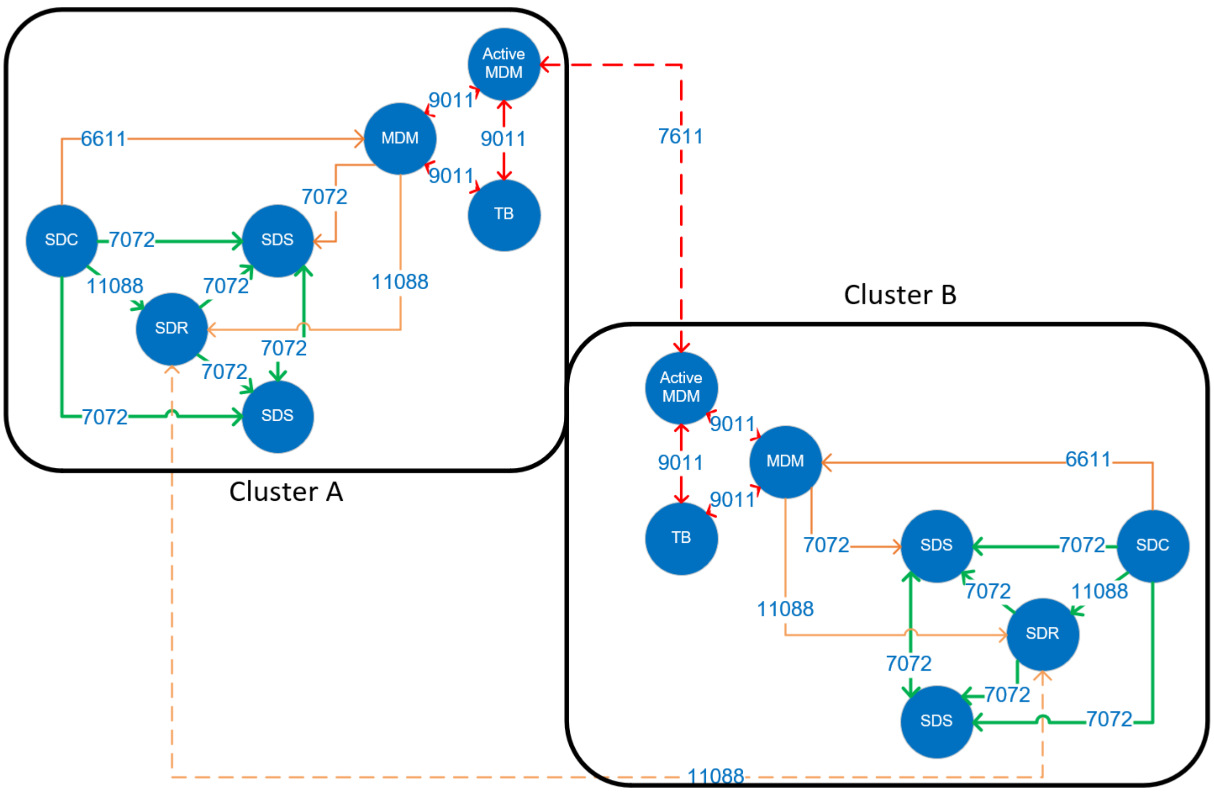
Refer to the product Networking Best Practices guide for more information.

In certain cases, when latency is high, you will likely need to increase the RPO of your Replication Consistency Groups. This can be done in the RCGs tab. Visit **REPLICATION > RCGs**, select an RCG, and click the **Modify > Modify RPO** command to increase the RPO value.

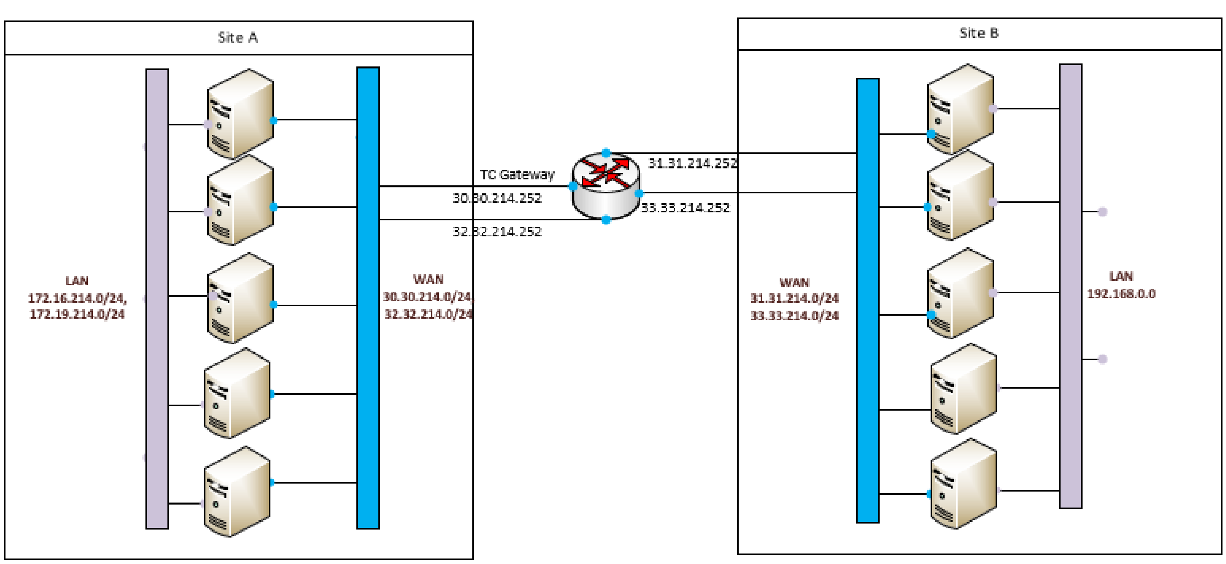


6.4.1 Routing and firewall considerations for remote replication

Section 6.1 emphasized TCP/IP ports for MDM (7611) communications between replicating clusters as well as SDR (11088) communications used in transporting replication journal logs.



For replication use cases involving distant clusters, we will need interconnectivity for these IP ports provided over routed networks. The best practice for networking in this situation is to reserve two networks for intra-cluster SDR and MDM communications. Here is an example of such a configuration.



This configuration contains interconnected WAN switches at both ends. As an example, for Cisco switches the following command sequences would be in order.

The routes from the primary WAN switch to the gateway:

```
hostname(config)# route flex-mdm-sdr1 30.30.214.0 255.255.255.0 192.168.1.1
hostname(config)# route flex-mdm-sdr3 32.32.214.0 255.255.255.0 192.168.1.2
```

The routes from the secondary WAN to the gateway:

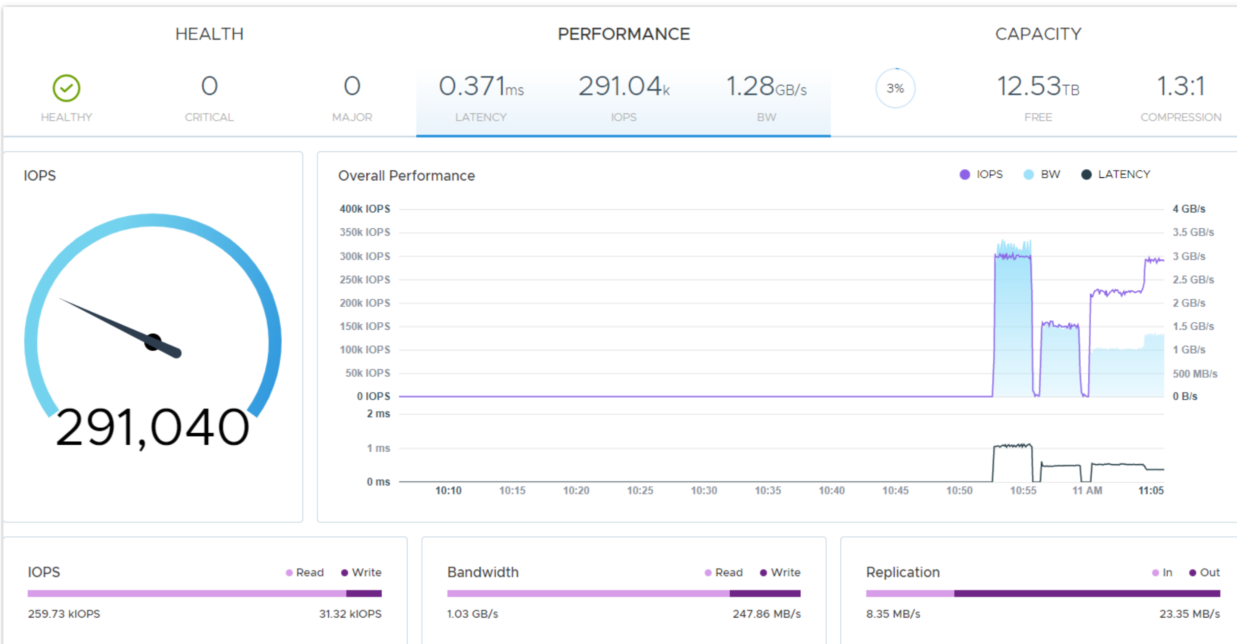
```
hostname(config)# route flex-mdm-sdr2 31.31.214.0 255.255.255.0 192.168.1.1
hostname(config)# route flex-mdm-sdr4 33.33.214.0 255.255.255.0 192.168.1.2
```

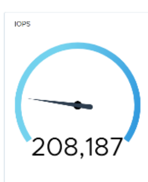
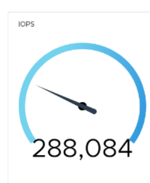
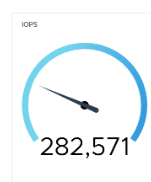
7 System component, network, and process failure

For our final considerations related to replication, we must face the reality that servers, processes, and network links do periodically fail. The following tests account for a few of these types of failures. The tests were performed on a 6-node R740xd PowerFlex node cluster with three SSDs per storage pool. Replication was active on both storage pools at the time of the failures.

7.1 SDR failure scenarios

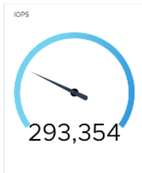
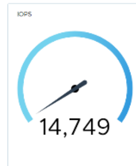
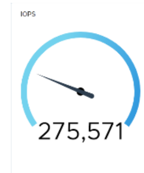
Let us start with a baseline workload. We will go on to fail an SDR, observe the impact, and observe the later impact of restarting it.



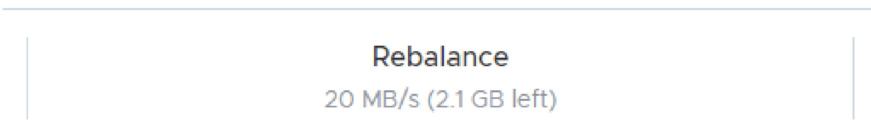
		
Immediately after failing the SDR, we see a drop in I/O processing	The I/O resumes slightly lower	After restarting, the I/O is slightly impacted, but eventually ramps back up to the baseline.

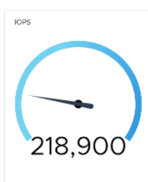
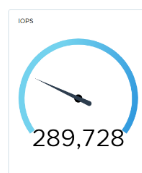
7.2 SDS failure scenarios

We will perform the same test for SDS failure.

		
Baseline workload	IOPs just after fail the SDS	Five seconds later, it starts ramping up and within 10 seconds resumes the baseline workload indicating the system was more than capable of handling the workload with five active SDS systems

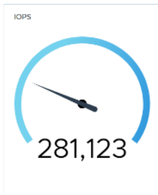
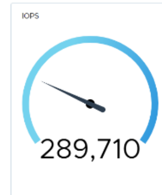
And as expected, we see rebalance activity



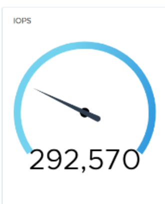
	
Next, we restart the failed SDS, and we see an immediate drop, but not substantial after restarting the SDS	As the rebalance continues, the I/O ramps back up to the baseline

7.3 Network link failure scenarios

Now, we will fail a network link to demonstrate how the updated native load balancing affects our I/O rate. The system has a network configuration consisting of four data links between systems.

		
Again, we establish a baseline	We fail a link and notice a 3-second drop in I/O	5 seconds later, the baseline returns

After reconnecting the failed port, the baseline I/O level resumes within a few seconds with no noticeable dip.



All these failure scenarios demonstrate the resilience of PowerFlex. It also shows that the system is well tuned, and that rebuild activity does not severely impact our workload.

8 Conclusion

You should now have a better understanding of PowerFlex 3.5 native asynchronous replication including configuration and the journaling method selected.

In summary, it is recommended you start small. Follow the recommendations mentioned. Account for the total replication bandwidth, including all write I/O of all your replicated data. Size your journaling space reserves as recommended. Include margins of error for network and component failure. Include 15% overhead for the replication process itself as well, as possible failures of PowerFlex processes including SDS system or other component failures.

A Technical support and resources

Dell.com/support is focused on meeting customer needs with proven services and support.

Storage technical documents and videos provide expertise that helps to ensure customer success on Dell EMC storage platforms.