Introduction

ONTAP 9

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Introduction

Learn about ONTAP SnapMirror active sync

SnapMirror active sync, also known as SnapMirror Business Continuity (SM-BC), allows business services to continue functioning in the event of a complete site failure. This technology enables applications to failover seamlessly to a secondary copy without manual intervention or custom scripting.

NetApp SnapMirror active sync (SM-as) is designed to be a more granular, lower-cost, easier-to-use application-level protection with automatic failover. SnapMirror active sync enables mission-critical business services to keep operating, even during a complete site failure. With SnapMirror active sync, you can now synchronously replicate multiple volumes of an application (by adding them to a consistency group) between sites at geographically dispersed locations. You can automatically failover to the secondary copy in case of disruption of the primary, thus enabling business continuity for tier one applications.

Regulations for financial institutions in some countries require businesses to periodically be serviceable from their secondary data centers. SnapMirror active sync, with its high availability clusters, enables these data center switchovers for business continuity.

Available beginning with ONTAP 9.9.1, SnapMirror active sync is supported on AFF and All-Flash SAN Array (ASA) clusters. The primary and secondary clusters must be of the same type: either ASA, ASA r2, or AFF. SnapMirror active sync protects applications with iSCSI or FCP LUNs or NVMe namespaces.

SnapMirror active sync supports both symmetric and asymmetric configurations. Support for symmetric active/active was introduced in ONTAP 9.15.1. Symmetric active/active configuration allows both copies of a protected LUN to perform read and write I/O operations with bidirectional synchronous replication, enabling each LUN copy to serve local I/O requests.

Beginning July 2024, content from technical reports previously published as PDFs has been integrated with ONTAP product documentation. The ONTAP SnapMirror active sync documentation now includes content from *TR-4878: SnapMirror active sync*.

Benefits

SnapMirror active sync provides the following benefits:

- Continuous availability for business-critical applications.
- Ability to host critical applications alternately from primary and secondary sites.
- Simplified application management using consistency groups for dependent write-order consistency.
- The ability to test failover for each application.
- Instantaneous creation of mirror clones without impacting application availability.
- The ability to deploy protected and non-protected workloads in the same ONTAP cluster.
- LUN, NVMe namespace, NVMe subsystem, or storage unit identity remains the same, so the application sees them as a shared virtual device.
- The ability to reuse secondary clusters with flexibility to create instantaneous clones for application usage for dev-test, UAT or reporting purposes without impacting application performance or availability.

SnapMirror active sync allows you to protect your data LUNs or NVMe namespaces, which enables applications to fail over transparently for the purpose of business continuity in the event of a disaster. For more information, see Use cases.

Key concepts

SnapMirror active sync uses consistency groups to ensure your data is replicated. SnapMirror active sync uses the ONTAP Mediator or, beginning with ONTAP 9.17.1, the Cloud Mediator for automated failover, ensuring the data is served in the event of a disaster scenario. When planning your SnapMirror active sync deployment, it is important to understand the essential concepts in SnapMirror active sync and its architecture.

Asymmetry and symmetry

In symmetric active/active configurations, both sites can access local storage for active I/O. Symmetric active/active is optimized for clustered applications including VMware vMSC, Windows Failover Cluster with SQL, and Oracle RAC.

In asymmetric active/active configurations data on the secondary site is proxied to a LUN, namespace or storage unit.

For more information, see SnapMirror active sync architecture.

Consistency group

For AFF and ASA systems a consistency group is a collection of FlexVol volumes that provide a consistency guarantee for the application workload that must be protected for business continuity. In ASA r2 systems, a consistency group is a collection of storage units.

The purpose of a consistency group is to take simultaneous snapshot images of a collection of volumes or storage units, thus ensuring crash-consistent copies of the collection at a point in time. A consistency group ensures all volumes of a dataset are quiesced and then snapped at precisely the same point in time. This provides a data-consistent restore point across volumes or storage units supporting the dataset. A consistency group thereby maintains dependent write-order consistency. If you decide to protect applications for business continuity, the group of volumes or storage units corresponding to this application must be added to a consistency group so a data protection relationship is established between a source and a destination consistency group. The source and destination consistency must contain the same number and type of volumes.

Constituent

An individual volume, LUN, or NVMe namespace (beginning with ONTAP 9.17.1) that is part of the consistency group protected in the SnapMirror active sync relationship.

ONTAP Mediator

The ONTAP Mediator receives health information about peered ONTAP clusters and nodes, orchestrating between the two and determining if each node/cluster is healthy and running. ONTAP Mediator provides health information about:

- Peer ONTAP clusters
- Peer ONTAP cluster nodes
- Consistency groups (which define the failover units in a SnapMirror active sync relationship); for each consistency group, the following information is provided:
  - Replication state: Uninitialized, In Sync, or Out of Sync
  - Which cluster hosts the primary copy

- Operation context (used for planned failover)

With this ONTAP Mediator health information, clusters can differentiate between distinct types of failures and determine whether to perform an automated failover. ONTAP Mediator is one of the three parties in the SnapMirror active sync quorum along with both ONTAP clusters (primary and secondary). To reach consensus, at least two parties in the quorum must agree to a certain operation.

> Beginning with ONTAP 9.15.1, System Manager displays the status of your SnapMirror active sync relationship from either cluster. You can also monitor the ONTAP Mediator's status from either cluster in System Manager. In earlier releases of ONTAP, System Manager displays the status of SnapMirror active sync relationships from the source cluster.

ONTAP Cloud Mediator

ONTAP Cloud Mediator is available beginning with ONTAP 9.17.1. ONTAP Cloud Mediator provides the same services as ONTAP Mediator, except that it is hosted in the cloud using the NetApp Console.

Planned failover

A manual operation to change the roles of copies in a SnapMirror active sync relationship. The primary sites becomes the secondary, and the secondary becomes the primary.

Automatic unplanned failover (AUFO)

An automatic operation to perform a failover to the mirror copy. The operation requires assistance from the ONTAP Mediator to detect that the primary copy is unavailable.

Primary-first and primary bias

SnapMirror active sync uses a primary-first principle that gives preference to the primary copy to serve I/O in case of a network partition.

Primary-bias is a special quorum implementation that improves availability of a SnapMirror active sync protected dataset. If the primary copy is available, primary-bias comes into effect when the ONTAP Mediator is not reachable from both clusters.

Primary-first and primary bias are supported in SnapMirror active sync beginning with ONTAP 9.15.1. Primary copies are designated in System Manager and output with the REST API and CLI.

Out of Sync (OOS)

When the application I/O is not replicating to the secondary storage system, it will be reported as **out of sync**. An out of sync status means the secondary volumes are not synchronized with the primary (source) and that SnapMirror replication is not occurring.

If the mirror state is `Snapmirrored`, this indicates a SnapMirror relationship is established and the data transfer is complete, meaning the destination volume is up-to-date with the source volume.

SnapMirror active sync supports automatic resync, enabling copies to return to an InSync state.

Beginning with ONTAP 9.15.1, SnapMirror active sync supports automatic reconfiguration in fan-out configurations.

Uniform and non-uniform configuration

- **Uniform host access** means that hosts from both sites are connected to all paths to storage clusters on both sites. Cross-site paths are stretched across distances.
- **Non-uniform host access** means hosts in each site are connected only to the cluster in the same site. Cross-site paths and stretched paths aren't connected.

Uniform host access is supported for any SnapMirror active sync deployment; non-uniform host access is only supported for symmetric active/active deployments.

Zero RPO

RPO stands for recovery point objective, which is the amount of data loss deemed acceptable during a given time period. Zero RPO signifies that no data loss is acceptable.

Zero RTO

RTO stands for recovery time objective, which is the amount of time that is deemed acceptable for an application to return to normal operations non-disruptively following an outage, failure, or other data loss event. Zero RTO signifies that no amount of downtime is acceptable.

SnapMirror active sync configuration support by ONTAP version

Support for SnapMirror active sync varies depending on your version of ONTAP:

ONTAP version	Supported clusters	Supported protocols	Supported configurations
9.17.1 and later	• AFF • ASA • C-Series • ASA r2	• iSCSI • FC • NVMe for VMware workloads	• Asymmetric active/active Asymmetric active/active does not support ASA r2 and NVMe For more information about NVMe support, see NVMe configuration, support, and limitations. • Symmetric active/active

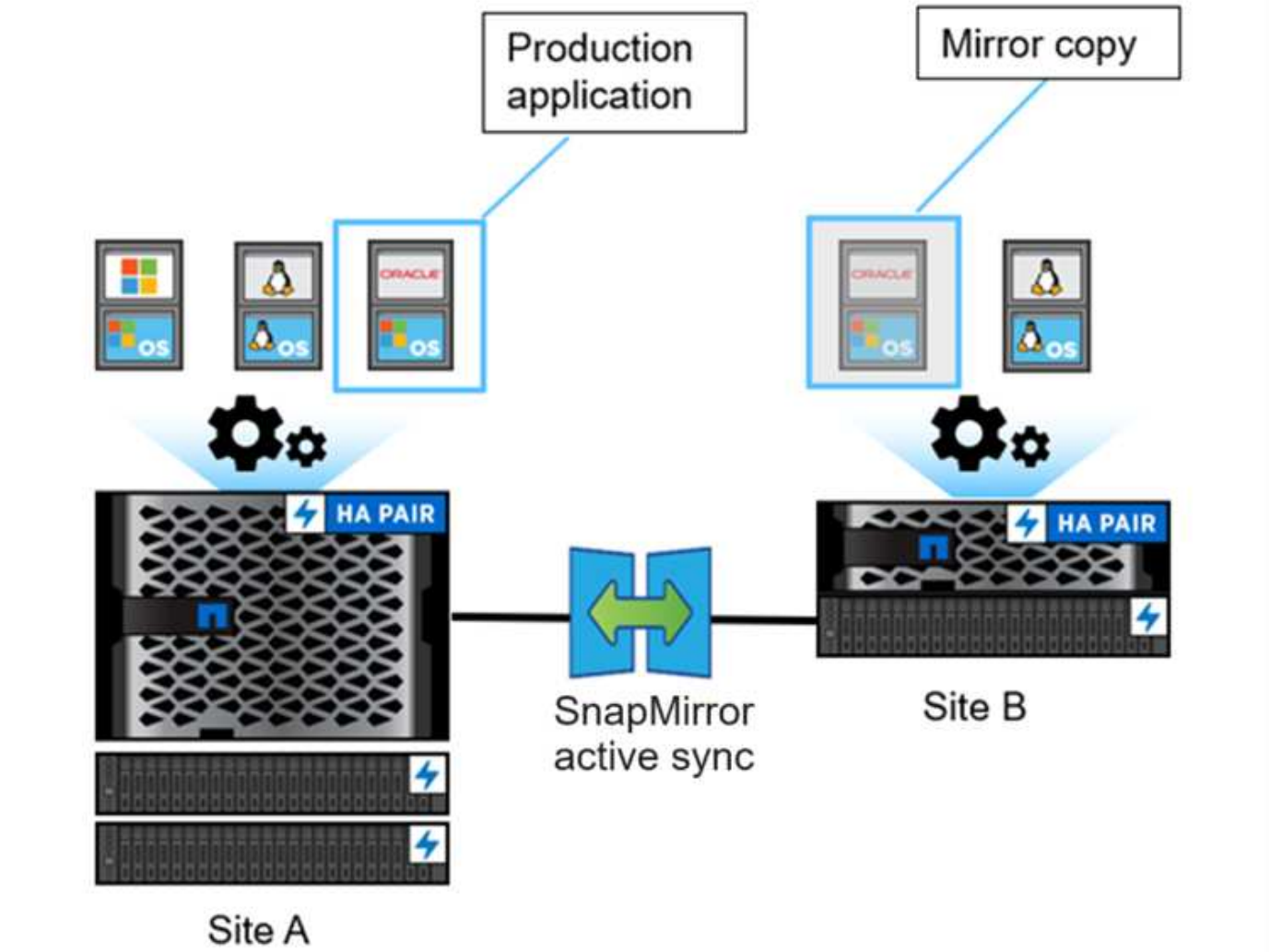
9.16.1 and later	• AFF • ASA • C-Series • ASA r2	• iSCSI • FC	• Asymmetric active/active • Symmetric active/active Symmetric active/active configurations support 4-node clusters in ONTAP 9.16.1 and later. For ASA r2, only 2-node clusters are supported.
9.15.1 and later	• AFF • ASA • C-Series	• iSCSI • FC	• Asymmetric active/active • Symmetric active/active Symmetric active/active configurations support 2-node clusters in ONTAP 9.15.1. 4-node clusters are supported in ONTAP 9.16.1 and later.
9.9.1 and later	• AFF • ASA • C-Series	• iSCSI • FC	Asymmetric active/active

Primary and secondary clusters must be of the same type: either ASA, ASA r2, or AFF.

ONTAP SnapMirror active sync architecture

The SnapMirror active sync architecture enables active workloads on both clusters, where primary workloads can be served simultaneously from both clusters. Regulations for financial institutions in some countries require businesses to be periodically serviceable from their secondary data centers as well, called "Tick-Tock" deployments, which SnapMirror active sync enables.

The data protection relationship to protect for business continuity is created between the source storage system and destination storage system, by adding the application specific LUNs or NVMe namespaces from different volumes within a storage virtual machine (SVM) to the consistency group. Under normal operations, the enterprise application writes to the primary consistency group, which synchronously replicates this I/O to the mirror consistency group.



Even though two separate copies of the data exist in the data protection relationship, because SnapMirror active sync maintains the same LUN or NVMe namespace identity, the application host sees this as a shared virtual device with multiple paths while only one LUN or NVMe namespace copy is being written to at a time. When a failure renders the primary storage system offline, ONTAP detects this failure and uses the Mediator for re-confirmation; if neither ONTAP nor the Mediator are able to ping the primary site, ONTAP performs the automatic failover operation. This process results in failing over only a specific application without the need for manual intervention or scripting which was previously required for the purpose of failover.

Other points to consider:

- Unmirrored volumes which exist outside of protection for business continuity are supported.
- Only one other SnapMirror asynchronous relationship is supported for volumes being protected for business continuity.
- Cascade topologies are not supported with protection for business continuity.

The role of mediators

SnapMirror active sync uses a mediator to act as a passive witness to SnapMirror active sync copies. In the event of a network partition or unavailability of one copy, SnapMirror active sync uses the mediator to determine which copy continues to serve I/O, while discontinuing I/O on the other copy. In addition to the on-

premises ONTAP Mediator, beginning with ONTAP 9.17.1, you can install ONTAP Cloud Mediator to provide the same functionality in a cloud deployment. You can use ONTAP Mediator or ONTAP Cloud Mediator, but you cannot use both at the same time.

The Mediator plays a crucial role in SnapMirror active sync configurations as a passive quorum witness, ensuring quorum maintenance and facilitating data access during failures. It acts as a ping proxy for controllers to determine the liveliness of peer controllers. Although the Mediator does not actively trigger switchover operations, it provides a vital function by allowing the surviving node to check its partner's status during network communication issues. In its role as a quorum witness, the ONTAP Mediator provides an alternate path (effectively serving as a proxy) to the peer cluster.

Furthermore, it allows clusters to get this information as part of the quorum process. It uses the node management LIF and cluster management LIF for communication purposes. It establishes redundant connections through multiple paths to differentiate between site failure and InterSwitch Link (ISL) failure. When a cluster loses connection with the Mediator software and all its nodes due to an event, it is considered not reachable. This triggers an alert and enables automated failover to the mirror consistency group in the secondary site, ensuring uninterrupted I/O for the client. The replication data path relies on a heartbeat mechanism, and if a network glitch or event persists beyond a certain period, it can result in heartbeat failures, causing the relationship to go out-of-sync. However, the presence of redundant paths, such as LIF failover to another port, can sustain the heartbeat and prevent such disruptions.

ONTAP Mediator

ONTAP Mediator is installed in a third failure domain, distinct from the two ONTAP clusters it monitors. There are three key components in this setup:

- Primary ONTAP cluster hosting the SnapMirror active sync primary consistency group
- Secondary ONTAP cluster hosting the mirror consistency group
- ONTAP Mediator

ONTAP Mediator is used for the following purposes:

- Establish a quorum
- Continuous availability via automatic failover (AUFO)
- Planned failovers (PFO)

ONTAP Mediator 1.7 can manage ten cluster pairs for business continuity.

When the ONTAP Mediator is not available, you cannot perform planned or automated failovers. The application data continues to synchronously replicate without any interruption for zero data loss.

ONTAP Cloud Mediator

Beginning with ONTAP 9.17.1, ONTAP Cloud Mediator is available as a cloud-based service in the NetApp Console for use with SnapMirror active sync. Similar to ONTAP Mediator, ONTAP Cloud Mediator provides the following functionality in a SnapMirror active sync relationship:

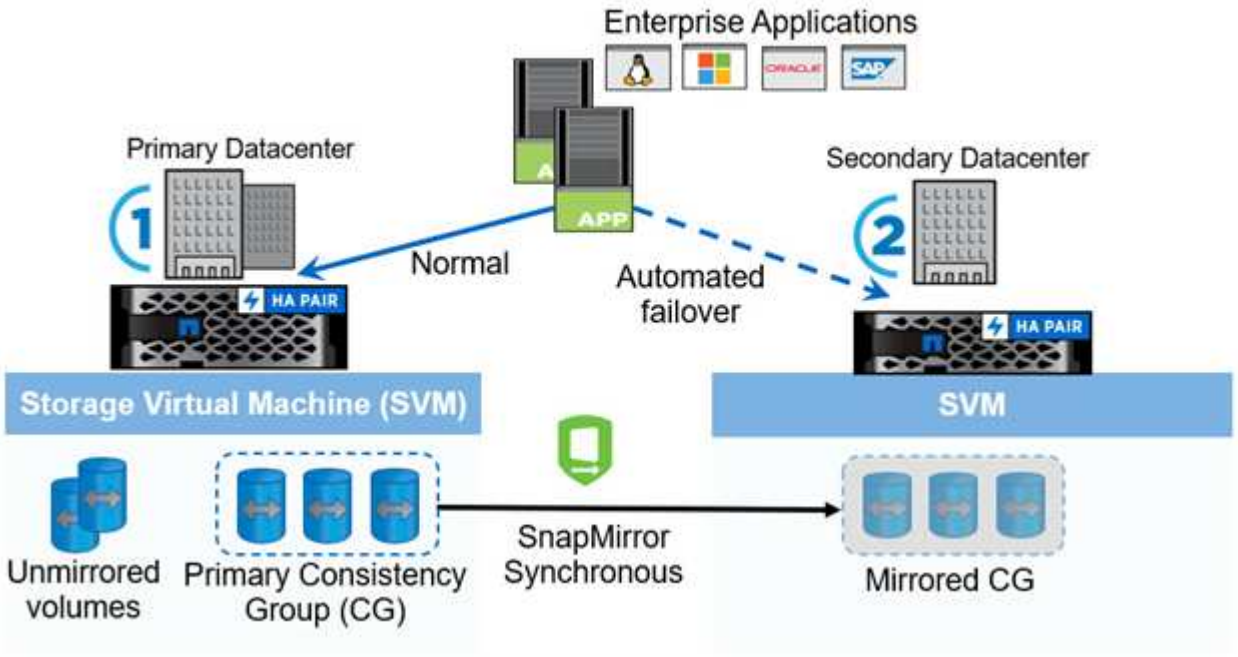
- Provides a persistent and fenced store for HA or SnapMirror active sync metadata.
- Serves as a ping proxy for controller liveliness.
- Provides synchronous node health query functionality to aid in quorum determination.

The ONTAP Cloud Mediator helps simplify SnapMirror active sync deployment by using the NetApp Console

cloud service as a third site that you do not need to manage. The ONTAP Cloud Mediator service provides the same functionality as the on-premises ONTAP Mediator; however, ONTAP Cloud Mediator reduces the operational complexity of maintaining a third site. In contrast, ONTAP Mediator is available as a package and must be installed on a Linux host running at a third site with independent power and network infrastructure for its operations.

SnapMirror active sync operation workflow

The following figure illustrates the design of SnapMirror active sync at a high level.



The diagram shows an enterprise application that is hosted on an storage VM (SVM) at the primary data center. The SVM contains five volumes, three of which are part of a consistency group. The three volumes in the consistency group are mirrored to a secondary data center. In normal circumstances, all write operations are performed to the primary data center; in effect, this data center serves as the source for I/O operations, while the secondary data center serves as a destination.

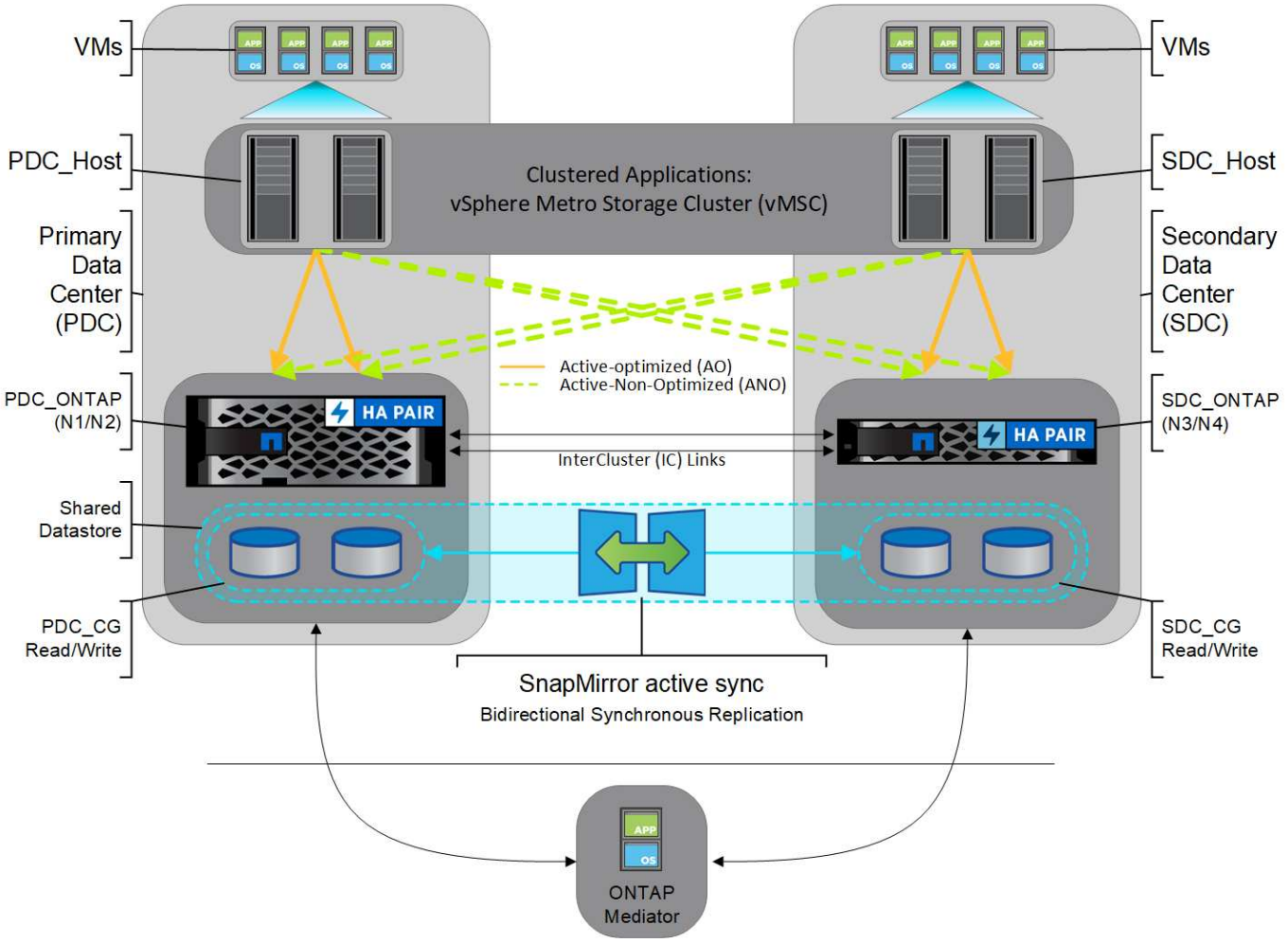
In the event of a disaster scenario at the primary data center, ONTAP directs the secondary data center to act as the primary, serving all I/O operations. Only the volumes that are mirrored in the consistency group are served. Any operations pertaining to the other two volumes on the SVM is affected by the disaster event.

Symmetric active/active

SnapMirror active sync offers asymmetric and symmetric solutions.

In *asymmetric configurations*, the primary storage copy exposes an active-optimized path and actively serves client I/O. The secondary site uses a remote path for I/O. The storage paths for the secondary site are considered active-non-optimized. Access to the write LUN is proxied from the secondary site. NVMe protocol is not supported in asymmetric configurations.

In *symmetric active/active configurations*, active-optimized paths are exposed on both sites, are host specific, and are configurable, meaning hosts on either side are able to access local storage for active I/O. Beginning with ONTAP 9.16.1, symmetric active/active is supported on clusters with up to four nodes. Beginning with ONTAP 9.17.1, symmetric active/active configurations support NVMe protocol on two node clusters.



Symmetric active/active is targeted for clustered applications including VMware Metro Storage Cluster, Oracle RAC, and Windows Failover Clustering with SQL.

Use cases for ONTAP SnapMirror active sync

The demands of a globally connected business environment demand rapid recovery of business-critical application data with zero data loss in the event of a disruption such as a cyber-attack, power outage, or natural disaster. These demands are heightened in arenas such as finance and those adhering to regulatory mandates such as the General Data Protection Regulation (GDPR).

SnapMirror active sync provides the following use cases:

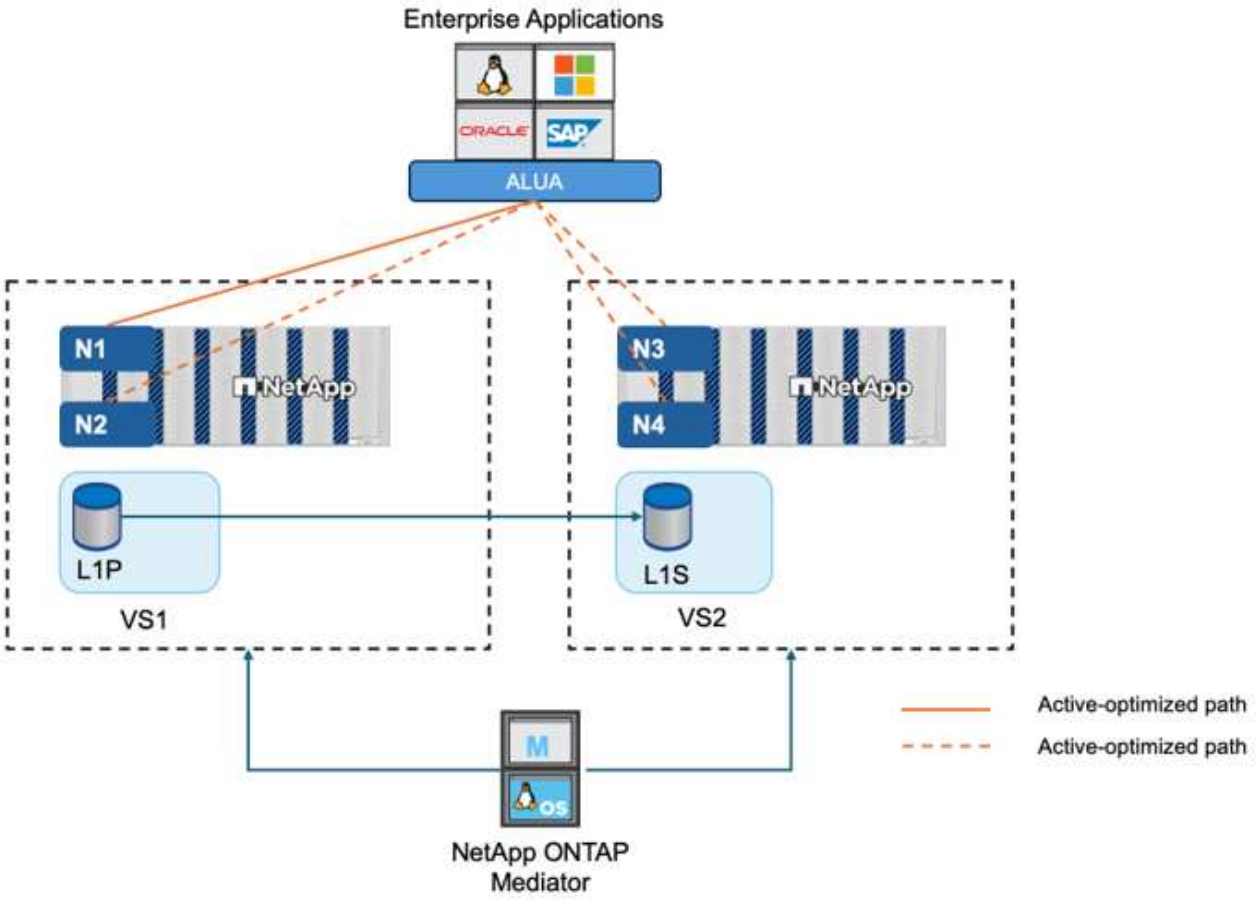
Application deployment for zero recovery time objective (RTO)

In a SnapMirror active sync deployment, you have a primary and secondary cluster. A LUN in the primary cluster (`L1P`) has a mirror (`L1S`) on the secondary; both LUNs share the same serial ID and are reported as read-write LUNs to the host. In asymmetric configurations read and write operations, however, are only serviced to the primary LUN, `L1P`. Any writes to the mirror `L1S` are served by proxy.

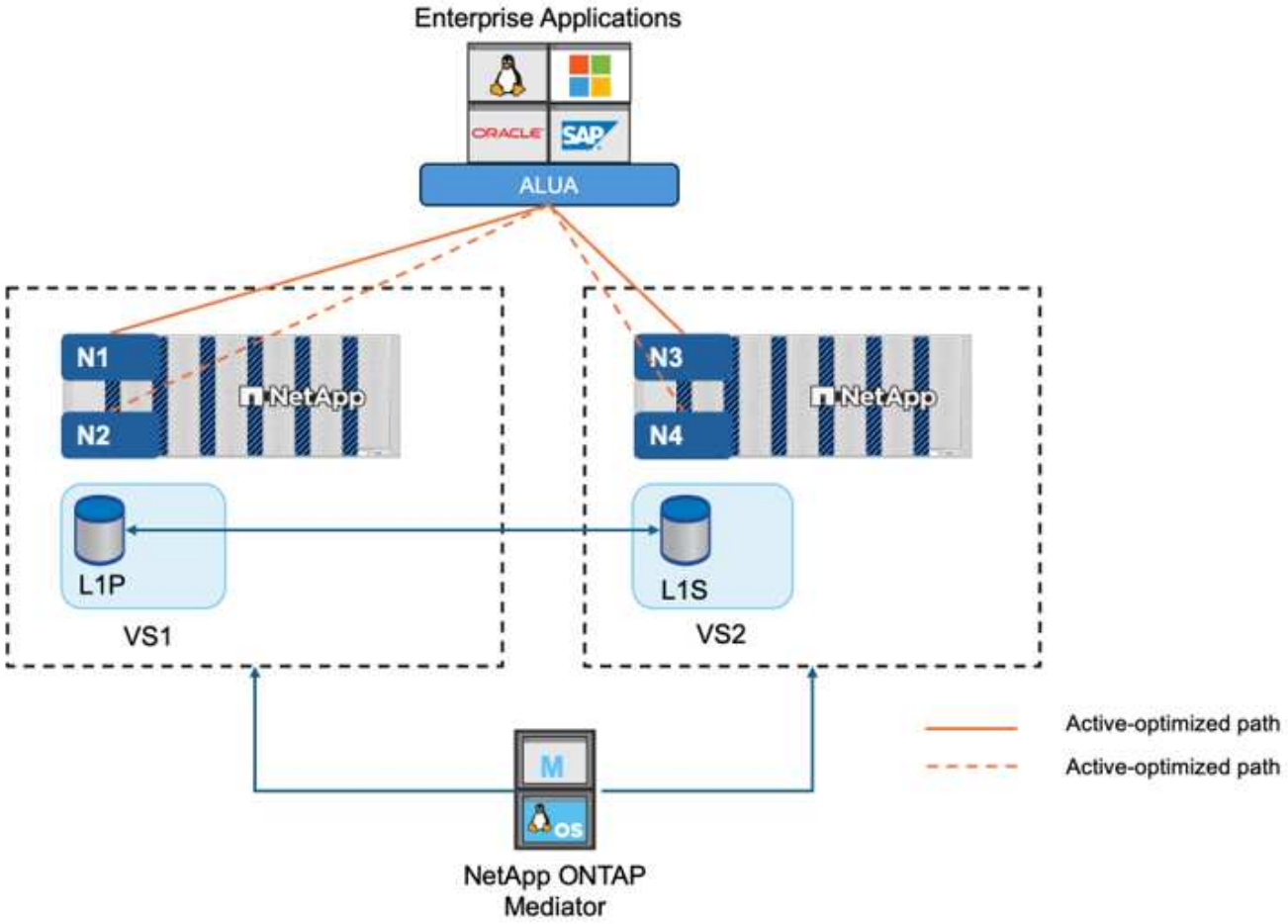
Application deployment for zero RTO or transparent application failover (TAF)

TAF is based on host MPIO software-based path failover to achieve non-disruptive access to the storage. Both LUN copies—for example, primary (L1P) and mirror copy (L1S)--have the same identity (serial number) and

are reported as read-writable to the host. In asymmetric configurations however, reads and writes are serviced only by the primary volume. I/Os issued to the mirror copy are proxied to the primary copy. The host's preferred path to L1 is VS1:N1 based on asymmetric logical unit access (ALUA) access state Active Optimized (A/O). ONTAP Mediator is required as part of the deployment, primarily to perform failover (planned or unplanned) in the event of a storage outage on the primary.



TAF operates in two modes: Automated Failover and Automated Failover Duplex. With Automated Failover, reads and writes are serviced only by the primary volume, therefore, IOs issued to the mirror copy (which cannot service writes on its own) are proxied to the primary copy. With Automated Failover Duplex, both the primary and secondary copies can service IOs so no proxy is necessary.



If you are using NVMe for host access with ONTAP 9.17.1, only the AutomatedFailoverDuplex policy is supported.

SnapMirror active sync uses ALUA, a mechanism that allows an application host multipathing software with paths advertised with priorities and access availability for the application host communication with the storage array. ALUA marks active optimized paths to the controllers owning the LUN and others as active non-optimized paths, used only if the primary path fails.

SnapMirror active sync with NVMe protocol uses Asymmetric Namespace Access (ANA), which enables application hosts to discover optimized and non-optimized paths to NVMe namespaces that are being protected. The ONTAP NVMe target publishes the appropriate path states to enable application hosts to use the optimal path for a protected NVMe namespace.

Clustered applications

Clustered applications, including VMware Metro Storage Cluster, Oracle RAC, and Windows Failover Clustering with SQL, require simultaneous access so the VMs can be failed over to other site without any performance overhead. SnapMirror active sync symmetric active/active serves IO locally with bidirectional replication to meet the requirements of clustered applications. Beginning with ONTAP 9.16.1, symmetric active/active is supported in a configuration in four-node clusters, expanding from the two-node cluster limit in ONTAP 9.15.1.

Disaster scenario

Synchronously replicate multiple volumes for an application between sites at geographically dispersed locations. You can automatically failover to the secondary copy in case of disruption of the primary, thus enabling business continuity for tier one applications. When the site hosting the primary cluster experiences a

disaster, the host multipathing software marks all paths through the cluster as down and uses paths from the secondary cluster. The result is a non-disruptive failover enabled by ONTAP Mediator to the mirror copy.

Extended application support

SnapMirror active sync provides flexibility with easy-to-use application-level granularity and automatic failover. SnapMirror active sync uses proven SnapMirror synchronous replication over an IP network to replicate data at high speeds over LAN or WAN, to achieve high data availability and fast data replication for your business-critical applications such as Oracle, Microsoft SQL Server, and so on, in both virtual and physical environments.

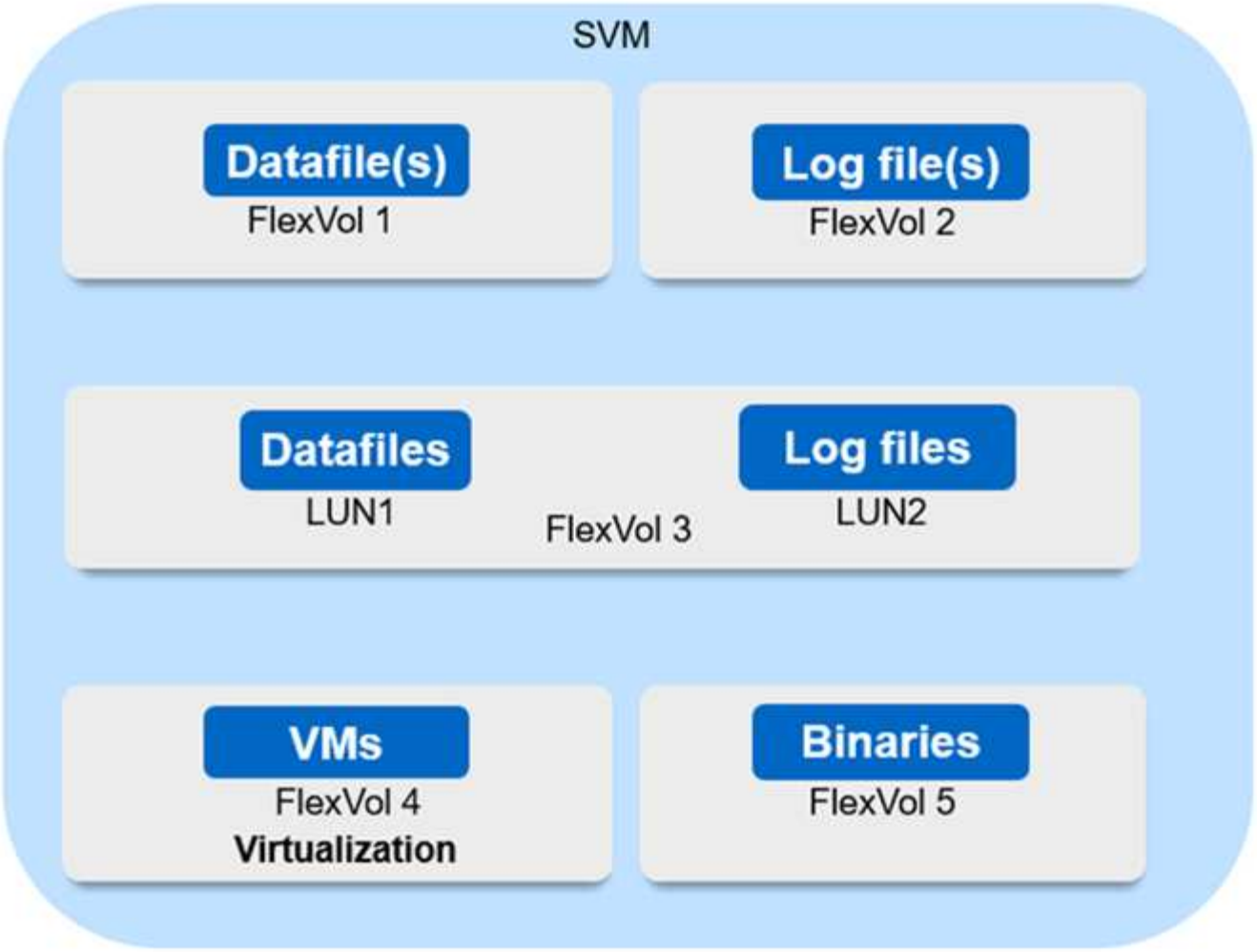
SnapMirror active sync enables mission-critical business services to continue operating even through a complete site failure, with TAF to the secondary copy. No manual intervention or additional scripting is required to trigger this failover.

Deployment strategy and best practices for ONTAP SnapMirror active sync

It is important that your data protection strategy clearly identifies the workloads that need to be protected for business continuity. The most critical step in your data protection strategy is to have clarity in your enterprise application data layout so that you can decide how you are distributing the volumes and protecting business continuity. Because failover occurs at the consistency group level on a per-application basis, make sure to add the necessary data volumes to the consistency group.

SVM configuration

The diagram captures a recommended storage VM (SVM) configuration for SnapMirror active sync.



- For data volumes:
  - Random read workloads are isolated from sequential writes; therefore, depending on the database size, the data and log files are typically placed on separate volumes.
    - For large critical databases, the single data file is on FlexVol 1 and its corresponding log file is on FlexVol 2.
    - For better consolidation, small-to-medium-size noncritical databases are grouped such that all the data files are on FlexVol 1 and their corresponding log files are on FlexVol 2. However, you will lose application-level granularity through this grouping.
  - Another variant is to have all the files within the same FlexVol 3, with data files in LUN1 and its log files in LUN 2.
- If your environment is virtualized, you would have all the VMs for various enterprise applications shared in a datastore. Typically, the VMs and application binaries are asynchronously replicated using SnapMirror.

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