

VMAX³ Remote Replication Fundamentals



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Welcome to VMAX³ Remote Replication Fundamentals.

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Course Overview

Description	This course provides an introduction of the VMAX ³ Remote Replication. It includes an overview of the Remote Replication architecture, features, and functionality.
Audience	This course is intended for professionals who will be positioning, designing, deploying, managing and supporting a solution using the VMAX systems. It is also suitable for anyone seeking to learn the basics of the VMAX ³ Remote Replication products.
Objectives	Upon completion of this course, you should be able to: • List the Remote replication business requirements and benefits • Explain the Remote Replication family of products and use cases • Define the architectural components and connectivity options • List the various Remote Replication topologies • Describe SRDF dynamic operations • Identify the various Remote Replication modes • Describe Remote Replication management options • List the VMAX³ SRDF/A new features • Describe the EMC Open Replicator for VMAX³

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VMAX³ Remote Replication Fundamentals



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This course provides an introduction of the VMAX³ Remote Replication. It includes an overview of the Remote Replication architecture, features, and functionality.

Module: Introduction to VMAX³ Remote Replication

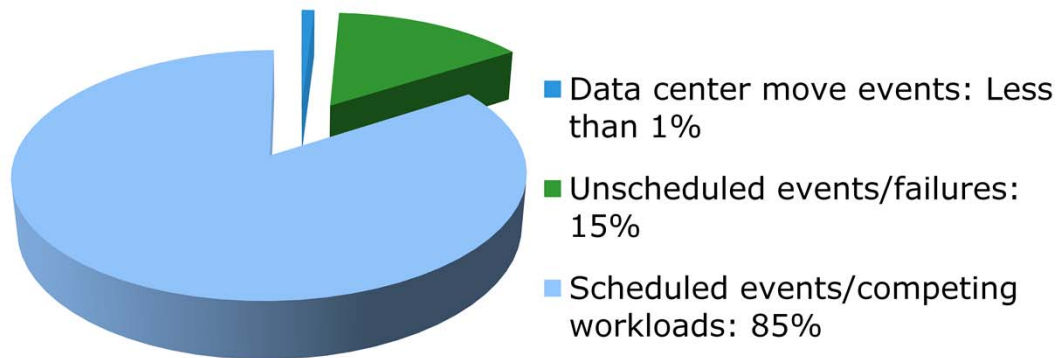
Upon completion of this module, you should be able to:

- Describe the VMAX³ Remote Replication solution
- Describe the benefits of the VMAX³ Remote Replication solution
- Identify a key use case

This module focuses on VMAX³ Remote replication business requirements and benefits, the Remote Replication family of products, and typical use cases.

Business Challenges

Planned/Unplanned Downtime



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The first thing to consider when selecting an information or data protection strategy is the source of outages.

Less than one percent of outages are caused by natural disasters, such as hurricanes and earthquakes, or major business events, such as mergers and acquisitions.

Unscheduled events account for most of the remaining fifteen percent of outages.

The other fifteen percent or so, can be devastating if and when it occurs. Without preparation, an unplanned outage can severely impact the viability and profitability of a business.

Planned downtime represented by normal housekeeping events account for approximately eight-five percent of all information outages. Planned downtime is often predictable, and manageable; so business continuity is assured even during regular maintenance windows eight-five percent of the time (or the majority of time).

Replication technologies can also be applied to scheduled events, such as occasional migrations and more frequently data re-purposing for decision support or test and development.

Remote Replication Benefits

Protect against local and regional site disruptions

- Continuous data availability
- Multiple remote-recovery sites
- Meet regulatory requirements
- Support multiple service levels with tiered storage

Migrate, consolidate, or distribute data across storage platforms

- Data center consolidations
- Technology refreshes

Enable fast recovery

- Application restart
- Business resumption

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SRDF is a designed solution for mission critical enterprise storage systems. It represents the most reliable, scalable and trusted solution to ensure stock trading to continue to operate; airlines continue to the skies and Banks continue to give users seamless access to their money.

For cloud scale deployments, SRDF provides a mechanism to maintain consistency across many storage systems, so that recovery, the most important part of replication, is feasible no matter what the configuration.

The correct remote replication solution can limit exposure to planned and unplanned downtime by enabling operations at remote sites. SRDF provides an organization with efficient data replication tools to meet corporate or government standards, while still meeting Total Cost of Ownership requirements and lower RPO/RTO. SRDF offers data protection, and fast business restart in the event of a disaster.

Remote Replication Overview

With SRDF user can create real-time or write-consistent at different VMAX arrays at diverse distances

User can restart operations at a secondary site with zero data loss



SRDF offers various levels of business continuance and disaster recovery solutions

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SRDF is EMC's Remote Replication technology that enables the remote mirroring of a data center with minimal impact to production application performance.

The VMAX³ SRDF remote replication solution provides disaster recovery and data mobility solutions for the VMAX³ arrays. SRDF is EMC's Remote Replication technology that enables the remote mirroring of data centers with minimal impact to production application performance.

Remote Replication Overview – Cont.

SRDF products offer the ability to maintain multiple, host-independent, remotely mirrored copies of data

SRDF allows VMAX³ systems to be in the same room, different buildings, or hundreds to thousands of kilometers apart



SRDF can integrate with other products such as:
Microsoft Cluster Enable
VMware SRM

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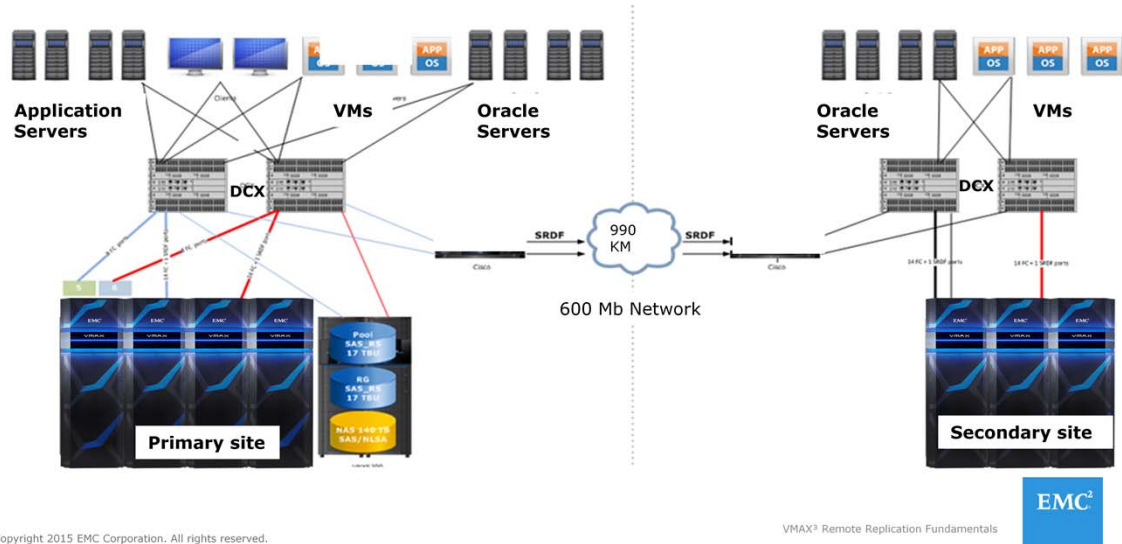
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The copy process between the sites is accomplished independently without the host. There are no limits to the distance between the source and the target copies. SRDF can integrate with other products such as Microsoft Cluster Enable, VMware Site Recovery Manager (SRM) and with TimeFinder.

Remote Recovery Use Case

Entertainment Industry IT Infrastructure



This SRDF implementation example is a media and entertainment industry customer with a large customer base. The primary site servers use VMAX SRDF; remotely replicated 990 KM to a target site with another VMAX system. The approximate SRDF I/O traffic rates average about 25 MB/sec. The SRDF groups use SRDF/A mode for synchronization.

VMAX³ Remote Replication Suite

Two replication licenses available:

Remote Replication Suite
SRDF Family Block
Multiple sites
Replicator File

SRDF Registered
Single remote replication
Partial arrays replication

Remote Replication Suite:

- SRDF/S
- SRDF/A
- SRDF/CE,
- File Replication

Protection

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The remote protection suite offers our industry leading SRDF synchronous and asynchronous multi-site Disaster Recovery software. There are two VMAX³ Remote Replication Suite replication licenses available:

Remote Replication Suite which includes:

- SRDF Family Block
- Multiple sites
- Replicator File

SRDF Registered which can be used for:

- Single remote replication
- Partial arrays replication

Module Summary

The key points covered in this module are:

- Remote Replication business benefits
- Remote Replication family of products
- Remote Replication solution typical use case

This module focused on the VMAX³ Remote replication business benefits, Remote Replication family of products and the typical use case.

Module: VMAX³ Remote Replication Architecture

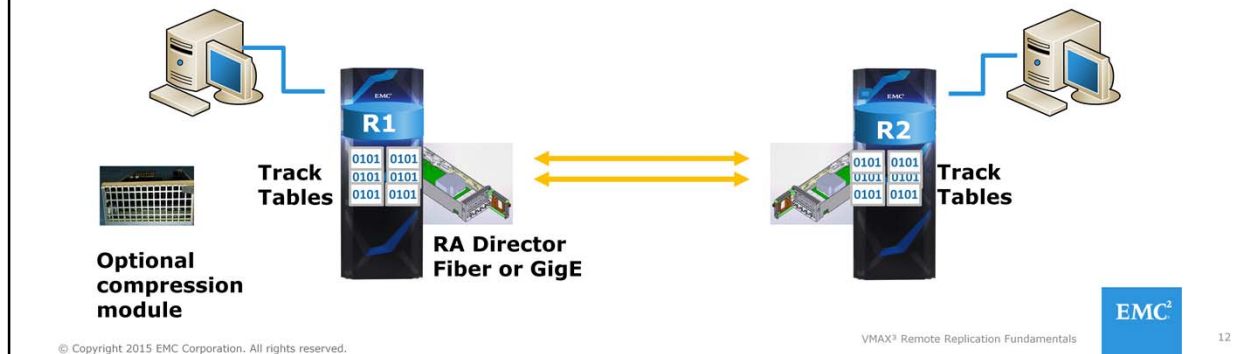
Upon completion of this module, you should be able to:

- Describe the Remote Replication architecture and key terminology
- Identify VMAX³ Remote Replication components

This module focuses on the VMAX³ Remote Replication architectural components and connectivity options, the topologies and dynamic operations.

VMAX³ SRDF Architectural Components

- Data mirroring between physically separate VMAX systems
- Host operating system, DBMS, file-system independent
- Uses SRDF Directors (RA) as a communication channel
- Architecture enables differential resynchronization capabilities (Track Tables)
 - Only changed data is copied in events such as link down or a power down

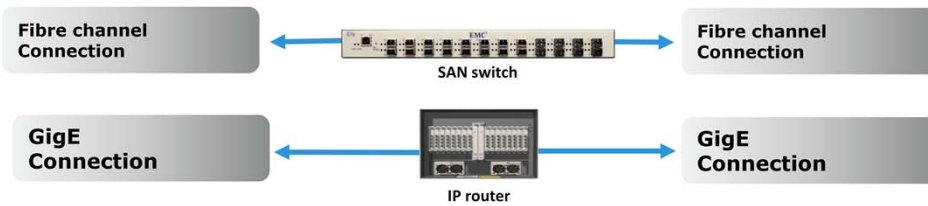


SRDF disaster recovery solutions use “active, remote” mirroring and dependent-write logic to create consistent copies of data. Dependent-write consistency ensures transactional consistency when the applications are restarted at the remote location.

SRDF provides comprehensive business continuity and restart capabilities for planned and unplanned outages. This online, host-independent, mirrored data solution duplicates production site data on one or more physically separate target VMAX systems. What makes this technology a leader in the industry is its use of track tables. Track tables maintain the differential between source and target devices; track tables have a unique capability to send only changed information at the track level. This allows SRDF to operate in several modes that are addressed later in this course.

SRDF compression is accomplished using an optional compression I/O module; compression can be set at the SRDF group level.

VMAX³ SRDF Director Types



Hardware I/O module	Ports	Speed
FC 8 Gb Fiber Optical	4	2/4/8 Gb/s
FC 16 Gb Fiber Optical	2	4/8/Gb/s
10Gb Ethernet Optical	2	10 Gb/s
1Gb Ethernet Optical	4	1000 Mb/s



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The SRDF family offers great flexibility in deployment depending on the business needs by offering fully tested, integrated and flexible hardware, software and communication options.

EMC offers native Gigabit Ethernet and Fibre channel capability for the VMAX³ series systems. The Fibre Channel or Gigabit Ethernet front-end I/O module is installed and configured in the VMAX³ systems.

The maximum number of SRDF supported groups and devices vary by Enginuity level; the table illustrated shows the maximum limits.

The connectivity protocol options include:

- Asynchronous Transfer Mode (ATM)
- Internet Protocol (IP)
- Dense Wavelength Division Multiplexing (DWDM)
- Coarse Wavelength Division Multiplexing (CWDM)
- T1/E1-T3/E3, and
- Synchronous Optical Networking (SONET)

SRDF Groups and Ports

- SRDF Groups define relationship between local and Remote VMAX³ systems
- RA ports are assigned to SRDF groups
- All SRDF devices must belong to a SRDF group
- Up to 32 ports per RA instance
- All configured ports on an RA will have the same topology: Switched Fabric or Point-to-Point (P2P)
- All configured ports on a SRDF group have to use the same protocol (GIGE or FC)

VMAX³ group limits

- 250 RDF Groups per System
- 250 RDF Groups per RDF port
- 32 RDF ports per Engine

Supported Features

- SRDF HW Compression GIGE/FC
- SRDF SW Compression GIGE/FC



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SRDF groups define the relationships between the local SRDF instance and the corresponding remote SRDF instance.

All SRDF devices must be assigned to an SRDF group. Each SRDF group communicates with its partner SRDF group in another array across the SRDF links. RA ports are assigned to SRDF Groups with SRDF management software. All SRDF Devices must belong to a SRDF Group.

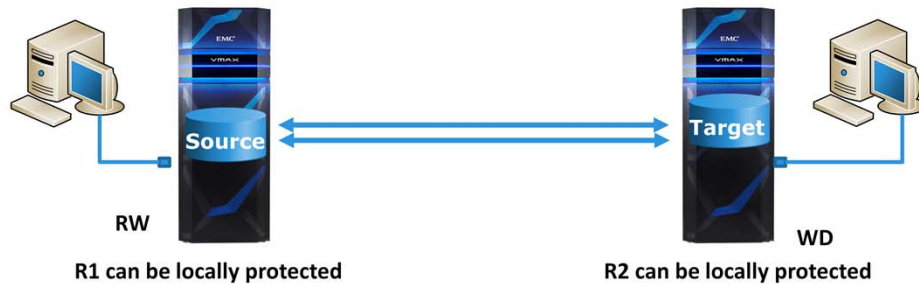
VMAX³ and VMAX arrays will support up to 250 SRDF groups per system. When a VMAX³ is connected to a VMAX, it will support 64 SRDF groups.

All configured ports on a SRDF group will have the same topology (Switched Fabric or P2P).

All configured ports on an RA have to use the same protocol (GIGE or FC).

VMAX³ SRDF Devices

- SRDF logical device types:
 - Primary R1 devices – Primary device with Read/Write (R/W) access to local host
 - Secondary R2 devices – Secondary devices are typically Write Disabled (WD) to secondary host
- The attached host is unaware of SRDF protection



Only THIN devices are supported on VMAX³

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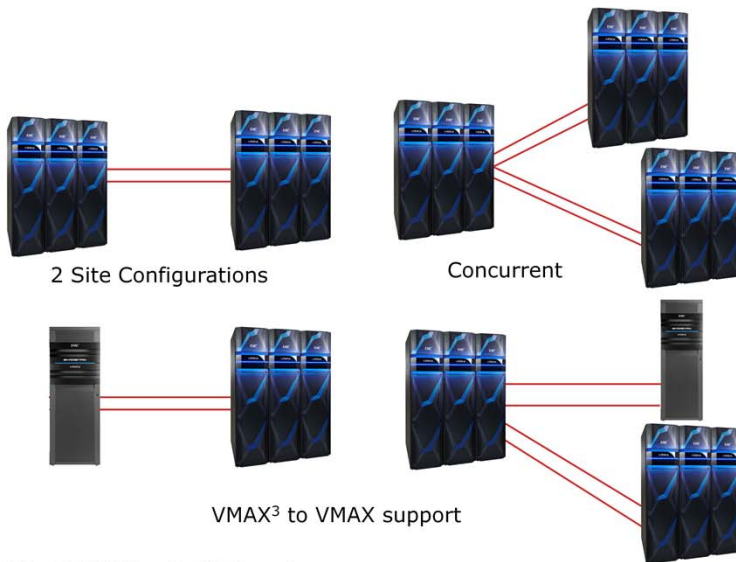
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At the primary site, a local host connects to a VMAX³ array. The device containing the production data to be remotely mirrored is called the primary (R1) device, also referred to as the source device.

At the secondary site, a second host (optional) connects to the remote VMAX³ with the secondary (R2) device, also referred to as the target device, and contains the remotely mirrored data.

The R1 and R2 devices appear as a mirror to the local device. They are not a physical mirror, but an entry on the track tables. The VMAX³ system's R1 and R2 devices communicate through SRDF links. Under normal circumstances, the R1 device presents a Read-Write (RW) status to the host that accesses the R1. The R2 device presents Write-Disabled (WD) status to its host.

VMAX³ Remote Replication Topologies



- SRDF Remote Replication
 - Offering Zero RPO for Synchronous environments
 - And Near Zero RPO for Async environments
- Enhanced SRDF support
 - 2 site replication between VMAX3 Arrays
 - 2 Site Replication between VMAX and VMAX3 arrays
 - Concurrent replication between VMAX³ arrays or a mix of V2 and V3

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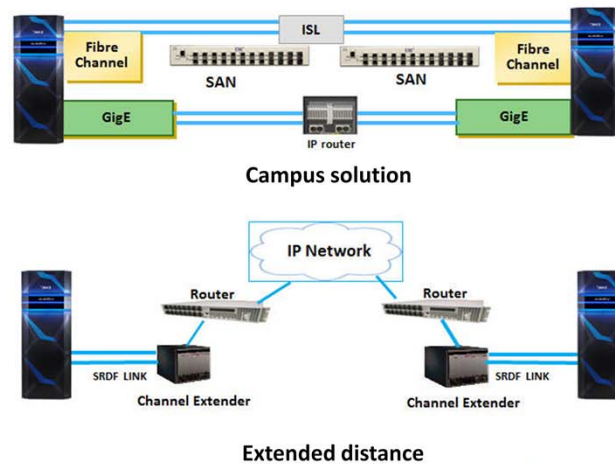
SRDF supports regular synchronous and asynchronous SRDF, both between VMAX³ systems and between VMAX³ and VMAX² systems. It also supports concurrent SRDF, replicating to two systems concurrently. In a two site configuration, synchronous, asynchronous and adaptive copy disk modes are supported. A three site configuration will support concurrent modes of synchronous or asynchronous. Adaptive Copy Disk mode can be used in both two site and three site configurations.

SRDF Connectivity – Distance Solutions

- Campus solution can operate up to 200 Kilometers apart
- The Extended Distance WAN solution enables units to be at trans-oceanic or trans-continental distances

For Extended solutions:

- Recovery Point Objective (RPO)
 - The maximum tolerable period in which data might be lost
- Recovery Time Objective (RTO)
 - The time it takes to recover a service



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Campus solution is limited to transmit data over short distances using VMAX systems and SAN equipment; typically, the distance is smaller than 200 kilometers using channel extenders or long distance fiber-optic cables.

Extended Distance Wide Area Network provides SRDF connectivity over long distances using telecommunications networks, such as IP, SONET, or ATM.

The Extended Distance Wide Area Network solution enables units to be at trans-oceanic or trans-continental distances for all types of directors. Typically, OC3, ATM, T3, and E3 lines, or IP are offered by lease carriers.

Fibre Channel SRDF can leverage write acceleration, sometimes referred to as Fast Write, a performance enhancement feature offered by distance extension and/or switch products.

When selecting the ideal business continuance solution, the selection is determined by the distances separating the data centers, the Recovery Point Objective and Recovery Time Objective, and how well the applications tolerate network latency. Shorter distances reduce network latency, which allows using synchronous disk replication and data center mirroring. The SRDF solution can be tailored to meet various Recovery Point Objectives/Recovery Time Objectives.

VMAX³ SRDF Link Configuration Types

Unidirectional

Data moves in one direction on the SRDF links



Bidirectional

Data moves in both directions on the SRDF links



Dual-directional

Data moves in one direction on each SRDF group of links



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There are three types of SRDF Link configurations:

Unidirectional

Bidirectional, and

Dual-directional

Unidirectional is a one-way mirror relationship.

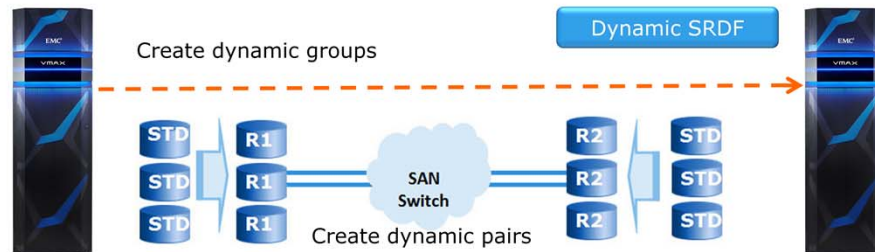
Bidirectional is a two-way mirror relationship where data moves in both directions on the SRDF links.

Bidirectional configuration is only recommended in Campus mode due to the overhead associated with the change of direction.

Dual-directional is an extended distance solution with two unidirectional SRDF RA groups, primary and secondary, in each VMAX system.

VMAX³ Dynamic Operations

- Create Dynamic SRDF Groups
 - A dynamic SRDF group represents a logical link between two VMAX arrays
- Create Dynamic Pairs
 - Enables dynamic relationships between R1 and R2 devices
- SRDF devices can dynamically swap “personality” between R1 and R2
- Dynamic SRDF provides flexibility to tailor a SRDF environment



Changes to devices to R1 or R2 are dynamically via EMC software

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Dynamic SRDF provides the capability to change SRDF Groups and device pairings, as needed, without requiring a configuration change to be performed manually by EMC personnel. The two main operations are: creating dynamic SRDF groups and device pairs. Only Dynamic SRDF is supported on VMAX³ arrays.

A dynamic SRDF group represents a SRDF logical link between two VMAX³ arrays. After a Dynamic SRDF group has been created, the SRDF device pairs can be added.

An SRDF device is a logical device paired with another VMAX³ logical device that resides in a second array; the arrays are connected by SRDF links.

An SRDF device pair cannot include ProtectPoint devices. Dynamic SRDF enables the creation and deletion of SRDF pairs while the VMAX system is in operation. Once established, the new SRDF pairs can be synchronized and managed in the same way as configured SRDF pairs.

A requirement for Dynamic SRDF groups is ‘Switch’ connectivity, which is a SAN or GigE switch topology.

SRDF groups define the relationships between the local SRDF director/ports and the corresponding remote VMAX³ SRDF director/ports. Any VMAX³ device that has been configured as an SRDF device must be assigned to an SRDF group.

SRDF devices can dynamically swap “personality” between R1 and R2. After a personality swap, the R1 in the device pair becomes the R2 device and the R2 becomes the R1 device. Swapping R1/R2 personalities allows the application to be restarted at the remote site without interrupting replication if an application fails at the production site. After a swap, the R2 side (now R1) can control operations while being remotely mirrored at the primary (now R2) site. All volumes created on a VMAX³ array will automatically be created as dynamic SRDF capable.

Module Summary

Key points covered in this module:

- Remote Replication architectural components
- Remote Replication connectivity options and topologies
- SRDF dynamic operations

This module covered Remote Replication architectural components, connectivity options and topologies SRDF dynamic operations.

Module: VMAX³ Remote Replication Features and Capabilities

Upon completion of this module, you should be able to:

- Describe the VMAX³ Remote Replication key features and capabilities
- Identify the usage of key features and capabilities in an IT environment

This module focuses on the VMAX³ modes of Remote Replication, the new SRDF/A features and SRDF architectural elements.

VMAX³ SRDF Modes of Operation

SRDF/Synchronous (SRDF/S)

- Maintains a real-time copy of production data

SRDF/Asynchronous (SRDF/A)

- Maintains a consistent copy at a remote secondary site

SRDF/Data Mobility(DM)

- The VMAX SRDF data migration solutions

SRDF/CG

- SRDF consistency groups preserve the dependent-write consistency of devices



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SRDF modes of operation address different service level requirements and determine how R1 devices are remotely mirrored across the SRDF links. Also, how I/Os are processed and when the host receives acknowledgment of a write operation relative to when the write is replicated.

Synchronous Replication (SRDF/S) provides real-time mirroring of data between the source VMAX³ and the target VMAX³ systems.

Data Mobility (SRDF/DM) transfers data from the source devices to the remote devices without waiting for an acknowledgment, using Adaptive Copy mode.

Asynchronous Replication (SRDF/A) places host writes into 'cycles' or 'chunks' and then transfers an entire chunk to the target system.

SRDF/CG - SRDF consistency groups preserve the dependent-write consistency of devices within a group by monitoring data propagation from source devices to their corresponding target devices. If consistency is enabled, and SRDF detects any write I/O to a R1 device that cannot communicate with its R2 device, SRDF suspends the remote mirroring for all devices in the consistency group before completing the intercepted I/O and returning control to the application.

These operational modes can be changed dynamically using EMC software, the operational method can be specified on a per device basis or as a device group.

VMAX³ SRDF Modes of Operation – cont.

SRDF/Cluster Enabler (CE)

- Microsoft Failover Cluster integration

SRDF/Automated Replication (AR)

- Combines SRDF and TimeFinder to provide a long distant disaster restart solutions

Concurrent SRDF

- Three site disaster recovery with parallel operations

Cascaded SRDF

- Three site configuration uses bunker site
- Combines Synchronous and Asynchronous modes



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SRDF/Cluster Enabler (CE) allows combination with the features of Microsoft Failover Cluster integration.

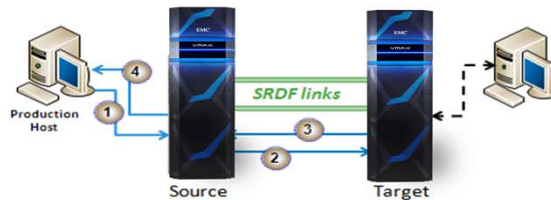
SRDF/AR is an automated remote replication solution that uses both SRDF and TimeFinder to provide a periodic asynchronous remote replication of a re-startable data image for UNIX and Windows environments. It is the least expensive of the listed solutions, because it can be configured to run on lower bandwidth networks than the other solutions, it offers a typical RPO of hours.

Concurrent SRDF permits the maintenance of two data copies. Usually, one copy running SRDF/S is maintained at a nearby location and offers zero data loss if the primary site fails. The second copy operating in SRDF/A mode offers an out of region recovery site with an RPO of seconds to minutes.

- Cascaded SRDF three site configuration uses bunker site and combines Synchronous and Asynchronous modes. Data from a primary site is synchronously replicated to a secondary site, and then asynchronously replicated to a tertiary site. The major benefit provided with a “cascading” configuration is its inherent capability to continue replicating from the secondary site to the tertiary sites in the event that the primary site goes down.

Synchronous Mode

1. The write I/O is received from production host/server into cache of source and placed in FIFO queue
2. The write I/O is transmitted to the cache of the target array
3. Receipt acknowledgment is provided by target array back to cache of the source array
4. Ending status is presented to production host/server



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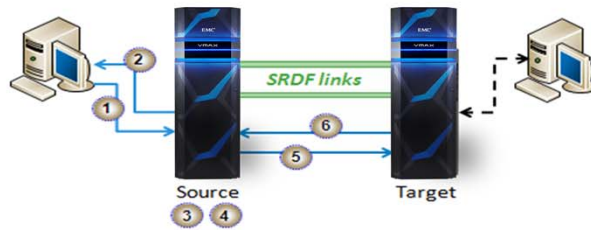
SRDF Synchronous Mode is primarily used in SRDF campus environments. In this mode of operation, the VMAX³ maintains a real-time mirror image of the data of the remotely mirrored devices.

Data on the source (R1) target (R2) devices are always fully synchronized at the completion of an I/O sequence through a first-in, first-out queue (FIFO) model. All data movement is at the block level with synchronized mirroring.

Synchronous SRDF writes from the host to the primary and do not finish until they are acknowledged at the primary VMAX³ and the write data is resident in the secondary VMAX³ system's cache. This means that the logical device is busy at the primary host including read-following-write operations throughout the SRDF operation.

Adaptive Copy Disk Mode

1. The write I/O received from host/server into cache of source
2. Ending status is presented to host/server
3. I/O is de-staged and processed using Disk Mode
4. I/O is placed in SRDF queue
5. I/O is transmitted to cache of the target
6. Receipt acknowledgment is provided by target back to cache of source



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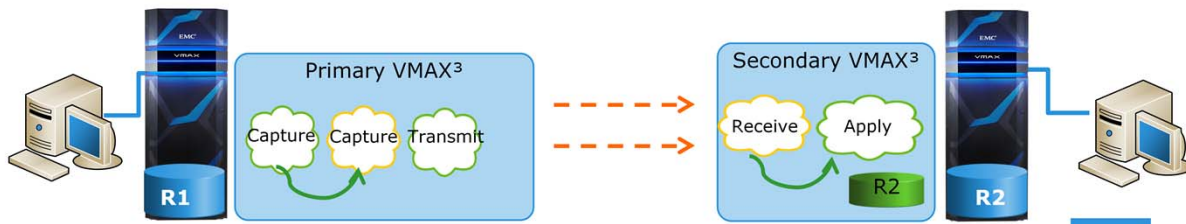
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SRDF Adaptive copy modes facilitate data sharing and migration. These modes allow the primary and secondary devices to be more than one I/O out of synchronization. The maximum number of I/Os that the R2 can be out of synchronization is known as the maximum skew value. The default value is equal to the entire logical device. The transfer steps are illustrated here.

SRDF Adaptive Copy Disk Mode is designed for bulk data transfer. Host write tasks accumulate on the primary device as invalid tracks rather than in global memory. A background process sends them to the corresponding secondary device.

SRDF/Asynchronous Mode

1. Capture cycle – there may be more than one
2. Transmit – Sending capture to remote site
3. Receive – Receives capture at target site
4. Apply – Writes data to target devices



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SRDF/Asynchronous (SRDF/A) maintains a dependent-write consistent copy between the R1 and R2 devices across any distance with no impact to the application. Host writes are collected for a configurable interval into “delta sets”. Delta sets are transferred to the remote array in timed cycles.

The data flow of SRDF/A can be summarized in simple steps:

Source-site Delta Sets include Capture and Transmit; Target-site, Receive, and Apply.

Capture captures all incoming writes to the source devices involved in the SRDF/A group, when minimum time elapses, a new capture cycle starts, there may be more than one capture at the Primary VMAX³.

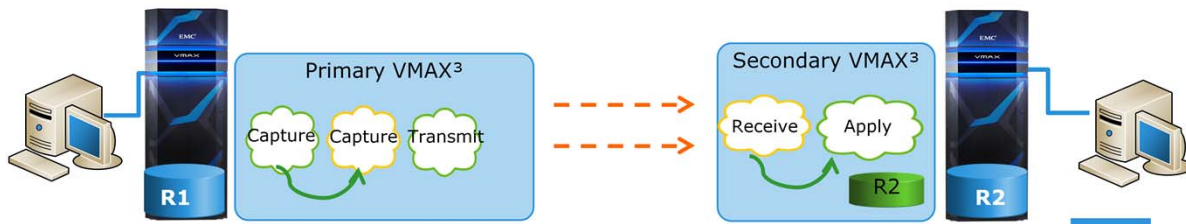
Transmit transfers its contents from the source to the target system.

Receive on the target system receives the data being transferred by the source-side Transmit Delta Set.

The Apply cycle writes the Delta Set to the target device to create a consistent recoverable remote copy and this completes the Delta Set cycle.

SRDF/A with Multi-Cycle Mode (MCM)

- Allows more than two Delta Sets on Primary Site
- Cycle are More Granular with Incremental Updates
- Cycle switch occurs at Minimum Cycle Time
- Both sites must be VMAX³ arrays



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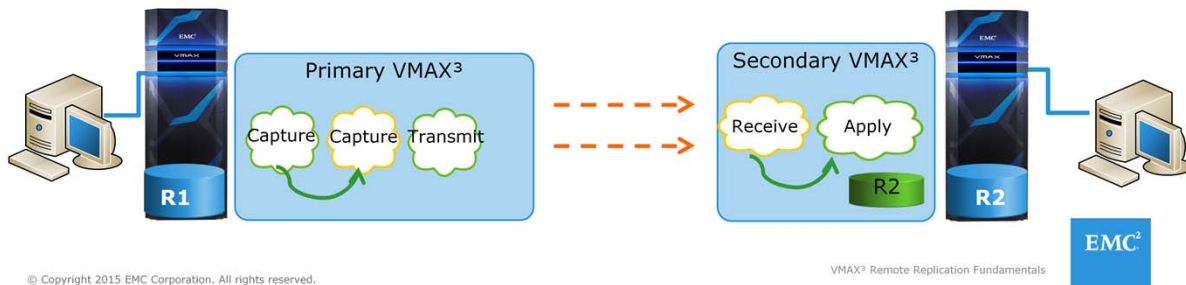
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SRDF/A Multi-Cycle Mode (MCM) creates multiple SRDF/A cycles on the R1 side at regular intervals, which will provide smaller incremental updates to the R2; cycle switch occurs at minimum cycle time. Both sites must be VMAX³ arrays.

SRDF/A operations vary depending on whether the SRDF session mode is single or multi-session with Multi Session Consistency (MSC) enabled.

VMAX³ SRDF/A MCM Design

- Minimum cycle time has elapsed
- Capture set added to transmit queue
- New capture set created
- Capture set added to transmit queue



SRDF/A Multi-Cycle Mode (MCM) allows more than two capture cycles on the R1 side, when the `minimum_cycle_time` has elapsed the data from the capture cycle will be added to a transmit queue and a new capture cycle will occur. The transmit queue is a feature of SRDF/A, it provides a location for R1 captured cycle data to be placed so a new capture cycle can occur.

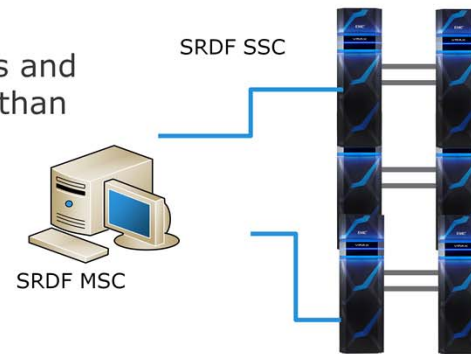
The capture cycle will occur even if no data is transmitted across the link. If no data is transmitted across the link the capture cycle data will again be added to the transmit queue. The transmit queue holds the data until it is transmitted across the link. The transmit cycle will transfer the data in the oldest capture cycle to the R2 first and then repeat the process.

The benefit of this technique is to capture controlled amounts of data on the R1 side; each capture cycle will occur at regular intervals and will not contain large amounts of data waiting for a cycle to occur.

Another benefit is data that is sent across the SRDF link will be smaller in size and should not overwhelm the R2 side. The R2 side will still have two delta sets, the receive and the apply.

Single and Multi-Session Modes

- Single Session Consistency cycle switching performed by HYPERMAX OS
- Multiple Session Consistency combines and co-ordinates cycle switching for more than one VMAX system at the host



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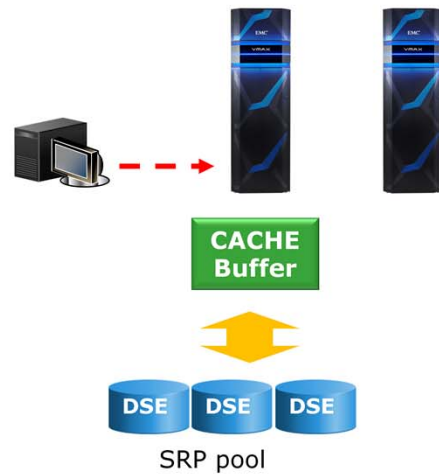
For single SRDF/A sessions (SSM), cycle switching is controlled by Enginuity. Each session is controlled independently, whether it is in the same or multiple arrays.

For multiple SRDF/A sessions (MSC) mode, multiple primary SRDF groups and multiple secondary SRDF groups are in the same SRDF/A MSC session. Cycle switching is controlled at the host level by SRDF software to maintain consistency. MCM supports Single Session Consistency (SSC) and Multi Session Consistency (MSC).

SRDF/A Delta Set Extension

Allows offloading of SRDF/A delta sets from cache to specially configured device pools:

- Delta Set Extension Pools
- Intended to make SRDF/A resilient to temporary increases in write workloads or loss of link



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SRDF/A Delta Set Extension (DSE) provides a mechanism for augmenting the cache-based Delta Set buffering mechanism of SRDF/A with a disk-based buffering ability. This extended Delta Set buffering ability may allow SRDF/A to be maintained through larger and/or longer SRDF/A throughput imbalances than would be possible with cache-based Delta Set buffering alone.

In previous versions of Enginuity, SRDF/A Delta Set Extension (DSE) extended the space available for an SRDF/A session's cycles by spilling its cycle data from cache to a user configured DSE pool. With VMAX³, SRDF/A spills tracks to Storage Resource Pool (SRP) designated for use by DSE. When running SRDF/A MCM, smaller cycles on the R2 side eliminate the need for DSE on the R2 side. DSE pool or associating a DSE pool with an SRDF group is no longer needed with VMAX³ arrays.

SRDF/A Write Pacing

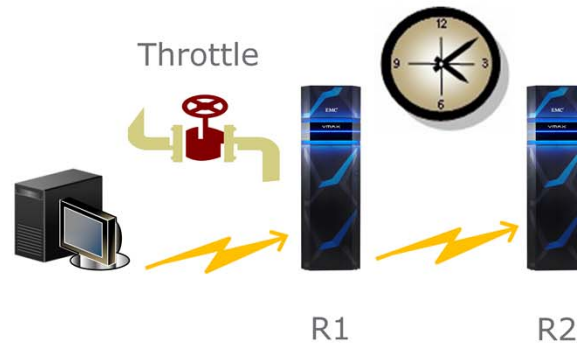
Uses existing SRDF/A features

Monitors SRDF/A service rates

Monitors host I/O write rates

Engenuity-based algorithm

Enhanced Group level pacing



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The SRDF/A write pacing feature helps to secure the availability of an SRDF/A session by preventing conditions that can cause cache overflow on both the R1 and R2 sides.

SRDF/A detects when the SRDF I/O service rates are lower than the host I/O rates; then it takes corrective action to slow host I/O rates to match the SRDF I/O service rates.

SRDF/A write pacing helps control the amount of cache used by SRDF/A. This can prevent cache from being exhausted on the R1 side of the SRDF link, thereby keeping the SRDF/A sessions to continue.

VMAX³ introduces enhanced group-level pacing. Enhanced group-level pacing throttles host I/Os to the DSE spill-over rate for an SRDF/A session.

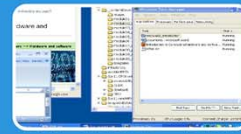
When DSE is activated for an SRDF/A session, host-issued write I/Os are throttled so their rate does not exceed the rate at which DSE can offload the SRDF/A session's cycle data. The system will pace at the spillover rate until the usable configured capacity for DSE on the SRP reaches its limit, at that point, the system will then either drop SRDF/A, or pace to the link rate option.

All existing pacing features are supported and can be utilized to keep SRDF/A sessions active. Enhanced group-level pacing is supported between VMAX³ arrays and VMAX² arrays.

VMAX³ SRDF FAST Coordination

Enabled at the array level

- Enabled by default
- No software interface to DISABLE
- Only VMAX³ to VMAX³



R1 performance metrics transmitted across the link

- R1 metrics are merged with the R2 metrics
- R2 reflects R1 metrics
- Allows FAST movement decisions for R2 data to account for R1 workload



SLOs associated with R1 and R2 devices can be different



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SRDF FAST Coordination is enabled at the VMAX³ Array level by default, only VMAX³ to VMAX³ is supported. Performance metrics are periodically transmitted from R1 to R2, across the SRDF link.

The R1 metrics are merged with the R2 metrics; this instructs FAST to factor the R1 device statistics into the move decisions that are made on the R2 device. Service Level Objectives (SLO) associated with R1 and R2 devices can be different.

VMAX³ SRDF Supported Features

Volume Support

- Non Meta VMAX³ to Meta on VMAX2
- R2 larger than R1 supported
- Thick on VMAX² to Thin on VMAX³

Compression

- Gigabit Ethernet and Fibre Channel
- Hardware and Software
- Hardware compression requires I/O module



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Meta devices do not exist on VMAX³ arrays however there is support for creating SRDF pairs between VMAX2 Meta devices and VMAX³ non-Meta devices. Device pairs consisting of an R2 larger than R1, with one Meta and one non-Meta are supported, regardless of whether the R2 is the Meta or the non-Meta device. R2 larger than R1 is a one way replication since a restore from a larger to smaller SRDF devices are not supported. SRDF will also support thick to thin replication. All volumes created on a VMAX³ array will automatically be created as dynamic SRDF capable.

Geometry Compatible Mode

- SRDF will be allowed from existing VMAX (V1/V2) to VMAX³ systems
- VMAX³ will support multiple SRDF protocols depending on remote track size
- 2 tracks on Legacy map to 1 track on VMAX³
- Outgoing 128 KB IO split into two 64KB IOs

R1	R2	Configuration	Support
VMAX	VMAX ³	R1 < R2	Limited
VMAX ³	VMAX	R1 > R2	Unsupported



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On the VMAX³ the track size is 128K. When creating an RDF pair between a device on a VMAX² array, which track size is 64k, and a device on a VMAX³ array, compatibility problems arise if the device on the legacy VMAX² array has an odd number of cylinders. If the device on the VMAX² array will become the R1 then the resulting RDF pair will end up as a R2 larger than R1 relationship and the RDF support will be limited.

If the device on the VMAX² array would become the R2 then RDF device pair will result in an R1 larger than the R2 relationship which is not an allowed configuration.

The Geometry Compatible Mode (GCM) of operation will allow full RDF support in an environment where a device on a legacy VMAX² array with an odd number of cylinders is paired with a device on a VMAX³ array.

A volume with GCM attribute set is referred to as a GCM device and its size is referred to as the device's GCM size.

Module Summary

Key points covered in this module:

- The Remote Replication modes
- The new VMAX³ SRDF/A features
- The VMAX³ SRDF Architectural elements

This module covered the Remote Replication modes, the new SRDF/A features and architectural elements.

Module: VMAX³ Remote Replication Management Overview

Upon completion of this module, you should be able to:

- Describe the VMAX³ Remote Replication management options

This module focuses on the VMAX³ Remote Replication management options and operations.

Remote Replication Management Software

The Remote Replication management software:

Solutions Enabler

- consisting of commands that can be invoked on the command line, or within scripts

Unisphere for VMAX

- User-friendly GUI software to manage the VMAX³

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VMAX³ Remote Replication Fundamentals

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The remote protection suite offers our industry leading SRDF synchronous and asynchronous multi-site Disaster Recovery software. SRDF has been revised for VMAXs to include parallelized data flow to improve application response times.

EMC provides Remote Replication software to manage the SRDF environment for each particular business objective.

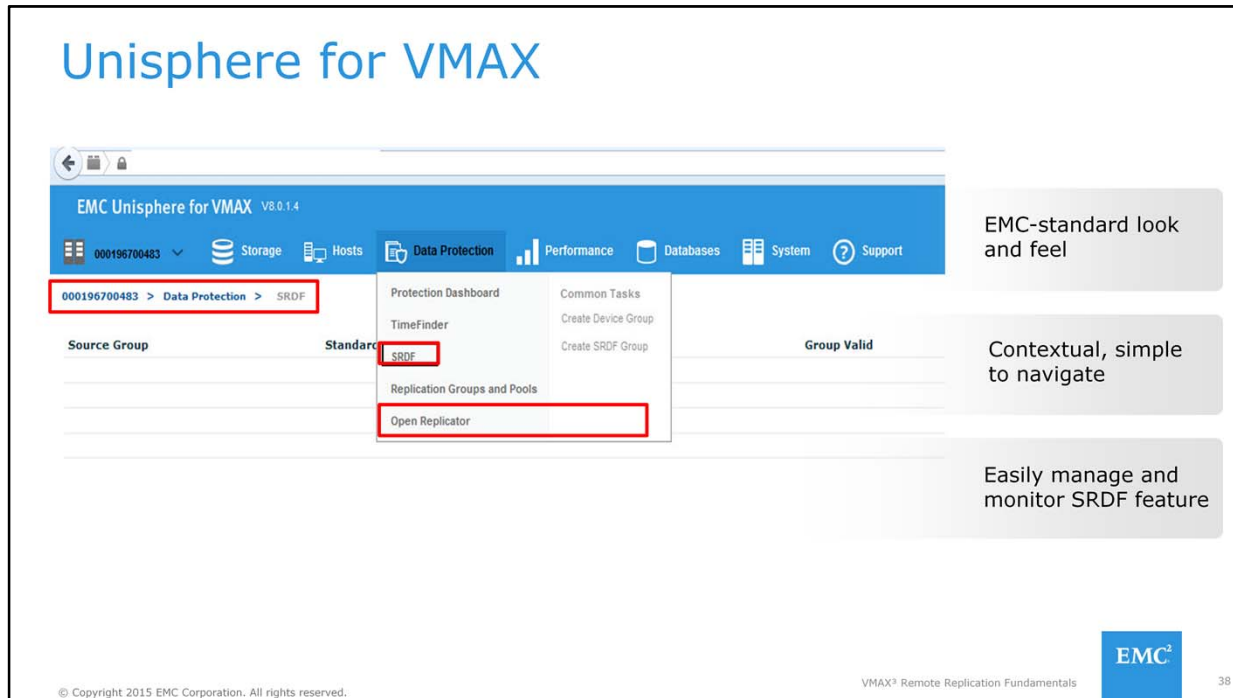
The EMC® Solutions Enabler provides a Command Line Interface (SYMCLI) to manage SRDF operations from the Command Line, or within scripts.

Solutions Enabler provides a Command Line Interface (SYMCLI) to manage SRDF operations from the Command Line.

These commands can be used to monitor device configuration and status, and perform control operations on the SRDF features.

Alternatively Unisphere for VMAX, a GUI can also be used.

Unisphere for VMAX



Unisphere for VMAX is EMC's management console for the VMAX. Unisphere offers navigation and streamlined operations to simplify and reduce the time required to manage your data center.

Unisphere provides a user interface for the configuration and management of VMAX³ arrays and can be used to operate and monitor SRDF remote mirroring functions. Additionally, it provides health indicators for SRDF/A cache usage, cycle time, and throughput at user-configurable polling intervals.

Unisphere is contextual and simple to navigate. With Unisphere users can easily and rapidly manage and monitor all VMAX³ SRDF features.

Open Replicator can also be managed with Unisphere.

VMAX³ SRDF Recovery Operations

Failover

Failback

Update

Split

Establish



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Some of the VMAX³ Recovery Operations include:

Failover - A failover moves production applications from the primary site to the secondary site for a disaster on the primary site or in order to test the recovery solution. The R1 become Read only and R2s R/W enabled.

Failback – Brings production back to the primary site after a disaster. The R1 becomes R/W enabled and R2 read only, R1 are refreshed from R2s.

Update begins transfer of accumulated invalid tracks from the R2s to the R1s, while production work continues on the R2s.

The **split** command suspends the links between source (R1) and Target (R2) volumes. The source devices continue to be read write enabled. The target devices are set to read write enabled. It enables read and write operations on the and target volumes.

Establish – After a Split the Establish will allow the R2 devices to synchronize with the data from the R1 device.

There are other operations that can be performed, for more information please read the Solutions Enabler SRDF CLI product guide.

VMAX³ SRDF Software Basic Operations

Dynamic operations	SRDF state changes
Create Dynamic Groups	Set Synchronous mode
Create Dynamic device pairs	Set Asynchronous mode
Swap device personality	Set Adaptive Copy mode
Delete Dynamic Groups	Change R1 and R2 states Read Read/Write Not Ready
Delete Dynamic devices	

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Some of the common SRDF dynamic operations include:

Create Dynamic Groups, makes a new logical connection in a physical cable; SRDF Groups may be dynamically added, deleted and/or modified.

Create Dynamic SRDF device pairs allows the user to pair Primary (R1) and Secondary (R2) devices via EMC software.

Swap device personality switches the R1 and R2 personalities, at its completion the remote site will have the R1 devices.

The software can also delete all the above groups and devices.

Also, the device states can be changed to:

Set Synchronous mode

Set Asynchronous mode

Set Adaptive Copy mode

Change R1 and R2 states:

Read/Write (Write Enabled) — The R1 device is available for Read/Write operations; this is the default R1 device state.

Read Only (Write Disabled) — Write Protected to all write operations to that device.

Not Ready — Not Ready to the host for read and write operations to that device.

There are many other operations that can be performed, for more information please read the Solutions Enabler SRDF CLI product guide.

Module Summary

The key concepts covered in this module are:

- The VMAX³ Remote Replication management options
- The different SRDF management operations

This module covered the VMAX³ Remote Replication management options and operations.

Module: EMC Open Replicator Overview

Upon completion of this module, you should be able to:

- Open Replicator Overview
- Open Replicator Pull operations
- VMAX³ Open Replicator Support
- Open Replicator management software

This module focuses on the EMC Open Replicator overview and operations.

Open Replicator Overview

- Open Replicator provides a method for copying device data from various types of arrays within a SAN to or from a VMAX³ array

Fast

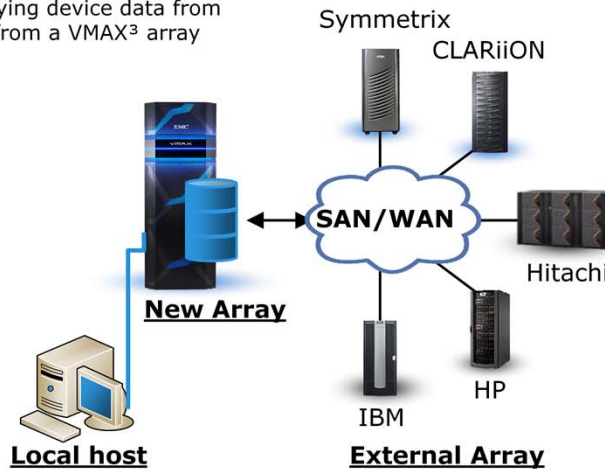
Uses the SAN / WAN to make full copies
No server or LAN impact

Simple

Utilize existing infrastructure
Software-based controls
Can be used for ad-hoc or pull data

Open

From various types of Arrays
Application and host independent



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VMAX³ Remote Replication Fundamentals

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Open Replicator provides a method for copying device data from various types of arrays within a Storage Area Network (SAN) from a VMAX³ array. EMC Open Replicator is a tool that can be used to migrate data from older Symmetrix arrays, CLARiiON or VNX arrays, and certain third-party storage arrays to a VMAX³ array.

Open Replicator operations are controlled from a local host attached to a VMAX³ array. Data copying is accomplished as part of the storage system process and does not require host resources. The data can be copied online between the VMAX³ array and remote devices, allowing host applications, such as a database or file server, to remain operational during the copy process.

Open Replicator Pull Operations

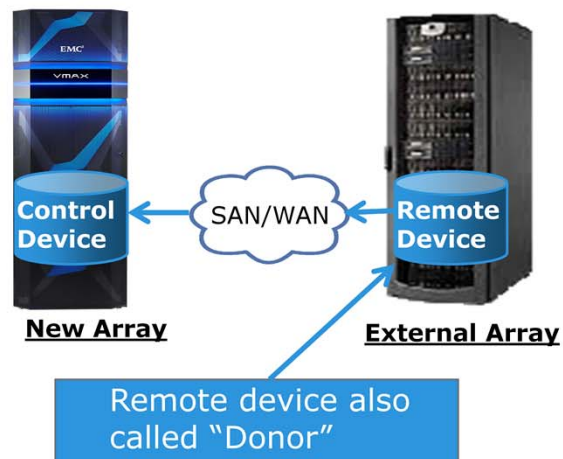
Copies the data from external "Donor" array volume to a VMAX³ volume

Copy operations are either hot (online) or cold (offline)

Control VMAX³ is host accessible

Can be larger than Remote

Remote should not be modified or read by any host during transfer



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VMAX³ Remote Replication Fundamentals

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In pull operations, the VMAX³ volume can again be in a live state during the copy process, which makes either restoring remotely vaulted volumes or migrating from other storage platforms very fast and efficient. The local hosts and applications can begin to access the data as soon as the session begins, even before the data copy process has completed. Hot pull is a way to perform migrations with minimal application down time.

Copy operations are either hot (online) or cold (offline).

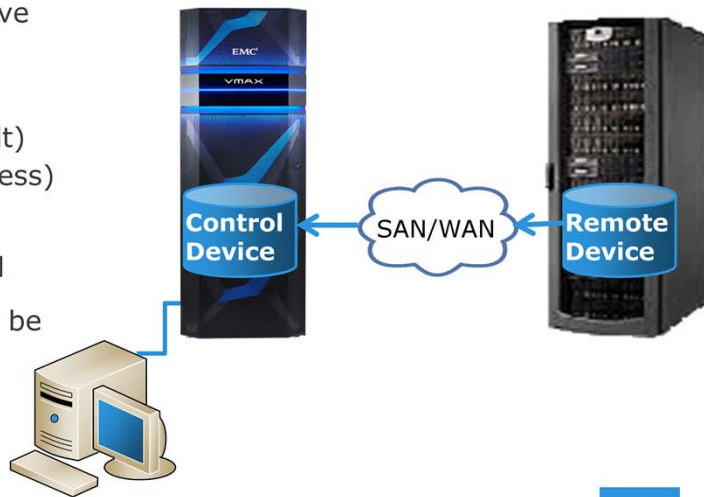
Rather than using the terms "source" and "target," which might be confusing in the Open Replicator context, we use the terms "control" and "remote," where the Control Device always resides on the Symmetrix running Open Replicator. The Remote Device, also called "DONOR", is passive and does not require any software.

On pull operations, the remote devices should not be updated by array hosts for the duration of the copy process. At activation, all Control tracks are marked protected:

- Background copy initiated between Remote and Control
- A read or write from the control device causes the track to be pulled over before access is permitted (CopyOnAccess behavior). Copying continues until complete if -copy option specified.

Open Replicator Pull Options

- Control Devices can have active host access
- The copy modes are
 - Background copy (default)
 - Nocopy (CopyOnFirstAccess)
 - Donor Update
- Differential option not allowed
- Front-end zero detection may be specified



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Open Replicator Hot Pull permits host access of the Control Devices while data transfer is in progress. After a hot pull session is activated, data on the Control Device is pulled from the Remote Device before a new read or write to the Control Device is permitted. An attempt to read or write data that has not already been transferred will cause a priority data move from the Remote to the Control Device before the write is allowed, this behavior is known as “Copy on First Access”. The default behavior is to start a background copy as soon as the session is activated.

The nocopy option results in control data not being copied in the background. Data is only moved when a new read or write is directed against the Control Device.

The donor update option permits new writes to the Control Device to be pushed to the Remote Device. This option results in the remote site containing the most current data. If the data pull is unexpectedly aborted because of a failure of network connectivity, there is no loss of the data that was written to the Control Device between the times when the session was activated

Hot Pull Data Protection through Donor Update

The “donor update” feature enables arrays to propagate (update) writes to the local device back to the remote device (donor) as data is being pulled from the remote device

Whether during or after data transfer, all new writes are sent to the remote device(s)

If a link fails during a hot pull, it is OK to terminate the session

Upon restarting, the remote device contains the most recent data

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To protect against potential data loss due to a SAN failure or other connectivity issue during a hot pull operation, you can use the donor update option. When enabled, this feature also causes all writes to the control device from the host to be immediately copied to the remote device. Because the data is fully copied to the remote and control devices, if a failure occurs, the session can safely be terminated and created again to fully recover from any mid-copy failure.

Open Replicator includes a feature that protects against potential data loss due to a SAN failure or other connectivity problems during an active Open Replicator live pull session. The “donor update” feature enables arrays to propagate (update) writes to the local device back to the remote device (donor) as data is being pulled from the remote device.

VMAX³ Open Replicator Support

- Only Hot and Cold Pull is supported
- Donor Update is supported with Hot pull.
- Uses Enginuity Data Services to managed data movements
- THIN devices are supported
- VMAX³ supports 512 Sessions
- Port throughput
 - ceiling
 - utilization
- VMAX³ Open Replicator does not supported SRDF and TimeFinder devices
- Federated Live Migration is not supported



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VMAX³ Remote Replication Fundamentals



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With VMAX³, support for Open Replicator has moved to the Enginuity Data Services (EDS) array module to managed data movements so the Mapping requirements are far simpler than in the older version with regards to hot pulls.

This new underlying support has resulted in changes to Solutions Enabler (SE) ORS functionality in several areas. VMAX³ supports a maximum of 512 ORS sessions. Only ORS pull sessions are supported and there can be only be one remote device for pull sessions.

VMAX³ Open Replicator does not support SRDF and TimeFinder devices.

The functions related to the setting of port throughput ceilings and the reporting of port throughput utilization have changed to reflect the changes to directors and the number of ports. The feature by which ORS throughput values are controlled has been changed from the symrcopy to symqos.

The Open Replicator PACE feature allows throttling to limit SAN bandwidth usage of the copy process; with VMAX³ Open Replicator Pace is not used. Devices involved in TimeFinder or SRDF replication cannot be used for ORS on a VMAX³. Federated Live Migration (FLM) is not supported.

Open Replicator Session Considerations

Control Device

- Cold - One zoned remote port required
- Hot - Two zoned remote ports required

Restriction lifted

- Not all mapped ports need access to remote device
- Map and Unmap device

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Enginuity Data Services (EDS) emulation will dynamically find directors and ports that can access an ORS session's remote devices and it will use these directors and ports for the data transfer.

VMAX³ Open Replicator requires at least one zoned remote port for cold sessions and at least two zoned remote ports from at least two different directors for hot sessions.

In previous versions, to start a hot pull Open Replicator session, all the ports the control device was mapped to had to have access to the remote device. This restriction has been removed with the new zoning requirements.

With the previous version of Open Replicator, devices were blocked from being explicitly mapped and unmapped from ports; in order to map a control device to a port, it had to be in a masking view. With VMAX³ control devices do not have to be in a masking view and can be mapped and unmapped.

VMAX³ Open Replicator Software

The Open Replicator Software provided for VMAX³ is:

Solutions Enabler

- Solutions Enabler
 - consisting of the “symrcopy” command

Unisphere for VMAX

- Operations are listed under “Data Protections”

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VMAX³ Open Replicator Software includes, Solutions Enabler that uses the consisting of the “symrcopy” command.

For more information see the EMC® Solutions Enabler 8.0 documentation at support.emc.com

Unisphere for VMAX³ has all the options to manage the Open Replicator operations.

Module Summary

The key concepts covered in this module are:

- Open Replicator overview
- Open Replicator Pull operations
- VMAX³ Open Replicator Support
- Open Replicator management software

This module focused on the EMC Open Replicator overview, operation, support and management.

Course Summary

Key points covered in this course:

- Remote replication business requirements and benefits
- Remote Replication family of products and use cases
- The architectural components and connectivity options
- List the various Remote Replication topologies and dynamic operations
- Identify the various Remote Replication modes
- Describe Remote Replication management options
- EMC Open Replicator overview

This course covered the Remote replication business requirements and benefits Remote Replication family of products; also, the architectural components, connectivity options, dynamic operations, the various Remote Replication modes and management options. Also, EMC Open Replicator for VMAX³.