Array-based Data Protection: Making Data Recovery Fast, Easy, and Cost-Effective

Disk-based data protection is increasingly essential as a supplement to tape-based protection to meet rapid recovery requirements for business-critical enterprise applications. Among the various disk-based solutions, array-based data protection offers distinct benefits that take advantage of the latest technologies to provide fast, affordable recovery for any size organization.

BY SONYA R. SEXTON

Across enterprises of all types and sizes, not only are online operations generating more data, but more of that data is linked to vital applications that cannot fail without incurring serious consequences, including loss of revenue, decreased productivity, a damaged reputation, and even legal penalties. For a growing number of applications, the service-level requirements for data recovery time are now measured in minutes or hours, not days. Because traditional tape-based recovery can be time-consuming, enterprises must deploy disk-based protection technologies extensively to meet increasing requirements for rapid recovery.

Heightened demand for rapid recovery is driving innovation in disk-based data protection technology. The evolution of external disk storage devices to support low-cost ATA and Serial ATA (SATA) media is a key development that has helped reduce the cost of implementing disk-based solutions. Additional developments in disk-based data protection include enhancements to user environments, resulting in friendlier, more efficient interfaces, and application programming interface (API)—level integration with complementary programs to help increase operational effectiveness.

Types of data protection

Data protection functionality consists of two broad types: remote replication to a second array, whether in a second data center at the same location or at a distant site, and point-in-time copying within a single system. These functions can be used individually or in combination. Remote replication, often called remote mirroring, replicates file or block changes to application data to one or more remote nodes in real time. Point-in-time copying (see Figure 1) creates copies of volumes at a particular point in time; these copies are often referred to as snapshots or clones. A clone is a complete block-for-block copy of a volume at a particular point in time. These copies are often referred to as snapshots or clones.

A snapshot is a virtual copy comprising pointers to the base volume and an index of blocks that have changed in the original volume since the snapshot creation; as new data is written to the source volume, old data is copied to the snapshot index. A clone is a complete block-for-block copy of a volume at a particular point in time.

The range of data protection technologies is best surveyed based on where the software services run in the I/O path. Most implementations run on either host platforms or the controllers of external storage arrays. A third implementation is also emerging—one that runs in the network, either on a dedicated appliance or in the network switch.
Host-based technologies tend to be the most cost-effective of available data protection technologies, but they are point solutions, providing one type of data protection service (either remote mirroring or local point-in-time copying) for a specific application type. Also, because they must be deployed for individual servers and are often modified to follow OS or application revisions, management overhead can be high in environments with multiple servers. These solutions compete with production applications for processing resources on both the primary and target nodes.

Network-based technologies have had limited deployments. Available as either an appliance or a blade option with storage area network (SAN) switches, they are deployed directly in the I/O path between the hosts and the external storage devices or as a node on the network. They are intended to operate between disparate disk systems. Note that supported systems each require discrete interoperability engineering.

Array-based technologies are gaining wider acceptance, particularly with organizations following consolidation strategies to effectively manage growth. These data protection implementations allow organizations to use the same solution for their entire environment and provide a wide range of mature rapid recovery mechanisms, including remote replication, local point-in-time copying, and combinations of the two. Cost-effectiveness can be enhanced through one-time, device-based licensing (as opposed to capacity-based licensing) combined with tiering support, both within arrays (by means of drive intermix) and across arrays (by means of interoperability between the full range of storage platforms, from entry-level to enterprise). Most leading storage arrays provide a basic set of data protection options; a smaller subset provide premium options. Given the increasing importance of rapid recovery, premium options can be a key factor when evaluating storage consolidation platforms. For more information about Dell/EMC arrays and data protection software, see the “Dell/EMC CX3 series and array-based replication” sidebar in this article.

Beyond software functionality, hardware differences also have a direct impact on the effectiveness of a given solution. Among the most important distinctions is the ability of the hardware architecture to sustain demanding performance levels for production applications in tandem with extensive deployment of data protection services. Choice products offer powerful performance architectures designed for consolidation with challenging requirements for rapid recovery. These products generally support more active copy and replication sessions than less-advanced platforms.

**Array-based data protection: Exploring the range of functionality**

Array-based data protection provides the most extensive functionality of any of the available data protection technologies. This expanded functionality allows administrators to tailor recovery service levels for diverse applications. Choice products complement extensive functionality with elegant tools for administering the replication services to enable both efficiency and operational excellence. Choice products also provide flexibility in configuring disk resources for use as replication repositories—for example, the ability to configure global repositories using low-cost disks within the array, which can centrally support all data protection operations with efficient use of disk resources.

**Remote mirroring**

Replication between a source array and one or more remote arrays is generally supported in two operational modes: synchronous and asynchronous. In synchronous mode, both the source and target arrays must acknowledge a write operation before the next write can occur. This mode provides recovery at the exact point of failure, with near-zero data loss. In asynchronous mode, writes can continue on the source volume while the target volumes are updated in the background.

The interconnect channels between the source and target arrays are a key part of any remote mirroring implementation. Standard Fibre Channel links are practical for distances of up to 10 km (about 6 miles) for most applications; beyond that range, channel latency and interference can become problems. Use of optical line drivers and repeaters or dense wavelength division multiplexing (DWDM) can extend Fibre Channel range up to 100 km (about 60 miles). For longer distances, remote communication services must be provided through an internal IP option in the array or an external protocol conversion of Fibre Channel to IP. These conversion products are readily available from most switch providers.

In synchronous mode, the application is dependent on the bandwidth of the link connecting the source and target. The connection bandwidth should be planned to exceed the maximum peak of the application I/O load. Because high bandwidth over long distances can be expensive, synchronous mode is often used with targets at campus- or municipal-area ranges for quick recovery from room, building, or site disasters. Many enterprises

---

**Figure 1. Point-in-time copying using clones and snapshots**

![Diagram showing point-in-time copying using clones and snapshots]
consider synchronous mirroring mandatory for critical applications that have low tolerance for downtime and near-zero tolerance for data loss.

In asynchronous mode, applications can be less dependent on link bandwidth than in synchronous mode, so the connection bandwidth can be planned to accommodate the average application I/O load, as opposed to the peak load. As a result, asynchronous mode is more cost-effective than synchronous mode for providing rapid recovery from regional or geographic disasters, particularly if the application has some tolerance for data loss.

Both synchronous and asynchronous mirroring modes are supported on most arrays; beyond operational modes, however, array-based products become markedly different. These differences include the range of mirroring functions supported as well as the types of administrative aids that facilitate operational effectiveness and efficiency.

**Premium remote mirroring features**

Choice arrays provide advanced levels of functionality and manageability that enable high levels of disaster tolerance, cost-effective mechanisms for rapid recovery, and unique applications that enhance the business value of data and improve storage administration. The following premium mirroring features can add significant value to array platforms.

**Integration with point-in-time copying.** Best practices for rapid recovery call for at least two versions of production data at a recovery site: the active mirror and a full-volume point-in-time copy (see Figure 2). The ability to combine mirroring and point-in-time copying helps provide data recoverability for the broadest range of contingencies. This feature also provides application benefits by enabling a secondary server to mount a fully consistent readable and writable copy of the mirrored data and then perform operations such as decision analysis, application testing, or backup.

**Suspend and resume capabilities with fast and reverse resynchronization.** Giving administrators the ability to control mirroring operations and quickly establish a desired state of consistency at both the source and target brings flexibility that benefits both recovery and operational effectiveness. Advanced products also provide a throttling mechanism that allows administrators to control the performance impact of resynchronization.

**Session persistence.** This feature provides rapid recovery of the replication sessions themselves. It uses a write intent log on the source array to facilitate fast resynchronization of the target in the event of a temporary session disruption. In the event of a line disruption, less-advanced products require administrators to reestablish replication sessions from the beginning.

**Fan-in and fan-out mirroring.** Fan-in mirroring (sometimes called many-to-one mirroring) replicates data from multiple sources to a single target, enhancing the economics of disaster recovery by allowing multiple sites to use a single array—potentially a low-cost platform—as a copy repository. When used in combination with suspend and resume functions, fan-in mirroring helps enable consolidated backups, simplified failover, and consolidated remote processing activities, among other applications. In contrast, fan-out mirroring (sometimes called one-to-many or n-way mirroring) replicates data to multiple targets, enhancing disaster tolerance by allowing multiple recovery copies and facilitating nondisruptive data migration.

**Bidirectional mirroring.** Bidirectional mirroring (see Figure 3) allows arrays to function as both sources and targets, helping reduce the cost of disaster recovery in distributed environments and providing increased flexibility in enabling rapid recovery.

**Discrete drive types.** This feature gives administrators flexibility when optimizing disk resources at the target (for example, mirroring from RAID-1 Fibre Channel drives to RAID-5 SATA drives). Additionally, it allows administrators to respond nimbly to changing service-level objectives with data migration projects (for example, reallocating an application to a secure site and from RAID-5 SATA drives to RAID-1 Fibre Channel drives).

**Consistency groups.** During a rolling disaster, data can become inconsistent at the target. Applications such as databases that require a certain sequence of write operations to multiple volumes, or dependent writes, are particularly vulnerable. If consistency is not
The Dell/EMC CX3 UltraScale™ series of storage systems is designed to support demanding production I/O workloads in combination with the full breadth of array-based replication services. This series features architectural enhancements that are designed to significantly enhance replication performance—including up to two and a half times more processing power plus significant bandwidth increases on the internal buses and I/O interfaces when compared with previous-generation Dell/EMC CX series arrays.1 Equipped for powerful processing and high throughput, each array model in the CX3 series supports both remote mirroring and point-in-time copy operations. Hundreds of mirroring and point-in-time copy sessions can be performed simultaneously by a single array.

Optional replication programs that run on the CX3 series arrays include the EMC® MirrorView™ application for remote replication, the EMC SnapView™ application for local point-in-time copying, and the EMC SAN Copy™ application for cross-array data migration. Reflecting the rich heritage of EMC as a pioneer of array-based replication technologies, all three programs combine advanced functionality with a remarkably accessible user environment and full API-level integration across all services. In addition, the programs work with any supported data types and OS platforms and are production-proven, with thousands of deployments operational across all major industries. These software distinctions, in combination with the uniquely powerful processing architecture of the CX3 series, deliver exceptional capabilities for array-based replication.

Remote replication: MirrorView
MirrorView performs both synchronous and asynchronous remote mirroring over Fibre Channel links, including Fibre Channel tunneling over IP links for regional and geographic disaster recovery implementations. The software delivers a full set of premium replication and operational management features in an easy-to-use package that is both flexible and affordable. It works on all CX3 series platforms and facilitates mirroring between different array models and generations. With storage tiering supported across all CX products, IT organizations can take advantage of cost-effective disk media to bring disaster recovery within budget for organizations and applications within the enterprise.

Local point-in-time copying: SnapView
SnapView combines the ability to create local snapshots and clones in a single cost-effective package. In addition to copy and restore functions, SnapView includes advanced tools for automating copy operations and helping provide data consistency across versions. Tightly integrated with MirrorView, SnapView can be used to help optimize rapid recovery at disaster recovery sites, to support secondary processing operations such as backup and archiving, and to perform testing and mining. SnapView functionality is enhanced by the Replication Manager application for Microsoft® Exchange software, which provides key integration to automate disk-based backup and restore operations for Exchange stores. SnapView has unique flexibility to copy data to different RAID formats and disk media, enabling storage administrators to cost-effectively implement disk-to-disk backup and restore.

Cross-array data migration: SAN Copy
SAN Copy allows full-volume copy operations between Dell/EMC arrays, including both CX and AX platforms. It enables administrators to perform data migrations nondisruptively over any distance using Fibre Channel and Fibre Channel–to–IP tunneling technologies. The software comes with a full set of advanced features that enhance operational efficiency and give administrators flexibility to copy, relocate, distribute, and back up data from one storage system to another as requirements change. The software leverages the built-in storage-tiering capabilities of Dell/EMC array platforms to help contain storage costs.

1 These performance improvements are for a Dell/EMC CX3 array with an Intel® Pentium® 4 Xeon® processor at 2.88 GHz when compared with a Dell/EMC CX300 array with an Intel Pentium II processor at 800 MHz. Actual performance will vary based on configuration, usage, and manufacturing variability.
maintained at the target, rapid recovery can be compromised. In most cases, a full recovery from backup is required. By establishing consistency groups, administrators can provide write order integrity at the target, because this feature requires writes to all volumes in the group to complete in the proper order before an acknowledgment is sent to the application.

**Bandwidth optimization for asynchronous mode.** Techniques for grouping write changes for a definable period of time (referred to as delta sets) and intelligently filtering repeated changes so that only the most current are transmitted to the target can greatly help to reduce bandwidth requirements, enabling administrators to configure the system for the average write workload rather than the peak workload—which can provide significant cost savings in wide area network (WAN) replication.

**Point-in-time copying**
The ability to create either virtual copies (snapshots) or complete block-for-block copies (clones) of volumes is crucial to rapid recovery from logical or user errors and some forms of data corruption, such as viruses. Point-in-time copies can also be used for offline processing operations, such as backups, software testing, and data mining. These services typically generate copies locally, within the same array as the source volume. Because snapshots do not generate a complete one-for-one volume copy, they save space and can be created nearly instantly. However, generating a snapshot increases write overhead because every new write to the volume is accompanied by a copy of the old data to the snapshot index. A read access to the snapshot can also impose a performance penalty, particularly if the read requires access to the old data still residing in the source. By contrast, full-volume copies require a repository that is equal to or greater in size than the source volume, and they take more time to generate than snapshots do; however, they can be produced as a background operation and therefore have less impact on production operations than snapshots do. Also, access to volume copies does not impose performance penalties on operations to the source volume.

**Premium point-in-time copying features**
Choice arrays provide advanced tools for both creating copies and managing copy operations effectively. The following premium point-in-time copying features can add significant value to array platforms.

**Copy repository right-sizing.** Setting up snapshot repositories to effectively accommodate copy-on-write operations while making optimum use of valuable disk resources can be particularly challenging because write activity varies for individual applications. The ability to monitor write overhead on a particular logical unit (LUN) and then intelligently right-size the snapshot repository is a tremendous boon.

**Remote copying.** Although less-advanced array platforms permit only local copies, the ability of more-advanced platforms to create point-in-time copies on a remote array gives administrators powerful options for nondisruptive data migration and offline processing by a secondary server, which can use remote resources effectively to mitigate the performance overhead of offline operations from production nodes.

**Versioning with scripting.** This feature allows administrators to automatically generate multiple copies of individual LUNs in succession, providing a series of time-stamped images to use for rapid recovery. This is particularly crucial with logical corruption and viruses, which may not be detected immediately.

**Application integration.** The ability to integrate point-in-time copying operations with application hot-backup routines and then orchestrate the copy process through the application can address difficult consistency issues with backing up database applications and helps automate a traditionally labor-intensive procedure.

**Log-based resynchronization.** Administrators can quickly update full-volume point-in-time images by applying changes logged since the last image was created, allowing fast, low-overhead synchronization of full-volume images.

**Reverse resynchronization.** The ability to establish consistency on a production LUN using a simple resynchronization process not only helps speed up restores, but also helps reduce the potential for administrative error. This feature can also complement offline processing when a reprocessed LUN represents a new desired state of consistency for a source LUN.

**Consistent split and restore.** This feature helps provide consistent resynchronization for applications such as databases that interact with multiple LUNs.

**Flexible and efficient data protection**
As online operations continue to proliferate and dictate new requirements for rapid recovery across a growing base of applications, evaluating the benefits of array-based data protection becomes increasingly important. Array-based data protection extends the benefits of centralized operations to all levels of business, which can help improve efficiencies in both management and cost of ownership and provide the flexibility to tailor recovery scenarios for a complete range of disaster situations. In addition, array-based data protection can provide valuable management aids for administrators. Although basic features are commonly available among popular array platforms, choice array platforms deliver premium features that enhance rapid recovery capabilities and enable administrators to meet high levels of operational excellence.

Sonya R. Sexton is a competitive intelligence analyst, focused on storage systems, for the Enterprise Marketing Operations Group at Dell.