

EMC Data Domain Global Deduplication Array

A Detailed Review

Abstract

Large IT organizations experiencing substantial data growth are struggling to cost-effectively deploy disk-based backup and network-efficient disaster recovery (DR) strategies. Data deduplication technology that provides both performance and capacity scalability, multi-site DR flexibility, and easier end-to-end backup administration is critical to deliver operational simplicity and cost savings to the user. This white paper introduces the EMC[®] Data Domain[®] Global Deduplication Array (GDA), the industry's highest-performance inline deduplication storage system for enterprise backup applications, and explains how it delivers scalable performance and capacity, enhanced multi-site disaster recovery, and simpler, end-to-end backup administration.

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Executive summary

Over the last five years, IT has moved aggressively toward redesign of backup architectures. The new best practice in place of tape for operational recovery is to back up to deduplication storage systems. This resolves the many operational issues with tape, while also dealing more effectively with explosive data growth. In addition, the ability to replicate deduplicated data over the WAN, versus tapes on trucks, provides automated protection of edge data in distributed enterprises. As virtualization evolves toward enablement of the private cloud, deduplication storage will prove to be the standard alternative for its backup and recovery.

However, deduplication storage controllers are not yet fast enough to scale individually to support the largest data centers. If groups of individual systems are used, the job can be done, but redundancy checking will only be within the context of a single system. To create a bigger, faster system with global deduplication, an architectural extension is needed that enables a multi-controller system while maintaining global deduplication.

The EMC® Data Domain® Global Deduplication Array (GDA) is a multi-controller Data Domain system enabled by an extension of the Stream-Informed Segment Layout (SISL)™ scaling architecture. With the GDA, EMC extends its leadership position in deduplication storage by delivering a system that scales efficiently across multiple deduplication controllers and drives new levels of simplicity for data center backup consolidation.

Unlike other multi-controller deduplication storage systems, GDA is optimized for fast performance using minimum hardware. Most alternatives, through either inefficient disk I/O or deduplication post-processing, compromise their efficiency and become much harder to manage, with performance and replication unpredictability among other limitations.

The Global Deduplication Array offers:

- **Scalable, inline deduplication storage for backup**
Without a sufficiently large and fast enough single deduplication system, multiple systems may have to be deployed to accommodate very large amounts of backup data, leading to potential overall deduplication inefficiency and unbalanced utilization of resources over time. However, existing multi-controller deduplication systems fail in delivering a simple, efficient, and scalable inline deduplication system. The Global Deduplication Array provides a single deduplication storage pool across two controllers. GDA scales without compromising on deduplication efficiency or operational simplicity and automatically load balances resource utilization transparently to the backup application.
- **Scalable and flexible multi-site disaster recovery**
As the size of data centers and the number of remote sites to protect increase, the complexity and cost of managing islands of tape-based disaster recovery (DR) solutions increase exponentially. Existing network infrastructures are limited in bandwidth and can have complex topologies in a geographically distributed organization, which makes the use of traditional replication for DR impractical and very expensive. GDA provides a scalable, reliable, and easy-to-manage DR solution to protect multiple petabytes of data for large enterprise data centers with hundreds of remote sites using EMC Data Domain Replicator software.
- **Simpler end-to-end backup administration**
Large backup environments often have multiple hardware and software components, including backup servers, software, and storage systems, which put pressure on end-to-end backup administration, capacity planning, and system management. Minimizing hardware and software components and leveraging software for tightly integrated end-to-end backup administration is critical for operational simplicity. The multi-controller GDA presents a single, large storage pool for backup and replication policies, which greatly reduces backup policy administrative overhead. Compared to other multi-controller products, the limited number of hardware components in GDA makes it as easy to deploy and manage as any other Data Domain appliance.

Data Domain systems have revolutionized disk-based backup, disaster recovery, and remote office data protection with high-speed, inline deduplication. The flagship, single-controller Data Domain systems are

faster than most competing multi-controller systems. Unlike many competitive systems, Data Domain systems deduplicate all new data globally against all currently stored data. Furthermore, many competing products that use multiple controllers to produce a global deduplication system increase complexity. The goal in designing GDA was to use the minimum number of the most flexible components and points of management to produce the simplest, most scalable multi-controller global deduplication system.

Introduction

This white paper introduces the EMC Data Domain Global Deduplication Array and explains how it delivers scalable performance and capacity, enhanced multi-site disaster recovery, and simpler, end-to-end backup administration. Read this white paper to find out how the EMC Data Domain Global Deduplication Array solves the most challenging backup, recovery, and DR issues in data centers with over a hundred and up to several hundred terabytes of data to protect.

In the following sections, we will describe the unique characteristics of GDA, including innovative EMC global deduplication technology, and deployment scenarios typically found for multi-controller global deduplication systems in large enterprises as well as evaluation criteria to consider.

Audience

This white paper is intended for EMC customers, technical consultants, partners, and members of the EMC and partner professional services community who are interested in learning more about the Data Domain Global Deduplication Array.

Global Deduplication Array overview

The EMC Data Domain Global Deduplication Array is the industry's fastest inline deduplication storage system for enterprise backup applications. GDA presents a single, inline deduplication storage pool to the backup application across two EMC Data Domain DD880 controllers. Multi-terabyte datasets are dynamically and transparently load balanced across the controllers, simplifying capacity management, performance management, and backup administration.

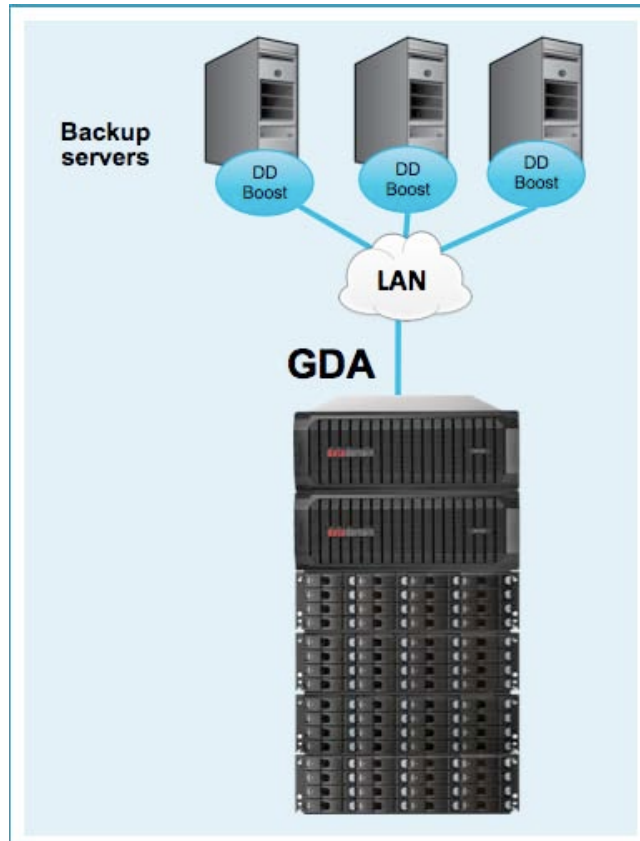


Figure 1. Global Deduplication Array

The Global Deduplication Array is tightly coupled with backup software, enabling industry-leading, inline deduplication performance, dynamic distribution of load between the two controllers, and simplicity of operation. The GDA supports Symantec NetBackup and Backup Exec applications using the Data Domain OpenStorage plug-in with the embedded EMC Data Domain Boost software. EMC Data Domain Boost software distributes parts of the deduplication process to the DD Boost Library that runs on backup servers. Distributing parts of the deduplication process lowers CPU utilization on the backup servers, reduces network load, and increases the throughput performance of Data Domain systems. In the second half of 2010, GDA will also support EMC NetWorker® in a similar way.

For backup environments with hundreds of terabytes of data to process, administrators can target many backup policies to GDA and leverage a common deduplication storage pool for all data protected by those policies. GDA accommodates hundreds of concurrent backup jobs, about 50 percent higher backup throughput, and 100 percent higher restore throughput than a comparable Data Domain single-controller system, allowing more backups to complete sooner while putting less pressure on limited backup windows. The innovative global deduplication technology that enables GDA minimizes the need to reconfigure complex backup policies or load balance policies for performance and capacity management. Consequently, very large datasets can easily be protected with administrative simplicity while maximizing overall deduplication efficiency and therefore minimizing physical storage footprint.

With DD Replicator software, GDA can automate wide area network (WAN) vaulting of deduplicated data for use in disaster recovery, remote office backup, or multi-site tape consolidation. Enabled through DD Boost managed file replication, GDA allows the backup software to centrally control and manage the replication of backup data to and from GDA and any other Data Domain systems. GDA can support replication fan-in of hundreds of remote offices using smaller Data Domain systems. Cross-site deduplication further minimizes bandwidth requirements since only unique data is transferred across any of the WAN segments.

For greater data protection and availability, GDA can also leverage the storage unit group failover functionality within Symantec NetBackup to provide N+1 redundancy. When required, failover within the backup software, plus replication and backup policy management, can provide higher availability to backup operations. If this additional protection is required, EMC recommends applying the N+1 failover design described in the white paper [*EMC Data Domain Boost for Symantec NetBackup and NetBackup Storage Unit Group Failover*](#).

Scalable inline deduplication storage for backup

Due to their CPU-centric design, every generation of Data Domain systems has gotten much bigger and faster; from 2004 to 2009, they increased 40x in performance and 60x in capacity. Data Domain single-controller systems are simple to use and many large data centers will find them more than sufficient to do the job. However, there are some cases when a large multi-controller system is better. When data is split across separate deduplication systems, for example, the deduplication effects are not combined, limiting the opportunity to save storage. Also, over time, these systems may start to be utilized unequally, putting pressure on backup administrators to manually load balance storage resource utilization.

The GDA delivers a single global deduplication storage pool across two Data Domain controllers. While deduplicating across controllers inline, GDA scales performance and capacity beyond the highest-end Data Domain single-controller system while seamlessly balancing operations across the controllers.

Global deduplication: With GDA, inline global deduplication takes place across all backup jobs sent to the system from all backup servers and replication sources. This is the same methodology used in single-controller Data Domain appliances except now the data is stored across two Data Domain controllers.

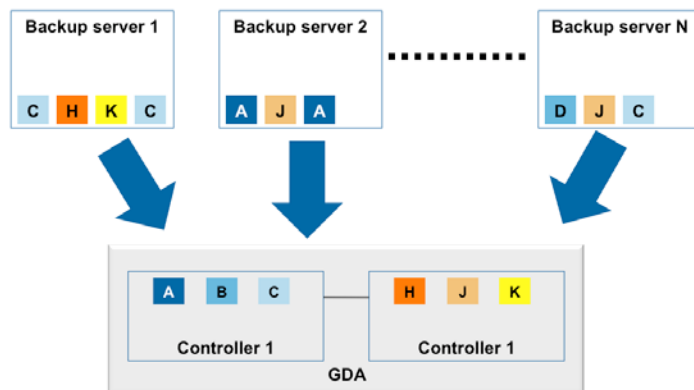


Figure 2. Global deduplication takes place across all backup servers and all backup jobs. Deduplicated data is efficiently distributed between controllers

Scaling capacity: For enterprises with hundreds of terabytes of data, GDA can store twice the capacity of backup data as the largest single-controller Data Domain system. GDA provides sufficient capacity to accommodate very large backups that cannot be split into multiple storage systems and scales to support a large number of clients, capable of processing hundreds of backup jobs concurrently. GDA also helps to significantly reduce the physical storage required for long-term retention. With a global namespace across the controllers, GDA presents one, easy-to-use large storage pool to backup applications. Physical storage capacity can be added to GDA in increments of two expansion shelves at a time, one per controller.

Safely completing all critical backups within a limited backup window and retaining sufficient copies of data for rapid recovery are primary goals in any backup environment. Therefore, the larger the dataset to be protected, the faster and larger the target backup storage system needs to be. However, just because a system is fast *or* large does not mean it will be able to meet the demands of a large enterprise data center. For example, high ingest throughput would be overkill if the system could not accommodate the capacity. Vice versa, if the overall backup and deduplication processing speed is too slow, the system will never be able to leverage its entire capacity during the life of the system. Unlike other inline deduplication systems, GDA has been designed to provide the right balance between performance and scalability to complete large daily backups and retain sufficient copies of data at the primary data center and the DR site.

Scaling throughput: GDA delivers the industry's fastest inline deduplication throughput, about 50 percent faster than the fastest single-controller Data Domain system, allowing users to substantially minimize backup windows or back up more data within the same backup window. The GDA takes advantage of both controllers and uses this processing power to scale performance while minimizing disk footprint.

Specifically, there are two ways to scale GDA throughput:

- To maximize throughput, connect more backup servers and execute more backup jobs concurrently, and take full advantage of distributed segment processing on the backup server with DD Boost (see the "Global deduplication technology" section). Likewise, using both controllers, GDA scales restore performance linearly compared to what can be achieved with a single controller to ensure rapid recovery from a disaster for large datasets.
- Data centers with hard-to-predict data growth have the flexibility to start small with a single-controller GDA and add a second controller later, enabling scalability while protecting the initial investment.

Automated and transparent load balancing of capacity and performance: GDA does not require backup administrators to provision backup policies per controller or monitor the individual controllers for performance and capacity management. Transparent to the backup application, DD Boost software automatically routes data to the proper GDA controller and maintains global deduplication efficiency between the controllers. Data is then automatically sent from the backup servers to the controller with similar data. Over time, GDA monitors capacity utilization and rebalances deduplicated data transparently between controllers over the standard IP-based system interconnect. Similarly, if a controller is added to single-controller GDA, backup policies do not need to be modified to benefit from the expanded capacity. GDA will automatically load balance capacity utilization between both controllers. This flexible capacity expansion greatly reduces backup administration as existing backup policies do not need to be modified.

Scalable and flexible multi-site disaster recovery

Many large organizations with hundreds of terabytes of data distributed across multiple locations have adopted Data Domain inline deduplication systems. Data Domain Replicator software is used for network-efficient DR, enabling the transition away from complex, tape-based disaster recovery. With Data Domain Replicator and high-throughput deduplication, replication is simple to set up and manage. There is no complex process required to start or manage replication and network bandwidth is minimized since only deduplicated and compressed data is transferred over the WAN. In contrast, "post-process" deduplication storage systems land data on disk in native format before starting deduplication as a secondary step. Cost-efficient replication cannot start on these systems until after the deduplication process has completed.

With market-proven Data Domain Replicator software, GDA can be used as a scalable, network-efficient and reliable replication target to meet stringent network-based disaster recovery objectives for very large and distributed backup environments. With DD Boost managed file replication, GDA provides the greatest flexibility by offering replication topologies for many remote sites and multiple large data centers. In the first release, data can be replicated to or from GDA using Symantec NetBackup optimized duplication, which centrally manages the duplication of backup images between Data Domain systems. In the second half of 2010, EMC NetWorker will support a similar type of replication management. More information about all replication types can be found in the [*EMC Data Domain Replicator*](#) white paper.

With Symantec NetBackup optimized duplication, the backup administrator configures NetBackup policies to selectively replicate individual backup images from the GDA to another Data Domain system. Unlike traditional NetBackup vaulting to tape, data is not read by the backup server to be written elsewhere. Instead, NetBackup delegates the data movement to the Data Domain storage system that holds the data, and it can then use highly efficient replication to move data offsite. NetBackup decides when to start replicating the job and knows when it is finished. Using this approach, NetBackup knows that the destination Data Domain system holds a copy of the backup image and retention periods for each copy can be managed independently.

GDA provides a highly scalable disaster recovery storage solution, enabling DR consolidation for hundreds of remote sites. Unlike competing offerings with limited consolidation capabilities, GDA provides the industry's largest fan-in replication ratio and provides cross-site data deduplication to reduce the WAN bandwidth needed to protect data from remote offices.

Managed file replication can be used to implement DR for a highly distributed organization with various network bandwidths and topologies. It provides the flexibility of broad replication topologies including one-to-one, bi-directional, many-to-one, one-to-many, and cascaded. In these topologies, Data Domain Replicator also enables cross-site deduplication, which means a unique segment is only transferred over the WAN once, regardless of the number of systems storing that segment in the replication topology.

Simpler end-to-end backup administration

GDA takes advantage of the same operational simplicity benefits that DD Boost offers with single-controller Data Domain systems. This allows the backup application to view GDA as a single global storage system to target all backup policies to, without any need to manually configure each policy to a specific GDA controller.

This seamless integration of GDA into the backup environment as well as the scalability of the system eliminates the additional complexity that comes with multi-system deployments. As more heterogeneous backup servers are deployed and as more backup policies are created, they can all target the same Global Deduplication Array to minimize operational costs. GDA minimizes the number of deduplication storage systems in a large deployment, thereby reducing overall management costs, including the additional configuration or reconfiguration of backup policies.

With DD Boost, backup applications can control replication of data between multiple Data Domain systems and GDA to provide backup administrators a single point of management for tracking all backups and duplicate copies. This enables GDA to become a key foundational element of a multi-site tape consolidation strategy. The scalability of restore performance in GDA allows consolidated tape operations with centralized tape management for large numbers of remote systems or a large data center, further reducing the overall management complexity of backup environments.

Operational simplicity is the cornerstone of Data Domain systems as they seamlessly integrate into users' backup environments with limited management overhead. Like all Data Domain systems, GDA ships with EMC Data Domain Enterprise Manager, a simple Web-based rich application for managing multiple Data Domain systems. DD Enterprise Manager provides a single system view of GDA, so users are not burdened with any learning curve. It allows management of multiple Global Deduplication Arrays from a central workstation and provides a high-level overview of the health status of individual controllers in the system and enables the administrator to drill down into areas of interest. Centralized management gives administrators more ability to monitor and control systems, which drives maximum efficiency and a greater return on investment.

DD Enterprise Manager dashboards provide a global view across the controllers and a view for each individual controller in GDA (Figure 3). The operational simplicity of the dashboards helps reduce administrative costs. Further, DD Enterprise Manager makes it easy and intuitive for backup application administrators to manage DD Boost functionality. Administrators can easily configure DD Boost-specific features such as managed file replication using simple task-based wizards.



Figure 3. The DD Enterprise Manager GUI provides a summary view of the GDA file system utilization, system status, and deduplication ratio

Complementing the DD Enterprise Manager GUI-based interface, administrators can also manage the Global Deduplication Array through a comprehensive set of command line interfaces (CLI) over Secure Shell (SSH). The CLIs can be used for initial system configuration and subsequent updates using scripts. SNMP monitoring allows administrators to easily integrate GDA systems with existing heterogeneous SNMP monitoring tools. Simple script-ability along with SNMP monitoring provides additional management flexibility.

All Data Domain systems have an automatic call-home system reporting feature, called autosupport, which provides customizable e-mail notification of complete system status to EMC Support and to a selected list of administrators. GDA takes advantage of and extends the autosupport mechanism to provide a unified notification for all controllers in the system, making ongoing management easy for administrators. This non-intrusive alerting and data collection capability enables proactive support and service without administrator intervention, further simplifying ongoing management.

Global deduplication technology

GDA is enabled by extensions to the Data Domain SISL architecture that enables all other Data Domain systems. This maintains the use of mature and scalable Data Domain technology for most activities while scaling and balancing load across controllers.

Distributing inline global deduplication across multiple controllers

The GDA leverages DD Boost software to separate the process of inline deduplication normally performed in one Data Domain controller across several processing points. The GDA uses stateless routing and the distributed segment processing functionality of the DD Boost software to distribute parts of the deduplication process, including compression, to the backup servers to avoid sending duplicate data to the GDA controllers.

- **Stateless routing:** Initial analysis of incoming data is performed by the DD Boost software executing on the backup server. This analysis uses a process called “similarity mapping,” which determines to which GDA controller it will send a chunk of data.
- **Distributed segment processing:** Once a chunk of data is profiled, it is directed to a particular GDA controller. The backup server then interacts with the chosen GDA controller to determine which small

segments of the chunk are new and which are redundant on the basis of the segment fingerprints. New segments are compressed and sent to the controller, which stores them on its own disks.

DD Boost is available today using Symantec products within the Data Domain OpenStorage plug-in, and will be available later in 2010 with EMC NetWorker. This distribution of parts of the deduplication process is transparent to the backup application. The distributed segment processing function of DD Boost software does not store any data on the backup server.

The distributed deduplication process element on the backup server breaks up the backup image data into large chunks with an average size of about ~1 MB, and determines which controller should store the chunk. These chunks are established based on content patterns and are not aligned to traditional block or file boundaries. The routing decision is based on the composition of the data in the chunk, which ensures similar chunks are always mapped and sent to the same destination controller to achieve the best deduplication and storage efficiency. While the similarity mapping analysis function is sophisticated and has been refined for a number of years in Data Domain research and development labs, it results in a simple decision to direct the chunk to one controller or another. As a result, the GDA does not have to constantly monitor state on both controllers, and this minimizes cross-controller communication, simplifying the approach and making it more resilient.

This routing also adapts quickly to any changes in the system, including the addition of more capacity. The routing function will dynamically change over time depending on the utilization of the systems. If there is more data on one controller than on the other, the GDA will transparently and dynamically rebalance the data. Future chunks will then automatically be routed to the new destination.

Once the destination controller for the chunk is determined, the distributed DD Boost software then breaks up the chunk into smaller (Data Domain traditional ~8 KB) segments and computes fingerprints for each segment. It then checks with the chosen destination controller to determine which segments are already stored and then compresses and sends only unique segments to be stored on that controller. This protocol is derived from the directory replication protocols in Data Domain Replicator software, so it is quite mature.

The local compression algorithm can be configured on GDA through DD Enterprise Manager. This provides more flexibility in choosing the optimal setting based on user datasets. The default setting is “lz”, which is the least aggressive setting for compression and consumes the least amount of CPU resources for the compression phase. There are two more settings available – “gzfast” and “gz” – which are, respectively, more aggressive than “lz” both in terms of the compression they provide and the CPU resources they consume.

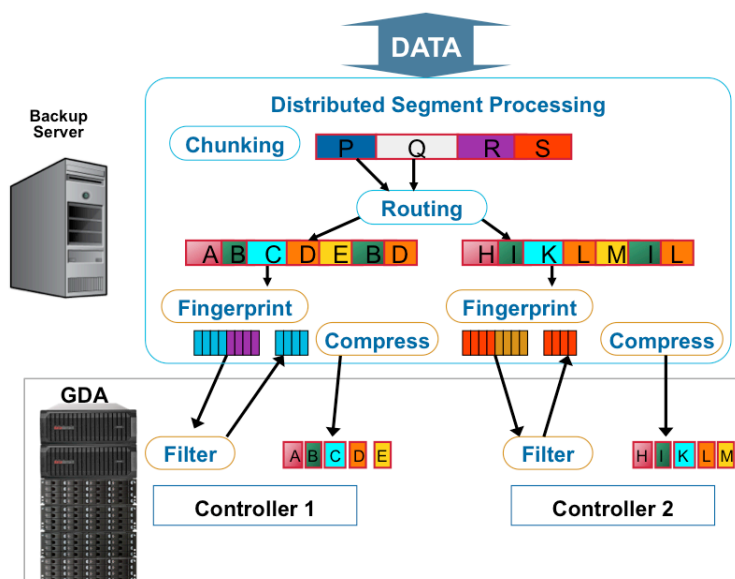


Figure 4. Scaling inline deduplication across multiple controllers, with distributed segment processing on the backup servers

By routing data at the data chunk level instead of at the file level, the GDA with DD Boost software provides finer granularity for optimal deduplication efficiency. Data chunks with similar patterns may come from multiple backup jobs and multiple backups servers. DD Boost routes those similar chunks to the appropriate GDA controller independently of which backup jobs or backups servers it came from.

The Data Domain global deduplication architecture helps maintain excellent deduplication while scaling efficiently. With this unique architecture, global deduplication takes place across all backup servers sending data to GDA, providing optimal storage efficiency across all backups.

Scaling performance

Write performance of an inline deduplication system is determined by how fast it can eliminate duplicates before writing the data to disk. The global deduplication file system takes advantage of the processing capabilities of multiple controllers to scale performance.

The GDA demonstrates this scalability by offering about 50 percent faster backup throughput than a single-controller system with a comparable generation of controller. As illustrated in Figure 4, each backup job on a backup server is intelligently divided into chunks and then routed to the controllers. GDA also scales the restore performance since reads are dispatched to each controller, which independently process the reads.

Distribution of parts of the deduplication process to backup servers also minimizes inbound network traffic. DD Boost sends only unique data over the network, which reduces the required network bandwidth by 80 to 99 percent.

Capacity balancing

The GDA presents a single storage pool across controllers and keeps both the logical (actual data written to the system) and physical (actual deduplicated data stored on the system) capacity balanced. The total capacity storage pool is presented as the sum of the physical capacities of the system controllers. The chunking and routing algorithms are designed to evenly distribute data while providing cross-controller deduplication. Automated load-balancing capacity utilization of deduplicated data between controllers is transparent to the backup applications and backup administrators.

This load-balancing technique is particularly useful when a new controller is added to an existing single-controller GDA. Without load balancing, the system would simply balance storage capacity by sending most new data to the newly added controller and the new controller would quickly become a performance bottleneck. Routing more data to the empty controller would also impact the overall deduplication efficiency of the array as data would not be routed to its natural destination with similar data segments.

GDA manages this by reassigning and transparently migrating some of the deduplicated data from one controller to the other. The backup servers automatically route new incoming data to the new destination, based on which has data similar to the newly migrated deduplicated data.

Scaling other operations

GDA is a fully scalable system and enhances all of its internal operations across controllers without causing resource contention. This is necessary to maintain predictable and high-speed operation of the system. Specifically:

- **Cleaning throughput** is scaled by distributing the data to be cleaned to each controller, which is necessary to allow the system to sustain high write performance and manage newly available free space.
- **Data verification** also scales by distributing data verification to the destination controller for each data chunk and allowing each controller to verify data independently in parallel.
- **Collection replication** scales since it is always done between identical systems, for example, a two-controller source system can only replicate to another two-controller destination system. Data on each source controller is replicated in parallel to its peer controller on the destination. Even though the data

is replicated independently, the destination system always presents a consistent view of the file system for the data that it has received.

- **DD Boost managed file replication** is scaled by utilizing both controllers for reading data on a source system and for writing data on a destination system. GDA also scales the number of concurrent managed file replication jobs to hundreds, which allows data from many single-controller systems at remote sites to be consolidated on a larger GDA system.

Resilient to data loss

Like all Data Domain systems, GDA is built as *protection* storage — the storage of last resort. The goal of Data Domain systems is to ensure user data is well protected by applying a set of design principles that ensure end-to-end data verification and self-healing as soon as possible after backups. Restores from a Data Domain system may be the final line of data defense. If the data has encountered even simple changes such as bit-flips on SATA drives, it becomes infinitely unavailable. By leveraging all of the existing EMC Data Domain Data Invulnerability Architecture elements and building on proven Data Domain designs, GDA has the foundation required for true data resilience. To learn more about the Data Invulnerability Architecture please read the [*EMC Data Domain Data Invulnerability Architecture*](#) white paper.

To extend this architecture, GDA has been designed to minimize the use of new complex data structures. This design simplicity greatly reduces the chances of software errors that could lead to data corruption. Although there is global deduplication across both the controllers of a GDA, it does not employ global data structures that need to be updated by each controller to centrally keep track of the state of all the components of the system. By design, each controller maintains its own data structures that the other controller does not need to access. This allows each controller to apply the same end-to-end verification logic, through the Data Invulnerability Architecture, that is already proven after years of usage in single-controller Data Domain deduplication storage systems.

Moreover, since each controller handles the end-to-end data verification function, data resiliency with GDA also scales linearly as controllers are added to the system, maximizing utilization of available resources across all controllers in the system. By minimizing cross-controller communication, and using Data Invulnerability Architecture processes, GDA scales data resiliency simply and cost-effectively by leveraging the industry-proven data integrity protection built into all Data Domain systems.

Typical deployment scenarios

Organizations can leverage the scalability of GDA in various ways to accommodate large backup environments and advanced disaster recovery strategies, including the following deployment scenarios:

- Data center backup without and with DR
- DR solution for hundreds of remote sites
- Cross-site data protection between multiple large data centers

Data center backup without and with DR

A data center that currently uses a large tape library to protect hundreds of terabytes of data within limited backup windows can deploy GDA as its primary backup target. GDA offers unprecedented performance and scalability, enabling backup policies as large as 200 TB to complete within a 16-hour backup window. GDA offers enterprise-class performance by ingesting backup data concurrently from multiple backup servers (see Figure 5).

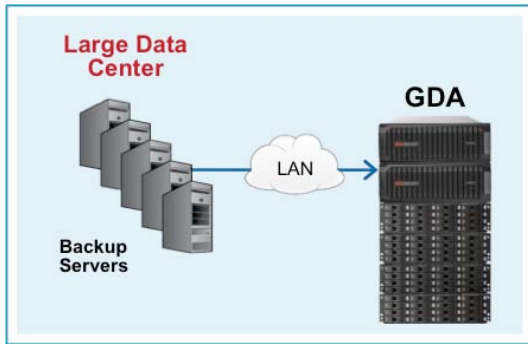


Figure 5. Data center backup without DR

Unlike any competitive deduplication storage system, GDA leverages distributed segment processing to reduce the amount of data sent to GDA, thereby minimizing networking requirements.

In large enterprise environments, tape has been the primary technology for offsite data protection. Protecting a large amount of backup data against site disasters with the fastest “time-to-DR” readiness requires a network-efficient replication technology and a scalable target system at the DR site. With managed file replication, through DD Boost integration with selected backup software offerings, the backup software delegates the data movement to the storage system that holds the data, and uses DD Replicator to get the file elsewhere. Backup images stored on GDA can be efficiently replicated over a WAN to another GDA or any other Data Domain systems located at a remote DR site, as illustrated in Figure 6.

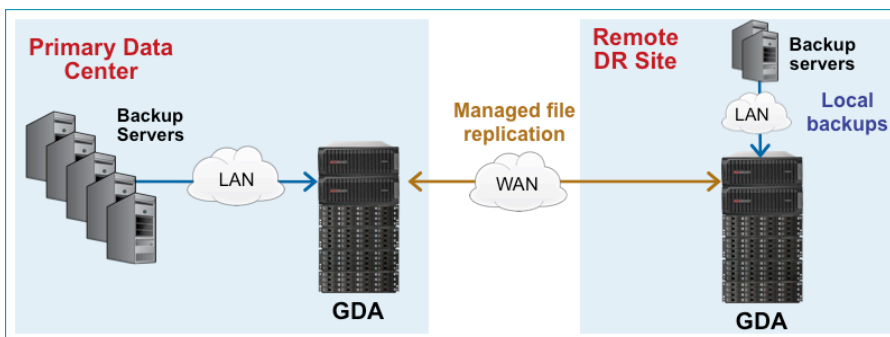


Figure 6. Data center backup with DR

GDA can start replicating to the DR site while backing up to enable fast “DR-readiness” within limited daily replication windows. All replication policies are centrally managed from the backup software using DD Boost managed file replication, greatly reducing management overhead and lessening the load on the backup servers as they are no longer in the data path when making copies of backup images. Recovery of backup images is also controlled from the backup software and can take place from either GDA.

Figure 6 also illustrates an additional benefit of using GDA as the replication target as it can also be used concurrently for local backup and recovery operations. In addition, GDA provides the flexibility to replicate data via IP to leverage existing networks.

DR solution for hundreds of remote sites

In a highly distributed environment, every remote office may have its own local backup infrastructure to protect and recover critical data. Protecting data against disasters at every site with physical tapes is too complex and too expensive and does not scale efficiently. With Data Domain systems, each remote site can back up data to a local Data Domain system and then replicate those backup images using DD Boost managed file replication to a target GDA located at a central data center.

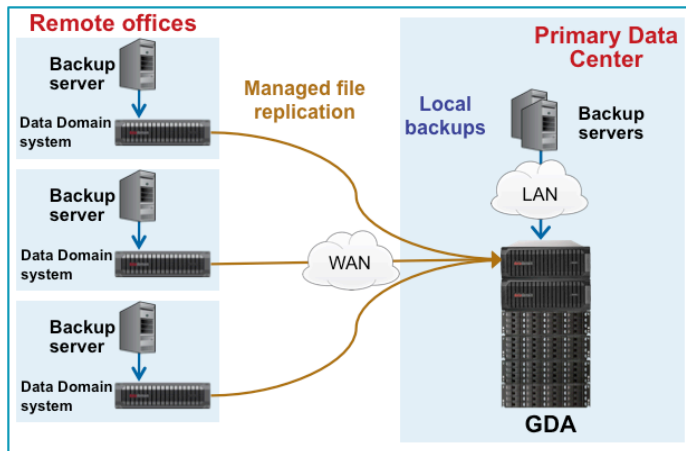


Figure 7. DR solution for remote sites

Figure 7 illustrates how GDA is an ideal replication target to accommodate hundreds of remote sites with hundreds of terabytes of data to store and protect for DR purposes. GDA provides the industry's largest fan-in scalability as a replication target. For maximum investment protection and minimum data center footprint, the same GDA can also be used to store local backups at the primary data center.

Cross-site data protection between multiple large data centers

Enterprises with three or more large data centers may not have separate DR sites to protect each data center. However, using managed file replication and DD Replicator, each large data center can implement GDA to store local backups and also replicate to a remote GDA at one of the other data centers, making each GDA the DR target system for one other, as shown in Figure 8.

With optimized duplication, GDA supports bi-directional replication, allowing each GDA to concurrently replicate content to each other. Also centrally managed from NetBackup, the replication policies are set up once and replication begins automatically whenever backups are written to each GDA.

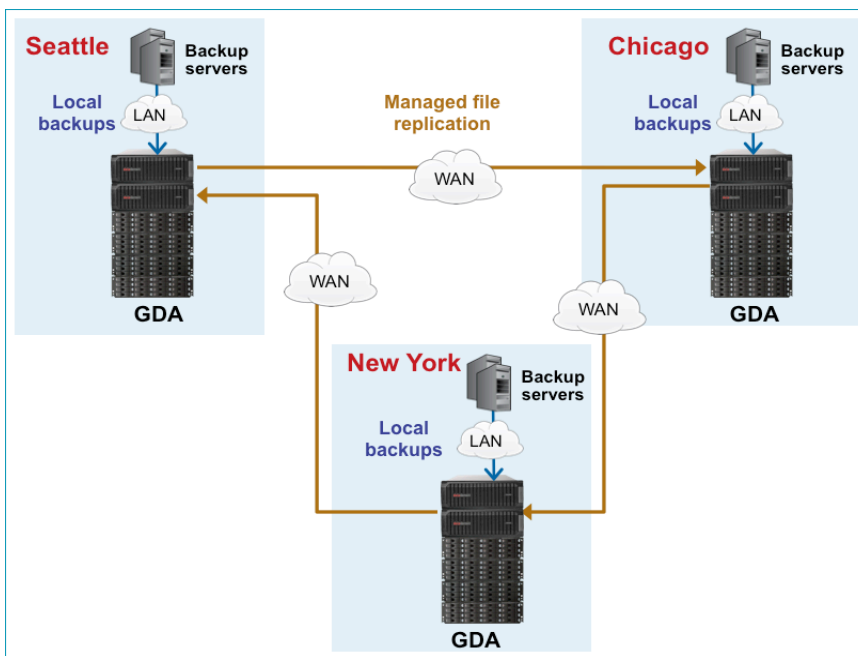


Figure 8. Cross-site data protection between multiple large data centers

GDA enables large organizations with multiple data centers to implement a comprehensive, scalable, and cost-effective DR solution by maximizing the utilization of their investment, and minimizing footprint and energy consumption while leveraging their existing network infrastructure

Evaluation criteria to consider

As IT managers investigate multi-controller storage systems as a possible solution to meet their large backup and disaster recovery requirements, they need to understand how these larger systems effectively scale and meet stringent disaster recovery goals without adding management complexity. Deduplication effectiveness, scalability, and data availability mechanisms can vary widely, and their side effects can compromise the reality of an otherwise-promising set of specifications.

The following sections explore the unique approach Data Domain systems take to address these large backup environment requirements. Data Domain single- and multi-controller deduplication storage systems' critical features will be reviewed including highlights of their benefits and the limitations of alternative products.

Global deduplication

There are two benefits of “global” deduplication that are the keys to cost-efficiency:

- **Smaller footprint:** Through storing data segments uniquely across more backup data, the footprint of the overall system should be smaller than the sum of data on two discrete deduplication systems.
- **Less bandwidth:** By storing far less data, the replication of new segments is more cost-efficient by reducing the WAN bandwidth required.

However, one must implement global deduplication the right way in order to successfully take advantage of these benefits and therefore maximize the deduplication effectiveness in a global fashion. To truly gain the efficiencies outlined above, global deduplication must work to maximize the data reduction ratio of the system. Specifically, to maximize the “globality” of reference, all new data needs to be compared against all previously stored data in a system regardless of where it comes from, which protocols are used to store or access the data, and which deduplication controller it is serviced by. This is what the GDA does. Many “global” deduplication systems do a lot less; sometimes these systems only check against a small portion of the already stored deduplicated data, which makes it unclear how much more efficient they are than multiple single-node systems.

For example, less efficient solutions only compare new data to a previous version of the same file in the same client. If the same file resides on 100 servers, that file may be stored 100 times. While these deduplication techniques may show very good deduplication ratios in limited lab tests, they do not take advantage of deduplicating data across the entire dataset. It is only about as efficient as conventional storage snapshots.

Here is how to test the “globality” of the reference. Take a large file and copy it across three different clients, renaming it slightly each time. Back up each client's version of the file, once. (If there is a different virtual tape drive or file system on each controller, back up to each of them.) If this is in a proof-of-concept test on an empty system, then look to see how much physical space has been consumed. When performing this test on the GDA, you will see that the total data stored is only slightly more than the physical data size of the original file alone, demonstrating how efficiently GDA globally deduplicates the dataset. Like any Data Domain systems, deduplication with the GDA takes place at the segment level independently of the data format, source, and file name.

Another important criterion for an efficient global deduplication deployment is the ability to deduplicate data independently of the backup format and application type. For example, unlike GDA, some “global” deduplication systems promote themselves as “content aware,” which means they are backup format dependent. Therefore, backup application integration and new functionality may lag when new versions of backup applications are released. The GDA is backup application agnostic and data is deduplicated concurrently from multiple backup servers without having to know how backups are formatted. In the future, multiple protocols supported by single-node Data Domain implementations will be supported on the

GDA. Like the single-node products today, all data written to a GDA is deduplicated against all data stored, regardless of protocol or client software.

Scalability

Inline and CPU-centric vs. post-process and disk-centric. Deduplication systems have been available since 2002. (The two earliest to market were EMC Avamar® and EMC Data Domain.) Over that time, many experiments from many vendors have been put forth. The results are clear: When comparing across all factors, inline approaches are more successful by a large margin over post-process approaches. Post-process approaches used to offer an order of magnitude more addressable capacity and throughput than inline approaches, but this is no longer the case.

SISL takes the pressure off of disk accesses as a bottleneck so that the system relies on the speed of the CPU to deliver inline deduplication performance. Over the last 20 years, CPU performance has improved by a factor of millions, while disk performance has only improved by 10x or so and this performance improvement advantage will continue well into the future.

As a result, Data Domain deduplication storage systems offer the best price/performance deduplication controllers in the industry.

EMC has taken the built-in speed and scale advantages of the Data Domain inline deduplication technology and expanded on them in the GDA. This allows all of the system processes — from ingest speed to read speed, from space reclamation to data verification — to scale more robustly.

Load balancing. One promise of scalability in a multi-controller system is the ability to expand when an entry configuration starts to reach its limits. Some grid architectures may utilize an overflow mechanism that allows controllers to utilize available cache storage on other controllers in order to ensure that a backup does not fail because of lack of space, but the two systems' data is not deduplicated globally across all their storage. This also creates storage hot spots that need to be spread out manually. The GDA solves this more simply by automatically spreading load and data between the first controller's resources and the second once the second is added, resulting in all data being deduplicated globally.

Global namespace. With the GDA, files are stored and accessible on the multi-controller system irrespective of which controller or network interface is used to store or access the actual deduplicated data. The GDA provides a global namespace, which spans its file system across its controllers. Unlike alternative multi-controller systems, users do not need to choose which controllers the backup job will land on. When using DD Boost, backup servers only need to be aware of one IP address of the target GDA.

Other multi-node VTL systems add additional sizing and performance balancing complexities. Backup servers can only communicate to a fixed number of virtual tapes drives presented on each controller. Instead of a global namespace like GDA with DD Boost, each controller has its own. Users first must carefully provision the appropriate number of virtual tape drives on each controller for optimal performance and then configure the optimal number of streams per backup server to avoid introducing performance bottlenecks in the I/O path. All these steps must be completed manually by a backup operator and repeated often as the backup environment changes in size.

No disk contention between controllers. The GDA offers global deduplication, but each controller manages its own storage. This optimizes performance since controllers are never fighting over the same disks.

A shared storage cluster architecture, especially one that needs to do byte-for-byte comparisons to validate new versus old data, requires a careful and complex balancing act of underlying disk resource contention to deliver performance at capacity; this is a sizing exercise that only the vendor can properly maintain. It requires disk resources to be actively managed as new backup sets are added to the system and if performance or capacity needs to be increased.

Data availability

Like all Data Domain systems, the GDA has been designed to not only deliver scalability and simplicity but also, and most importantly, data integrity and data invulnerability. As mentioned previously, it is the storage of last resort. Data recoverability must be assured at all cost and to do this, EMC relies on the Data Invulnerability Architecture. Because the GDA is an extension of the same underlying architecture, it is built on this very solid foundation.

For example, Data Domain systems actively verify data from end to end, from the file level through the content of blocks, after data is stored. Because the system has its own software-based RAID 6, if something has gone wrong the system will typically repair the corruption. In contrast, most storage systems slowly repair blocks over time, and file links are sometimes only validated after they fail and something might be missing during a read. In a backup system, a read means the data has gotten lost in primary storage, so this may be the only copy left. It is very bad news to find that it is missing. With Data Domain systems, if there's a link corruption, it can be discovered when the primary data is still available for a new backup.

Fundamentally, if data is corrupted and uncorrected, it will be gone forever and will be infinitely unavailable to the user. At that point, the concept of "high availability" becomes a moot point and it does not matter whether a multi-controller system offers some form of higher availability. Due to the superior importance of data invulnerability, it is more critical to have highly reliable data, rather than simply a higher availability multi-controller system.

Reliable data protection systems like Data Domain deduplication storage systems must deliver an aggressive online data verification approach, where a number of methods need to be employed to ensure that data is accurately stored, available, and recoverable at any time. If a system is required to be taken offline in order to perform any data verification processes, it is likely that data verification will never be performed until actual data loss has occurred. Furthermore, taking a system offline will halt backup processes until data verification is complete.

Evaluation criteria summary

As a multi-controller global deduplication system, the EMC Data Domain Global Deduplication Array benefits not only from EMC's industry leadership with its reliable, fast, and simple inline deduplication and data invulnerability approaches, but also scales efficiently, simply, and reliably to address the backup and disaster recovery requirements of very large data centers.

When evaluating multi-controller deduplication systems, IT organizations should carefully assess the approaches taken in critical feature areas such as global deduplication, scalability, and data availability. With its unique architecture, the GDA deduplicates data globally, irrespective of which source the data comes from, and across both GDA controllers, providing optimal deduplication efficiency across the entire enterprise data set. The GDA scales data deduplication inline by capitalizing on the CPU-centric scalability approach of Data Domain systems and without compromising on data integrity, data recoverability, and operational simplicity.

Conclusion

Large IT organizations currently redesigning their backup architecture are looking to deploy deduplication storage systems that scale in performance and capacity. These systems must accommodate their demanding backup policies without compromising on disaster recovery and operational simplicity. The EMC Data Domain Global Deduplication Array (GDA) delivers a scalable, multi-controller inline deduplication storage system for large enterprise data center backups, recoveries, and flexible multi-site disaster recovery with optimal performance, data reduction, and simplicity of operation.

Based on the simplicity of the market-proven Data Domain systems architecture and innovative global deduplication technology, GDA presents a single, large storage pool for backup and replication, greatly reducing backup policy administrative overhead. Compared to other multi-controller systems, GDA provides the right balance between performance and scalability to complete large daily backups and retain sufficient copies at the primary data center and DR site. And for organizations with largely distributed backup operations, when deployed as a replication target, GDA provides the industry's largest fan-in scalability.

The Data Domain global deduplication architecture has been designed for applicability across all leading backup applications and for future scalability. The breadth of the high-performance inline deduplication architecture provides the foundation for future generation multi-controller deduplication systems.