

White Paper

SGI® InfiniteStorage Data Migration Facility (DMF) A New Frontier in Data Lifecycle Management

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1 A Growing Need for Data Lifecycle Management

With volumes of stored data growing seemingly without limits, organizations are struggling to meet their burgeoning storage demands. While the acquisition cost of high-performance disk storage continues to decrease, the cost of maintaining and managing large volumes of primary storage makes a storage strategy based solely on disk increasingly undesirable. The only alternative for many has been manually archiving data from primary disk to tape or other forms of storage—a time consuming and error prone process that can inhibit or even prevent access to critical data when it's needed.

Increasingly, Data Lifecycle Management (DLM) is being discussed as the solution to the chaos produced by rapidly growing data stores, excessive quantities of primary storage, and manual data archiving. The goal of DLM is to rationalize the management of large volumes of data. Under DLM, each file is uniquely classified and then managed from cradle to grave to ensure that it is stored on appropriate storage and given an appropriate level of data protection. Naturally, appropriate storage and protection may change as a file ages.

In most cases, data goes through a fairly predictable lifecycle. It is accessed most heavily in the first few weeks after creation, and then frequency of access drops off significantly as data ages. Data may eventually be deleted, but an increasing amount of data must be retained indefinitely. In some cases, data retention is mandated by corporate governance and regulatory requirements.

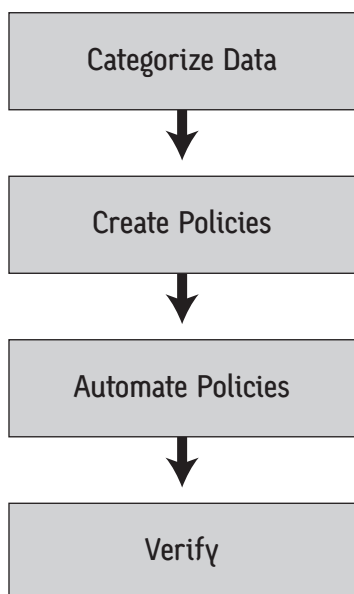


Figure 1. Steps involved in Data Lifecycle Management

The steps required in DLM are summarized in Figure 1. The process begins with categorizing all data to be managed. Categorization is largely a manual process and includes considerations such as criticality of data as well as regulatory compliance. Once the data has been categorized, policies are created to ensure that each category has an appropriate level of access, the required level of data protection, disaster recovery, etc. These policies can then be automated using a storage hierarchy. The final step is to verify that the system is working as defined and that corporate governance and regulatory requirements are being met.

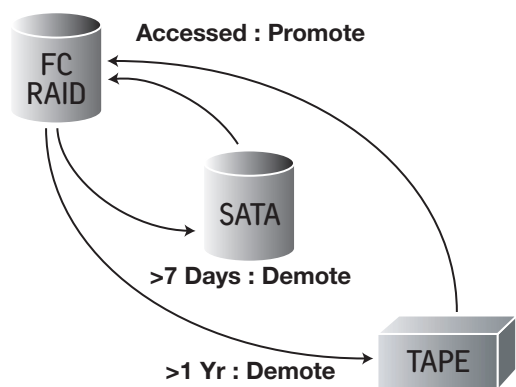
Regardless of data access patterns or retention requirements, any DLM solution must meet a number of key requirements:

- Improve data management while reducing total cost of ownership (TCO).
- Ensure adequate data protection by providing security, guaranteeing data integrity, and facilitating backup.
- Recognize and accommodate the fact that not all data is equal. The most critical or most frequently accessed data may require high performance storage, high levels of data protection, and provisions for online disaster recovery. At the other extreme, non-critical data might be best accommodated on nearline or offline storage and have relatively modest data protection requirements.
- Adapt to new technologies. For instance, the recent availability of inexpensive serial ATA (SATA) disk storage offers an alternative to primary disk with cost and performance characteristics intermediate between disk and tape.

Organizations engaged in data-intensive pursuits such as manufacturing, digital media, oil exploration, and scientific research are feeling the effects of rapid and accelerating data growth even more than those in other industries. These users require solutions that can accommodate extremely large datasets (terabytes to exabytes), while assuring that data is always accessible without user or administrator intervention.

While there is a lot of industry discussion of DLM, real solutions that can meet the requirements are rare. Some vendors are trying to position old products that have little or nothing to do with managing data over time as players in this field. Meanwhile, hundreds of SGI customers with data intensive environments are already meeting their critical data storage and management requirements using SGI® InfiniteStorage Data Migration Facility (DMF). DMF allows data to be transparently migrated from primary disk to secondary disk, tape and/or other media automatically according to site-defined criteria. The location of

data is fully-transparent and data is recalled to primary storage immediately on first access without the need for user or administrator intervention. DMF virtualizes storage assets, creating a scalable storage pool transparent to user applications. This fully-automated, tiered approach to data storage adapts automatically to changing usage patterns to ensure data is always accessible and users are always productive while greatly simplifying storage management tasks for busy administrators, dramatically reducing the cost of the overall storage infrastructure.



Access = Sub Second Sub Second Seconds to Minutes

Figure 2. Example 3-tier DMF deployment with high-performance primary disk, lower cost nearline disk (SATA), and tape. Data moves automatically and transparently up or down the storage hierarchy based on user-defined criteria such as time of access, size, owner and group.

Features of DMF include:

- **Unsurpassed Capacity.** SGI customers are already using DMF to manage hundreds of terabytes and even petabytes of storage at a fraction of the cost of disk-only solutions.
- **Scalable Performance.** DMF offers fast access, low system overhead and efficient scheduling. The most active DMF sites today are moving up to 3TB a day between primary and secondary storage. DMF—in combination with SGI® Origin® or Altix® servers—has the parallelism and scalability to meet the needs of the most demanding data environments. In a recent benchmark, an Origin system was able to move 10TB of data from disk to tape in one hour, proving that—correctly architected—DMF can achieve unparalleled performance. (See <http://www.sgi.com/pdfs/3523.pdf> for more information.)

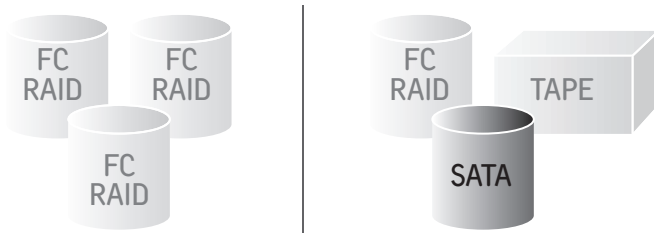
- **Data Integrity.** DMF provides positive, verifiable data security with auditing, media checking, recovery, journaling and two-phase commits. DMF can be configured to maintain up to 64 separate copies of the same file in multiple locations (two copies is typical) to protect against data loss.
- **Data Always Remains Easily Accessible.** With archiving solutions, locating data often requires users or administrators to manually locate the needed tapes and restore data to disk. DMF ensures that data remains accessible without user or administrator intervention. Users don't have to know where their data is to access it.
- **Ease of Administration.** Once DMF is configured, everything happens automatically, reducing the administrative burden associated with managing large data stores and the manual archival and retrieval of data.
- **Reduced TCO.** By growing data storage with less expensive SATA disk, tape, or other media the total cost of deploying many terabytes of new storage can be dramatically reduced. With the removal of manual data migration one administrator can manage much more data, greatly reducing administration costs.

This paper explores the benefits of DMF for streamlining data management for the most data-intensive environments. Usage scenarios are discussed along with the core technologies that have made DMF so successful.

2 Reducing TCO with InfiniteStorage DMF

The cost of acquiring storage and of managing data is greatly reduced by the introduction of DMF. In some environments SGI customers have grown data under management from the 10s of TB to the 100s of TB with no additional storage administration resources.

A simple example illustrates the impact of DMF on storage total cost of ownership. Consider a typical SGI customer with 10TB of disk storage. To meet rapidly growing storage needs, this customer needs to expand total storage to 20TB in one year. The relative cost of an all disk solution versus DMF plus a high capacity tape library is illustrated in figure 3.



**65% Lower cost
of acquisition**

Figure 3. Cost comparison shows typical % difference in cost of a configuration of 10 or 20TB of all Fibre Channel RAID vs. a Configuration of the same capacity consisting of Fibre Channel RAID, SATA, Tape and DMF

As this example clearly demonstrates, the cost advantages of deploying DMF are extremely significant, even ignoring potential savings in electricity, cooling, and administration. For this customer, having 10% of total storage capacity in the form of high-performance disk was adequate to ensure that there was always room on disk for all active data sets. Other customers faced with the same scenario but requiring a higher percentage of disk might opt to add additional high performance disk or less expensive nearline disk to increase total capacity, and still achieve substantial savings through the deployment and use of DMF as an adjunct to primary disk storage.

In DMF environments, the percentage of high-performance disk versus total storage typically ranges from 2% to 10% with the average being around 3%. In other words, for each 100TB of total storage DMF users typically maintain between 2 and 10TB of primary disk storage with 3TB being the average.

3 Storage Growth in Data-Intensive Environments

Data centers supporting scientific, technical and creative applications are facing a serious dilemma. Their current storage systems lack the capacity to allow them to take their operations to the next level. New processes, more detailed calculations, and increased productivity are being stymied due to the expense of scaling storage capacity and related storage bottlenecks.

In the following customer examples the need for increased storage capacity in the next year ranges from two to twenty times current levels. Given the huge amounts of disk storage that many of these customers have, disk-only solutions will be prohibitively expensive and cumbersome.

3.1 Energy

The energy industry relies on increasingly large volumes of complex scientific and engineering data to make investment and management decisions to discover and extract oil and gas from underground reservoirs. Success in this industry depends on advanced visualization of data assets and the ability to leverage the expertise of individuals scattered across the globe.

For example, an oil company has increased its recovery rate exponentially by including advanced visualization in its seismic modeling process. In order to visualize the model data, the data must be made accessible from the compute systems to the visualization system, remote data centers, and geographically distributed modeling and analysis experts across the corporate network. Even with a Gigabit Ethernet network, it takes two hours a day for the 2TB data sets to be made available for visualization. The data sets are increasing with some models now moving into the 10s of terabytes requiring a 5X increase in storage capacity for each data set stored. With this amount of data, a data set cannot even be moved in an entire day using more traditional data management methods.

3.2 Manufacturing

In the manufacturing industry, success often hinges on leveraging the latest technologies—such as solid modeling, computer-aided engineering, conceptual and large assembly design, manufacturing process simulation, and visually collaborative design review—to achieve and sustain competitive advantage. As a result of these innovations, product design and manufacturing have become increasingly data driven. Reliable storage, data delivery, and data management are critical to ensure the success of the digital processes on which advanced product design depends. Advanced computing systems are becoming more capable every year, enabling more-detailed engineering simulations that in turn require significantly greater storage resources.

For example, a turbo-machinery company is currently using computational fluid dynamics to analyze one mode cycle of a model with 10 million points and five results variables. This requires 4GB of input and results in 220GB of output. The company's researchers would like to be able to analyze more than one mode cycle with models of 50 million points and 20 results variables, but that would result in 4TB of data, a 20X increase which is beyond the capacity of their current storage system and which would take hours to access through traditional methods.

3.3 Media

The media industry is becoming ever more data driven as it migrates to all digital processes. By managing multiple projects with effective content dataflow, companies are achieving greater productivity and more timely delivery of higher-quality projects. Hollywood's recent propensity for movie sequels makes the data management needs of media companies even more critical.

For example, consider a production company working simultaneously on three closely related films. Each picture results in up to 70TB of images and associated data. This data must be available for each subsequent film and derivatives such as video games, trailers, tie-ins, etc. With 210TB of data, it becomes impractical to store it all online, yet the data must be easily accessed as necessary.

3.4 Sciences

Researchers in fields ranging from climatology to molecular modeling are struggling to cope with rapidly expanding data sets in the face of shrinking funding. For example, a scientific imaging research facility is combining current and historic brain-mapping image data to enable time-study research for local and global users. Researchers need to grow from 10TB to over 150TB of globally accessible image data to support their research mandate and to qualify for program funding. Furthermore, they need to do this in such a way that all data remains available to all users in the most efficient manner possible, without additional head count for administration. They need to grow their data stored by 20X and make it available to a global user community in the most cost-effective way possible.

3.5 Government

Government and defense institutions increasingly depend on digital technology to carry out their missions. As a result, these institutions are now trying to cope with quantities of data that would have been unthinkable just a few years ago. It is not unusual to find data sets ranging from hundreds of terabytes to petabytes and beyond.

For example, one government institution takes a live satellite feed into a compute center where the feed is analyzed by multiple operators. The institution's mission for the coming year is to increase the granularity of its results and the frequency of reporting—a requirement that will increase data set sizes by 2X and time per job to almost two hours with the current infrastructure. The institutions simply cannot meet their future mission goals with current tools.

4 Understanding DMF

Note to Reader: Section 4 is intended for the technical reader and can be skimmed or omitted by those interested primarily in the high-level features, advantages, and applications of DMF.

SGI customers have already achieved great success implementing DMF for data lifecycle management. Most customers report that once they assign policies for each category of data they can rapidly implement those policies with DMF and then simply forget about it. DMF does all the work of data management with very little administrator overhead.

To fully appreciate the flexibility and robustness of DMF, it is necessary to know a little bit about how DMF works. DMF has successfully withstood the rigors of use in data-intensive environments because of a number of factors:

- **Data Integrity.** DMF features ensure that the highest levels of data integrity are maintained at all times. All database operations use journaling and two-phase commit. DMF also maintains multiple copies of each migrated file to protect against media failures.
- **Parallelism.** DMF is designed so that multiple operations occur in parallel. User operations don't wait for other operations to complete. Maximum bandwidth is typically only limited by the aggregate bandwidth of attached nearline storage (for example, in configurations with tape, the number and types of tape drives are typically the limiting factor).
- **Scalability.** DMF is architected to manage up to 2 billion migrated files at one time, 18 million terabytes in a single instance, and single file sizes up to 9 million terabytes.
- **Simple Administration.** Once DMF is configured, there are few ongoing tasks for an administrator to perform, guaranteeing that a virtually limitless amount of storage can be maintained by very few personnel.

4.1 File Migration

DMF automatically manages the free space on primary disk storage to ensure that disk space is always available, freeing system administrators from the time consuming task of constantly monitoring and provisioning storage.

File migration occurs in two stages:

- Stage One: A file is copied (migrated) to secondary storage
- Stage Two: After the copy is secure, the file is eligible to have its data blocks released (this usually occurs only after a minimum space threshold is reached)

A file with all nearline copies completed is called fully migrated. A file that is fully migrated but whose data blocks have not yet been released is called a dual-state file; its data exists both online and nearline, simultaneously. After a file's data blocks have been released, the file is called a nearline file.

The daemon process dmfsmon monitors the filesystems managed by DMF and takes action according to a number of key parameters that can be configured separately for each managed filesystem:

- **FREE_SPACE_MINIMUM** specifies the minimum percentage of filesystem space that must be free. When this value is reached, dmfsmon will take action to migrate and free enough files to bring the filesystem into compliance. For example, setting this parameter to 10 indicates that when less than 10% of the filesystem space is free, dmfsmon will migrate and free files to achieve the percentage of free space specified by **FREE_SPACE_TARGET**.
- **FREE_SPACE_TARGET** specifies the percentage of free filesystem space dmfsmon will try to achieve if free space falls below **FREE_SPACE_MINIMUM**. For example, if this parameter is set to 15 and **FREE_SPACE_MINIMUM** is set to 10, dmfsmon takes action when the filesystem is less than 10% free and migrates and frees files until 15% of the filesystem is available.
- **MIGRATION_TARGET** specifies the percentage of filesystem capacity that is maintained as a reserve of space that is free or occupied by dual-state files. DMF attempts to maintain this reserve in the event that the filesystem free space reaches or falls below **FREE_SPACE_MINIMUM**.

The default values that DMF uses for these parameters are generally used by most customer sites because they have been found to work well for large filesystems. For instance, a 10TB filesystem with **FREE_SPACE_MINIMUM** set to the default value of 5%, **FREE_SPACE_TARGET** set to 10%, and **MIGRATION_TARGET** set to 80% maintains a minimum of 500GB to 1TB of free space. Dual-state files occupy up to 8TB of the filesystem while the remaining 2 TB is occupied by regular files.

Some customers set **MIGRATION_TARGET** even higher (up to 90%) depending on the number of unmigratable files the filesystem contains. A high value maximizes the number of dual-state files in the filesystem, which gives DMF the most flexibility if there's a sudden burst of file creation activity. The space occupied by these files can be immediately freed should that become necessary.

The following figure illustrates the relationship between these parameters and shows how DMF controls free space in the file system.

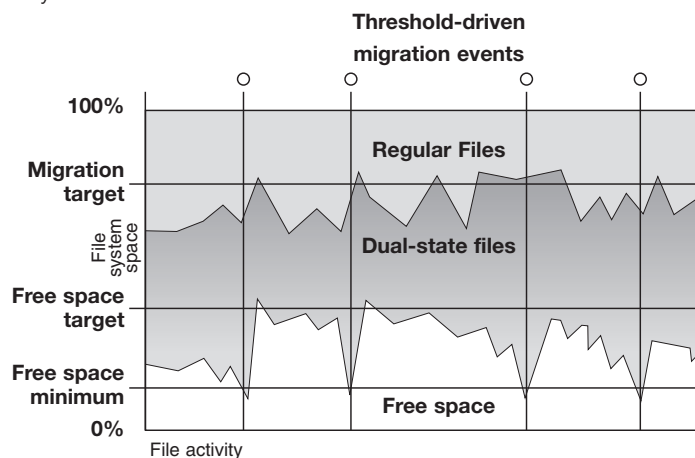


Figure 4. Automated free space management by DMF

By pre-migrating files to maintain a pool of dual-state files, DMF ensures that disk space can be freed rapidly whenever it becomes necessary. When dmfsmon detects a filesystem that has fallen below **FREE_SPACE_MINIMUM**, it triggers the dmfs-free process which creates a list of files to be migrated. These files are weighted by time of last access, size, user id, group id and whether or not the file is currently dual-state. DMF can also be customized to weight files based on other site-defined criteria.

Most customer sites implement policies based primarily on file size. For instance, many sites migrate small files to faster tape devices to ensure rapid access while larger files are targeted to high capacity tape storage. However, many sites have implemented unique policies based on other criteria to achieve particular goals. Some sites use particular group ids to ensure that critical files are always migrated offsite for increased data protection. Files can be assigned to special groups automatically or as necessary to ensure migration. Other sites share their DMF infrastructure between multiple departments. A given department may purchase its own tape drives and media and then create a policy based on user id and/or group id to ensure that its files go to the resources it owns.

Once dmfsfree creates its migration candidate list based on site-defined selection criteria, each file on the list is passed to the dmfsdaemon (the master daemon at the heart of DMF operations) which requests that the appropriate processes handle the migration of each file with the appropriate media.

The state of each managed file is maintained in the file's inode. The file's inode also contains the DMF key (Bit File Identifier – BFID) that maps the file to the DMF daemon database. Great care has been taken to ensure the robustness of this database. This is one of the keys to the overall effectiveness of DMF. The DMF database employs full transaction journaling and two-phase commit. The combination of these two features ensures that DMF applies only whole transactions to its database. In the event of an unscheduled system interrupt, it is always possible to replay the database journals in order to restore consistency between the DMF databases and the filesystem.

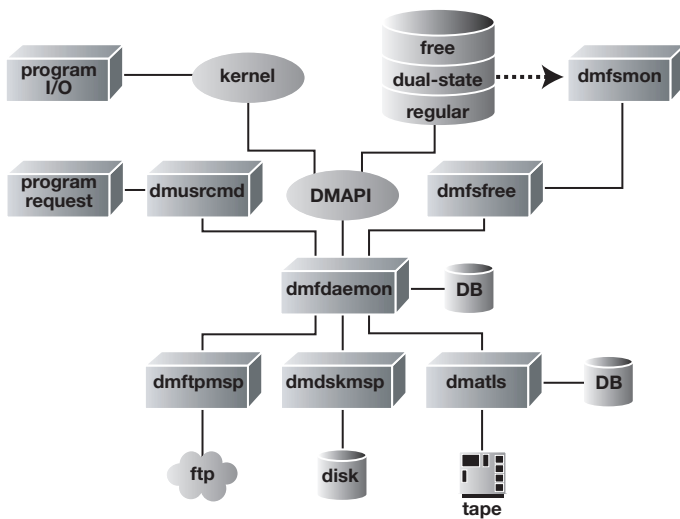


Figure 5. Block diagram showing DMF and its major components

4.2 Choosing Migration Targets

Nearline media is the destination of all migrated data and is managed by daemon-like DMF components called the media-specific process (MSP) and the library server (LS). Multiple copies of each file can be created (two copies is standard) and these can be directed to different MSPs. This increases the robustness of DMF and allows it to be flexibly configured for a variety of purposes including disaster recovery. MSPs are available for:

- Disk—Provides migration to disks (fibre, SATA, or other) and other random access devices like NFS-mounted filesystems
- FTP—Supports migration of data across IP networks to local or remote locations
- Tape—Tape libraries are the most common migration target currently in use

The FTP MSP (dmftpmisp) uses the FTP protocol to transfer to and from disks of another system on the network. The disk MSP

(dmtdskmsp) is similar, but uses a filesystem mounted on the DMF server itself. The tape MSP (dmtdats) uses either SGI® OpenVault™ or Tape Management Facility (TMF) as a mounting service and to organize and control tape operations.

All of the MSPs have the ability to create multiple read- and/or write-children so that a large number of operations can occur in parallel to increase DMF throughput.

4.3 N-tier Migration

Less expensive disk resources, such as SATA disk arrays, can be used in n-tier migration hierarchies. For example in a three-tier configuration, a secondary disk tier is configured as a disk MSP and designated to run in Disk Cache Manager (DCM) mode to serve as a cache between primary disk and tape. Smaller or frequently-recalled files can be kept in cache rather than on tape to enhance the speed with which they can be recovered to primary disk. While short-lived files may never reach tape at all.

Files move automatically from cache to tape when their recall rates decline. Files that don't reside in the cache can be recalled directly from tape to primary storage as necessary. Customers wishing to implement data protection policies via DMF can also maintain a second copy of each cached file on tape.

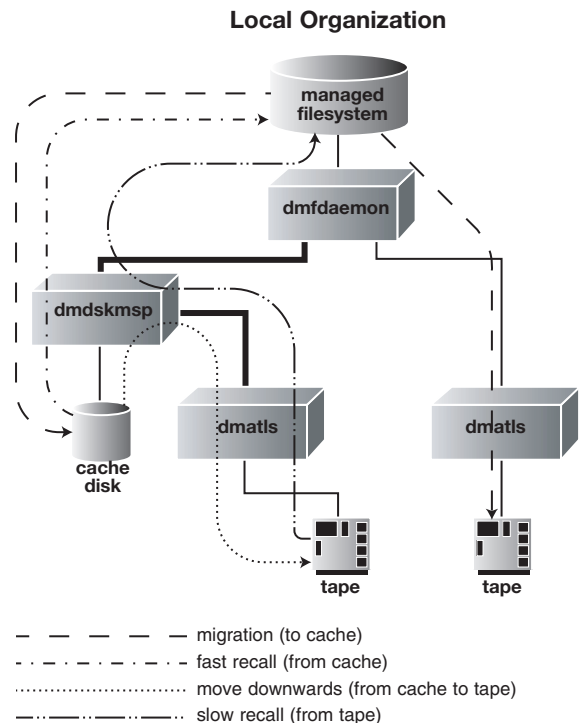


Figure 6. Example of a three-tier migration hierarchy

4.4 User Access to DMF

DMF integrates closely with the XFS® filesystem and can be accessed by users in two ways:

- Through normal file I/O requests
- Through explicit user commands

4.4.1 DMF Access through Normal File I/O Requests

Any user or application request to read or write data in a filesystem managed by DMF may trigger a recall of a file to primary disk if that file has been migrated. Note that an XFS filesystem utilizing DMF can be mounted and accessed by NFS, CIFS (SAMBA®), or CXFS™ as normal. In other words, the presence of DMF on the file or metadata server is transparent to remote users. File recall occurs automatically if a file is migrated just as it does for a local user or application.

The XFS filesystem integrates with DMF using the industry standard Data Migration Application Programmer's Interface (DMAPI). Filesystems that are used with DMF must be mounted with the DMAPI option:

On IRIX: mount -o dmi

On Linux: mount -o dmapi

When DMF migrates a file to secondary storage it sets DMAPI events in the file's inode which remains on disk. When the kernel commences I/O to a migrated file, DMAPI sends those events to the dmfd daemon, which triggers a recall of the file's data from secondary storage. The user's request is delayed while the file is recalled to disk, otherwise all activity is transparent.

4.4.2 DMF Access through Explicit Commands

There are some situations where it is advantageous to know or manipulate the migration state of a file. For instance, at the completion of a large project it may be desirable to explicitly migrate files to free up disk space for new projects.

DMF provides a full suite of user level commands and a programming library to allow users and applications to explicitly monitor and control file migration. DMF user commands exist to check the migration state of a file, explicitly migrate or recall a file, and a few other common functions. Library routines provide similar functionality for programmers so that applications can take explicit advantage of DMF. When the appropriate command or library call is made, the dmfd daemon is notified. It takes the appropriate action (recall to primary storage, migrate to tape, etc.) and clears or sets DMAPI events in the file's inode accordingly.

Explicit command access to DMF is also available for remote user access. To utilize these, remote systems must have the DMF client software installed¹. Remote DMF requests are sent to an instance of dmusr cmd running on the local system and then relayed to the DMF server.

4.5 DMF Administration

Before DMF is installed, a site must first categorize its data and design the proper policies for managing data in each category. Then DMF can be configured to implement these policies. The initial configuration of DMF also involves choosing the appropriate hardware to deliver the necessary primary disk capacity, secondary disk capacity, tape library capacity and the necessary number of tapedrives. Additional thought must be given to bandwidth between the DMF server and storage subsystems to ensure that data can be migrated and recalled at the rate necessary to achieve operational goals. Once the hardware is in place, configuring DMF involves choosing the migration parameters for each filesystem to be managed and configuring the selection criteria by which files will be chosen for migration to implement DLM policies.

SGI Professional Services is available to assist customers with DMF planning, deployment, configuration and management, helping to tailor the DMF environment to meet the most specific and demanding requirements. Experienced SGI personnel will assess site needs, identify inefficiencies, estimate future requirements, and tailor a streamlined DMF solution to meet the most exacting DLM requirements.

Once DMF is configured, most maintenance tasks can be configured to run automatically on a periodic basis. Convenient scripts are provided with DMF that allow these tasks to be regularly scheduled using DMF's built in task scheduler:

- DMF can automatically merge tapes that are becoming sparse—that is, full of data that has been deleted by the owner. By configuring DMF to merge sparse tapes the media pool is examined on a regular basis to reclaim unusable space.
- Recording media eventually becomes unreliable. Sometimes, media transports become misaligned so that a volume written on one cannot be read from another. Two utilities are provided that detect failing media. The **dmatsnf** utility is used to scan a DMF volume for flaws, and **dmatread** is used for recovering data. The volume merge process is also capable of recovering data from failing media. DMF can detect and recover data from failing media in many cases. However, some media failures can be unrecoverable. For this reason, DMF is normally configured to maintain a minimum of two copies of each nearline file.

¹Supported platforms for client software include IRIX®, SGI ProPack™ (Linux®), AIX®, Red Hat® Linux, Solaris™ and Windows®.

Integrity of data is a central concern to the DMF administrator. Regular attention to the following items helps ensure the highest level of data integrity:

- Regular backups must still be performed to protect unmigrated files, inodes, and directory structures because DMF moves only the data associated with files, not the file inodes or directories. The process of backup can be simplified by creating a policy of migrating 100% of DMF-managed filesystems, leaving only a small amount of data to be backed up. Backup can be performed using the IRIX **xfsdump** and **xfstore** utilities (DMF includes tools to make it simple to execute these regularly) or using other backup programs that are DMF and DMAPI- aware.
- DMF databases record all information about stored data. The DMF databases must be synchronized with the filesystems that DMF manages. Much of the work done by DMF ensures that the DMF databases remain aligned with the filesystems. DMF can be configured to automatically examine the consistency and integrity of the DMF daemon and MSP databases. These databases must also be periodically backed up to protect them from loss. DMF includes a script to accomplish this. This task also uses the **dmdbcheck** utility to ensure the integrity of the databases before saving them.
- DMF journal files must be retained and protected between full backups of the DMF databases. After a database backup is performed, old journal and log files may be removed to prevent the spool directory from filling up. Tools are provided which can be scheduled to run after database backup to remove these old files.

5 Solving Real-World Data Management Problems

Returning now to the earlier industry examples, the solutions the customer chose in each case can be investigated. Most of the customers in the earlier examples actually faced two related problems:

1. Economically and efficiently storing data
2. Accessing that data to create effective workflows

All of the customers chose to implement DMF together with SGI® InfiniteStorage Shared Filesystem CXFS™ —SGI's industry-leading solution for heterogeneous, high-speed data access over a SAN. The combination of DMF and CXFS gives all servers connected to a SAN—running the most commonly used operating systems—unparalleled access to important data without the bottlenecks associated with traditional storage solutions.

5.1 Energy

The oil company discussed previously required a 5X increase in data storage. At the same time, they needed to move data much more efficiently between compute and visualization systems. The pairing of CXFS with DMF provides their local data centers with the bandwidth and storage capacity they need to efficiently process and store huge data sets, accelerating workflow. CXFS allows data to be shared between globally dispersed data centers at high bandwidth, without replication, making it possible for this company to process and visualize data without resorting to copying, saving countless hours. DMF has allowed the company to dramatically and cost-effectively scale storage capacity without sacrificing the ability to access archived data rapidly.

5.2 Manufacturing

The requirements faced by the turbo-machinery company were even more extreme. It needed to increase storage capacity by 20X while streamlining workflow. Again, the solution was a combination of CXFS and DMF. After implementing CXFS, it was no longer necessary to copy data, saving countless hours of unproductive waiting time. With CXFS, engineering workstations, compute servers, and visualization systems all have direct high-speed access to shared data over a storage area network with no delays. DMF has allowed the company to dramatically scale its storage pool at a fraction of the cost of high-performance disk all while meeting strict policy requirements for data retention by manufacturers. Idle data is transparently migrated to lower-cost media and recalled to primary storage as needed. This creates a nearly infinite storage pool for a fraction of the cost of high-performance disk, ensuring that data is always available.

5.3 Media

In our media example, the company would have required 210TB of disk storage to meet its needs. By combining 50TB of primary disk storage, 60TB of SATA disk, a 100TB tape library, and DMF the company was able to dramatically reduce its storage costs by more than half without sacrificing ease of access or user productivity.

In addition, CXFS allowed the company to dramatically increase workflow by virtually eliminating unproductive data copying. Now, instead of wasting valuable time waiting for digital assets to be copied, the staff simply accesses those assets directly as needed with no waiting. Each staff member's productivity has increased dramatically, allowing the company to handle the workload with confidence. The increases in workflow and elimination of data copies has actually reduced the company's total storage requirement.

5.4 Sciences

For the brain mapping research facility, CXFS gives all visual workstations and servers in the facility shared high-speed access to the growing pool of brain image data. DMF allows researchers to store most of their image data in tape libraries, dramatically reducing storage costs. A relatively small pool of high-performance disk is used as primary storage for active data. Data is transparently migrated from disk to tape as it becomes inactive. Attempts to access migrated data result in the data being automatically recalled to primary storage for use. The combination of CXFS and DMF has worked out extremely well. Researchers are happy because they can access any data set whenever they need it, without worrying about where it is stored; plus performance is far better than it was in the past. Administrators are happy because they have already scaled their storage pool by 10X with virtually no increase in administration costs and no additions to administrative staff.

5.5 Government

The satellite data acquisition site had a need to increase both workflow and storage capacity. The use of CXFS, high-performance 2Gb-per-second Fibre Channel infrastructure, and high-performance disk arrays are allowing researchers to improve their workflow by 3X using their existing computing systems. CXFS virtually eliminates the data extraction that consumed so much of their previous workflow, allowing them to spend more time processing data and less time moving and managing it. DMF on the back end manages the rapidly growing pool of archived data. Expanding storage with tape and DMF instead of disk saved them over 50% of the cost of expanding their storage pool. As demands continue to grow, the new storage architecture will continue to scale in place for many years to come.

6 SGI® InfiniteStorage Data Lifecycle Management Server

The overwhelming explosion of data continues to create significant challenges for customers seeking to effectively and efficiently manage the data lifecycle. With long experience and proven expertise, SGI has the right solutions to meet the DLM challenges of even the most data-intensive environments, easing administrative burdens and conserving critical budget dollars without sacrificing performance.

With the recent introduction of the SGI InfiniteStorage Data Lifecycle Management Server, SGI makes it even easier to size, order, and install a complete DMF solution without sacrificing flexibility or expandability. Built on proven technology, Data

Lifecycle Management Server delivers over a decade of SGI experience managing the largest and most demanding data environments in the world at capacities and prices suitable for any size environment.

The SGI InfiniteStorage Data Lifecycle Management Server provides:

- Lower cost of storage acquisition and management with virtualization and policy automation
- Superior data protection with proven data integrity features
- Higher productivity with industry-leading data access performance
- Investment protection with virtually limitless scalability
- Easy to size and deploy, pre-set configurations for NAS and SAN environments

InfiniteStorage DMF—whether alone or packaged as part of Data Lifecycle Management Server—is designed to deliver levels of functionality and scalability that other vendors have yet to seriously contemplate, making it the best choice for data lifecycle management.

7 For More Information

More information on real-world applications of DMF can be found in the following SGI Success Stories:

- SGI and UCLA LONI: Taking Brain Research to the Next Level; www.sgi.com/pdfs/3155.pdf
- SGI and TotalFinaElf: Successful Exploration for Oil by Visualizing the Past and Future; www.sgi.com/pdfs/3216.pdf
- Fleet Numerical Meteorology and Oceanography Center; www.sgi.com/pdfs/3168.pdf
- SGI Solutions Deliver the Power Behind WETA Digital's Two Towers; www.sgi.com/pdfs/3454.pdf
- Queensland Parallel Supercomputer Foundation: Shared SGI Systems Power Research Statewide; www.sgi.com/pdfs/3484.pdf
- Danish Broadcasting; www.sgi.com/pdfs/3480.pdf
- DaimlerChrysler: A SAN for Data Availability and Protection in an SGI Solutions Brief entitled, SGI Storage Solutions for Product Development; www.sgi.com/pdfs/3425.pdf



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