



Analysis of Fujitsu ETERNUS8000
Models 800, 1200 and 2200
Analysts: Russ Fellows, Jane Wood

The new models of Fujitsu ETERNUS8000 disk storage system, models 800, 1200 and 2200, were announced in January, 2009. The ETERNUS8000 is primarily an open system storage product and is the successor to the ETERNUS6000.

Products and vendors that compete with the ETERNUS8000 include 3PAR T800 systems, EMC Symmetrix DMX-4, Hitachi Universal Storage Platform, and IBM System Storage DS8000.

HIGHLIGHTS

- Designed primarily for open system environments
- Supports Fujitsu Mainframe (Global Server) environments in Japan only
- Multiple Connectivity Options:
 - A maximum of 128 switched fabric fibre channel ports
 - A maximum of 64 iSCSI Gigabit Ethernet ports
 - Support for FCLINK and OCLINK in Global Server environments
- Resource sharing and access security with a LUN masking implementation called Host Affinity
- Centralized web-based management software
- Support for RAID 0, 1, 5, 6-dual parity, and RAID1+0 with global hot spare disks
- Online logical volume expansion with data redistribution
- RAID group sizes of 4 to 32 disk drives for RAID 1+0 and 4 or 8 for RAID 5
- Power Reduction Technologies:
 - Support for 1TB NearLine SATA drives
 - ETERNUS Eco-Mode for infrequently accessed data (MAID)
- Block level data protection with error detection codes added to every data block
- Duplexed write cache with ECC protection
- Write cache data written to disk if power fails
- Supports storage controller based Disk Data Encryption
- Controller to controller communication using internal PCI-Express switch based bus
- Redundant FC router for backend data transfer to disks
- Support for intermix of 146, 300, 450, 500GB, 750GB and 1TB FC and SATA disk drives
- Call home feature for proactive maintenance and to minimize response time
- Hot swappable, and redundant, components
- Up to Eight (8) active controllers supported
- Up to 512GB of cache
- Supports up to 2,760 disk drives
- Maximum raw capacity of 2.728PB
- Support for up to 16,384 open logical volumes and 8,192 mainframe volumes
- Optional point-in-time copy feature called One Point Copy creates snapshot copies
- Optional Equivalent Copy which creates clones and mirrors
- Support for remote copy in synchronous or asynchronous mode over fibre channel and iSCSI remote links with Remote Equivalent Copy. Supports stacked and consistency mode
- Disk Traffic Control (DTC) performance feature to separate I/O based on sequential or random access

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OVERVIEW

There are three models of the ETERNUS8000 that vary in capacity, performance, and connectivity – model 800., model 1200 and model 2200. The model 800 is not sold in North America. The various models may be used both for direct connect storage and for Storage Area Networks. Heterogeneous server attachment is supported (individual server operating system support is listed in the configuration section of this document).

In Figure 1 below, the three models of the ETERNUS8000 product line are illustrated.



Figure 1: ETERNUS8000 Product Line—Model 800, Model 1200 and Model 2200 respectively with maximum physical capacity

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Model Comparison

			Model 800	Model 1200	Model 2200
Form Factor			Floor Standing		
Number of Controllers			2	2, 4	2, 4, 6, 8
RAID Levels			0, 1, 5, 6, 1+0		
Min/Max Disk Drives			8 / 60	16 / 1020	64 / 2760
Storage Capacity	FC disk drive	Physical Capacity ¹	26.1 TB	301.2 TB	818.4 TB
		Logical Capacity ²	19.6 TB	233.7 TB	637.5 TB
	Nearline SATA disk	Physical Capacity ¹	58.0 TB	1,004.0 TB	2,728.0 TB
		Logical Capacity ²	43.8 TB	783.3 TB	2,136.9 ³ TB
Maximum Volumes / RAID group			128		
Maximum Logical Volumes			3,712	16,384	16,384
Maximum LUN Size			32 TB (Concatenated) or 8 TB (Regular LUN)		
Host Interface			FC 8Gbps; FC 4Gbps; iSCSI 1Gbps		
Number of Host Interfaces	Fibre		4 - 16	4 - 64	16 - 128
	iSCSI		4 - 8	4 - 32	4 - 64
Cache Capacity			8GB - 16GB	8GB - 256GB	32GB - 512GB
Drive Interface			Fibre Channel - 4Gbps		
Maximum drive enclosures			4	68	184

¹Calculated as 1k byte = 1,000 bytes and includes system disk capacity

²Calculated as 1k byte = 1,024 bytes and when formatted as RAID5. User capacity depends on system environment

³Only RAID5 and RAID6 are supported on Nearline SATA drives

Table 1: Fujitsu ETERNUS8000 Model Comparison (Open Systems)



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The following is for Fujitsu Mainframe (aka Global Server) connectivity **only**. Fujitsu Mainframe support is only offered on ETERNUS8000 systems sold within Japan.

			Model 800	Model 1200	Model 2200
Form Factor			Floor Standing		
Number of Controllers			2	2, 4	2, 4, 6, 8
RAID Levels			1		
Min/Max Disk Drives			8 / 60	16 / 1020	64 / 2760
Storage Capacity	FC disk drive	Physical Capacity ¹	6.1 TB	49.6 TB	49.6 TB
		Logical Capacity ²	2.7 TB	22.5 TB	22.5 TB
Maximum Volumes / RAID group			96		
Maximum Logical Control Units			16	32	32
Maximum Logical Volumes			1,024	8,192	8,192
Host Interface			FCLINK Channel (Max 2Gbps), OCLINK Channel (Max 17MB/s)		
Number of Host Interfaces	FCLINK Channel		4 – 8	4 – 32	4 – 64
	OCLINK Channel		4 – 8	4 – 32	4 – 64
Cache Capacity			8GB – 16GB	8GB – 256GB	32GB – 512GB
Drive Interface			Fibre Channel – 4Gbps		
Maximum drive enclosures			4	68	184

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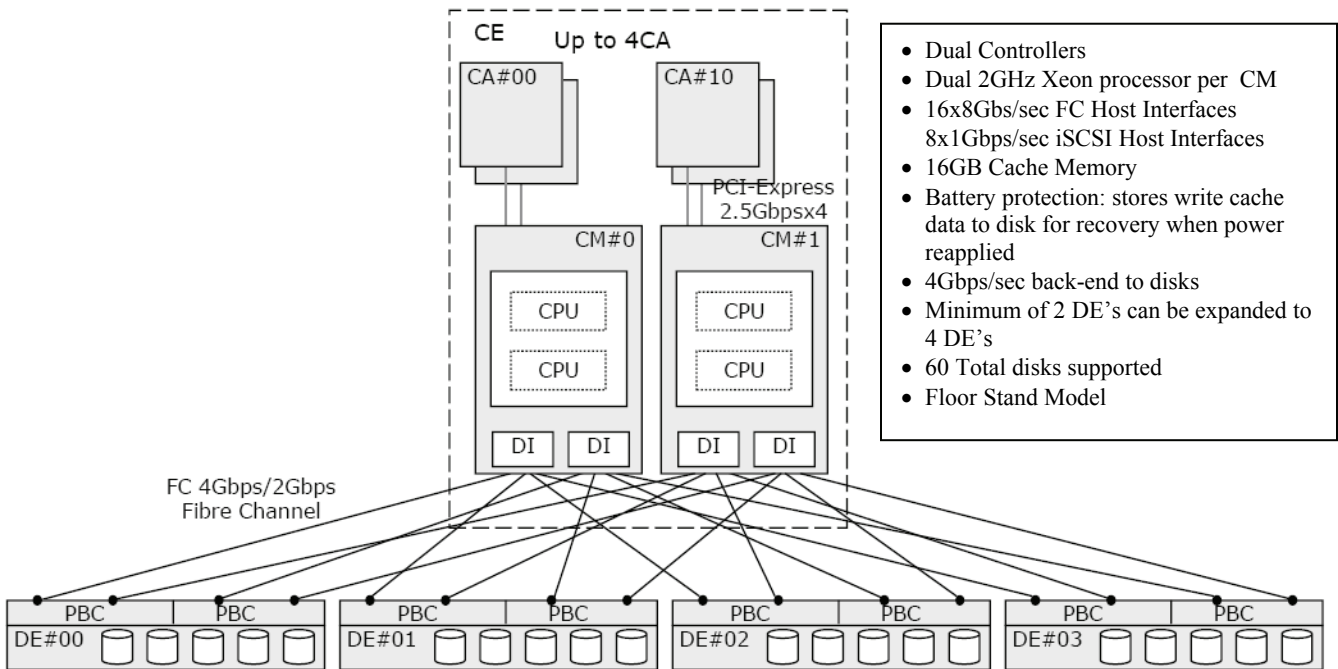
Table 2: Fujitsu ETERNUS8000 GlobalServer Models (Japan Only)

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PRODUCT ARCHITECTURE

The ETERNUS8000 uses multiple controllers internally – up to eight active controllers in the largest configurations. The ETERNUS8000 supports PCI-Express bus architecture in all Models and high-speed router based communication (FRT's) for write cache mirroring in Models 1200, and 2200. Additionally, models 1200, and 2200 utilize backend routers (BRT's) for data transfer between the controllers and the Disk Enclosures (DE's).

Model 800 – sold primarily in the Japanese markets to satisfy lower capacity requirements on Fujitsu mainframes - uses a shared PCI-Express bus architecture for communication between two controllers and for the attachment of the channel adapters and device adapters. In the Model 800 there are four (4) PCI-Express busses running at a rate of 2.5Gbps each. Each of the two (2) controllers in the Model 800 can support a dual processor environment. Figure 2, below illustrate the maximum configuration and architecture of the ETERNUS8000 Model 800.



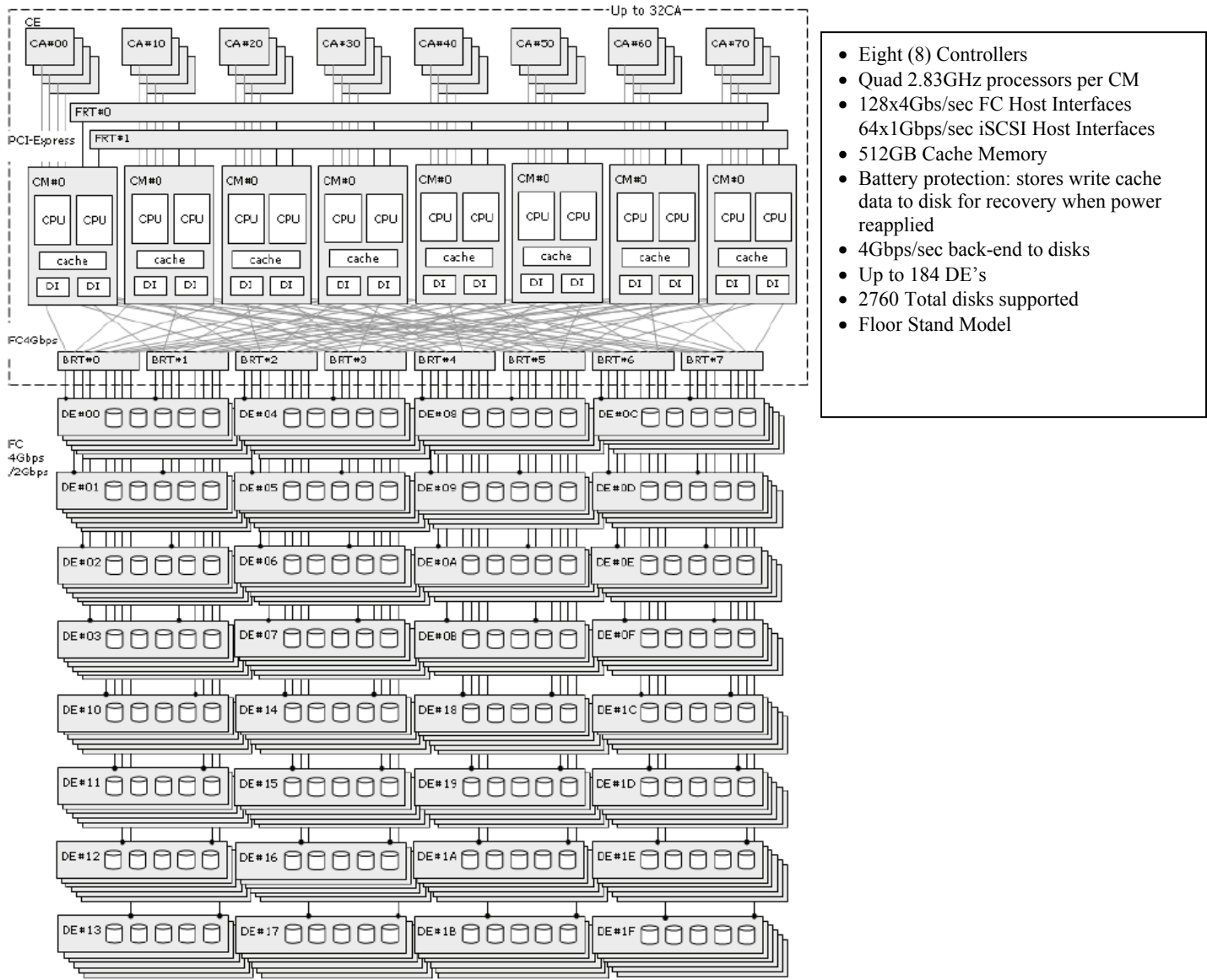
Maximal DE configuration: 4 DEs = Base Unit (includes 2 DEs) + 2 Added DEs

Figure 2: ETERNUS8000 Model 800 (Source: Fujitsu)

The model 1200 supports up to four (4) controllers, each with dual processors. Other than the total number of controllers, and disks, the model 1200 is architecturally similar to the model 2200.

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The Model 2200 uses a shared PCI-Express bus architecture for communication between up to eight (8) controllers and for the attachment of the channel adapters and device adapters. The PCI-Express bus runs at a speed of 2.5Gbps/sec. Additionally the Model 2200 employs high-speed FC switches for rapid communication between controllers when mirroring write cache data. Each of the up to eight (8) controllers in the Model 2200 support a dual processor environment. On the backend, the Model 2200 employs high-speed routers running at 4Gbps/sec between the controllers and the Disk Enclosures (DE's). Figure 4 below illustrates the maximum configuration and architecture of the ETERNUS8000 Model 2200.



- Eight (8) Controllers
- Quad 2.83GHz processors per CM
- 128x4Gbps/sec FC Host Interfaces
- 64x1Gbps/sec iSCSI Host Interfaces
- 512GB Cache Memory
- Battery protection: stores write cache data to disk for recovery when power reapplied
- 4Gbps/sec back-end to disks
- Up to 184 DE's
- 2760 Total disks supported
- Floor Stand Model

Maximal DE configuration: 184 DEs = Base Unit (includes 40 DEs) + 11 Expansion Racks + 144 Added DEs

Figure 3: ETERNUS8000 Model 2200 Maximum (Source: Fujitsu)

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Controllers

The Controller Enclosure (CE) contains the Channel Adapters, redundant power supply units, fans and the Controller Module (CM). The CM's contain the system processors, cache and device interfaces.

Each CM may run in an active-passive mode, or in active-active mode for faster performance. The device adapters or interfaces, which attach the drives to the controller, are attached with fibre channel arbitrated loop interfaces with dual ports on each disk drive and support a back end to Fibre Channel speed of up to 4Gbps.

The model 800 controller card contains a dual core (two processors) 2GHz Intel Xeon processor while the controller card in models 1200 and 2200 contains a quad core (four processors) 2.83GHz Intel Xeon processor.

Host interface connectivity (Channel Adapters) for the ETERNUS8000 supports a mixture of fibre channel and iSCSI.

Cache is utilized for multiple purposes, including for read and write operations, as well as maintaining information required for data protection and replication functions such as Fujitsu's array based replication and point-in-time copy data protection software. Cache is allocated dynamically, with more detail covered on page 11 under the section entitled "Cache" in this document.

Channel Adapters

The Channel Adapters (CAs) provide fibre channel and iSCSI interfaces to the host (server) system, and in the case of the GlobalServer, FCLINK and OCLINK interfaces. The CA's process commands from the host and manage accesses to the cache. The channel adapters plug into a PCI-Express bus on the controller module. Up to sixteen fibre channel host connections per controller may be installed (four, four port channel adapter cards). For service, an entire controller module must be taken out of operation (a failover to another controller module must be done), which includes not only the CA but also the Cache and Device Interface modules, before the channel adapter is replaced. After replacement, the controller module can be returned to service.

Table 3 below summarizes channel adapter connectivity.

Interface	Model 800	Model 1200	Model 2200
Number of FC (4Gb) ports	16	64	128
Number of FC (8Gb) ports	16	64	128
Number of iSCSI (1Gb) ports	8	32	64
Number of FCLINK ports (GS only)	8	32	64
Number of OCLINK ports (GS only)	8	32	64

Table 3: ETERNUS8000 Models Host Connectivity

Device Interfaces

Integrated with the controller module, the Device Interface adapters (DIs) connect the disk drives to the controller modules over a fibre channel arbitrated loop interface. All models support device adapters with up to

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four fibre channel arbitrated loop ports per controller. Dual arbitrated loops are used to connect the dual ported disks so that a single loop failure will not result in loss of access to the disk.

Each drive enclosure supports one dual loop pair with 4 Gb/sec connectivity to the disk enclosures. In addition, the disk enclosures support switched connectivity within the enclosure, providing isolation in the case of a drive failure.

RAID Groups

Similar to other storage systems, Logical volumes (LUNs or Volumes) that are allocated to hosts are created from RAID groups of disks. As noted in Table 1 up to 16,384 logical volumes per open storage system system may be defined.

The ETERNUS storage systems support multiple RAID configurations providing different levels of protection and performance. The RAID levels supported are RAID 0, RAID 1 or mirrored volumes, RAID 1+0 with data mirrored on multiple disks and then striped (4 to 32 disks), RAID 5 on 3 to 16 disks with rotating parity, and RAID 6 with dual parity disk per RAID group. GlobalServer only supports RAID1.

Fujitsu supports the following RAID group size and number of disks in individual RAID groups for ETERNUS8000 systems:

RAID	Number of Drives	RAID Grouping
RAID0	2 – 16	Any
RAID1*	2	2(1D+1M)
RAID1+0	4 – 32	Even numbers only from 4(2D+2M) to 32(16D+16M)
RAID5	4 or 8	4(3D+1P), 8(7D+1P)
RAID6	8 or 16	8(6D+2P) to 16(14D+2P)

* Fujitsu GlobalServer ONLY supports RAID1

Table 4: ETERNUS8000 RAID Grouping Options

Different capacity drives may be intermixed within a system and disk enclosure. It is recommended that a RAID group consist of the same capacity drives; otherwise, the smallest drive capacity will be utilized for all drives within the RAID group. Fibre Channel and Nearline SATA drives may **not** be mixed in a RAID group.

Hot Spare

Hot spare disk drives are global spares that may be used by any RAID group with access to the hot spare. The hot spares allow rebuilding to start automatically when a disk drive fails, or before failure if a high drive error rate is detected. After replacing a failed drive, the data is copied to the replaced drive and the original spare returned to spare status. If using different capacity drives in the system, the hot spare must be equal to or greater than the largest capacity drive. Hot spares are defined to the system via the ETERNUSmgr function.

When both fibre channel disk drives and Nearline SATA disk drives are installed, hot spare disks must be defined for each type.

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When invoking hot sparing, a hot spare disk with the same capacity as the failed disk will be used first; if one does not exist, a larger capacity spare disk will be used. There is no limit for the number of hot spares that can be defined for the system.

Disk Devices

The ETERNUS8000 supports 4 Gb Fibre Channel interface disk drives as well as slower devices.

The characteristics of the disk devices supported are listed in Table 5, below.

Specification	Drive Type	Drive Type	Drive Type
Max. Capacity (GB)	500, 750, 1000 NearLine SATA	300 FC	36*, 73* 146, 300, 450 FC
Rotational Speed (RPM)	7,200	10,000	15,000
Buffer Size (MB)	16	4	8

* Fujitsu GlobalServer only

Table 5: Disk Drive Characteristics

Note that the 1TB Nearline SATA drives are only supported using RAID5 or RAID6

MAID - Eco-Mode

Fujitsu utilizes Massive Array of Idle Disks (MAID) technology for infrequently accessed data in order to reduce power and cooling requirements. This feature is referred to as 'ETERNUS Eco-Mode'. By allowing RAID groups that are infrequently accessed to spin down when they are not used, the total power consumption may be reduced.

The Eco-Mode feature controls the disk drive rotation within a RAID group, affecting all drives that form a RAID group. This feature is managed through ETERNUSmgr. Eco Mode is disabled when system activity requires access to the RAID group, including for data protection operations, mirror copying, RAID group rebuild operations and other system required activity.

Eco Mode utilizes a setting, in conjunction with RAID group activity to determine if a RAID group should be spun down. If there is no activity, and the setting indicates the group should be spun down, then Eco Mode takes effect. If either of these two conditions is not met, then the group will remain spinning. Eco Mode uses time frames for a specific RAID group and may be enabled for the following time frames:

- Everyday - The mode is enabled every day from the specified start time to the specified end time.
- Every week - The mode is enabled every day from the specified start time to the specified end time.
- Specific day – The day or date of the month, along with start, and number of days is specified
- Specific week – A day of the week within the month, along with the start and ending day of the week and the starting and ending time are specified
- Last Access Time – A specific amount of time has elapsed since a RAID group was last accessed, this may be set to 10, 20, 30, 40, 50 or 60 minutes (default is 30 minutes)

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Evaluator Group Comments: *The lower power consumption of Eco-Mode is a unique feature in the enterprise storage system market, and provides customers with flexibility in matching their storage systems to business requirements.*

Disk Data Encryption

ETERNUS provides data encryption and protects critical, security sensitive data from unauthorized access to drives that have been removed from the storage system. Setup and management of encryption is via the ETERNUS management console and encryption is on a by LUN basis.

There are two primary encryption algorithms supported:

- Fujitsu Original Encryption mode
- AES 128-bit (Advanced Encryption Standard) mode

All data within the system is encrypted and decrypted within the controller as shown below in Figure 5. When encryption is enabled, data stored on disks is all encrypted with the same key. By keeping the key separate from the drives, Fujitsu provides a high level of security if drives are lost or stolen.

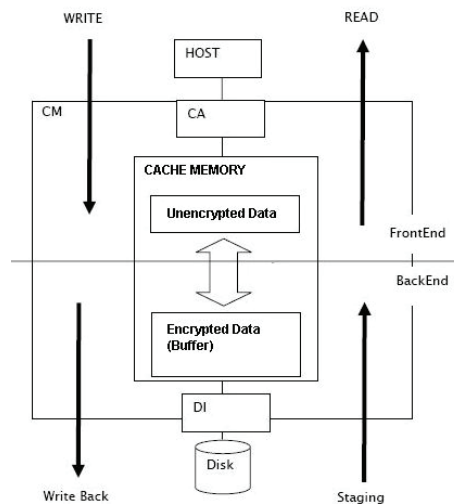


Figure 4: Disk Data Encryption Detail (Source: Fujitsu)

Evaluator Group Comments: *The encryption capabilities of the Fujitsu ETERNUS 4000 and 8000 are unique, particularly in the enterprise market in which the E8K competes. The security provided is very good, in that the encryption key is never stored on a disk drive. As a result, data is protected unless the encryption key is compromised, or the entire system is accessible. In comparison to systems that utilize disk encryption, the Fujitsu approach is somewhat less scalable and less flexible, but provides better security. This level of security is unmatched by other storage vendors without using additional encryption devices (e.g. network or disk) and provides Fujitsu ETERNUS8000 customers with a security mechanism that is inexpensive, effective and secure.*



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Additionally, the ETERNUS8000 supports encryption during replication using standard IPsec security (AES encryption with HMAC-MD5 authentication). This feature is enabled through the use of the optional iSCSI Remote Adapter for remote replication. For more information see the **Remote Replication** section on page 25 in this document.

Cache

Each of the ETERNUS8000 series controllers contain cache. Only write data is mirrored from one controller to another controller. The amount of cache dedicated to mirroring between the controllers varies along with the percentage of total data that is write data.

The write data is mirrored between the controllers over a PCI-Express bus link. Table 5 below describes the number of controllers and cache capacities for the ETERNUS models.

Specification	Model 800	Model 1200	Model 2200
Number of Controllers	2	2, 4	4, 6, 8
Max Cache Size (GB)	16	256	512

Table 5: ETERNUS 8000 Models Controllers and Cache Mix

Battery

All ETERNUS8000 models protect write data in cache memory that has not yet been written to its intended target drive at the time of a power fault by keeping battery power applied to the cache memory and specific disks (known as “system disks”) long enough so that the write cache data is safely stored on the system disks. Later, after the power fault has been cleared and power has been reapplied to the subsystem, the write data is restored to cache memory from the system disks and the write data is then correctly written to its original target disk drives.

The maximum number of batteries that can be installed with model 800 is three (3); the model 1200 supports six (6) and model 2200 supports eight (8) batteries. Battery life is specified at two and a half to three years. The expiration date may be read through the ETERNUSmgr web-based software.

LUN Management

Fujitsu refers to their LUN masking and LUN management features as ‘Host Affinity.’ Some vendors term this feature LUN Masking, or LUN Management, or LUN Mapping. LUN access or Host Affinity is controlled by the ETERNUSmgr configuration software, which is included with the system. Host Affinity controls LUN access, which provides a security mechanism at the LUN level. A Host Affinity group is defined as a set of LUNs that are made available to a specific set of servers. The server is identified by the World Wide Name of the host bus adapter.

LUNs can be assigned to multiple servers, with one LUN used in different Host Affinity groups allowing for multi-host data access for cluster or other configurations using host software to coordinate data sharing.

A LUN may be comprised of one or more RAID groups, or a partial RAID group.



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Virtual / Thin Provisioning

Fujitsu does **not** support virtual capacity of volumes, which is sometimes known as “Thin Provisioning” or “Virtual Provisioning.” When Fujitsu announced the new ETERNUS8000 models in January, 2009, Fujitsu also stated that thin provisioning capabilities would be available in 2009.

Fujitsu does support expansion of a LUN through “Logical Device Expansion,” or LDE.

RAID Migration

The support for on-line RAID migration effectively copies data from one RAID group to another, new RAID group. The target RAID group must be as large, or larger than the source group. There are few restrictions to RAID migration, allowing administrators to re architect data layout to support changing requirements.

LUN Concatenation

LUN concatenation adds new space for a volume and expands volume capacity that can be used from the server. This feature obtains the area to be used for capacity expansion from unused areas in an existing RAID group, or an unused RAID group. LUN concatenation creates a new volume with the obtained area, and concatenates these volumes to be used as a large capacity volume. LUN concatenation can be used for volume expansion when creating a new volume or expanding an existing volume. Up to 16 volumes may be concatenated. Concatenation of multiple free areas in the different RAID group is possible. Concatenation is possible even if the RAID level is different. Maximum volume capacity after the concatenation is 32 (TB).

Disk Traffic Control (DTC)

DTC is a performance optimization that optimizes the back end disk drive by segmenting sequential and random accesses into separate extents when they both occur simultaneously. The two I/O streams (sequential and random) are processed alternately on a time interval basis to provide optimum usage of the disk drive resource.



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PERFORMANCE

Performance tests for some past models of the ETERNUS8000 have been performed and audited by the Storage Performance Council. It is expected that either the model 1200 or model 2200 will complete the SPC-1 and SPC-2 benchmarks in the future. The information will be available at www.storageperformance.org.

Evaluator Group Comments: The benchmark results for the older ETERNUS8000 model 1100 are published for both SPC-1 and SPC-2 and show performance levels that match or exceed many of their competitors. With results for the new model 1200 likely to exceed those of the 1100, the new ETERNUS8000 systems are likely to provide very good price and performance levels.

Specific performance enhancements of the new models 1200 and 2200 over prior models of the ETERNUS8000 system include:

- **PCI-Express Bus** – The dedicated PCI-Express bus provides the high-speed interconnect for controller to controller communications. This high-speed bus is part of the high performance elements that Fujitsu has designed into the ETERNUS family.
- **Overall throughput enhancements** – Use of higher performance 2.83GHz XEON processors for the models 1200 and 2200, coupled with 8Gbps/sec front-end and 4Gbps/sec back-end, and larger cache sizes enables the ETERNUS8000 to provide improved performance versus previous models.



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RAS FEATURES

ETERNUS storage systems maintain data integrity and provide data availability via the following mechanisms:

- RAID protection of disk devices
- Redundancy of active components
- Dual power source
- Write cache data de-stage to disk
- Concurrent configuration changes
- Hot spare disk drives
- Concurrent maintenance on components
- Concurrent firmware upgrades
- Parity protection
- ECC (Error Correction Code)
- BlockGUARD

Data Integrity

Data integrity is expected of any storage system and the methods that system vendors employ to ensure data integrity are important for any analysis. Fujitsu has implemented an end-to-end integrity checking mechanism that is called BlockGUARD. BlockGUARD will put an extra eight bytes of information on every 512-byte data block as it enters the system at the channel adapter. These eight bytes are retained with the data as long it is stored within the system. The eight bytes are composed of a four byte cyclical redundancy check (CRC) and four bytes that are the block ID. This information is checked whenever the block is stored on the disk by the device adapter and is also checked when data is retrieved, both at the device adapter and the channel adapter. The BlockGUARD characters are stripped whenever data is sent to the host by the channel adapter.

Data integrity is also a part of the cache function. Data in cache is error-correction code (ECC) protected to be able to detect and correct cache memory errors.

Redundant Copy

When a disk is identified for preventive replacement (before hard failure), the redundant copy function builds the identified disk's data from the other disks in the RAID group to a hot spare. Once that action is complete, the disk at risk is detached and the hot spare is incorporated into the RAID group ensuring data integrity. This is accomplished by using Fujitsu S.M.A.R.T (Self-Monitoring Analysis and Reporting Technology) technology in the disk drive to collect patrol and error statistics.

Redundant Power System

The power system is based on redundant power supplies in the modular enclosures with dual line cord inputs. The modular architecture and dual power inputs ensure the greatest amount of power problem isolation. All power system components are replaceable non-disruptively.

Battery Backup

For all ETERNUS8000 models, the battery backup maintains power for the cache and also for the system disks; where write cache is de-staged at the time of a power fault.



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Parity

The PCI and PCI-Express busses have parity generating and checking circuitry that verify hardware integrity for data transfers at the time that they are placed onto and taken off of the busses.

Error Checking and Correction (ECC)

The cache memory on each controller module uses ECC to detect all single and double bit errors and correct single bit errors.

BlockGUARD

The data assurance by appending check-sums into every data block is part the error detection system.

Hot Spares

Using hot spare disks is a configuration option. The operation of handling hot spares is as described in the RAID Groups section of this document. After a failed drive is replaced, the data will be copied to the replaced drive and the original spare returned to spare status.

RAID 6

With the use of dual parity drives in a RAID 6 configuration, the subsystem is better protected in the event of a double disk failure (two disk drives fail concurrently in a SATA drive configuration.)

Concurrent Maintenance

A modular architecture is based on modules being able to be taken out of service while others take over the workload. The ETERNUS8000 operates in a mode where some components can be replaced without failing over to another controller while others require a failover to occur for service. Fujitsu states the following components can have concurrent maintenance to provide access assurance.

- Array Controller, contains – Controllers, cache and channel adapters
- Power Supplies
- Cooling Fans
- Disks

Concurrent Firmware Updates

Firmware updates in the ETERNUS8000 is accomplished by the following operation:

1. If controllers are active/passive, then failover of LUN from primary to secondary controller
2. Copy the firmware to the controllers flash ROM
3. If active /passive controllers, then fail the LUNs back their original primary path
4. Repeating steps for remaining controllers

Remote Call Home

The ETERNUS8000 system supports remote call home with several remote support features including:



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- Send Communication Log
- Automatic sending of system Log
- Manual system log sending

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CONNECTIVITY OPTIONS

The following table lists supported servers and operating systems:

Host Vendors	Supported Servers	Supported Operating Systems
Fujitsu	PRIMEQUEST	Windows Server® 2003 for Itanium-based Systems, Windows Server® 2008 for Itanium-based Systems, Red Hat Enterprise Linux AS (V.4 for Itanium), Red Hat Enterprise Linux(V.5 for Itanium)
	SPARC Enterprise	Solaris 10 Operating System
	PRIMEPOWER	Solaris 8 Operating System, Solaris 9 Operating System, Solaris 10 Operating System
	PRIMERGY	Windows 2000 Server, Windows Server 2003, Windows Server 2003 x 64 Editions, Windows Server 2008 (32-bit), Windows Server 2008 (64-bit), Red Hat Enterprise Linux AS v.3, Red Hat Enterprise Linux AS v.4, Red Hat Enterprise Linux ES v.3, Red Hat Enterprise Linux ES v.4, Red Hat Enterprise Linux 5 (for x86), Red Hat Enterprise Linux 5 (for Intel64), SUSE Linux Enterprise Server 9 for x86, SUSE Linux Enterprise Server 9 for EM64T, SUSE Linux Enterprise Server 10 for x86t, SUSE Linux Enterprise Server 10 for EM64T, VMware ESX Server 2, VMware ESX Server 3.0, VMware EXS Server 3.5
	GlobalServer	OSIV/MSP, OSIV/F4 MSP, OSIV/XSP, AVM/EX, AVM/EXS
Sun	Sun Fire, Sun Blade, Sun Enterprise	Solaris 8 Operating System, Solaris 9 Operating System, Solaris 10 Operating System
HP	HP 9000 series	HP-UX 11v2, HP-UX 11v3
IBM	pSeries, RS/6000 series	AIX 5.2, AIX 5.3
Others	IA server vendors (various companies)	Windows 2000 Server, Windows Server 2003, Windows Server 2003 x 64 Editions, Windows Server 2008 (32-bit), Windows Server 2008 (64-bit), Red Hat Enterprise Linux AS v.3, Red Hat Enterprise Linux AS v.4, Red Hat Enterprise Linux ES v.3, Red Hat Enterprise Linux ES v.4, Red Hat Enterprise Linux 5 (for x86), Red Hat Enterprise Linux 5 (for Intel64), SUSE Linux Enterprise Server 9 for x86, SUSE Linux Enterprise Server 9 for EM64T, SUSE Linux Enterprise Server 10 for x86t, SUSE Linux Enterprise Server 10 for EM64T, VMware ESX Server 2, VMware ESX Server 3.0, VMware EXS Server 3.5

Table 6: ETERNUS8000 Open Systems Servers and OS Support – Fibre Channel

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Multi-Path IO

Fujitsu provides a multi pathing driver, referred to generically as MPD for the operating platforms supported by the ETERNUS8000 line. For each platform there is a specific driver package known as ETERNUSmpd.

The ETERNUS8000 supports both fixed path access on a per LUN basis, and dynamic multi-path access to each LUN. As with other enterprise class systems, the ETERNUS8000 series permits symmetric LUN access. This is a mode which Fujitsu refers to as “Unassigned CM” in that a controller is not assigned to a LUN.

The ETERNUS8000 systems do not have a controller module (CM) assigned to a specific LUN, allowing access to any LUN through any path and any controller module. This capability provides a high degree of fault tolerance, and provides improved load-balancing capabilities.

The diagram below illustrates LUN access configuration for AIX, although this is also the case for other OS environments. Figure 5 below illustrates symmetric access.

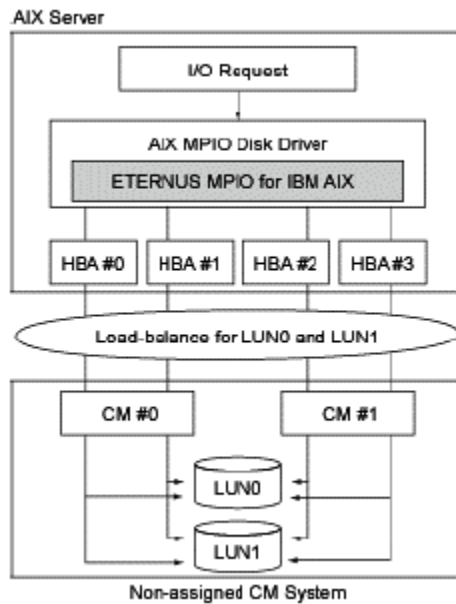


Figure 5: Symmetric MPIO Access for ETERNUS8000 (Source: Fujitsu)

Solaris

Fujitsu provides a device driver for Solaris platforms supporting MPIO, utilizing Fujitsu’s multi-path driver, or MPD.

Windows

Fujitsu provides a device driver for Windows platforms supporting MPIO, utilizing Fujitsu’s multi-path driver, or MPD.

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Linux

Fujitsu provides a device driver for Linux platforms supporting MPIO, utilizing Fujitsu's multi-path driver, or MPD.

IBM AIX

For the AIX platform, Fujitsu's MPD is an interface to AIX's native multi-pathing I/O capabilities. The ETERNUS MPIO for AIX is an IBM Path Control Module (PCM) that utilizes AIX's native multi pathing capabilities, through the MPIO interface. ETERNUS systems utilizing this software may be accessed as an MPIO device by AIX. This allows active/active symmetric logical unit access via AIX.

ETERNUS MPIO for IBM AIX performs load-balancing over the usable paths to improve the access performance.

iSCSI Connectivity

The following table lists supported servers and operating systems for iSCSI host interface.

Supported Servers	Supported Operating Systems
Industry Standard Server	Windows 2000 Server, Windows Server 2003, Windows Server 2003 R2, Windows Server 2003 x64 Editions, Windows Server 2003 R2 x64 Editions, Microsoft Windows Server 2008, Red Hat Enterprise Linux 5, SUSE Linux Enterprise Server 9, SUSE Linux Enterprise Server 10, VMWare ESX/ESXi 3.x.x

Table 7: ETERNUS8000 Supported Servers and Operating Systems – iSCSI

iSCSI Connectivity

The E8K supports iSCSI connectivity. There are several options for iSCSI which may be implemented. The following are supported by the ETERNSU8000 systems:

- iSNS (internet Storage Name Services)
- Changing TCP/IP settings
- CHAP authentication
- Host affinity mode
- Cancel reservation
- Header Digest
- Data Digest

Specification	Model 800	Model 1200	Model 2200
Number of iSCSI Hosts	256	1024	1024
Number of Affinity Groups	256	512	512
Affinity Groups per Port	64	64	64

Table 8: ETERNUS 8000 iSCSI Host Limitations



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SOFTWARE FEATURES AND FUNCTIONS

The ETERNUS SF software suite includes a number of offerings that provide options for system and SAN management, data protection and disaster recovery, backup and archiving, local replication and path failover.

Storage Management

SMI-S Interface

The SNIA along with the DTMF have created a set of storage management interface specifications, known as “SMI-S” interface.

Evaluator Group Comment: Prior models of the ETERNUS8000 have supported and been certified to be interoperable with SMI-S version 1.1 frameworks. Check with the vendor to confirm the status of current models.

ETERNUSmgr (Included)

ETERNUSmgr is a device management application that is included with ETERNUS storage systems, including ETERNUS8000 systems. The backend program is embedded in the ETERNUS systems and is accessed by a web browser, the ETERNUSmgr frontend software or other operation management software. This browser based management application is used to configure, manage and monitor (including email notification) one or more ETERNUS systems.

ETERNUSmgr Aid (Optional)

ETERNUSmgr Aid adds management value to ETERNUSmgr with its simplified GUI interface and additional management features. Customers will find it easier to manage their ETERNUS storage systems. ETERNUSmgr Aid is optional software that is installed on an administrative server.

ETERNUS SF Storage Cruiser (Optional)

Storage Cruiser is a SAN management application that provides configuration, specification, and monitoring of a SAN environment. It may also be used to manage the relationship between the storage as viewed from the host server and the physical storage, allowing the whole storage system’s configuration and failure conditions to be managed. It will manage the ETERNUS family and also supports other selected vendors products.

ETERNUS SF Storage Cruiser consists of two modules, with an optional third module:

- The Agent feature is installed on each server node being managed
- The Manager feature is installed on the selected administrative server
- (Optional) A remote Client may be installed on any computer used to perform management functions

ETERNUS SF AdvancedCopy Manager (Optional)

The ETERNUS SF AdvancedCopy Manager provides backup and replication with flexible options and works in conjunction with the optional Advance Copy functions of ETERNUS systems. It allows non-stop high-speed backup of major databases such as Oracle and SQL Server. The methods used are Equivalent Copy (EC), One-Point Copy (OPC), differential backup/replication (QuickOPC) and SnapOPC.

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Data Protection Software

Fujitsu has termed their point in time copy feature for the ETERNUS series, One Point Copy (OPC). There is local mirroring (Equivalent Copy), along with three different versions of One Point Copy:

- One Point Copy (OPC)
- Quick OPC
- Snap OPC

	Equivalent Copy	One Point Copy (OPC)		
		One Point Copy	QuickOPC	SnapOPC
Copy Type	Mirror	Clone	Clone	PIT
Architecture	Full Copy	Bit Map	Bit Map	Bit Map
Max # Copies	Maximum concurrent EC, OPC, QOPC or SnapOPC copies by model: Model 400 = 2048 ; Model 600 = 4096			
Re-sync	Yes	No	Yes	No
Potential Data Exposure	Synchronous—none	Exposure is back to time OPC was activated	Exposure is back to time QuickOPC was activated	Exposure is back to time when snap was taken
Availability for Restore	Mirror available after completion of initial mirror	Available for restore immediate, or able to replace volume after copy complete	Available for restore, or able to replace volume immediately	Available for restore only after command completes
DR, Fail-over Capability	Yes On Mirror suspend or break	Yes Able to replace volume after copy complete	Yes Able to replace volume as soon as command completes	No Not for DR or fail-over, depends on source data
Default Action	Mirror. Copy is a true mirror until it is split	Copy when command issued	Copy when command issued	Copy on Write
Additional Capacity	100%	100%	100%	Changes only
Access to Copy	R/W after split	R/W immediate	R/W immediate	R/O
Performance Impact	Some impact	Small Impact	Minimal	Minimal

Table 9: Fujitsu ETERNUS8000 Data Protection Options

One Point Copy (OPC)

The copy is a “clone” copy where an exact original copy is made to another physical area. Entire volumes may be copied using OPC.

OPC has two copy phases; the logical phase and the physical phase. The logical phase starts after the OPC command is initiated. A bitmap that represents the copy is created in cache memory. That process

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takes a few seconds and after completion, the copy is available for use. The physical phase then starts which is the process of the storage system copying the data to the copy location and this happens in the background. During the physical phase, host access to data is available. The copied volume is available almost instantly after OPC initiates, upon completion of the logical phase. This is accomplished as follows:

- Read to Target – If the requested block has been previously copied to the target, a normal read is done to the target volume. If the requested block has not been copied, the system will copy the block from the source to the target and then honor the read from the target volume.
- Write to Source – If the requested block has been copied to the target, a normal write operation is done to the source. If the requested block has not been copied yet, the original block is copied to the target and the write is then done to the source.
- Write to Target – If the requested block has been copied to the target, a normal write operation is done. If the block has not been copied, the bitmap is changed to indicate the copy has been done and the normal write is done.

The process of the physical copying persists through a power down or reboot.

There are three speed settings (pacing parameters) to control the amount of storage system resources consumed for the copy operation. The speed or priority settings are controlled via the management software, ETERNUSmgr. The three speed options are **low**, **high** and **automatic**. The automatic setting changes the priority dynamically in response to the system workload.

One Point Copy consumes cache memory for the bitmap and the additional data being moved for the copy.

QuickOPC

After One Point Copy has been run, an administrator may execute a QuickOPC operation which shortens the copy time. The design leverages the use of a bitmap, which tracks changed blocks for the volume. This function will only copy changes from the source volume since the last One Point Copy operation occurred.

SnapOPC

SnapOPC operates similar to other Copy on Write point in time copy operations. Rather than copying the new data to the copy volume, the old data is copied to the duplicate volume. Space is saved by only saving the original blocks of data, when new data is written to the SnapOPC volume. By copying only a portion of the source volume, it minimizes copy volume capacity.

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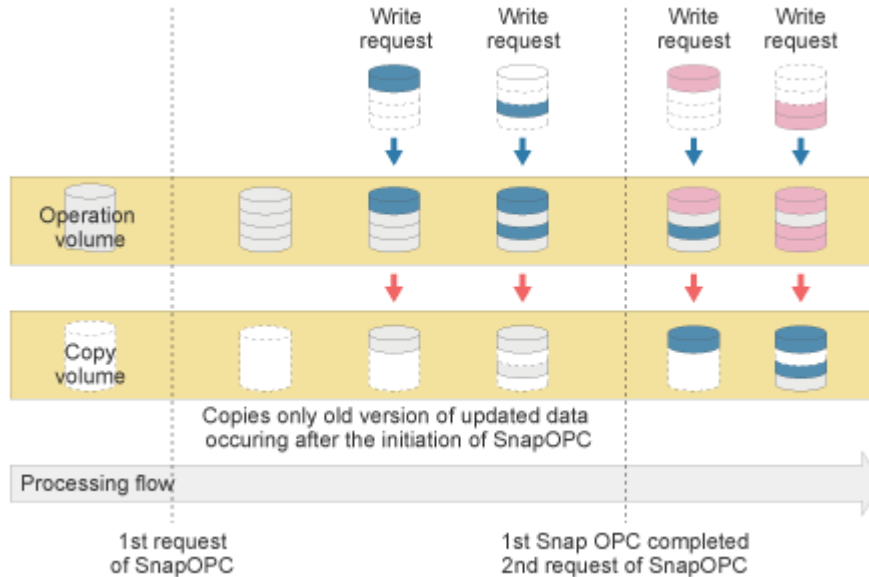


Figure 6: Example of SnapOPC for ETERNUS8000

SnapOPC+

Is a function that backs up the previous state of updated data areas to a copy destination area on a generation-by-generation basis.

Equivalent Copy (EC)

Fujitsu local mirroring and replication product is known as Equivalent Copy (EC). The mirror is an exact image copy made to another physical area. Entire volumes may be copied as initiated by the Fujitsu management software.

The mirror volume must be a local volume, thus the ETERNUS8000 supports local, in-system mirroring. Like the One Point Copy feature, space for the copy must be reserved previously and be at least the same size. The RAID configuration may be different in the source and target.

The copied volume is not available until the initial copy is complete and either a “detach” (split or break) or a “suspend” command has been issued. If suspended, a “resume” may be issued which will cause a resynchronization to be done. The resynchronization is the application of incremental updates that have been made to the source volume to the target. The target volume is not available during a resume. If a “detach” has been done, the target volume becomes independent at that time.

The process of the physical copying for the mirror persists through a power down or reboot. As in One Point Copy, Equivalent Copy consumes cache memory for the bitmap (and the additional data being moved for the copy). To use EC, at least 1GB of cache for each controller module must be installed. While very similar to One Point Copy, the differences are that Equivalent Copy supports the Suspend/Resume function and the mirror volume is not available until the copy is complete.

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Replication

Remote Advanced Copy

Fujitsu's remote replication for the ETERNUS4000 and 8000 series is known as Remote Advanced Copy. This supports replication between multiple ETERNUS 4000 or 8000 storage systems. When referencing remote mirroring specifically, this feature is also known as Remote Equivalent Copy (REC). Fujitsu's RAC product supports both synchronous and asynchronous remote replication.

Remote replication is supported over both FC and IP connections, utilizing the FCP or iSCSI protocols respectively. Utilizing iSCSI replication provides a cost effective method that utilizes TCP/IP connections without requiring an FCIP converter as is typically the case when using FC protocols.

Fujitsu ETERNUS Remote Advanced Copy / Remote Equivalent Copy provides the following features:

- Maintain an exact byte-for-byte copy of production data in a remote location
- Write order consistency is supported for both Sync and Asynchronous replication
- Consistency groups are supported
- Failover to secondary sites for disaster recovery
- Integration with OPC for secondary site backup operations
- Management of replication pairs using ETERNUS Advanced Copy Management
- Choose between synchronous and asynchronous mirroring for ETERNUS systems

Figure 7 below illustrates the basic example of an asynchronous replication scenario between two ETERNUS8000 storage subsystems.

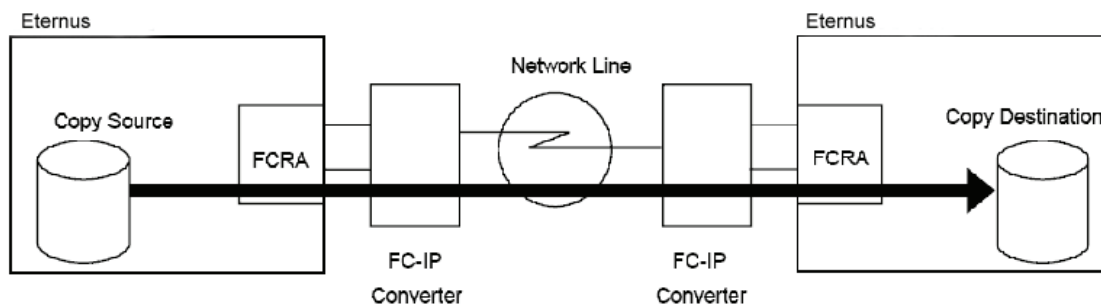


Figure 7: Example of Asynchronous Replication between Two Systems

Evaluator Group Comment: *The ability to support replication between the midrange ETERNUS4000 and the data-center ETERNUS8000 products is a significant feature for customers. Most products that the ETERNUS8000 compete against do not utilize compatible replication software between their midrange and high-end systems. By allowing customers to replicate between platforms, Fujitsu's ETERNUS customers are better able to utilize the most cost effective products for their business needs. Competing products force customers to purchase high-end systems at remote sites, regardless of the need for such a system.*

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iSCSI Remote Adapter (optional hardware)

The iSCSI Remote Adapter (iSCSI-RA) provides a number of features for the ETERNUS4000 and 8000 series storage systems.

- Optimized TCP acceleration
 - Provides optimization for all TCP protocols (FTP, iSCSI, etc)
 - High bandwidth using large TCP window size
 - Supports up to 300 Mbps effective TCP transfer rate per card
 - Supports 500 ms RTT TCP connections
- Encrypted TCP Communication
 - Utilizes AES encryption with HMAC-MD5 authentication
 - Supports standard IPsec security
- Bandwidth Control
 - Traffic shaping and QoS
 - Automatic TCP window size adjustment with 50 micro-second precision
- Embedded WAN acceleration
 - All functions supported on once chip on an AMC (Advanced Mezzanine Card)

Evaluator Group Comments: The Fujitsu iSCSI –RA cards provide a significant advantage for customers looking to deploy a cost effective remote replication setup. The use of iSCSI leverages TCP/IP, thereby removing the need for FCIP converters commonly found with FC based replication. Additionally, the encryption provides a level of security mandated by many companies either for security requirements or best practices guidelines. Finally, the inclusion a TCP accelerator can eliminate the need for a separate WAN accelerator in many cases. As a result, it is possible for customers to save well over \$100,000 using the Fujitsu iSCSI-RA cards rather than external encryption and WAN accelerators.

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SPECIFICATIONS

Model	Width(cm)	Depth(cm)	Height(cm)	Weight(kg)
800	59.0	99.5	140.0	440
1200	74.0	99.5	180.0	4,230
2200	126.0	99.5	180.0	10,930

Table 10: ETERNUS8000 Physical Specifications

Specification	Model 800	Model 1200	Model 2200
Power Requirements			
Voltage	AC200-240V	AC200-240V	AC200-240V
No. of Phases	Single	Single	Single
Frequency	50/60Hz	50/60Hz	50/60Hz
Max. Power Consumption(W)	2.8	36.7	96.4
Max. Heat Dissipation (KJ/h)	10,100	132,200	347,100
Environmental Conditions			
Temperature			
Operating	5-35 degrees Centigrade	5-35 degrees Centigrade	5-34 degrees Centigrade
Non-Operating	0-50 degrees Centigrade	0-50 degrees Centigrade	0-50 degrees Centigrade
Humidity			
Operating	20-80%RH	20-80%RH	20-80%RH
Non-Operating	8-80%	8-80%	8-80%

Table 11: ETERNUS8000 Electrical and Environmental Specifications



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ANNOUNCEMENT HISTORY

Date	Announcement
January, 2009	Announces the new ETERNUS8000 family of storage systems Models 800, 1200 and 2200
April, 2006	Announcements of ETERNUS8000 family of storage systems: Models 700, 900, 1100 and 2100

Table 12: ETERNUS8000 Announcement History



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EVALUATOR GROUP COMMENTS

Summary

Fujitsu's ETERNUS8000 provides high performance, data-center class reliability for open system environments. Fujitsu continues to supply excellent data integrity features – demonstrating their understanding that this has become an expectation for storage systems in the enterprise open systems storage space.

The closest competitor to the Fujitsu ETERNUS8000 may be 3PAR systems T800 system. Both systems provide many excellent data center class features, but lack the ability to compete head-on with the EMC Symmetrix, Hitachi USP and IBM DS8000. The primary features lacking in both the 3PAR and Fujitsu systems is a lack of mainframe connectivity, advanced replication features, heterogeneous storage management and business implementation services. However, for sites that do not require these features, the Fujitsu ETERNUS8000 may be an excellent choice.

Strengths:

The ETERNUS8000 provides good performance, matching that of the IBM DS8300 Turbo in similar configurations for SPC and ESRP benchmark configurations. Additionally, when configured for similar capacity, the ETERNUS provides a competitive price, and price / performance levels compared to competing systems.

Overall, the ETERNUS8000 product is a well architected external storage system. Other than lacking mainframe connectivity, the features are on par with that of most major competitors. The inclusion of multiple RAID levels, including RAID 6, along with good performance and expandability, an excellent choice of data protection options coupled with the industries best in class warranty provide a compelling package.

One strength of the ETERNUS8000 is the software compatibility with the midrange ETERNUS4000 product line. This feature is somewhat unique in the storage industry for major vendors. EMC, HP, Hitachi, IBM and Sun all utilize different and incompatible storage software between their midrange and high-end systems. By providing compatibility between the Fujitsu 4000 and 8000 product lines, customers are able to utilize lower cost systems at remote sites for data continuity. It is common to have high availability requirements for only one or two applications, which may be only a small portion of the total capacity of a storage system. By allowing an ETERNUS4000 to serve as the replication target for an ETERNUS8000, Fujitsu enables customers to better match storage system deployments to business requirements. In contrast, most vendors require the deployment of a second high cost system at a remote site. This flexibility provides Fujitsu customers a significant advantages in terms of cost savings, and an enhanced capability to upgrade from a midrange ETERNUS4000 to an ETERNUS8000 system.

The addition of storage encryption is another unique feature offered by Fujitsu on the ETERNUS8000 that provides a high level of data security for environments that are looking to deploy security beyond perimeter security. By including the feature within the array, no external equipment is required,

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thereby increasing the likelihood that customers will be able to easily implement the ETERNUS's storage encryption capabilities.

The Eco Mode feature leverages the idea of spinning down inactive disks, an innovation known as MAID, pioneered by Copan Systems. Fujitsu is one of the first vendors to embrace this idea and incorporate it into their mainstream storage array products. Although the settings are cursory and operate at the RAID group, the capability to selectively spin down drives is an advantage for many deployment scenarios where near-line access capabilities are required, and power and cooling costs are a concern.

Perceived Challenges:

In comparison, to EMC's Symmetrix, HP's XP, Hitachi's USP and IBM's DS8000 data-center products, the Fujitsu ETERNUS8000 provides features and performance that are roughly on par with these systems. However, the data replication and management options available for the E8K are limited in comparison to the other vendors' products. In addition, there are two issues that impact the ETERNUS8000's applicability for specific environments: Lack of mainframe connectivity and a lack of widespread business consulting service offerings.

The biggest potential issue with the Fujitsu E8K system is the lack of mainframe connectivity. Typically, data center environments that require the high-end reliability, capacity, availability and performance of a system like the ETERNUS8000 also require some amount of mainframe connected storage. The primary competitors of the ETERNUS8000 all support mainframe storage connectivity. However, for open system only environments, or other scenarios where mainframe connectivity is not required, the Fujitsu ETERNUS8000 is a solid contender.

The other issue that may prove to be a disadvantage for ETERNUS8000 customers is the comparative lack of business consulting services available for complex implementations. While Fujitsu has a good presence throughout the world, and significant storage expertise, their service offerings are not as diverse or broad as their tier 1 competition, including EMC, HP and IBM.

Another issue that may impact the ETERNUS8000 includes a fewer number of data replication options. Competing products provide complex replication support, including three site replication, whereby synchronous replication occurs to a nearby secondary system, and the secondary system in turn replicates asynchronously to a more distant third system.

Other minor issues include a lack of support for thin provisioning, and a lack of flash or SSD drives within the Fujitsu ETERNUS8000. However, Fujitsu has issued a statement of direction indicating that both of these items will be available on the ETERNUS8000 product line before the end of 2009.

Finally, competing systems also typically offer a greater number of management options. Specifically, EMC offers Control Center, IBM provides Tivoli Storage Manager; and HP, Hitachi and Sun provide Storage Essentials for enterprise heterogeneous storage management. While the ETERNUS8000 provides support for these products, the integration is not as robust as each vendors specific storage management product provides. However, due to the cost and complexity, many environments have



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chosen not to deploy SRM applications. Thus, Fujitsu's lack of a product in this category may not be an obstacle for many storage environments.

Challenges remain for Fujitsu in the high-end data-center storage market. Fujitsu continues to build their direct sales channel and add to their sales and SE force around the world. In particular, the revamping of the Fujitsu name in the European market will take time after a long-standing partnership operating as Fujitsu-Siemens. However, the ETERNUS8000's high quality, solid features and performance coupled with a relatively low price provide an excellent alternative to the three major competitors in the high-end storage market.

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