



White Paper

FUJITSU Storage ETERNUS DX series Extreme Cache/Extreme Cache Pool best fit for fast processing of vast amount of data

Extreme Cache / Extreme Cache Pool, which expands cache capacity of FUJITSU Storage ETERNUS DX series significantly, cuts operation hours by reducing response time.

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Introduction

Facing to rapid cloud computing growth and big data handling, fast response time of disk storage is required to process ever expanding massive data in real time.

FUJITSU Storage ETERNUS DX series^{*1} (hereinafter as ETERNUS DX series) has been solving every issues by providing world top class performance and scalability.

ETERNUS DX series introduced Extreme Cache/Extreme Cache Pool which expands cache capacity significantly to process unprecedented vast data at high-speed. This introduction increases cache hit ratio and improves performance drastically.

This paper shows the test result which proves effectiveness of introduction of Extreme Cache/Extreme Cache Pool. quick sort^{*2} is used for character handling of data processing.

This paper shows the verifications that were performed on January 2015.

^{*1} The ETERNUS DX60 S4/S3 and ETERNUS DX8100 S4 are excluded.

^{*2} quick sort is a high performance data sort/merge utility which provides functions to process various records such as high performance data sort, merge, copy, record selection/reorganization/integration used for corporate system data tally and analysis. And it is widely used in the industry such as common batch processing.

The information stated in this document is current as of November 2018.

1. Disk storage system cache

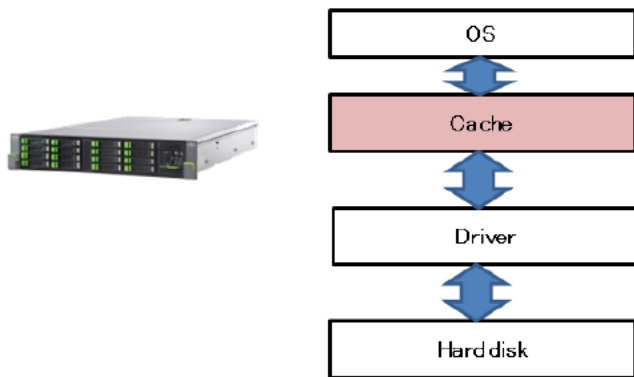
1.1 Role of cache

Disk storage system has cache as well as server has cache.

■ Server's cache

Placing data of high access frequency on cache (memory) enhances response time by eliminating hard disk access when the data needs to be read.

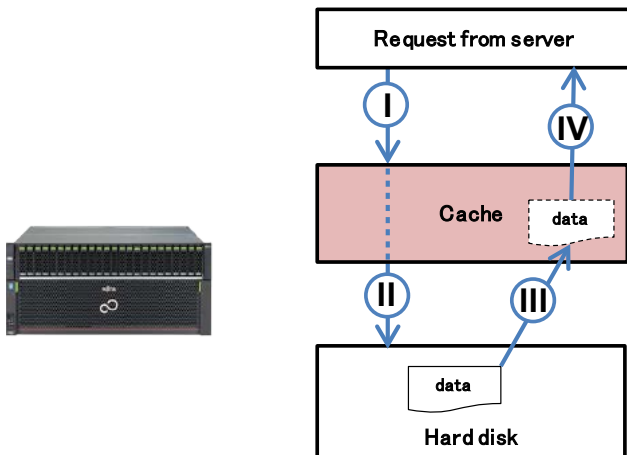
Figure: Server's cache



■ Disk storage system's cache

Placing data of high access frequency on cache inside of storage system enhances response time by eliminating hard disk access when the data needs to be read.

Figure: Data access flow



• Data access flow

When the data is not on cache, hard disk is accessed.

- I. Check if the data is on cache (cache miss).
- II. Access the data on hard disk.
- III. Loading the data onto cache.
- IV. Send the data to the server.

When the data is on cache, II, III operations are skipped, so the response time is improved.

- I. Check if the data is on cache (cache hit).
- IV. Send the data to the server.

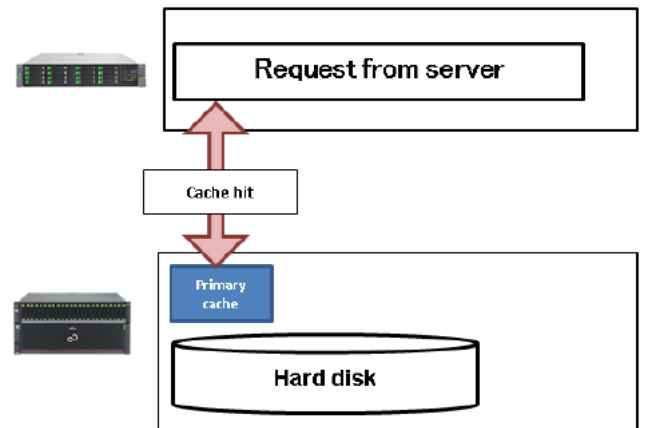
1.2 Primary cache and secondary cache

There are two kinds of cache for disk storage, primary cache and secondary cache.

■ Primary cache

This cache is equipped on most of storage systems and configured with DRAM. It responds to the request from server very high speed, but cache hit is limited due to its not big capacity.

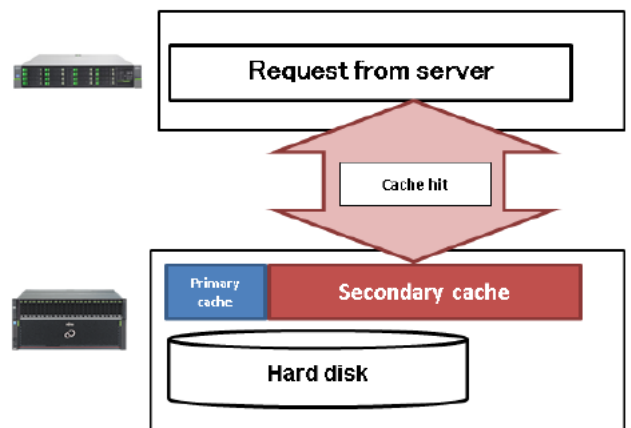
Figure: Response to the server with cache hit



■ Secondary cache

This cache consists of flash and enlarges cache capacity drastically. This will increase cache hit rate from server access.

Figure: Response to the server when adding secondary cache



1.3 Usage of flash

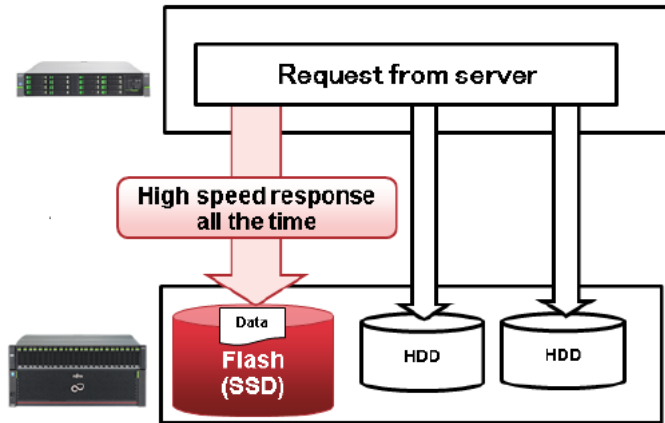
Flash is a nonvolatile memory and popular as a high speed response time memory medium.

There are three kinds of usage of flash on ETERNUS DX series.

1.3.1 Used as fixed volume

When a specific data requires high speed access always, flash is used as a fixed volume.

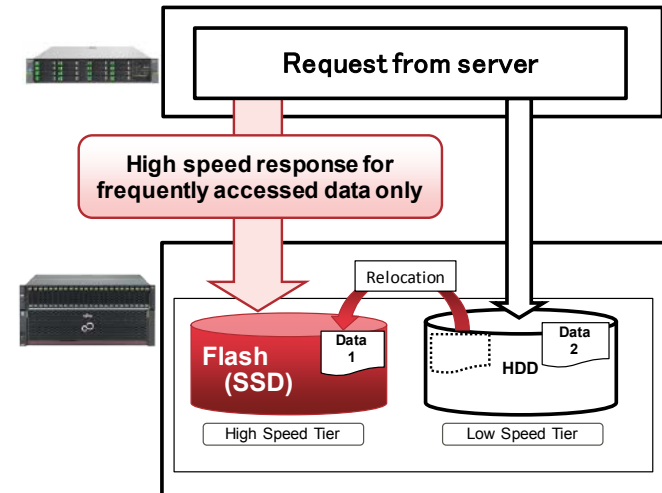
Figure: Configure flash as a fixed volume



1.3.2 Used as automatic storage tiering volume

When frequently accessed data requires high speed access, flash is used as automatic storage tiering volume.

Figure: Configure flash as automatic storage tiering volume



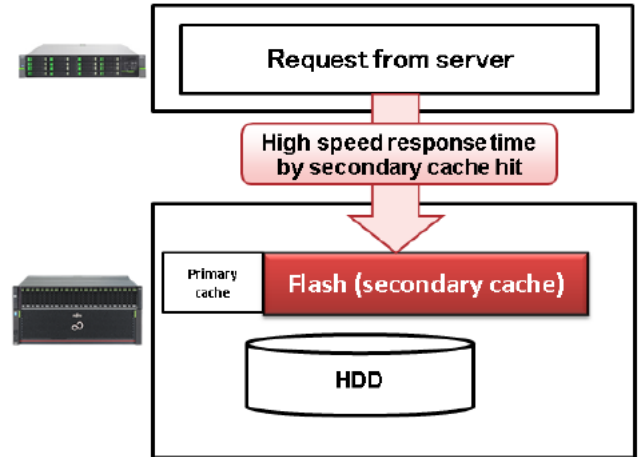
High Speed Tier: Frequently accessed data

Low Speed Tier: Less frequently accessed data

1.3.3 Used as cache

Flash is used as cache to increase cache hit ratio. This flash effect covers entire disk storage system.

Figure: Used as cache



2. Extreme Cache and Extreme Cache Pool

Secondary caches of ETERNUS DX series are Extreme Cache and Extreme Cache Pool.

2.1 Extreme Cache used by mid range and enterprise models

Secondary cache equipped on ETERNUS DX series mid range models and enterprise models is Extreme Cache.

- Capacity of Extreme Cache

It extends cache capacity of disk storage 100 times at maximum.

Table: Cache capacity of mid range and enterprise models

Model	ETERNUS DX500 S4	ETERNUS DX600 S4	ETERNUS DX8900 S3	ETERNUS DX8900 S4
Max. primary cache	128GB	256GB	6,144GB	18.4TB
Max. secondary cache (Extreme Cache)	5.6TB	5.6TB	67.2TB	307.2TB

- Extreme Cache composition and installation place
Extreme Cache uses PCIe Flash Module (hereinafter PFM). PFM is a PCIe card with flash (SSD). Because of low latency PCIe connection, its response time is fast.

PFM is installed in controller enclosure.
Hot expansion is possible at later time.

Figure: Extreme Cache installation place (mid range model)

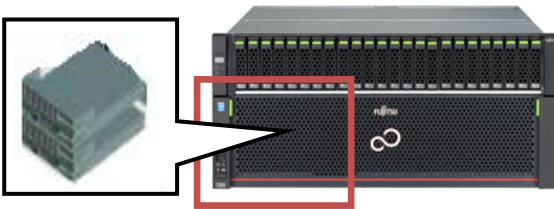
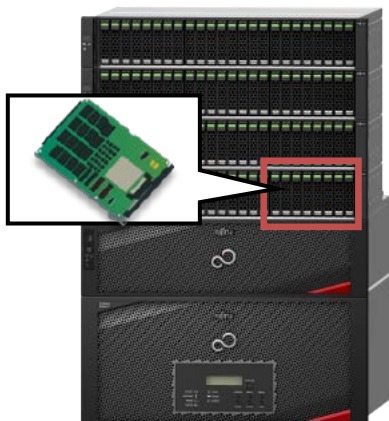


Figure: Extreme Cache installation place (enterprise model)



- Capacity of Extreme Cache

Please select Extreme Cache capacity based on business capacity and data access kind.

Table: Required Extreme Cache capacity

Business capacity	2ndary cache (PFM) capacity
Up to 20TB	1.4TB
Over 20TB	2.8TB
Over 40TB	4.2TB
Over 60TB	5.6TB

2.2 Extreme Cache Pool used by entry models

Secondary cache equipped on ETERNUS DX series entry models is Extreme Cache Pool.

- Capacity of Extreme Cache Pool

It extends cache capacity of disk storage 100 times at maximum.

Table: Cache capacity of entry models

Models	ETERNUS DX60 S4	ETERNUS DX100 S4	ETERNUS DX200 S4
Max. primary cache	8GB	32GB	64GB
Max. secondary cache (Extreme Cache Pool)	None	800GB	800GB

- Extreme Cache Pool composition and installation place
Extreme Cache Pool uses Flash (SSD) placed on drive slot as cache.

Flash (SSD) uses 2 slots on the controller enclosure. Hot expansion is possible during operation.

Figure: Extreme Cache Pool installation place



*Extreme Cache Pool can be used on mid range models,
But we recommend to use Extreme Cache on mid range models.

- Capacity of Extreme Cache Pool

Please add 2 flashes (SSDs) on empty slots.

Model	2ndary cache capacity
ETERNUS DX100 S4	800GB (400GB SSD: x 2)
ETERNUS DX200 S4	

2.3 Eligible work for Extreme Cache / Extreme Cache Pool

Extreme Cache and Extreme Cache Pool is suitable for vast amount of work requiring quick response.

■ System consolidating multiple works

Below we show an example system consolidating system A and system B.

System A: Online centric quick processing work.
(assuming Web handling such as web screen service at web terminal)

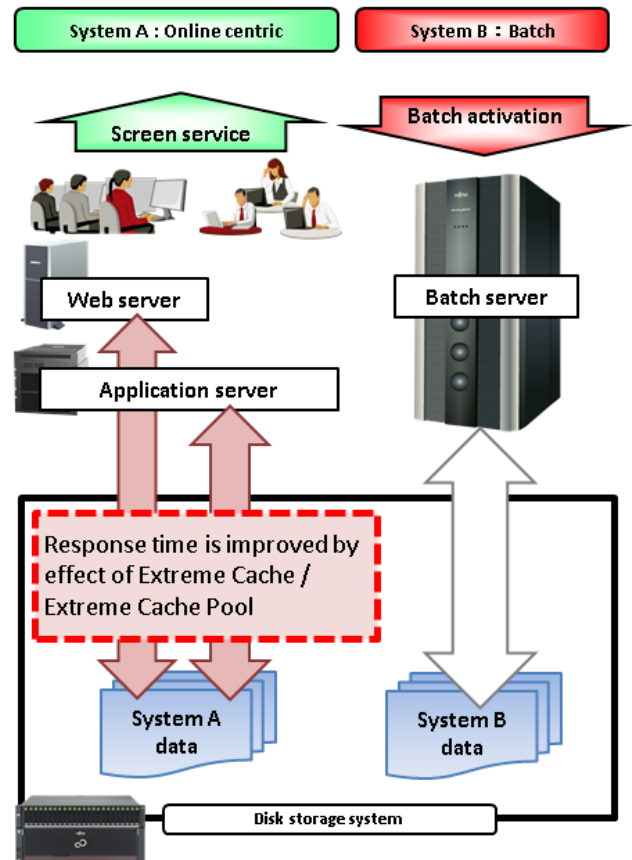
- System characteristics.
Terminal user is sensitive to response and many screens are serviced.
Data access is very frequent, but data amount of each one screen service is small.
- I/O access characteristics
The number of access is very large, most of them are random access.
Data length of each access is short.

System B: Batch centric vast amount data processing.
(CSV file generation batch process)

- System characteristics
Batch initiation may be at middle of online work.
Repeat process of adding master data to all the records of source file many times.
- I/O access characteristics
Source file access is vast amount of sequential read.
The number of access is relatively small.
Data length of each access is long.

System B's I/O access tends to have strong locality and requires high throughput, whereas system A's I/O access is even very sparse but still requires high speed response time.
Introduction of Extreme Cache/Extreme Cache Pool improves system A's response time.

Figure: System example consolidating multiple work



2.4 Setting of Extreme Cache and Extreme Cache Pool

Both Extreme Cache and Extreme Cache Pool can be available by setting "Extreme Cache setting" and "Capacity setting" from ETERNUS Web GUI.

■ Extreme Cache settings

Select Extreme Cache or Extreme Cache Pool, as secondary cached to be used.

■ Memory Size Settings

According to installed PFM or flash, specify capacity used as secondary cache. Usually specify all the capacity.

*Extreme Cache Pool is maximum 400GB per CM.

You can modify Tuning Parameters, but usually it is not necessary. But if write exceeds 50% on read/write ratio, then set Monitoring I/O parameter to "Read/Write".

■ Tuning Parameter Settings

- Initial Caching Threshold (Default value:1)

- Caching Threshold (Default value:5)

This is a threshold value which is related frequency of data storing to Extreme Cache/Extreme Cache Pool.

- "Not relocate Cache Data" check box

Once Extreme Cache/Extreme Cache Pool is full, then no more new data is stored (relocated).

- Monitoring I/O

Read : Hold blocks used as Read operation only.

Read/Write: Hold blocks used as Write operation also.

Figure: ETERNUS Web GUI "Setup Extreme Cache" screen

Setup Extreme Cache

▼ Information
Please enter the settings of Extreme Cache.

▼ Extreme Cache Settings
Cache Used: Extreme Cache Extreme Cache Pool Not Used

▼ Extreme Cache Pool Memory Size Settings

CM	Memory Size	Encryption by CM
CM#0	400 GB	Off
CM#1	400 GB	Off

▼ Tuning Parameter Settings

Initial Caching Threshold: 1 (1 - 16)

Caching Threshold: 5 (1 - 16) Not relocate Cache Data

Monitoring I/O: Read Read / Write

3. Verification of vast amount of data process

Verify our assumption "2.3 Eligible work for Extreme Cache / Extreme Cache Pool".

3.1 Verification purpose

The following two verifications are targeted.

- Verify effectiveness of Extreme Cache by comparing process times and response times between before and after installation.
- Verify effectiveness of Extreme Cache Pool by comparing process times and response times between before and after installation.

3.2 Assumption

Assuming the following two systems are working.

- System A:
 - Picking process of warehouse management and banking withdrawal process (heavy random read access).
 - This process requires some fixed response time because they are processed all the time.
- System B:
 - Reading master data at DWH. (many sequential read accesses)
 - Work of which load is high, so it will degrade response time of system A temporarily.

3.3 Verification test

System A is assumed online process and system B is assumed batch process, those 2 kinds of processes are executed for verification.

■ Verification system

- System A (online process)
 - Data is allocated on disk storage system for random read access.
 - Execute PowerSORT to process data (data merge).
 - This process is done on vast amount of data of which data access is more than 100,000 files (125,000 files).
- System B (Batch process)
 - Data is allocated on disk storage system for sequential read access.
 - Execute PowerSORT to process data (data merge).
 - This process is done on vast amount of data of which data access is more than 800,000 files (875,000files).

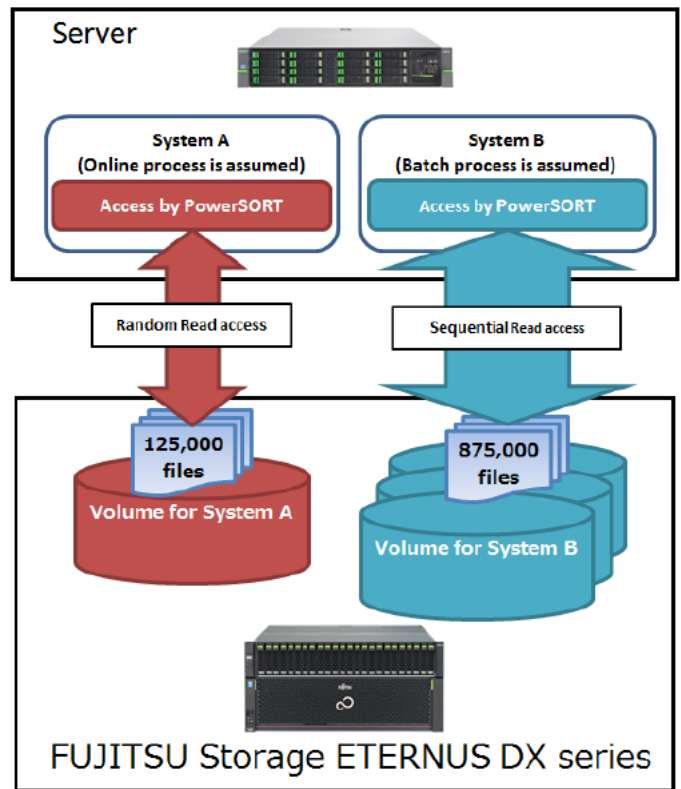
■ Verification pattern

The following verification patterns are tested.

- Verification 1-1: Before installing Extreme Cache
- Verification 1-2: After installing Extreme Cache
- Verification 2-1: Before installing Extreme Cache Pool
- Verification 2-2: After installing Extreme Cache Pool

Same verification model is used for all the verifications before/after installing Extreme Cache/Extreme Cache Pool.

Figure: Secondary cache verification model



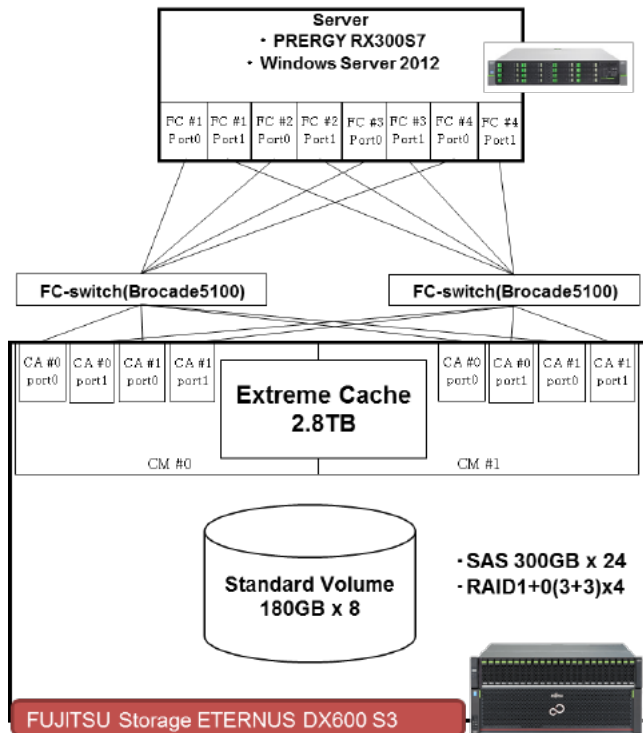
3.4 Expected result

- Before installing Extreme Cache / Extreme Cache Pool
 - Primary cache will be exhausted by system B access, so no cache hit operation will occur for system A access resulting degraded response time due to hard disk access.
- After installing Extreme Cache/Extreme Cache Pool
 - By installing Extreme Cache/Extreme Cache Pool, system A access can be handled as cache hit operation because cache capacity will be vastly expanded, so response time of system A will be greatly improved.

3.5 Verification environment

Below is the system configuration and used components of verification system including both online operation and batch operation together.

■ System configuration for Extreme Cache verification



■ System configuration for Extreme Cache Pool verification

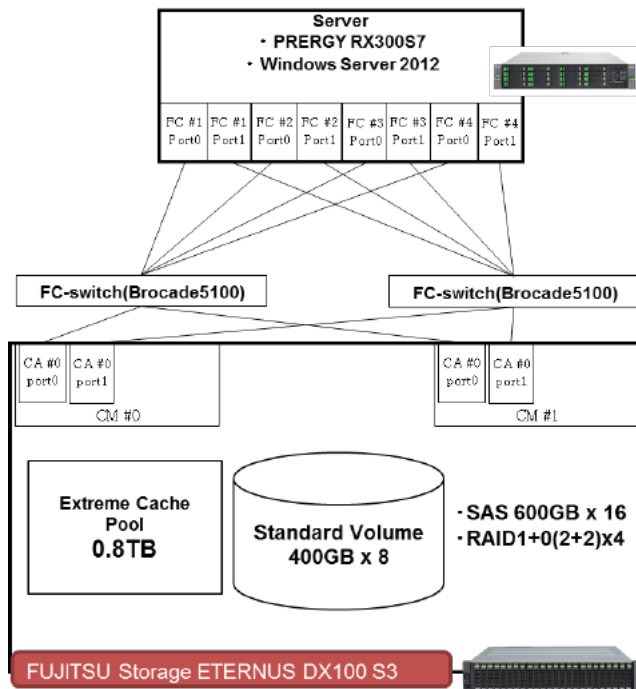


Table: Used component

Server	Model	PRIMERGY RX300 S7 x1
	HBA	8GB Port x 8
	OS	Microsoft Windows Server 2012
	Application	PowerSORT Server V7.0.0
Disk storage system	Model	ETERNUS DX 600 S3
	CA Port	8GB/s x8
	Primary cache	32GB
	2ndary cache	Extreme Cache 2.8TB
	HDD	300GB SAS(10.000rpm)×24 * (RAID1+0(3+3)×4)
FC-Switch	Model	Brocade 5100

Table: Used component

Server	Model	PRIMERGY RX300 S7 x1
	HBA	8GB Port x 8
	OS	Microsoft Windows Server 2012
	Application	PowerSORT Server V7.0.0
Disk storage system	Model	ETERNUS DX 100 S3
	CA Port	8GB/s x4
	Primary cache	8GB
	2ndary cache	Extreme Cache Pool 800GB
	HDD	600GB SAS(10.000rpm)×16 * (RAID1+0(2+2)×4)
FC-Switch	Model	Brocade 5100

3.6 Verification result

3.6.1 Extreme Cache verification result

■ Process time and response time comparison
Data processing time and volume access response time before/after Extreme Cache installation.

Table: Data processing time and response time before Extreme Cache installation

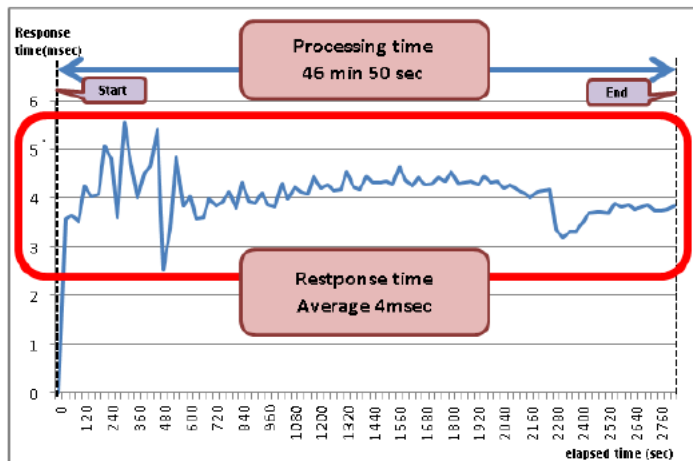


Table: Comparison before/after Extreme Cache installation

	Before	After	Effect
Processing time	2810sec (46:50)	2092sec (34:52)	25% reduction
Average response time	4msec	0.2msec	Improved to 1/20

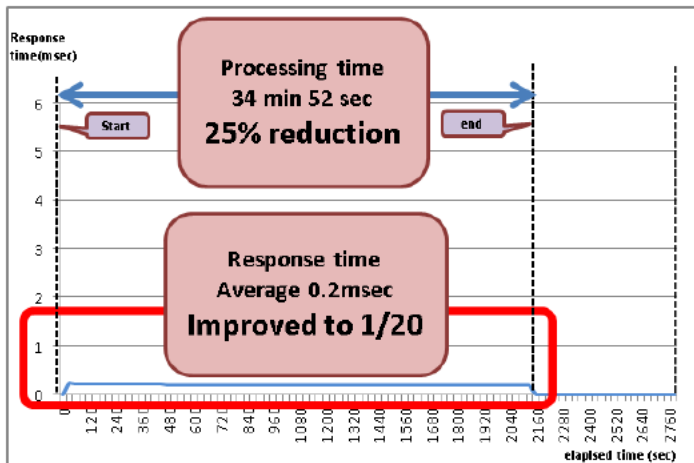
■ Disk busy ratio comparison
Compare target volume disk busy ratio (ratio of busy when disk is accessed).

Table: Disk busy ratio

Verification case	Disk Busy(%)
Verification 1-1 (Before Extreme Cache installation)	Over 90 to 100%
Verification 1-2 (After Extreme Cache installation)	Under 5 to 10%

The time used for disk access is greatly reduced, so it proves that disk bottleneck is solved.

Table: Data processing time and response time after Extreme Cache installation



3.6.2 Extreme Cache Pool verification result

■ Process time and response time comparison
Data processing time and volume access response time before/after Extreme Cache Pool installation.

Table: Data processing time and response time before Extreme Cache Pool installation

Table: Comparison before/after Extreme Cache Pool installation

	Before	After	Effect
Processing time	3282sec (54:42)	2375sec (39:35)	28% reduction
Average response time	5.8msec	0.4msec	Improved to 1/15

- Disk busy ratio comparison
- Compare target volume disk busy ratio (ratio of busy when disk is accessed).

Table: Disk busy ratio

Verification case	Disk Busy(%)
Verification 2-1 (Before Extreme Cache Pool installation)	Over 85 to 90%
Verification 2-2 (After Extreme Cache Pool installation)	Under 10 to 15%

The time used for disk access is greatly reduced, so it proves that disk bottleneck is solved.

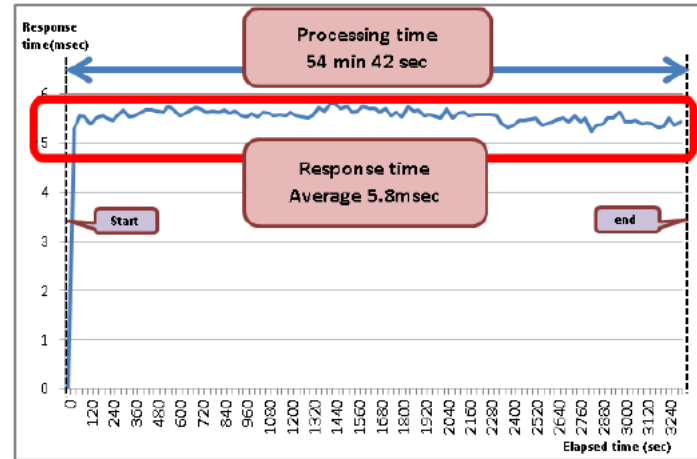
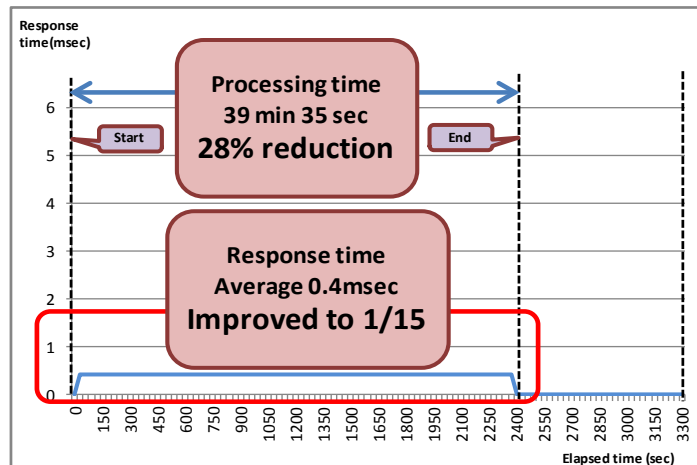


Table: Data processing time and response time after Extreme Cache Pool installation



4. Conclusion

From this verification, we can confirm that Extreme Cache/Extreme Cache Pool can improve online response time to achieve over 25% reduction of processing hour.

Average response time becomes under 1/20 by Extreme Cache, and under 1/15 by Extreme Cache Pool, so drastic response time improvement is recognized.

From those facts, at vast amount of file access environment, Extreme Cache/Extreme Cache Pool is a very effective device to improve response time of online processing.

Manner of data utilization becomes diverse by entering rapid cloud and big data age, so the high storage performance is expected.

Extreme Cache/Extreme Cache Pool of FUJITSU Storage ETERNUS DX series is most suitable for high speed vast data processing.

Contact

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Website: <http://www.fujitsu.com/eternus/>

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