# White Paper
# Features and Benefits of Fujitsu All-Flash Arrays for Virtualization and Consolidation
## ETERNUS AF S3/S2 series

Fujitsu All-Flash Arrays are extremely effective tools when virtualization is used for server consolidation. The ability to flexibly set the Deduplication/Compression function based on the purpose enables operations best suited for server usage.

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## Preface

In recent years, companies have experienced rapid growth in the quantity of business data, as typified by the term “big data,” and this in turn has created a need for high-speed system processing.
Unfortunately, the very high running costs associated with using additional servers to cope with this demand has made the question of how best to use virtualization to consolidate servers a key consideration. Processing increased quantities of data at high speed and the reduction of IT costs are urgent issues for corporate systems.
Accordingly, this white paper introduces how Fujitsu All-Flash Arrays provide the flexibility to fit in with operating practices while the performance is still maintained.

The product lineup and product information stated in this document are current as of November 2019.

■ Target Readers
This white paper targets readers who are engaged in the planning, design, and management of virtualization systems that use VMware solutions. This white paper also targets Fujitsu customers, partners, and service staff who are considering the installation of virtualization systems that use VMware solutions.
The white paper describes the distinctive functions of Fujitsu All-Flash Arrays in the context of using virtualization for server consolidation. It also explains the benefits of the FUJITSU Storage ETERNUS AF S3/S2 series to readers interested in Fujitsu All-Flash Arrays or in virtualization and consolidation.

■ Naming Conventions
The following abbreviations are used in this document.

- FUJITSU Storage ETERNUS AF150 S3 ····· ETERNUS AF150 S3
- FUJITSU Storage ETERNUS AF250 S3 ····· ETERNUS AF250 S3
- FUJITSU Storage ETERNUS AF650 S3 ····· ETERNUS AF650 S3
- FUJITSU Storage ETERNUS AF S3/S2 series ····· ETERNUS AF S3/S2 series
- Solid State Drive ····· SSD
- Hard Disk Drive ····· HDD

# 1. All-Flash Arrays and Issues with Using Existing Storage for Virtualization and Consolidation

Progress in the technology of virtualization has led to its use for both servers and clients in numerous systems. Meanwhile, increases in the number of CPU cores and memory capacity in the servers used as virtualization platforms have made it commonplace to host a large number of virtual systems on a small amount of hardware. The advantages of using virtualization to consolidate systems or subsystems include reducing the amount of hardware, making good use of resources, and cutting operation and maintenance costs, space requirements, and power consumption. While companies can enjoy maximum benefits by consolidating large numbers of systems, storage systems that use conventional HDDs pose a number of problems that can make virtualization and consolidation difficult to achieve.

The arrival of the all-flash array represents the next-generation storage system that provides unparalleled performance through the use of SSDs. Unfortunately, their high price and lack of storage capacity have limited their use to specialist applications such as scientific computation and analytical databases that need high-performance storage systems. However, the falling price and growing capacity of SSDs in recent years together with the use of techniques such as the Deduplication/Compression function are opening up the potential for using all-flash arrays in general-purpose applications, especially in virtual environments.

This chapter describes the problems with using existing storage systems for virtualization and consolidation, and how the use of all-flash arrays can resolve these problems and deliver benefits.

## 1.1. Problems with Existing Storage Systems

■ Performance limit for magnetic disks

Because I/Os on storage systems that use conventional HDDs depends on physical access to the magnetic disk, they are inevitably constrained by the speed of disk rotation and lose time due to head seek movement. Performance suffers most notably when asked to perform multiple random accesses. In recent years, the amount of data that systems must deal with has been increasing due to the advancement of BI by using big data. Accordingly, the increased data density of magnetic disks have improved the HDD storage capacity. However disk speeds have not increased. Typically, their performance falls off significantly beyond a mean response time of 20ms at 1000 IOPs (RAID1+0) or 750 IOPs (RAID5) per RAID group. Performance is hard to ensure for the increasing data in the existing storage systems.

■ Problems when using virtualization for system consolidation

The use of virtualization for consolidation requires that the volumes used by a number of virtual servers and virtual clients (VDI) be combined in the same high-capacity storage system. This affects the storage system in the following ways.

• Increased access concurrency to the same disk

To achieve the cost-benefits of using virtualization for consolidation, high-capacity HDDs must be used for disk consolidation. This significantly degrades response time because it results in concurrent accesses to the same disk occurring more frequently. In particular, the performance cannot be ensured when disks are pooled in a virtual file system due to the difficulty of estimating the concurrency and the proportion of random and sequential accesses to a specific disk.

• Increase in storage system load

The use of virtualization for consolidation increases the load of storage systems. The storage system needs to provide sufficient processing ability to handle the total IOPs of the consolidated virtual systems.

## 1.2. Benefits of All-Flash Arrays

■ Fast response and high IOPs performance

A feature of the SSDs used in all-flash arrays is that, because the data is stored on NAND flash memory, their speed of response is not constrained by physical restrictions. The 0.5ms mean response time for SSDs is more than 40 times faster than the 20ms mean response of the HDDs used in conventional disk storage systems, and their IOPs performance is approximately 100 times better. In particular, because random access does not cause performance degradation in SSDs, they can operate at high loads (deliver a high level of IOPs performance) without compromising response times.

■ Benefits of using virtualization for consolidation

SSDs maintain fast response even when specific drives are subject to high loads which is one of the consequences of consolidation. This makes it particularly valuable on systems that tend to have high I/O concurrency, such as systems with a large number of VDIs. Using all-flash arrays for consolidated virtual systems such as databases, file servers, and business servers can provide more reliable response times and other performance improvements.

■ ETERNUS AF S3/S2 series, an ideal choice for virtualization and consolidation

The ETERNUS AF S3/S2 series, which is a part of Fujitsu's all-flash arrays, is an SSD storage system with functions and hardware that have been purpose-designed to make the most of the SSD performance. Their functions include the use of 4K-aligned access for more efficient SSD access and longer life, optimization of I/O access for garbage collection (a cause of access performance degradation), and a flexible write-through function for better write performance.

The ETERNUS AF S3/S2 series is designed to work with various virtualization platforms and their associated storage functions. Use of the ETERNUS AF S3/S2 series helps overcome the problems associated with virtualization and consolidation.

• Class-leading performance for an all-flash array

The SSDs best suited for random access with class-leading all-flash array performance provide unparalleled performance even when virtualization and consolidation increase concurrent access to each drive.

• High-performance hardware and software technology

High performance CPUs are installed and multi-processing technology is adopted to maintain response performance even under heavy loads that occur with virtualization and consolidation.

The ETERNUS AF S3/S2 series also includes the volume-level Deduplication/Compression function unique to Fujitsu and the Quality of Service (QoS) automation function that enable storage consolidation for systems that require storage capacity and for those that require high performance. In particular, the controller performance and SSD capacity of the ETERNUS AF650 S3 are among the highest in its mid-range class, making it a high-performance all-flash array that is suitable for the integration of multiple virtual systems and for VDI platforms that support large numbers of clients.

The ETERNUS AF S3/S2 series also supports the many operational and administrative functions of Storage Foundation Software ETERNUS SF. Utilizing ETERNUS SF can improve business continuity in consolidated virtual environments.

# 2. Configurations for System Consolidation Using Virtualization

This chapter describes the configurations targeted for consolidation using virtualization and configurations used after the ETERNUS AF650 S3 is installed as the storage system.

## 2.1. Configurations Targeted for Consolidation Using Virtualization

Typical systems consist of servers and connected storage systems according to the use.
Configurations vary widely depending on the business, as does the use of the storage system. In those configurations, drives might be shared by multiple servers, clustering might be used, or servers might not have external drives.
Application-specific server operating configurations may require the addition of servers for specific purposes or the expansion of extra storage capacity.
The operational benefits of this approach include simplifying business-based maintenance and managing performance and backups.

Figure 1 shows an example system configuration prior to server consolidation using virtualization.

- Business
  The system has a separate storage system for each business with a varying quantity of connected servers.
- Database
  Clustering is used with dedicated servers for reasons of performance and reliability.
  The configuration operates with multiple database systems.
- Virtual client
  The configuration allows the number of servers and storage capacity to be increased in accordance with the number of users.
- File server
  Rather than a storage system, the configuration only uses a RAID with internal drives.

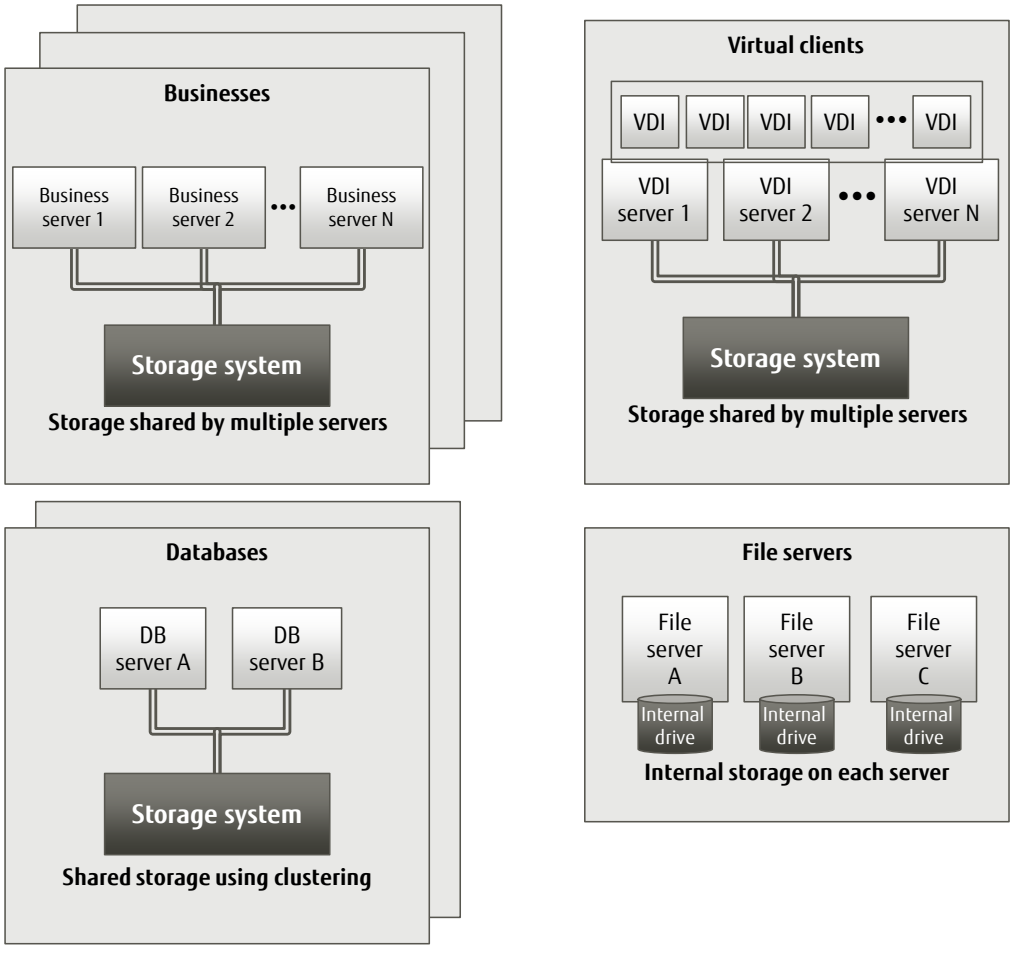


Figure 1 Example system configuration prior to server consolidation using virtualization

## 2.2. System Configuration after Server Consolidation Using Virtualization

Figure 2 shows an example system configuration after server consolidation using virtualization.
Virtualize all the business servers, DB servers, file servers, and VDI environments to consolidate them using the ETERNUS AF650 S3. The virtual servers are not aware which physical server is to be used.

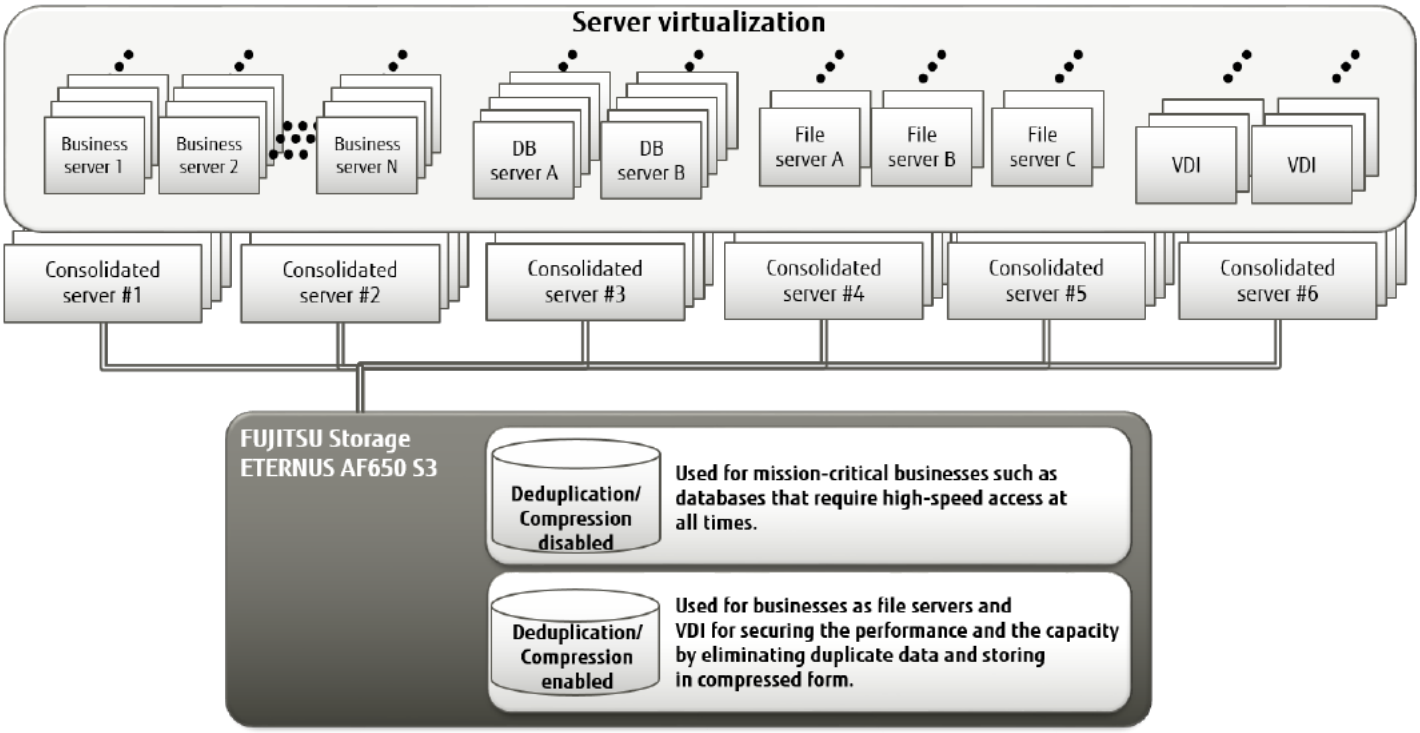


Figure 2 Example system configuration after server consolidation using virtualization

Consider the following points when consolidating servers using virtualization.
- Processing ability
- Drive capacity
- Backups

■ Processing ability
Consolidating all storage systems in a single storage system may degrade the performance by turning I/Os into a bottleneck.
Using an all-flash array as a storage system provides sufficient performance even when data is heavily accessed from the servers.
To achieve equivalent performance from a conventional HDD configuration, a very large number of HDDs are required.

■ Drive capacity
While there may have been no need to pay close attention to drive capacity in past systems where a storage system was provided on business-by-business basis, storage capacity does become a consideration when systems are consolidated using virtualization.
Some of the SSDs installed in the ETERNUS AF S3/S2 series have a capacity of approximately 30.72TB, which is comparable to that of conventional HDDs.
The Deduplication/Compression function offers more efficient use of the SSD capacity.

■ Backups
Although business-based backups were available in the past, virtualization restricts how backups are performed.
Virtualization platform functions and storage system functions can be used to back up virtualized areas. The ETERNUS AF S3/S2 series supports backups of virtual environments using Storage Foundation Software ETERNUS SF. For details about the functions of the virtualization platform and Storage Foundation Software ETERNUS SF that the ETERNUS AF S3/S2 series supports, refer to "3.5 Improvements in Operational Efficiency and Business Continuity".

## 3. Use of the ETERNUS AF S3 series with Virtualization and Consolidation

This chapter explains how the ETERNUS AF S3 series can be used when virtualization is used for consolidation.
The following summarizes the basic specifications and functions of the ETERNUS AF S3 series.

- ETERNUS AF650 S3 hardware specifications
  Number of CPU cores: 12
  Number of controllers: 2
  System memory: 768GB, 1,536GB
  Maximum number of drive enclosures: 0 - 43
  Number of drives: 2 – 1,056
  Maximum physical capacity*1: 32,440TB
  Interface: FC 32Gbit/s, FC 16Gbit/s, iSCSI 10Gbit/s

Figure 3 ETERNUS AF650 S3

- ETERNUS AF250 S3 hardware specifications
  Number of CPU cores: 8
  Number of controllers: 2
  System memory: 128GB
  Number of drive enclosures: 0 - 10
  Number of drives: 2 – 246
  Maximum physical capacity*1: 8,110TB
  Interface: FC 32Gbit/s, FC 16Gbit/s, iSCSI 10Gbit/s

Figure 4 ETERNUS AF250 S3

- ETERNUS AF150 S3 hardware specifications
  Number of CPU cores: 4
  Number of controllers: 2
  System memory: 32GB
  Number of drive enclosures: Not supported
  Number of drives: 2 – 24
  Maximum physical capacity*1: 92TB
  Interface: FC 32Gbit/s, FC 16Gbit/s, iSCSI 10Gbit/s

Figure 5 ETERNUS AF150 S3

*1: Physical capacity calculated on basis of 1TB = 1,000GB, 1GB = 1,000MB

- Deduplication/Compression function
  The ETERNUS AF S3 series performs Deduplication/Compression using the installed Storage Acceleration Engine.
  Write data from the servers is separated in the system memory.
  Deduplicated data separated in the system memory is eliminated and the remaining data is compressed using the Storage Acceleration Engine.
  The data in the system memory (now reduced in size) is written to a dedicated volume as a background process.
  The ETERNUS AF150 S3 does not support the Deduplication/Compression function.
  - Reduces the required number of drives by using the SSD capacity more efficiently.
  - Extends the SSD life by minimizing the amount of data written to the SSD.

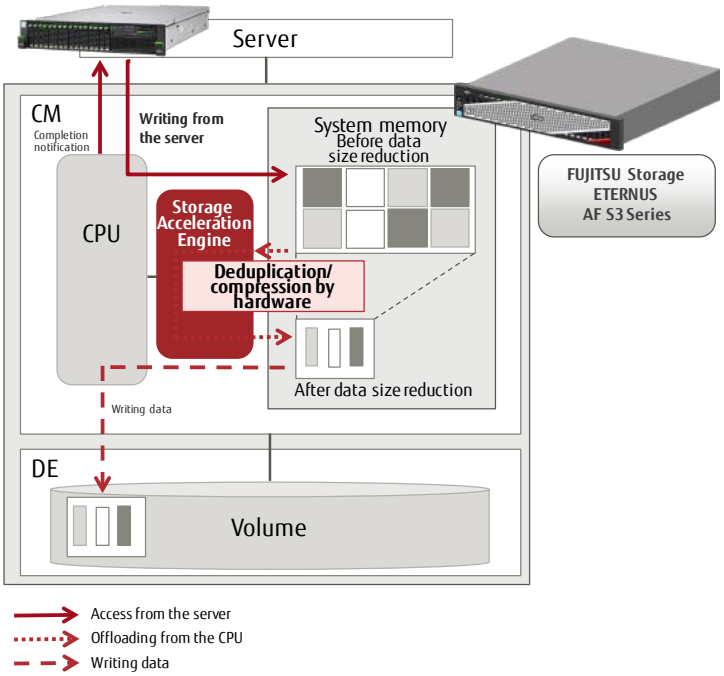


Figure 6 Deduplication/Compression operation

■ Quality of Service (QoS) automation function *1
This function maintains reliable system operation by automatically adjusting the response based on business priority.
The following target settings can be specified.
- Priorities for QoS automation
- Target response times

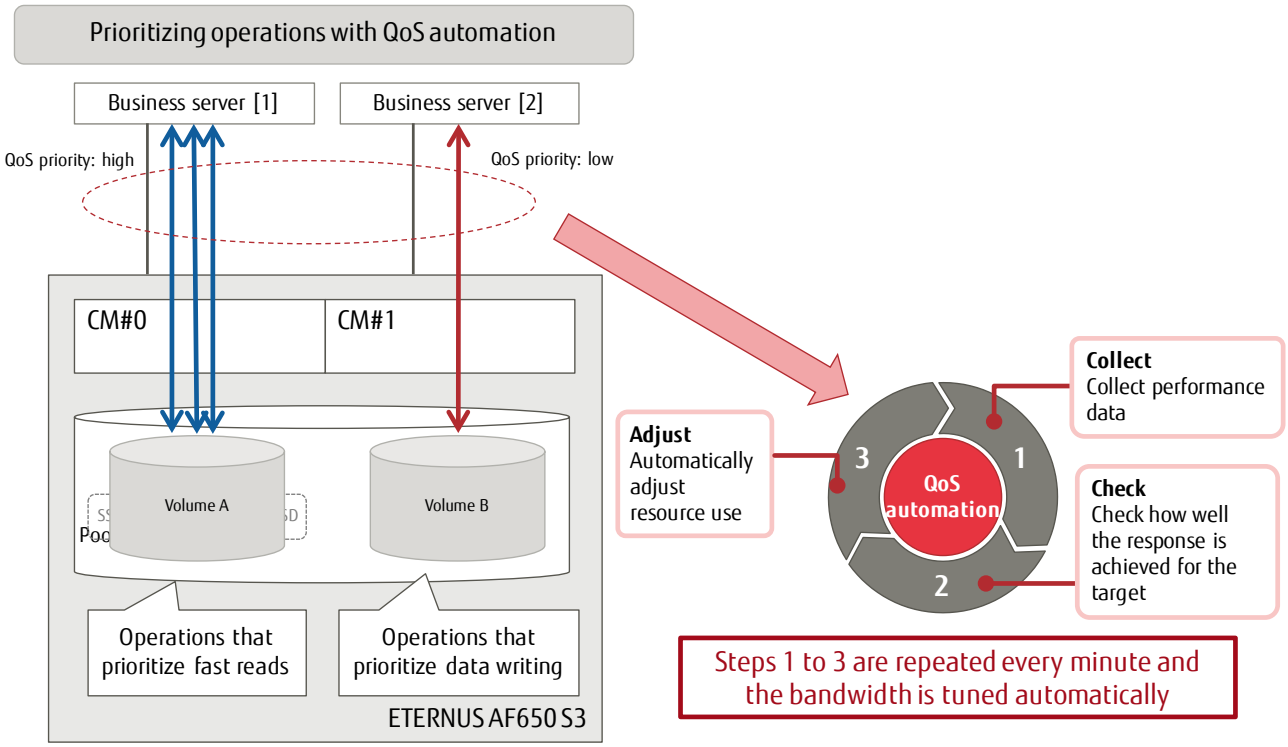


Figure 7 QoS automation operation

*1: The ETERNUS SF Storage Cruiser QoS Management option is required to use this function.
The function is available on volumes that do not use the Deduplication/Compression function.

## 3.1. Virtualization of Servers and Consolidation of Storage

By prioritizing the physical server specifications, business operations can become difficult when servers are virtualized. Consolidation using server virtualization can be achieved with a high level of efficiency if the IOPs of the servers is within the storage system and RAID performance capabilities. For HDD storage systems, the concept of random and sequential access must be considered and the servers to be consolidated must be dealt with according to their relative proportions. In contrast, no such consideration is required in the case of all-flash arrays, because it is possible to calculate how many servers can be combined simply by adding up their IOPs.
For systems where a server consolidation has been restricted by the RAID performance, using the all-flash array enables consolidation of the storage systems while virtualization reduces the number of servers. The ETERNUS AF S3/S2 series can provide a platform for reliable operation of the consolidated configuration by using the QoS automation function to coordinate resource allocation to virtual servers automatically.

## 3.2. Performance of the ETERNUS AF S3/S2 series for Server Virtualization and Consolidation

Consolidating a large number of servers using virtualization results in the heavy concentration of storage accesses. Conventional HDD storage systems use a large number of HDDs and distribute RAID groups to ensure performance. In contrast, the ETERNUS AF S3/S2 series described in this white paper is an all-flash array that uses SSDs and can maintain fast response even when many servers access a single RAID group simultaneously.

For server virtualization and consolidation, the performance requirement of a disk storage system is determined by adding up the IOPs of each server. The required IOPs rises in proportion to the number of servers.

Performance requirement (IOPs) of disk storage system = [business server A IOPs] + [business server B IOPs] + •••
(Total IOPs for the number of servers to be consolidated)

For conventional HDDs, IOPs per RAID group is important for determining the response performance. Because the response performance of SSDs is largely unaffected by increases in IOPs, the number of consolidated servers has a minimal effect. Extremely fast response performance is maintained even if the servers to be consolidated are added up to the performance limit of the storage system.

The following section describes the differences between conventional HDD storage systems and the ETERNUS AF S3/S2 series in terms of the number of servers that can be consolidated.

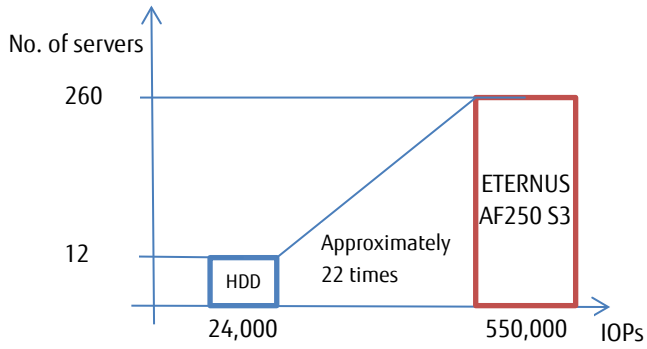


Figure 8 Comparison of the number of consolidated servers using the HDD storage system and the ETERNUS AF250 S3

Assuming 2,000 IOPs (8KB Read:Write=3:1) per server, one ETERNUS AF250 S3*1 can be used to consolidate approximately 22 times as many servers as an HDD configuration. The same level of response performance as the HDD configuration can be maintained even as servers are added.

*1: ETERNUS AF250 S3 (8 paths, 4 CAs, 2 CMs, 10 RAID1 groups configuration) with a response performance of 0.5ms or less

## 3.3. Combining Performance with Storage Efficiency through Appropriate Use of the Deduplication/Compression Function

For the ETERNUS AF S3/S2 series, whether the Deduplication/Compression function is performed can be specified for each volume.
For example, use volumes with the Deduplication/Compression function disabled for business server data areas that require fast access speed, and enabled for business server system areas that require storage efficiency.
The same storage system can provide both performance and storage efficiency.

### 3.4. Cost Reduction through Low-Cost SSDs and Efficient Use

The ETERNUS AF S3/S2 series supports Value SSDs[*1] with excellent cost efficiency for enterprise applications. The price per capacity of these Value SSDs has fallen to around 1.6 to 4 times that of HDDs. Although the upper limit for writing times is lower than that of conventional SSDs, Value SSDs can still be adequate for system consolidation (virtualization) by using the Deduplication/Compression function to reduce the number of writing times.
Furthermore, given their performance superiority over HDDs, Value SSDs are suitable for RAID5 or RAID6 configurations designed for storage efficiency. The cost can be minimized by combining Value SSDs with a reduction in capacity achieved by using an efficient RAID configuration and a reduction in data size achieved by using the Deduplication/Compression function.

Figure 9 shows the assumed reduction in capacity achieved by replacing the 600GB SAS disks in a RAID1+0 configuration with 1.92TB Value SSDs in a RAID5 configuration and by reducing the data size with the Deduplication/Compression function.

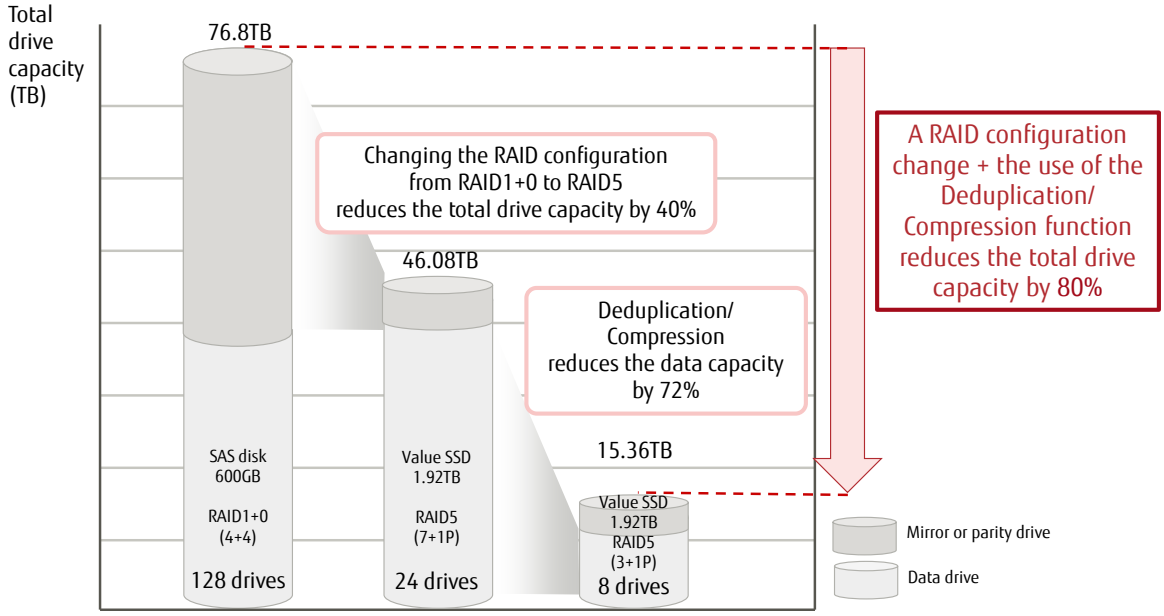


Figure 9 Capacity reduction by changing the RAID configuration and by using the Deduplication/Compression function

Because SAS disks (600GB/15krpm) with RAID1+0 (4+4) use disk mirroring, only half of the total drive capacity is available for data disks. Accordingly, the total drive capacity is 0.6TB × 128 drives = 76.8TB, and the data disk capacity is 76.8TB / 2 = 38.4TB.

If Value SSDs (1.92TB) are used for the 38.4TB data capacity, 38.4TB / 1.92TB = 20 drives are required. Therefore, the RAID5 configuration requires only 24 drives ([7+1P] × 3).
The total drive capacity of 1.92TB × 24 drives = 46.08TB corresponds to a 40% reduction compared to the RAID1+0 SAS disks.

The following shows the effect by an average 72%[*2] reduction in data size that is achieved by using the Deduplication/Compression function. As the required data drive capacity is 38.4TB × 0.28 = 9.98TB, a RAID5 configuration can be achieved with only eight ([3+1P] × 2) Value SSDs (1.92TB).
The total drive capacity of 1.92TB × 8 drives = 15.36TB corresponds to an 80% reduction compared to the 24TB of SAS disks.

The cost can be determined using the total drive capacity and the unit price of capacity for each drive. Value SSDs cost roughly twice as much as SAS disks (600GB/15krpm) per unit of capacity. Figure 10 shows how a reduction in the capacity, which is achieved by adopting the RAID configuration and the Deduplication/Compression function shown in Figure 9, can have an effect on the cost when Value SSDs are used.

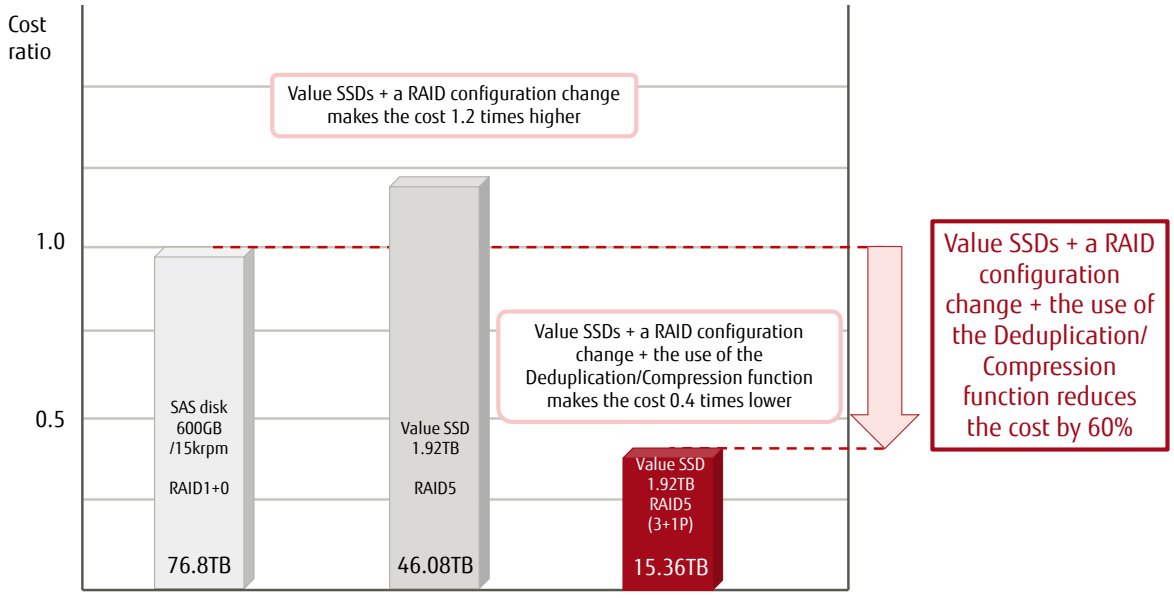


Figure 10 Effect on the cost of using Value SSDs

The drive cost of using Value SSDs (1.92TB) relative to 76.8TB of SAS disks can be calculated as follows.
The cost of the total Value SSD capacity of 40.08TB that is needed after the RAID configuration is changed is (46.08TB × 2) / 76.8TB = 1.2 times that of the SAS disks.

Similarly, the cost of the total Value SSD capacity of 15.36TB that is needed when both the new RAID configuration and the Deduplication/Compression function are used is (15.36TB × 2) / 76.8TB = 0.4 times that of the SAS disks. In other words, the drive cost is 60% less than that of installing SAS disks.

This reduction in the drive cost provided by using Value SSDs with the Deduplication/Compression function delivers significant benefits when large capacity is required for system consolidation using virtualization.
When the performance improvement is taken into account, the ETERNUS AF S3/S2 series also represents a good return on investment relative to existing storage systems even when the Deduplication/Compression function is not used, in which case the cost is still only slightly higher than for SAS disks.

*1: High-capacity SSDs with a low upper limit for the writing frequency. Models are available with a guaranteed lifespan of 5 years based on a drive write per day (DWPD) of between one and three times. (DWPD indicates the maximum number of times the entire drive capacity can be overwritten per day.)
*2: Estimated value for the case when the Deduplication/Compression function is used on a volume that contains a VDI system drive created by full cloning.

The following compares the cost per IOPs performance between SSDs and HDDs.
The IOPs performance of SSDs is approximately 100 times better than HDDs. For example, when HDDs are used for a system that requires a total of 100,000 IOPs in the consolidated virtual environment, 100 RAID groups must be configured. However, 100,000 IOPs can be achieved with just a single RAID group when SSDs are used.
Even after the price difference between Value SSDs and HDDs is reflected, the cost can be reduced to approximately 1/60th using the IOPs performance ratio.

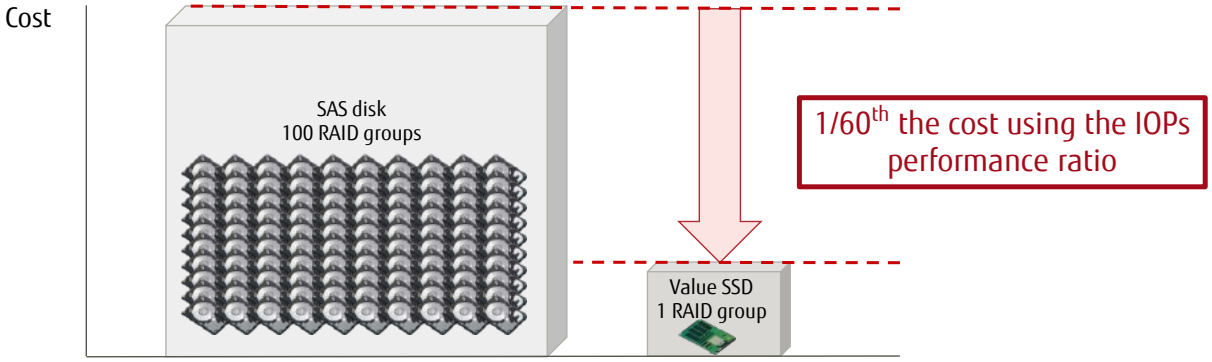


Figure 11 Cost comparison using the IOPs performance ratio

### 3.5. Improvements in Operational Efficiency and Business Continuity

Consolidation facilitates more efficient operation because it enables use of virtualization platform functions for centralized management of virtual systems. The ETERNUS AF S3/S2 series supports the main virtualization platform functions.

- Windows
  Live Storage Migration, Hyper-V Replica, Offloaded Data Transfer (ODX)
- VMware vSphere
  VMware vSphere Virtual Volumes (VVols), Storage DRS, Storage vMotion, Storage Thin Provisioning, vStorage API for Array Integration (VAAI), vStorage APIs for Storage Awareness (VASA), ETERNUS vCenter Plug-in
- OpenStack volume management function

While the hardware consolidation by virtualization improves efficiency, it also means that any hardware problems will impact a large number of virtual systems. This creates a need for business continuity measures such as backups and hardware redundancy. Storage Foundation Software ETERNUS SF is equipped with various functions that improve business continuity.

- Advanced Copy functions*1
  These functions provide high-speed copying using the storage system features and a variety of copying methods for enabling backups based on the requirements.
  Rapid copying by QuickOPC can back up virtual volumes with minimal downtime.
- Remote Advanced Copy (REC) functions*1
  Copying between storage systems enables data backups to a remote ETERNUS AF S3/S2 series or ETERNUS DX S5/S4 series and supports disaster recoveries.
- Storage Cluster function*2
  This function improves availability by using redundant storage systems.
- Performance information acquisition function and diagnosis function*3
  This function acquires, analyzes, and automatically diagnoses the performance information on the storage system, virtualization platform, OSs, network switches, and Fibre Channel switches. The performance of the entire system environment can be visualized and analyzed for an extended period of time.

*1: Functions of ETERNUS SF AdvancedCopy Manager
*2: Function of the ETERNUS SF Storage Cruiser Storage Cluster option
*3: Function of ETERNUS SF MA

To enable integrated storage management, ETERNUS SF supports the existing disk storage systems, ETERNUS AF S3/S2 series, as well as the ETERNUS DX S5/S4 series. If a system uses the ETERNUS AF S3/S2 series as a business storage system and the ETERNUS DX S5/S4 series as a backup destination storage system, SF can be used for centralized storage management and backups.

Figure 12 shows a configuration example for when the ETERNUS AF650 S3 and ETERNUS SF are used for server virtualization and consolidation. The management server where ETERNUS SF Storage Cruiser/ETERNUS SF AdvancedCopy Manager is installed performs high speed backups with QuickOPC in the storage system or backups to another storage system with REC, and manages storage system redundancy with the Storage Cluster function. The server where ETERNUS SF MA is installed collects, analyzes, and automatically diagnoses the performance information of the entire system environment.

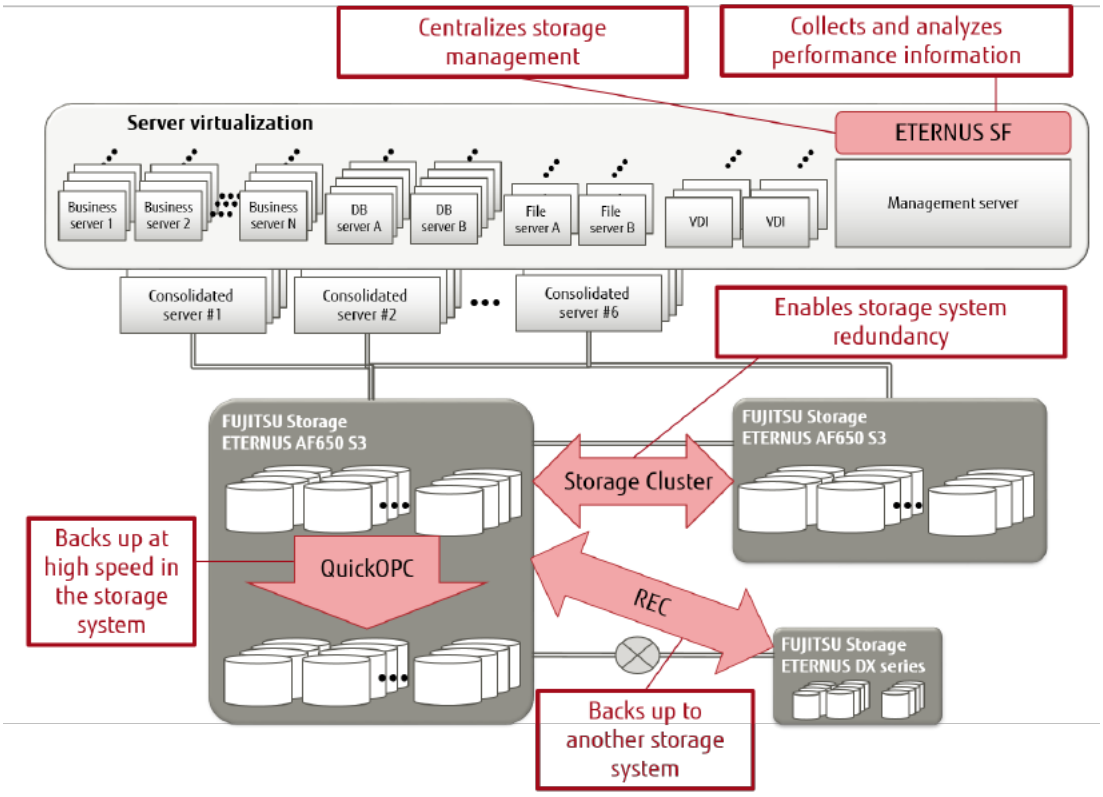


Figure 12 Configuration example with the ETERNUS AF650 S3 and ETERNUS SF for virtualization and consolidation

## 4. Conclusions

While all-flash arrays were once seen as offering performance at a high price, the increasing capacity and falling cost of SSDs means they are now a practical type of storage system. It is anticipated that all-flash arrays will be adopted on many systems in the future. There is particularly strong potential for their use with virtualization for the consolidation of servers and clients, an area that has posed challenges for storage systems in the past.

While the use of virtualization for consolidation requires a large storage capacity, this capacity requirement can be minimized when all-flash arrays are used in RAID configurations that have high storage efficiencies together with the Deduplication/Compression function.

Thanks to Fujitsu's unique functions, the ETERNUS AF S3/S2 series can be used to consolidate a wide variety of business systems by enabling or disabling the Deduplication/Compression function as required.
Equipped with an extensive set of functions and offering best-in-class performance for an all-flash array, the ETERNUS AF S3/S2 series enables virtualization to be used to consolidate a diverse range of systems by improving operational efficiency and business continuity while still delivering on both performance and cost.

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