White Paper

Empowered by Innovation

NEC

VMware vSphere Virtual Volumes Changes the Virtualization Environment

New Forms of Interaction between Virtual Machines and Storages

1. Introduction

VMware vSphere® Virtual Volumes ("Virtual Volumes") is drawing attention as a groundbreaking technology that resolves many of the issues facing the current virtualization environment. Announced officially as a new framework for VMware vSphere® 6.0 on February 3, 2015, Virtual Volumes enables virtual machines to operate more closely with servers and storages, which is expected to lead to increased performance and more efficient operation.

This White Paper describes the background to the birth of Virtual Volumes and provides details on the solutions that it realizes. The White Paper first takes a look back on how virtualization technology has evolved thus far and NEC's approach to virtualization, in order to help you better understand Virtual Volumes.

1-1. Progress toward server virtualization

The start of the 21st century saw exponential growth in server and storage capacity requirements due to a number of factors including the full-scale penetration of the Internet and the arrival of the era of Big Data. Demand kept growing so fast that meeting it through the conventional means of simply adding physical servers in response to resource shortages became impractical. This brought the concept of "server virtualization" into the spotlight. The issues that existed before servers were virtualized and how server virtualization resolved those issues are described below.

● Server virtualization offered savings in installation space and power consumption

If you need to add servers, and if that involves installing physical servers, you will need new installation space for them. Depending on the number of servers you need to add, it may not be enough to simply install additional racks; it may in fact be necessary to prepare a new server room. In this case, securing installation space itself may become a key challenge. Also, adding physical servers leads to an increase in power consumption. These issues, combined with air conditioning expenses, posed problems in terms of both cost and environmental impact. Server virtualization was quickly recognized as an effective way to solve these problems. This technology builds multiple virtual servers on a single physical server and allows that physical server to be used as if multiple servers exist.

The use of this technology has made it possible to ease the problems of installation space and power consumption.

● Server virtualization eases operation and management workloads

As installing additional servers increases the number of physical servers, the management workload becomes highly loaded. If a problem occurs that cannot be solved online when the physical servers are scattered across rooms, divisions, etc., it is necessary for personnel to go to the place where the faulty server is for troubleshooting. Also, when physical servers of different types are mixed, they may differ in the management and operation software they use, the restoration method, and so on, which means that all these characteristics have to be understood for each type of server. There have been cases in which these factors resulted in a sharp increase in the workload of system administrators, leading to a serious understaffing problem. Server virtualization reduces the number of physical servers, which makes it possible to concentrate scattered servers in a single location and to decrease the number of server types, resulting in a reduction in the operation and management workloads.

● Server virtualization enables efficient use of resources

When you increase the number of servers by installing additional physical servers, it is difficult to create an optimal resource design within the limited pre-installation period. There have been cases, too, in which the installed servers are used differently than originally planned because of a change in the operating environment after installation or for some other reason. As a result, while there are excess resources in some places, performance degradation or capacity shortage occurs in other places.

With virtual servers, you can reallocate resources more flexibly than with physical servers. This allows you to change the allocation of resources according to the situation after the start of operation without having to perform detailed performance design in advance.
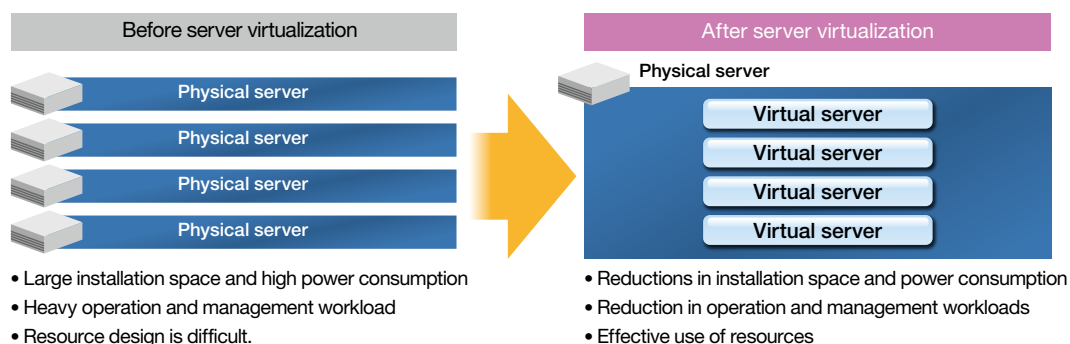
Before server virtualization	After server virtualization
Physical server	Physical server
Physical server	Virtual server
Physical server	Virtual server
Physical server	Virtual server
	Virtual server
• Large installation space and high power consumption	• Reductions in installation space and power consumption
• Heavy operation and management workload	• Reduction in operation and management workloads
• Resource design is difficult.	• Effective use of resources

Figure 1: Benefits of server virtualization

1-2. Progress toward desktop virtualization

A more familiar "virtualization" technology may be desktop virtualization. As server virtualization enters the mainstream, a new trend, "desktop virtualization," is starting to draw attention. Desktop virtualization is a technology that enables the desktop screen of a PC environment installed on a server to be used from a remote location via a network. NEC provides several types of virtualization solutions, each tailored to a specific purpose, and many of these are deployed on VMware® Horizon from VMware, the industry de-facto standard in virtualization.
The benefits of desktop virtualization are described below.

● Desktop virtualization provides enhanced security and prevents information leaks.

One of the benefits is that, because applications and data reside on servers in the desktop virtualization environment, the risk of information leaks can be reduced should the terminal be lost. In order to lower the risk further, desktop virtualization is often introduced in combination with "thin client terminals" that have no data input/output devices such as hard disk drives.

● Desktop virtualization makes it easier to update the OS and software.

As the use of IT is spreading, there has also been an increase in security threats including malware infections and unauthorized accesses that exploit security holes. While security software is effective in protecting against these threats, software definition files are updated so frequently that it is hard to maintain an accurate grasp of the update status of every single physical PC. Naturally, it is even more difficult to ensure that the same security measures are applied uniformly to all physical PCs, resulting in an ever-growing burden on the system administrator.
By introducing desktop virtualization, the tasks of updating software and applying security measures that were conventionally performed on an individual physical PC basis can be executed at once on a server, which eases the workload of the system administrator.
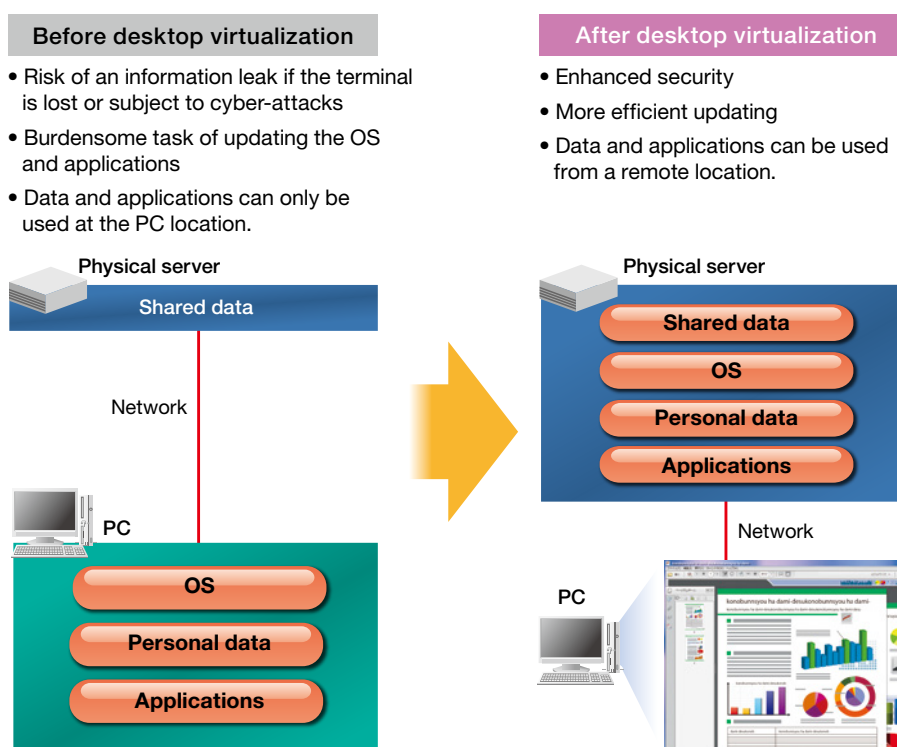
Figure 2: Benefits of desktop virtualization

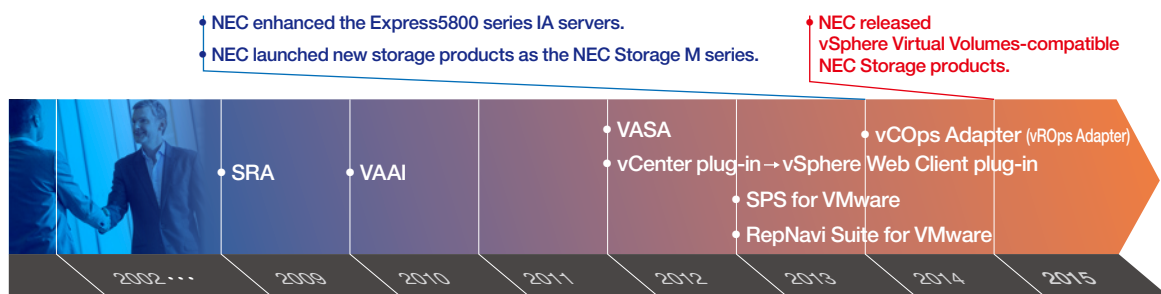## 1-3. NEC's efforts to promote virtualization

In 2002, NEC forged a pioneering partnership with VMware, the leading provider in the virtualization software industry. Since then we have developed a number of products and solutions, including servers in the Express5800 series and storage products in the NEC Storage M series, all of which are ideal for virtualization.

Focusing on the development of link functions that provide enhanced compatibility with VMware vSphere®, the most widely used server virtualization software in the world, NEC has brought to market Storage Replication Adapter, VMware vSphere® Storage APIs - Array Integration, and a range of other products since 2009. For Virtual Volumes, the new framework of the recently released VMware vSphere 6.0, we started advance evaluation of the β version under development[1] and our storage products were certified as being compatible at the same time that VMware vSphere 6.0 was launched[2] by VMware.

[1]. There are only six companies in the world that have passed the β certification test for vSphere Virtual Volumes; NEC is one of them.
[2]. On March 12, 2015, NEC became the first company in Japan to acquire vSphere Virtual Volumes certification.

■ Collaboration between NEC and VMware

- NEC is the first Japanese manufacturer to forge a hardware alliance with VMware.
- Express5800 and NEC Storage acquired hardware certification.
- NEC conducted advance evaluation of the next VMware product and developed and released compatible products.

NEC enhanced the Express5800 series IA servers.
NEC launched new storage products as the NEC Storage M series.

NEC released vSphere Virtual Volumes-compatible NEC Storage products.

SRA   VAAI   VASA
vCenter plug-in → vSphere Web Client plug-in
vCOps Adapter (vROps Adapter)
SPS for VMware
RepNavi Suite for VMware

2002···   2009   2010   2011   2012   2013   2014   2015

SRA: Storage Replication Adapter   **VAAI**: Storage APIs - Array Integration   **VASA**: vSphere API for Storage Awareness
SPS: NEC Storage PathManager   **vCOps**: vCenter Operations Manager   **vROps**: vRealize Operations Manager

Figure 3: History of collaboration between NEC and VMware

2. About vSphere Virtual Volumes

VMware has long been promoting software-defined data center (SDDC), an architecture in which all the components in a data center are controlled by software. At the core of this architecture is the concept of software-defined storage (SDS). The aim of this concept is to shift from the conventional hardware-centric design approach to one that is more focused on applications (virtual machines) in order to enable operation and management of storage independent of hardware as well as storage optimized for applications. Virtual Volumes is one of the technologies that realize SDS. It has been developed to advance the integration of storage and VMware vSphere® virtualization software and to allow virtual machines and storage to be managed in an integrated manner.

2-1. Issues with conventional virtualization environments

Virtual Volumes was developed in response to new issues that had arisen from the increasing use of virtualization environments.

Conventionally, virtual disks are managed on an LUN basis (the unit used by the server to recognize a single storage system). With this method, the storage creates an LUN to identify an area that may be used by several virtual machines and multiple virtual machines use the area of that LUN as a virtual disk on the server. In this case, the only processing performed on the storage is LUN creation, and the storage is unaware of which virtual servers use that LUN.

As a result, the storage performs management based on LUNs while the server performs management based on virtual disks (VMDKs), and this difference in management granularity has come to affect system performance as well as system operation and management. Specifically, the following issues have been identified:

Issue 1: Virtual disks cannot be operated and managed in a way appropriate for the service level of a virtual machine.

Since the settings on the storage are LUN-based, a special high-performance service cannot be provided to a specific virtual machine according to importance or priority when multiple virtual machines use the same LUN. Because the backup and snapshot settings are LUN-based as well, detailed settings cannot be configured or managed for each virtual machine individually. Also, if a certain virtual machine places a high load on a shared resource such as cache memory or a physical disk, the consequent degradation in performance may spread to the other machines that share the same LUN.

Issue 2: The various functions of storage products cannot be used effectively, resulting in an increase in the server load.

When the snapshot function of the storage is used to create snapshots, snapshots can be created only for each LUN. Creating snapshots for each virtual machine requires processing on the server, which leads to an increase in traffic.

The same is true when a backup is created. From an operational perspective, it is ideal to back up and restore data on each virtual machine. The backup function of the storage, however, can only back up all the data of a particular LUN. This method introduces operational complexity because, when data is restored, the other virtual machines using the same LUN are also rolled back to the state they were in when the data was backed up.

Other operations such as virtual machine replication and cloning place a high load on the server, which can degrade performance.

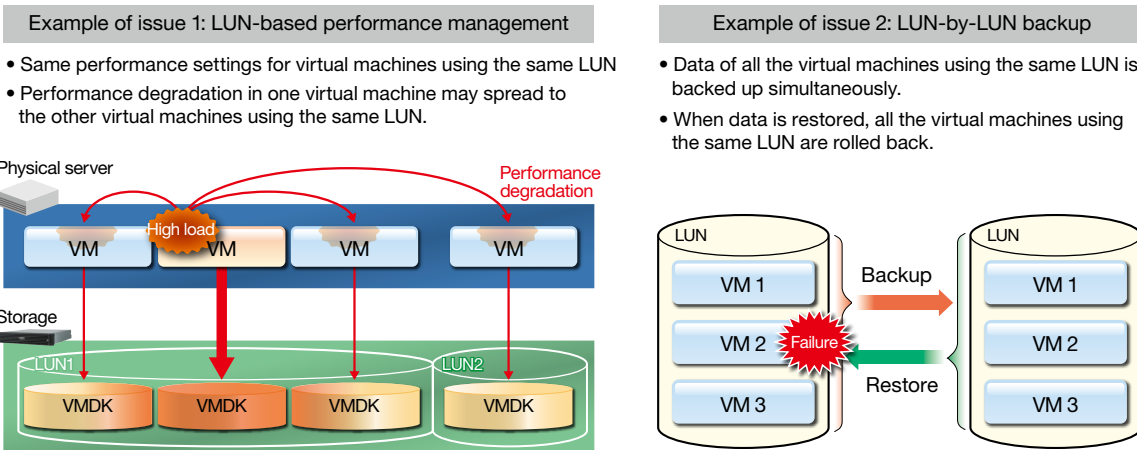| Example of issue 1: LUN-based performance management	Example of issue 2: LUN-by-LUN backup
• Same performance settings for virtual machines using the same LUN • Performance degradation in one virtual machine may spread to the other virtual machines using the same LUN.	• Data of all the virtual machines using the same LUN is backed up simultaneously. • When data is restored, all the virtual machines using the same LUN are rolled back.

Figure 4: Issues with LUN-based performance management

The technology that is expected to resolve all these issues is vSphere Virtual Volumes.

2-2. Overview of vSphere Virtual Volumes

The concept of vSphere Virtual Volumes itself is very simple. It is centered around an attempt to divide the data area used by virtual machines into new common units called "virtual volumes (VVOLs)" and have the storage and the server recognize these common units.

Since virtual machines correspond to VVOLs on a one-to-one basis, it is possible to select a policy according to the service level and to decide which storage a virtual machine is to use.

Implementation of vSphere Virtual Volumes

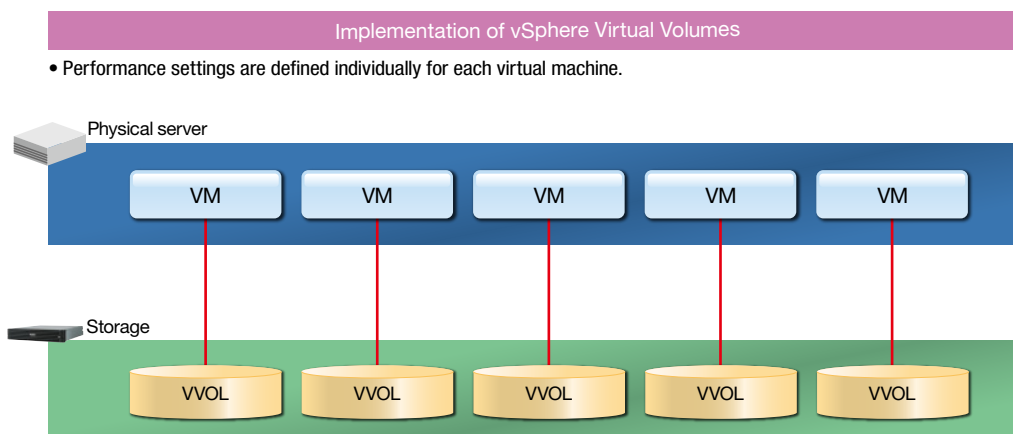• Performance settings are defined individually for each virtual machine.

Figure 5: Image of implementation

What kinds of benefits does Virtual Volumes bring? Let us look at some specific examples.

2-3. Service level-based easy operation and management of virtual machines —— *Solution to issue 1*

Since the storage can identify the virtual volume created for each virtual machine, it is possible to operate and manage virtual volumes on an individual virtual machine basis. The server administrator can create a VVOL easily just by selecting a "storage policy" when creating a new virtual machine. This storage policy, typically given a name like GOLD or SILVER, is a template in which the information about the storage is configured, including its performance, importance, and whether individual functions are to be used or not. Several different policy types are normally available. Once the storage administrator creates the storage policies, the server administrator can allocate an appropriate storage area (VVOL) to a virtual machine as necessary. Also, the virtual volume capacity and storage policy can be changed even after the start of operation, eliminating the need for excessive provisioning (allocating extra storage capacity beforehand to cover possible capacity shortages). This improves the operational efficiency of the entire storage.

Storage policy	GOLD	SILVER
• Capacity	• Small capacity	• Large capacity
• Performance information	• High performance	• Low performance
• Snapshot function	• Snapshot function used	• Snapshot function not used
• Replication function	• Replication function used	• Replication function not used
• Cloning function	• Cloning function used	• Cloning function not used
• Encryption function	• Encryption function used	• Encryption function not used

Figure 6: Creation of a virtual machine using a storage policy

2-4. Making effective use of storage functions to ease the load on the server —— *Solution to issue 2*

● Significantly reducing the time it takes to start and replicate a virtual machine

In desktop virtualization, a template is prepared and replicated to create virtual machines (clones). These operations can be accelerated as well. Two cloning features are available: full clone and fast clone. For template replication operations, the fast clone feature whereby only a difference data file is created on the storage is used. This reduces the amount of capacity required, compared to the full clone feature whereby the whole virtual machine is copied. Also, because templates are shared, there is another benefit of a higher cache memory hit ratio.
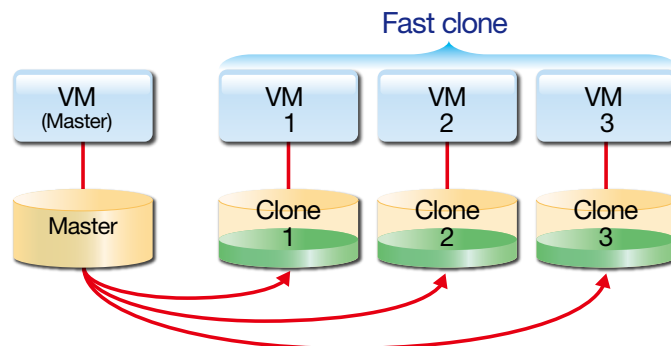
Figure 7: Conceptual diagram of the fast clone feature

● Changing the snapshot processing to leverage storage functionality

The conventional snapshot function creates a difference management file (*****-delta.vmdk) that stores the state of a virtual machine at a certain point in time so that the virtual machine can be rolled back to that state in the event of a failure. When multiple snapshots are created, however, it may be necessary to scan all the snapshots depending on the processing involved, which can degrade performance. There are other problems as well, such as the time it takes to consolidate snapshots and the size of the snapshot file, which becomes larger the longer snapshot function is used. These shortcomings make it difficult to use the snapshot function in the production environment. In fact, VMware has recommended users to create not more than two or three snapshots and to not use the snapshot function continuously for more than 24 to 72 hours. When creating snapshots in an environment that deploys Virtual Volumes, the snapshot function of the storage is used.

The processing is the same as with the conventional snapshot function. However, while the snapshot command is issued from the server, the actual processing is performed on the storage, thus allowing the snapshot function to be executed without placing an excessive load on the server or network.

● Making effective use of storage functions

We stated earlier in this chapter that, in an environment that deploys Virtual Volumes, the virtual volumes (VVOLs) used by virtual machines are recognized by both the server and storage. This allows us to use the functions provided by storage products.

For example, the creation of backups and the restoration of data in case of a failure can be accomplished more conveniently and faster in an environment that deploys Virtual Volumes.

In the past, data was backed up on an LUN-by-LUN basis. When the data of an LUN shared by multiple virtual machines was restored, therefore, all the other normal virtual machines using the same LUN were rolled back to the previous state as well. In an environment that deploys Virtual Volumes, data is backed up and restored on an individual virtual machine basis

and these operations are performed by making effective use of storage-specific functions such as VVOL replication and overwriting. This enables more finely tuned troubleshooting.
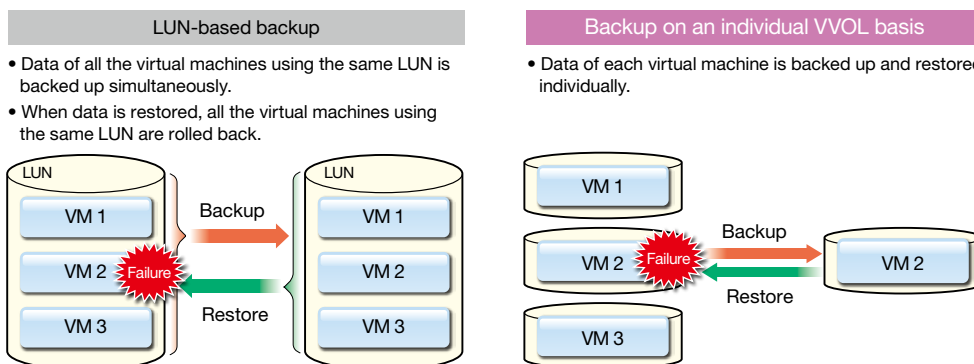
LUN-based backup	Backup on an individual VVOL basis
• Data of all the virtual machines using the same LUN is backed up simultaneously. • When data is restored, all the virtual machines using the same LUN are rolled back.	• Data of each virtual machine is backed up and restored individually.

Figure 8: Virtual machine backup and restore

*For more information about backup and restore, also see "3-5. Enhanced backup/restore function."

3. NEC Storage solutions for environments that deploy Virtual Volumes

We now understand the benefits of Virtual Volumes. Implementing these benefits requires a storage design that is compatible with VVOL. As a partner of VMware, NEC has collaborated on Virtual Volumes implementation from an early stage, which has enabled us to provide Virtual Volumes-enabled storage products ahead of other companies. The NEC Storage M series, a suite of NEC storage products, offers not only the functions proposed by VMware, for Virtual Volumes but also a set of solutions designed to allow users to make the most effective use of an environment that deploys Virtual Volumes. Described below are Virtual Volumes link functions that only NEC can provide.

● **NEC Storage M series of solutions for environments that deploy Virtual Volumes**

1 All the standard functions proposed by VMware for Virtual Volumes are supported. (Examples: VVOL-based snapshot and cloning functions)

2 In addition to policy-based simple configuration and management, a function to link with Virtual Volumes associated with each policy is also available. ◀ Only NEC can provide this.

- I/O control function for each virtual machine
- Automatic optimum data allocation for each virtual machine
- SSD L2 cache setting for each virtual machine
- Cloning function for space saving and load reduction

3 The backup and restore functions are utilized. ◀ Only NEC can provide this.

Figure 9: NEC Storage M series of solutions for environments that deploy Virtual Volumes

3-1. I/O control function for each virtual machine
NEC Storage IO Load Manager

As servers and storages are virtualized, more virtual machines access a single storage unit. Under normal load conditions, this does not pose a problem. In some cases, however, there is a specific virtual machine placing a high load on the storage, which might limit access to the storage by other virtual machines. If this causes a slowdown in the processing of a mission-critical business-level virtual machine, it could lead to a serious problem. The I/O control function keeps the I/O performance (number of data inputs and outputs per second) above a certain level to prevent such a situation from occurring. With a typical I/O control method, an upper limit is set for the I/O flow. If a load exceeding the upper limit is applied, the I/O flow of the virtual machine that is placing the excessive load is controlled so as to prevent it from affecting other virtual machines. With NEC's I/O control function, a lower limit can be set in addition to this common upper limit setting. This means that the I/O flows of other machines are controlled to prevent the I/O flow of a higher priority virtual machine from dropping below a certain value, thus guaranteeing the high performance of the higher priority machine. NEC's I/O control function allows I/O flows to be finely controlled based on priorities so as to keep the entire system running stably. The I/O upper and lower limits can be registered in advance as storage policies, such as GOLD and SILVER. Users can use these limits with ease as

all they need to do is to choose a storage policy when creating the VVOL area, thereby preventing them from forgetting to set the limits or setting the limits incorrectly.
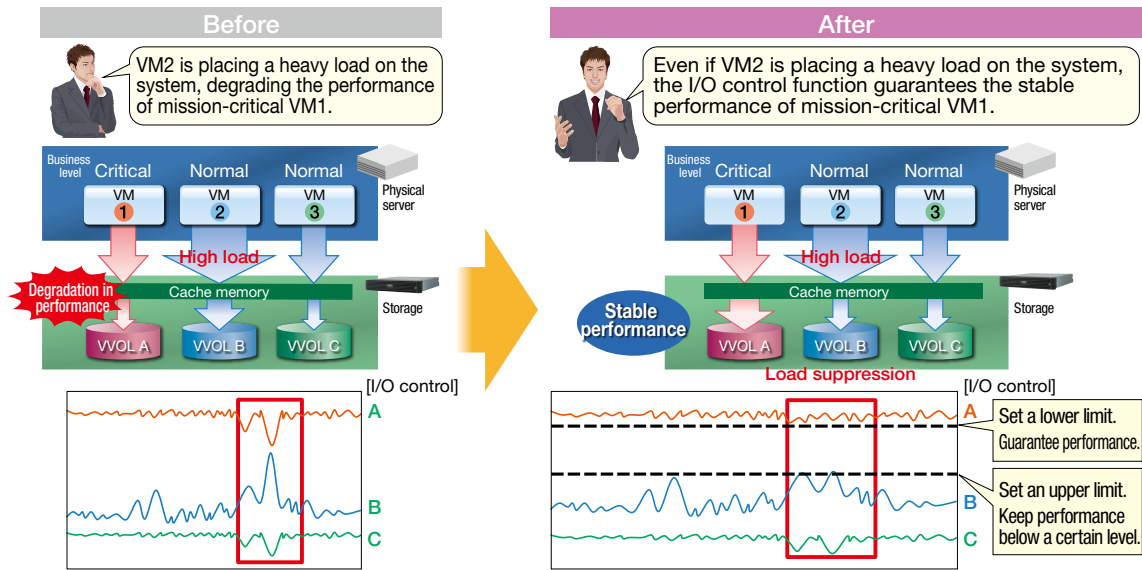

Figure 10: I/O control for each virtual machine

3-2. Automatic optimum data allocation for each virtual machine
NEC Storage PerforOptimizer

Storage consists of several physical disks supporting different levels of performance, such as SSD, SAS HDD, and nearline SAS HDD. Storing frequently accessed data and infrequently accessed data together in the same high-performance, expensive device is inefficient. The automatic optimum data allocation function automatically allocates data to optimum disk areas based on access frequency.

An SSD supporting high-speed data access, a high-performance SAS HDD, and a high-capacity, low bit-cost nearline SAS HDD are combined into a hierarchical structure to create a storage pool. Data is automatically allocated to optimum disks in different storage levels, such as by distributing frequently accessed data to the SSD and infrequently accessed data to the nearline SAS HDD. This control can be exerted on an individual virtual machine basis. Not only simple access times but also the amount of transferred data and application-specific access patterns (random vs. sequential and read vs. write) are analyzed by unit time for each data file. Data is automatically reallocated using NEC's unique algorithm. Here, NEC's know-how plays a key role.

It is also possible to preset the capacity ratio of each physical disk according to the storage policy, such as GOLD or SILVER. Users can have data allocated to optimum data areas in the same storage pool as appropriate for the intended use, simply by choosing a storage policy when creating the VVOL area. This allows users to maximize the storage performance and optimize storage costs automatically.
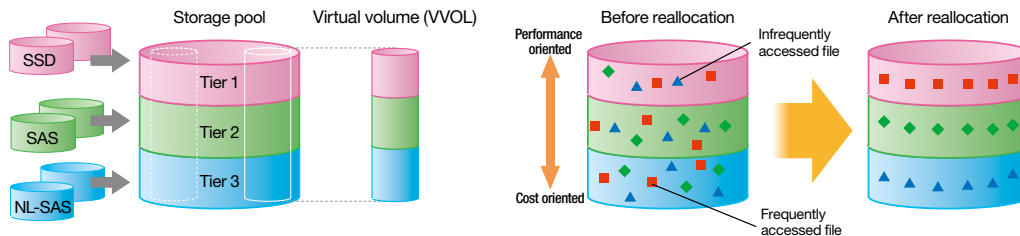

Figure 11: Automatic optimum data allocation

3-3. SSD L2 cache setting for each virtual machine
NEC Storage PerforCache

Increasing the hit ratio of the storage cache memory is effective in boosting the processing speed of a virtual machine. NEC Storage PerforCache uses an SSD with high I/O performance as an L2 cache that supplements the L1 cache.

When the server issues a request to read data, if the requested data is in the cache memory, the data is read immediately from the cache memory without accessing the disk. This is known as a *cache hit*. However, if the requested data is not in the

cache memory, the disk must be accessed to fetch the data. This is known as a *cache miss*. Since the speed of accessing the hard disk is generally slower than the CPU throughput, concentrated accesses to the hard disk caused by a series of cache misses will cause a delay in CPU request processing, leading to the occurrence of a wait state or hot spot. This condition can seriously impact system performance. NEC Storage PerforCache eliminates hot spots by using an SSD L2 cache to supplement the primary (L1) cache and thereby raise the cache hit ratio.

The L2 cache can be implemented quickly and effortlessly regardless of whether the system is operating or stopped. All that is required is to convert the SSD in the storage to an L2 cache; there are no additional costs because a cache does not need to be physically added. For example, if the size of the template data that a virtual machine frequently reads is very large and the L1 cache cannot store all of it, you can have the data allocated to the L2 cache, which results in a higher hit ratio and enhanced virtual machine performance.

It is possible to turn on or off the L2 cache function or change the cache capacity for each virtual machine individually, as well as to choose between read only mode and read/write mode. As a result, even if there is a drop in performance that was not anticipated in the design phase, this state can be recovered without causing service down time. Furthermore, in the event of failure or when the controller must be temporarily replaced for maintenance, the L2 cache can be automatically enabled to minimize any drop in response speed.
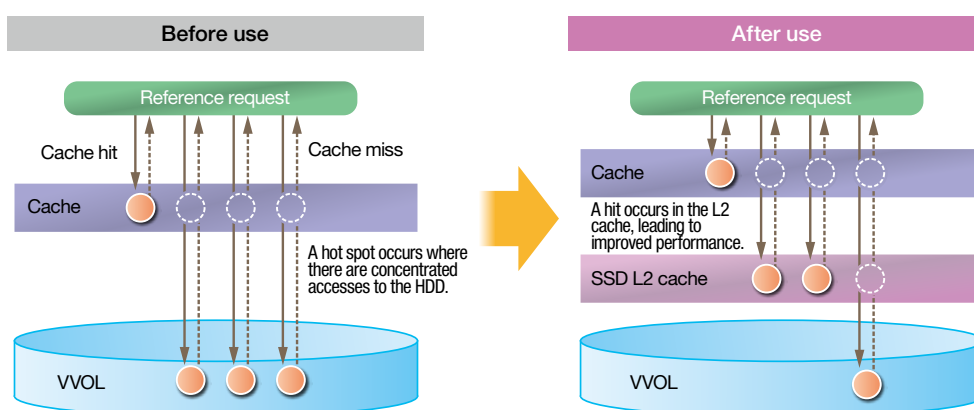

Figure 12: SSD L2 cache

3-4. Cloning for space saving and load reduction

When a thin client environment is built through desktop virtualization, many cloned virtual machines are used. Conventional cloning requires the full storage capacity of a single virtual machine for every clone, putting pressure on the storage capacity. Also, hot spots are prone to develop as access concentrates when multiple machines are used simultaneously or during the boot processing at startup, etc.

The cloning provided by VVOL allows you to choose between *full clone* in which the whole virtual machine is copied as with the conventional method, and *fast clone* in which only differences from the master data are managed. Managing only difference data enables a dramatic reduction in the required storage capacity compared with conventional cloning. NEC's solution takes the cloning provided by VVOL one step further by storing the master data accessed by multiple clones in the SSD as shared master data. The SSD's fast response speed can therefore be leveraged to improve throughput and prevent concentrated accesses, thereby eliminating hot spots.
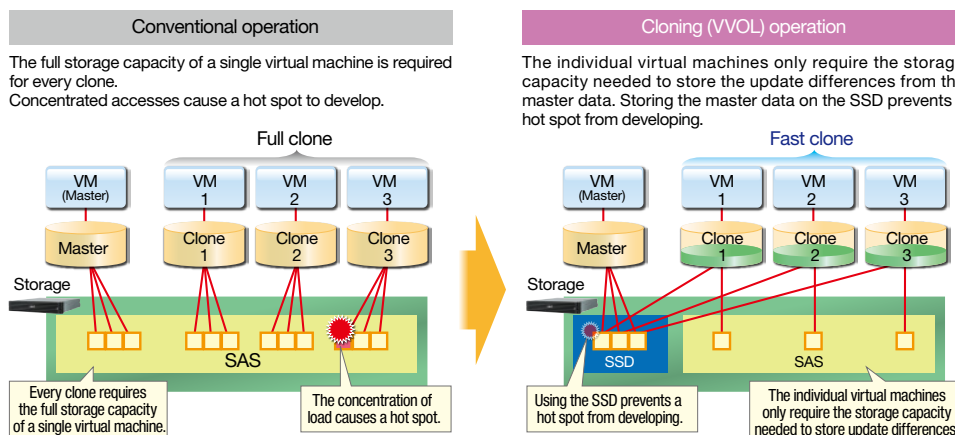

Figure 13: Enhanced cloning function

3-5. Enhanced backup/restore function

Since the conventional backup/restore function backs up and restores data on a LUN-by-LUN basis, it is not possible to back up the data of only a specific virtual machine when multiple virtual machines share the same LUN. Likewise, when backup data is restored, it is not possible to restore the data of only a specific virtual machine, causing all the other virtual machines to be rolled back to the state they were in when the data was backed up.

In an environment that deploys Virtual Volumes, this problem is solved because the backup/restore function can be used for each virtual machine individually, making the backup/restore operations significantly more convenient. While the backup/restore commands are issued from the server, the actual processing is done on the storage, which enables the backup/restore operations to be carried out without placing a load on the CPU of the server. Now that the storage system is responsible for the backup/restore operations, the effectiveness of its functions become a key factor. The NEC Storage series offers the functions and solutions described below to provide users with an easy-to-use backup environment.

(1) DynamicDataReplication (DDR)

This function creates a replication volume in the storage that contains the master volume.

Since the processing is executed on the storage itself, large amounts of data can be backed up at high speed while the server is online and performing processing. Moreover, when executing a restore in the event of failure, processing can be resumed as soon as the restore processing starts, without waiting for all the data to be copied from the replication volume. This feature is known as *an immediate restore*, and is highly effective in minimizing failure-related service down time.
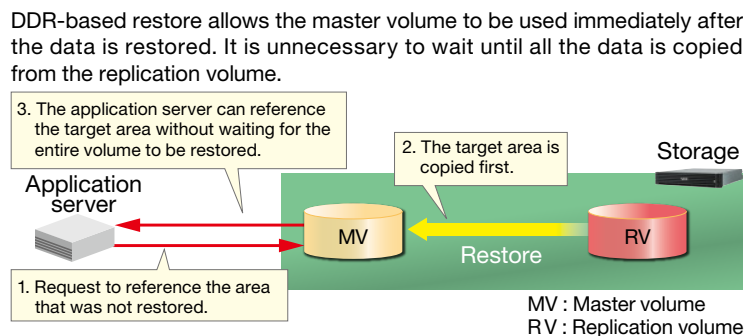

Figure 14: Utilization of the restore function

The replication volumes created by DDR can also be used for purposes other than failure recovery. One example is using a replication volume to perform load-heavy work such as searching or referencing data in the storage, thereby preventing a drop in application server performance.

(2) RemoteDataReplication (RDR)

RDR creates a replication volume in a different storage, and can be used to, for example, replicate the data in storages in adjacent storage enclosures to enable rapid recovery and business continuity in the event of storage failure. Other uses include backing up application data to remote locations as a disaster recovery measure or to allow production data to be used at the remote location for non-critical processing such as data searches, patch application, and system evaluations. This feature is ideal for reducing the load on servers performing critical processing while maintaining data consistency at the remote location.
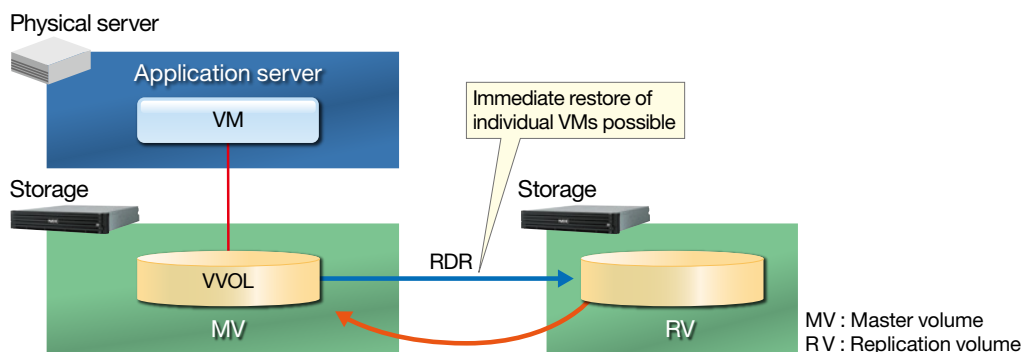

Figure 15: Conceptual diagram of RemoteDataReplication (RDR)

(3) DirectDataShadow (DDS)

This technology enables server-less multi-generation backup, with the NEC Storage M series storage connected directly to the NEC Storage HS series storage.

A virtualization environment is not only required to provide high-speed backup; it must also allow users to store backups covering multiple generations. NEC provides a low-cost, high-capacity storage—the NEC Storage HS series—that is optimized for exactly this kind of application. Whereas conventional backup systems require a separate backup server and backup software to be installed and operated, at considerable cost to the user, NEC's DDS solution offers a simple configuration that does not require the purchase of additional backup servers or software. DDS also enables a number of data streamlining features, such as deduplication to compress data and reduce the amount of data backed up when creating clones, etc., as well as an option to only back up difference data. The NEC Storage HS series for backup can be installed in nearby or remote locations, allowing you to create a backup system for disaster recovery that is both low-cost and easy to use, thereby contributing to operations management and communications costs reductions.
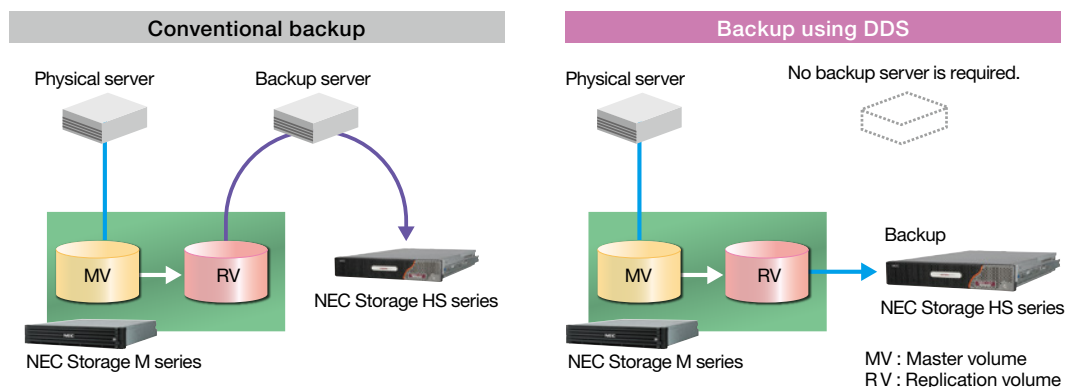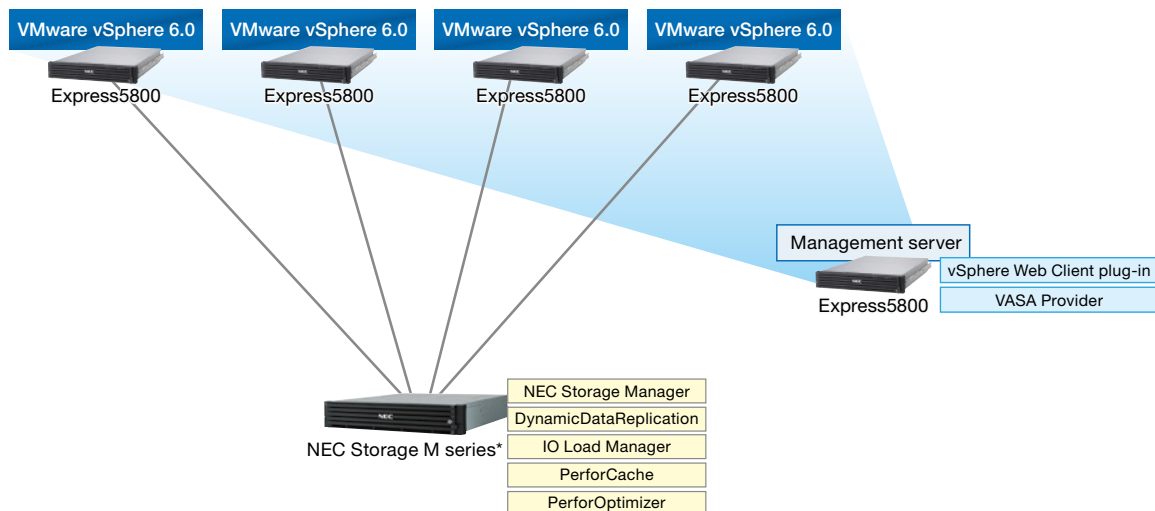

Figure 16: Conceptual diagram of DirectDataShadow (DDS)

4. Configuration example

An example of the NEC-recommended configuration for creating a virtualized environment that supports Virtual Volumes is shown below.

*Supported storage models: NEC Storage M110/M310/M510/M710 (FC/iSCSI models)

Figure 17: Configuration recommended for an environment that deploys Virtual Volumes

5. Conclusion

As we have seen, Virtual Volumes brings the following benefits to users:

●Ability to configure storage settings for each virtual machine

Since virtual volumes used by virtual machines can be recognized by both the server and storage, the settings are easy. The problem of storage settings being limited to a specific LUN can be solved.

●Storage policy-based simple management

Operation is easy because a VVOL is automatically created just by selecting a storage policy when creating a virtual machine.

The capacity and the storage policy can be changed at any time, eliminating the need to provide unnecessary capacity or excessive functionality in anticipation of possible capacity shortages in the future. This improves the operational efficiency of the entire storage.

●More convenient backup/restore function and faster snapshot and cloning

Data can be backed up and restored quickly and easily on an individual virtual machine basis. Also, by making effective use of the functions provided by the storage system, snapshots and cloning can be executed while reducing the load on the server and network.

●Closer linkage with storage

Closer linkage with storage allows the virtualization environment to be operated and managed more efficiently than ever before.

Realizing the potential of virtualization technology early, NEC has been promoting the development of products and solutions based on this technology ahead of other companies.

Regarding virtualization software in particular, we forged a partnership with VMware, the leading company in the industry, in 2002. Now, we not only develop and sell VMware-compatible products but also work together with VMware to perform evaluations and joint certifications of future products as well as to create industry standards.

NEC's engineering team specializing in VMware products offers a one-stop service, providing customers with solutions that match their needs from among a rich suite of products designed to realize a virtualization environment. These products include hardware such as server and storage products dedicated to virtualization environments and software such as operation and management software that supports environments that deploy VMware. Leveraging this strength, we have delivered virtualization products and solutions to a large number of corporate customers in a wide range of business fields and industries as well as to local public organizations, educational institutions, and other non-corporate entities. We also offer after-sales support in Japan*, including a quick troubleshooting service, from about 400 support centers across Japan with a staff of about 3,500 certified engineers.**

NEC intends to provide social infrastructure that helps enrich people's lives, by taking concrete actions such as further enhancing the performance of the virtualization environment of the NEC Storage series and making its software products compatible with Virtual Volumes.

* For support services outside Japan, please contact local NEC offices.
** As of February 2015

For further information, please contact: