Virtual Machines and Storage interactions

VMware vSphere Virtual Volumes

NEC Corporation of America
NEC and VMware provision for cloud implementation, IT resource consolidation, and simplified management of virtual environment.

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. As the new framework for VMware vSphere® 6.0, Virtual Volumes enables virtual machines to operate more closely with servers and storages, which is expected to provide better performance and more efficient operation.

This White Paper describes the background to the development of Virtual Volumes and provides detailed explanation on the benefits and solutions related to the implementation of this technology.

To give a better understanding of Virtual Volumes, this document will first provide an overview of how virtualization technology has evolved thus far, then will describe NEC's approach to maximize the benefits of virtualization and virtual volumes.

1-1. Progress toward server virtualization

In the past decade the requirements for servers and storage capacity experienced exponential growth due to a number of factors, including the widespread of Internet and the proliferation and escalation of Big Data. Demand was growing so fast that adding more physical servers in response to resource shortages became impractical. The concept of “server virtualization” entered the spotlight as a strategy to deal with the rapid growth in resource requirements. Some of the major issues addressed by virtualization are:

Physical space and power consumption

Most companies installed physical servers to satisfy demand for more compute resource. The issue was finding enough space and power for those new servers.

Depending on the number of servers needed, it was not feasible to simply install additional racks, which often required a new server room. In many cases, securing installation space became a key challenge. Adding physical servers also increased power consumption. Those issues, combined with air conditioning expenses, impacted cost and the environment.

Server virtualization was quickly recognized as an effective way to address those problems. Virtualization technology provides multiple virtual servers on a single physical server, allowing one server to be used as if multiple separate servers were installed.

Using virtual technology enabled organizations to increase compute resource without adding costs and resources of installation space, cooling, and power consumption.

Server administration and management resources

Installing additional physical servers increases the complexity and resources required to manage a large number of servers. If a problem that couldn’t be fixed electronically occurred, personnel were often required to physically troubleshoot physical servers across buildings, rooms and divisions. Additionally, when different types of servers from different vendors are mixed, they differ in software management, administration and restoration methods. This disparity in management process and physical location requires a more complex understanding of each type of server, how they interact together and a careful map of each of their locations. Those factors increase the workload of system administrators, leading to errors due to the complex environment.

Server virtualization reduces the number of physical servers, which facilitates the consolidation of scattered servers into a single location. Fewer servers typically results in a decrease of server types, which reduces operation and management workloads. Additionally, virtual operating systems provide management tools that make it easier to manage the virtual environment.
Resource Efficiency

When you increase the number of physical servers, it is difficult to create an optimal architecture combining existing and incremental resources efficiently. Consequently, some areas might have excessive resource capacity while others might have shortage and performance degradation. There are also cases where the installed servers are used differently than originally planned due to changes in the operating environment affecting resource efficiency.

Virtual servers drastically simplify management of compute resources. It allows proper relocation of server resources without the need of advanced performance design. Server virtualization enables efficient use of existing resources and simpler adjustment to changes in requirements or in the virtual environment.

**Before Desktop Virtualization**

**Physical server**
- Large installation space and high power consumption
- Heavy operation and management workload
- Challenging resource design

**After Desktop Virtualization**

**Single Physical server + virtual servers**
- Reductions in installation space and power consumption
- Reduction in operation and management workloads
- Effective use of resources

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**Figure 1: Benefits of server virtualization**

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1-2. Progress toward desktop virtualization

Server virtualization became mainstream and the most efficient industry trend. Consequently, desktop virtualization has become prominent. Desktop virtualization is a technology that enables the virtual image of a desktop screen to be installed on a server, and used from a remote location through the network.

NEC provides several types of virtualization solutions, each tailored to a specific purpose. Many of them are deployed on VMware® Horizon from VMware, the industry prevailing standard in virtualization.
The major benefits of desktop virtualization are enhanced security and simplified management.

Enhanced security

Because applications and data reside on servers that are behind the firewall in the desktop virtualization environment, the risk of information leaks can be reduced in case the terminal is lost or stolen. 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, increasing security and preventing information leaks.

Simplified software updates

Desktop virtualization makes it easier to update software and Operating Systems.

With the increased use of Internet and data exchange in the workplace, security threats including malware infections and unauthorized accesses became major issues. While security software is effective in protecting against threats, software definition files are updated so frequently that it is hard to maintain an accurate grasp of the update status of every single computer. Naturally, it becomes challenging to ensure that the same security measures are applied uniformly to all physical devices, resulting in an ever-growing overload on the system administrator. Also, keeping application software at the same level on all computers is another burden on the system administrator and can result in processing errors due to down-level application and OS software.

By introducing desktop virtualization, the tasks of updating software and applying security measures that were conventionally performed regularly in each PC can be executed altogether in the server. This simplifies system management and minimizes security risks due to out-of-date OS and application software.

![Diagram: Before and After Desktop Virtualization](image-url)

**Before desktop virtualization**
- Risk of an information leak if the terminal is lost or subject to cyber-attacks
- Burdensome task of updating the OS and applications
- Data and applications can only be used at the PC location.

**After desktop virtualization**
- Enhanced security
- More efficient updating
- Data and applications can be used from a remote location.

Figure 2: Benefits of desktop virtualization
In 2002, NEC established 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 high availability servers such as Express5800 series, and reliable storage solutions, like the M-Series ideal for virtualization.

Focusing on 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.

VSphere 6.0 is the most updated virtualization platform in the market. Since NEC participated in the whole development of vSphere 6.0, our storage solutions are not only certified, but support vSphere 6.0 more efficiently than other competitors.

1There are only six companies in the world that have passed the β certification test for vSphere Virtual Volumes; NEC is one of them.

### 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 developed and released products based on advanced testing of next-generation VMware products.

![Figure 3: History of collaboration between NEC and VMware](image)

### 2. About vSphere Virtual Volumes

VMware has been promoting the concept of Software-Defined Data Center (SDDC), an architecture in which all the components in a data center are controlled by software. Software Defined Storage (SDS) is at the core of this architecture with the purpose of shifting from a hardware-centric design to one focused on applications (virtual machines). SDS enables (1) independent operation and management, and (2) optimized storage for applications. Virtual Volume is one of the key technologies of SDN designed to advance the integration of storage and VMware vSphere® virtualization software, allowing integrated management of virtual machines and storage.

Virtual Volumes were developed to address the new issues that surfaced from the increasing adoption of virtualization environments.

Conventionally, virtual disks are managed on a logical unit (LUN) basis (the unit used by the server to recognize a single storage system). With this method, the storage system creates a LUN to identify an area that will be used by several virtual machines. Multiple virtual machines share the LUN as virtual disks on the server. The only processing performed by the storage system is LUN creation, and the storage is unaware of which virtual servers share that LUN.
NEC’s support for VVOL dramatically improves management of individual virtual machines and images. The complexity of dealing at the LUN level for conventional storage and virtual volume level for VMware will be eliminated.

As a result, the storage performs management based on LUNs while the server performs management based on virtual disks (VMDKs.) This difference in management granularity has affected 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 properly at the service level of a specific virtual machine.**

Since the settings on the storage are LUN-based, (instead of virtual-disk-based), a special high-performance service cannot be provided to a specific virtual machine’s virtual disk according to importance or priority when multiple virtual machines share the same LUN. Because backup and snapshot settings are also LUN-based, detailed settings cannot be configured or managed for each virtual machine individually. In addition, 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 increased server load.**

Unique capabilities of storage systems including quality-of-service (QoS), replication, data tiering, and performance monitoring all, operate at the LUN level and cannot be used/tuned to work with virtual volumes.

For example, when the snapshot function of conventional storage is used to create snapshots, those snapshots only can be bone for a LUN. Creating snapshots for each virtual disk requires processing on the server, which can result in degraded performance.

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 (virtual disk level). The backup function of storage, however, can only back up all the data of a particular LUN. This method creates extra operational complexity because, when data is restored, the other virtual machines using the same LUN are also rolled back to the state they were when the data was backed up.

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

vSphere Virtual Volumes is the technology designed to address those issues.
2-1. Overview of vSphere Virtual Volumes

The concept of vSphere Virtual Volumes itself is very simple. It is centered on dividing the data area used by virtual machines into new common units called “virtual volumes (VVOLs)”, having both, storage and server, recognize those common units.

Since VVOLs are assigned to individual virtual machines, administrators can select a policy according to the service level requirements of each virtual machine.

What benefits do Virtual Volumes deliver? Following are several specific examples.

2-2. Storage policy operation and management at the individual virtual machine (VVOL) level - Solution to issue 1

Because the storage system can now identify virtual volumes created for each virtual machine, it is possible to operate and manage virtual volumes on an individual virtual machine basis. The server administrator can easily create a VVOL by selecting a “storage policy” when while creating a new virtual machine. This storage policy, typically given a name like GOLD or SILVER, is a template in which storage policy information is defined, 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 as needed, thus eliminating the need for demand of excessive provisioning (allocating extra storage capacity beforehand to cover possible capacity shortages). This improves the operational efficiency of the entire storage system.
2-3. Making effective use of storage functions at the VVOL level to reduce server load - Solution to issue 2

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

In desktop virtualization, a template is prepared to define the standard desktop. This template is used to create new virtual desktops (clones). These operations can be accelerated by using the storage system offload some of the work to create a clone.

Two cloning features are available: full clone and fast clone. When using templates and the fast clone feature, only changed data is created on the storage system and the duplicate data is only stored once. When compared to the full clone approach (the whole virtual machine is placed on the physical storage), fast cloning reduces physical capacity required, and because common data is shared, a higher cache memory hit ratio improving performance.

Changing snapshot processing to leverage storage functionality

Conventional VMware 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. This is managed by the virtualization software because the storage system is managing at the LUN, and not at the virtual volume level. When multiple snapshots are created, however, it may be necessary to scan all the snapshots depending on the processing involved, which can degrade server performance. There are also other problems, such as the time it takes to consolidate snapshots and the size of the snapshot file, which becomes overtime, based on the amount of use of this feature. Those shortcomings make it inefficient to use the snapshot function in a 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.

On the other hand, when creating snapshots in an environment that deploys Virtual Volumes, the snapshot function of the storage system is effective and do not impact performance. The processing is the same as with the conventional snapshot function; however, while the snapshot command is still issued from the server, the actual processing is performed on the storage system, allowing the snapshot creation to be executed without placing an excessive load on the server or network.

Making effective use of storage functions

As stated earlier, virtual volumes (VVOLs) used by virtual machines are recognized by both the server and storage. This allows administrators to efficiently maximize the functionality and operation of their storage system.

For instance, the process of backing up and restoring data is much simpler and faster in an environment that deploys Virtual Volumes, using its replication capabilities on the storage system.

In the past, data was backed up on an LUN basis. Consequently, when a LUN shared by multiple virtual machines was restored, both the failing and the normally operating virtual machines sharing the same LUN were also rolled back to the previous state, making recovery of a single virtual machine complex and time consuming.

Nowadays, in an environment that deploys Virtual Volumes, data is backed up and restored on an individual virtual machine basis using VVOLs. VVOLs enable administrators effectively use storage-specific functions such as VVOL replication and overwriting, facilitating faster troubleshooting and simplifying recovery.
3. NEC Storage Solutions for Virtual Volumes

Implementing the benefits of Virtual Volumes requires a storage design that is compatible with VVOL. As a partner of VMware, NEC has collaborated on Virtual Volumes implementation from an early in its development, enabling us to deliver Virtual Volumes-enabled storage products ahead of competitors. The NEC Storage M-series is a suite of storage products that offer not only the Virtual Volume features from VMware, but also a set of solutions designed to maximize performance and simplify usability in environments that deploys Virtual Volumes. Described below are standard Virtual Volumes functions that the NEC M-Series support and NEC M-Series unique functions that extend Virtual Volumes benefits even farther.

**NEC M-Series Storage solutions for environments that deploy Virtual Volumes:**

1. **Standard functions of VMware for Virtual Volumes**
   - SDS model with Virtual Volumes for simplified operation and management
   - VVOL-based snapshot, for data backup and restoration
   - Cloning for performance, minimizing load on server and network
   - Elimination of pre-allocated LUN/Volumes for greater data management
   - Policy-driven automation

2. **In addition to policy-based simple configuration and management, NEC offers a function to link with Virtual Volumes associated with each policy**
   - QoS 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. **Maximization of backup and restore functionalities**
   - 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.

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

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

As servers and storage are virtualized, more virtual machines access a single physical storage unit. Under normal load conditions, this does not pose any problem. In some cases, however, a specific virtual machine might start placing a high load on storage, which might limit access to storage by other, virtual machines that require higher priority. If this causes a slowdown in processing of a mission-critical business-level virtual machine, it could lead to serious problems. The NEC Storage M-Series, quality of service (QoS) I/O control function allows setting minimum and maximum I/O limits. Consequently, the I/O control can keep I/O performance (number of data inputs and outputs per second) for high priority virtual machines above a certain level and throttle lower level virtual machines to a maximum I/O level to prevent storage overload and stagnation of mission-critical virtual machines. With a typical I/O control method, an upper limit is set for the I/O operations. If a load exceeding the upper limit occurs, the IOPS of the virtual machine that is placing an excessive load is controlled, preventing it from affecting other higher priority virtual machines. With NEC’s I/O control function, a lower limit can also be set. This means that the I/O load of a higher priority virtual machine will not
drop below a targeted I/O level, guaranteeing higher I/O levels for higher priority virtual machines. NEC’s I/O control function provides QoS based on priorities, which keeps the entire system running smoothly. The I/O upper and lower limits can be registered in advance as storage policies, such as GOLD and SILVER. Users can simply choose a storage policy when creating the VVOL area, simplifying VVOL creation and eliminating errors in VVO definition.

### 3-2. Automatic data tiering for each virtual machine with NEC Storage PerforOptimizer

Hybrid storage consists of several types of storage with different performance and cost profiles, such as SSD, SAS HDD, and nearline SAS HDD. Storing frequently accessed data and infrequently accessed data together on a high-performance expensive storage is inefficient. NEC’s PerforOptimizer automatically allocates data to the optimum storage based on access frequency.

SSD (for high speed data access), high-performance SAS HDD (for mid-tier performance), and high-capacity nearline SAS HDD (for low cost moderate access) are combined into a hierarchical structure creating a tiered storage pool. Data is automatically allocated to optimum disks in different storage levels, by distributing frequently accessed data to SSD, less frequently accessed data to nearline SAS HDD, and infrequently accessed data to nearline SAS HDD. Tiering can be applied on an individual virtual machine basis. Not only access time but also the amount of transferred data and application-specific access patterns (random vs. sequential and read vs. write) are analyzed for each data file. Data is automatically reallocated using NEC’s unique algorithm. NEC’s deep knowledge of storage and access patterns played a key role in defining these unique algorithms.

It is also possible to create templates that specify the ratio of tiering media based on storage policy, such as GOLD or SILVER. Users can assign a predefined policy to optimum data areas in the same storage pool based on the intended use, simply by choosing a predefined storage policy when creating the VVOL area. This allows users to maximize storage performance and optimize storage costs simply through predefined templates.
3-3. SSD L2 cache setting for each virtual machine *NEC Storage PerforCache*

Increasing the hit ratio of 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 requests received from the application, concentrated accesses to the hard disk caused by a series of cache-misses will result in delays, leading to wait time for the I/O to complete or hot spots on highly accessed disk drives. This 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 with.

L2 cache can be implemented quickly and effortlessly regardless of whether the system is operating or stopped. All that is required in a hybrid system is to redefine SSD in the storage system to L2 cache; there are no additional costs because existing SSD is being repurposed as L2 cache. For example, if the size of data that a virtual machine frequently reads is very large and the L1 cache cannot store all of it, the data can be allocated to L2 cache resulting in higher hit ratios and enhanced virtual machine performance.

It is possible to manage L2 cache at the virtual machine level. L2 cache can be turned on or off; the cache capacity can also be set individually, in read-only mode or read/write mode. It can all be defined at the virtual machine level. As a result, if there is an unexpected drop in performance that was not anticipated in the design phase, adjustments can be made to the affected virtual machine without affecting any other virtual machines and without causing service downtime. 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 during the maintenance period.

![Figure12: SSD L2 cache](image)

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 when many virtual machines execute boot-processing at startup.

V VOL allows you to choose between full clone, which copies the whole virtual machine (current conventional method), and fast clone, which only copies differences from the master data. Fast clone provides a dramatic reduction in required storage capacity compared to conventional cloning. NEC’s solution takes VVOL fast cloning one step further by storing the master data accessed by multiple clones on SSD as shared master data. The SSD’s fast response speed is leveraged to improve throughput and prevent concentrated accesses causing hot spots.

![Figure13: Enhanced cloning function](image)
3-5. Enhanced backup/restore function

Since conventional backup/restore functions backup and restore data on a LUN-by-LUN basis, it is not possible to backup the data of 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 a specific virtual machine, causing all other virtual machines on the LUN to be rolled-back to the state they were when the data was backed up.

In a Virtual Volume environment this problem is solved because the backup/restore function is used for each virtual machine individually, making backup/restore operations significantly more convenient. Additionally, with NEC M-Series storage, backup/restore commands are issued from the server but the actual processing is done on the storage system. This enables backup/restore operations to be carried out without placing significant load on the CPU of the server or the data path. With the NEC M-Series storage system responsible for backup/restore operations, M-Series effectiveness becomes a key factor. NEC M-Series Storage also provides the functions and solutions described below assuring efficient and easy-to-use backup/restore capabilities.

1. DynamicDataReplication (DDR)

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

Since the processing is executed on the storage system, large amounts of data can be backed up at high speed while the server is online and performing other processing. Additionally, when executing a restore in the event of failure, processing of data on the master volume 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.

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 I/O load-intensive work such as searching or referencing data in replication volume, while production work addressing the master volume continues without causing an impact to the production application server performance.

2. RemoteDataReplication (RDR)

RDR creates a replication volume in a different storage system (remote data center or different system in the same data center). For example, an external replication volume can be used 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 allowing production data to be used at the remote location for non-critical processing such as data mining, patch application, and new system evaluation. RDR is ideal for reducing the load on servers performing critical production processing while maintaining data consistency at remote locations.

Figure 14: Utilization of the restore function

Figure 15: Conceptual diagram of RemoteDataReplication (RDR)
3. DirectDataShadow (DDS)

This technology enables server-less multi-generation backup, with a NEC M-Series storage, connected directly to a High Availability NEC HYDRAstor storage for example, without the need of a server.

A virtualization environment must not only provide high-speed backup, but it must also allow users to store multiple generations of backup. NEC HYDRAstor provides a low-cost, high-capacity storage that is optimized for exactly this kind of application. 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 and effective multi-generational backup solution 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, as well as an option to only back up difference data. The NEC HYDRAstor 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, contributing to operations management and communications costs reductions.

![Conceptual diagram of DirectDataShadow (DDS)](image)

Figure 16: Conceptual diagram of DirectDataShadow (DDS)

4. Configuration Example

The following illustration demonstrates an NEC-configuration using NEC Express5800 servers with NEC M-Series SAN storage and associated storage software solution, providing a fast, flexible and efficient virtualized environment supporting Virtual Volumes.

![Configuration recommended for an environment that deploys Virtual Volumes](image)

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

5. Conclusion

With the maximized use of Internet, information and data exchange across all industries, servers and storage capacity became key requirements to keep systems up and running, while storing valid information. Over the years, and as businesses requirements increased, systems became more complexes and space and power consumption became major issues. Virtualization is currently the most efficient and cost-effective solution to simplify system administration while reducing costs and environmental impact.

VMware vSphere virtual volumes became the industry-standard virtualization solution, and VMware vSphere 6.0 has the latest technology to address many of the issues facing traditional and virtual server and storage environments. NEC is a pioneer partner of VMware, developing and integrating our own state-of-art
NEC Corporation of America is a leading technology integrator providing solutions that improve the way people work and communicate. NEC delivers integrated solutions for Society that are aligned with our customers’ priorities to create new value for people, businesses and society, with a special focus on safety, security and efficiency. We deliver one of the industry’s strongest and most innovative portfolios of communications, analytics, security, biometrics and technology solutions that unleash customers’ productivity potential. Through these solutions, NEC combines its best-in-class solutions and technology, and leverages a robust partner ecosystem to solve today’s most complex business problems. NEC Corporation of America is a wholly-owned subsidiary of NEC Corporation, a global technology leader with a presence in 160 countries and $28 billion in revenues. For more information, visit necam.com.

In this document, we briefly explained Software-Defined Data Center (SDDC) and how Software-Define Storage (SDS) is the core of this architecture on virtualizing storage and optimizing it for applications. We described in details some of the issues that might occur without the appropriate solution, and how NEC M-Series Storage solution with VMware Sphere 6.0 could effectively address them, preventing system failure and virtually managing and storing data without impacting performance.

In a nutshell, here are some of the key benefits of VMware Sphere 6.0 Virtual Volumes on NEC M-Series Storages:

- **Simplified operation and greater data management:**
  Since virtual volumes are recognized by both server and storage, settings and configurations are easier at the virtual machine level, eliminating the problem of storage settings limited to specific LUNs, simplifying operational tasks, improving resource utilization and allowing more granular service-level application.

- **Higher performance and more convenient backup/restore capabilities:**
  Virtualized cloning, Snapshotting, and NEC automatic data tiering maximize storage functionalities and performance, and minimize server and network overload. Quality of Service (QoS) keeps system running smoothly and assures that missing-critical business-level data is protected and prioritized in case of system failure.

- **Policy-driven automation:**
  VVOLs allow policy-based metrics to be applied automatically to storage for each individual virtual machine rather than at the datastore level. Protocols such as Storage provider (SP), Storage Container (SC) and Protocol Endpoint (PE) eliminates the need to admins to ensure storage presentation and multi-pathing are consistent and uniform across all hosts. PEs also bring the ability to scale storage from a vSphere perspective to much larger configurations, making storage management simpler and more efficient.

- **Greater and sophisticated scalability:**
  With Virtual Volumes and Protocol Endpoints (PE), we can now have 256 PE devices from multiple different arrays presented to the same ESXi host, which means thousands of thousands of VVols presented to an ESXi host, resulting in scalability to sizes that was not achievable before.

NEC’s approach to maximize the benefits of virtualization and virtual volumes is based on a highly skilled team of engineers and developers, trained and specialized in VMware products. NEC offers a one-stop service, and provides customers with a rich suite of products and solutions designed to implement a cost-effective and high-performance virtualized environment. We have delivered virtualization products and solutions globally to a large number of SMB and Enterprises, educational institutions, local public organizations and healthcare providers.

The benefits of NEC M-Series Storage solutions with VMware Sphere 6.0 Virtual volumes is proven to increase performance and simplify system operation and management, enabling businesses to get the most of their storage investments, and take full advantage of the differentiated capabilities that only NEC storage solutions can offer.

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