IBM

IBM System Storage N series Reference Architecture for Virtualized Environments

Understand Clustered Data ONTAP benefits for dynamic cloud solutions

Size the right solution meeting your business requirements

Design scalable cloud solutions using N series storage

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IBM System Storage N series Reference Architecture for Virtualized Environments

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Preface

This IBM® Redbooks® publication provides deployment guidelines, workload estimates, and preferred practices for clients who want a proven IBM technology stack for virtualized VMware and Microsoft environments. The result is a Reference Architecture for Virtualized Environments (RAVE) that uses VMware vSphere or Microsoft Hypervisor, IBM System x® or IBM BladeCenter® server, IBM System Networking, and IBM System Storage® N series with Clustered Data ONTAP as a storage foundation. The reference architecture can be used as a foundation to create dynamic cloud solutions and make full use of underlying storage features and functions.

This book provides a blueprint that illustrates how clients can create a virtualized infrastructure and storage cloud to help address current and future data storage business requirements. It explores the solutions that IBM offers to create a storage cloud solution addressing client needs. This paper also shows how the Reference Architecture for Virtualized Environments and the extensive experience of IBM in cloud computing, services, proven technologies, and products support a Smart Storage Cloud solution that is designed for your storage optimization efforts.

Clients face many common storage challenges, and some clients have variations that make them unique. With RAVE, a proven and scalable solution has been created that consists of a rack of servers, storage, and networking components. Thus, we have carefully sized three scenarios, *Entry*, *Mainstream*, and *Advanced*, each based on preferred practices for real world workloads.

When used as the storage foundation, the IBM System Storage N series offers unified storage solutions. These solutions provide industry-leading technologies for storage efficiencies, instantaneous virtual machine and data store cloning for virtual servers and virtual desktops, and virtual data center backup and business continuance solutions.

This book is for anyone who wants to learn how to successfully deploy a virtualized environment. It is also written for anyone who wants to understand how IBM addresses data storage and compute challenges with IBM System Storage N series solutions with IBM servers and networking solutions. This paper is suitable for IT architects, business partners, IBM clients, storage solution integrators, and IBM sales representatives.

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Part 1

Solution design

This part of the book, solution design, describes the IBM System Storage N series with its latest operating system, Clustered Data ONTAP, as part of a modern and advanced infrastructure for cloud-based solutions. It provides details about a common architecture that is suitable for multiple models of cloud implementations, and addresses key design aspects of the storage, such as sizing and integration with other components of the infrastructure. In this chapter, readers can also find information about the features and capabilities of N series storage and the latest preferred practices.

In this part of the book, we provide information about the following topics:

- Introduction
- Architecture and design
- Introduction to Clustered Data ONTAP 8.2
- VMware vSphere integration
- Microsoft Hyper-V integration
- Server
- Networking
- Storage
- Storage design
- Common cloud services and deployment models

1

Introduction

This chapter provides an introduction to the Reference Architecture for Virtualized Environments, also referred to as *RAVE* version 2. The new architecture is based on the IBM System Storage N series, with its new Clustered Data ONTAP Operating System, as a key component in designing, building, and operating infrastructure with virtualized server, and for cloud-based solutions. RAVE version 1 was based on Data ONTAP 7-mode Operating System.

The following topics are covered:

- About this book
- Purpose and benefits
- Storage platform for cloud

1.1 About this book

The Reference Architecture for Virtualized Environments (RAVE) is a comprehensive update to the IBM Redpaper™ publication REDP-4865, dated 22 December 2012:

http://www.redbooks.ibm.com/redpapers/abstracts/redp4865.html

This is a storage centric technical book that focuses on IBM System Storage N series and its new operating system, Clustered Data ONTAP version 8.2. and its optimized integration with virtualized and shared infrastructures as a foundation for cloud-based solutions.

Beyond the expected technological updates to introduce the latest changes in the featured products, this book also addresses recent trends in data centers such as multiple hypervisors, converged infrastructure, and the storage aspects of software-defined Data Center (SDDC). Design details emphasize operational aspects associated with cloud-based solutions. The book provides a broader range of sample configurations that now cover the full spectrum from low-cost and entry-level deployments, all the way to the enterprise and service providers class of implementation, with Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS) models.

N series Clustered Data ONTAP, the focal point of the architecture, enables IT and businesses to realize the benefits of a truly non-disruptive, always-on, massively scalable and flexible storage solution for most computing environments. IT organizations can meet higher Service Level Objectives (SLOs) because planned and unplanned storage downtime caused by common operational routines such as code updates and hardware upgrades can be eliminated at the storage level. This aspect is well covered throughout the book and is an important advantage for any infrastructure that supports cloud-based solutions.

Another important aspect of Clustered Data ONTAP, which is addressed in this reference architecture, is the support of multiple storage controllers, also referred to as storage nodes, or just nodes, which are managed as a single logical pool, so operations can scale more easily. Seamless scalability allows companies to start small and grow big from a simple two-node entry-level storage cluster deployment and grow to 68 PB with 24 nodes with the high-end models, and it is a key features of Clustered Data ONTAP.

Preferred practices from IBM, VMware, and Microsoft were incorporated into this document, so beyond integration between the various components, the book also provides realistic sample configurations with the associated sizing details and the performance considerations. It also includes an implementation guide in an easy-step format.

This reference architecture stands out as the most flexible architecture that covers the broadest range of implementations of the current market needs for building cloud-based solutions. Conceptually the architecture is not new, but it does feature for the first time, N series with Clustered Data ONTAP. Together with the power of the virtualization capabilities from VMware and Microsoft, and the complementing features of the converged infrastructure delivered by the IBM Flex System, it brings a whole new level of simplicity, flexibility, and efficiency to data centers.

Agile infrastructure that is delivered economically has tremendous value to organizations around the world, regardless of business models. The fact that certain implementations of this architecture can start at a very low cost with minimal footprint, yet can scale easily over time and include set of advanced and unique features, makes the value proposition of this reference architecture a very compelling one.

The common architecture that is described and discussed here can be deployed by small businesses at a very low cost, by using hardware models that were designed for their type of environments. This book includes sample configurations that specifically meet the requirements of small businesses. Furthermore, there are references to solutions with hybrid clouds and the integration between internal and self managed infrastructure, and large cloud service providers, which can be found in the advanced sections of the following chapters:

- Chapter 9, “Storage design” on page 129
- Chapter 10, “Common cloud services and deployment models” on page 135
- Chapter 11, “Data protection and disaster recovery” on page 149

One of the major challenges in running a virtualized environment is to adapt to new methods of operation, mostly the automation of provisioning, on-demand consumptions of compute resources by the end-users, and the approach to cost, hence metering, billing, and monitoring. From a storage perspective, this book provides information about these aspects as well.

1.2 Purpose and benefits

This book provides a blueprint that illustrates the integration of IBM System Storage N series with Clustered Data ONTAP in virtualized environments that are based on VMware and Microsoft with x86 compute nodes. In addition to architectural level, the book provides specific design and configuration options to cover a wide range of deployment sizes from very small to very large. These configurations can be used as a reference or as-is (for as-built), depending on the specific requirements.

As with the first version that was published in December 2012, this book is also intended for Solution Architects and IT specialists who are seeking information about preferred practices when incorporating IBM System Storage N series in the design of their virtualized and cloud infrastructure, and how to benefit from the advanced features of Clustered Data ONTAP to save cost and time over the entire lifecycle of the solution. Here we list the new N series with Clustered Data ONTAP related topics that are covered in this document:

- Storage design with Clustered Data ONTAP
- Comprehensive information about data protection and its related operational aspects
- Sizing overview with realistic workloads
- Broad range of sample configurations
- The N series management tools
- Integration with virtualization technology from Microsoft
- Easy setup guide for both VMware and Microsoft server virtualization environments
- Reference to cloud service providers with IaaS and PaaS models
- Orchestration tools, OpenStack, SDK, and APIs

1.3 Storage platform for cloud

Although storage centric, and specifically N series with Clustered Data ONTAP, the architecture described in this book is aimed for cloud-based solutions because it emphasizes the key features of the Clustered Data ONTAP that optimizes IT operations in the support and management of virtualized servers and shared infrastructures.

We describe the architecture, which by itself is not a packaged product and is not a cloud platform. The book is designed to be a set of references and preferred practices that will help architects design cloud-based solutions with IBM System Storage N series. It also focuses on how to use the various storage features and capabilities in order to create a storage platform that is optimized to be an integral part of infrastructure for cloud solutions.

The differences between the various cloud models (private, public, hybrid) are not at the infrastructure level, because they are all similar from the storage and data management perspective. The differences are in the way the services are being consumed, the ownership of the infrastructure and other responsibilities such as security and access, and what is the balance between the shared and the dedicated components of the solution. Thus, the architecture described in this book can be relevant to all cloud models and the authors do not distinguish between them when referring to the technical integration of the storage with the other infrastructure components.

To state clearly, this book is suitable for public, private, and hybrid cloud, whether on the premises or externally hosted, as self-managed or as a managed service.

2

Architecture and design

The architecture and design chapter is the core of this book because it describes the storage entity as part of the infrastructure and provides examples that can be followed by IT architects when they design new cloud solutions. We describe one common architecture that can be implemented in multiple ways that makes it relevant to businesses at all sizes and models, including service providers. We also provide details about the storage design, its sizing, and operational related considerations.

The following topics are covered:

- Introduction to virtualized environments
- Introduction to cloud-based solutions
- Architecture overview
- Architectural approach
- Configurations and components
- Solution classification
- Sample workloads

2.1 Introduction to virtualized environments

This chapter describes the architecture of virtualized environments using VMware vSphere and Microsoft Hyper-V as two optional hypervisors, with hardware infrastructure components and management tools from IBM. At a deeper level, specific designs and sample configurations in this chapter provide details about the hardware components, including System x Server and BladeCenter that are commonly used by many clients and business partners, hence standard equipment in many data centers.

Converged infrastructure is becoming standard and quickly being adopted, particularly in mid-size and the enterprise clients, as well as by service providers. Even smaller constellations can benefit from a converged infrastructure because of the flexibility that it offers and the economical advantages that go beyond the procurement cost. The IBM Flex System Enterprise Chassis (with x86 compute nodes) is also covered in this chapter and throughout the entire book in order to address this important transformation to a converged infrastructure and provide referenced to environments that require more flexibility with better consolidation efficiencies.

As already mentioned, this book is storage centric and focuses on N series with Clustered Data ONTAP. With that in mind, readers can find in this chapter additional details about the unique features of N series Clustered Data ONTAP and how they come into play as part of the design, to enable solutions that are built on infrastructures that are more flexible and more scalable.

The architecture is kept at the essential level of creating a solid virtualized environment as the stage towards cloud-based infrastructure, and continues to the level of Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS). To make it more relevant for a broader range of implementations, from an entry level to a large service provider type, or enterprise level deployment, this chapter offers a comprehensive context by grouping the components into solution stacks with several configurations and a supporting sizing information.

2.2 Introduction to cloud-based solutions

Business agility in today's world relies on IT infrastructure more than ever before. New technologies are being introduced more often on a shorter cycle and data is being generated faster than ever and being consumed on demand, anywhere at any time. The technology drives social and cultural changes that ultimately impact businesses, forcing them to compete more globally, and to be able to adjust and embrace changes rapidly and more often. The higher rate of change dictates the need for flexible infrastructures that are scalable, elastic, reliable, and economical. In addition, there is a need for smarter and faster ways to connect the consumers.

The silos approach of optimized, dedicated compute nodes, the operating system, and the storage components of the infrastructure, for a specific solution, can rarely be justified economically nowadays, and is becoming obsolete in most cases. Virtualization, efficiencies in storage and the data management, and principles of economies of scale promoting shared infrastructure and Software-Defined-Data-Center (SDDC) to the front line of IT and IM services replacing the silos, are prominent characteristics of cloud-based solutions, regardless of the actual model (private, public, hybrid, internal, external or any other combination).

The cloud-based architectural approach illustrated in Figure 2-1 provides a fast and predictable way to scale IT infrastructures. It describes the transformation from application-based silos with dedicated hardware to a shared infrastructure that enables cloud solutions through a stage of adopting virtualization. The matching infrastructure is based on hardware from IBM in a traditional stack of System X servers and RackSwitch™ networking, and in a converged model with Flex System Enterprise Chassis and x86 compute nodes. Both server platforms are supported by N series storage with Clustered Data ONTAP.

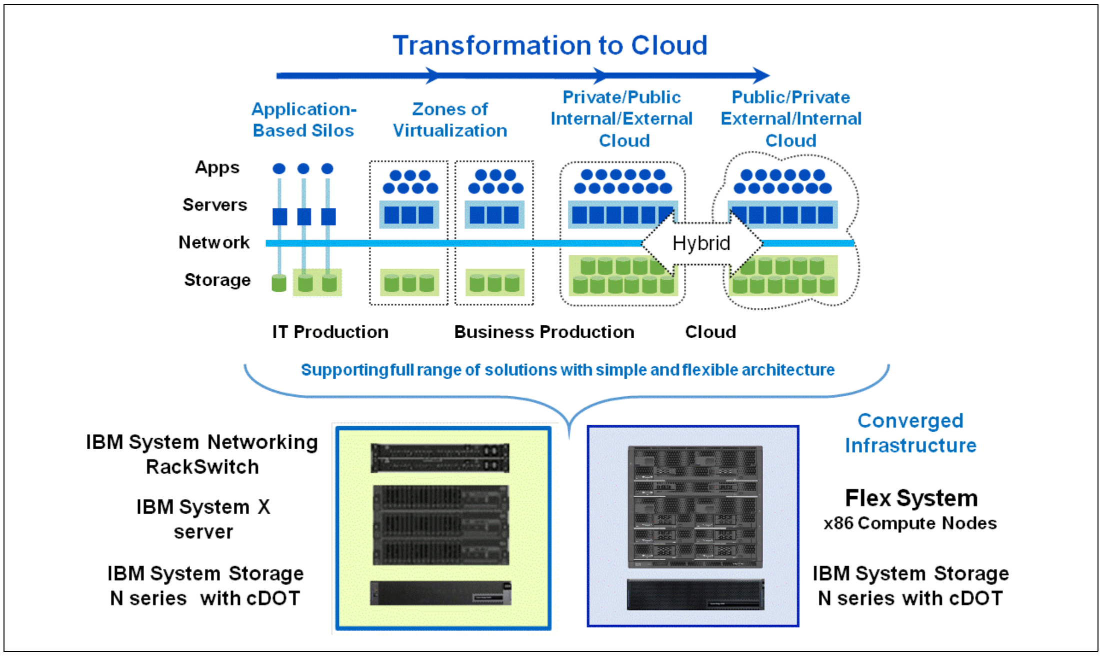


Figure 2-1 The transformation to the cloud

Flexibility is the value of the infrastructure, based on the features and functions of its components that can be associated with optimization of changes to the IT/IM services, often, a combination of minimizing cost, time, and risk, which are the exact reasons why companies are adopting cloud infrastructure. In addition to the right set of well-integrated infrastructure components, a cloud-based solution must include a comprehensive set of management tools with orchestration capabilities to handle logical flow of interactions between the business and the infrastructure, such as provisioning requests, metering and billing, monitoring, reporting, all with complete automation and self-service in order to simplify the access and usability of the service.

2.3 Architecture overview

The logical view of the architecture is depicted in Figure 2-2. The concept is simple and common, because it only includes the most essential components of the infrastructure, which also gives it the most flexibility to be used in multiple models of cloud implementations and services.

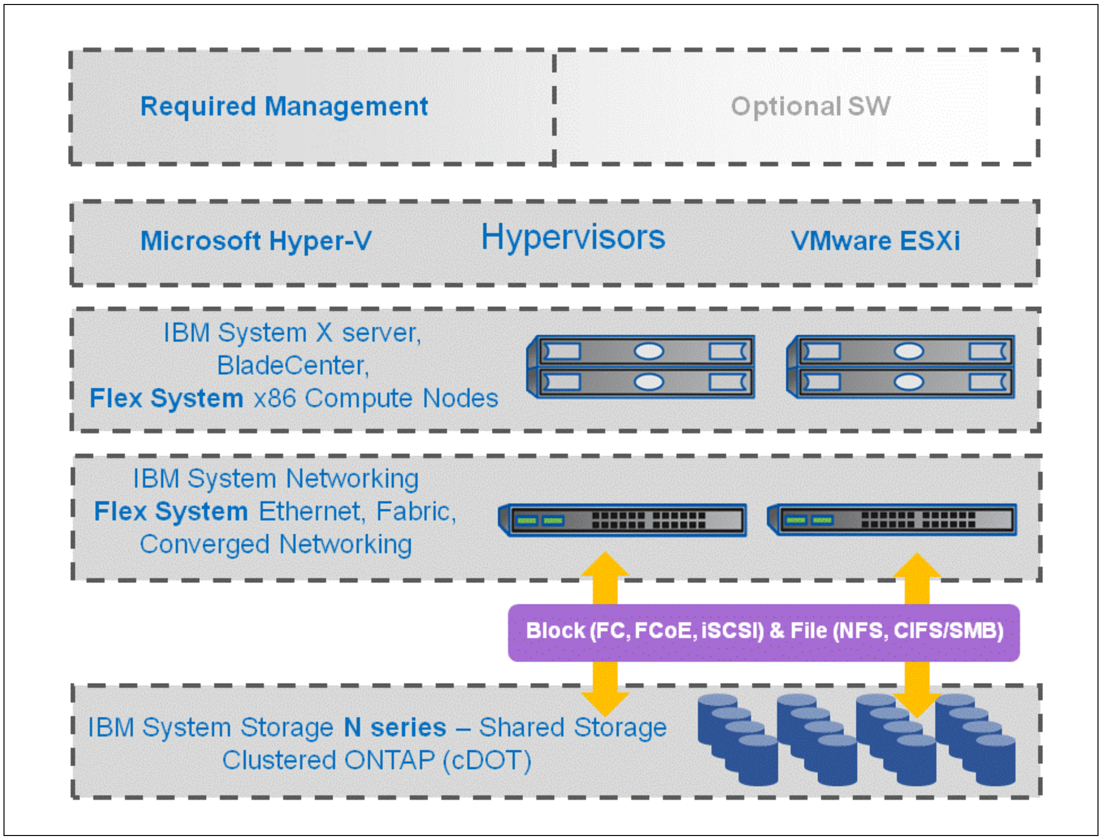


Figure 2-2 Logical Architecture N series Clustered Data ONTAP for virtualized environments

The entire IBM System Storage N series product line, running Clustered Data ONTAP 8.2, offers similar features and functions including optimized capabilities to serve as a shared storage with a unified architecture. Clustered Data ONTAP also offers new level of scalability now from a single node (no high availability) to 24 nodes in a cluster, so storage architects can easily design system for different needs and environments. The maximum number of nodes in the cluster will vary based on the specific storage model and protocols used, but in all cases, N series with Clustered Data ONTAP offers great flexibility.

The storage system supports multiple protocols, hence the solution can be based on SAN (FCP, iSCSI, FCoE) or NAS (NFS, SMB/CIFS), as well as a mixed environment with any combination of the protocols. For connectivity with the physical servers, the architecture suggests IBM System Networking with rack-mount form factor as well as Ethernet, fabric, and converged networking modules that can be configured in the chassis of IBM BladeCenter or the Flex System. For physical servers, the architecture features the IBM X servers and x86 compute nodes as part of the Flex System Enterprise Chassis. Besides management software that is required for the infrastructure, there is no additional application or a software package, so the top layer in the stack in the proposed architecture is the hypervisor, and both Microsoft Hyper-V 2012 and VMware vSphere (ESXi) are covered in this book.

The combination of integrated components increases value to businesses because it optimizes deployment, administration, support and scalability, hence reduces cost. To support business agility, IT teams must have the ability to add or reduce resources such as memory and disk storage capacity when required, in order to accommodate business demands from the users. IBM System x and IBM System Storage N series Clustered Data ONTAP support this dynamic scaling of resources. Furthermore, the combination of System x, N series with Clustered Data ONTAP, and hypervisor from VMware or Microsoft enable a flexible infrastructure in which its components are tightly integrated, so it is easier to manage and control, and as a result, to automate the infrastructure and to consume services at a lower cost. Hence this architecture is very suitable for the dynamic nature of cloud-based solutions.

In addition to VMware vSphere and Microsoft Hyper-V, the following key infrastructure components provide the foundations for this cloud-ready architecture.

IBM System x3650M4, HS23, HX5 servers, and Flex System with x240 & x440 compute nodes, are all optimized to meet the virtualization management and advanced workload demands of various cloud-based solutions.

The IBM N series N3220/40, N6250, and N7550T models were selected to bring high performance SAN and NAS features in a unified system with set of efficiency features, including deduplication and thin provisioning. In addition, N series products offer data protection capabilities for virtualized servers with no-performance-impact snapshots and thin replication for enabling and supporting disaster recovery and business continuity.

IBM System Networking enables Ethernet components that form the backbone connectivity. The combination of high performance adapters and low latency, cut-through switches enables the high-speed infrastructure that is critical for resource utilization and load balancing within the cloud. To provide additional flexibility, clients can choose IBM Fiber Channel (FC), Ethernet switches for their deployment, and converged networking solution as the IBM Flex System™ Fabric CN4093 10Gb Converged scalable switch.

Performance is a key consideration when supporting virtualization and elasticity requirements. Performance for most client needs to be balanced with affordability, and the architecture, along with preferred practices, do emphasize this delicate balance between cost and performance. The next set of attributes includes reliability and availability that are of paramount importance when designing an architecture for cloud services, and these aspects are also integrated features that are well covered in this book.

2.4 Architectural approach

The IBM System x and IBM System Storage N series, based on Clustered Data ONTAP, with VMware vSphere (ESXi) or Microsoft Hyper-V server 2012 as the server virtualization technologies, were brought together in this reference architecture to offer relevancy in a wide range of implementations and consumption models of cloud-based solutions.

Solutions based on this architecture can easily be sized to fit the needs of a wide range of deployment from Server Message Block (SMB) to enterprise clients. In terms of business and consumption models, the architecture is suitable for all types of cloud deployments (private, public, hybrid, internal, external, and various combinations) and can easily be used as the foundation layer to a more advanced and solution-specific type of services. By default, the architecture aims at the level of Infrastructure-as-a-Service (IaaS). The rest of the book complements the architecture and design section by covering integration, implementation, and operational aspects, suitable for both service providers and individual entities that manage their own cloud-based solutions.

IaaS is a common, lower level layer that cloud-based solutions can be built on. Thanks to advanced technologies, particularly the latest Clustered Data ONTAP of the IBM System Storage N series, the architecture can be used as the building block for Platform-as-as-Service (PaaS), and for application specific types of workloads, hence Software-as-a-Service as well.

This book provides guidelines and details about the architecture of the infrastructure and the storage design options that will benefit most businesses. Three different sets of configurations are listed in this section, all based on VMware vSphere 5.1 and Microsoft Hyper-V server 2012, and N series with Clustered Data ONTAP. Although these configurations share the same architecture, each one is designed to meet a different workload size with different performance requirements. The three sets of configurations are as follows:

- Entry
- Mainstream
- Advanced

The *Entry* set of configurations is aimed towards small environments but has the capabilities to offer the full range of features and functions that typically can only be found in expensive highly integrated platforms. The value is realized thanks to the unified architecture of Clustered Data ONTAP and the fact that the same storage operating system (OS) is used across all the configurations, regardless of the storage model used.

The *Mainstream* set offers the most flexibility for midsize companies and deployments, because it can start from fairly small two-nodes storage cluster at a low price point and can scale up and out significantly. The *Mainstream* set is based on the mid-range platform of the N series, which is a solid model that offers the greatest versatility and can be also used by the service provider for a solution that starts small and grows over time.

The *Advanced* set of configurations includes a storage model that is a member of the N series high-end line. The configurations in this group are aimed towards high performance and high capacity where the ability to scale fast, reliably, and economically is a must. To complement the features of the storage platform, the server options in the *Advanced* group include Flex System and the entire stack is positioned as a converged infrastructure.

Thanks to its unified architecture, the IBM System Storage N series offers unique scalability in three dimensions, both out and up as well as scalability at the operational level. This means that significant growth in data will not have a significant impact on IT resources.

In some cases, it might be more economical to scale by adding more storage controllers, by designing a solution that includes many small, entry-level storage units, versus the scale up approach of upgrading to a bigger controller model. The decision of scaling up or out will depend on a comprehensive understanding of the full operational complexity of the environment. This includes the performance characteristics, the management aspects, the integration between the hardware component of the infrastructure and the virtualization layer, the specific features of the software packages, and of course, cost comparison and the experience of the IT staff. In some cases, infrastructure cost is less expensive when scaling out by using multiple smaller servers and storage units, but the management cost and operational limitation might offset those cost savings.

2.5 Configurations and components

The set of components consists primarily of hardware and management software from IBM as well as hypervisor and management software from VMware and Microsoft. The *Entry* configuration class is aimed for smaller environment, lower cost, but it offers the same set of features and functions as the larger classes of configurations. Standalone *x3650 M4* are used as servers for the *Entry* set of configurations and the storage model is the *N3220*.

For the *Mainstream* set of configurations, the mid-range N series *N6250* is used, and for servers, the option of *x3650* or *BladeCenter* and *Flex System* based compute nodes if the environment is more demanding.

Networking for both the Entry and the Mainstream are based on the IBM RackSwitch G8124E, however, in case of BladeCenter and Flex System, then the networking will be based on their respective add-on modules for networking. For the Advanced set of configurations, the networking is based on converged networking or Ethernet module of Flex System.

The Advanced class of configurations is based on the converged chassis Flex System with x240 & x440 that are x86 compute nodes. For the storage layer of the Advanced class, N7550T is being used.

2.5.1 An early introduction to Cluster Data ONTAP

Because Clustered Data ONTAP is new, it is important to introduce the concept of the “storage cluster”. As indicated by the official name of the new operating system, “cDOT” stands for Clustered Data ONTAP. The same familiar Data ONTAP operating system of N series storage is now offered as a cluster, which means that more one storage entity can have more than 2 controllers, or nodes. Clustered Data ONTAP supports up to 24 storage nodes (or storage controller units), within the storage cluster. Storage nodes can be added in pairs (known as HA pairs for high availability pairs), so the minimum setting with high availability is a two-node cluster. In a four-node cluster, there are two HA pairs.

> **Note:** N series as a single-node cluster is a viable option and a supported configuration, however, preferred practices call for a two-node setting in production for high availability that is not possible in a single-node cluster. A single-node cluster can be upgraded to a two-node cluster.

In most cluster configurations, a storage node has to be connected to a dedicated switch (interconnect switch) in order to enable and maintain key functionality; this connection requires 10 GbE. The interconnect switch is not part of the standard data center network infrastructure, but dedicated to the storage only. Storage configurations are built and shipped with two interconnect switches by default when the cluster includes two or more nodes. Only specific switch models are supported and the current version is CN1610.

Clustered Data ONTAP 8.2 does support a switchless cluster configuration. With only two nodes in a cluster, redundant 10 GbE connectivity directly between the storage nodes is supported. Figure 2-3 illustrates the two options for connecting a two-node storage cluster. In the top section, the two controller units are connected directly to each other. The illustration does not show the required HA connections that are standard, hence also required. The lower section of Figure 2-3 illustrates the same two-node cluster but with the CN1610 interconnect switch.

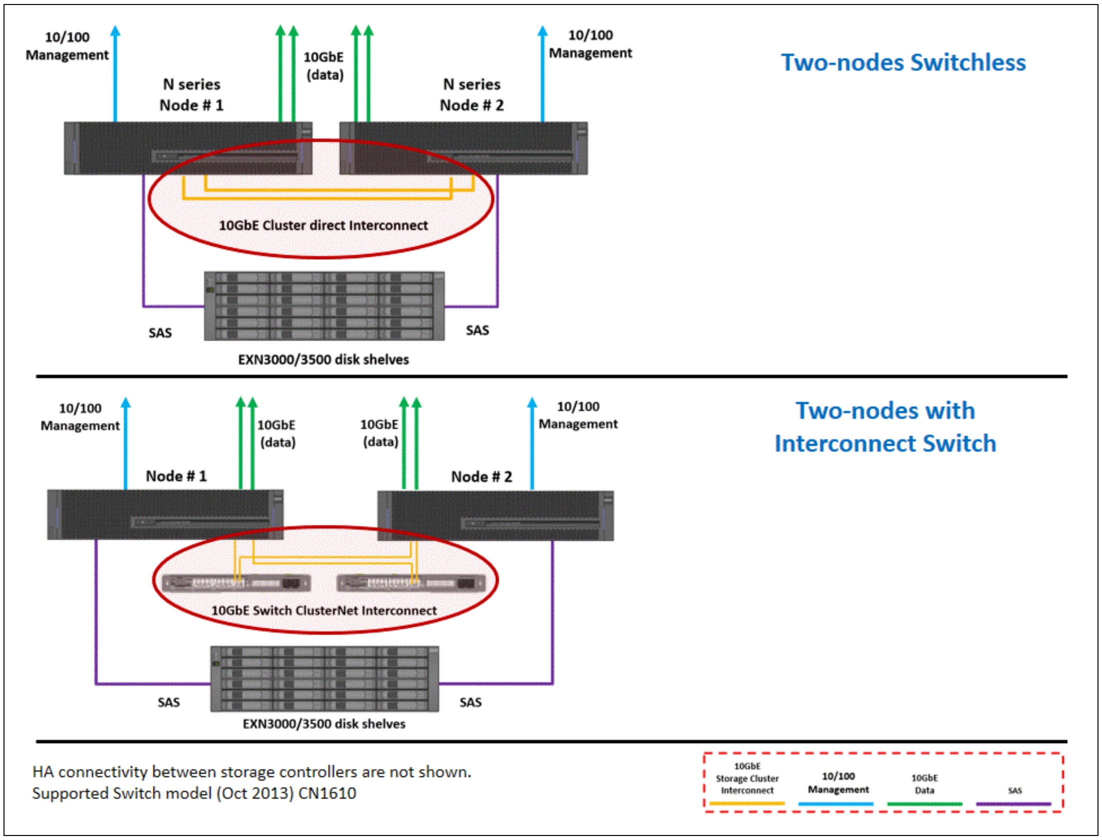


Figure 2-3 Options for two-nodes interconnect, HA connectivity not shown

2.5.2 About cluster limits

As mentioned, Clustered Data ONTAP 8.2 supports up to 24 nodes in a cluster. It is important to understand that the maximum number of supported storage nodes is a function of what N series storage model is included and what protocols are being used. At the time of writing this book, Clustered Data ONTAP supports the following maximum number of nodes per cluster:

- N7950T, N7550T: Maximum 24 nodes for NAS and up to eight nodes in SAN configuration
- N6XXX: Maximum of *eight* nodes per cluster
- N3XXX: Maximum of *four* nodes per cluster

Chapter 3, "Introduction to Clustered Data ONTAP 8.2" on page 23 provides more details about the limits in cluster configurations. Figure 3-1 on page 25 lists limits per model.

To provide information about a larger environment, Figure 2-4 illustrates a four-node cluster with two *CN1610* interconnect switches. To simplify the diagram and focus on the cluster interconnect and external connectivity, the HA connectivity between each of the nodes in an HA pair are not shown.

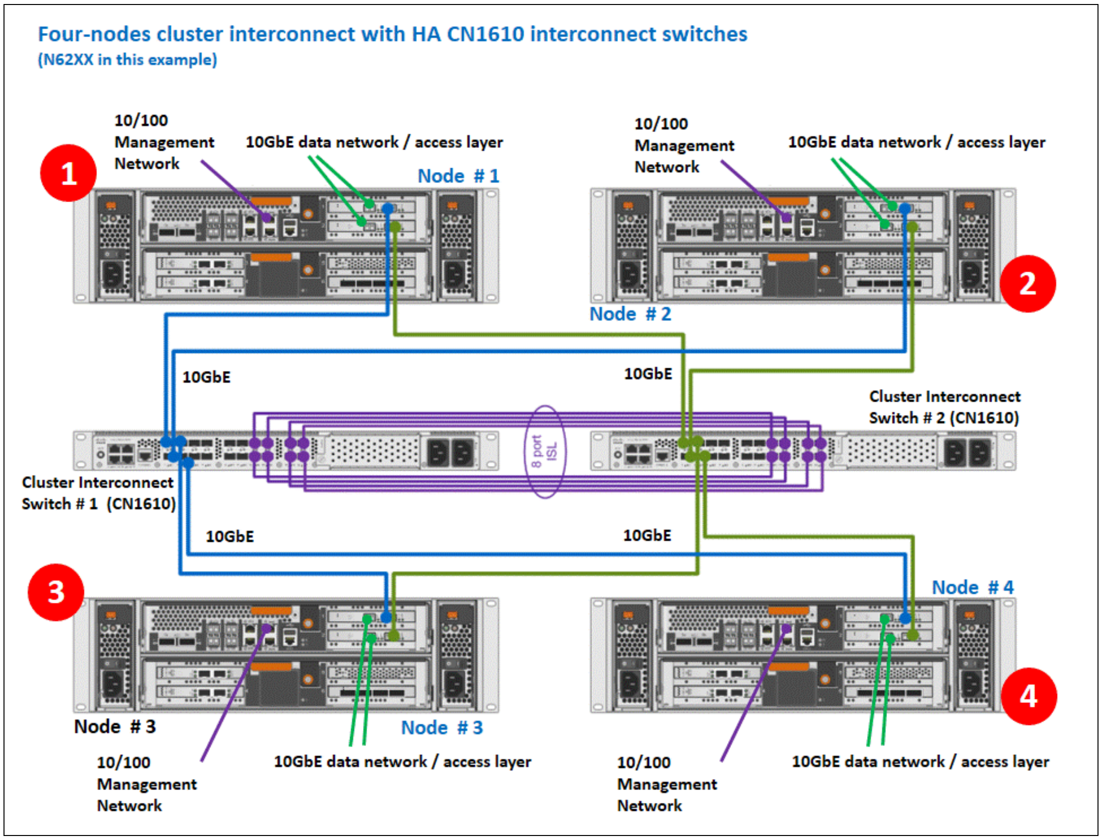


Figure 2-4 Four-nodes interconnect. HA connectivity is not shown

Understanding the concept of nodes in the storage cluster is critical in order to understand the operational capabilities, including how to scale with capacity, performance, and how to guarantee operational efficiency. It is also important for understanding the sizing assumptions and the workload examples.

2.5.3 Architectural diagram and components

Figure 2-5 illustrates the components that are part of the architecture. Optional components are mentioned if they add value to the solution and no matching alternatives are available. Details about sample configurations, software versions, hardware models, and part numbers are provided in other sections of this book.

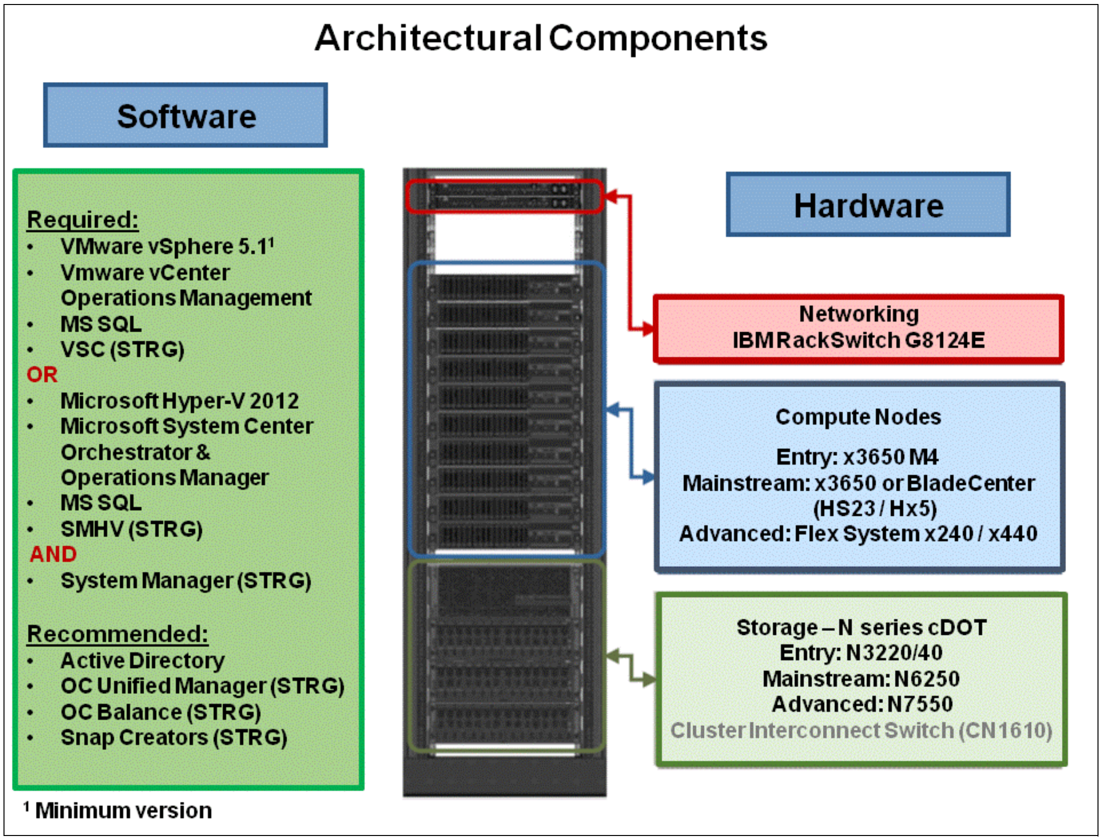


Figure 2-5 Architectural components

An example of storage, server, and networking components that complete the full infrastructure hardware stack is illustrated in Figure 2-6.

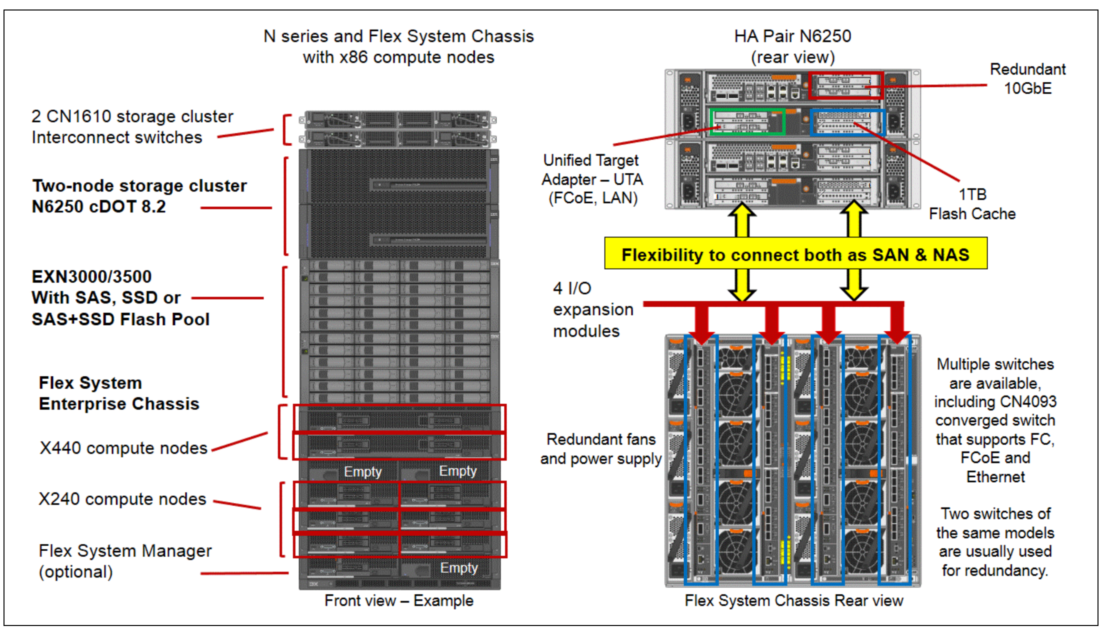


Figure 2-6 Hardware components and connectivity options

2.6 Solution classification

In this section, we discuss the characteristics of different set of configurations to help with their positioning.

As infrastructures become increasingly complex and heterogeneous, the need for more cost-effective end-to-end solutions that are easier to manage is also growing. IT organizations are seeking solutions that can manage and scale across the entire infrastructure. So it is important to develop an architecture that easily adapts to clients' businesses needs and supports dynamic growth.

The charts in Figure 2-7 indicate, for each configuration in the Entry, Mainstream, and Advanced sets, the maximum number of virtual servers (VMs) that can be supported. It is important to understand that the sizing was done based on very specific assumptions that do not represent every set of requirements clients are facing. The assumptions are described in Appendix A and can be modified as needed. It is also important to understand that proper sizing by a qualified engineer is required prior to deciding on the configuration and the design of the storage system.

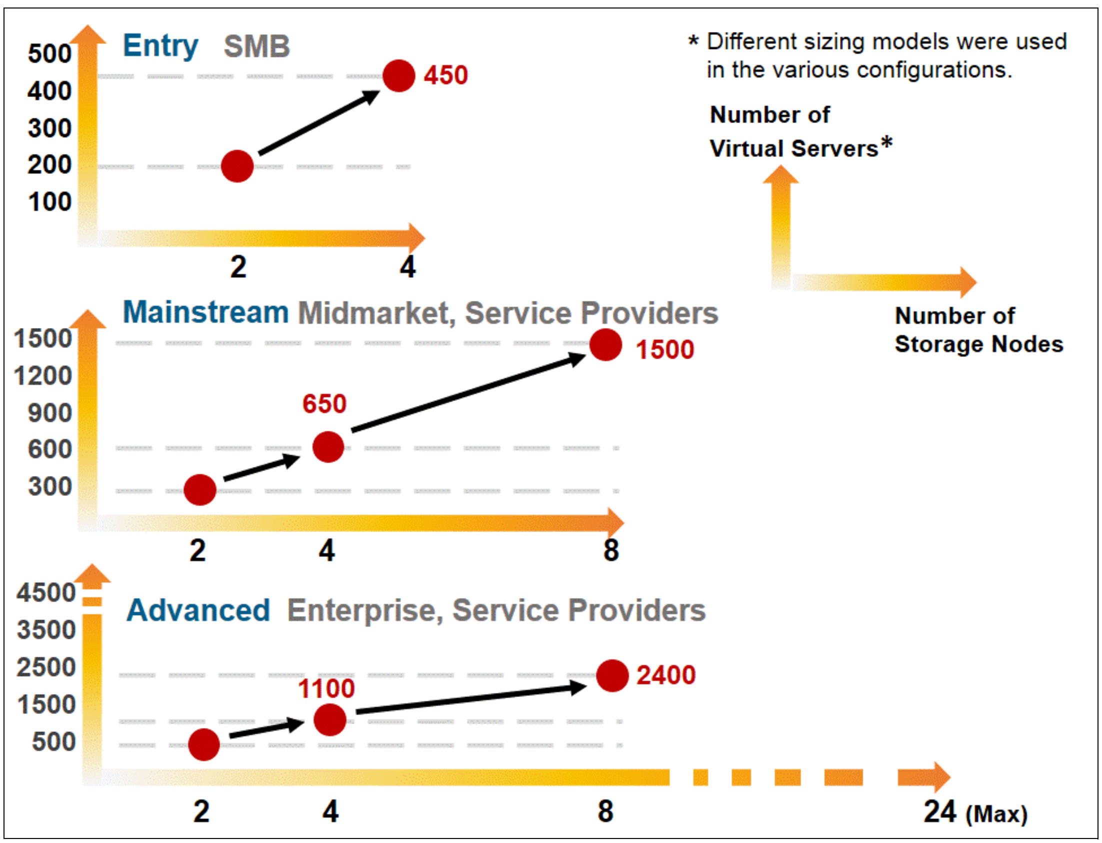


Figure 2-7 Solution classification indicating number of VMs per storage configuration

Next, Figure 2-8 lists the various load characteristics in terms of Virtual Servers, based on the solution components introduced earlier and as indicated by the charts in Figure 2-7. It is important to understand that the workloads and sizing information provided are based on several assumptions (described in appendix A) and that the sizing models used were not the same for all configurations. Despite the common architecture, various implementation models can be accommodated for different environments, because each can be unique, hence the infrastructure components must be sized by a qualified engineer; this is true for the N series storage and all other components.

Important: This book is not a sizing guide and should only be considered for reference. Each solution requires its own sizing, which needs to be conducted by a qualified engineer from IBM or by an IBM partner.

	Entry	Mainstream	Advanced
Networking	IBM G8124E	IBM G8124E or Blade	Flex System Ethernet or Converged
Servers[A]	x3650 M4	x3650 M4 or BladeCenter HS23 / HX5	Flex System Enterprise x240 or X440 Compute Nodes
Storage[B]	**N3220**	**N6250**	**N7550**
Number of Storage Controllers	**4**	**8**	**8**
Range of VMs[C]	**Up to 450**	**Up to 1500**	**Up to 2400**

A - Suggested server models
B - All configurations are based on 600GB 10K SAS. N6250 & N7550 also include 1TB Flash Cache per controller.
C - Number of VMs is based on specific sizing models as described in appendix A

Figure 2-8 Summary of workloads per category

Note: The information in this book regarding estimation of hardware requirements is based on sizing models, assumptions, sizing tools, and empirical data gathered from existing installations. Individual performance requirements are likely to vary based on individual client environments, applications, risk to business, and other similar considerations.

2.7 Sample workloads

This section discusses sample workloads for solution architecture.

Attention: Obtaining sizing support and guidance: Sizing practices and calculations are complex and should be conducted for each individual case. Clients should engage with IBM pre-sales engineers who are familiar with various sizing tools and techniques, to identify the required sizing parameters and their values for each workload, application, and task performed on and by the storage, and the other components of the infrastructure. Sizing calculations should also account for additional room for growth and for storage operations that are not directly serving data, such as storage deduplication, data replication, and other similar tasks.

2.7.1 Virtual Servers type workload

The following set of configurations, starting with Figure 2-9, are based on each group of the solution classification mentioned earlier: *Entry*, *Mainstream* and *Advanced*. Figure 2-9 outlines the *Entry* configuration.

Specifications	Entry Class Configurations		
Configuration #	# 1	# 2	# 3
Server Type	x3650	x3650	x3650
Number of servers[A]	2 - 4	8 - 14	16 - 30
Networking Switch	IBM G8124E	IBM G8124E	IBM G8124E
N series Model	N3240	N3220	N3220
Number of Storage Nodes	2	2	4
Interconnect Switch	No	No	Yes
Total Raw Capacity[B]	48TB	43TB	115TB
Disk Type	2TB SATA	600GB 10K SAS	600GB 10K SAS
Number of Server VMs[C]	Up to 80	Up to 200	Up to 450
Comments	This configuration is recommended for functional testing only	Two-node cluster does not require an interconnect switch	with four-node cluster an interconnect switch is required

A - Estimation of Hosts servers
B - Total capacity for the entire storage cluster. Figures are not for useable capacity.
C - Please refer to appendix A to learn more about the sizing models and assumptions used.

Figure 2-9 Sample configurations - Entry

Figure 2-10 outlines the *Mainstream* configuration.

Specifications	Mainstream Class Configurations		
Configuration #	# 1	# 2	# 3
Server Type	x3650 or HS23 / HX5 or x240 / x440	x3650 or HS23 / HX5 or x240 / X440	x3650 or HS23 / HX5 or x240 / x440
Number of servers[A]	16	32	76
Networking Switch	IBM G8124E or Blade or Flex System networking modules	IBM G8124E or Blade or Flex System networking modules	IBM G8124E or Blade or Flex System networking modules
N series Model	N6250	N6250	N6250
Number of Storage Nodes	2	4	8
Interconnect Switch	No	Yes	Yes
Total Raw Capacity[B]	58TB	115TB	230TB
Disk Type	600GB 10K SAS	600GB 10K SAS	600GB 10K SAS
Flash Cache	2 X 1024GB	4 X 1024GB	8 X 1024GB
Number of Server VMs[C]	Up to 300	Up to 650	Up to 1500
Comments	Interconnect switch is not required.		

A - Estimation of Hosts servers. Calculations are based on about 20 VM guests per host. Assuming BladeCenter, Flex System or x3650.
B - Total capacity for the entire storage cluster. Figures are not for useable capacity.
C - Please refer to appendix A to learn more about the sizing models and assumptions used.

Figure 2-10 Sample configurations - Mainstream

Figure 2-11 outlines the *Advanced* configuration.

Specifications	Advanced Class Configurations		
Configuration #	# 1	# 2	# 3
Server Type	BladeCenter HS23 / HX5 or Flex System x240 / x440	BladeCenter HS23 / HX5 or Flex System x240 / x440	BladeCenter HS23 / HX5 or Flex System x240 / x440
Number of servers[A]	26	56	120
Networking Switch	BladeCenter or Flex System networking modules	BladeCenter or Flex System networking modules	BladeCenter or Flex System networking modules
N series Model	N7550T	N7550T	N7550T
Number of Storage Nodes	2	4	8
Interconnect Switch	No	Yes	Yes
Total Raw Capacity[B]	58TB	115TB	230TB
Disk Type	600GB 10K SAS	600GB 10K SAS	600GB 10K SAS
Flash Cache	2 X 1024GB	4 X 1024GB	8 X 1024GB
Number of Server VMs[C]	Up to 500	Up to 1100	Up to 2400
Comments	Interconnect switch is not required.		

A - Estimation of Hosts servers. Calculations are based on about 20 VM guests per host. Assuming BladeCenter or Flex System.
B - Total capacity for the entire storage cluster. Figures are not the for useable capacity.
C - Please refer to appendix A to learn more about the sizing models and assumptions used.

Figure 2-11 Sample configurations - Advanced

Appendix A covers the assumptions used to determine the values of the required parameters for sizing the storage for a specific workload, or for the development of a model. N series with Clustered Data ONTAP offers a lot of flexibility when it comes to sizing the storage, and appendix A sheds some light on that aspect as well.

2.7.2 Mixed workload

The *Entry*, *Mainstream,* and *Advanced* set of configurations were designed and sized to support only virtual servers, simply because server virtualization addresses the largest common interest of cloud-based infrastructure and IaaS platforms. To some degree, the specific software packages and applications installed on virtual servers are merely nuances. From the storage perspective, it is critical to design the solution in a way that it can support the total required IOPS, capacity, and latency, regardless of what runs higher than the hypervisor in the stack. But when the OS and software packages are known, it is easier to design the storage in a way that it can perform in an optimized way at a lower cost.

If there is a known breakdown of applications that require lower latency, or a set of VMs running software that manipulates critical data, certain data protection features can be properly implemented for those VMs. Quality of Service (QoS) can be implemented effectively when we know that some of the VMs running on the storage are of a lesser or higher level of importance to the business as well.

Figure 2-12 describes a specific set of applications, each with its own set of performance requirements, that were simplified for the purpose of this paper. The mixed workload on the storage includes VDI, Microsoft Exchange, Microsoft SQL, and Microsoft SharePoint. Designing the storage now, when the applications are known, is more effective. Figure 2-13 illustrates that concept by showing specific allocation of the different applications to set the storage virtual machines (SVMs). Details about SVMs and Quality of Service (QoS) are covered in Chapter 3, “Introduction to Clustered Data ONTAP 8.2” on page 23.

Application	Total Users	Total Active Users	IOPS per Active User	Total IOPs	kb/s per Active User	Total MB/s	Capacity (TB)
VDI	3000	2400	15	36000	70	164	59
MS SQL Server	2500	1250	3	3750	52	63	1
MS Exchange	3500	2100	2	4200	25	51	2
MS SharePoint	2000	400	1.5	600	2	1	1
This example is not related to any of the previous Entry, Mainstream or Advanced configurations.It is provided to demonstrate a mixed workload envionment.				44550		280	62

Figure 2-12 Mixed workload Four-nodes N6250

Figure 2-13 also shows the high level design of a four-node cluster based on the N series N6250 model. Each set of two nodes (an HA pair) has 5 EXN3500 disk expansion units, each with 24 X 600 GB, 10K SAS drives, to a total of 240 disks. In addition, each controller has a 512 GB Flash Cache card (1 TB per HA pair and 2 TB total for the cluster). Color coded representation of the various applications is also shown on the disk expansions in the form of the SVMs. While the current configuration is based on a single type of disk, other configurations may include different disk types such as SATA or SSD. This offers some of the flexibility mentioned and the layout of the SVMs as part of the design can utilize the different disks to offer lower latency, lower cost, and other combinations that leverage the storage hardware.

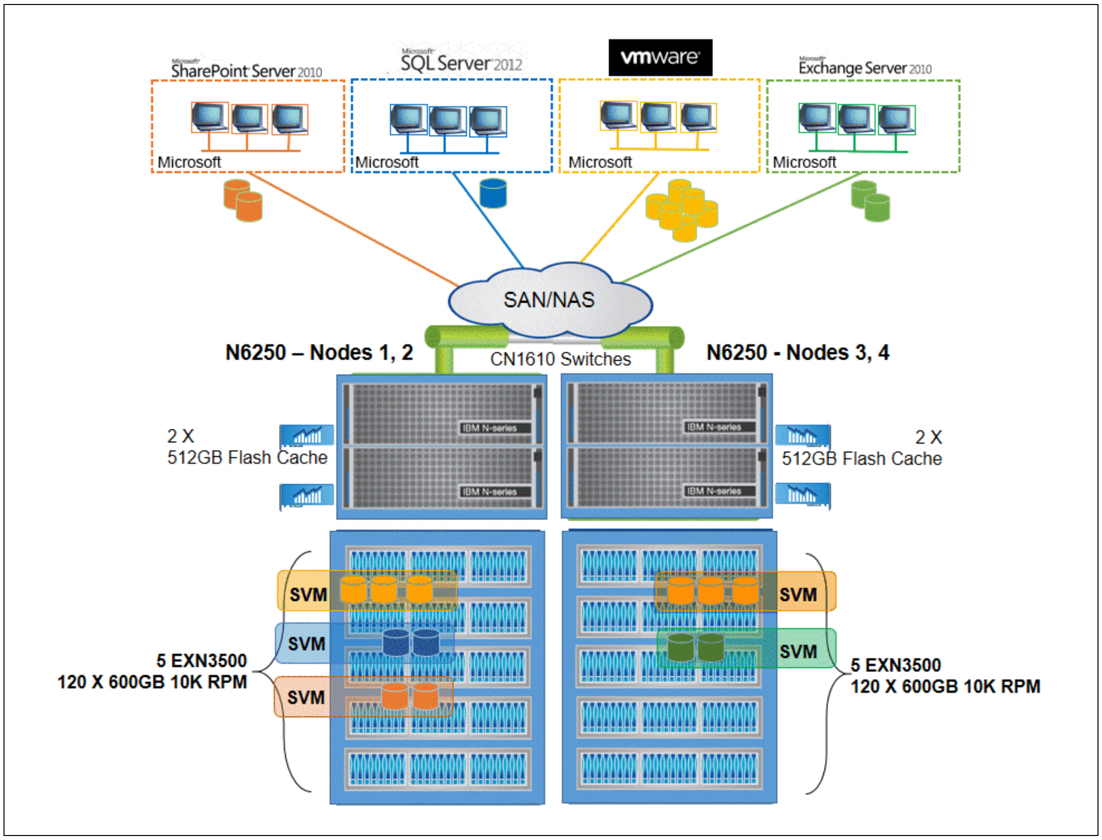


Figure 2-13 N series SVMs and design with a mixed workload

3

Introduction to Clustered Data ONTAP 8.2

IBM System Storage N series is now available with a new operating system called Clustered Data ONTAP. The current version, which is also the first version of N series with Clustered Data ONTAP, is 8.2. This chapter provides details about the key features and capabilities of the new storage operating system of N series.

The following topics are covered:

- N series with Clustered Data ONTAP 8.2
- Clustered Data ONTAP concept in the context of cloud-based solutions
- Additional features

3.1 N series with Clustered Data ONTAP 8.2

IT environments are evolving, and virtualization is being leveraged to transform data centers and to increase utilization, efficiency, and flexibility of infrastructures. It is important that all layers of the infrastructure will meet those new challenges and offer an adequate set of capabilities. This chapter discusses the key features of the IBM System Storage N series with the new operating system, Clustered Data ONTAP 8.2, which makes it suitable for tomorrow's challenges in the data center.

This book features Clustered Data ONTAP version 8.2, which is the first Clustered Data ONTAP version available on the IBM System Storage N series, and as of October 2013, is also the most current version available. Clustered Data ONTAP is different from previous ONTAP versions by the fact that it offers a storage solution that operates as a cluster with scale-out capabilities. Previous versions of ONTAP supported features and functionality of up to two individual storage controllers that are connected together to form a unit that is highly available (known as an HA pair) in Active-Active and Active-Passive implementations. Clustered Data ONTAP uses the same HA pair approach, but multiple HA pairs are now supported to form a single cluster storage entity with new set of features and capabilities that are complementary to the recent trends and transformation in the data center.

These new features and capabilities are discussed in this chapter and are grouped based on the following categories:

- Non-disruptive operations
- Flexible architecture
- Enhanced scalability
- Storage and operational efficiencies

Details about these features are provided in this chapter and some additional information is also provided in Chapter 8, “Storage” on page 101.

Two storage controllers (an HA pair) are the smallest cluster size configuration with high availability. Each one of the two controllers is referred to as a *storage node* in the cluster, hence one HA pair is a *two-node cluster*. Nodes must be added to a cluster in HA pairs, so a cluster always contains an even number of storage nodes. A 24-node cluster is built on 12 HA pairs. A single-node cluster is also supported and is considered a viable configuration, however, it does not offer high availability. A second node can be added to a single-node cluster as described at the beginning of the flow illustrated in Figure 3-2.

The two nodes in the HA pair must be the same storage controller model, and to operate as an HA pair, they need to be connected to each other. This connectivity is in addition to any connectivity to the interconnect switch (if required based on number of nodes). Not all the HA pairs in a cluster need to be of the same storage model. For example, a six-node cluster can be based on two HA pairs of N6250 and one HA pair of N7550T. The same concept applies to gateway models of the N series, and gateways can be mixed with non-gateway models.

The maximum number of nodes in a cluster is determined by the N series model and the protocol used. Mixing models is not advisable, however it is acceptable for periods of migrations and upgrades, since it is easier to achieve maximum operational flexibility if all nodes in the cluster are equal in terms of performance capabilities and capacity.

Figure 3-1 illustrates the maximum number of nodes in a cluster. Figure 3-2 provides an example of how N series cluster can scale in a non-disruptive way from a single node to a multi-node with different models of N series in the mix (interconnect switches are not shown in Figure 3-2).

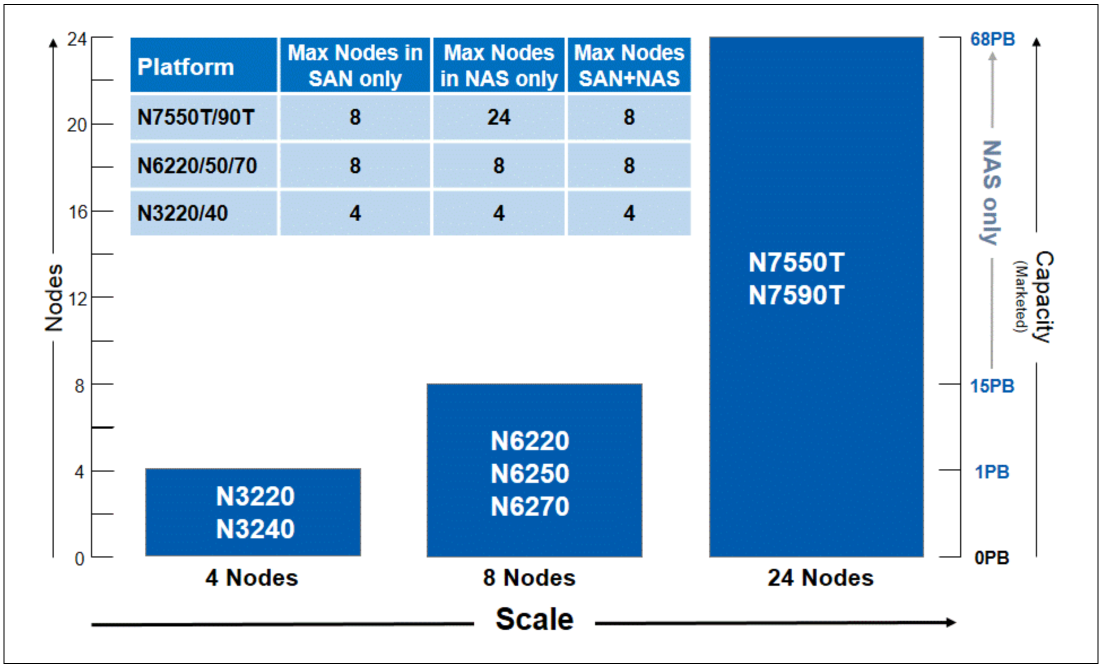


Figure 3-1 Cluster limits per N series model

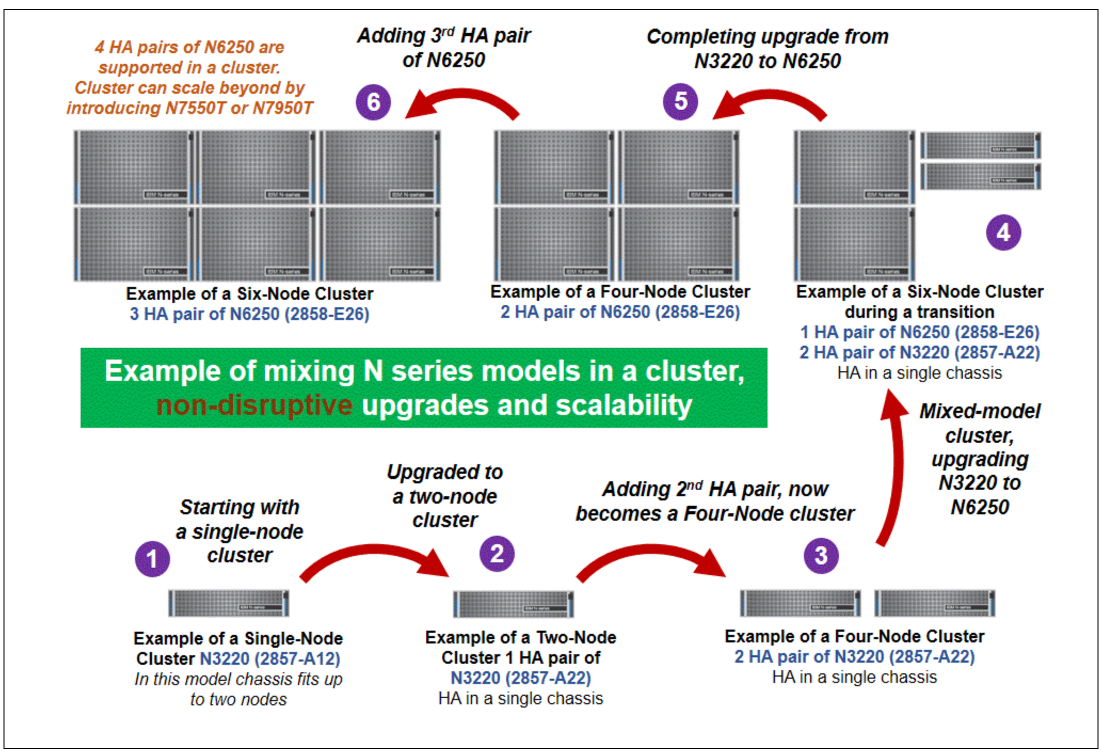


Figure 3-2 Examples of mixed-model cluster and non-disruptive upgrades

3.1.1 Non-disruptive operations

Non-disruptive operations (NDO) provides fundamental value to Clustered Data ONTAP and establishes its affinity to cloud-based solutions and service providers environments. Figure 3-3 provides an illustration of three aspects of operations where the non-disruptive capabilities of N series come to play.

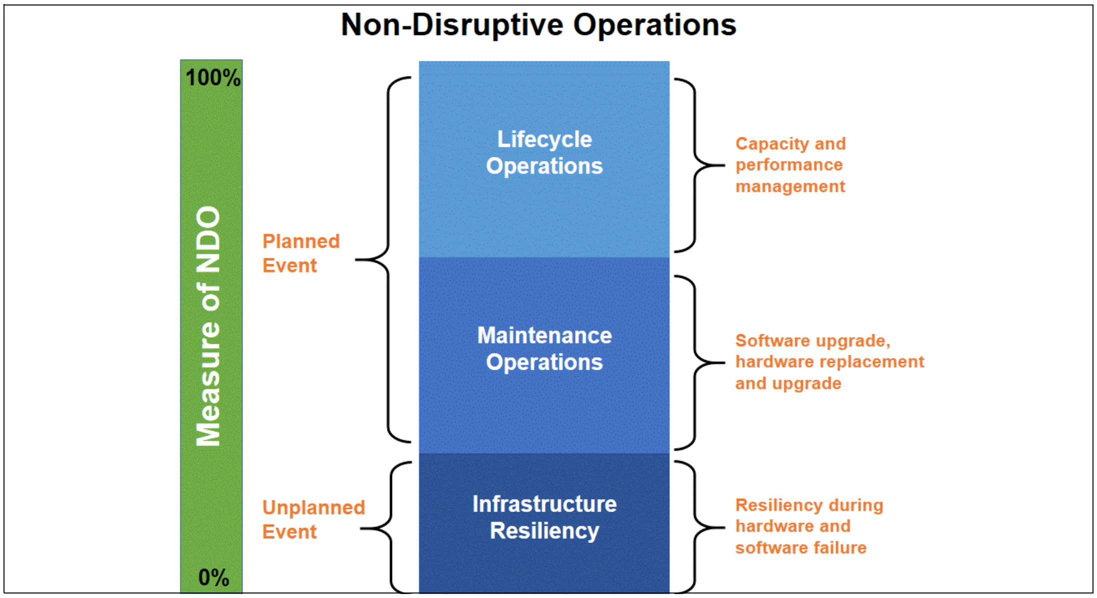


Figure 3-3 Aspects of NDO

Most of the N series features and specific technologies that enable or contribute to the NDO ability are listed here and are also covered in greater detail in Chapter 8, “Storage” on page 101:

- DataMotion
- LIF MIgrate
- Aggregate Relocate
- HA pair
- Multipathing
- Redundant FRU components
- RAID DP

These features, together or individually, support the following list of NDO use cases:

- Transition from a two-node switchless cluster to a switched cluster
- Grow cluster beyond two nodes
- Optimize and balance performance and capacity across nodes with DataMotion
- Upgrade controllers with Aggregate Relocate
- Perform rolling upgrades across multiple controllers
- LIF migration
- Multipath access in SAN environment
- Continuously available shares with Server Message Block (SMB) 3.0
- Cluster Quorum and data availability

The following sections provide examples of five use cases of how clients can benefit from the NDO capabilities of N series with Clustered Data ONTAP 8.2.

Lifecycle Operations: Capacity and Performance Management & Optimization

The Challenge: Tie workloads to a pool of storage that may not be cost optimized or performance optimized for the workload.

NDO Solution: Migrate storage resources to storage resources within the cluster that have a price/performance optimization-matched workload SLA. for example, if current storage media used is SATA and it was determined that SAS drives are more adequate.

Enabling feature: DataMotion for Volumes.

NDO solution: Migrate network resources to have the most optimized path to the migrated dataset.

Enabling feature: LIF Migrate.

Lifecycle Operations: Storage Scalability

The Challenge: Prevent inefficient and costly over provisioning of deployment of storage resources. Over provisioning has larger up front storage costs for resources that will go unused for some period of time.

NDO solution: Rapidly deploy storage controllers and seamlessly add capacity to a cluster, allowing a customer to grow as needed. Essentially, Clustered Data ONTAP offers easy ways to add the resources when they are needed and no need to provision in advance for future usage. Clustered Data ONTAP supports scaling out by adding more storage nodes and scaling up from a capacity perspective. For service providers this reduces operational cost as well as cost of acquisition yet does not risk SLAs.

Enabling feature: Basic Clustered Data ONTAP operations.

NDO solution: Migrate storage resources to storage resources within the cluster that have a price/performance optimization-matched workload SLA.

Enabling feature: DataMotion for Volumes.

NDO solution: Migrate network resources to have the most optimized path to the migrated dataset.

Enabling feature: LIF Migrate

Maintenance Operations: Hardware Replacement and Upgrade

The Challenge: The hardware component in a storage system is no longer adequate due to changes in business requirements calling for a replacement or upgrade. The replacement or upgrade of each component is done online while data continues to serve application requests.

NDO solution: Reassign storage resources to the partner node during the intended hardware upgrade or replacement.

Enabling feature: Aggregate Relocate, High-Availability Pair configuration.

NDO solution: Migrate storage resources to a storage resource within the cluster not involved in the upgrade.

Enabling feature: DataMotion for Volumes.

NDO solution: Migrate network resources to have the most optimized path to the migrated dataset.

Enabling feature: LIF Migrate.

Maintenance Operations: Software Non-disruptive Upgrade (NDU)

The Challenge: The software and firmware in the storage subsystem have enhancements to optimize existing features and introduce new features. Upgrading the software should not impact data availability in a predictable, easy-to-use, and timely process.

NDO solution: Reassign storage resources to the partner node during the intended software upgrade.

Enabling feature: High-Availability Pair configuration.

NDO solution: Migrate storage resources to a storage resource within the cluster not involved in the upgrade.

Enabling feature: DataMotion for Volumes.

NDO solution: LIF Migrate.

Infrastructure Resiliency: Storage Subsystem Resiliency

The Challenge: In the event of a hardware or a software failure, the storage subsystem needs to maintain an active path to access data from the client or host applications. Failure in either the software or the hardware should not disrupt normal operations.

NDO solution: Reassign storage resources to the partner node during the intended software upgrade.

Enabling feature: High-Availability (HA) Pair configuration.

NDO solution: Systems are designed with several components and paths for the same function in case of failure.

Enabling feature: Multipath HA, Redundant FRU Components.

NDO solution: The Storage system has several out-of-the-box features to protect data integrity.

Enabling feature: Write Anywhere File Layout (WAFL) File System and RAID-DP Technologies.

Figure 3-4 illustrates the concept of NDO scaling and workload balancing.

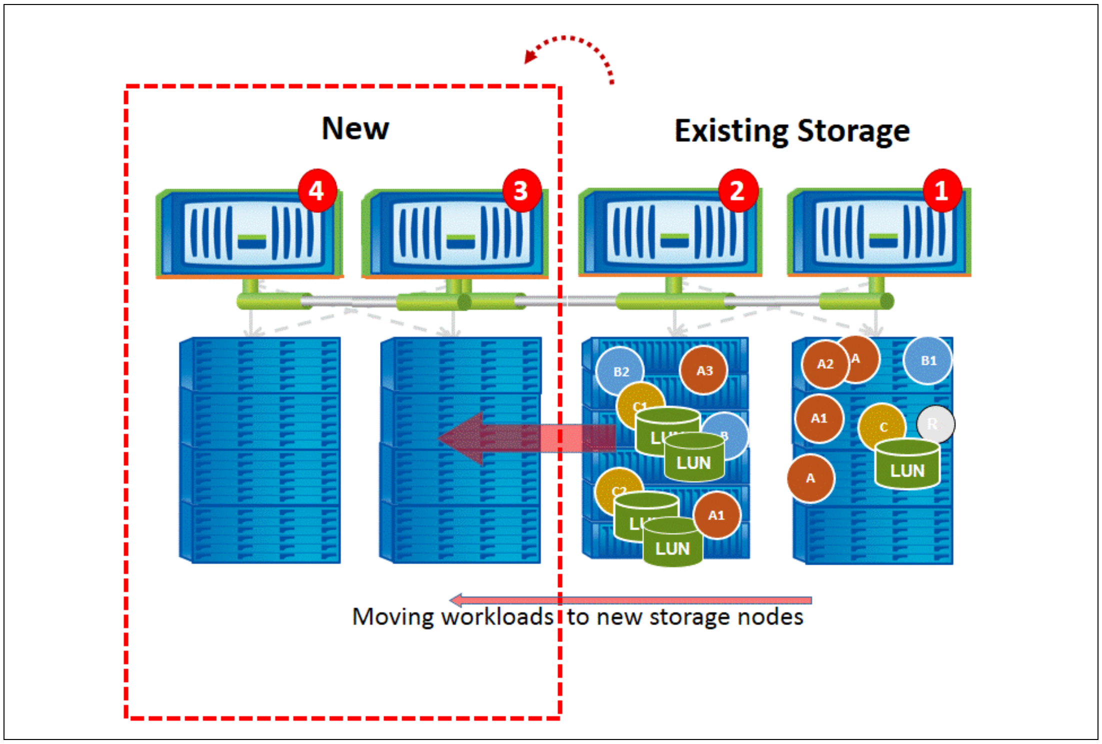


Figure 3-4 NDO scaling and workload balancing

3.1.2 Flexible architecture

The N series supports both SAN (block) and NAS (file) protocols: FCP, iSCSI, FCoE, NFS, and CIFS. If clients require an additional protocol, it can simply be added. In today's fast pace of business and with the constant changes in requirements, having a flexible infrastructure is key to serving the business successfully, an aspect that is measured by SLAs, cost, productivity, and mitigation of risks.

Beyond the support of multiple protocols, all N series models have the same operating system and can be managed by the same exact tools, yet the right model can still be carefully selected to meet specific set of workloads.

The storage system can be configured with various media types, including SATA, SAS, and SSD disk drives. Mid-range and high-end models support internal cache technology (Flash Cache) and multiple features of storage efficiencies (such as compression, deduplication, thin provisioning, cloning, and so on) are also available across all platforms.

This unified architecture offers a tremendous level of flexibility to accommodate changes coming from the business whether knowingly and planned or not. In either case, N series contributes to a highly flexible infrastructure.

The flexibility contributes to the following benefits:

- Business agility and time to market, because IT can respond faster to business needs
- Cost savings - opex, less resources are required (people, power, space, bandwidth)
- Cost savings - capex, storage efficiencies and Virtual Storage Tier (VST) for cost/performance optimization
- Can accommodate multiple business models, such as service providers, private cloud, multi-tenants, pay-as-you-grow, on-demand models of consumption, and so on.

For additional details about the benefits of the flexible architecture as part of the overall architecture, see Chapter 2, “Architecture and design” on page 7. For benefits in the context of Storage Design, Common Cloud Implementations, and Data Protection respectively, see Chapter 9, “Storage design” on page 129, Chapter 10, “Common cloud services and deployment models” on page 135, and Chapter 11, “Data protection and disaster recovery” on page 149.

3.1.3 Scalability

N series offers scalability in three dimensions. Two are known and obvious; the third has tremendous value, particularly in large and complex environments. It is expected from any storage in the data center, particularly a shared storage, to scale. Traditionally, scalability refers to the ability to add capacity and recently also to the ability to improve, or optimize performance. In the context of cloud infrastructure, there is also a need to be elastic, which basically means to scale up and down as needed to avoid those under utilized yet costly resources. N series with Clustered Data ONTAP easily supports both of those dimensions of capacity and performance by adding more disk enclosures and more storage nodes (controllers). N series with NAS can scale up to 24 nodes and 68 PB of raw data. Operational scalability is less common in the data center but certainly welcome and is the third dimension.

Figure 3-5 provides an illustration of the full range of features that contribute to the N series scalability from efficiency, unified architecture, data protection, integration with application, different disks that are supported and management tools. Some may seem to be just a technology or a component of, but in reality, they all contribute to the unified architecture, hence to the tremendous capabilities when it comes to scalability. So when it comes to cloud, scalability aspects should be looked at in the context of the entire ecosystem system of all the involved resources and how well the storage integrates and simplifies the end-to-end operations. Automation is a big part of the operational scalability, and many of the features in N series Clustered Data ONTAP 8.2 are based on software as well as easy to implement rules and policy based approaches to minimize the complexity of the managed environment.

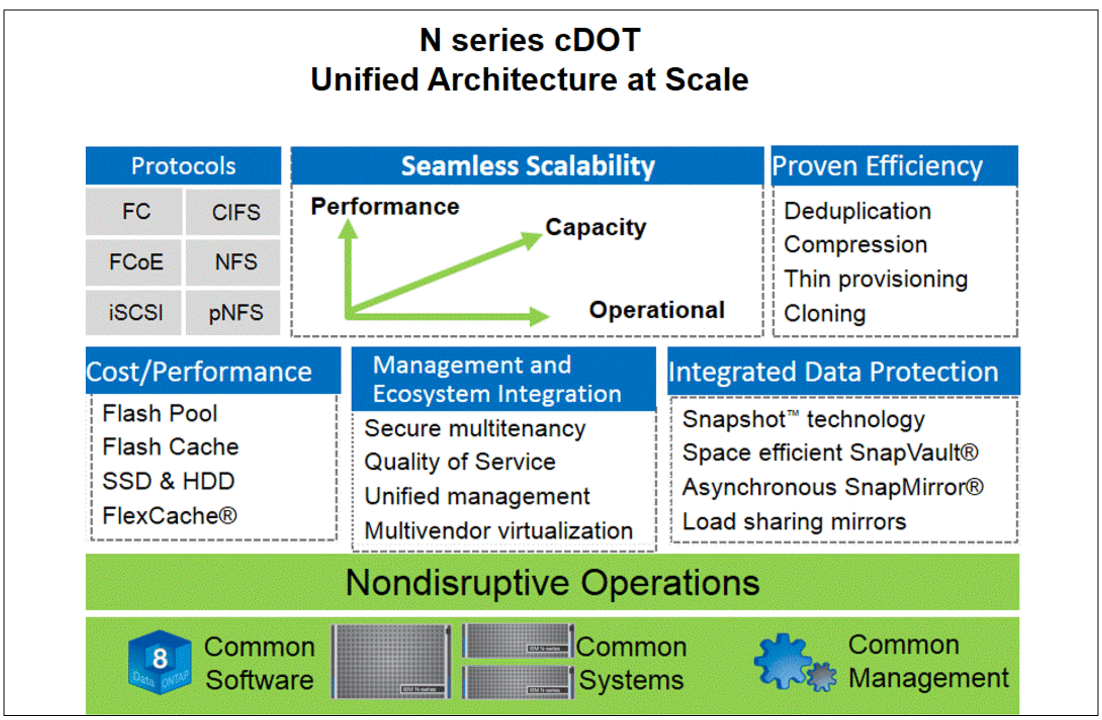


Figure 3-5 Scalability in multiple dimensions

3.1.4 Storage and operational efficiencies

Storage and operational efficiencies contribute to cost reduction, increased productivity, and faster response time to business needs. N series is known for its storage efficiencies and operational efficiencies, as implemented by the following features:

Deduplication: Transparently eliminates duplicate blocks of data in each flexible volume, while preserving the files and LUNs that use those blocks. Only unique data blocks are stored. Duplicate blocks may be shared by many files or LUNs. Deduplication is being leveraged also by Flash technology of N series.

Compression: Compresses data stored on disk or during data replication to minimize consumed bandwidth.

FlexVol cloning: Near-instantaneous flexible volume cloning. The cloned flexible volume will share common blocks with it's source volume, until those blocks are changed.

LUN cloning: Near-instantaneous LUN cloning. The cloned LUN will share common blocks with it's source LUN, until those blocks are changed.

Thin provisioning: Allows flexible volumes and LUNs to consume space as it is needed, rather than consuming it all when the volume or LUN is created.

Virtual storage tiering: Allows “hot” data that is frequently accessed to be transparently stored on faster flash media that is configured on the same storage or on a host that is connected to the storage. The flash media can work with both SAS and SATA types of HDDs. Here we list the three forms of Flash that are optional features in N series:

- Flash Accel: A host-based read cache that maintains data coherency with the Clustered Data ONTAP system.
- Flash Cache: A PCI-e based read cache inside nodes that make up the cluster.
- Flash Pool: A storage (aggregate-level) cache used to improve performance of both reads and writes.

Flash Cache is not supported on the entry-level N series product line. A combination of multiple flash features is supported with some exceptions that are described in Chapter 8, “Storage” on page 101.

From an operational perspective, a shared infrastructure can help data centers become more efficient. Clustered Data ONTAP provides a single, large resource pool for tenants and applications, which means less waste. Physical storage can be allocated when it is needed, and where it is needed. This contributes to reduction in the datacenter footprint and operational expenses:

- Simpler capacity planning: Minimizes purchasing storage capacity up-front, so no forklift upgrades with data migration. It is easier to plan for growth and scale over time.
- Clustered Data ONTAP provides Unified SAN and NAS: As mentioned earlier as part of the flexible architecture, storage administrators can use the same tools and processes to manage all types of storage. A unified system means less training and less “tribal knowledge.”
- On-demand performance and capacity optimization: As new storage systems are required, new storage “entities” can be created. Active projects can be migrated to faster storage. Data can be archived to less expensive online storage without lengthy projects or painful outage windows.

Integrated data protection with RAID-DP, Snapshot, SnapMirror, and SnapVault RAID-DP is simple to configure, and offers 100% double-disk failure protection. Snapshot provides users the ability to restore their own files, or gives users the ability to restore entire volumes and LUNs. SnapMirror and SnapVault provide same-site or alternate site DR functionality that Clustered Data ONTAP provides a single system to manage.

Additional tools that can help analyze, automate, and control the environment, to further improve your operational efficiency, are covered in the storage management section in Chapter 8, “Storage” on page 101.

3.2 Clustered Data ONTAP concept in the context of cloud-based solutions

The ability to scale easily in order to increase capacity and improve performance, and the flexibility to do so with different type of storage models, including non N series that are supported by the N series gateway, is a great advantage from two perspectives.

The first aspect concerns procurement cost and running lean operation. In the dynamic nature of cloud-based environments, it is important to be able to scale over time as more users subscribe to the service. The IT team or the service provider would like to achieve the highest possible level of utilization from all of their resources, so the ability to add more controllers, capacity, and upgrades as the business grows, rather than designate unused resources in advance, is a great advantage.

The second aspect has major cost value as well, but this time it is at the operational level. With similar operating system the infrastructure can scale without the burden of learning new technologies as all models are identical in terms of user interface and management tools. This benefit becomes even more valuable when one considers the automation and orchestration side of cloud-based environments. With different type of hardware, endless adjustments to automation script are required and each failure may impact the availability of the service. Since all models of N series run the same exact operating system and being managed by the same tools, the risks of impacting service due to changes is significantly lowered.

Additional features that make N series unique and very well positioned to support cloud-based infrastructures are described in the next sections and include storage virtual machine (SVM), Virtual Storage Tier (VST) and Quality of Service (QoS).

3.2.1 Storage virtual machine (SVM)

Clustered Data ONTAP virtualizes storage from the clients' perspective by implementing the storage virtual machine (SVM). The SVM is a logical abstraction that represents the physical storage resources in the cluster. A cluster uses at least one SVM, but can have multiple SVMs, which are given access to resources such as data volumes and logical interfaces (LIFs) that are created and assigned to the physical resources of the cluster, but that can be moved or reallocated to different physical resources as needed, all transparent and non-disruptively to the client. For example, a flexible volume may be non-disruptively moved to a new node and aggregate, or a data LIF could be transparently reassigned to a different physical network port.

SVMs can support all of the Clustered Data ONTAP protocols (NFS, CIFS, iSCSI, FCP, FCoE) and, because each SVM is a secure entity, meaning each SVM is only aware of the resources which have been assign to it, SVMs support secure multi-tenancy.

Because SVMs completely abstract the physical storage from the clients, Clustered Data ONTAP systems are highly resilient and extremely scalable. Data volumes and LIFs can be moved non-disruptively for performance or capacity reasons, but also for upgrades, hardware refreshes, and so on. See Figure 3-6.

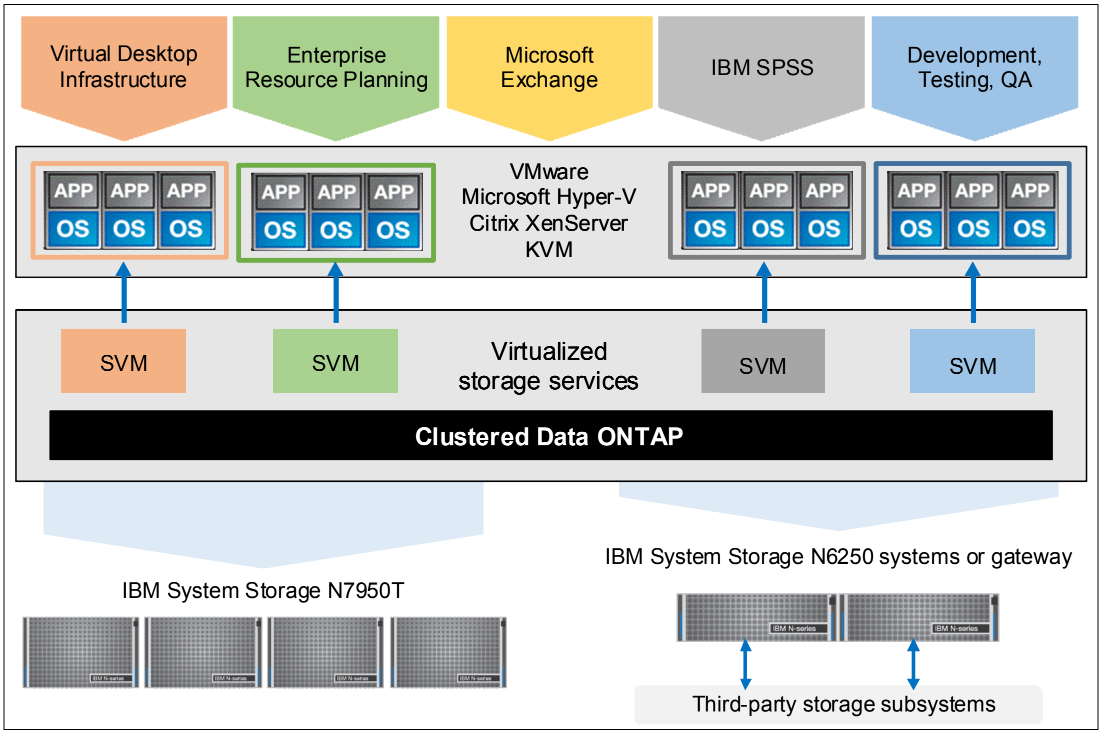


Figure 3-6 SVM provides abstraction layer

Components of an SVM

Following are the components of an SVM. For operational aspects, it is called a *vserver*.

Logical interfaces (LIFs)

All SVM networking is done through logical interfaces (LIFs) that are created within the SVM. As logical constructs, LIFs are abstracted from the physical networking ports on which they reside. There are multiple roles for LIFs:

- **Data LIF:** These LIFs are used by clients to access their data and are assigned to and associated with SVMs. Data LIFs can only be assigned to Data Ports and con be configured to fail over to other data ports or be migrated to other data ports throughout the cluster.
- **Cluster LIF:** Used only for intra-cluster traffic, cluster LIFs can only be assigned to cluster ports. These LIFs can failover to cluster ports on the same node, but cannot be migrated or fail over to ports on a remote node.
- **Node-management LIF:** Used to manage the individual physical node, node-management LIFs provide a dedicated IP address for performing system maintenance, and can provide access to the node when it has become inaccessible from the cluster. Node-management LIFs can be assigned to node-management ports or data ports and can be configured to fail over to other ports on the same node.
- **Cluster-management LIF:** Cluster-management LIFs provide an interface to manage the entire cluster. They can be configured on node-management ports or data ports and can fail over to any node-management or data port in the cluster.

- **Intercluster LIFs:** Used for intercluster communication, intercluster LIFs are used for backup and replication traffic. They can be configured on data ports or intercluster ports. Intercluster LIFs can fail over to any intercluster or data port on the same node only.

Flexible volumes

A flexible volume is the basic unit of storage for an SVM. An SVM has a root volume and can have one or more data volumes. Data volumes can be created in any aggregate that has been delegated by the cluster administrator for use by the SVM. Depending on the data protocols used by the SVM, volumes can contain either LUNs for use with block protocols, files for use with NAS protocols, or both concurrently.

Namespace

Each SVM has its own namespace. All storage resources assigned to that SVM, regardless of which physical controller it resides on, can be accessed through the single namespace. Volumes may be junctioned at the root of the namespace or beneath other volumes that are part of the namespace hierarchy. See Figure 3-7.

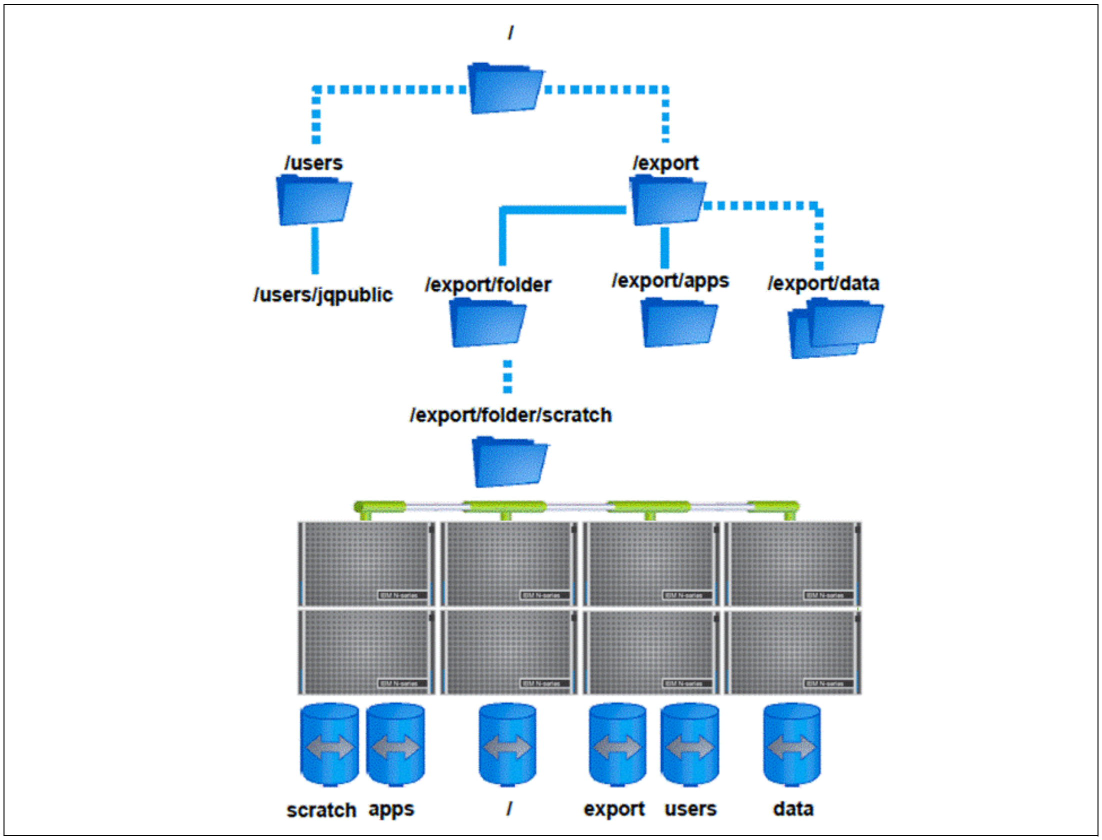


Figure 3-7 Clustered Data ONTAP, namespace example

3.2.2 Secure multi-tenancy

Secure multi-tenancy is an implementation of virtual partitions within a shared physical storage environment for the purpose of sharing the physical environment among multiple distinct tenants in a secure way. Clustered Data ONTAP supports multiple tenants in its core through a Storage Virtual Machine (SVM) that was mentioned earlier in this chapter. Multi tenancy is very common in a service provider environments, but the same concept can help IT maintain segregation between different business units within the same company, separate data pertaining to different projects, clients, and so on.

Data volumes and logical network interfaces (LIFs) are created and assigned to an SVM and may reside on any node in the cluster to which the SVM has been given access. A SVM may own resources on multiple nodes concurrently, and those resources can be moved non-disruptively from one node to another. For example, a flexible volume may be non-disruptively moved to a new node and aggregate, or a data LIF could be transparently reassigned to a different physical network port. In this manner, the SVM abstracts the cluster hardware and is not tied to specific physical hardware. See Figure 3-8.

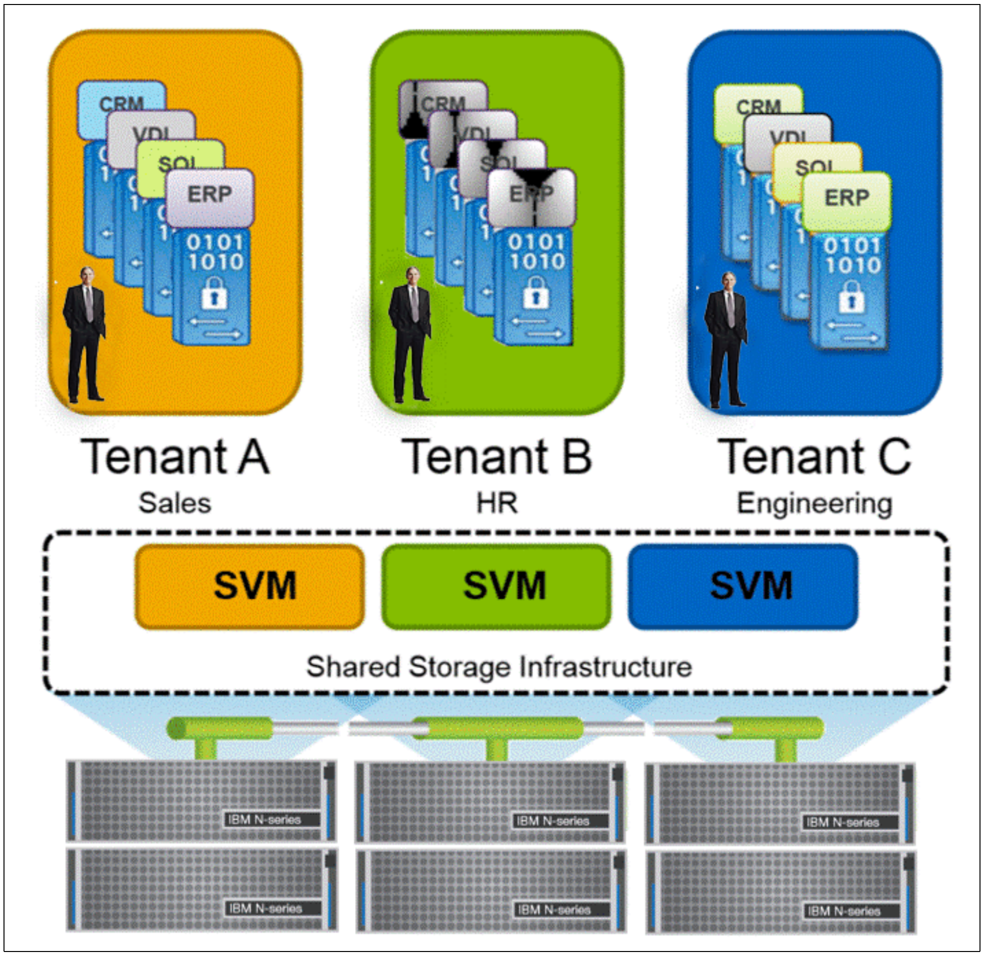


Figure 3-8 Secure Multi-Tenancy with N series and Clustered Data ONTAP 8.2

3.2.3 Software-defined storage (SDS)

Software-define storage (SDS) is not a technology and there is no industry standard to describe what its characteristics are, but it is a well-coined terminology now. It was formed out of necessity to adapt to the transformation occurring in data centers, the transformation to cloud-based solutions. In essence, SDS refers to the abstraction of the physical elements, similar to server virtualization. This section describes the capabilities of the software that is at the core of Clustered Data ONTAP and that contribute to the ability of the N series storage platforms to operate as part of a dynamic and flexible infrastructure. With Clustered Data ONTAP 8.2, N series brings pioneering-software-based storage technologies to enable and support dynamic and flexible infrastructures, the fundamental attributes of all cloud models. Most of these technologies were covered earlier in this chapter and also as part of the architecture discussion in Chapter 2, “Architecture and design” on page 7, so we now focus on value realization of those software-based features to help IT architects and operations teams design, build, and operate their storage platform in an optimized way.

3.3 Additional features

The additional features covered in this section are optional but certainly provide tremendous value, particularly from a cost-savings perspective and being able to do more with the storage.

3.3.1 Quality of Service (QoS)

Quality of Service (QoS) works with both SAN and NAS storage, and it runs across the entire N series line. Previous technical documents may refer to QoS also as FlexShare, which is a limited and older version. As of Clustered Data ONTAP 8.2, FlexShare is not longer used and QoS is the new terminology. The QoS feature also works with the N series gateways.

Storage QoS offers significant benefits for all types of storage environments:

- Achieve greater levels of consolidation
- Set limits corresponding to service-level agreements (SLAs)
- Add additional workloads with less risk of interference
- Limit performance of less critical services

In a multi-tenant cloud environment, whether private or public, the first tenants on a particular resource might see a level of performance in excess of their SLA. This can create a perception of performance degradation as additional tenants are added and performance decreases. Storage QoS allows you to avoid this problem by assigning a performance capacity limit to each tenant in accordance with the SLA. That way, a tenant cannot exceed the set performance limit, even when resources are available, and the tenant is therefore less likely to notice changes in perceived performance over time.

With QoS, it is much easier to establish different tiers of services based on SLAs. Tiers can be limited to IOPS. For example, a higher IOPS limit is assigned to an application that requires lower latency and higher performance or to customers that paid for premium service.

Storage QoS is based on policy groups. At first, a policy is created, and then a limit is applied to the group. For instance, a policy group can contain a single storage virtual machine (SVM) or a collection of volumes or LUNs (within an SVM) used by an application or a tenant.

Policy groups are created with the **`qos create`** command. Policies can be created either with the policy group or at a later time, with the **`qos modify`** command. An object is assigned to a policy group via the object's command structure: **`volume`** for volume objects, **`vserver`** for Vserver (used for SVM) objects, **`lun`** for LUN objects, and **`volume file`** for file objects.

QoS workload management allows the control over a resource that can be consumed by storage objects (such as volumes, LUNs, VMDKs, or SVMs) to manage performance spikes and improve business satisfaction. Throughput limits are expressed in terms of MB/sec (for sequential workloads) or I/O operations per second (for transactional workloads) to achieve fine-grained control. When a limit is set on an SVM, the limit is shared for all objects within that SVM. This allows you to set a performance limit on a particular tenant or application, but it leaves the tenant or application free to manage the assigned resources however it chooses within that limit.

For IT teams that are very familiar with their users and infrastructure, QoS can help increase the storage utilization as some services and users can tolerate higher latency compared to others, and by being familiar with the different workloads that represent the different users and business needs, IT teams can certainly protect the expected performance for one service while knowingly allow a certain degradation of performance on other workloads at times.

It is advisable to apply QoS in conjunction with other features of the N series storage and to be very familiar with all the operational aspects beyond sheer performance. Housekeeping tasks within the storage can end up competing on resources (for example, deduplication and replication schedule). In addition, by becoming familiar with the various workloads, despite the likelihood of their dynamic nature, particularly in public cloud settings or when introducing services to new community of users, storage administrators can control and manage the environment. They can achieve very high utilization of their storage, while still minimizing the risk to the business, and maintain an optimal cost-performance balance. See Figure 3-9.

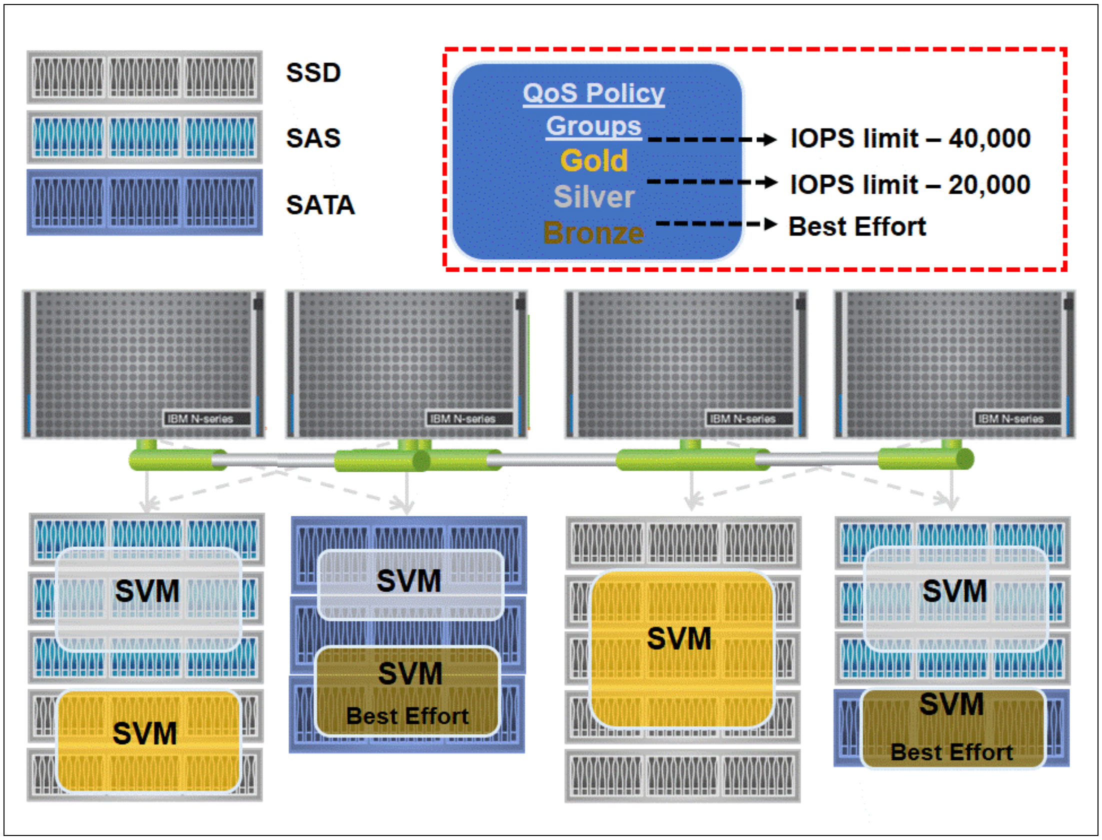


Figure 3-9 QoS in N series Clustered Data ONTAP is based on Policy groups

3.3.2 Virtual Storage Tier (VST)

Balancing performance and efficiency will maximize realized value from any solution. The flexibility to mix different types of disk drives and also flash-based technology in the same cluster, and in the same HA pair, is one of the most beneficial features of the unified architecture of the ONTAP storage platform. This flexibility can immediately be translated to flexibility of every cloud-based solution to easily accommodate changes in workloads as it is likely for business to change requirements over time.

Virtual Storage Tier (VST) offers dynamic optimization of performance and it is done automatically. If a specific known workload calls for higher or lower latency, the storage can be configured with SSD drives or other flash-based technology for those more demanding workloads and with SATA for workloads that can tolerate higher latency to provide the flexibility and the dynamic range for VST to operate. This saves from investing in all-flash expensive storage.

The N series Virtual Storage Tier provides an end-to-end approach to intelligent caching. VST can be implemented at both the server level and at the storage level. At the server level, Flash Accel enables PCI-e Flash and SSD devices on the application host to be utilized as server cache. This allows specific applications which need ultra-low latency and high throughput to be accelerated in virtualized environments. At the storage level, there are two ways to implement VST.

Flash Cache is controller based, provides acceleration of random read operations and generally provides the highest performance solution for file services workloads.

Flash Pool is implemented at the disk shelf level allowing SSD drives and traditional hard disk drives to be combined in a single Data ONTAP aggregate. In addition to read caching, Flash Pool also provides write caching and is particularly well suited for OLTP workloads which typically have a higher percentage of write operations.

All three VST technologies improve overall storage performance and efficiency and are simple to deploy and operate. See Chapter 8, “Storage” on page 101 for more information about VST.

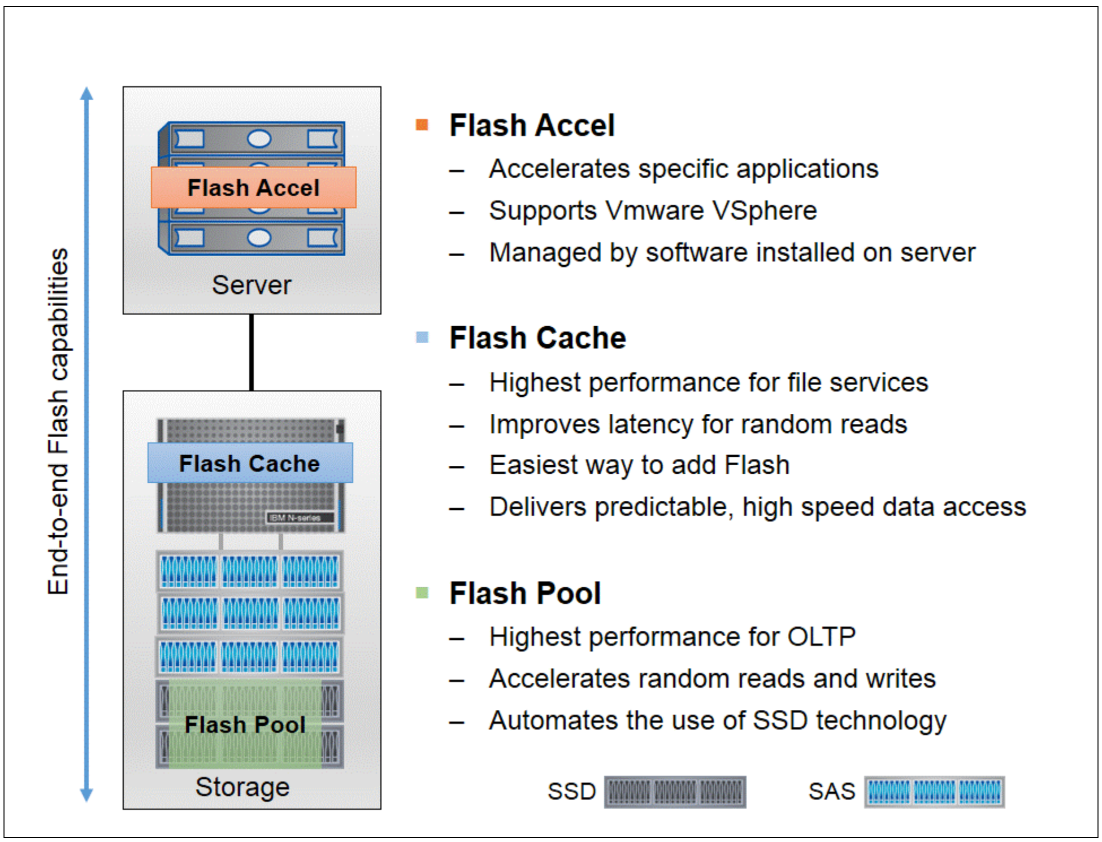


Figure 3-10 Flash technologies as part of Virtual Storage Tier of N series

3.3.3 Single namespace

A cluster namespace is a collection of file systems hosted from different nodes in the cluster. Each SVM has a file namespace that consists of a single root volume. The SVM namespace consists of one or more volumes linked by means of junctions that connect from a named junction inode in one volume to the root directory of another volume. A cluster can have more than one SVM. All the volumes belonging to the SVM are linked into the global namespace in that cluster. The cluster namespace is mounted at a single point in the cluster. The top directory of the cluster namespace within a cluster is a synthetic directory containing entries for the root directory of each SVM namespace in the cluster. In Clustered Data ONTAP, FlexVol volumes containing NAS data are junctioned into the owner SVM in a hierarchy. This hierarchy presents NAS clients with a unified view of the storage, regardless of the physical location of FlexVol volumes inside the cluster.

Junctions allow each FlexVol volume to be accessible like a directory or folder. A junction is conceptually similar to a mount in UNIX, where a directory is an entry point to another file system. Unlike a mount, a junction requires no client-side configuration.

NFS clients can access multiple FlexVol volumes using a single mount point. CIFS clients can access multiple FlexVol volumes using a single CIFS share.

The NAS namespace consists of the hierarchy of FlexVol volumes within a single SVM as presented to the NAS clients.

See Chapter 8, “Storage” on page 101 for more information about FlexVol volumes.

These are the key benefits of a single namespace:

- Datasets can be distributed to increase performance.
- The namespace is unchanged as volumes move; no remount is needed.
- No client code is needed.
- It is easy to manage and change.
- It scales to many petabytes.
- It can be accessed via single NFS mount or CIFS share.
- The physical storage layout can be managed independently of the logical storage layout.

4

VMware vSphere integration

Server virtualization is a prerequisite technology towards the implementation of shared infrastructure and cloud-based solutions. Solid integration between the server layer and other components of the infrastructure is required for the optimization of the entire infrastructure stack. This chapter highlights the features of the IBM System Storage N series that enable such integration with VMware vSphere.

The chapter provides limited details about those key features with some preferred practices of how to use them, but it is not an implementation guide by itself. The intention is to offer a reference and to educate the readers about the benefits of the improved functionality that clients can achieve by implementing these features as part of the solution that includes both IBM System Storage N series with Clustered Data ONTAP and VMware server virtualization technology.

The book is also written with the assumption that the readers are familiar with the basic terminologies of server virtualization, technologies, features, and functions from VMware. Despite the topic of the chapter, the book is not intended for educational purposes of the readers about those technologies, unless it is in the context of designing and implementing cloud-based solutions with specific integration with the N series storage.

The following topics are covered:

- Introduction to server virtualization
- Virtual Storage Console (VSC)
- Enabling cloud computing and automation with VSC
- Multi protocol capability for datastores
- Provisioning and Cloning features for virtual machines
- Snapshot technology
- Storage configuration
- Storage virtual machine (SVM)
- Using deduplication or compression with VMware
- Further information
- Further information

4.1 Introduction to server virtualization

With unmatched storage efficiency, performance, and data protection capabilities, N series storage solutions complement the manageability, utilization, and cost-saving benefits of VMware's server virtualization software. N series with Clustered Data ONTAP now offers greater availability and scalability across the entire product line and greater flexibility. The same key attributes covered in Chapter 3, “Introduction to Clustered Data ONTAP 8.2” on page 23 are virtues for server virtualization and will be discussed in this chapter while reviewing tools and features that enable the integration between the storage and the server virtualization technologies and streamline the operation.

As established earlier, N series with Clustered Data ONTAP 8.2 is an optimized storage platform for cloud-based solutions, thanks to its non-disruptive operations capabilities, its flexible architecture, and its seamless scalability. Unless specified otherwise, the reader should assume that all covered features, tools, and capabilities listed in the following sections are available on the entire N series product line. N series with Clustered Data ONTAP elevates the storage capabilities to a level that complement the features and functions from VMware in a way that truly enables dynamic infrastructure, cost savings and greater operational flexibility. It is recognized to be at the best-of-breed class and is used in multiple types of environments, including IaaS, PaaS, and DaaS by services providers. Figure 4-1 illustrates some of the common attributes of VMware’s vSphere and IBM N series with Clustered Data ONTAP.

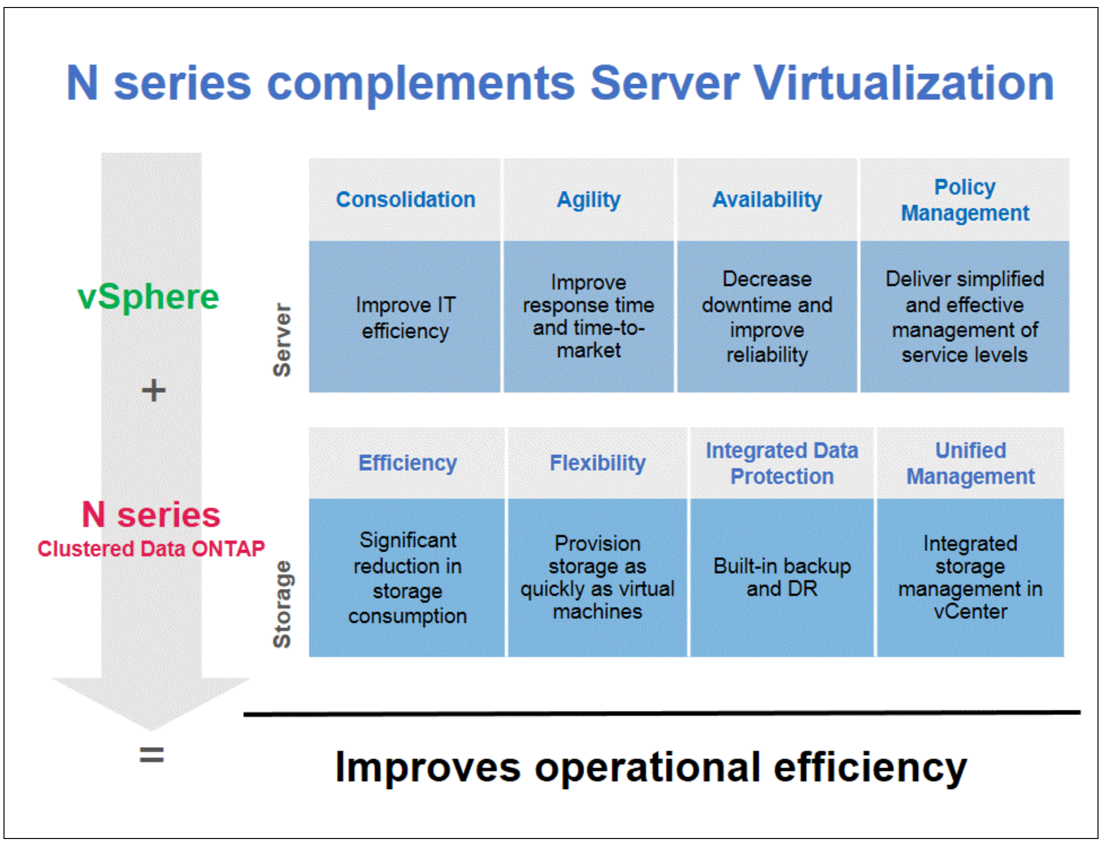


Figure 4-1 Improved operational efficiency with N series Clustered Data ONTAP and vSphere

The additional features and tools that are covered in the following sections are mainly focused on operational and storage efficiencies. But as mentioned, they are covered from the specific perspective of the integration, so technical details about how certain storage features work can be found in Chapter 8, “Storage” on page 101, or in reference to additional resources that are mentioned throughout this book. The approach with N series Clustered Data ONTAP is to offer a flexible storage platform for IT cloud and storage architects, to allow multiple models of cloud implementations and various methods of operations managing the infrastructure. A service offering and business model suitable for a service provider, although built on similar technologies and using similar products, may not be adequate for other clients and vice versa.

Before features can be introduced, the integration between the products needs to be established. Virtual Storage Console (VSC) is a comprehensive storage management tool for N series that integrates with vCenter and is covered in the next section. This is followed by details about the unified architecture and the flexibility of the N series storage platforms and Clustered Data ONTAP 8.2, and then by storage efficiency features and other beneficial technologies in virtualized environments. At the end of the chapter, we provide a list of software modules and versions that are required or advised in a common virtualized environment and examples of storage settings.

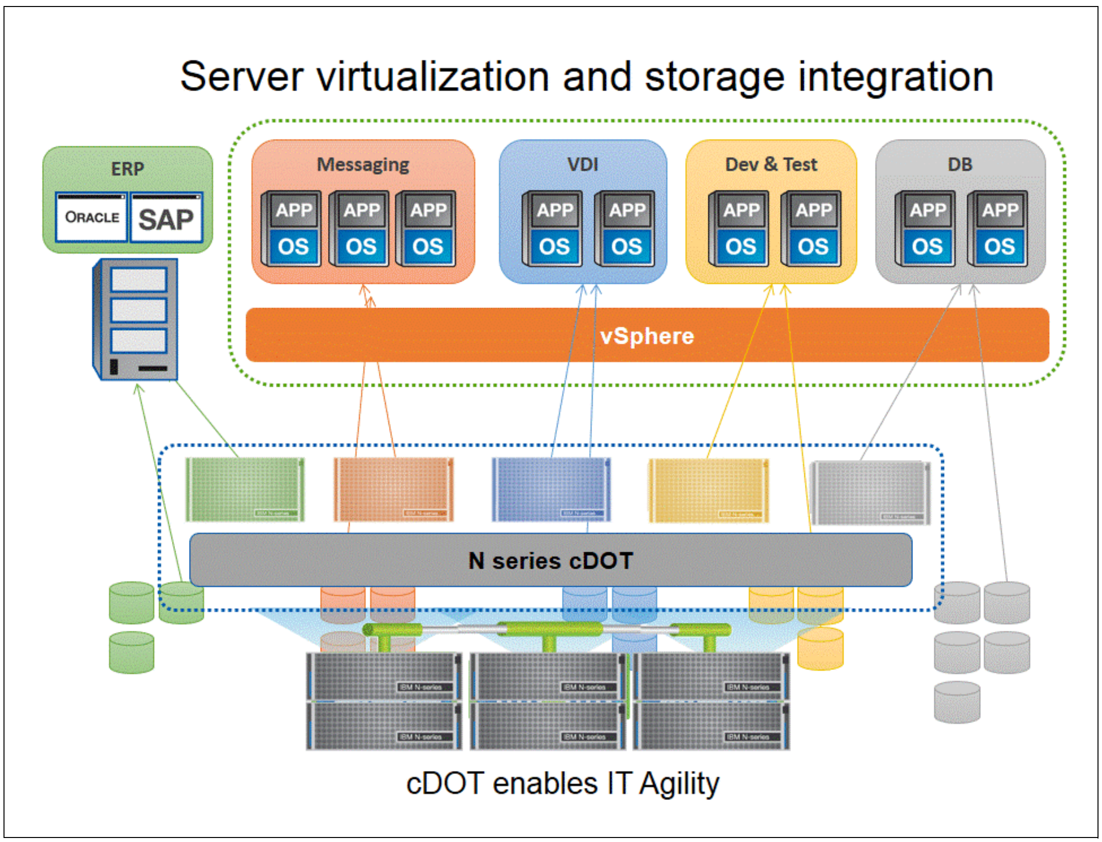


Figure 4-2 N series Clustered Data ONTAP - integration with server virtualization

4.2 Virtual Storage Console (VSC)

Virtual Storage Console (VSC) provides integrated, comprehensive storage management for infrastructures that are based on virtualization technologies from VMware. It is a vSphere client plug-in that provides end-to-end virtual machine lifecycle management for VMware virtual server and desktop environments running on Clustered Data ONTAP storage platforms. It provides storage discovery, health monitoring, capacity management, provisioning, cloning, backup, restore, and disaster recovery. VMware administrators can access and execute all of these capabilities directly from VMware vCenter, enhancing both server and storage efficiencies without affecting the policies created by the storage administrators. This improves collaboration between IT teams and increases productivity.

The high level benefits of VSC are as follows:

- Improve efficiencies by enabling virtual infrastructure (VI) administrators to directly manage storage using vCenter
- Boost responsiveness with real-time discovery and reporting on storage health and usage
- Increase availability with near-instant backups, granular restores, and cost-effective DR
- Reduce storage costs with automatic thin provisioning and deduplication of data stores
- Enable a dynamic infrastructure by rapidly provisioning and cloning thousands of VMs

VSC version 4.2.1 is the current version available and it supports the latest vSphere version 5.5. with the following capabilities and benefits.

Provisioning and Cloning

The following capabilities and benefits are provided:

- Provisions datastores without Storage Admin intervention
- Manages (selects and load balances) storage paths and applies multi-pathing policies
- Secures storage access; masks LUNs, creates NFS exports
- Manages deduplication and thin provisioning
- Resizes (grows and shrinks) datastores and configures autogrow (NFS)
- Provides instant cloning of VMs, virtual servers, and desktops
- Supports native storage efficiencies, I/O offload, pre-deduplicated clones

Backup and Recovery

The following capabilities and benefits are provided:

- Backs up VMs and datastores: Initiated from Home view or vSphere navigation tree, Immediate or scheduled, VMware file system-consistent or crash-consistent
- Updates existing SnapMirror relationship at completion of backup for integrated DR
- Recovers at all levels of granularity - Initiated from Home view or vSphere navigation tree, Datastores, VMs, VMDKs and guest files
- Mounts backups for post-backup content verification

Figure 4-3 summarizes the key features and benefits of VSC.

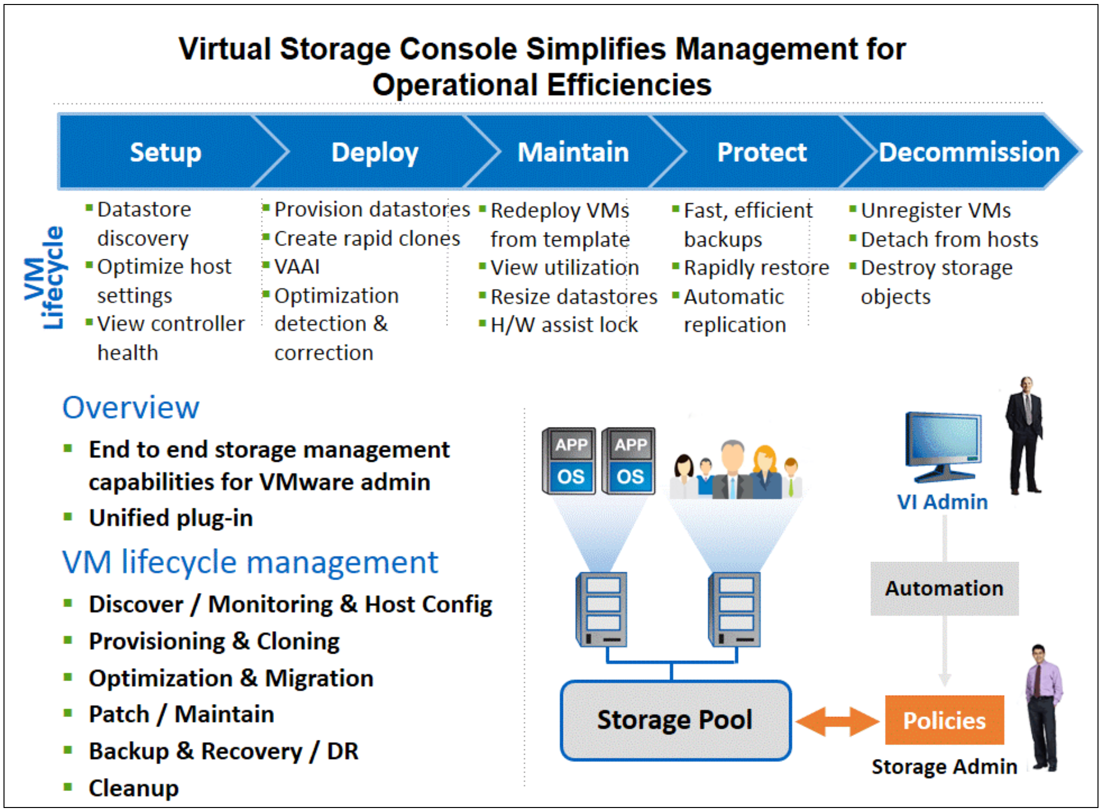


Figure 4-3 VSC - features and benefits

For additional information about VSC, see the Installation and Administration Guide for VSC 4.2:

https://library.netapp.com/ecm/ecm_get_file/ECMP1149724

4.3 Enabling cloud computing and automation with VSC

VSC enables you to provision and manage VMs in secure multi-tenant cloud environments. Whether you are a client, service provider, or cloud provider, you can securely administer partitions of shared application, compute, and storage resources (storage virtual machines or SVMs), from within the vCenter framework, maintaining desired service levels and security for each tenant. VSC is designed to simplify storage management operations, improve efficiencies, enhance availability, and reduce storage costs in both SAN-based and NAS-based VMware infrastructures. It provides VMware administrators with a window into the storage domain. It also provides the tools to effectively and efficiently manage the lifecycle of virtual server and desktop environments running on the ONTAP storage system.

Although the three basic VSC functional areas are monitoring, provisioning, and backup, it is also useful to focus on the larger topic of infrastructure automation. When clients need seamless integration across your infrastructure, the storage administrator and the VMware administrator at a basic level must execute in a coordinated way so that systems are configured optimally to support the services being provided. Some form of “cross-domain” or “cross-management-boundary” execution is needed to provide this coordination.

VSC provides this capability for storage and virtual infrastructure (VI) administrators. It changes the role of the storage administrator from someone who provisions storage for the VI administrator, which the VMware administrator then consumes, to a model where the storage administrator can assign pools of storage resources to be managed by the VI administrator. These resources with Clustered Data ONTAP 8.2 are based on Storage Virtual Machine (SVM) that was covered earlier in Chapter 3, “Introduction to Clustered Data ONTAP 8.2” on page 23.

The SVM is essentially a virtual resource, a software managed entity, hence the operational flexibility that is also aligned with software-defined trends in the data center, all to enable dynamic model for cloud-based solutions. Through the VSC plug-in for VMware vCenter, the VMware administrator can now consume these resources on demand while the storage team monitors and maintain the overall resources of the storage cluster. VSC helps ensure that the preferred practices are applied to resources consumed by the VI administrator and it helps with the overall IT collaboration.

Thus, the workload of the storage administrator to support the VI administrator is reduced. Services can be brought on-line more quickly, and are more dynamic. Service levels and performance are assured, and checks and balances are automatically implemented. As a result, clients will experience improved operations in the IT infrastructure, a reduction in the time used for operational tasks, and a reduction in resources consumed. For complete end-to-end automation, N series with Clustered Data ONTAP can also be integrated with VMware vCloud.

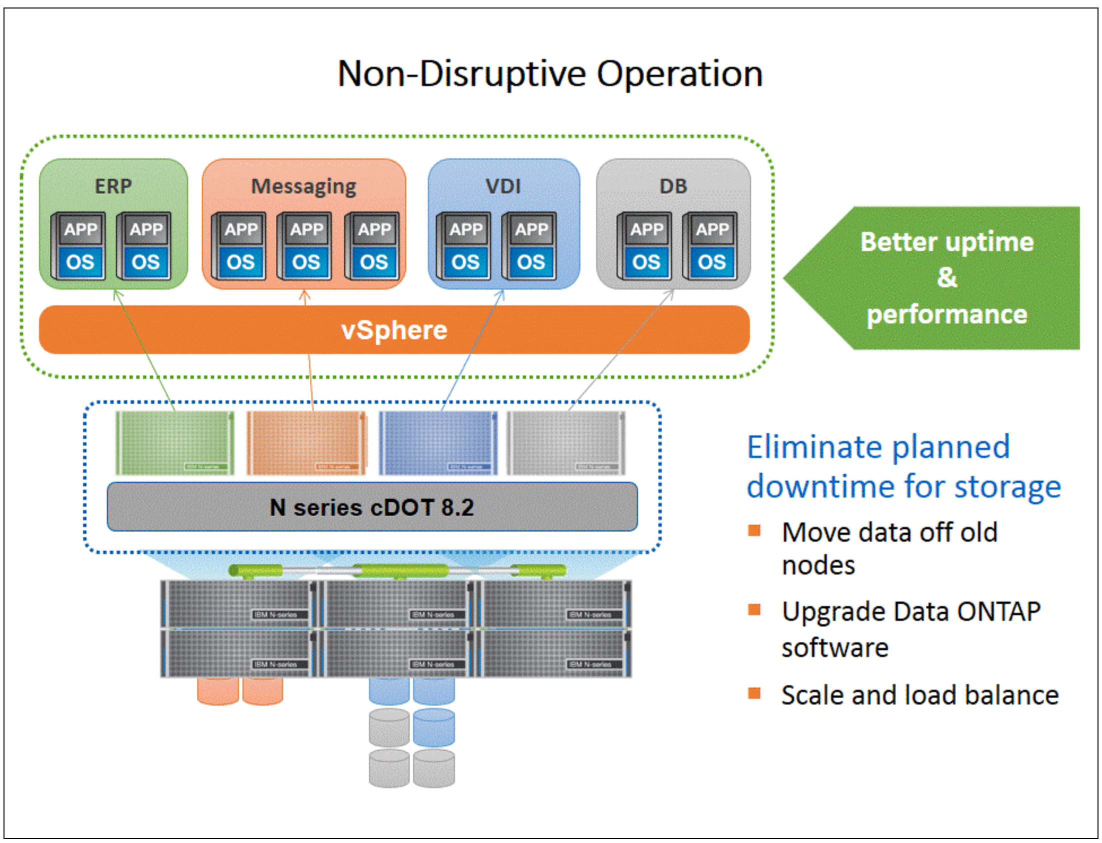


Figure 4-4 N series Non-disruptive storage operation in a vSphere environment

Programmable APIs

Virtual Storage Console for VMware vSphere supports programmable application interfaces (APIs) for VMware vCloud and Provisioning and Cloning. The APIs are exposed using Simple Object Access Protocol (SOAP). They provide a layer above the Manageability SDK, the VMware VI SDK, and the VMware vCloud SDK, but do not require any of these in the customer application or script.

Virtual Storage Console for VMware vSphere provides synchronous APIs that enable you to manage credentials for multiple vCenter Servers, discover vCloud Director objects for vCloud tenants, and provision and clone vApps. You must have the appropriate vCloud Director privileges to perform these tasks. These APIs are Storage Profile unaware. This means that you are responsible for placing the virtual machines into appropriate Storage Profiles after a cloning or provisioning operation is performed. More information about working with the VMware vCloud APIs is available in the NetApp Communities Forum mentioned above.

The Provisioning and Cloning Application Programming Interface (API) is designed to be leveraged with the VI SDK. It provides end-to-end automated datastore provisioning and off-loads the intricacies of storage object cloning while cloning virtual machines. Note that Provisioning and Cloning performs the same role-based access control checks that Virtual Storage Console for VMware vSphere performs.

N series storage APIs are available also for the OnCommand management suite, including Workflow Automation (WFA) and directly at the storage level. The extensive APIs simplify the integration of N series storage platforms in cloud environments where orchestration tools are already being used.

4.4 Multi protocol capability for datastores

The N series storage system provides flexibility in the method and protocol used to connect to storage. Each method and protocol has benefits and disadvantages, depending on the existing solution and VMware environment requirements.

Traditionally, most VMware scenarios use standard Fibre Channel SAN connectivity. With N series, you can keep using this method if it is already in the environment. However, fiber connectivity can be expensive if new purchases are required. For this reason, more environments are now implementing network connectivity methods to storage. Such methods include iSCSI, Network File System (NFS), and Common Internet File System (CIFS) as illustrated in Figure 4-5.

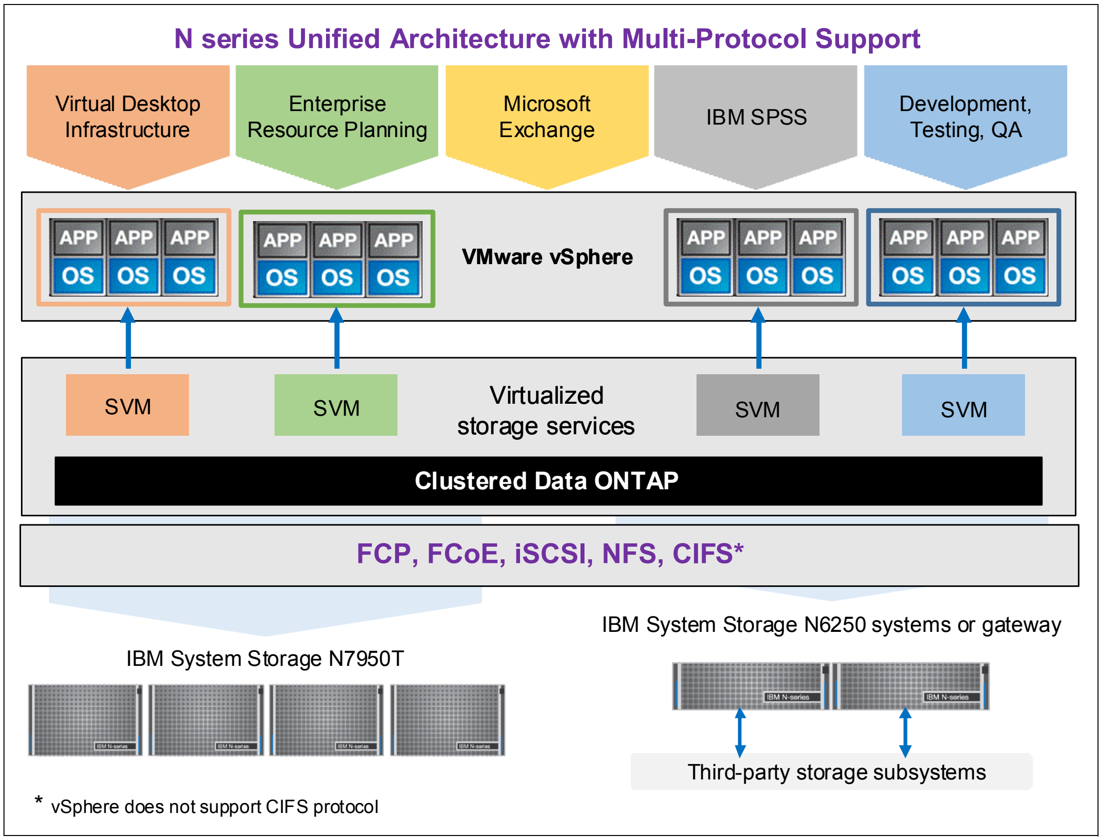


Figure 4-5 Unified architecture and multi-protocol support for VMware vSphere

Currently, VMware vSphere supports FC, FCoE, iSCSI, and NFS connections for datastores. All three methods are fully supported by N series systems. The multi protocol capabilities of N series is available on the entire product line and it is an important element of its unified architecture that contributes to flexible infrastructure. It is important to remember that the maximum number of storage nodes in a cluster is limited by the storage model and the protocols used. See Chapter 3, “Introduction to Clustered Data ONTAP 8.2” on page 23 for more details about cluster limits.

4.5 Provisioning and Cloning features for virtual machines

The Provisioning and Cloning capabilities are features of the Storage Virtual Console (VSC) as briefly described earlier in this chapter. VSC for VMware vSphere enables the provisioning of datastores and quickly create multiple clones of virtual machines in the environment. You can use Provisioning and Cloning to clone virtual machines, manage connection brokers, redeploy clones locally, and reclaim unused space on virtual machines.

With the Provisioning and Cloning capabilities of VSC, thousands of virtual machine clones and hundreds of datastores theoretically can be created at one time. In practice, however, multiple executions of fewer requests are advised. The ideal size of the requests depends on the size of the vSphere deployment and the hardware configuration of the vSphere Client managing the ESX hosts. See Figure 4-6.

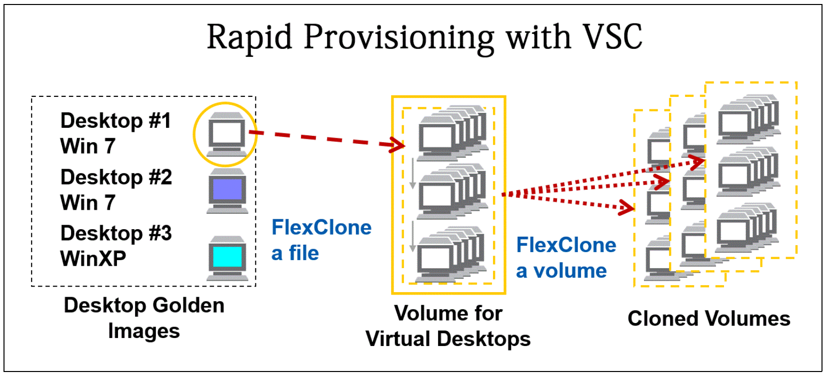


Figure 4-6 Rapid cloning (desktops in this case) with VSC

Before you perform a cloning operation, it is a good practice to enable the NFS plug-in for VMware VAAI. After you get the plug-in and place it in the correct directory, you can install it using the Monitoring and Host Configuration capability.

Details on locating and installing the plug-in are provided in the Knowledge base article 3013414, which is available online:

`http://kb.netapp.com/support/index?page=content&id=3013414`

The following restrictions apply to this feature:

- The cloned virtual machine always has one virtual CPU (vCPU) no matter how many vCPUs the source virtual machine has.
- If you attempt to clone a virtual machine that has been functionally aligned using Optimization and Migration, the clone will be misaligned.
- Provisioning and Cloning warns you when you attempt to clone a functionally aligned virtual machine. This is done because a functional alignment uses a prefix to get the virtual machine to align on the correct boundary. As a result, the virtual machine performs as though it has been aligned, but no changes have been made to the hard disk to ensure that the virtual machine is aligned to the storage system.
- You cannot use the cloning feature when the target virtual machine is being used by either Backup and Recovery or Optimization and Migration.
- Unless you log in as an administrator, you must have the appropriate RBAC privileges correctly assigned to complete this task successfully. For more information, see Authentication and user management with vCenter RBAC and Data ONTAP RBAC.

To clone virtual machines, simply select the vSphere Client Inventory, right-click a powered-down virtual machine (Figure 4-7) or template, and select **N series** → **Provisioning and Cloning** → **Create rapid clones**.

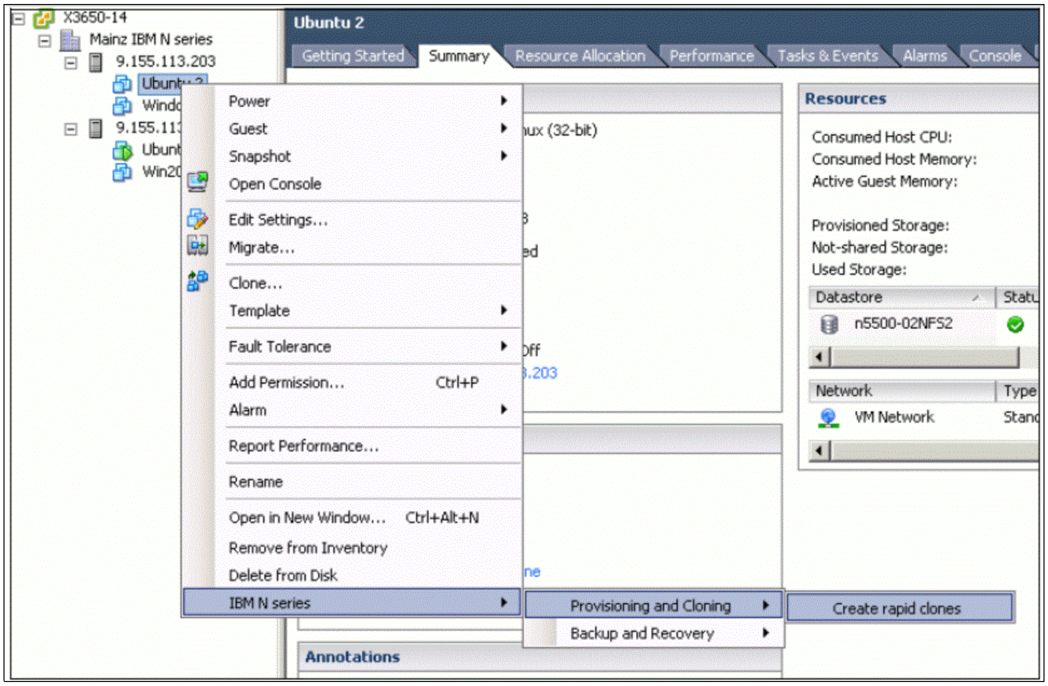


Figure 4-7 Cloning VMs

4.6 Snapshot technology

VMware is capable of taking a snapshot of guests. This enables you to make point-in-time copies that provide the fastest means to recover a guest to a previous point in time. N series storage systems have been providing clients with the ability to create snapshot copies of their data since their introduction. The basic concept of a snapshot is similar between VMware and N series systems. However, it is important to understand both the major differences between the two technologies, and when to use one rather than the other.

4.6.1 VMware snapshots

VMware snapshots provide simple point-in-time versions of guests, allowing quick recovery. The benefit of VMware snapshots is that they are easy to create and use because they can be executed and scheduled from within vCenter. There are two types of snapshots, memory snapshots (the default option), and quiesced snapshots. Memory snapshots are advised for point-in-time or ad hoc type snapshots, and the example provided by VMware documentation suggests that you use memory snapshots when upgrading a software.

If the upgrade failed or the results were not as expected, the state of the virtual machine can be reverted. In a quiesced snapshot, the system quiesces the file system of the virtual machine and ensures a consistent state of the guest file systems. It is advisable to use this method for automated and periodic backups. As preferred practice, VMware advises using additional backup methods and not relying only on its snapshot mechanism. It is also advised to schedule the snapshots to when the VM is not too busy and IO is low. For more information about native VMware snapshots, including usage guidelines, see the vSphere 5.5 Documentation section at the following website:

http://pubs.vmware.com/vsphere-55/index.jsp#

4.6.2 N series Snapshot technology

The patented N series Snapshot technology can easily be integrated into VMware environments. This technology provides crash-consistent versions of guests for full guest recovery, full guest cloning, or site replication and disaster recovery in most cases. The benefit of N series Snapshot is that the performance of the storage is not being impacted by the snapshot operation so the snapshots can be scheduled at any time and as many as allowed. This of course provides greater level of flexibility and peace of mind to the business and the IT operation team.

VMware states that, for optimum performance and scalability, hardware-based Snapshot technology is preferred over software-based solutions. In addition to no performance impact, the N series snapshot mechanism offers is robust and offer additional capabilities that integrate into other operational aspects such as replication, and automation of capacity utilization. The Virtual Storage Console completes the vCenter management by integrating N series Snapshot capabilities with single VMware management. For more details about the snapshot technology used by N series, see the NetApp publication: TR-4210 from July 2013 “Operational How-To Guide NetApp Snapshot Management”.

4.7 Storage configuration

This section provides information about preferred practices of the N series Clustered Data ONTAP configuration when is integrated with vSphere. The section emphasizes the storage design (layout) as well as performance, sizing, data protection, and storage efficiencies. See Chapter 8, “Storage” on page 101 for more details about the technical features mentioned in this section.

Since most storage functions that are related to efficiencies and data protection operate at the volume level, it is preferred practice to group multiple VMs with common characteristics and/or similar business requirements in terms of data protection in the same datastore, hence the same underlying NFS volume. While thin provisioning is common and is applicable as preferred practice to all volumes, and the same is true for deduplication, data protection, particularly backup snapshots and replication (SnapMirror) schedule will vary. It is advisable to group VMs based on the snapshot schedule and retention because the storage does not support multiple snapshots or replication schedules in one volume.

If different schedules are required for different VMs (very common), then the VMs should be grouped within the specific volume that has the relevant schedule implemented. For example, if several VMs need to be replicated to a DR site on a regular schedule, they should be grouped into one or fewer as possible datastores and SnapMirror schedule has to be configured. Another example is with several VMs that process critical data with high rate of changes. The business requires a snapshot backup every 6 hours with 7 days retention (42 snapshots total). Besides proper sizing for the required snapshot capacity, it will be more effective to group these VMs in one or fewer as possible datastores, where the particular snapshot policy will be implemented. An additional advantage of having many VMs per datastore, especially with the same guest operating system (OS), is better space efficiency using deduplication and VM cloning within the volume.

See the IBM Redbooks publication, *IBM System Storage N series with VMware vSphere*, for additional information about storage configuration.

4.7.1 Preparing N series LUNs for VMware vSphere

When provisioning LUNs for access through FC or iSCSI, they must be masked so that only the appropriate hosts can connect to them. Within Data ONTAP, LUN masking is handled by the creation of initiator groups (igroups).

An initiator group includes all of the FC worldwide port names (WWPNs) or iSCSI qualified names (IQNs) of each of the VMware ESXi servers from a specified group. This task is done from a pre-determined scope, so when assigning a LUN to an igroup, all the hosts listed on that group can see the it.

The igroup scope design depends on the virtual environment design. For instance, if you are dividing your VMWare servers into clusters that support different application tiers, you need to create an igroup for each of those clusters. That way, you ensure that all the hosts within that cluster have access to the same LUNs while avoiding the hosts from clusters to being able to see LUNs that are not relevant to them.

Using igroups for FC and iSCSI protocols: Separate igroups should be created for Fibre Channel and iSCSI LUNs, even if the same membership applies to them.

To identify the WWPN or IQN of the servers, for each VMware ESXi Server in vCenter, select a server. Then click the **Configuration** tab and select one of the storage adapters to see the SAN Identifier column, as shown in Figure 4-8.

The most common and convenient option is to create LUNs and format them as VMware file system (VMFS) for the guest operating systems. VMFS is a multi-access and scalable file system that was developed by VMware to store the guest operating system's disk files (.vmdk), the VM's configuration files (.vmx and .vmxf) and BIOS information (.nvram), as well as Snapshot files when available (*0001.vmdk).

Each LUN formatted with VMFS is called a *datastore*. Figure 4-8 shows an example of using a datastore through the vCenter console.

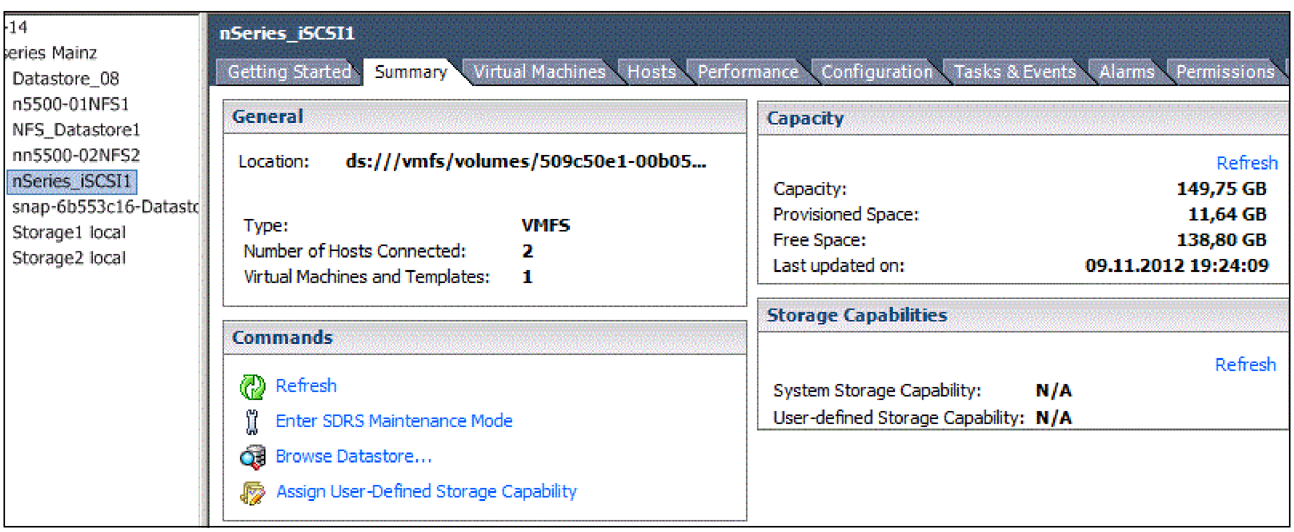


Figure 4-8 A datastore example

4.7.2 Presenting LUNs to an ESXi server over Fibre Channel

This section describes how to allocate a LUN to a host, so it can be used as a datastore and provide virtual disks for your virtual machines.

The storage limits were increased on VMware vSphere 5, making the storage and server administrators' environment easier to manage.

The following steps are considered to be completed prerequisites before you proceed:

1. LUN creation
2. An FCP Initiator Group with the WWPNs of the ESX hosts
3. The mapping of that LUN to the FCP Initiator group

Follow these steps to create a VMFS datastore over an FC LUN:

1. Open the **Virtual Infrastructure Client** and point it to your vCenter IP, typing your user name and password, as shown in Figure 4-9.

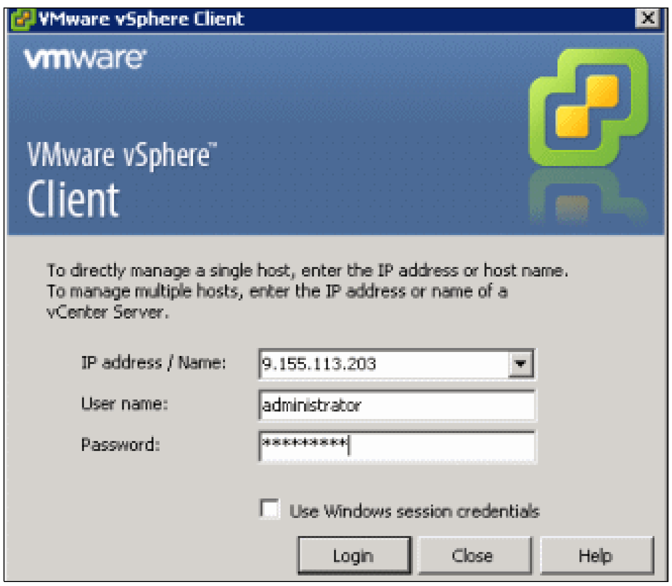


Figure 4-9 Logging using the Virtual Infrastructure Client

   After the console is opened, you can see the ESX host in the left pane and its properties in the right pane.

2. Rescan the storage LUNs to make the new LUNs available to the ESX host:

   a. Select the **ESXi Host**.

   b. On the **Configuration** tab, click **Storage**. Click the **Rescan** link.

   Selecting **Rescan** forces a rescan of all Fibre Channel and iSCSI HBAs, which is how VMware ESXi discovers changes in the storage available for use.

3. Repeat these steps for each host in the data center.

> **Double scan:** Some FCP HBAs require you to scan them twice to detect new LUNs. See VMware KB1798 at the following web address for further details:
>
> http://kb.vmware.com/kb/1798

After the LUNs are identified, you can provision them to the host as a datastore or assign them to a guest as an RDM.

To add a LUN as a datastore, follow these steps:

1. With vCenter opened, select a host.
2. In the right pane, select the **Configuration** tab.
3. In the Hardware box, select the **Storage** link and click **Add Storage**, as shown in Figure 4-10.

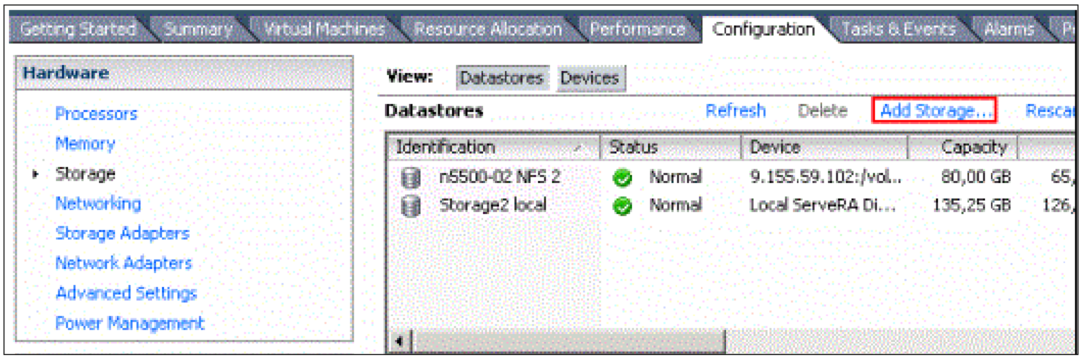


Figure 4-10 Adding storage

4. In the Add Storage wizard (Figure 4-11), select the **Disk/LUN** radio button and click **Next**.

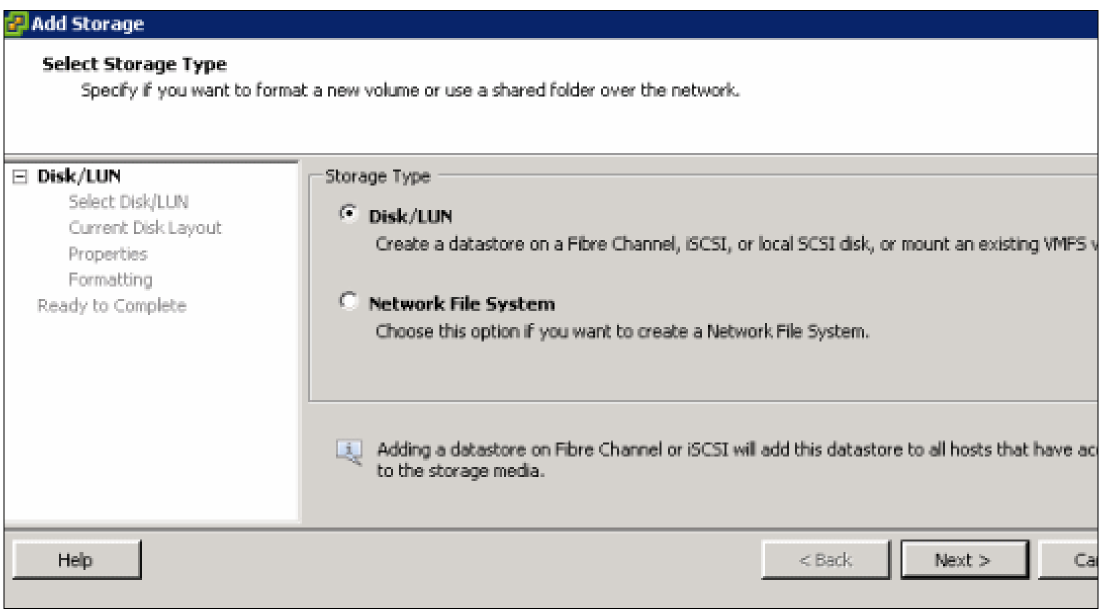


Figure 4-11 Add Storage wizard

5. Select the LUN that you want to use and click **Next** (Figure 4-12).

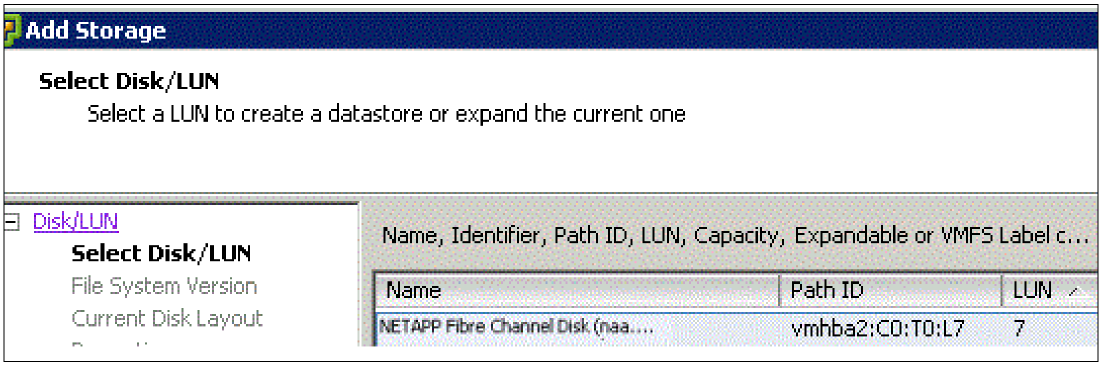


Figure 4-12 Selecting a LUN

6. Since VMware ESXi 5, the block size of a new created datastore has been changed to 1 MB, while maintaining the limit of 2 TB as the maximum file size, which means that the VM's disks are still limited to that size. If your infrastructure runs a mix of ESXi 5 and previous versions, it is desirable to create the datastores with VMFS-3, and VMFS-5 does not have backward compatibility. Figure 4-13 shows that selection window. Then click **Next**.

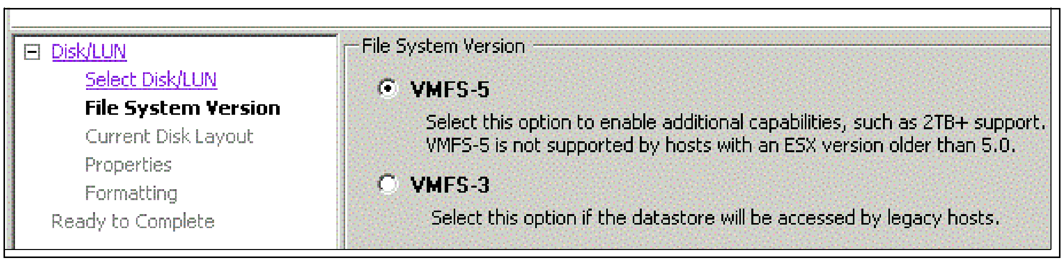


Figure 4-13 Datastore compatibility selection

7. View the selected LUN information as shown in Figure 4-14 and click **Next**.

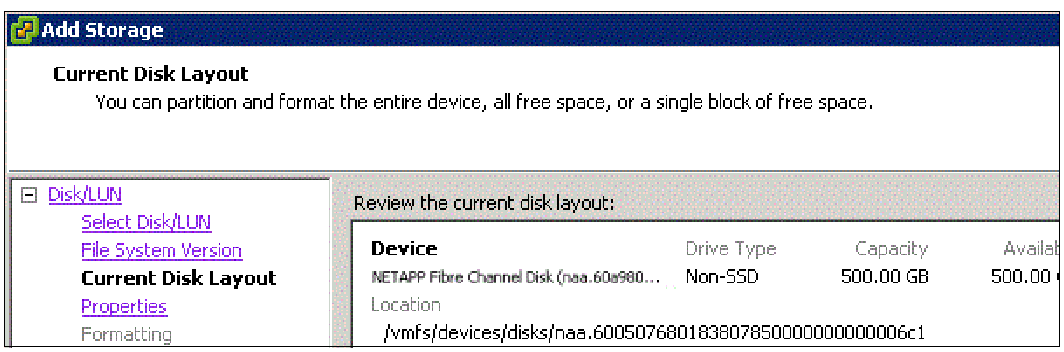


Figure 4-14 LUN information

8. Type a name for the datastore as shown in Figure 4-15 and click **Next**.

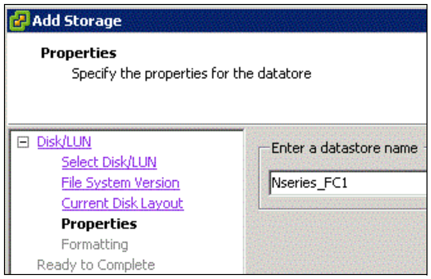


Figure 4-15 Define datastore name

9. Select if you want use all the LUN space by selecting **Maximum available space**, or select a different value on the **Custom space setting** as shown in Figure 4-16, then click **Next**.Unless you have a technical reason not to, select **Maximum available space**.

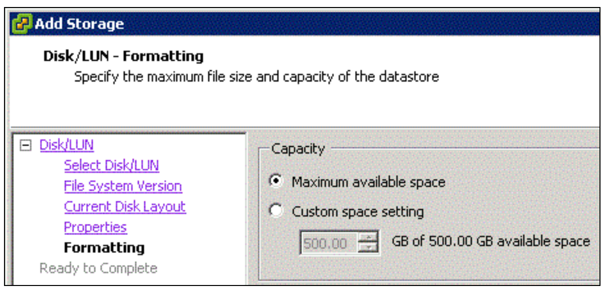


Figure 4-16 Selecting how much space of a LUN the datastore will take

10. Review the information entered and click as shown in Figure 4-17, and then click **Finish.**

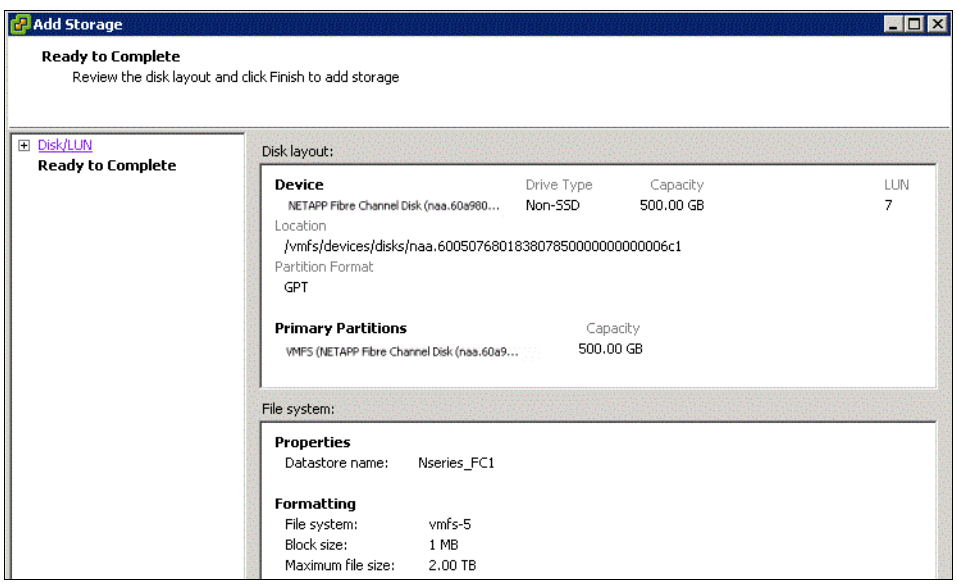


Figure 4-17 Reviewing datastore creation information.

11. After its creation, clicking the datastore will show details (see Figure 4-18).

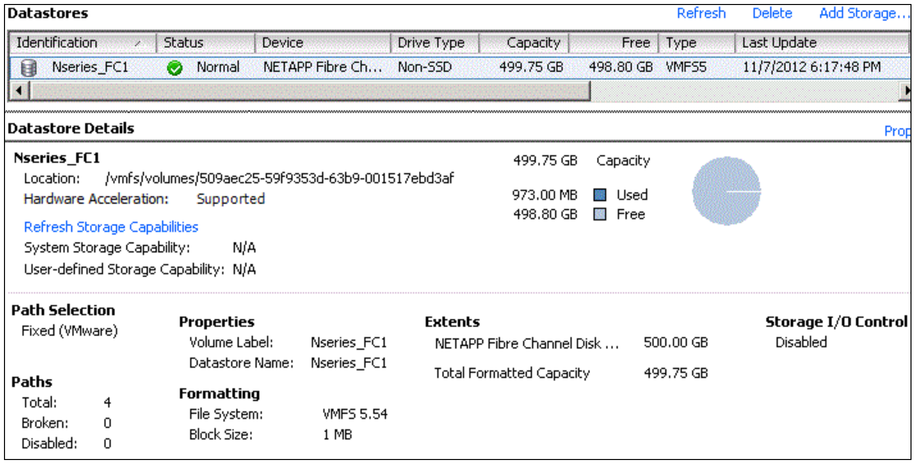


Figure 4-18 Datastore information

4.7.3 Using N series LUNs for Raw Device Mapping

With Raw Device Mapping (RDM), a guest operating system can access an external storage system regardless of the disk format. It is based on a VMDK file in a VMFS volume. This file is not a regular data file, but rather a pointer to external storage. This VMDK pointer file contains only the disk information describing the mapping to the external LUN of the ESX server.

RDM uses *dynamic name resolution* to access to the external storage system. With dynamic name resolution, it can use a permanent name to a device by referring to the name of the mapping file in the /vmfs subtree. All mapped LUNs are uniquely identified by VMFS, and the identification is stored on its internal data structures.

Any change in the SCSI path, such as a Fibre Channel switch failure or the addition of a new host bus adapter, has the potential to change the vmhba device name. The name includes the path designation (initiator, target, or LUN). Dynamic name resolution compensates for these changes by adjusting the data structures to re-target LUNs to their new device names.

The RDM device is most commonly used when virtual infrastructure administrators need to build a cluster where the VM‘s data resides on external storage device. You can only use RDM over the Fibre Channel.

4.7.4 Presenting an iSCSI LUN directly to a virtual machine

LUNs can be presented directly to virtual machines when using Fibre Channel through RDM. In the same way, LUNs can be directly accessed by a guest machine using iSCSI.

To implement this procedure, use the following steps:

1. On Windows 2008, click **Start** → **Administrative Tools** → **iSCSI Initiator**. On Windows 2003, the iSCSI client must be downloaded from the following website:

   http://www.microsoft.com/download/en/details.aspx?id=18986

   You can then install it by just accepting the defaults.

2. You might receive a message stating that the iSCSI service is not running yet. Click **Yes** to enable it.
3. On the iSCSI menu, click the **Configuration** tab and check the server's IQN, as shown in Figure 4-19. If you want to change it, click the **Change** button and make your modifications accordingly.

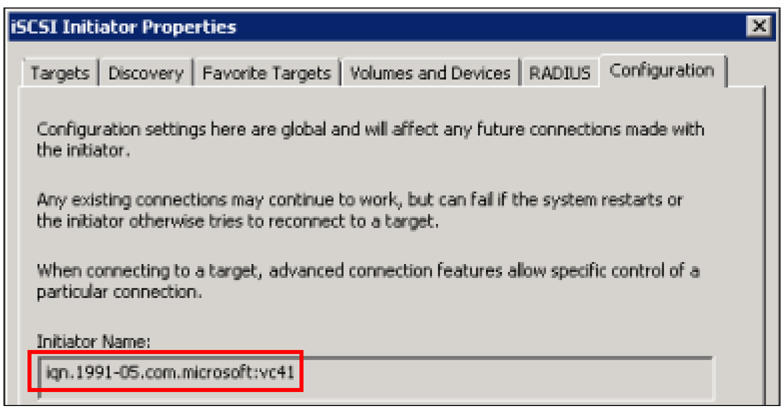


Figure 4-19 Collecting the VM's IQN

4. Create an iSCSI Initiator group.
5. Create and assign a LUN to it.
6. Click the **Discovery** tab, then click **Discover Portal**. Type the N series data IP interface for "IP address or DNS name", as shown in Figure 4-20.

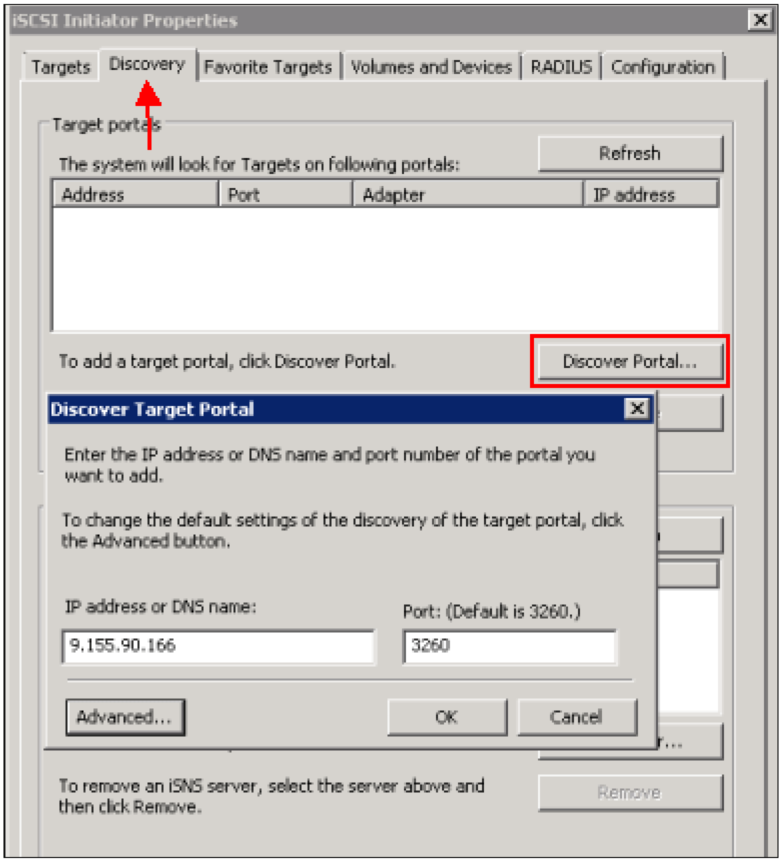


Figure 4-20 Adding the storage iSCSI data interface

7. Click **Targets**; the N series IQN will display as Inactive. Click **Connect**, as shown in Figure 4-21.

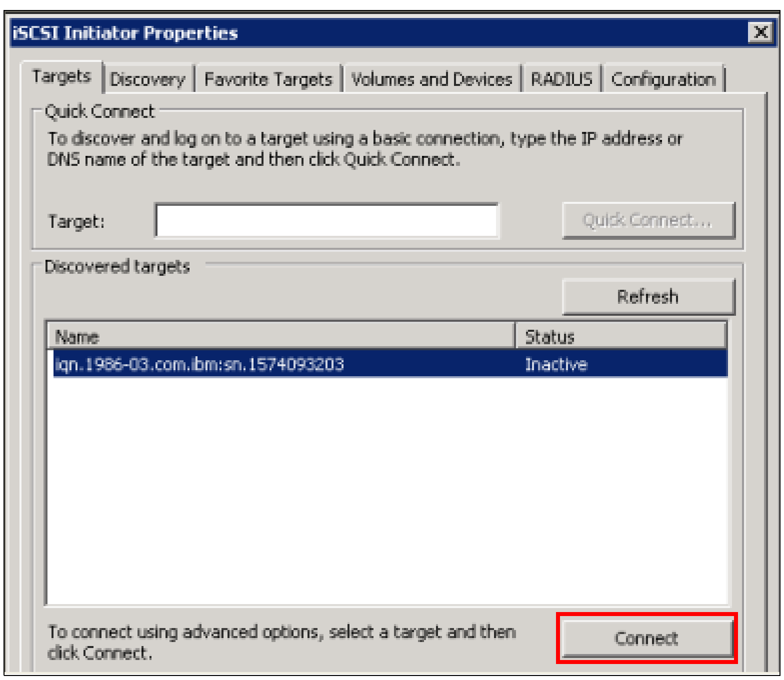


Figure 4-21 Connect to the target iSCSI

8. Accept the message and enable multipath if you have multiple NICs configured to access the storage. This choice is highly preferable. It changes the status to Connected.
9. Open Server Manager within that VM. Expand **Storage** and select **Disk Management**. The assigned LUN is shown there, as shown in Figure 4-22. If not, right-click **Disk Management** and select **Rescan**.

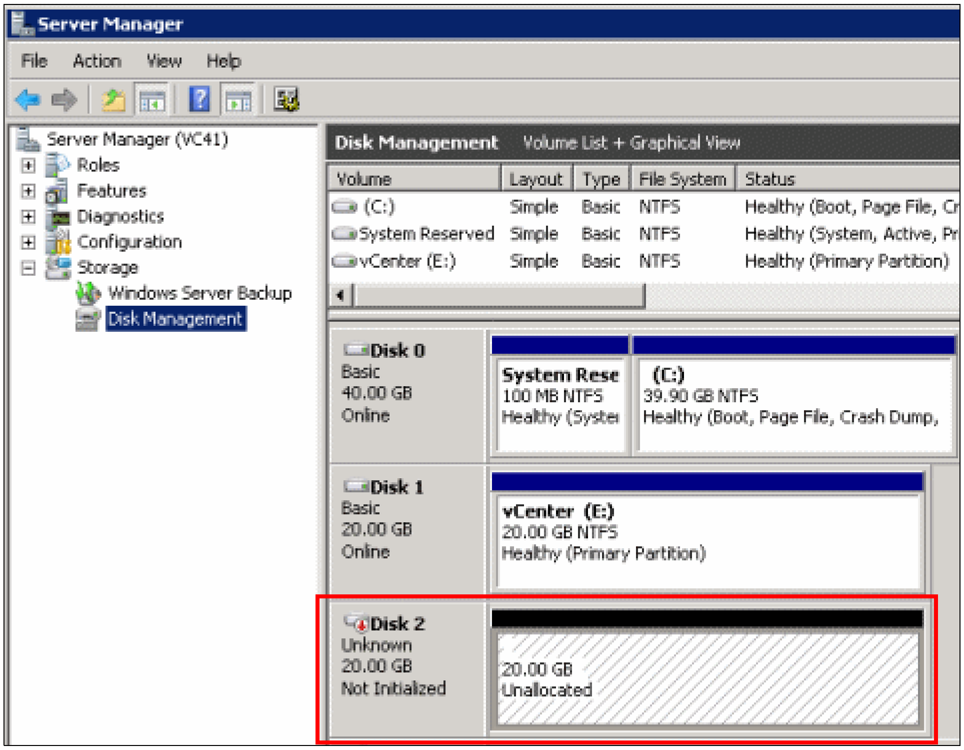


Figure 4-22 The allocated LUN shows in Disk Management

4.7.5 NFS volumes on VMware vSphere 5.1

NFS is widely used by server administrators due to its low cost and flexibility. An NFS volume can be increased (grown) and reduced (shrunk) at the N series level at any time without downtime, reflecting those operations on the VMware side with a rescan of its storage adapters.

NFS also offers an advantage of the datastore size that can be created. The VMware host does not have a limit for it, so the datastore can be as large as the storage volume size supported by the storage, which currently is 100 TB. It gives the administrator a central management point, instead of managing multiple datastores as with VMFS datastores.

Also, the integration on NFS and N series provides transparent access to VM-level storage virtualization offerings such as production-use block-level data deduplication, immediate zero-cost VM and datastore clones, array-based thin provisioning, automated policy-based datastore resizing, and direct access to array-based Snapshot copies.

Using NFS is also supported with integrated tools such as the Site Recovery Adapter for Site Recovery Manager and the VSC.

With NFS, you have access to a volume hosted in a storage system over an Internet Protocol network. Servers can take advantage of NFS to mount storage volumes as though they were locally attached.

VMware hosts require the creation of a VMkernel portgroup in order to access NFS. It is necessary because all the traffic between the storage system and the host must flow through IP network.

4.8 Storage virtual machine (SVM)

The storage virtual machine (SVM) is currently only covered in Chapter 3, "Introduction to Clustered Data ONTAP 8.2" on page 23 and earlier in the current chapter in the context of enabling cloud environments (Chapter 4.3, "Enabling cloud computing and automation with VSC" on page 45). SVM plays a major role in enabling the storage ability to operate non-disruptively.

While solid and reliable integration between the storage and the vSphere is critical, this integration is just a step during the build of the infrastructure. After the environment is up and running, it is very important, from a business perspective, to operate as efficiently as possible. Minimizing and even eliminating downtime due to planned or unplanned maintenance is one of the key values of N series and Clustered Data ONTAP and it is possible thanks to the architecture and the utilization of SVM. For more details about SVM, you can read section 3.2.1, "Storage virtual machine (SVM)" on page 32.

4.9 Using deduplication or compression with VMware

As previously explained, deduplication refers to the concept of storing multiple instances of the same information into a single point. Then a pointer is used to refer to it on the next occurrence, so files that potentially might be stored in an environment many times are stored only once. Microsoft Exchange and Symantec Vault are commercial products known for the usage of deduplication. VMware environments deduplicate extremely well. N series deduplication provides Advanced Single Instance Storage (A-SIS) at the storage level, rather than the application level. This significantly reduces the amount of storage that is used when the same files are stored multiple times. The deduplication process is shown in Figure 4-23.

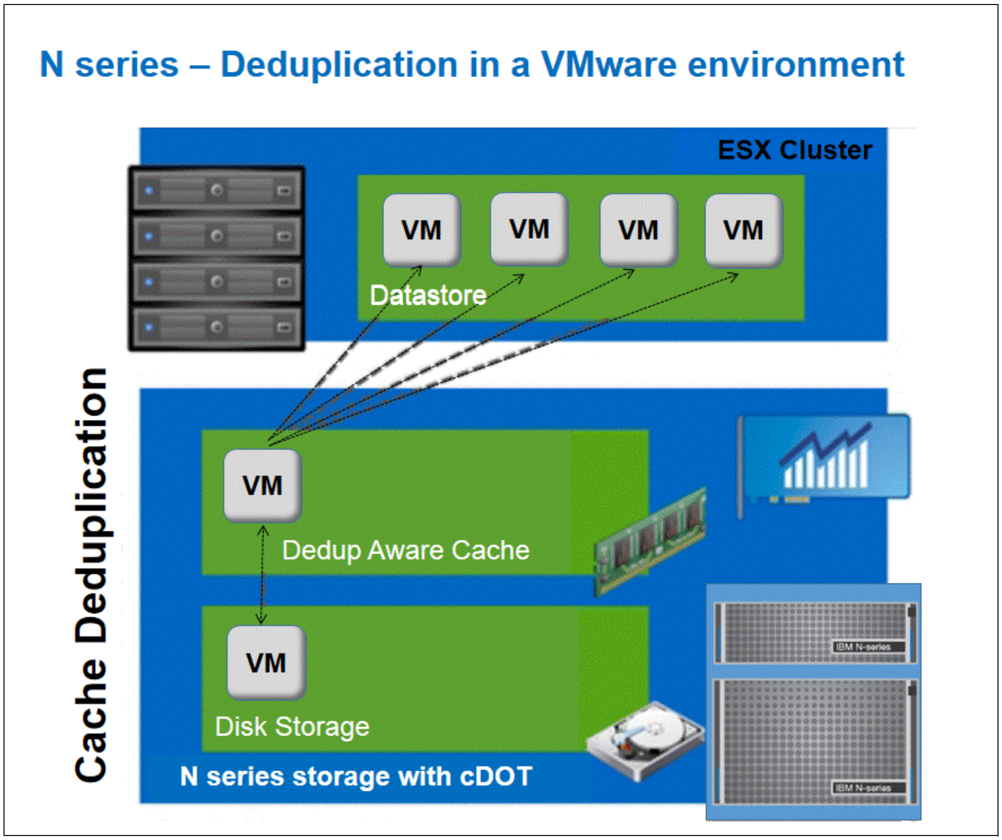


Figure 4-23 N series deduplication in a VMware environment with Flash Cache

4.10 Further information

For details about IBM VMware offerings, refer to the following website:

`http://www.ibm.com/systems/xbc/cog/vmwareesx.html`

For further details about how to integrate N series with VMware vSphere, see the IBM Redbooks publication *IBM System Storage N series with VMware vSphere 5*, SG24-8110, which is available at the following website:

`http://www.redbooks.ibm.com/abstracts/sg248110.html?Open`

For more information about native VMware Snapshots, including usage guidelines, see the Datacenter Administration Guide at the following website:

`http://pubs.vmware.com/vsphere-51/topic/com.vmware.ICbase/PDF/vsphere-esxi-vcenter-server-51-virtual-machine-admin-guide.pdf`

5

Microsoft Hyper-V integration

In addition to integration with VMware vSphere, this book provides information about the N series Clustered Data ONTAP capabilities to be integrated with Microsoft Windows server 2012 as a hypervisor, Hyper-V).

The following topics are covered:

- Introduction to storage integration
- Introduction to Windows Server 2012 R2
- N series integration with Microsoft environments
- Multi-protocol support for attaching external storage
- SnapManager for Hyper-V (SMHV)
- SnapDrive
- Infrastructure automation
- Further information

5.1 Introduction to storage integration

As established in earlier chapters, the benefits of the cloud are clear, and the journey towards cloud-based solutions starts with virtualization. Windows servers have built-in virtualization capabilities as hypervisors and, together with the Microsoft System Center, IT teams can design, build, and operate cloud-based solutions that are based on elastic and scalable infrastructures with automation, resource pooling, and dynamic provisioning.

The approach taken in this reference architecture is based on a broad view of the data center, identifying common aspects of the infrastructure and operations that are relevant for server virtualization based on Microsoft technology as the foundation to all cloud models. Storage, networking, security, and orchestration tools are essential components as well, yet this book mainly focuses on the integration between the IBM System Storage N series and the server virtualization technology that Microsoft offers, as well as the associated tools for management and other operational aspects of the environment.

The Microsoft hypervisor technology is based on Windows server 2012 R2 editions (standard and data center), which offers tremendous features for enabling cloud platforms. While surveying the various features and capabilities that are based on Microsoft's products, this book identifies the matching N series features to offer a complementary storage platform that is highly optimized for performance and cost, that is reliable and economical to deploy and operate, and that is flexible to scale and accommodate changes from the business in a simple way.

5.2 Introduction to Windows Server 2012 R2

Windows Server 2012 R2 offers businesses an enterprise-class, multi-tenant datacenter and cloud infrastructure that simplifies the deployment of IT services in an affordable way. With Windows Server 2012 R2, IT can improve end user experience and the level of the service offering while still being aligned with corporate policies. Windows Server 2012 R2 is suitable for any size of implementation from small to large enterprises or service providers and, unless specified differently, the topologies and aspects addressed in this book are relevant to them all, regardless of size or business models.

Microsoft lists the benefits of Windows Server 2012 R2 under the following seven topics:

- Server virtualization
- Storage
- Networking
- Server management and automation
- Web application platform
- Access and information protection
- Virtual desktop infrastructure

This chapter only covers the server virtualization, the storage, and the management and automation aspects, but comprehensive details about all aspects are well documented by Microsoft and can be found at the following link:

`http://technet.microsoft.com/en-US/evalcenter/dn205287.aspx?wt.mc_id=TEC_141_1_27`

Windows Server 2012 R2 is scalable and supports up to 64 processors and 1 terabyte of memory for Hyper-V guests, and VHDX virtual hard disks up to 64 terabytes. See 5.8, "Further information" on page 75 for links to Microsoft sources that provide more details about the specific improvements and differences between the current Windows Server 2012 and the previous 2008 versions.

5.2.1 Components of Windows Server 2012 R2

Microsoft classifies the capabilities of Windows Server 2012 R2 in the following seven topics:

- Server virtualization
- Storage
- Networking
- Server management & automation
- Web application platform
- Access & information protection
- Virtual desktop infrastructure

In the context of storage integration, which is the leading topic for the reference architecture, this chapter only covers the server virtualization, the storage, and the management and automation. Comprehensive details about all aspects are well documented by Microsoft and can be found at the following link:

http://technet.microsoft.com/en-US/evalcenter/dn205287.aspx?wt.mc_id=TEC_141_1_27

Server virtualization

Microsoft Hyper-V Server 2012 provides enhanced capabilities and features that help consolidate servers effectively while making maximum use of resources.

Hyper-V Network Virtualization decouples server configuration from network configuration to provide multiple virtual dedicated networks. This enables seamless communications among virtual machines and migration across physical servers and, while isolating these networks from one another, this also enhances security.

Hyper-V has capabilities to improve the protection of virtual machine protection, and help better manage the virtualization layer. It includes elements to manage and isolate network traffic, which is useful as metering and also for monitoring and troubleshooting.

Hyper-V Server enables tremendous flexibility in managing virtual machines with many live migration capabilities.

Storage

Windows Server 2012 R2 helps businesses and IT operators utilize their existing investments in SAN hardware by the introduction of the Off-load Data Transfer (ODX) feature. This allows better leverage of the shared storage and reduces impact on processing and networking at the server level.

Windows Server 2012 includes many other enhancements that are storage related features, that are not in the context of the architecture presented in this book, which is based on the N series as a NAS and SAN storage platform. However, they offer more improvements for local direct attached types of storage implementation.

Off-loaded Data Transfer (ODX) provides CPU and network off-loading to SAN hardware so file copy and move operation occurs by leveraging the storage rather than the CPU of the server. It comes into play with the provisioning of new virtual machines that occur often in cloud-based environments and when disks need to be migrated.

Such features help solve the problem of high CPU and network bandwidth utilization during file copy and move operations. They can help you to make better use of SAN hardware for copying data across and between servers.

ODX is a token-based mechanism for reading and writing data between the storage systems. Instead of routing the data through the host, a token is copied between the source and destination and it represent the data for the copy operation.

5.3 N series integration with Microsoft environments

This section provides a quick overview of the technologies that enable integration between the N series storage and data management tools and Microsoft Hyper-V and System Center (see Figure 5-1).

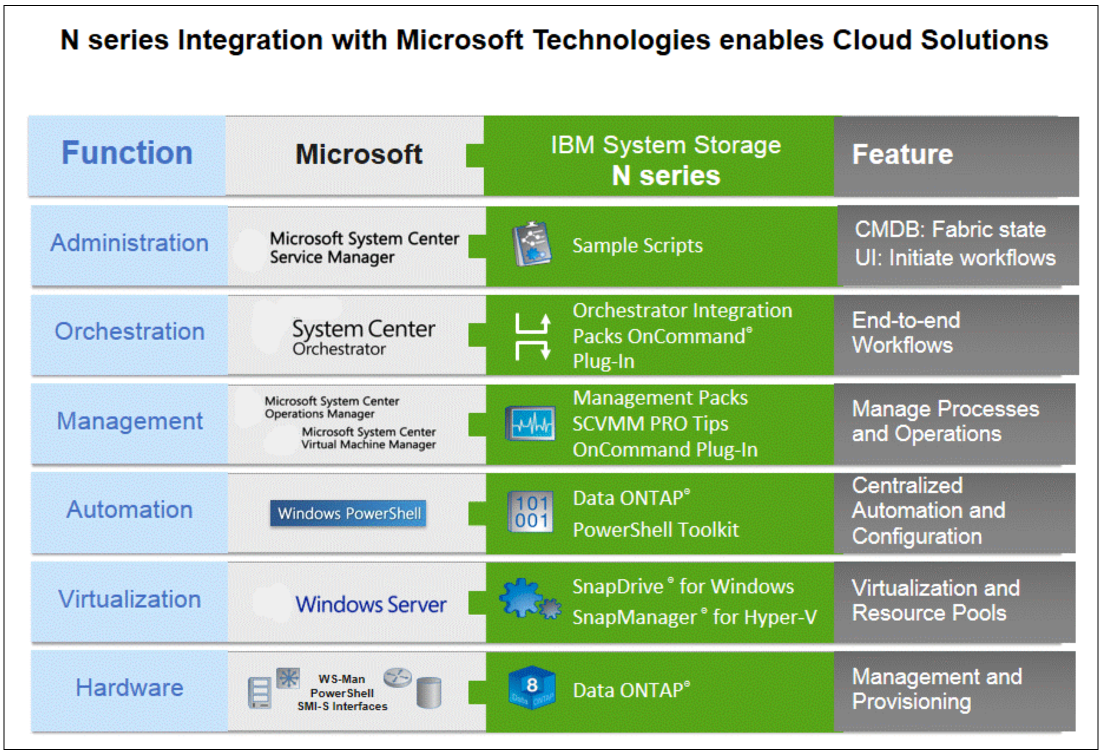


Figure 5-1 Comprehensive integration covers all functionality

5.4 Multi-protocol support for attaching external storage

Microsoft Windows Server 2012 supports both SAN and NAS deployment, which is also supported by the IBM System Storage N series with Clustered Data ONTAP 8.2 and, as described later in this section, by the SnapManager for Hyper-V (SMHV) tool. There are different storage considerations when implementing N series storage for Hyper-V environments based on SAN versus NAS. It is advisable to review the additional material from Microsoft and NetApp that is provided as a reference at the end of this chapter. See 5.8, “Further information” on page 75.

The most notable change introduced by Microsoft is Server Message Block (SMB) version 3.0, also known as Common Internet File System (CIFS). IBM System Storage N series supports SMB 3.0 and can fully integrates with the features and capabilities it offers to extend additional benefits to clients in deployments of virtualized environments. This includes the non-disruptive operations supporting cluster client with a failed node.

Microsoft aspects of SMB were enhanced and enhancement to SMB with Windows Server 2012:

- SMB Transparent Failover
- SMB Scale Out
- SMB Multichannel
- SMB Direct
- SMB Encryption
- VSS for SMB file shares
- SMB Directory Leasing
- SMB PowerShell

In terms of SAN protocols, FC, iSCSI and FCoE are all supported by the Windows Server as well as the N series storage system.

5.5 SnapManager for Hyper-V (SMHV)

SnapManager for Hyper-V (SMHV) allows IT organizations to take advantage of NetApp Snapshot and SnapMirror technologies to provide fast, space-efficient disk-based backups in a Hyper-V environments with N series storage while placing minimal overhead on the associated virtual infrastructures. It enhances the end-to-end operation associated with data protection of the virtualized servers. This section refers to SMHV version 2.0 as the current and latest version that supports Clustered Data ONTAP 8.2.

5.5.1 Capabilities of SMHV

SMHV offers the following capabilities:

- Allows system administrators to create hardware-assisted backup and restore of Hyper-V VMs running on N series storage.
- Provides integration with Microsoft Hyper-V VSS writer to quiesce the Hyper-V VMs before creating an application-consistent Snapshot copy of the VM in SAN LUNs.
- Supports backup and restore of VMs running on continuously available Server Message Block (SMB) shares that are hosted on Data ONTAP 8.2 based systems. Backup operations are performed using a Remote VSS plug-in located in Data ONTAP.
- Allows administrators to create application-consistent backups of Hyper-V VMs if Microsoft Exchange, Microsoft SQL Server, or any other VSS-aware application is running on VHDs in the VM.
- Provides replication with SnapMirror and vaulting with SnapVault of backup sets to secondary locations for DR planning.
- Supports the backup and restore of shared VMs configured using Windows Failover Clustering (WFC) for high availability (HA) and also on Microsoft Cluster Shared Volumes (CSVs); SMHV supports the seamless processing of scheduled VM backups, regardless of any VM failovers.
- Supports management of multiple remote Hyper-V parent systems from one console.
- Supports performing fast crash-consistent backup and restore of virtual machines.

5.5.2 Deployment considerations of SMHV

SMHV supports backup and restore of virtual machines on dedicated disks, cluster shared volumes (CSVs), or SMB 3.0 shares. SMHV can back up only VM data stored in VHDs that reside on Clustered Data ONTAP storage systems. It does not back up data on pass-through or direct-attached iSCSI or vFC disks. SMHV does not support master boot record LUNs for VMs running on shared volumes or CSVs. It does support LUNs created on thin-provisioned volumes and can perform backups and restores on these volumes.

To host VMs in SMB 3.0 shares in Windows Server 2012, the storage system should be running Clustered Data ONTAP 8.2.

SnapDrive 7.0 for Windows (SDW) must be installed on the host system. It is advisable to use SnapDrive to provision LUNs or shares to host virtual machines.

Figure 5-2 provides an overview of the deployment of SMHV.

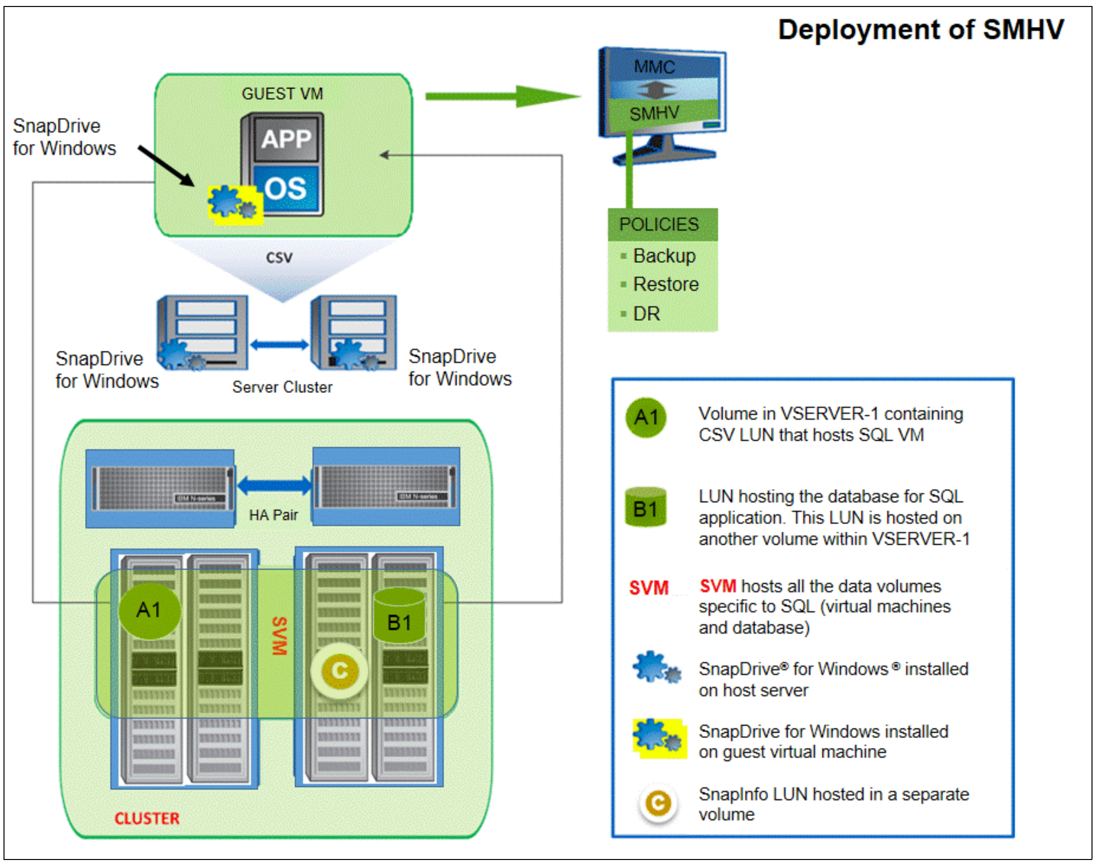


Figure 5-2 Deployment of SMHV

5.5.3 Backup operation

SMHV offers two backup types:

- Application-consistent backups: These are created in coordination with Volume Shadow Copy Service (VSS) to make sure that the applications running in the VM are quiesced before creating the Snapshot copy.
- Crash-consistent backups: These do not involve VSS. The data in the backup will be the same as it would be after a system failure or power outage.

5.5.4 Distributed Application-Consistent Backup in Windows Server 2012

Introduced as part of CSV 2.0 in Windows Server 2012, this feature allows backup of all the VMs in a cluster to be consistent in one single application-consistent backup. The VSS provider is only called on the backup node. All cluster nodes can read/write to the CSV volume.

Distributed Application-Consistent Backup is faster because it avoids multiple backup requests to each node in the cluster. The entire backup operation is performed from the coordinator node (cluster owner) alone and by leveraging the new CSV writer and CSV shadow copy provider. It is more space efficient because it creates only one Snapshot copy for each volume instead of creating one Snapshot copy for each node and volume combination. Figure 5-3 illustrates the architecture and components of the Distributed Application-Consistent Backup in SAN environments.

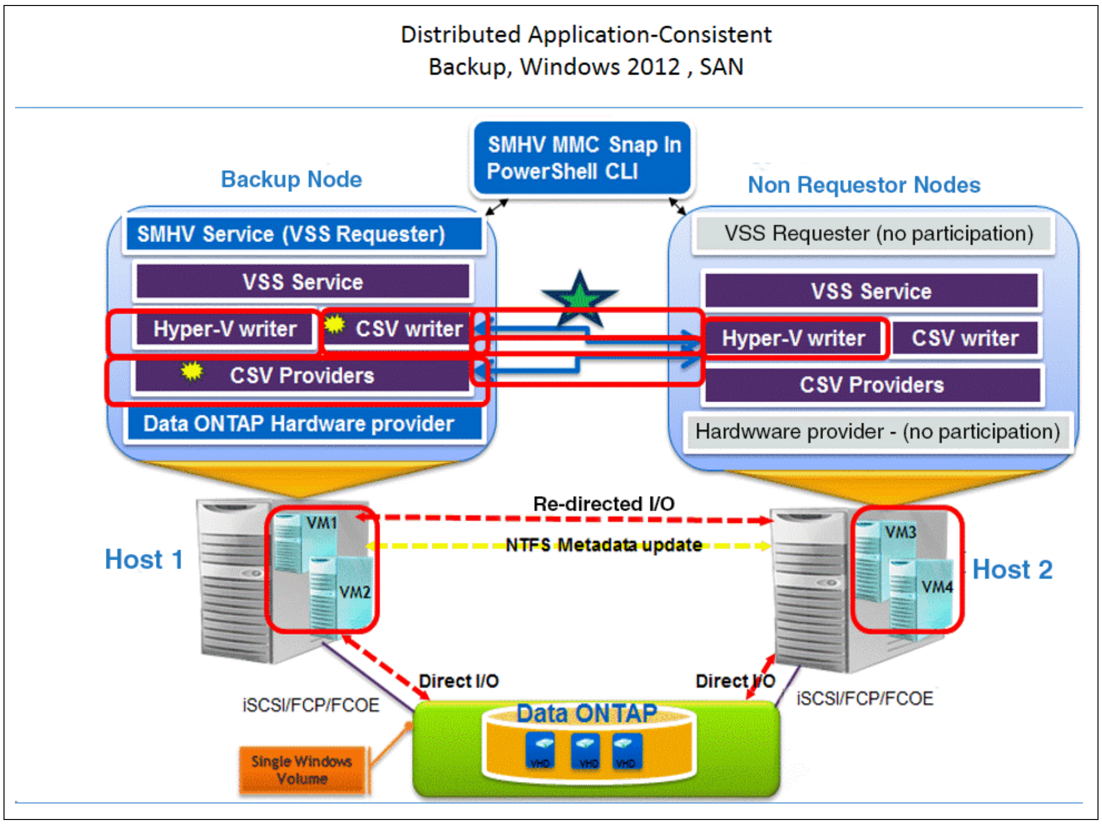


Figure 5-3 Distributed Application-Consistent Backup in SAN environment

Clustered Data ONTAP 8.2 supports two important features specifically developed for Windows Server 2012 environments, continuously available shares for Hyper-V over SMB and Remote VSS.

The user can create continuously available SMB shares using the provisioning templates in SnapDrive 7.0 for Windows and host virtual machines on them.

These virtual machines can be backed up by using SnapManager for Hyper-V with Remote VSS.

5.5.5 Application-consistent backup: Server Message Block (SMB)

Figure 5-4 outlines an Application-Consistent Backup for VMs residing in Server Message Block (SMB) 3.0 shares on a Windows 2012 server.

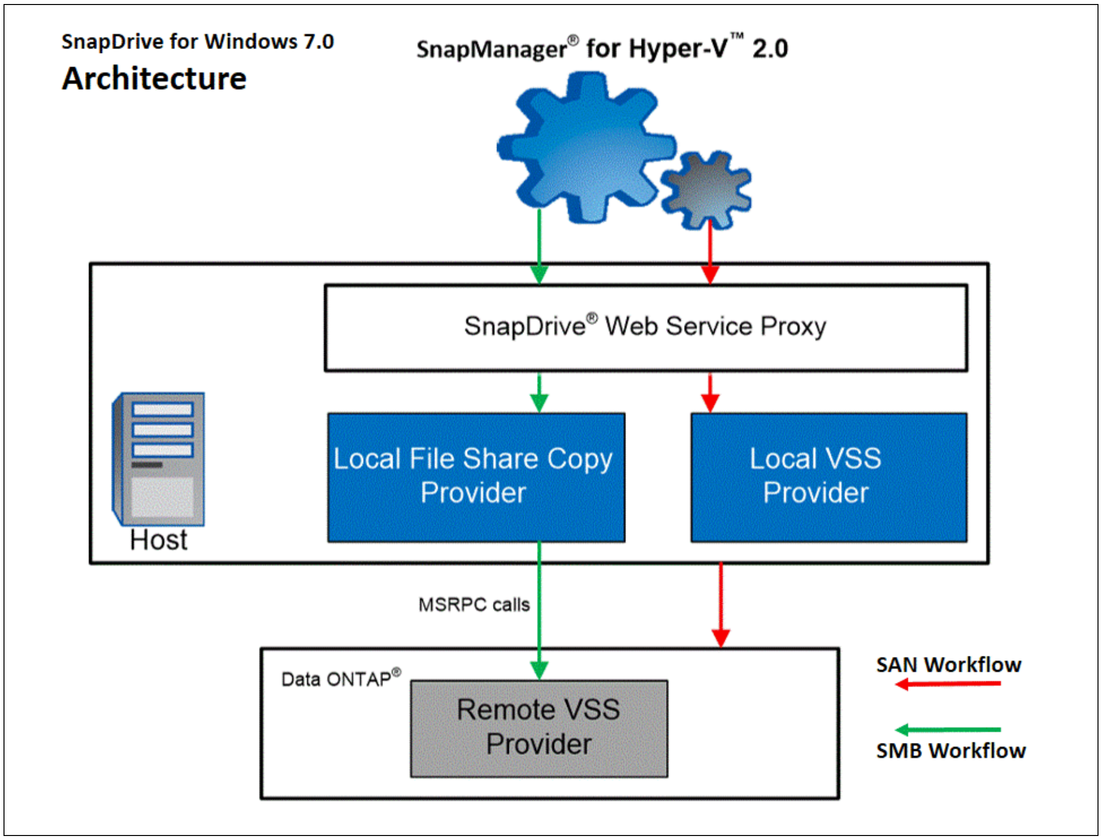


Figure 5-4 Application-Consistent Backup for VMs

5.5.6 Crash-consistent backup

Crash-consistent backups offer faster backup and restore cycles; they are not dependent on VSS:

1. The user chooses the crash-consistent backup option in the backup dataset wizard.
2. SnapManager for Hyper-V (SMHV) API calls VSS to collect VM metadata. The LUNs on which the VMs are hosted are identified.
3. SnapDrive API is called to create a Snapshot copy of the LUNs. Only one Snapshot copy is created for each LUN, regardless of the number of VMs running on it.
4. Backup is registered as crash-consistent backup type.
5. Upon completion of the local backup, SMHV updates an existing SnapMirror relationship on the volume, if the SnapMirror option was selected.

5.5.7 SMHV and SnapMirror

SMHV can perform failover and failback of Hyper-V VMs using Windows PowerShell cmd lets in SMHV Windows PowerShell. Windows PowerShell **`cmd let "restore-backup"`** must be used along with the switch **`-RestoreToAlternateHost`** and the server name. VMs in SMB shares can be restored by using **`"restore-backup"`** and **`-Restoretoalternatehost`**, along with **`VirtualMachinePath`**, **`VHDs`**, and **`SnapshotFilePath`** switches.

The integration of SMHV and SnapMirror data protection functionality is shown in Figure 5-5.

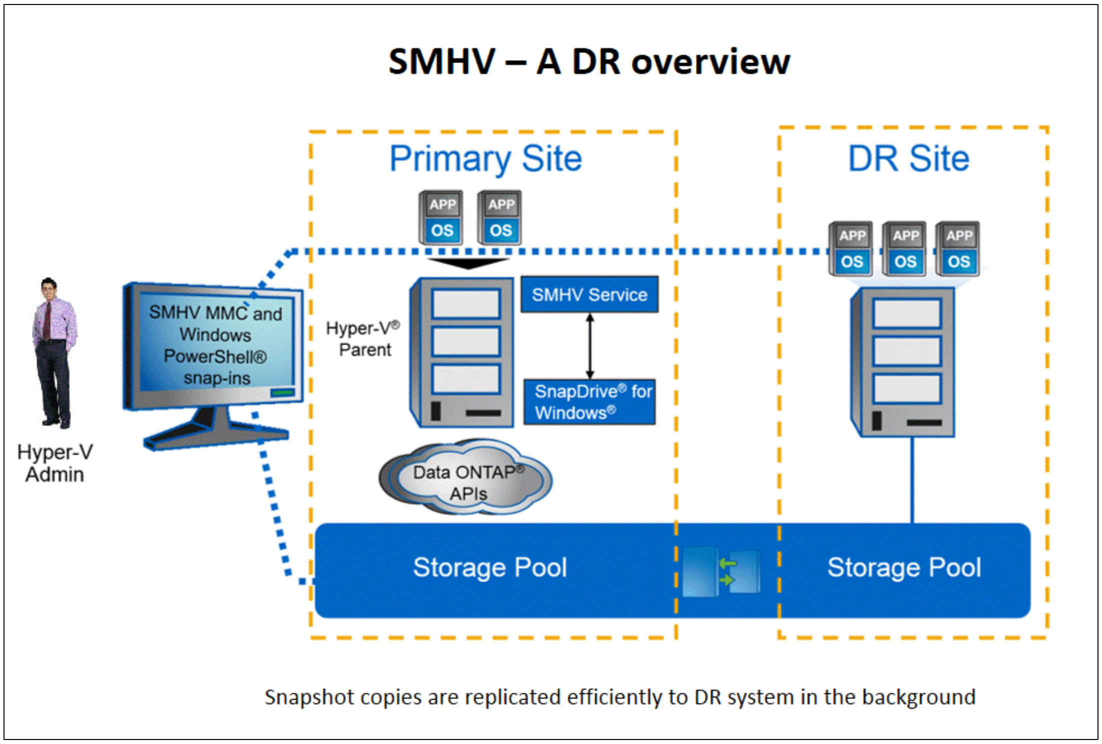


Figure 5-5 SMHV in a DR scenario

5.5.8 SMHV integration with SnapVault

With native integration and PowerShell. SMHV can be integrated with SnapVault to enhance data protection capabilities.

5.5.9 SMHV integration with OnCommand Workflow Automation 2.1

OnCommand Workflow Automation (WFA) 2.1 can be used to create SnapVault and SnapMirror policies to be used from SMHV.

5.6 SnapDrive

This section describes the features and benefits of using SnapDrive (version 7) in Microsoft environments to improve operational efficiencies associated with data protection and provisioning storage for virtual machines by leveraging the underlying storage capabilities of IBM System Storage N series to improve productivity, minimize risk, and reduce overall cost.

5.6.1 Benefits of SnapDrive 7.0 for Windows (SDW 7.0)

Here we list the benefits and capabilities of SDW 7.0:

- Increases administrator's productivity
- Flexible provisioning of storage resources
- File system-consistent Snapshot copies
- Automation of backup and restore
- Increases availability and reliability of application data
- Integration with Windows host clustering
- Integration with SnapManager products
- Rapid application recovery
- Storage efficiency -reclaiming storage space

5.6.2 Architecture and functions

Figure 5-6 provides a diagram of the architecture of the SDW 7.0.

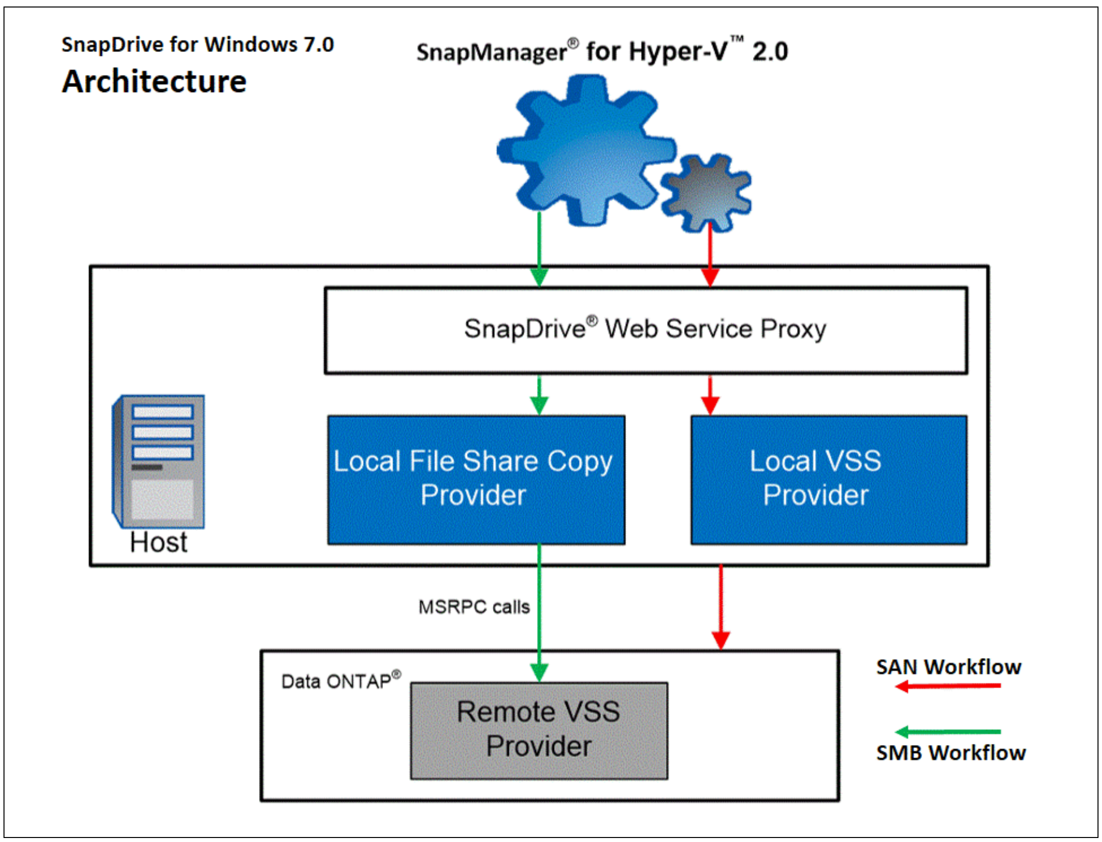


Figure 5-6 SnapDrive for Windows version 7.0 - Architecture

SDW 7.0 is a new version, and it brings additional features as listed here:

- Clustered Data ONTAP 8.2
- SMB 3.0 for Hyper-V (SMHV) and SQL Server (SMSQL) workloads
- Native SnapVault integration
- IPv6
- PowerShell cmd lets for SAN and SMB 3.0 workflows
- Windows Server 2012
- Virtual Fiber Channel support for guest VMs
- Group Managed Service Accounts
- Scalability
- 6-node Windows Failover Clustering - SAN
- 2-node Windows Failover Clustering - SMB 3.0
- vSphere 5.1 and later
- 5 Node Failover Clustering with FC RDM LUNs

The following capabilities are also provided:

- SDW 7.0 works with SMHV and other SnapManager for Microsoft products. It also works with VSC 4.2 in VMware environments.
- SDW 7.0 can create continuously available CIFS shares from the Hyper-V host using Windows PowerShell cmd lets to run VMs that can be backed up by SMHV
- Templates for Hyper-V, home directories, and SQL Server can be provisioned and are available with SnapDrive for Windows (SDW) 7.0

5.6.3 Remote VSS

Volume Shadow Copy Service (VSS) is a framework that provides coordination of application I/O and physical storage on the same server and allows creation of application-consistent Snapshot copies of the storage.

Microsoft Windows Server 2012 extends the functionality of VSS to multiple servers. Remote VSS coordinates I/O activities during a backup process between both servers and provides application-consistent backup Snapshot copies of the storage, for applications running remotely on the storage server. Clustered Data ONTAP 8.2 extends the functionality of remote VSS by plugging into the VSS framework; a VSS service runs on an N series controller, and a VSS provider runs on a Windows Server 2012 machine. From a VSS perspective, the storage array acts in the same way as a Windows File Server as the capabilities are embedded in the storage operating system (OS).

5.6.4 Backup and restore operations

SDW integrates with *SnapVault*. SnapVault can be configured by using Powershell cmd lets, and updates can be initiated by the SnapManager for SQL or SnapManager for Hyper-V GUI. Each volume that has a SnapVault relationship can have a SnapVault policy with a threshold associated with it.

Files and directories in SMB shares can be restored from the secondary Snapshot copy using the mount and copy restore method. First, a FlexClone clone of the volume is created from the secondary Snapshot copy and mounted to a junction path. After this, a share is created in the SnapVault system based on the source share's storage footprint; the required files/directories are then copied from the secondary share to the primary share.

Thin provisioning is designed to present more logical storage to hosts or users than what the actual space on the physical storage pool is. Space reserved/LUN reservation allows the user to determine when space for the LUN is reserved or allocated from the volume; this is a property for a LUN. Space guarantee allows the user to determine when the space is reserved or allocated from the volume; and it is a property for the volume (see Figure 5-7).

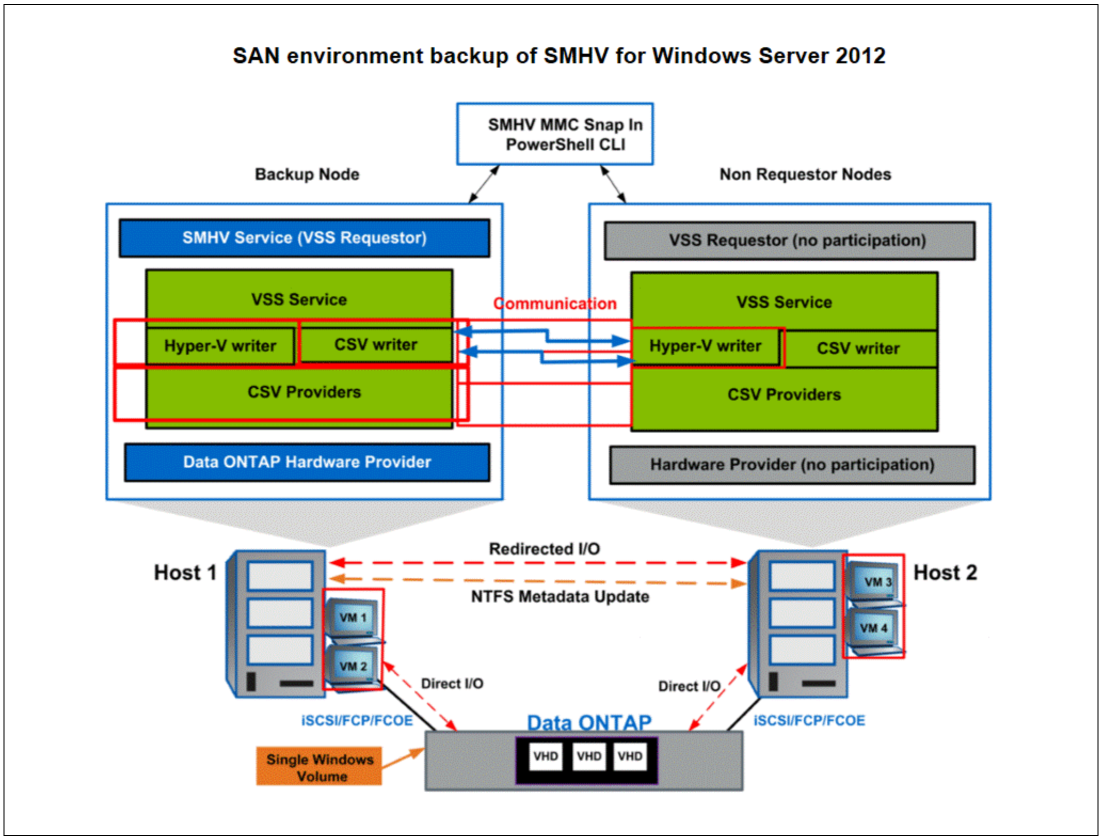


Figure 5-7 Backup of Windows Server 2012 in a SAN environment

5.7 Infrastructure automation

Complete infrastructure automation can be achieved by integration Microsoft Windows and N series features and functions as shown in Figure 5-8.

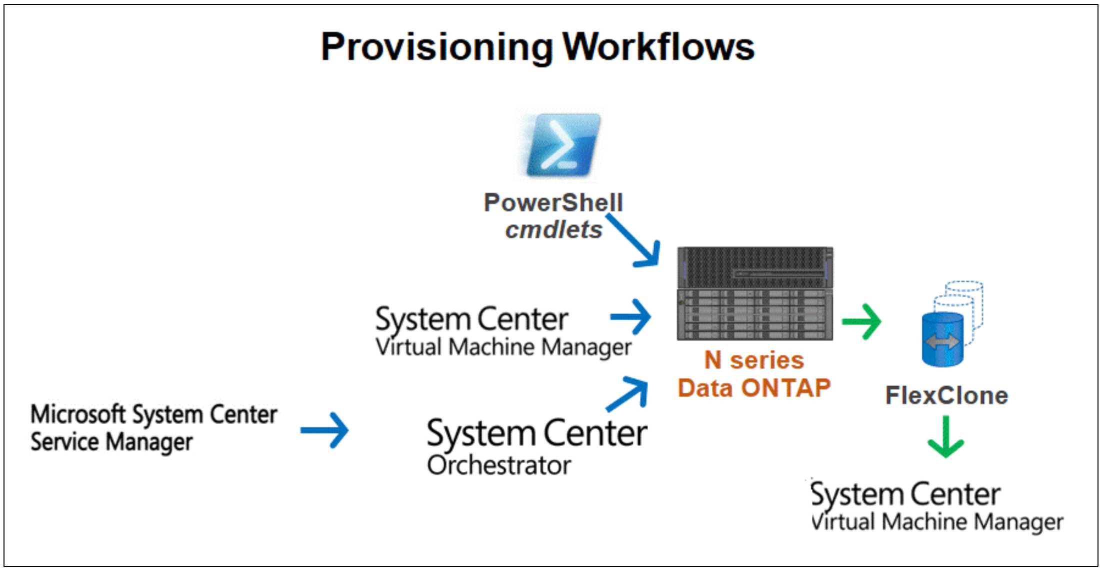


Figure 5-8 N series storage provisioning workflow

5.8 Further information

The following list includes links for additional information:

- Deploy Hyper-V over SMB:
  http://technet.microsoft.com/en-us/library/jj134187.aspx
- Windows Server 2012 Overview
  http://www.microsoft.com/en-us/server-cloud/windows-server/overview.aspx
- What's New in Windows Server 2012
  http://technet.microsoft.com/en-us/library/hh831769.aspx
- Protect Data on Remote SMB File Share Using VSS
  http://technet.microsoft.com/en-us/library/jj612865.aspx

6

Server

This chapter describes the IBM System x components that are used as building blocks for the VMware vSphere environment.

The following topics are covered:

- Rack and power infrastructure
- Host/compute solution classification
- Entry x3650 M4 host/compute nodes
- Mainstream HS23 host/compute nodes
- Mainstream HX5 host/compute nodes
- Mainstream or Advanced with Flex System
- Management node vCenter server
- Active Directory server
- Further information

6.1 Rack and power infrastructure

Optimized infrastructure equipment is critical to drive improved IT efficiency and availability for the data centers of today and tomorrow. The IBM rack and power infrastructure offerings are custom designed for IBM System x servers, and they provide the following benefits:

- Improved data center efficiency:
  - Increased power efficiency
  - Increased space efficiency (avoid over-design)
  - Lower cost through better data center utilization
- Improved IT availability:
  - Improved uptime
  - Act before downtime impacts business
  - Match utilization, power resources, and capacity planning

In addition, IT availability and efficiency are primary drivers to data center spending:

- Servers per rack are up 50 percent since the year 2000.
- Energy consumption is up 20 percent due to more memory, with improved utilization due to virtualization.
- Higher power densities are needed at the server and rack levels.

In today's online environment, even minutes of downtime can have a significant impact on an organization's operations, client satisfaction, and financial results, thus making high availability an essential feature. The technology fundamentals for today's data center require a solid foundation of rack and power infrastructure that delivers the ability to securely manage and control power resources, servers, and appliances in the data center and across the network. This is imperative to maintain the highest levels of IT availability, and drive operational efficiencies.

IBM has announced over 40 new products, refreshing the offerings across the entire rack and power options portfolio, including the following items:

- Three new racks that are 1200 mm deep. This new lineup includes a new 47U tall rack and new 42U versions including a "dynamic" rack that is ship-loadable.
- An IBM lineup of optional universal power supply (UPS) units that includes new rack-mounted and tower units supporting voltages and configurations not previously available, with new 1500, 2200, 3000, and 6000 volt-ampere (VA) units.
- A new line of 0U Strip Power Distribution Units (PDUs), designed for tool-less installation in the new racks. These PDUs have 24 outlets for today's server-dense rack installations.
- IBM is also offering new Local and Global Console Managers that support unique cabling options ("conversion options") to enable chaining up to 1,024 managed devices that can be managed from a single console.

These offerings are shown in Figure 6-1.

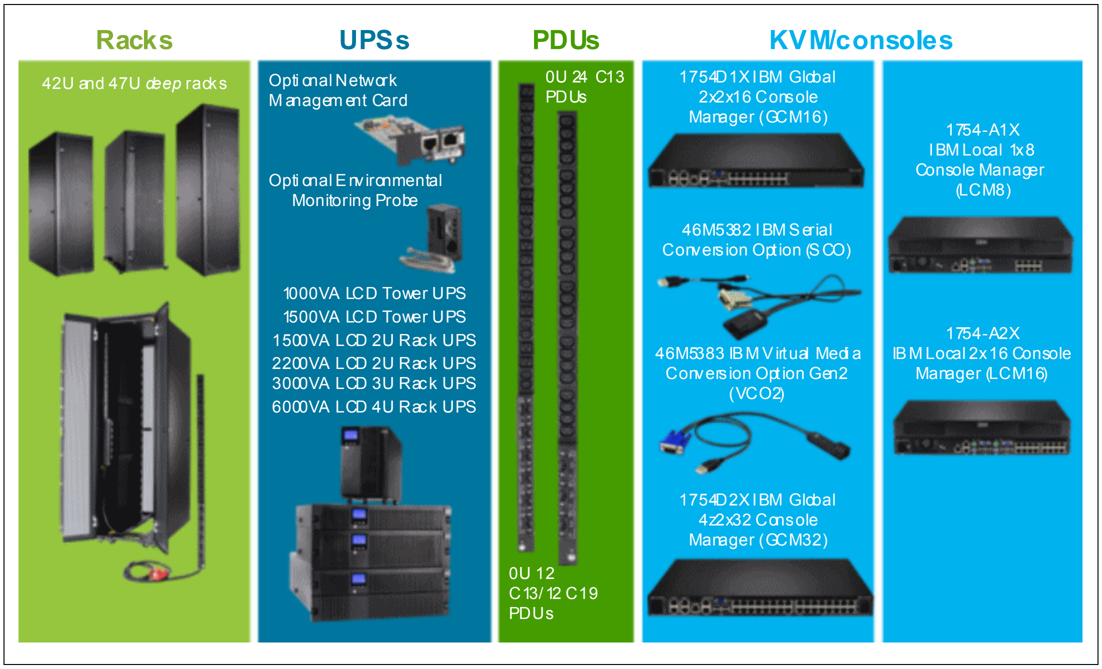


Figure 6-1 System x rack and power choices

Table 6-1 lists the rack and power items used in all of these offerings.

Table 6-1 Rack and power parts list

Part number	Description	Quantity
1754D1X	IBM Global 2x2x16 Console Manager	1
46M5383	IBM Virtual Media Conversion Option VCO2	11
172319X	1U 19-inch Flat Panel Monitor Console Kit with DVD	1
40K5372	IBM Keyboard with Integrated Pointing Device	1
53956KX	IBM 6000VA 4U Rack UPS (230V)	2
46M4110	IBM LCD UPS Network Management Card	2
46M4004	IBM 1U 12 C13 Switched and Monitored DPI PDU	4
40K9614	IBM DPI 30A Cord (NEMA L6-30P)	4
93604PX	IBM 42U 1200 mm Deep Dynamic Rack	1

6.2 Host/compute solution classification

The compute nodes are the processing elements for the offering. Virtualization technology in VMware vSphere and Microsoft Hyper-V allows each user to see the compute node as a dedicated resource, even though it is shared among other users. The previously introduced reference architecture solution classification is composed out of three classes, Entry Level, Mainstream, and Advanced, each with several configuration examples with different counts of storage nodes in the storage cluster.

The number of required compute nodes varies for each group of configurations and it depends on the total number of supported virtual servers. Since this reference is provided from the perspective of the storage, multiple storage configurations were selected to explain the options with IBM System Storage N series and its Clustered data ONTAP. So the server count was calculated to meet the storage capabilities:

- Entry has four x3650 M4 servers (or x3550 if requirements allow). For four-node storage cluster six servers are required.
- Mainstream has between 4 and 18 servers of x3650 or HS23/HX5 servers. and a Flex System option with the same count of x240 compute nodes
- Advanced has 8 - 36 compute nodes of Flex system x240 / X440 combination.

IBM is a leader in technology and innovation, and has a deep understanding of virtual environments. With substantial investments in green initiatives and energy-smart designs, IBM not only provides high performing, easy-to-manage servers, but can also help minimize costs for power and cooling.

6.3 Entry x3650 M4 host/compute nodes

The x3650 M4 is an outstanding 2U two-socket business-critical server, offering improved performance and pay-as-you grow flexibility along with new features that improve server management capability. This powerful system is designed for your most important business applications and cloud deployments.

Combining balanced performance and flexibility, the x3650 M4 is a great choice for a range of small and medium businesses, and even up to large enterprises. It can provide outstanding uptime to keep business-critical applications and cloud deployments running safely. Ease of use and comprehensive systems management tools make it easy to deploy. Outstanding RAS and high-efficiency design improve your business environment and help save operational costs.

The x3650 M4 offers numerous features to boost performance, improve scalability, and reduce costs:

- The Intel Xeon processor E5-2600 product family improves productivity by offering superior system performance with 8-core processors and up to 2.9 GHz core speeds, up to 20 MB of L3 cache, and up to two 8 GT/s QPI interconnect links.
- Up to two processors, 16 cores, and 32 threads maximize the concurrent execution of multithreaded applications.
- Intelligent and adaptive system performance with Intel Turbo Boost Technology 2.0 allows CPU cores to run at maximum speeds during peak workloads by temporarily going beyond processor TDP.
- Intel Hyper-Threading Technology boosts performance for multithreaded applications by enabling simultaneous multithreading within each processor core, up to two threads per core.
- Intel Virtualization Technology integrates hardware-level virtualization hooks that allow operating system vendors to better utilize the hardware for virtualization workloads.
- Intel Advanced Vector Extensions (AVT) significantly improve floating-point performance for compute-intensive technical and scientific applications compared to Intel Xeon 5600 series processors.
- Twenty-four Load Reduced DIMMs (LRDIMMs) of 1333 MHz DDR3 ECC memory provide speed, high availability, and a memory capacity of up to 768 GB (running at 1066 MHz).

- Theoretical maximum memory bandwidth of the Intel Xeon processor E5 family is 51.6 GBps, which is 60 percent more than in the previous generation of Intel Xeon processors.
- The use of solid-state drives (SSDs) instead of, or along with, traditional spinning drives (HDDs) can significantly improve I/O performance. An SSD can support up to 100 times more I/O operations per second (IOPS) than a typical HDD.
- Up to 16 drive bays, together with internal backup and an optical drive at the same time, provide a flexible and scalable all-in-one platform to meet your increasing demands.
- The server has four integrated Gigabit Ethernet ports and two optional 10 Gb Ethernet ports with mezzanine cards that do not consume PICe slots.
- The server offers PCI Express 3.0 I/O expansion capabilities that improve the theoretical maximum bandwidth by 60 percent (8 GT/s per link) compared to the previous generation of PCI Express 2.0.
- With Intel Integrated I/O Technology, the PCI Express 3.0 controller is integrated into the Intel Xeon processor E5 family. This integration helps to dramatically reduce I/O latency and increase overall system performance.

Figure 6-2 shows the front view of the x3650 M4.

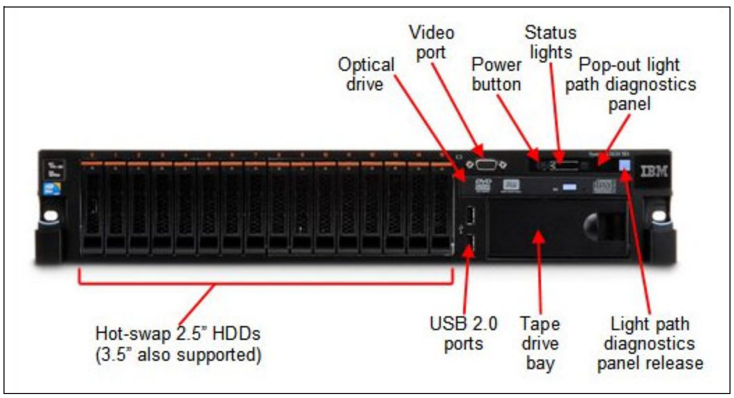


Figure 6-2 The x3650 M4 front view

Figure 6-3 shows the rear view of the x3650 M4.

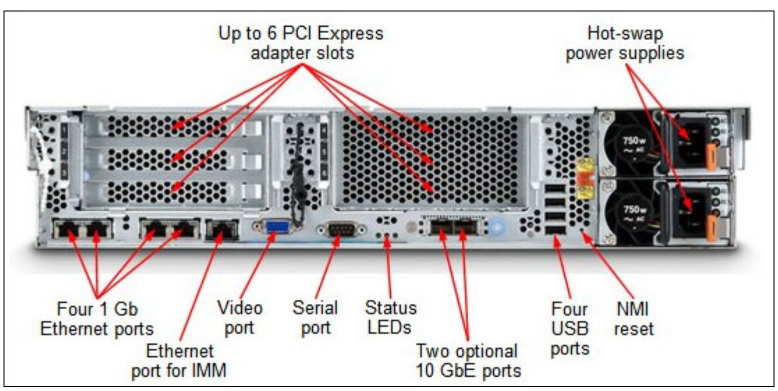


Figure 6-3 The x3650 M4 rear view

For additional details about the x3650 M4, see the *IBM System x3650 M4 Product Guide*, available at the following websites:

- http://www.ibm.com/systems/x/hardware/rack/x3650m4/
- http://www.redbooks.ibm.com/technotes/tips0850.pdf

6.4 Mainstream HS23 host/compute nodes

The Advanced configuration has servers with four sockets. In essence, this doubles the number of CPUs on the host node from 16 to 32. Because of this increase in the number of sockets, the Advanced configuration offers an almost doubling of the number of VMs, making for a rich mix of scaleup possibilities in an actively growing data center.

The IBM BladeCenter HS23 is a next-generation two-socket blade server running the Intel Xeon processor E5-2600 product family. With its industry-leading RAS features, energy efficiency, outstanding performance, flexible and scalable I/O, and complete systems management, HS23 offers a robust platform optimized for your mission-critical applications. Standard 30 mm single-wide form-factor protects your investments by providing compatibility with the IBM BladeCenter H, E, S, and HT chassis. The suggested use is a versatile platform to run a broad range of workloads, including infrastructure, virtualization, and enterprise applications.

The IBM BladeCenter HS23 gives you the networking capacity that you need to manage your data center. The new Virtual Fabric-capable integrated 10 GbE offers extreme speed, and the HS23 is designed with highly scalable I/O to give you a total of up to four 10 Gb physical ports that can be divided into up to 14 virtual ports, and the ability to run multiple I/O protocols (FCoE/iSCSI). Sixteen DIMM slots supporting up to 256 GB of DDR3 memory allow you to fit more and larger virtual machines per blade. In addition, the HS23 is backward-compatible with all BladeCenter chassis, including the original BladeCenter E.

The BladeCenter HS23 offers numerous features to boost performance, improve scalability, and reduce costs:

- The Intel Xeon processor E5-2600 product family improves productivity by offering superior system performance with up to 8-core processors and up to 3.0 GHz core speeds depending on the CPU’s number of cores, up to 20 MB of L3 cache, and QPI interconnect links of up to 8 GT/s.
- Up to two processors, 16 cores, and 32 threads maximize the concurrent execution of multithreaded applications.
- Intelligent and adaptive system performance with Intel Turbo Boost Technology 2.0 allows CPU cores to run at maximum speeds during peak workloads by temporarily going beyond processor TDP.
- Intel Hyper-Threading Technology boosts performance for multithreaded applications by enabling simultaneous multithreading within each processor core, up to two threads per core.
- Intel Virtualization Technology integrates hardware-level virtualization hooks that allow operating system vendors to better utilize the hardware for virtualization workloads.
- Intel Advanced Vector Extensions (AVT) can significantly improve floating point performance for compute-intensive technical and scientific applications.
- Up to 16 DDR3 ECC memory RDIMMs provide speeds up to 1600 MHz and a memory capacity of up to 256 GB.
- The theoretical maximum memory bandwidth of the Intel Xeon processor E5 family is 51.6 GBps, which is 60 percent more than in the previous generation of Intel Xeon processors.
- The use of solid-state drives (SSDs) instead of, or along with, traditional spinning drives (HDDs) can significantly improve I/O performance. An SSD can support up to 100 times more I/O operations per second (IOPS) than a typical HDD.

- The HS23 scales to 18 I/O ports on a single-wide blade with integrated Gigabit Ethernet and 10 Gb Ethernet ports and optional expansion cards, offering the choice of Ethernet, Fibre Channel, SAS, iSCSI, and FCoE connectivity.
- The HS23 offers PCI Express 3.0 I/O expansion capabilities that improve the theoretical maximum bandwidth by almost 100 percent (8 GTps per link using 128b/130b encoding) compared to the previous generation of PCI Express 2.0 (5 GTps per link using 8b/10b encoding).
- With Intel Integrated I/O Technology, the PCI Express 3.0 controller is integrated into the Intel Xeon processor E5 family. This helps to dramatically reduce I/O latency and increase overall system performance.

Figure 6-4 shows a view of the HS23 BladeCenter module.

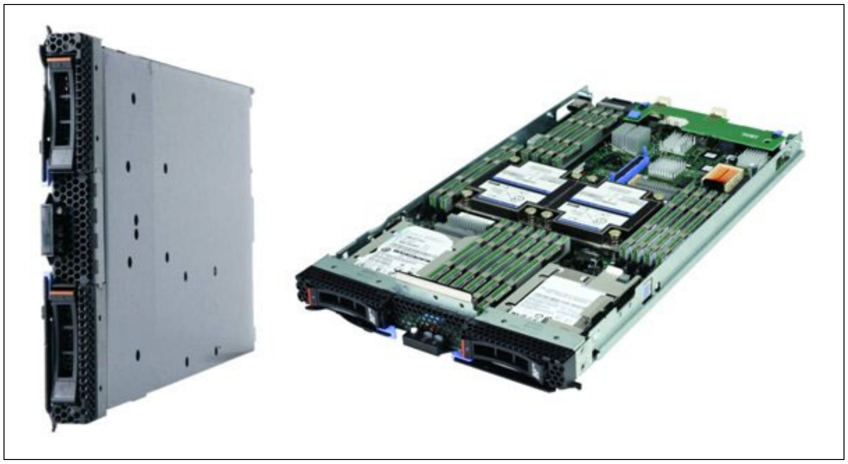


Figure 6-4 View of HS23 BladeCenter module

For additional details about the HS23, see the *IBM System HS23 Product Guide*, available at the following websites:

- `http://www.ibm.com/systems/bladecenter/hardware/servers/hs23/`
- `http://www.redbooks.ibm.com/technotes/tips0843.pdf`

6.5 Mainstream HX5 host/compute nodes

IBM has been designing and implementing chipsets under the IBM X-Architecture® name since 2001. The eX5 technology represents the fifth generation of products based on the same design principle that IBM began in 1997. That principle is to offer Intel Xeon processor-based systems that are expandable, offer “big iron” reliability, availability, and serviceability (RAS) features, with extremely competitive price/performance.

The eX5 technology is primarily designed around three major workloads: database servers, server consolidation using virtualization services, and Enterprise Resource Planning (application and database) servers.

The BladeCenter HX5 offers numerous features to boost performance, improve scalability, and reduce costs:

- The HX5 offers a choice of high-performance 4-, 6-, 8-, and 10-core Xeon processors with dual integrated memory controllers, clock rates of 1.86 GHz to 2.67 GHz, 12 MB to 30 MB of integrated Level 3 cache, and Intel Virtualization Technology (VT), Hyper-Threading (HT) technology, and Turbo Boost technology.

- By scaling to two blade servers, the HX5 can support up to 512 GB of memory, which is generally enough for even the most demanding virtualization, database, or ERP needs. If even that is not enough memory, however, then by using one blade server and one memory expansion blade, the HX5 can scale to 640 GB.
- Alternatively, with 40 DIMM slots the server and MAX5 can be populated with inexpensive 2 GB DIMMs (for 80 GB), while gaining the performance boost from using 8 memory controllers (4 in the server and 4 more in the MAX5 unit).
- Embedded virtualization (optional on all models) offers extremely high performance, enhanced security, and a zero-gigabyte HDD footprint. (In other words, there is no mechanical HDD to fail.)
- Solid-state drives (SDDs) use only 2 watts of energy per drive, versus 9 to 10 watts for 2.5-inch HDDs. This is as much as 80 percent less energy than a HDD uses (with a corresponding reduction in heat output).
- The extremely high degree of integration in the various BladeCenter chassis reduces the need for server components, thus replacing numerous fans, KVM and Ethernet cables, power supplies, external switches and other components with fewer shared hot-swap/redundant components in the BladeCenter chassis itself. This integration also can greatly reduce the amount of power consumed and heat produced, relative to an equivalent number of 1U servers. This can significantly reduce a data center power bill. The reduced data center footprint can also save on infrastructure cost.
- The midplanes used in all chassis provide high-speed blade-to-blade, blade-to-switch-module, and module-to-module communications internally and externally. The midplanes used in the BladeCenter H and BladeCenter HT chassis provide four 10 Gb data channels to each blade, supporting high-speed switch modules including 4X InfiniBand and 10 Gb Ethernet.
- The various BladeCenter chassis use ultra-high efficiency power supplies. Most industry-standard servers use power supplies that are between 70-75 percent efficient at converting power from AC wall current to the DC power used inside servers. BladeCenter power modules are up to 92 percent efficient. This helps save even more money, because more of the power input you are paying for is used for processing, rather than released into the data center as waste heat that requires even more energy to cool.
- BladeCenter design also reduces the number of parts required to run the system. Sharing fans, systems management, and optical media means fewer parts to buy and maintain, and fewer items that can fail and bring the overall solution down.

The HX5 can grow with your application requirements, due to the following abilities:

- The ability to grow from a single-wide 2-socket server blade to a double-wide 4-socket server configuration, optimized for compute-intensive workloads (with up to 4 processors/40 cores, 512 GB of memory, 4 PCIe cards, 16 I/O ports, and 4 SSDs in two server blades). Or, for memory-intensive workloads, with one server blade and one MAX5 memory expansion blade (2 processors/20 cores, 640 GB of memory, 4 PCIe cards, 16 I/O ports, and 4 SSDs).
- A choice of processor speeds (1.73 to 2.0 GHz), and shared L3 cache sizes (12 MB, 18 MB, 24 MB, or 30 MB).
- Up to two internal hot-swap 1.8-inch solid-state drives, and access to terabytes of external storage through the BladeCenter S chassis or IBM System Storage SAN and NAS storage devices. SSDs consume only 10-20 percent of the energy required by 2.5-inch HDDs.
- Two Gigabit Ethernet ports standard, plus optional 2-port or 4-port expansion cards or a BladeCenter PCI Express I/O Expansion Unit 3. One HX5 model includes a 10 Gb expansion card (optional in the other models).

Figure 6-5 shows a view of the HS23 BladeCenter module.

Figure 6-5 View of HX5 BladeCenter module

For additional details about the HX5, see the *IBM System HSX5 Product Guide*, available at the following websites:

- http://www.ibm.com/systems/bladecenter/hardware/servers/hx5/
- http://public.dhe.ibm.com/common/ssi/ecm/en/blo03039usen/BLO03039USEN.PDF

6.6 Mainstream or Advanced with Flex System

IBM Flex System represents an entirely new generation of technology, with more performance and bandwidth, and far more capability to consolidate and virtualize than previous systems. IBM Flex System offers a broad range of x86 and POWER® compute nodes in an innovative chassis design that goes beyond blade servers with advanced networking, including converged capabilities and system management to support extraordinary simplicity, flexibility, and upgradability.

Organizations can design their own solution and integrate with other infrastructure elements to innovate while still choosing the best architecture for their applications and ever-changing business needs. For our Mainstream and Advanced class of configurations, x240 and x440 compute nodes are used; Power compute nodes are not part of this architecture.

6.6.1 Flex System and N series: Common attributes

IBM Flex System and IBM System Storage N series together provides flexible shared infrastructure with clear benefits.

Flexibility

The following capabilities are provided:

- Scalability: Capacity and performance
- Modular: Power and x System
- Modular: Different storage controllers, different storage media
- Multi-protocol support
- Management, access, control

Unified architecture

The following capabilities are provided:

- Converged networking
- Single chassis
- Management / integrated management

Operations

The following capabilities are provided:

- Redundancy, reliability, availability
- Scalability: Enabled service models of on-demand and pay-as-you-grow
- Start small
- Easy to manage and deploy
- Cost per foot print
- Integration with Hyper-V and vSphere

Complementary

The following N series benefits are complementary to the Flex system:

- Always-on, non-disruptive operations (NDO)
- Performance Optimization (VST)
- Quality of Service (QoS)
- Workflow Automation

6.6.2 IBM Flex System Chassis

The IBM Flex System Enterprise Chassis is the foundation of the Flex System offering, which features 14 standard (half-width) Flex System form factor compute node bays in a 10U chassis that delivers high-performance connectivity for your integrated compute, storage, networking, and management resources.

Up to a total of 28 independent servers can be accommodated in each Enterprise Chassis, if double dense x222 compute nodes are deployed.

The chassis is designed to support multiple generations of technology, and offers independently scalable resource pools for higher usage and lower cost per workload.

With the ability to handle up 14 Nodes, supporting the intermixing of IBM Power Systems™ and Intel x86, the Enterprise Chassis provides flexibility and tremendous compute capacity in a 10U package. Additionally, the rear of the chassis accommodates four high speed I/O bays that can accommodate up to 40 GbE high speed networking, 16 Gb Fibre Channel or 56 Gb InfiniBand. With interconnecting compute nodes, networking, and storage that uses a high performance and scalable mid-plane, the Enterprise Chassis can support latest high speed networking technologies.

The ground-up design of the Enterprise Chassis reaches new levels of energy efficiency through innovations in power, cooling, and air flow. Simpler controls and futuristic designs allow the Enterprise Chassis to break free of “one size fits all” energy schemes.

The ability to support the workload demands of tomorrow's workloads is built in with a new I/O architecture, which provides choice and flexibility in fabric and speed. With the ability to use Ethernet, InfiniBand, Fibre Channel (FC), Fibre Channel over Ethernet (FCoE), and iSCSI, the Enterprise Chassis is uniquely positioned to meet the growing and future I/O needs of large and small businesses.

Figure 6-6 shows the Flex System chassis with multiple x240 compute nodes.

Figure 6-6 Flex System enterprise chassis - front view

6.6.3 The x240 compute module

The IBM Flex System x240 Compute Node, available as machine type 8737 with a three-year warranty, is a half-wide, two-socket server. It runs the latest Intel Xeon processor E5-2600 family (formerly code named *Sandy Bridge-EP*) processors. It is ideal for infrastructure, virtualization, and enterprise business applications, and is compatible with the IBM Flex System Enterprise Chassis (see Figure 6-7).

Figure 6-7 IBM Flex System x240 compute node

Figure 6-8 shows the x240 front layout.

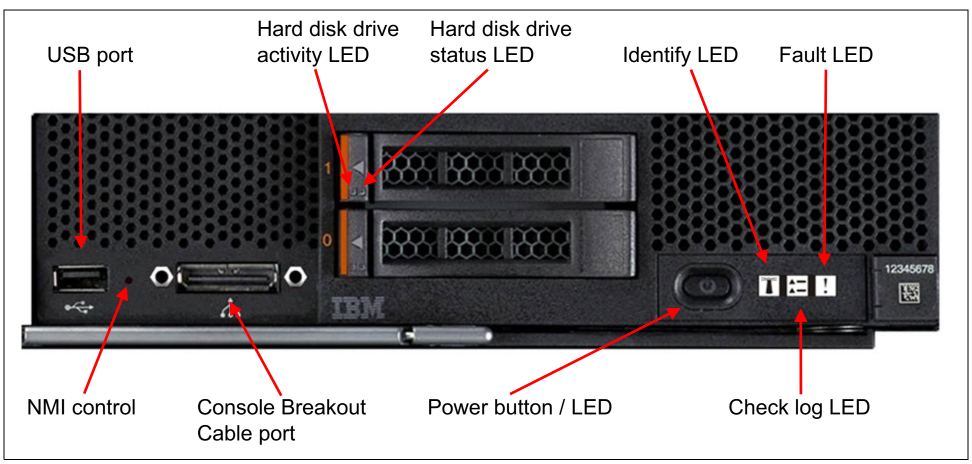


Figure 6-8 The front of the x240 showing the location of the controls, LEDs, and connectors

Features of the x240 are listed in Table 6-2.

Table 6-2 Features of the x240

Component	Specification
Machine types	8737 (x-config) 8737-15X and 7863-10X (e-config)
Form factor	Half-wide compute node
Chassis support	IBM Flex System Enterprise Chassis
Processor	Up to two Intel Xeon Processor E5-2600 product family processors. These processors can be eight-core (up to 2.9 GHz), six-core (up to 2.9 GHz), quad-core (up to 3.3 GHz), or dual-core (up to 3.0 GHz). Two QPI links up to 8.0 GT/s each. Up to 1600 MHz memory speed. Up to 20 MB L3 cache.
Chipset	Intel C600 series.
Memory	Up to 24 DIMM sockets (12 DIMMs per processor) using Low Profile (LP) DDR3 DIMMs. RDIMMs, UDIMMs, and LRDIMMs supported. 1.5V and low-voltage 1.35V DIMMs supported. Support for up to 1600 MHz memory speed, depending on the processor. Four memory channels per processor, with three DIMMs per channel.
Memory maximums	With LRDIMMs: Up to 768 GB with 24x 32 GB LRDIMMs and two processors With RDIMMs: Up to 512 GB with 16x 32 GB RDIMMs and two processors With UDIMMs: Up to 64 GB with 16x 4 GB UDIMMs and two processors
Memory protection	ECC, optional memory mirroring, and memory rank sparing.
Disk drive bays	Two 2.5" hot-swap SAS/SATA drive bays that support SAS, SATA, and SSD drives. Optional support for up to eight 1.8” SSDs.
Maximum internal storage	With two 2.5” hot-swap drives: ▶ Up to 2 TB with 1 TB 2.5" NL SAS HDDs ▶ Up to 2.4 TB with 1.2 TB 2.5" SAS HDDs ▶ Up to 2 TB with 1 TB 2.5" SATA HDDs ▶ Up to 3.2 TB with 1.6 TB 2.5" SATA SSDs. An intermix of SAS and SATA HDDs and SSDs is supported. Alternatively, with 1.8” SSDs and ServeRAID M5115 RAID adapter, up to 1.6 TB with eight 200 GB 1.8” SSDs. Additional storage available with an attached Flex System Storage Expansion Node.
RAID support	RAID 0, 1, 1E, and 10 with integrated LSI SAS2004 controller. Optional ServeRAID M5115 RAID controller with RAID 0, 1, 10, 5, or 50 support and 1 GB cache. Supports up to eight 1.8” SSD with expansion kits. Optional flash-backup for cache, RAID 6/60, and SSD performance enabler.
Network interfaces	x2x models: Two 10 Gb Ethernet ports with Embedded 10 Gb Virtual Fabric Ethernet LAN on motherboard (LOM) controller; Emulex BladeEngine 3 based. x1x models: None standard; optional 1 Gb or 10 Gb Ethernet adapters
PCI Expansion slots	Two I/O connectors for adapters. PCI Express 3.0 x16 interface.
Ports	USB ports: one external. Two internal for embedded hypervisor with optional USB Enablement Kit. Console breakout cable port that provides local keyboard video mouse (KVM) and serial ports (cable standard with chassis; additional cables are optional)

Component	Specification
Systems management	UEFI, IBM Integrated Management Module II (IMM2) with Renesas SH7757 controller, Predictive Failure Analysis, light path diagnostics panel, automatic server restart, remote presence. Support for IBM Flex System Manager™, IBM Systems Director, and IBM ServerGuide.
Security features	Power-on password, administrator's password, Trusted Platform Module 1.2
Video	Matrox G200eR2 video core with 16 MB video memory that is integrated into the IMM2. Maximum resolution is 1600x1200 at 75 Hz with 16 M colors.
Limited warranty	3-year customer-replaceable unit and onsite limited warranty with 9x5/NBD
Operating systems supported	Microsoft Windows Server 2012, 2008 R2, Red Hat Enterprise Linux 5 and 6, SUSE Linux Enterprise Server 10 and 11, VMware vSphere.5.5 and 5.1
Service and support	Optional service upgrades are available through IBM ServicePacs: 4-hour or 2-hour response time, 8 hours fix time, 1-year or 2-year warranty extension, and remote technical support for IBM hardware and selected IBM and OEM software.
Dimensions	Width 215 mm (8.5”), height 51 mm (2.0”), depth 493 mm (19.4”)
Weight	Maximum configuration: 6.98 kg (15.4 lb)

Up to 14 x240 Compute Nodes can be installed in the chassis in 10U of rack space. The actual number of x240 systems that can be powered on in a chassis depends on various power configuration options such as number of power supplies, their capacity, and so on.

The x240 supports an option that provides two internal USB ports (x240 USB Enablement Kit) that are primarily used for attaching USB hypervisor keys.

The x240 compute node features an onboard LSI 2004 SAS controller with two 2.5-inch small form factor (SFF) hot-swap drive bays.

The 2.5-inch internal drive bays are accessible from the front of the compute node. An onboard LSI SAS2004 controller provides RAID 0, RAID 1, or RAID 10 capability. It supports up to two SFF hot-swap SAS or SATA HDDs or two SFF hot-swap solid-state drives.

The x240 type 8737 has support for up to two hot-swap SFF SAS or SATA HDDs or up two hot-swap SFF SSDs. These two hot-swap components are accessible from the front of the compute node without removing the compute node from the chassis. Current disks sizes are supported for SAS and SATA. The x240 also supports 1.8-inch solid-state drives either 50 GB or 200 GB MLC SSD.

6.6.4 The x440 compute module

The IBM Flex System x440 Compute Node, machine type 7917, is a high-density, four-socket server that is optimized for high-end virtualization, mainstream database deployments, memory-intensive, and high performance environments.

The IBM Flex System x440 Compute Node is a double-wide compute node that provides scalability to support up to four Intel Xeon E5-4600 processors. The node’s width allows for significant I/O capability. The server is ideal for virtualization, database, and memory-intensive high performance computing environments.

Figure 6-9 shows the front of the compute node, which includes the location of the controls, LEDs, and connectors. The light path diagnostic panel is on the upper edge of the front panel bezel, in the same place as on the x220 and x240.

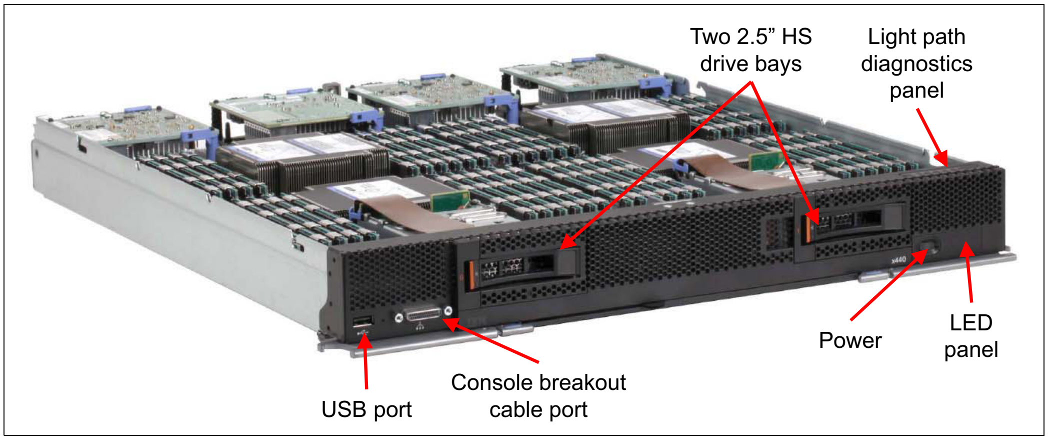


Figure 6-9 IBM Flex System x440 compute node

The x440 provides powerful compute resources. It supports up to four Intel Xeon processor E5-4600 product family processors, each with eight cores (up to 2.7 GHz), six cores (up to 2.9 GHz), or four cores (up to 2.0 GHz). There are two QPI links, up to 8.0 GTps each; up to 1600 MHz memory speed; up to 20 MB L3 cache per processor. In terms of memory, the x440 supports up to 1.5TB with LRDIMMs; up to 1.5 TB with 48x 32 GB and with RDIMMs; up to 768 GB with 48x 16 GB.

6.6.5 I/O modules of Flex System

The range of available modules and switches to support key network protocols allows you to configure IBM Flex System to fit in your infrastructure. However, you can do so without sacrificing the ability to be ready for the future. The networking resources in IBM Flex System are standards-based, flexible, and fully integrated into the system. This combination gives you no-compromise networking for your solution. Network resources are virtualized and managed by workload. These capabilities are automated and optimized to make your network more reliable and simpler to manage.

IBM Flex System gives you the following key networking capabilities:

- Supports the networking infrastructure that you have today, including Ethernet, FC, FCoE, and InfiniBand.
- Offers industry-leading performance with 1 Gb, 10 Gb, and 40 Gb Ethernet, 8 Gb and 16 Gb Fibre Channel, QDR and FDR InfiniBand.
- Provides pay-as-you-grow scalability so you can add ports and bandwidth when needed.

Networking in data centers is undergoing a transition from a discrete traditional model to a more flexible, optimized model. The network architecture in IBM Flex System was designed to address the key challenges customers are facing today in their data centers. The key focus areas of the network architecture on this platform are unified network management, optimized and automated network virtualization, and simplified network infrastructure.

Providing innovation, leadership, and choice in the I/O module portfolio uniquely positions IBM Flex System to provide meaningful solutions to address customer needs.

The IBM Flex System Fabric EN4093 scalable switch is shown in Figure 6-10.

Figure 6-10 IBM Flex System Fabric EN4093 scalable switch

6.6.6 Flex System Manager (FSM)

At the time of writing this book, Flex system Manager (see Figure 6-11) does not support the N series storage as an out-of-the-box option. Flex System though is highly optimized to manage all the compute nodes and other modules within the Flex system. As an appliance, Flex System Manager is delivered preinstalled onto a dedicated compute node platform, which is designed to provide a specific purpose. It is intended to configure, monitor, and manage IBM Flex System resources in up to 16 IBM Flex System Enterprise Chassis, which optimizes time-to-value. FSM provides an instant resource-oriented view of the Enterprise Chassis and its components, which provides vital information for real-time monitoring.

An increased focus on optimizing time-to-value is evident in the following features:

- Setup wizards, including initial setup wizards, provide intuitive and quick setup of the Flex System Manager.
- The Chassis Map provides multiple view overlays to track health, firmware inventory, and environmental metrics.
- Configuration management allows for repeatable setup of compute, network, and storage devices.
- Remote presence application provides for remote access to compute nodes with single sign-on.
- Quick search provides results as you type.

Beyond the physical world of inventory, configuration, and monitoring, IBM Flex System Manager enables virtualization and workload optimization for a new class of computing:

- Resource usage: Detects congestion, notification policies, and relocation of physical and virtual machines that include storage and network configurations within the network fabric.
- Resource pooling: Pooled network switching, with placement advisors that consider virtual machine (VM) compatibility, processor, availability, and energy.
- Intelligent automation: Automated and dynamic VM placement that is based on usage, hardware predictive failure alerts, and host failures.

Figure 6-11 IBM Flex System Manager

6.7 Management node vCenter server

The management node for all three configurations needs to host the VMware vCenter server. Compared to other virtualization solutions, you can run the vCenter server in a virtual machine. As a result, you do not need dedicated hardware to manage your cloud environments.

To implement a vCenter server, simply install the vCenter server in the Microsoft Windows virtual machine that runs on an ESXi host. By doing so, you realize additional benefits compared to using dedicated hardware:

- You have support for VMware High Availability (HA).
- You have support of VMware virtual machine migration functions in case of maintenance or other necessary downtime of the physical equipment.
- You are able to utilize VM-level utilities (for example, VMware Data Recovery) and VMware snapshot mechanisms for possible restore points. Thus, you create an additional level of security for your vCenter management server.

For more information and preferred practices about how to install the vCenter server, see the following website:

http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=2003790

6.8 Active Directory server

This section addresses the possible integration of a Microsoft Windows Active Directory server in the solution. This optional server provides an Active Directory and DNS environment for your servers. These services are required for the servers and computers to participate in a Microsoft Active Directory environment. If an Active Directory server is already available in your environment, this specific kind of server is not needed.

The Active Directory server can be virtualized with minimal impact on performance. If additional capacity is required (depending on individual workloads), a physical Active Directory server can be added, as is optional with the Mainstream and Advanced configurations. For more detailed information about Active Directory virtualization, see the VMware white paper, *Virtualizing a Windows Active Directory Domain Infrastructure*, which is available at the following website:

http://www.vmware.com/files/pdf/Virtualizing_Windows_Active_Directory.pdf

6.9 Further information

The following list includes links for additional information about IBM System x server:

- IBM System x Server Rack servers:

  http://www.ibm.com/systems/x/hardware/rack/index.html

- IBM System x Configuration and Options Guide:

  http://www.ibm.com/systems/xbc/cog/

- IBM x86 Server Reference:

  http://www.redbooks.ibm.com/redpapers/pdfs/redpxref.pdf

- IBM Flex System:

  http://www.ibm.com/systems/pureflex/flex-converged-infrastructure.html

- List of supported operating systems, see IBM ServerProven® at this website:

  http://ibm.com/systems/info/x86servers/serverproven/compat/us/nos/flexmatrix.shtml

7

Networking

This chapter explains how using a solution built around iSCSI SANs with high bandwidth 10 Gbps Ethernet makes advanced networking and storage architectures accessible to the value-conscious installation.

The following topics are covered:

- Ethernet switches
- Architecture with multiswitch link aggregation
- Storage load balancing
- Clustered Data ONTAP cluster network
- Further information

7.1 Ethernet switches

The IBM System Networking Virtual Fabric 10 Gb G8124E RackSwitch for IBM System x provides exceptional performance that is both lossless and low latency. In addition, the G8124E delivers excellent cost savings regarding acquisition costs and energy costs, along with feature-rich design regarding virtualization, CEE/FCoE, high availability, and its enterprise class Layer 2 and Layer 3 functionality.

Figure 7-1 shows the IBM RackSwitch G8124E.

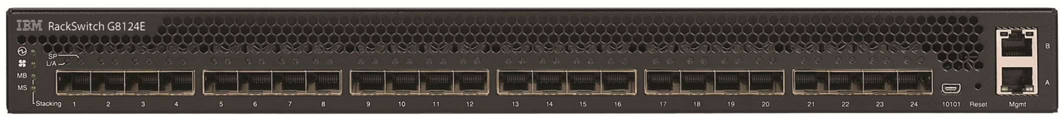


Figure 7-1 IBM RackSwitch G8124E

With support for 1 G or 10 G, this switch is designed for clients that are leveraging 10 G Ethernet today or have plans to do so in the future. This is the first Top of Rack 10 Gb switch for IBM System x designed to support IBM Virtual Fabric, which helps clients significantly reduce cost and complexity when it comes to the I/O requirements of most virtualization deployments today.

Virtual Fabric can help clients reduce the number of multiple I/O adapters down to a single dual-port 10 G adapter, in addition to reducing the number of cables and upstream switch ports required. Virtual Fabric allows clients to carve up a dual-port 10 G adapter into eight virtual NICs (vNICs) and create dedicated virtual pipes between the adapter and the switch for optimal performance, higher availability, and better security. This functionality provides the ability to dynamically allocate bandwidth per vNIC in increments of 100 Mb, while being able to adjust over time without downtime.

The IBM System Networking RackSwitch G8124E offers the following benefits:

- High performance:

  The 10 G Low Latency (as low as 570 nanoseconds) switch provides the best combination of extremely low latency, non-blocking line-rate switching and ease of management.

- Lower power and better cooling:

  The G8124E uses as little power as two 60-watt light bulbs, which is a fraction of the power consumption of most competitive offerings. Unlike side-cooled switches, which can cause heat recirculation and reliability concerns, the G8124E rear-to-front cooling design reduces data center air conditioning costs by having airflow match the servers in the rack. In addition, variable speed fans assist in automatically reducing power consumption.

- Virtual Fabric:

  Virtual Fabric can help clients address I/O requirements for multiple NICs, while also helping reduce cost and complexity. Virtual Fabric for IBM allows for the carving up of a physical NIC into multiple virtual NICs (2 - 8 vNICs), and it creates a virtual pipe between the adapter and the switch for improved performance, availability, and security while reducing cost and complexity.

- VM-aware networking:

  IBM VMready® software on the switch helps reduce configuration complexity while significantly improving security levels in virtualized environments. VMready automatically detects virtual machine movement from one physical server to another, and instantly reconfigures the network policy of each VM across VLANs to keep the network up and running without interrupting traffic or impacting performance. VMready works with all leading VM providers such as VMware, Citrix, Xen, and Microsoft.

- Layer 3 functionality:

  The switch includes Layer 3 functionality, which provides security and performance benefits because inter-VLAN traffic stays within the chassis. This switch also provides the full range of Layer 3 protocols from static routes for technologies such as Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP) for enterprise clients.

- Seamless interoperability:

  IBM switches interoperate seamlessly with other vendors' upstream switches. For more information, see Tolly Reports: Tolly Functionality and Certification: RackSwitch G8000 and G8124 and Cisco Catalyst Interoperability Evaluation, located at this website:

  http://www.bladenetwork.net/userfiles/file/PDFs/Tolly209116BladeRackSwitchInteroperability.pdf

- Fault tolerance:

  These switches learn alternate routes automatically and perform faster convergence in the unlikely case of a link, switch, or power failure. The switch uses proven technologies such as L2 trunk failover, advanced VLAN-based failover, VRRP, HotLink, Uplink Failure Detection (UFD), IGMP V3 snooping, and OSPF.

- Converged fabric:

  The switch is designed to support CEE/DCB and connectivity to FCoE gateways. CEE helps enable clients to combine storage, messaging traffic, VoIP, video, and other data on a common data center Ethernet infrastructure. FCoE helps enable highly efficient block storage over Ethernet for consolidating server network connectivity. As a result, clients can deploy a single server interface for multiple data types. This can simplify both deployment and management of server network connectivity, while maintaining the high availability and robustness required for storage transactions.

For more information and part numbers, see the following website:

http://www.redbooks.ibm.com/Redbooks.nsf/RedbookAbstracts/tips0787.html?Open

7.2 Architecture with multiswitch link aggregation

In this configuration, the storage network architecture uses multiswitch link aggregation (MSLA). The IP switches used for the Ethernet storage network support multiswitch link aggregation. Therefore, each storage controller requires one physical connection to each switch. The two ports connected to each storage controller are then combined into one multimode LACP VIF with IP load balancing enabled.

This design provides multiple active connections to each storage controller and provides a means to scale throughput by simply adding more connections. It requires multiple IP addresses per controller. Additionally, each connection uses two physical links for each active network connection to achieve path high availability (HA).

MSLA provides the following benefits:

- It provides multiple active connections to each storage controller.
- It easily scales to more connections by adding NICs and aliases.
- It provides two active connections to each storage controller.
- Storage controller connection load balancing is automatically managed by the EtherChannel IP load-balancing policy.
- It requires only one VMkernel port for IP storage to make use of multiple physical paths.

Figure 7-2 provides a sample design for multiswitch link aggregation.

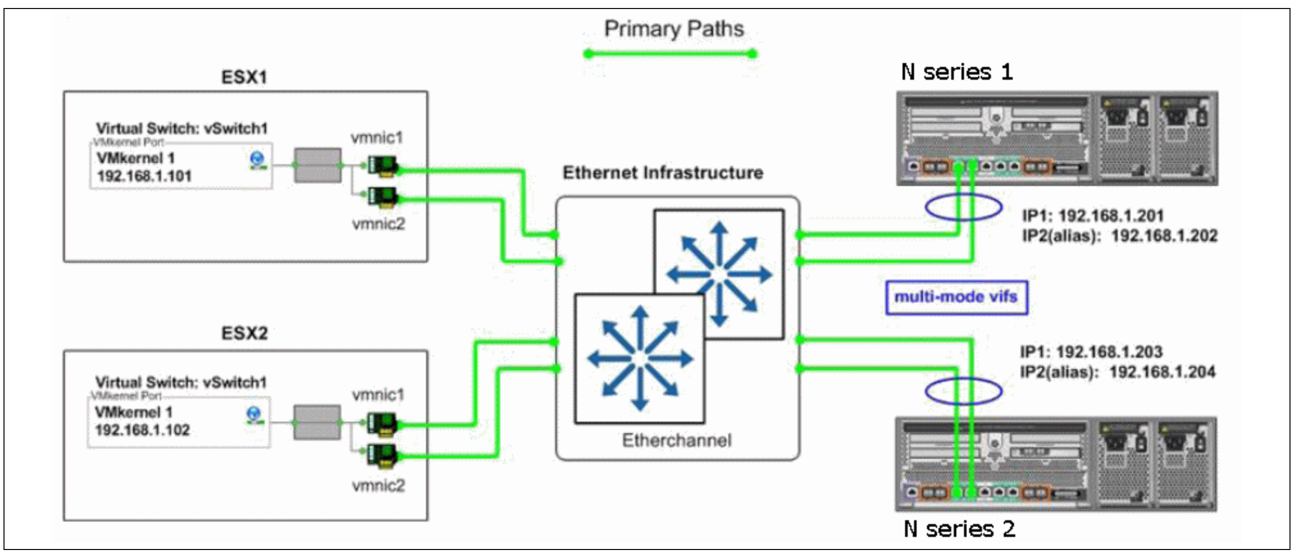


Figure 7-2 Multiswitch link aggregation design

7.3 Storage load balancing

The previous design can be improved with storage load balancing. Using multiple physical paths simultaneously on an IP storage network requires EtherChannel ports and multiple IP addresses on the storage controller, and multiple VMkernel ports defined for storage I/O in the ESX/ESXi hosts. This model results in a design that balances datastore connectivity across all interfaces. This balancing is handled by the RCU at the time the datastore is provisioned.

The layered multimode design requires each storage controller to have at least four physical network connections, as depicted in Figure 7-3.

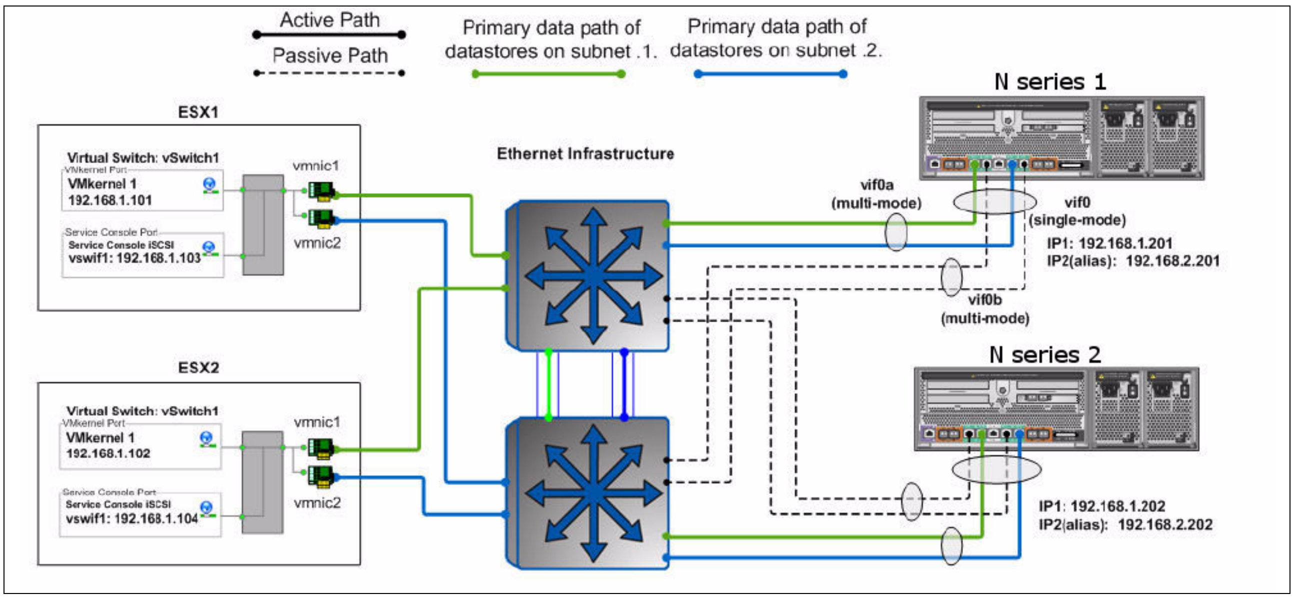


Figure 7-3 Layered multimode network design

The connections are divided into two multimode (active-active) EtherChannels, or VIFs, with IP load balancing enabled. One virtual interface (VIF) is connected to each of the two switches. These two VIFs are then combined into one single mode (active-passive) VIF. This configuration is also referred to as a second-level VIF.

This option also requires multiple IP addresses on the storage appliance. You can assign multiple IP addresses to the single-mode VIF by using IP address aliases or by using virtual local area network (VLAN) tagging.

Layered multimode EtherChannel provides the following benefits:

- The EtherChannel IP load balancing policy automatically manages storage controller connection load balancing.
- Data I/O to a single IP is aggregated over multiple links.

7.4 Clustered Data ONTAP cluster network

The cluster network consists of two CN1610 managed Layer 2 switches where each provides 16 10 GE Small Form-Factor Pluggable Plus (SFP+) ports and features four ISL ports with an inband/outband management port. These switches are designed to work in clusters ranging from two to eight nodes as a supported configuration, although there are ports to connect 12 nodes because four ports are reserved for further use.

Each of the controllers has to be connected to every switch. It is leading practice to use dedicated 10 GE cards to connect to the cluster network if possible (for example, e1a, e2a).

See Figure 7-4 for a cabling example.

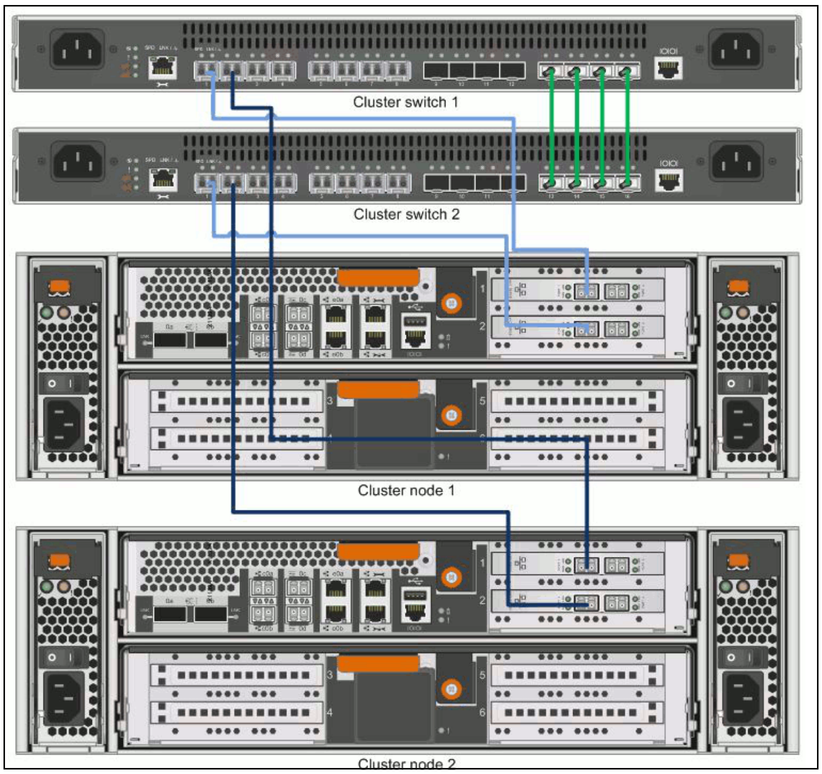


Figure 7-4 Cabling example of cluster network

7.5 Further information

This section includes links for additional information for networking components as part of the solution design.

- IBM Systems Networking Switches:

  http://www.ibm.com/systems/networking/switches/rack.html

- IBM System x Top of Rack switches Machine Type Model information:

  http://www.ibm.com/systems/xbc/cog/network_switches/network_switches.html

8

Storage

This chapter describes the IBM System Storage N series 3000 system that will be used as the unified storage foundation for the solution architecture that was introduced previously.

The following topics are covered:

- Introduction
- Entry portfolio
- Mainstream and advanced portfolio
- Midrange and enterprise portfolio
- HA pair hardware configuration
- Snapshots
- Flexible volume (FlexVol)
- Infinite Volumes
- Thin provisioning using FlexVol volumes
- FlexClone
- Deduplication
- Quality of Service (QoS)
- Data protection and load sharing
- Flash Cache
- Virtual Storage Tier
- Further information

8.1 Introduction

The IBM N series storage systems are hardware and software based data storage and retrieval systems. They respond to network requests from clients and fulfil them by writing data to or retrieving data from the disk arrays. They provide a modular hardware architecture running the Clustered Data ONTAP operating system and Write Anywhere File Layout (WAFL) software.

Clustered Data ONTAP provides a complete set of storage management tools through its command-line interface, N Series OnCommand System Manager or through the DataFabric Manager interface (which requires a license), and for storage systems with a remote management device such as the Service Processor (SP), the Remote LAN Module (RLM), or the Baseboard Management Controller (BMC) through the remote management device's Ethernet connection to the system console.

Figure 8-1 illustrates an overview of the N Series product portfolio.

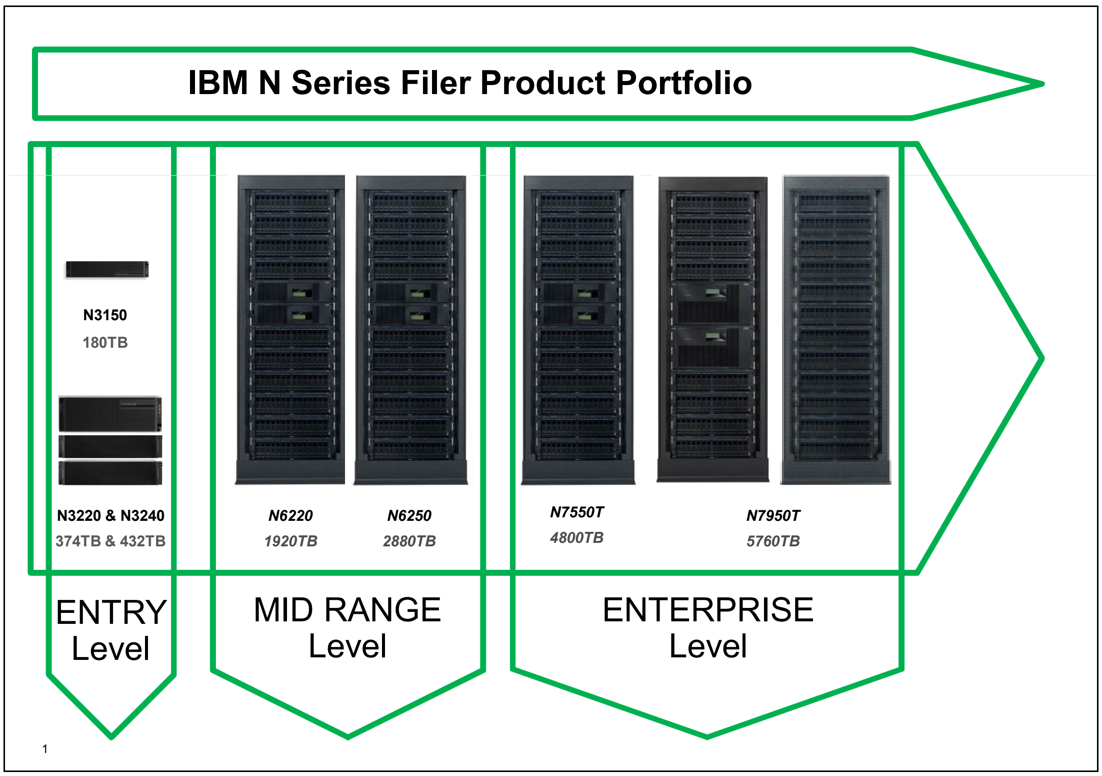


Figure 8-1 Product Portfolio for the IBM N Series Filers

See the *IBM System Storage Product Guide* brochure for further information about the product ranges available:

http://public.dhe.ibm.com/common/ssi/ecm/en/tso00364usen/TSO00364USEN.PDF

8.2 Entry portfolio

Figure 8-2 shows the N3000 modular disk storage system Entry portfolio. These systems are designed to provide primary and secondary storage for entry to midsize enterprises. N3000 systems offer integrated data access, intelligent management software, data protection capabilities, and expendability to 432 TB of raw capacity, all in a cost-effective package. N3000 series innovations also include internal controller support for Serial-Attached SCSI (SAS) or SATA drives, expandable I/O connectivity, and onboard remote management.

Figure 8-2 Entry systems

The following N3000 models are available:

- IBM System Storage N3150 is available as a single-node (Model A15) and as a dual-node (Model A25) (active-active) base unit.
- IBM System Storage N3220 is available as a single-node (Model A12) and as a dual-node (Model A22) (active-active) base unit.
- The IBM System Storage N3240 consists of single-node (Model A14) and dual-node (Model A24) (active-active) base units.

To summarize the differences, Table 8-1 provides a comparison of the N3000 series.

Table 8-1 N3000 series comparison

N3000 series overview[a]	**N3150**	**N3220**	**N3240**
Form factor	2U/12 Drive	2U/24 Drive	4U/24 Drive
Dual controllers	Yes	Yes	Yes
Maximum raw capacity [TB]	180	381	432
Maximum disk drives	60	144	144
Maximum Ethernet ports	8	8	8
Onboard SAS port	4	4	4
Flash Pool support	Yes	Yes	Yes
8 Gb FC support	No	Yes[b]	Yes[b]
10 Gbe support	No	Yes[b]	Yes[b]
Remote management	Yes	Yes	Yes
Storage protocols	iSCSI, NFS, CIFS	FCP, iSCSI, NFS, CIFS	FCP, iSCSI, NFS, CIFS

a. All specifications are for dual-controller, active-active configurations.
b. Based on optional dual-port 10 GbE or 8 Gb FC mezzanine card and single slot per controller.

8.2.1 N3150 models

In this section, we discuss the N series 3150 models.

> **N3150 notes:** Be aware of the following points regarding N3150 models:
>
> - N3150 models do not support the Fibre Channel protocol.
> - Compared to N32xx systems, the N3150 models have newer firmware, and no mezzanine card option is available.

N3150 Model 2857-A15

The N3150 Model A15 is a single-node storage controller that is designed to provide HTTP, Internet Small Computer System Interface (iSCSI), NFS, and CIFS support through optional features. Model A15 is a 2U storage controller that must be mounted in a standard 19-inch rack. Model A15 can be upgraded to a Model A25. However, this is a disruptive upgrade.

N3150 Model 2857-A25

The N3150 Model A25 is designed to provide identical functions as the single-node Model A15, but with the addition of a second Processor Control Module (PCM) and the Clustered Failover (CFO) licensed function. Model A25 consists of two PCMs that are designed to provide failover and failback function, thus helping to improve overall availability. Model A25 is a 2U rack-mountable storage controller.

N3150 hardware

The N3150 hardware includes the following highlights:

- It has a 2U footprint with 12 horizontal disks.
- It leverages the SAS shelf architecture.
- It has the same capacity HDD disks as EXN3000.
- It has the same SSD disks as EXN3000 shelves.
- The N3150 Processor Control Module (PCM) has newer firmware but there is no mezzanine card option available.
- It has 4x GbE ports and 2x 6 Gb SAS ports per PCM.
- There are 6- disk and 12-disk orderable configurations.
- Supported shelves and modules are EXN3000 and EXN3500 using 3 GB and 6 GB SAS IO modules.

Figure 8-3 shows the front and rear views of the N3150.

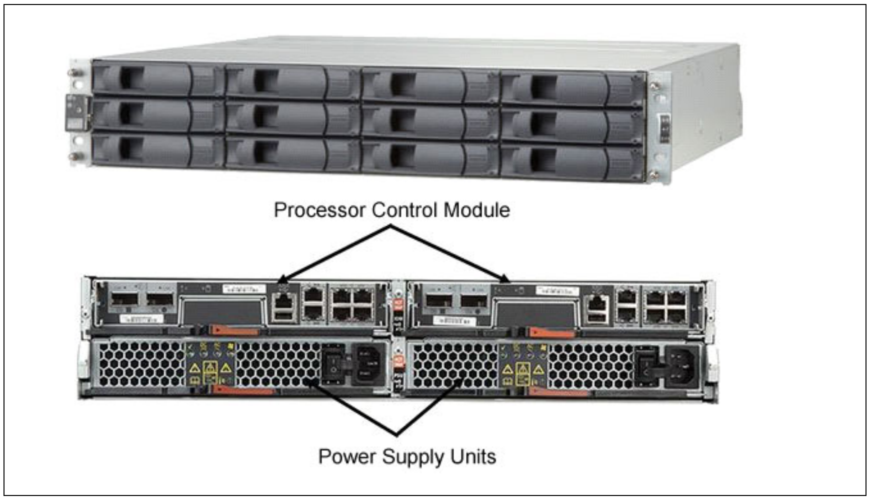


Figure 8-3 N3150 front and rear views

8.2.2 N3220

In this section, we discuss the N series 3220 models.

N3220 Model 2857-A12

The N3220 Model A12 is a single-node storage controller designed to provide HTTP, Internet Small Computer System Interface (iSCSI), NFS, CIFS, and Fibre Channel Protocol (FCP) support through optional features. Model A12 is a 2U storage controller that must be mounted in a standard 19-inch rack. Model A12 can be upgraded to a Model A22. However, this is a disruptive upgrade.

N3220 Model 2857-A22

N3320 Model A22 is designed to provide identical functions as the single-node Model A12, but with the addition of a second processor control module (PCM) and the Clustered Failover (CFO) licensed function. Model A22 consists of two PCMs that are designed to provide failover and failback function, thus helping to improve overall availability. Model A22 is a 2U rack-mountable storage controller.

N3220 hardware

The N3220 hardware includes the following highlights.

- It is based on the EXN3500 expansion shelf.
- It has 24 2.5” SFF SAS disk drives, with a minimum initial order of 12 disk drives.
- It has the following specifications (single node, 2x for dual node):
  - 2U, standard 19-inch rackmount enclosure (single or dual node)
  - One 1.73 GHz Intel dual-core processor
  - 6 GB random access ECC memory (NVRAM 768 MB)
  - Four integrated Gigabit Ethernet RJ45 ports
  - Two SAS ports
  - One serial console port & one integrated RLM port
  - One optional expansion I/O adapter slot on mezzanine card
  - 10 GbE or 8 Gb FC card provides two ports
  - Redundant hot-swappable, auto-ranging power supplies and cooling fans

Figure 8-4 shows the front and rear views of the N3220.

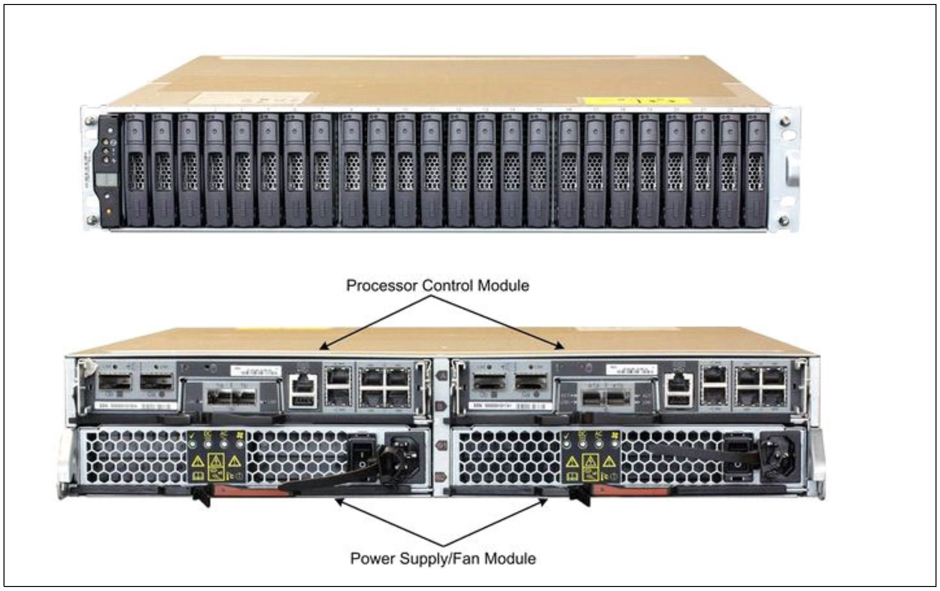


Figure 8-4 N3220 front and rear views

8.2.3 N3240

In this section, we discuss the N series 3240 models.

N3240 Model 2857-A14

The N3240 Model A14 is designed to provide a single-node storage controller with HTTP, iSCSI, NFS, CIFS, and Fibre Channel Protocol (FCP) support through optional features. The N3240 Model A14 is a 4U storage controller that must be mounted in a standard 19-inch rack. Model A14 can be upgraded to a Model A24. However, this is a disruptive upgrade.

N3240 Model 2857-A24

The N3240 Model A24 is designed to provide identical functions as the single-node Model A14, but with the addition of a second processor control module (PCM) and the Clustered Failover (CFO) licensed function. Model A24 consists of two PCMs that are designed to provide failover and failback function, thus helping to improve overall availability. Model A24 is a 4U rack-mountable storage controller.

N3240 hardware

The N3240 hardware includes the following highlights.

- It is based on the EXN3000 expansion shelf.
- It has 24 SATA disk drives, with a minimum initial order of 12 disk drives.
- It has the following specifications (single node, 2x for dual node):
  - 4U, standard 19-inch rackmount enclosure (single or dual node).
  - One 1.73 GHz Intel dual-core processor.
  - 6 GB random access ECC memory (NVRAM 768 MB).
  - Four integrated Gigabit Ethernet RJ45 ports.
  - Two SAS ports.
  - One serial console port and one integrated RLM port.
  - One optional expansion I/O adapter slot on mezzanine card.

– 10 GbE or 8 Gb FC card provides two ports.
– Redundant hot-swappable, auto-ranging power supplies and cooling fans.

Figure 8-5 shows the front and rear views of the N3240.

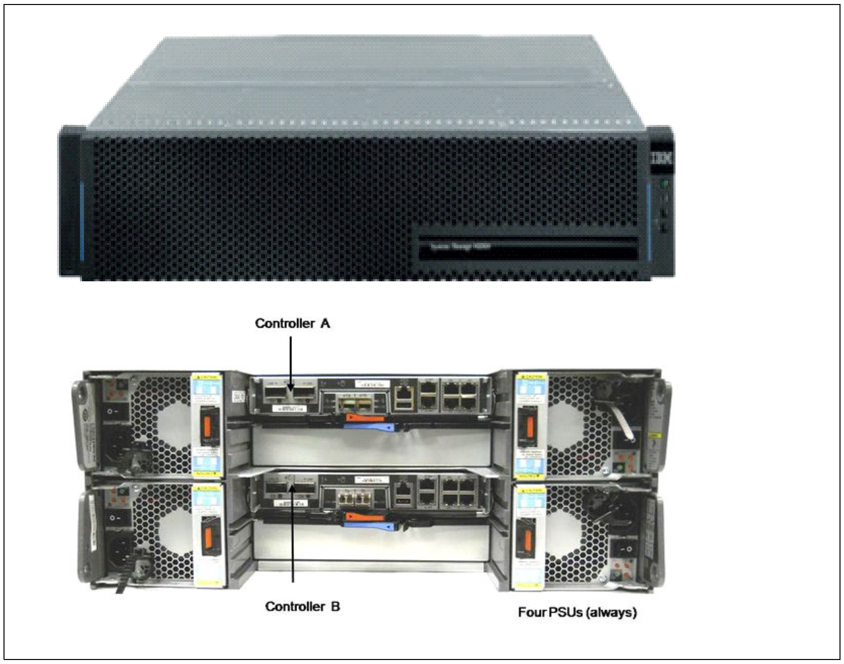


Figure 8-5 N3240 front and rear views

Figure 8-6 shows the Controller with the 8 Gb FC mezzanine card option.

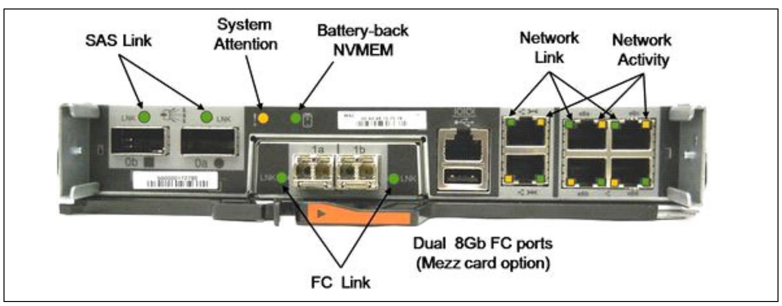


Figure 8-6 Controller with 8 Gb FC mezzanine card option

Figure 8-7 shows the Controller with the 10 GbE mezzanine card option.

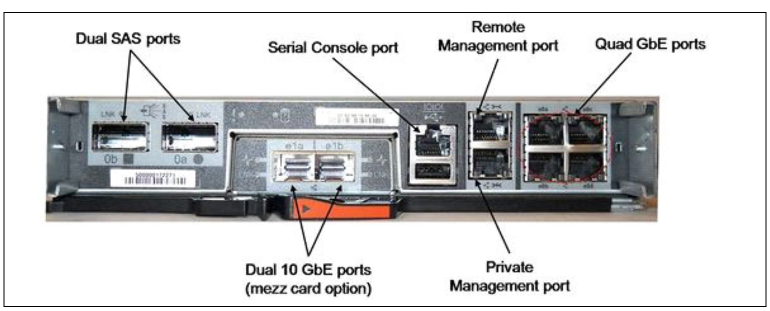


Figure 8-7 Controller with 10 GbE mezzanine card option

8.2.4 N32x0 common information

Table 8-2 lists ordering information for N32x0 systems.

Table 8-2 N32x0 configuration

Model	Form factor	HDD	PSU	Select PCM
N3220-A12, A22	2U chassis	24 SFF SAS 2.5”	2	One or two controllers, each with: ► No mezzanine card, or ► Dual FC mezzanine card, or ► Dual 10 GbE mezzanine card
N3240-A14, A24	4U chassis	24 SATA 3.5”	4	

Table 8-3 lists controller information for N32x0 systems with mezzanine cards.

Table 8-3 N32x0 controller configuration

Feature code	Configuration
	Controller with no mezzanine card (blank cover)
2030	Controller with dual-port FC mezzanine card (include SFP+)
2031	Controller with dual-port 10 GbE mezzanine card (no SFP+)

Table 8-4 lists information about the maximum number of supported shelves by expansion type.

Table 8-4 N3000 number of supported shelves

Expansion shelf (total 114 spindles)	Number of shelves supported
EXN 1000	Up to 6 Shelves (500 GB, 750 GB and 1 TB SATA disk drives)
ESN 3000	Up to 5 Shelves (300 GB, 450 GB, 600 GB, 900 GB SAS) or (500 GB, 1 TB, 2 TB, and 3 TB SATA disk drives)
EXN 3500	Up to 5 Shelves (450 GB, 600 GB, 900 GB SAS SFF disk drives)
EXN 4000	Up to 6 Shelves (144 GB, 300 GB, 450 GB and 600 GB F/C disk drives)

8.3 Mainstream and advanced portfolio

Figure 8-8 shows the N62x0 modular disk storage systems, which are designed to provide the following benefits:

- Increase NAS storage flexibility and expansion capabilities by consolidating block and file data sets onto a single multiprotocol storage platform.
- Achieve performance when your applications need it most with high bandwidth, 64-bit architecture and the latest I/O technologies.
- Maximize storage efficiency and growth and preserve investments in staff expertise and capital equipment with data-in-place upgrades to more powerful IBM System Storage N series.
- Improve your business efficiency by using N6000 and N7000 series capabilities, to reduce data management complexity in heterogeneous storage environments for data protection and retention.

Figure 8-8 Mainstream and Advanced systems

With IBM System Storage N62x0 series systems, you can meet your Network Attached Storage (NAS) needs and provide high levels of application availability for everything from critical business operations to technical applications. You can also address NAS and Storage Area Network (SAN) as primary and secondary storage requirements. In addition, you get outstanding value because our flexible systems offer excellent performance and impressive expendability at a low total cost of ownership.

Common features

The following list is an overview of common features:

- Simultaneous multiprotocol support for FCoE, FCP, iSCSI, CIFS, NFS
- File-level and block-level service in a single system
- Support for Fibre Channel, SAS and SATA disk drives
- Clustered Data ONTAP software
- Broad range of built-in features
- Multiple supported backup methods including disk-based and host-based backup and tape backup to direct, SAN, and GbE attached tape devices

Hardware summary

The following list is a hardware summary:

- Up to 5760 TB raw storage capacity
- 4 GB to 192 GB random access memory
- 1.6 GB to 8 GB nonvolatile memory
- Integrated Fibre Channel, Ethernet and SAS ports
- Quad-port 4 Gbps adapters (optional)
- Up to four Performance Acceleration Modules (Flash Cache)
- Diagnostic LED/LCD
- Dual redundant hot-plug integrated cooling fans and auto-ranging power supplies
- 19 inch, rack-mountable

N6240

The IBM System Storage N6240 storage controllers include the following models:

- Model C21, which is an active/active dual-node base unit
- Model E11, which is a single-node base unit
- Model E21, which is the coupling of two Model E11s

Exx models contain an I/O expansion module that provides additional PCIe slots. Note that I/O expansion is not available on Cxx models.

8.3.1 Common functions and features of mid-range models

This section describes the functions and features that are common to all mid-range models.

FC, SAS, and SATA attachment

FC, SAS, and SATA attachment options for disk expansion units are designed to allow deployment in multiple environments, including data retention, NearStore, disk-to-disk backup scenarios, and high performance, mission-critical I/O-intensive operations.

The IBM System Storage N series supports the EXN4000 FC storage expansion units, the EXN3000 SAS/SATA expansion unit, EXN3200 SATA expansion unit, and the EXN3500 SAS expansion unit. At least one storage expansion unit must be attached to the N series system.

All eight models must be mounted in a standard 19-inch rack. None of the eight models include storage in the base chassis.

Dynamic removal and insertion of the controller

The N6000 controllers are hot-pluggable. You do not have to turn off PSUs to remove a controller in a dual-controller configuration.

PSUs are independent components. One PSU can run an entire system indefinitely. There is no “two-minute rule” if you remove one PSU. PSUs have internal fans for self-cooling only.

RLM design and internal Ethernet switch on the controller

The Clustered Data ONTAP management interface, known as e0M, provides a robust and cost-effective way to segregate management subnets from data subnets without incurring a port penalty. On the N6000 series, the traditional RLM port on the rear of the chassis (now identified by a wrench symbol) connects first to an internal Ethernet switch that provides connectivity to the RLM and e0M interfaces.

Because the RLM and e0M each have unique TCP/IP addresses, the switch can discretely route traffic to either interface. You do not need to use a data port to connect to an external Ethernet switch. Setup of VLANs and VIFs is not required and not supported because e0M allows clients to have dedicated management networks without VLANs.

The e0M interface can be thought of as another way to remotely access and manage the storage controller, much like the serial console, RLM, or standard network interface. Use the e0M interface for network-based storage controller administration, monitoring activities, and ASUP reporting. The RLM is used when you require its higher level of support features. Connect host-side application data to the appliance on a separate subnet from the management interfaces.

RLM-assisted cluster failover

To decrease the time required for cluster failover (CFO) to occur when there is an event that the RLM is aware of, the RLM can communicate with the partner node instance of Clustered Data ONTAP. This capability was available in other N series models prior to the N6000 series, but the internal Ethernet switch makes the configuration much easier and facilitates quicker cluster failover, with some failovers occurring within 15 seconds.

8.4 Midrange and enterprise portfolio

In this section, we discuss the N6220, N6250 as these are two key models within the N 62xx range. We also will discuss the N7950T, our top model when it comes to expendability and the recently released N7550T. We include a chart comparing hardware features between the four models previously mentioned.

The IBM System Storage N6220, N6250, N7950T, and the N7550T storage controllers are designed to interoperate with products capable of data transmission in the industry-standard iSCSI, CIFS, FCP, FCoE, and NFS protocols. Supported systems include the IBM eServer™ System p®, System i® (NFS only), System x, and System z® (NFS only) servers.

8.4.1 Midrange models N6220 and N6250

The following hardware summary covers two of the IBM N series mid range models. See Figure 8-9.

Hardware summary

The hardware contains the following items:

- Up to 4800 TB raw storage capacity
- 12 to 40 GB of RAM (random access memory)
- Integrated Fibre Channel, Ethernet, and SAS ports
- Up to 4 Flash Cache modules
- Installs into a 19 inch IBM cabinet

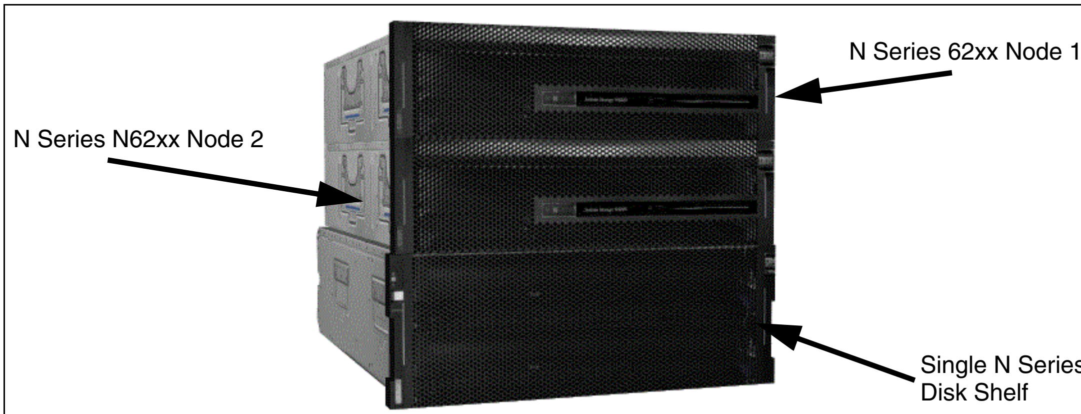


Figure 8-9 View of N62xx Dual Controller & 1 Disk Shelf

The main difference between the models is the internal hardware, for example, how much memory is installed or the number of processing cores.

In Table 8-5, we compare some hardware features of the N6220 and the N6250.

Table 8-5 N6220 & N6250 specifications

Feature	N6220	N6250
Machine Type / Model	2858-C15 to 2858-E25	2858-E16 to 2858-E26
Processor Type	Intel 2.3 Ghz (quad core)	Intel 2.3 Ghz (quad core)
Processors (No. of cores)	up to 2 (total of 8 cores)	up to 4 (total of 16 cores)

Feature	N6220	N6250
System Memory (RAM)	12GB to 24Gb	20GB to 40GB
Non Volatile Memory (NVRAM)	1.6GB to 3.2GB	2GB to 4GB
Fibre Channel ports (4GB)	up to 4	up to 4
SAS Ports (6GB)	up to 4	up to 4
Max Capacity	1920TB	2880TB

In Table 8-5, only some of the features are mentioned. For a full list of models and specifications for the N62xx range, see the brochure, *IBM System Storage N6000 series Data Sheet*, at the following website:

http://public.dhe.ibm.com/common/ssi/ecm/en/tsd03062usen/TSD03062USEN.PDF

8.4.2 Enterprise models N7550T and N7950T

These two models can be considered top of the tree when it comes to providing the end user with the most processing and expansion capability, the most recent model introduced being the N7550T. The N79xxT models are designed to delver high end enterprise storage and data management capabilities with mid range affordability. See Figure 8-10.

Hardware summary

The hardware contains the following items:

- Up to 5760 TB raw storage capacity
- 96 GB to 192 GB of RAM (random access memory)
- Integrated Fibre Channel, Ethernet, and SAS ports
- Support for 10 Gbps Ethernet port speed
- Support for 8 Gbps Fibre Channel speed

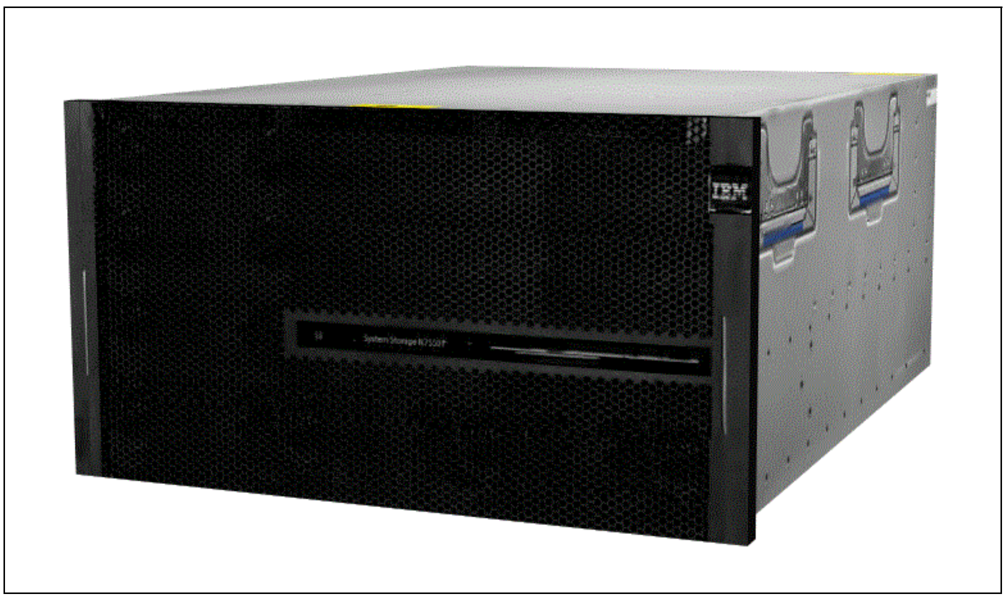


Figure 8-10 Front View of the N7550T N Series Model

With reference to Figure 8-10 on page 112, the front view for the N7950T is the same. The rear view of the 2 models is different, as you can see in Figure 8-11. The N7550T model chassis consists of 2 controllers in the single chassis. With the N7950T, the chassis contains a single controller, so with this configuration, you have a higher PCIe slot count.

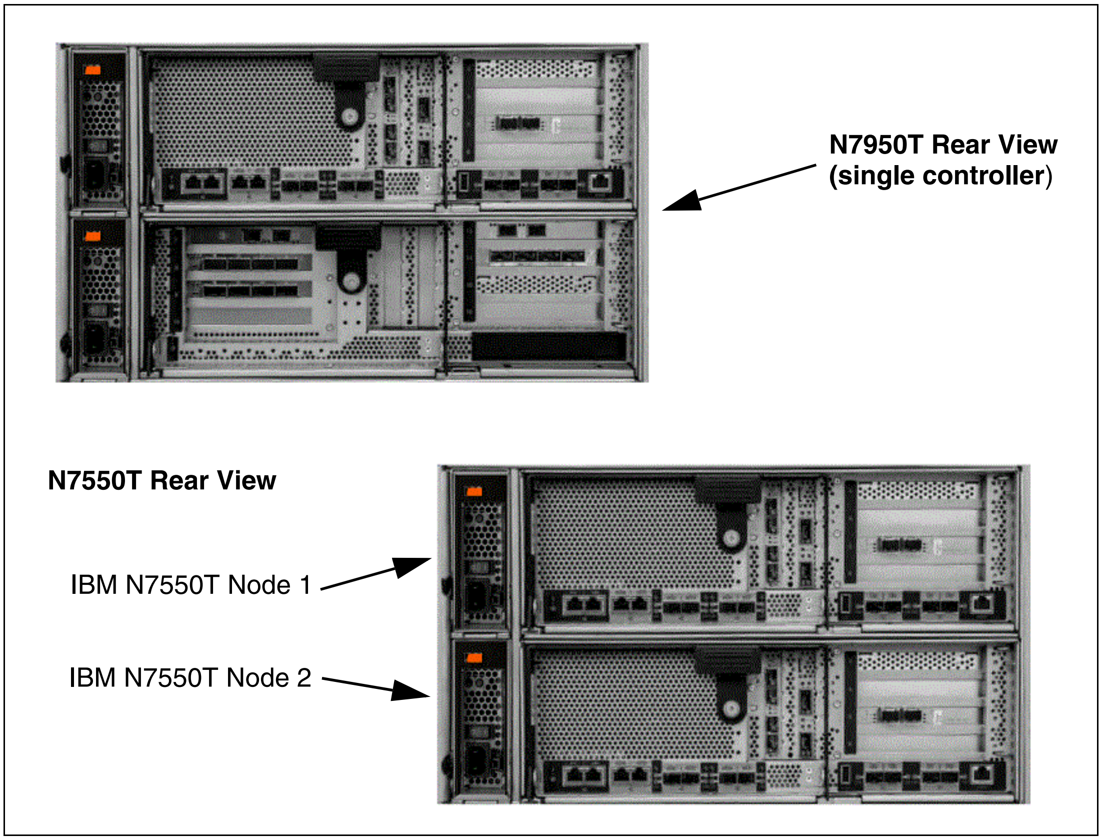


Figure 8-11 Rear View of the N Series N7550T & the N7950T models

For a comparison of key hardware features for the N7550T and the N7590T models, see Table 8-6.

Table 8-6 N7550T & N7950T specifications

Feature	N7550T	N7950T
Machine Type / Model	2867-C20	2867-E22
Processor Type	2.26.GHz (Nehalem quad core)	Intel 2.93 Ghz (6 core)
Processors (No. of cores)	4 (16 cores)	2 (24 cores)
System Memory (RAM)	96GB	192GB
Non Volatile Memory (NVRAM)	4GB	8GB
Fibre Channel Ports (8Gbps)	8	8
SAS Ports (6Gbps)	0 to 8	0 to 24
Max Capacity	4800TB	5760TB

In Table 8-6, only some of the features are mentioned. For a full list of models and specifications for the N7xx range, see the brochure, *IBM System Storage N7xxx series Data Sheet*, at the following website:

http://public.dhe.ibm.com/common/ssi/ecm/en/tsd02538usen/TSD02538USEN.PDF

To end this section, we have combined the prior tables for ease of cross reference, as this may aid your decision as to which is a more suitable model for your environment when deploying with RTCA. See Table 8-7.

Table 8-7 Comparison Table for the N Series models discussed in this chapter

	N6220	**N6250**	**N7550T**	**N7950T**
Machine Type / Model	2858-C15 to 2858-E25	2858-E16 to 2858-E26	2867-C20	2867-E22
Processor Type	Intel 2.3 Ghz (quad core)	Intel 2.3 Ghz (quad core)	2.26.GHz (Nehalem quad core)	Intel 2.93 Ghz (6 core)
Processors (No. of cores)	up to 2 (8 cores)	up to 4 (16 cores)	4 (16 cores)	2 (24 cores)
System Memory (RAM)	12GB to 24Gb	20GB to 40GB	96GB	192GB
Non Volatile Memory (NVRAM)	1.6GB to 3.2GB	2GB to 4GB	4GB	8GB
Fibre Channel Ports (8Gbps)	up to 4 (4 Gbps only)	up to 4 (4 Gbps only)	8	8
SAS Ports (6Gbps)	up to 4	up to 4	0 to 8	0 to 24
Max Capacity	1920TB	2880TB	4800TB	5760TB

8.5 HA pair hardware configuration

An N series Clustered Data ONTAP system consists of one or multiple HA pairs, which are all connected to a shared cluster network. Although the controllers in an HA pair are connected to other controllers in the cluster through the cluster network, the HA interconnect and disk-shelf connections are found only between the node and its partner and their disk shelves or array LUNs, hence only the nodes in the HA pair can take over each other's storage.

Figure 8-12 illustrates the functional design of multiple HA pairs.

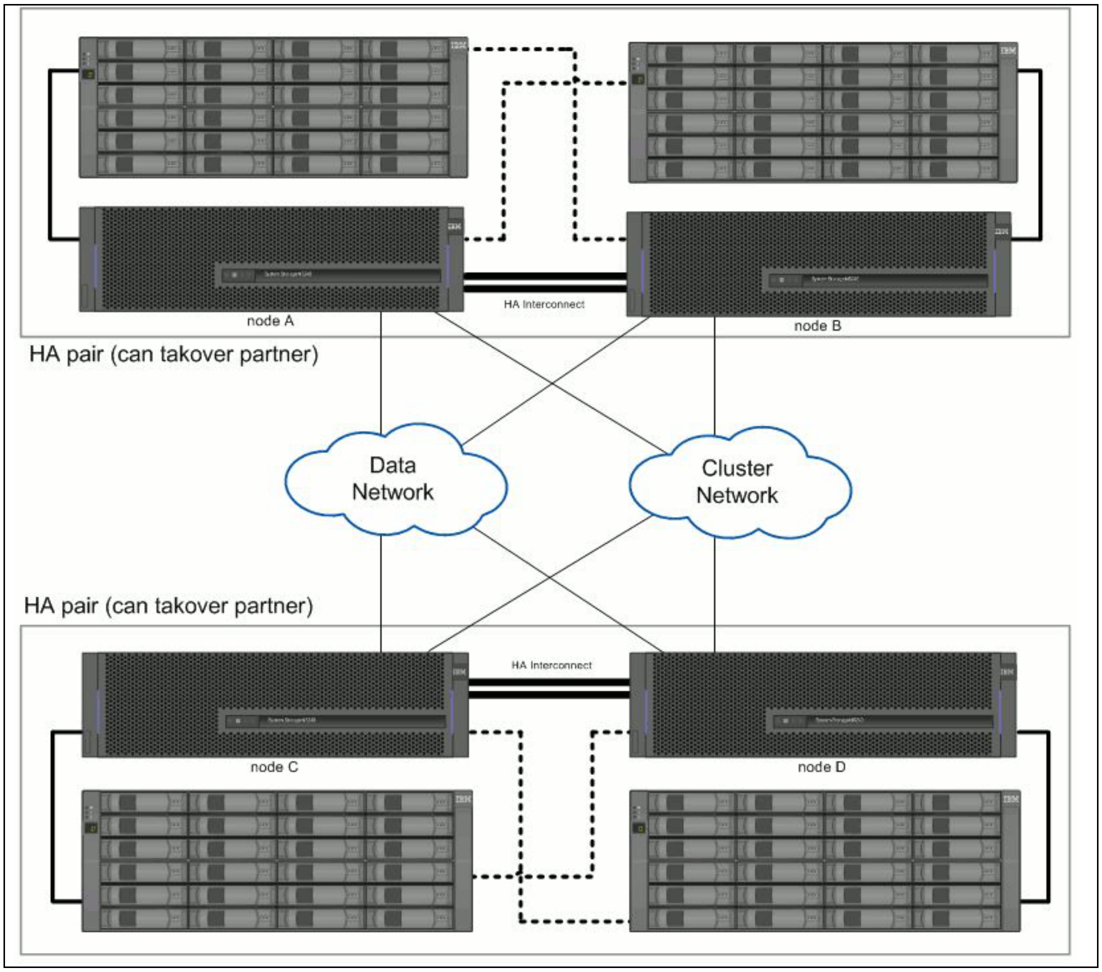


Figure 8-12 Functional design of multiple HA pairs

Regarding only the initial hardware setup of a single HA pair, nothing has changed in comparison to an N series 7-Mode system. Due to that, see the *IBM System Storage N series Hardware Guide* regarding the hardware setup, available at the following website:

http://www.redbooks.ibm.com/abstracts/sg247840.html

8.5.1 Cluster network

The cluster network consists of two CN1610 managed Layer 2 switches where each provides 16 10 GE Small Form-Factor Pluggable Plus (SFP+) ports and features four ISL ports with an inband/outband management port. These switches are designed to work in clusters ranging from two to eight nodes as a supported configuration, although there are ports to connect 12 nodes because four ports are reserved for further use.

Each of the controllers has to be connected to every switch. It is leading practice to use dedicated 10 GE cards to connect to the cluster network if possible (for example, e1a, e2a).

See Figure 8-13 for a cabling example.

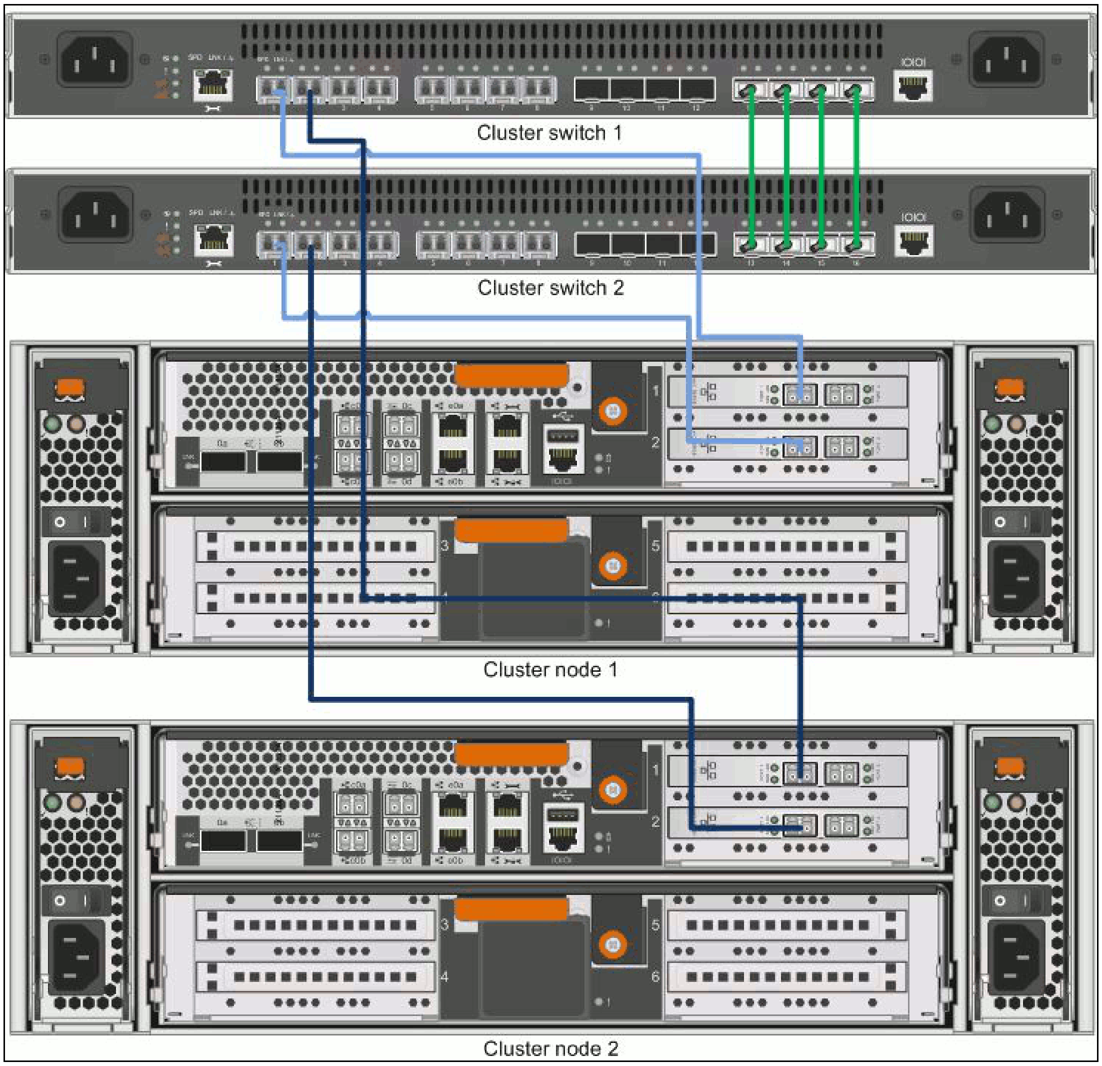


Figure 8-13 Cabling example cluster network

8.5.2 Switchless cluster

You can optionally configure two-node clusters without cluster network switches. Instead, you can apply the networking switchless-cluster option and use direct, back-to-back connections between the nodes. If you have a two-node switchless configuration in which there is no cluster interconnect switch, you must ensure that the switchless-cluster-network option is enabled. This ensures proper cluster communication between the nodes.

See Figure 8-14 for a cabling example.

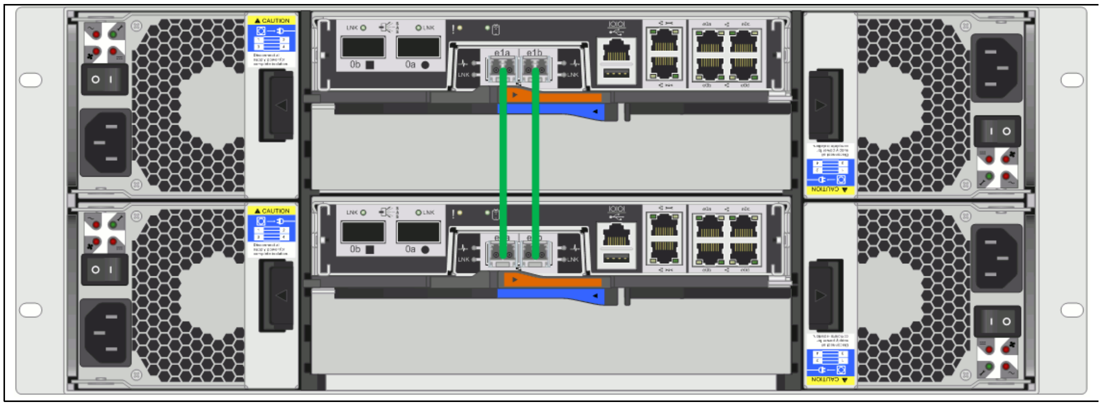


Figure 8-14 Cabling example switchless cluster

8.6 Snapshots

A Snapshot, as shown in Figure 8-15, is a read-only copy of the entire file system, as of the time the Snapshot was created. The filer creates Snapshots very quickly without consuming any disk space. The existing data remains in place; future writes to those blocks are redirected to new locations. Only as blocks in the active file system are modified and written to new locations on disk does the Snapshot begin to consume extra space.

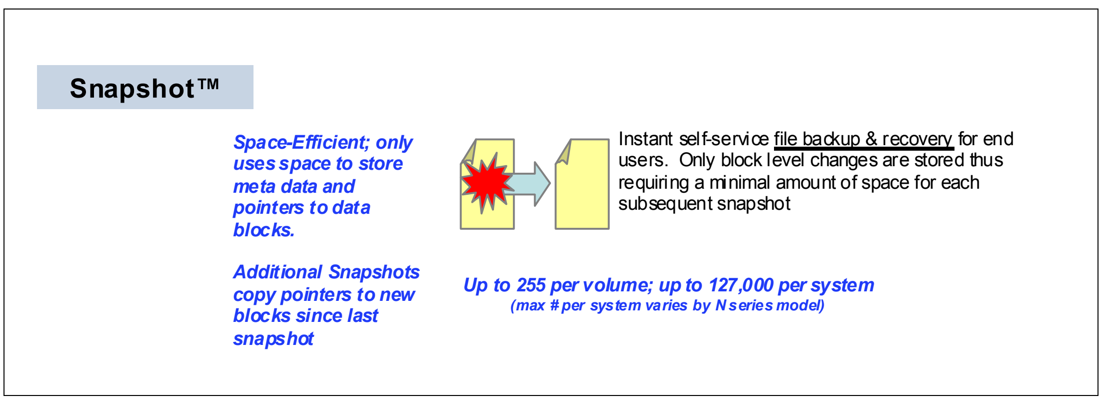


Figure 8-15 Snapshot

Volume Snapshots are exported to all CIFS or NFS clients. They can be accessed from each directory in the file system. From any directory, a user can access the set of Snapshots from a hidden sub-directory that appears to a CIFS client as *~snapshot* and to an NFS client as *.snapshot*. These hidden sub-directories are special in that they can be accessed from every directory, but they only show up in directory listings at an NFS mount point or at the root of CIFS share

Each volume on the filer can have up to 255 Snapshots at one time. Each aggregate on the filer can have up to 10 Snapshots at one time if Snapshot autodelete is enabled on that aggregate. If autodelete is not enabled, the aggregate can have up to 255 Snapshots. Because of the technique used to update disk blocks, deleting a Snapshot will generally not free as much space as its size would seem to indicate.

Blocks in the Snapshot can be shared with other Snapshots, or with the active file system, and thus might be unavailable for reuse even after the Snapshot is deleted.

8.7 Flexible volume (FlexVol)

A flexible volume (FlexVol) in Clustered Data ONTAP is a data container associated with a Vserver with FlexVol volumes. It gets its storage from a single associated aggregate, which it might share with other FlexVol volumes or Infinite Volumes. It can be used to contain files in a NAS environment, or LUNs in a SAN environment.

FlexVol volumes enable you to partition your data into individual manageable objects that can be configured to suit the needs of the users of that data.

A FlexVol volume enables you to take the following actions:

- Create a clone of the volume quickly and without having to duplicate the entire volume by using FlexClone technology.
- Reduce the space requirements of the volume by using deduplication and compression technologies.
- Create a sparse copy of the volume to balance loads or reduce network latency by using FlexCache technology.
- Create a Snapshot copy of the volume for data protection purposes.
- Limit the amount of space a user, group, or qtree can use in the volume by using quotas.
- Partition the volume by using qtrees.
- Create load-sharing mirrors to balance loads between nodes.
- Move the volume between aggregates and between storage systems.
- Make the volume available to client access using any file access protocol supported by Clustered Data ONTAP.
- Set up a volume to make more storage available when it becomes full.
- Create a volume that is bigger than the physical storage currently available to it by using thin provisioning.

8.8 Infinite Volumes

An Infinite Volume is a single, scalable volume that can store up to 2 billion files and tens of petabytes of data. With an Infinite Volume, you can manage multiple petabytes of data in one large logical entity and clients can retrieve multiple petabytes of data from a single junction path for the entire volume.

An Infinite Volume uses storage from multiple aggregates on multiple nodes. You can start with a small Infinite Volume and expand it non-disruptively by adding more disks to its aggregates or by providing it with more aggregates to use.

Infinite Volumes enable you to store multiple petabytes of data in a single volume that supports multi-protocol access, storage efficiency technologies, and data protection capabilities.

With Infinite Volumes, you can perform the following tasks:

- Manage multiple petabytes of data in a single logical entity with a single junction path and a single namespace.
- Provide multi-protocol access to that data using NFSv3, NFSv4.1, pNFS, and CIFS (Server Message Block (SMB) 1.0.

- Offer secure multi-tenancy by creating multiple Vservers with FlexVol volumes and multiple Vservers with Infinite Volume in a single cluster.
- Assign more storage to users than is physically available by using thin provisioning.
- Maximize storage efficiency by using deduplication and compression technologies.
- Optimize storage by grouping it into storage classes that correspond to specific goals, such as maximizing performance or maximizing capacity.
- Automatically place incoming files into the appropriate storage class according to rules based on file name, file path, or file owner.
- Protect data by creating Snapshot copies of the volume.
- Create a data protection mirror relationship between two volumes on different clusters, and restore data when necessary.
- Back up data with CIFS or NFS over a mounted volume to tape, and restore data when necessary.
- Increase the physical size of the Infinite Volume by adding more disks to the aggregates used by the Infinite Volume or by assigning more aggregates to the Vserver containing the Infinite Volume and then resizing the Infinite Volume.

8.9 Thin provisioning using FlexVol volumes

With thin provisioning, when you create volumes for different purposes in a given aggregate, you do not actually allocate any space for those volumes in advance. The space is allocated only when the application host needs it.

The unused aggregate space is available for the thinly provisioned volumes to expand or for creating new volumes. By allowing as-needed provisioning and space reclamation, thin provisioning can improve storage utilization and decrease storage costs.

A FlexVol volume can share its containing aggregate with other FlexVol volumes. Therefore, a single aggregate is the shared source of all the storage used by the FlexVol volumes it contains. Flexible volumes are no longer bound by the limitations of the disks on which they reside. A FlexVol volume is a pool of storage that can be sized based on how much data you want to store in it, rather than on the size of your disk. This flexibility enables you to maximize the performance and capacity utilization of the storage systems. Because FlexVol volumes can access all available physical storage in the system, dramatic improvements in storage utilization are possible.

The following discussion exemplifies how using FlexVol volumes can help maximize the capacity utilization of storage systems.

A 500-GB volume is allocated with only 100 GB of actual data; the remaining 400 GB allocated has no data stored in it. This unused capacity is assigned to a business application, even though the application might not need all 500 GB until later. The allocated but unused 400 GB of excess capacity is temporarily wasted.

With thin provisioning, the storage administrator provisions 500 GB to the business application but uses only 100 GB for the data. The difference is that with thin provisioning, the unused 400 GB is still available to other applications. This approach allows the application to grow transparently, and the physical storage is fully allocated only when the application truly needs it. The rest of the storage remains in the free pool to be used as needed. Storage administrators can set thresholds, so they are alerted when more disks need to be added to the pool.

See Figure 8-16 for a comparison of thin provisioning with traditional provisioning.

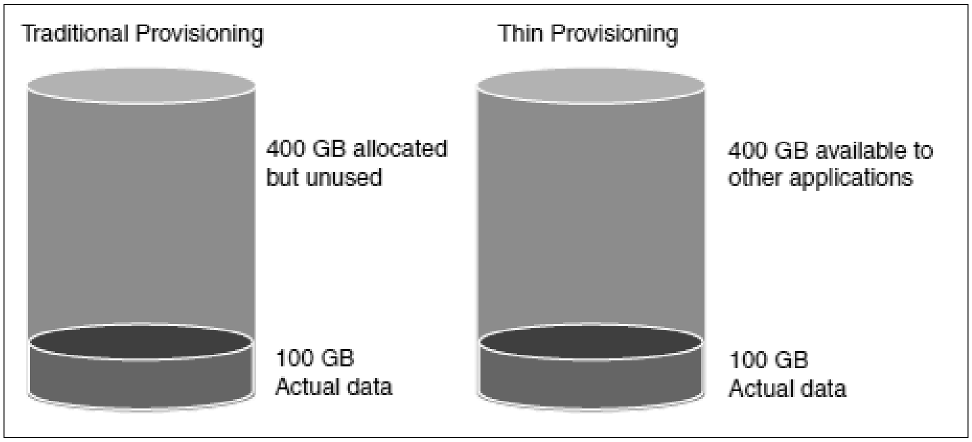


Figure 8-16 Thin provisioning compared to traditional provisioning

The FlexVol technology enables you to oversubscribe the free space to adapt rapidly to the changing business needs.

The benefits of using thin provisioning are as follows:

- It allows storage to be provisioned just like traditional storage, but it is not consumed until data is written.
- Storage-provisioning time is greatly reduced, because you can create the storage for an application quickly without depending on the actual physical space available.
- Through notifications and configurable threshold values, you can plan your procurement strategies well in advance and have enough storage for thin provisioned volumes to grow.
- You can set aggregate over-commitment thresholds by using Protection Manager. Using Provisioning Manager, you can also set policies for provisioning, exporting, and managing your space requirements.

8.10 FlexClone

FlexClone technology enables multiple, instant data set clones with no storage impact. It provides dramatic improvements for application test and development environments. It is also tightly integrated with file system technology and a microkernel design in a way that renders competitive methods archaic.

Within VMware vSphere environments, the FlexClone feature can be used for cloning VMs, datastore mounts, VMDK recovery to alternate datastore, and single file restore (SFR). Thus FlexClone technologies allow administrators to easily provision virtual machines.

With FlexClone, you can clone a volume, a file, or LUN and make it available to other servers. This method can be used to deploy multiple ESXi hosts. For example, you can install the ESXi operating system on a single server, and then use FlexClone to make a copy of that LUN to multiple servers. This N series feature is also helpful when you want to reproduce your production environment on a test area. FlexClone functionality is shown in Figure 8-17.

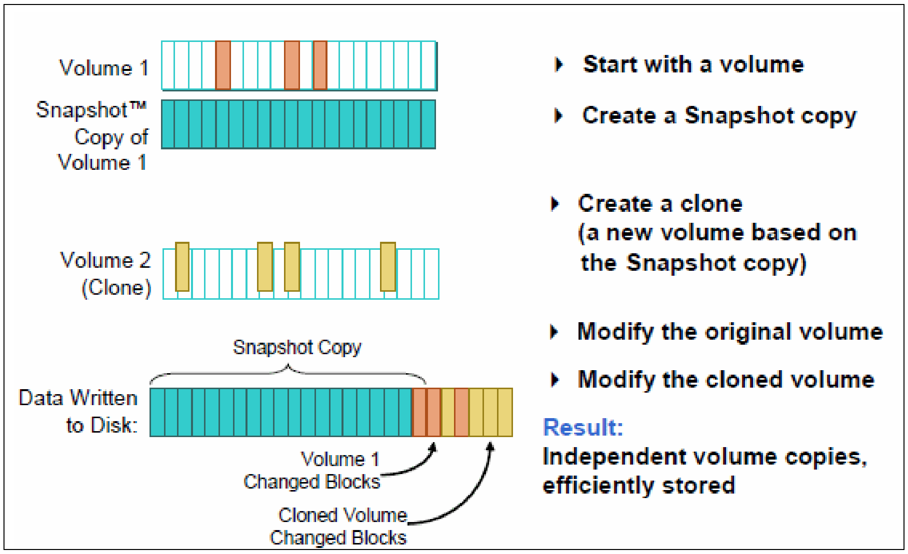


Figure 8-17 FlexClone cloning and space savings

Customizing the ESXi operating system: After using FlexClone, the ESXi operating system must to be customized to avoid IP and name conflicts with the original server from which the FlexClone was taken. VSC supports the vCenter administrator by simplifying these tasks.

8.11 Deduplication

Deduplication operates at the block level within the entire FlexVol volume, eliminating duplicate data blocks and storing only unique data blocks.

Clustered Data ONTAP writes all data to a storage system in 4-KB blocks. When deduplication runs for the first time on a FlexVol volume with existing data, it scans all the blocks in the FlexVol volume and creates a digital fingerprint for each of the blocks. Each of the fingerprints is compared to all other fingerprints within the FlexVol volume. If two fingerprints are found to be identical, a byte-for-byte comparison is done for all data within the block. If the byte-for-byte comparison detects identical fingerprints, the pointer to the data block is updated, and the duplicate block is freed. Figure 8-18 shows how the process works.

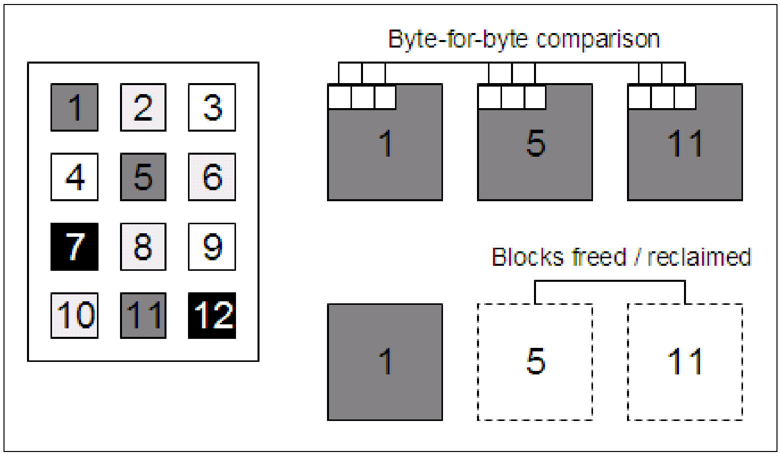


Figure 8-18 Fingerprints and byte-for-byte comparison

Deduplication runs on the active file system. Therefore, as additional data is written to the deduplicated volume, fingerprints are created for each new block and written to a change log file. For subsequent deduplication operations, the change log is sorted and merged with the fingerprint file, and the deduplication operation continues with fingerprint comparisons as previously described.

8.12 Quality of Service (QoS)

Quality of Service (QoS) is a Clustered Data ONTAP feature that provides the ability to group storage objects and set throughput limits on the group. With this ability, a storage administrator can separate workloads by organization, application, business unit, or production versus development environments.

QoS allows administrators to limit the number of I/O operations per second or raw throughput (MB/s) directed to a policy group that could consist of a single Storage Virtual Machine (SVM, formerly referred to as a Vserver), or a group of LUNs, flexible volumes, or files within an SVM.

In enterprise environments, storage QoS provides these benefits:

- Helps to prevent user workloads from affecting each other.
- Helps to protect critical applications critical applications that have specific response times that must be met.

In IT as a service (ITaaS) environments, storage QoS provides these benefits:

- Helps to prevent tenants from affecting each other.
- Helps to avoid performance degradation with each new tenant.

8.13 Data protection and load sharing

Data protection means backing up data and being able to recover it. You protect the data by making copies of it so that it is available for restoration even if the original is no longer available.

Businesses need data backup and protection for the following reasons:

- To protect data from accidentally deletions, application crashes, data corruption, and so on
- To archive data for future use
- To recover from a disaster

8.13.1 SnapMirror

Only asynchronous SnapMirror mirroring is supported. This can be set both within the cluster (intra-cluster) as well as between clusters (inter-cluster). The replication is at the volume level of granularity and is also known as a data protection (DP) mirror. Qtree SnapMirror is not available for Clustered Data ONTAP.

SnapMirror relationships can be throttled to a specific transfer rate using the **`snapmirror modify –throttle`** command.

8.13.2 SnapVault

SnapVault in Clustered Data ONTAP 8.2 delivers much of the same functionality you may be familiar with from 7-Mode: the ability to store Snapshot copies on a secondary system for a long period of time, without taking up space on your primary system.

However, SnapVault in Clustered Data ONTAP is based on a new engine that uses volume-based logical replication, as opposed to SV in 7-Mode, which used qtree-based replication. Since deduplication and compression operate at the flexible volume level, that represents a big advantage over 7-Mode. Storage efficiency is maintained while data is transferred to the backup system and is also maintained on the backup system. That translates to reduced backup times, and increased storage efficiency in the backup copy.

SnapVault is available in Clustered Data ONTAP 8.2 and above. Inter-cluster SnapVault is supported. SnapVault relationships between Clustered Data ONTAP and 7-Mode Data ONTAP are not supported.

8.13.3 NDMP

For FlexVol volumes, Clustered Data ONTAP supports tape backup and restore through the Network Data Management Protocol (NDMP). For Infinite Volumes, Clustered Data ONTAP supports tape backup and restore through a mounted volume. Infinite Volumes do not support NDMP. The type of volume determines what method to use for backup and recovery.

NDMP allows you to back up storage systems directly to tape, resulting in efficient use of network bandwidth. Clustered Data ONTAP supports dump engine for tape backup. Dump is a Snapshot copy-based backup to tape, in which your file system data is backed up to tape. The Clustered Data ONTAP dump engine backs up files, directories, and the applicable access control list (ACL) information to tape. You can back up an entire volume, an entire qtree, or a subtree that is neither an entire volume nor an entire qtree. Dump supports level-0, differential, and incremental backups. You can perform a dump backup or restore by using NDMP-compliant backup applications. Starting with Clustered Data ONTAP 8.2, only NDMP version 4 is supported.

8.13.4 Data protection mirror

A data protection mirror provides asynchronous disaster recovery. Data protection mirror relationships enable you to periodically create Snapshot copies of data on one volume; copy those Snapshot copies to a partner volume (the destination volume), usually on another cluster; and retain those Snapshot copies. The mirror copy on the destination volume ensures quick availability and restoration of data from the time of the latest Snapshot copy, if the data on the source volume is corrupted or lost.

If you conduct tape backup and archival operations, you can perform them on the data that is already backed up on the destination volume.

8.13.5 Load sharing mirror

A load sharing mirror of a source flexible volume is a full, read-only copy of that flexible volume. Load-sharing mirrors are used to transparently off-load client read requests. Client write requests will fail unless directed to a specific writable path.

Load-sharing mirrors can be used to enable the availability of the data in the source flexible volume. Load-sharing mirrors will provide read-only access to the contents of the source flexible volume even if the source becomes unavailable. A load-sharing mirror can also be transparently promoted to become the read-write volume.

A cluster might have many load-sharing mirrors of a single source flexible volume. When load-sharing mirrors are used, every node in the cluster should have a load-sharing mirror of the source flexible volume. The node that currently hosts the source flexible volume should also have a load-sharing mirror. Identical load-sharing mirrors on the same node will yield no performance benefit.

Load-sharing mirrors are updated on demand or on a schedule that is defined by the cluster administrator. Writes made to the mirrored flexible volume will not be visible to readers of that flexible volume until the load-sharing mirrors are updated. Similarly, junctions added in the source flexible volume will not be visible to readers until the load-sharing mirrors are updated. Therefore, it is advisable to use load-sharing mirrors for flexible volumes that are frequently read but infrequently written to.

SVM root volumes are typically small, contain only junctions to other volumes, do not contain user data, are frequently read, and are infrequently updated. SVM root volumes must be available for clients to traverse other volumes in the namespace. This makes SVM root volumes good candidates for mirroring across different nodes in the cluster.

In versions of Clustered Data ONTAP prior to 8.2, load-sharing mirrors were used to distribute access to read-only datasets. Clustered Data ONTAP 8.2 introduces FlexCache technology, which can also be used to distribute read access but provides write access and is space efficient.

Load-sharing mirrors are capable of supporting NAS only (CIFS/NFSv3). They do not support NFSv4 clients or SAN client protocol connections (FC, FCoE, or iSCSI).

8.14 Flash Cache

Flash Cache (previously called PAM II) is a set of solutions that combine software and hardware within IBM N series storage controllers to increase system performance without increasing the disk drive count. Flash Cache is implemented as software features in Clustered Data ONTAP and PCIe-based modules with either 256 GB, 512 GB, or 1 TB of Flash memory per module. The modules are controlled by custom-coded Field Programmable Gate Array processors. Multiple modules may be combined in a single system and are presented as a single unit. This technology allows sub-millisecond access to data that previously was served from disk at averages of 10 milliseconds or more.

> **Tip:** This solution is suitable for all types of workloads but provides the greatest benefit from IBM System Storage N series storage subsystems serving intensive random read transactions.

8.14.1 Flash Cache module

The Flash Cache option offers a way to optimize the performance of an N series storage system by improving throughput and latency while reducing the number of disk spindles/shelves required and the power, cooling, and rack space requirements.

A Flash Cache module provides an additional 256 GB, 512 GB, or 1 TB (PAM II) of extended cache for your IBM System Storage N series storage subsystem, depending on the model. Up to eight modules can be installed. Each module must be installed on a PCI express slot, and it only consumes an additional 18 watts of power per module. Extra rack space and ventilation is not required, making it an environmentally friendly option. Figure 8-19 shows the Flash Cache module.

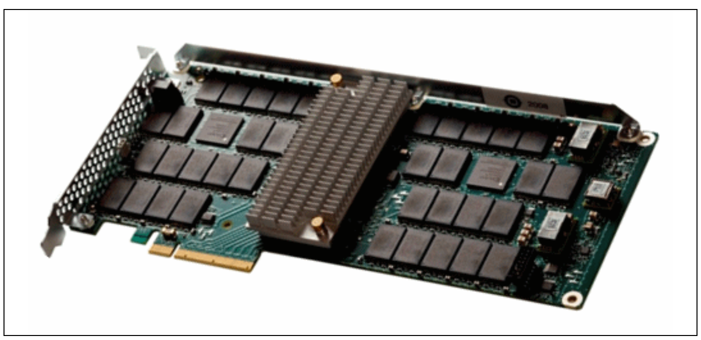


Figure 8-19 Flash Cache module

8.14.2 How Flash Cache works

Flash Cache replaces disk reads with access to an extended cache contained in one or more hardware modules. Your workload is accelerated in direct proportion to the disk reads replaced. The remainder of this chapter describes different workloads and how they are accelerated. It also explains how to choose and configure the best mode of operation, and how to observe Flash Cache at work.

8.15 Virtual Storage Tier

The N series Virtual Storage Tier offers a unique approach to automated storage tiering. Enabled by our foundational strengths in storage efficiency and intelligent caching, the Virtual Storage Tier (Figure 8-20) provides the following benefits:

- A real-time, data-driven response to your most demanding application workloads
- The ability to consolidate your data onto fewer storage tiers
- Industry-leading efficiency through integration of data deduplication and thin cloning
- Ready for immediate use
- Automated support for PCI-e Flash and SSD technologies

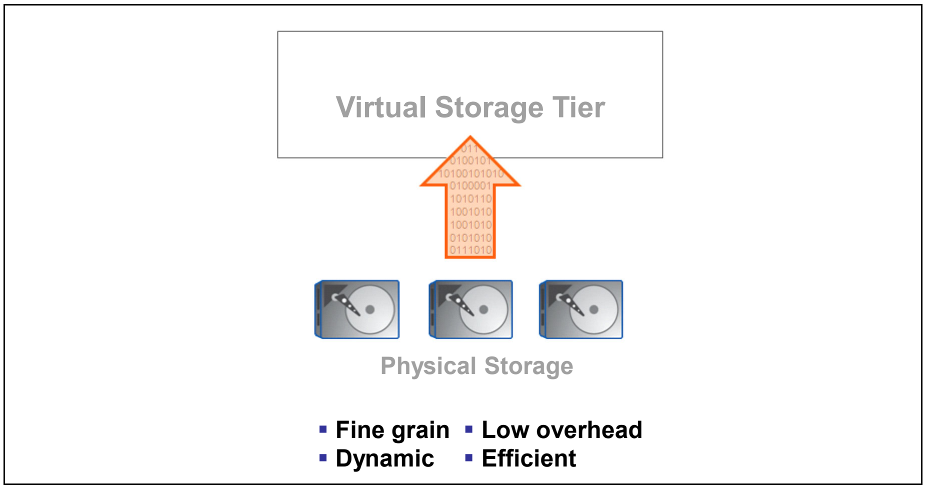


Figure 8-20 N series Virtual Storage Tier

Virtual Storage Tier provides the following benefits:

- The N Series Virtual Storage Tier provides fully automated use and optimization of Flash technology, both controller-based PCI-e-based Flash and solid-state disk (SSD).
- IBM N series Flash Cache PCI-e modules improve performance for workloads that are random read-intensive, reducing latency by a factor of 10 or more compared to hard disk drives.
- Flash Cache modules are available in capacities up to 1 terabyte and provide controller-based caching.
- IBM N series Flash Pool provides caching of both random read and write operations through the automated use of SSD drives, thereby enabling the use of capacity-optimized hard disk drive technology across the majority of application workloads.
- Flash Pool enables the creation of a Clustered Data ONTAP software RAID-protected aggregate that is composed of a combination of hard disk drives (HDDs) and solid-state disk drives.
- With Flash Cache and Flash Pool, you can significantly decrease the cost of your disk purchases and make your storage environment more efficient. Specific workload testing showed the following results:
  - File Services Workload: Combining Flash Cache with SATA disks can significantly improve I/O throughput and response time (compared to high-performance HDD configurations) while lowering the cost per terabyte of storage and saving on power.
  - OLTP Workload: Combining Flash Pool with SATA disks can match the performance of high performance HDD configurations (Fibre Channel or SAS), while providing more capacity, lowering the cost per terabyte of storage, and saving significantly on power.

– When placing a pool of VMs on an aggregate that is utilizing the Virtual Storage Tier technology, changes in the required performance on individual VMs will automatically rebalance the workload across the VMs existing in that aggregate.

8.16 Further information

Links for additional information about N series unified NAS storage solutions are listed here:

- For further N series 3000 systems information and specifications, see the following websites:

  http://www.ibm.com/systems/storage/network/n3000/appliance/index.html
  http://www.ibm.com/systems/storage/network/n3000/appliance/specifications.html

- For further N series 6000 systems information, see the following websites:

  http://www.ibm.com/systems/storage/network/n6000/appliance/index.html
  http://www.ibm.com/systems/storage/network/n6000/appliance/specifications.html

- For further N series 7000 systems information, see the following websites:

  http://www.ibm.com/systems/storage/network/n7000/appliance/index.html
  http://www.ibm.com/systems/storage/network/n7000/appliance/specification.html

- For more detailed information about N series hardware features, see the IBM Redbooks publication *IBM System Storage N series Hardware Guide*, SG24-7840:

  http://www.redbooks.ibm.com/abstracts/sg247840.html?Open

- For more detailed information about N series software features, see the IBM Redbooks publication *IBM System Storage N series Software Guide*, SG24-7129:

  http://www.redbooks.ibm.com/abstracts/sg247129.html?Open

- IBM System Storage N series Machine Types and Models (MTM) Cross Reference:

  http://www.ibm.com/support/docview.wss?uid=ssg1S7001844

9

Storage design

This chapter provides information about the essential elements that are part of the storage design. It also refers to certain operational aspects and business requirements that need to be incorporated into the plan.

The following topics are covered:

- Aggregates
- Storage virtual machine (SVM)
- Logical Interface (LIF)
- Multi-tenancy

9.1 Aggregates

Clustered Data ONTAP physically stores data in aggregates. An aggregate is made up of one or more RAID groups, has its own RAID configuration, and allows the storage administrator to allocate storage resources and group client data based on differing security, backup, performance or data sharing needs. Aggregates maintain a single copy of their data in a plex, which contains all the RAID groups belonging to that aggregate. The diagram below shows a RAID-DP aggregate (aggrA) with its single plex (plex0), which is made up of four RAID groups. RAID-DP is the standard and suggested default for N series.

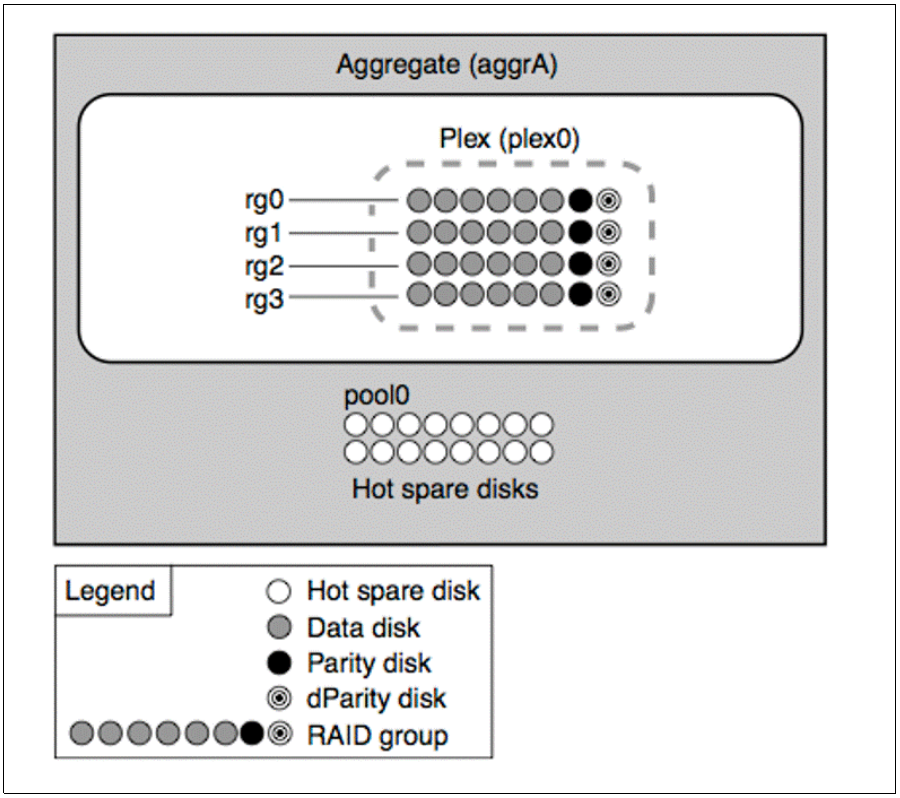


Figure 9-1 Aggregate - example

9.2 Storage virtual machine (SVM)

Clustered Data ONTAP virtualizes storage from the clients' perspective by implementing the storage virtual machine (SVM). The SVM is a logical abstraction that represents the physical storage resources in the cluster. A cluster uses at least one SVM, but can have multiple SVMs. These are given access to resources such as data volumes and logical interfaces (LIFs) that are created and assigned to the physical resources of the cluster, but can be moved or reallocated to different physical resources as needed, all transparent and non-disruptively to the client. For example, a flexible volume may be non-disruptively moved to a new node and aggregate, or a data LIF could be transparently reassigned to a different physical network port.

9.3 Logical Interface (LIF)

All networking in a Clustered Data ONTAP system is abstracted from the physical network ports of the underlying storage hardware. This is done by defining logical interfaces (LIFs), which are then bound to the physical (and sometimes virtual) ports underneath. LIFs provide tremendous flexibility in designing your storage system. They add resiliency, redundancy, and are a critical component in the ability of Clustered Data ONTAP to provide truly non-disruptive operations (NDO).

The networking architecture in a Clustered Data ONTAP system is made up of the following key components:

- Physical Ports: Network interface cards (NICs), HBAs, and onboard Ethernet ports.
- Virtual ports: VLANs, which subdivide a physical port into multiple logical ports; and interface groups, which treat several physical ports and a single logical port.
- LIFs: LIFs are logical network interfaces that are bound to either physical or virtual ports, as defined before.
- Routing groups: Also known as routing tables. Each LIF must be associated with a routing group and can only use the routes in that routing group. Each routing group must have at least one route to access clients outside its local subnet.
- DNS zones: Can be specified during LIF creation, which will provide a name for the LIF to be exported through the cluster's DNS server. Multiple LIFs can share the same name, enabling the DNS load balancing by distributing IP addresses to the names LIFs based on load.

Each network port (physical or virtual) has a default role defined for that port. These roles can be modified, based on your desired configuration. Here is a brief description of the types of ports that can be defined in a cluster:

- Data Ports: These are ports clients use to access their data, via CIFS, NFS, FC, or iSCSI. Each physical node must have at least one data port defined, and can use either physical or virtual ports.
- Cluster Ports: These are 10 GbE ports and are dedicated solely for intracluster traffic. Each physical node should have two cluster ports defined, and cannot use virtual (VLAN or interface group) ports.
- Node-management ports: As the name implies, these ports are used to manage the physical nodes. Node-management ports cannot be used for data traffic, and, on nodes with a dedicated e0M port, the node-management port cannot be changed and can only use the physical port. On other nodes, virtual ports may be used.
- Intercluster ports: These ports are optional and are used for transferring data between clusters for such things as SnapMirror and SnapVault. Intercluster ports can be assigned to physical or virtual ports.

LIFs also have several different roles, and the role of LIF is determined by the kind of traffic that will supported over the LIF. LIFs can have one of the following five roles:

- Data LIF: These LIFs are used by clients to access their data and are assigned to and associated with SVMs. Data LIFs can only be assigned to Data Ports and can be configured to fail over to other data ports or be migrated to other data ports throughout the cluster.
- Cluster LIF: Used only for intracluster traffic, cluster LIFs can only be assigned to cluster ports. These LIFs can failover to cluster ports on the same node, but cannot be migrated or fail over to ports on a remote node.

- Node-management LIF: Used to manage the individual physical node, node-management LIFs provide a dedicated IP address for performing system maintenance, and can provide access to the node when it has become inaccessible from the cluster. Node-management LIFs can be assigned to node-management ports or data ports and can be configured to fail over to other ports on the same node.
- Cluster-management LIF: Cluster-management LIFs provide an interface to manage the entire cluster. They can be configured on node-management ports or data ports and can fail over to any node-management or data port in the cluster.
- Intercluster LIFs: Used for intercluster communication, intercluster LIFs are used for backup and replication traffic. They can be configured on data ports or intercluster ports. Intercluster LIFs can fail over to any intercluster or data port on the same node only.Virtual Storage Tier.

Balancing performance and efficiency will maximize realized value from any solution. The flexibility to mix different types of disk drives and also flash-based technology in the same cluster, and in the same HA pair is one of the most beneficial features of the unified architecture of the ONTAP storage platform. This flexibility can immediately be translated to flexibility of every cloud-based solution to easily accommodate changes in workloads as it is likely for business to change requirements over time. Virtual Storage Tier (VST) offers dynamic optimization of performance and it is done automatically. If a specific known workload calls for higher or lower latency, the storage can be configured with SSD drives or other flash-based technology for those more demanding workloads and with SATA for workloads that can tolerate higher latency to provide the flexibility and the dynamic range for VST to operate. This saves you from investing in all-flash expensive storage.

The N series Virtual Storage Tier provides an end-to-end approach to intelligent caching. VST can be implemented at both the server level and at the storage level. At the server level, Flash Accel enables PCI-e Flash and SSD devices on the application host to be utilized as server cache. This allows specific applications which need ultra-low latency and high throughput to be accelerated in virtualized environments.   At the storage level, there are two ways to implement VST.

Flash Cache is controller based, provides acceleration of random read operations and generally provides the highest performance solution for file services workloads.

Flash Pool is implemented at the disk shelf level allowing SSD drives and traditional hard disk drives to be combined in a single Data ONTAP aggregate. In addition to read caching, Flash Pool also provides write caching and is particularly well suited for OLTP workloads which typically have a higher percentage of write operations.

All three VST technologies improve overall storage performance and efficiency and are simple to deploy and operate. See chapter 8 for more information about VST.

9.4 Multi-tenancy

As discussed in previous sections, the implementation of secure multi-tenancy on the N series storage is possible thanks to server virtual machine (SVM) technology. This section provides additional details about the storage design considerations to enable a multi-tenancy type environment.

As a general rule of thumb, multiple SVMs are required to support multiple tenants. SVMs can be created based on the various workloads, and different applications can be given access to manage their own application not being aware that it is served on a shared storage. To assure performance, QoS policies can also be assigned based on SVM.

Storage that supports multiple tenants can be designed based on the performance requirements (SSDs or Flash Cache enabled storage), data protection needs (replication using SnapMirror or SnapVault enabled backup, and so on), management policies, ownership and control. In some cases consolidating multiple tenants with similar requirements under the same SVM will be economical from the utilization of the physical resources, but also from operational aspects as the common policies can be applied to all tenants in the SVM.

A key feature of SVMs in Clustered Data ONTAP is that each is a logical entity that exists on the cluster, not bound to any single controller or HA pair. SVMs can contain resources from any node in the cluster and from multiple nodes concurrently. This empowers administrators with a great amount of flexibility. For example, data volumes for an SVM can reside on a single aggregate, or they can be distributed across multiple aggregates on multiple nodes. Using the data mobility features of Data ONTAP, these volumes can be relocated to different aggregates non-disruptively, even if the new aggregate is on a different node.

Likewise, data LIFs are logical and can be moved non-disruptively to new physical ports, VLANs, or interface groups. These ports can theoretically be on any node of the cluster; however, care must be taken to make sure that the LIF gets moved to a physical port that is connected to an appropriate physical network. NAS clients can connect to shares or exports using an SVM's data LIF on any node and access all of the SVM's data volumes regardless of the nodes and aggregates in which those volumes are contained. This allows for unprecedented flexibility at the physical level to introduce new resources to the cluster, retire resources from the cluster, and balance workload and capacity across the cluster.

Since each SVM requires a set of dedicated LIFs, it is important to understand the maximum number of LIFs per-node and per-port LIF maximums when designing a multi-tenant environment and calculating the number of SVMs. See the tables in Figure 9-2 to learn more about the limit number of LIFs in a particular type and size of environment.

LIFs limits for determining number of SMVs when designing Multi-tenancy environments

Resource	Maximum Value
IP LIFs per node	256
FCP LIFs per node	512
IP LIFs per port	256
iSCSI LIFs per port	16
FCP LIFs per port	16

Maximum in a SAN environment

Number of Nodes	FC/FCoE Data LIFs and Dedicated IP Management LIF	iSCSI Data LIF and Dedicated IP Management LIF
1	125	125
2	250	125
4	250	165
6	250	190
8	250	200

Maximum in a NAS environment

Number of Nodes	Combined Data/Management LIF	Separate Data and Management LIFs
1	125	125
2	250	125
4	500	250
6	750	375
8	1,000	500
10–24	1,000	1,000

Figure 9-2 LIFs limits

It is important to account for a node failure within an HA pair in a cluster. As such, if the maximum number of LIFs is 256, each node should still be limited to only 128 LIFs in order to provide the high availability.

Security role

In addition to the default accounts within the Clustered Data ONTAP system, it is also possible to create other user accounts and assign a customized set of privileges here to those accounts. The default cluster administrator account is the admin user. Cluster administrators have the ability to administer the entire cluster and all of its resources. For SVMs, the default administrator is the *vsadmin* user, Although the *vsadmin* user is created with every SVM, it still needs to be enabled in order to delegate administration of the SVM. SVM administrators may only administer their respective SVMs.

10

Common cloud services and deployment models

This chapter provides an overview of the various services and deployment models of cloud, while identifying key features of the IBM System Storage N series that fit and enhance the implementation of these models and the associated daily operation. The common service models are IaaS, PaaS, and SaaS, and by deployment models are private, public, and hybrid clouds. As such, this chapter provides the cloud context for all the earlier chapters that covered specific technologies, features, and capabilities.

The chapter assumes the same architecture of N series Clustered Data ONTAP with VMware or Microsoft server virtualization. Although it does not distinguish between the various physical server options, it assumes that a converged implementation by leveraging Flex System is a more suitable approach. To complete the end-to-end solution, the chapter also provides an overview of the cloud management and orchestration tools by VMware, Microsoft, IBM, and the open standard OpenStack.

The following topics are covered:

- Conceptual reference model
- Infrastructure-as-a-Service (IaaS)
- Platform-as-a-Service (PaaS)
- Cloud management and orchestration tools

10.1 Conceptual reference model

According to the US National Institute of Standards and Technology (NIST), a cloud computing service should have the following five essential characteristics:

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured service

While this list is essential, both business and technical communities tend to associate additional common attributes; some may seem related or simply an interpretation of the core attributes in the list above. These additional characteristics include automation and provisioning, flexibility or agility, secure multi-tenancy, performance scalability, availability and reliability, cost savings, and simplicity.

The characteristics of cloud services are driven by requirements and expectations of the consumers of those cloud services, and they are mostly associated with reducing risk, cost, complexity, and improving productivity. The traditional silos (mentioned in Chapter 2, “Architecture and design” on page 7) are the standard that most companies are already moving away from towards better models of deploying infrastructures and consuming IT/IM services. The first step of moving away from the siloed approach was by implementing server virtualization. When that step was completed, companies are recognizing that the same benefits need to be applied to the entire data center, otherwise the value realization from server virtualization is limited and that cloud has to be looked at as an eco-system.

Other vendors in the data center recognized the transformation that started with server virtualization. The concepts of software-define networking, storage, and software-defined data center were coined indicating that the vendors of the other infrastructure elements are also introducing technologies to support the transformation to the cloud by offering virtualization capabilities or the abstraction from the physical layer for the full range of functions.

Now that the infrastructure is virtualized, it needs to be accessible and available for the consumers in the most economical way. This means elasticity, using resources when needed and not to allocate resources in advance, so the on-demand and self service portals are now part of the mix. To allow scalability, speed of delivering services, and elimination of user errors, provisioning tools have replaced the role of IT in cloud-based services, and now the data center is automated.

The last element in the mix is the Orchestration tool. Orchestration tools are software that designed to handle the coordination, collaboration, and management of all the various technologies, people, and processes into a cohesive system. Orchestration tools provide flexibility to tailor the services also according to set of business rules and policies as well as the set of service level objectives (SLOs).

Figure 10-1 illustrates a conceptual model of a cloud provider. The infrastructure is in the core of the model, in this case featuring N series and Flex System as the core components that the architecture is based on to form the virtualized infrastructure. As indicated earlier, the architecture applies as-is to all services and deployment models and they are covered in the next sections.

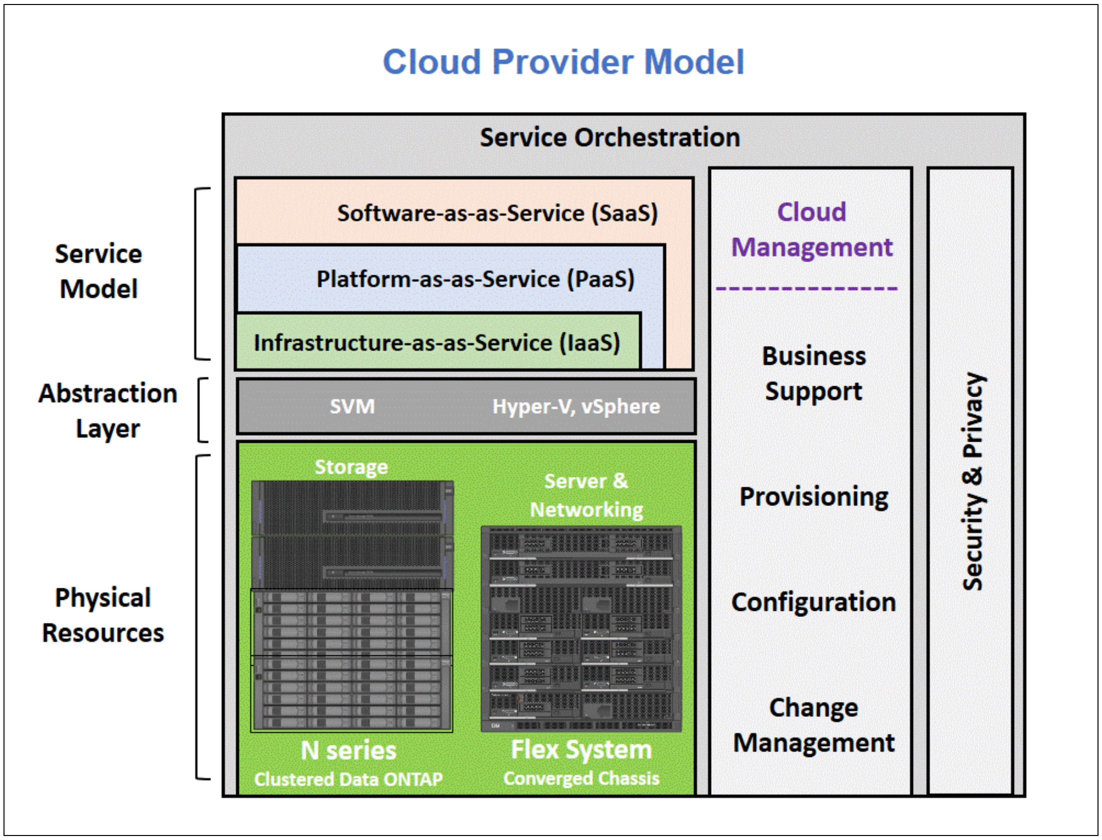


Figure 10-1 A conceptual cloud service provider model

10.2 Infrastructure-as-a-Service (IaaS)

Infrastructure as a service is the most common service model of a cloud as it is limited in most cases to compute resources based on processing units and memory, in most cases includes certain amount of space for storing data and a utility-based charging model of network bandwidth consumed beyond the standard. The cloud service providers running standard hardware to simplify the environment and all the compute resources consumed by their clients are virtualized. The consumer has access, through self-service portal where one can manage the resources as well as the account for billing, administration rights, and so on. Examples of IaaS offerings are provided later in this chapter.

N series has more than all the key attributes that are required from a storage platform to be well integrated in a virtualized infrastructure. Here are the essential features and capabilities:

- Non-disruptive operations
- Seamless scalability in multiple dimensions
- Its efficiencies, in storage capacity and cost/performance optimization
- QoS
- Multi-tenancy
- Software-defined storage, its flexibility as a result of the SSVM abstraction layer

Additional IBM System Storage N series capabilities that are relevant when it is part of an IaaS are its integration features with the hypervisor as covered in Chapter 4, “VMware vSphere integration” on page 41 and Chapter 5, “Microsoft Hyper-V integration” on page 63, the data protection and replication, its standard management tools, and the extensive set of APIs that offer the ability to integrate with orchestration tools, which are also covered later in this chapter. As established earlier throughout this book, the more integrated the end-to-end infrastructure is, the easier it is to implement automation to create the dynamic nature of the solution, that is, elasticity, autonomous and virtualized in a cohesive way, rather than independent per each element of the infrastructure.

Figure 10-2 illustrates the relationships between the cloud consumer and the cloud provider in the context of the three common service models: IaaS, PaaS, and SaaS.

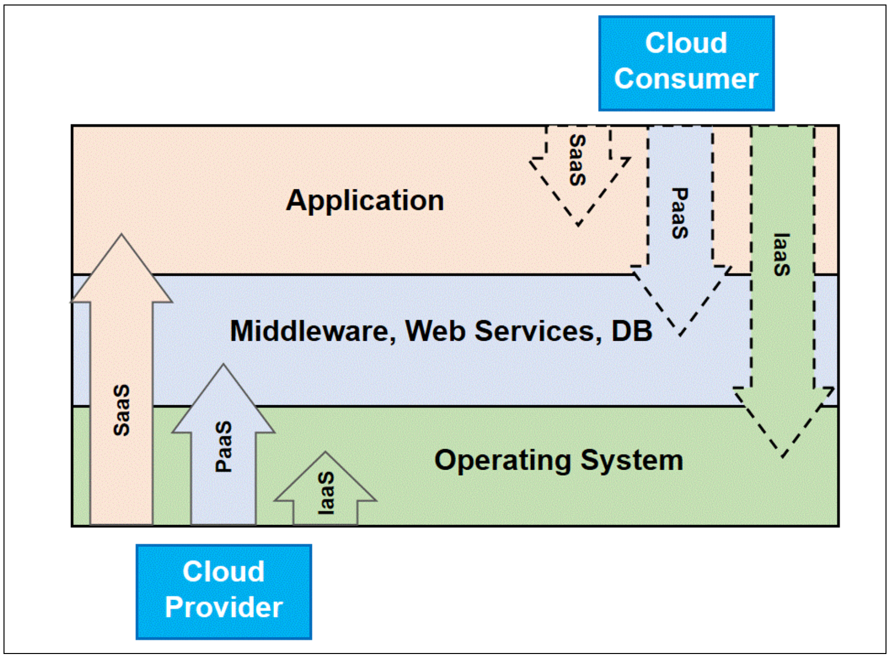


Figure 10-2 Provider and consumer views of cloud service models

Architecturally there is no difference at the infrastructure level between the various service models, the difference is only at the management software, provisioning mechanism, licensing, and other operational and procedural aspects that tend to be more complex in a PaaS model.

10.3 Platform-as-a-Service (PaaS)

From a service offering perspective, PaaS includes one additional layer on top of what the IaaS already includes and this layer usually includes a collection of tools that the cloud consumer can use to be more productive, usually in a test and development type of environment. As mentioned in the previous section, IaaS only provides access to the operating system (OS) over a virtual machine and in many cases the consumer of the service will need to spend precious time installing the common tools they need in order to start their work. Many cloud service providers therefore introduced the extra layer, and via the self service portal, consumers can select the software packages that will be automatically provisioned along with the OS as part of the environment.

It is common to see that PaaS offers a standard set of web services, integrated development environments (IDE), database, and application server. Figure 10-2 on page 138 illustrates how PaaS is a layer on top of the IaaS so the cloud provider has to build and maintain a more complex environment with more objects to be managed and included in its service catalog. The complexity is at the level of the infrastructure and also at the level of operations, including the back-end office, pricing and charge back models, licensing, and so on.

From an infrastructure perspective, a development type environment may need additional service such as backup or more bandwidth to allow testers to access early versions. If new features are being developed, there is also a risk of running into performance issues because the impact of the feature was unknown or because there is a need to perform certain stress testing.

The conclusion is that PaaS can be very complex, which is the reason why there are fewer cloud providers that offer this type of service. IBM System Storage N series is a flexible storage platform that can help service providers with their PaaS offerings. The snapshot technology and other data protection capabilities can save many lost hours in case of a bug or just a user error deleting important data. The ability to replicate data can be used also to copy data from a development environment to a production environment and from a public cloud to internal private cloud once the application is ready for deployment.

Another important feature of N series that can be very beneficial in PaaS models and be offered by the provider to the consumer is FlexClone. Consumers can quickly provision (as a self service) additional sets of the data to allow work in parallel by several individuals or to clone an existing data set to start new projects. FlexClone (covered in Chapter 8, “Storage” on page 101) increases productivity and has the least impact on changes in storage capacity consumed.

10.4 Cloud management and orchestration tools

This section provides an overview of the leading cloud management and orchestration tools by VMware, Microsoft, IBM, and OpenStack and some reference to the N series ability to integrate with these solutions.

10.4.1 VMware vCloud Automation Center (vCAC)

VMware vCloud Automation Center (vCAC) allows authorized users access to standardized IT services through a secure self-service portal, acting as a service governor and helping enforce business and IT policies throughout the service lifecycle. vCAC also provides a provisioning mechanism to help with the deployment of specific software packages with the VMs.

Overview of vCAC components

There are many components that make up a vCAC deployment. These are described next, to give you an understanding of why the architecture we have chosen has come about. It is also necessary to gain an understanding of what function the individual components perform in an overall deployment.

Figure 10-3 shows the vCAC components and how they are distributed in a logical architecture diagram.

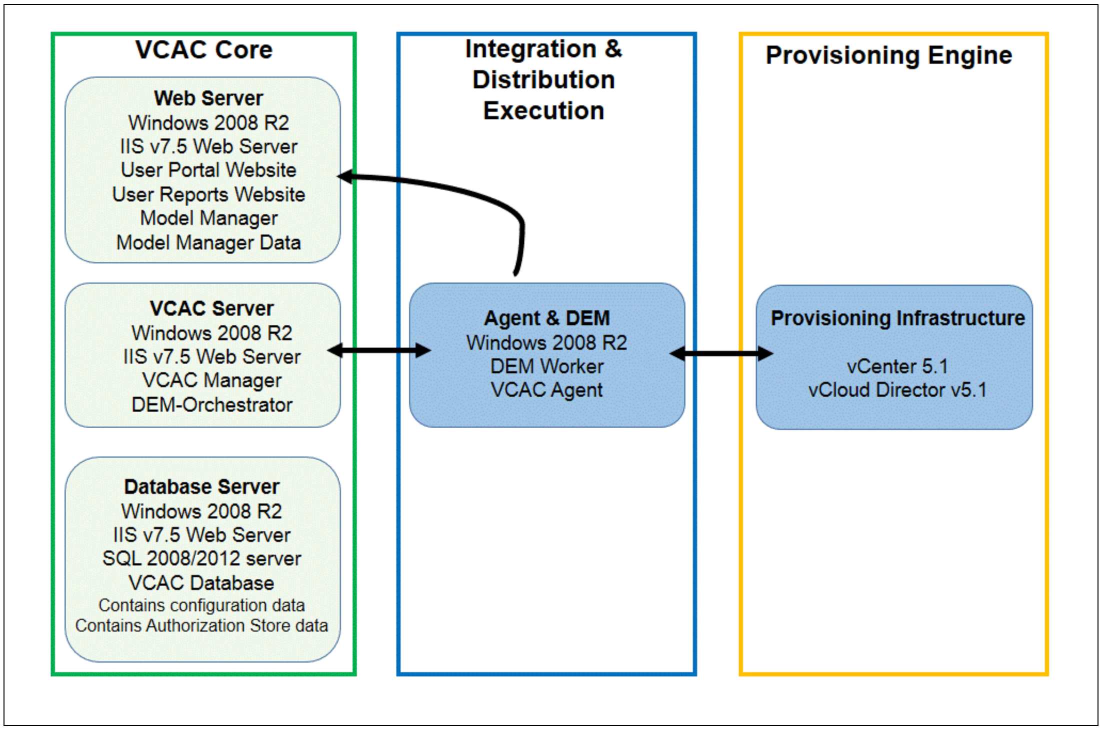


Figure 10-3 Components of VCAC

Features of vCAC

Following we describe some important vCAC features:

- Accelerated Application Deployment:

  Application release automation solution that also supports various other DevOps automation tools, abstracted from diverse infrastructure services.

- Automated Service Delivery:

  Automated lifecycle management of infrastructure and application services components by leveraging existing tools and processes.

- Intelligent resource management:

  Improve IT resource utilization by placement, prevention and reclamation of resources across all resources in the cloud, both physical and virtual.

- Policy Governance Engine:

  Policy driven workflow and mechanism to facilitate requests of IT resources by end-users.

- Unified IT Service Catalog:

  Comprehensive mechanism that empowers users to request and manage a variety of IT services in a simplified manner that seamless span multi-vendor, multi-cloud platforms.

- Flexible Automation Platform:

  Rapidly configure, adapt and extend our comprehensive, purpose-built functionality to meet unique IT and business needs.

- Anything-as-a-Service:

  Provide a flexible platform that allows IT to design and automate the delivery of application and IT services.

- Solutions Exchange:

  VMware Cloud Management Marketplace is the destination for real-world solutions from VMware and partners to automation your virtualized cloud infrastructure and applications.

10.4.2 Microsoft System Center 2012

System Center 2012 delivers unified management across all cloud services and deployment models. It is designed to support the processes and operating methods of a service provider as well as a small client environment that is self-managed. Its functionality also supports hybrid cloud scenarios with connectivity to Windows Azure or other public clouds, therefore a combination of multiple models. Microsoft positioned System Center as its Cloud OS and lists in its key features infrastructure provisioning, infrastructure and application monitoring, automation, self-service, and IT service management.

Capabilities of System Center

System Center as a suite of products includes the following capabilities: Infrastructure provisioning, monitoring, automation, self-service, application performance monitoring, and IT Service management. For storage integration with the server virtualization layer of Hyper-V, System Center is also involved in the management of the virtual machines and certain aspects of integration that enhance management capabilities, as described in Figure 10-4.

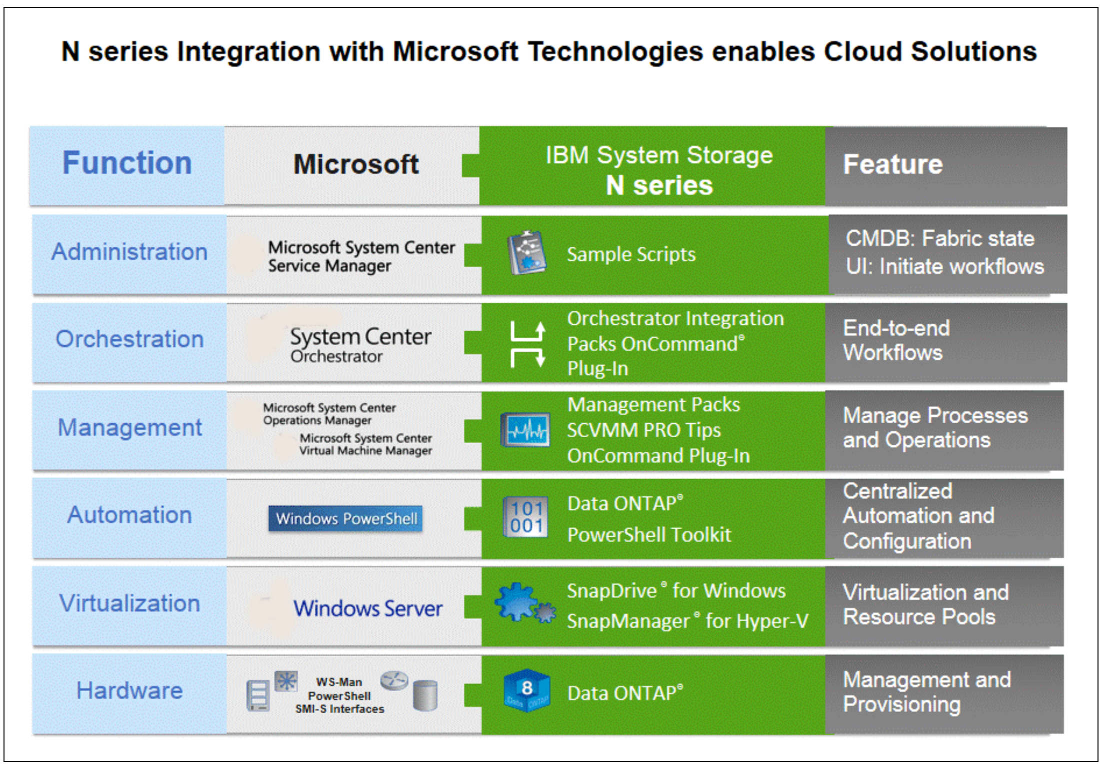


Figure 10-4 N series integration with System Center

10.4.3 IBM Service Delivery Manager (ISDM)

IBM Service Delivery Manager is a cloud management platform that enables the data center to accelerate the creation of service platforms for a wide spectrum of workload types with a high degree of integration, flexibility, and resource optimization with these core service management capabilities.

Features and benefits of ISDM

The list below includes the key features and benefits of the IBM Service Deliver Manager:

- Pre-configured service management software stack delivered via virtual images
- Secure User Centric Self-Service Portal, Automation Engine, and Catalog
- Automated provisioning and de-provisioning
- Integrated monitoring of physical and virtual cloud resources
- Metering, usage, and accounting
- Virtualization management
- Prepackaged workflow templates for key services

IBM Service Delivery Manager enables you to speed the deployment of private cloud solutions and greatly enhances time to value and maximum return on investments. Virtualization helps create a simplified, flexible IT environment that can save up to half of your valuable data center space while allowing you to more effectively use fewer resources.

This integrated service management software stack offers the following key features:

- Reduces the amount of integration work required to implement a cloud by offering a pre-bundled and integrated service management software stack, delivered as virtual images
- Reduces the risk associated with integration and accelerates a partner's ability to deliver private cloud computing capabilities to specific vertical markets
- Simplifies deployment and allows clients to leverage existing hardware while achieving both rapid time to value and strong return on investment
- Self-service portal interface for reservation of computer, storage, and networking resources, including virtualized resources
- Ability to track workflow status online
- Quickly provide services on demand, when you need them
- Automated provisioning and deprovisioning of resources
- Real-time monitoring of system environment
- Usage and accounting for customer billing
- Energy management to reduce costs
- Proven software technologies with embedded service management software included, providing IT managers visibility, control, and automation of service delivery infrastructure

ISDM is packaged and deployed as a set of four virtual machines, each of which includes certain software to enable the specific roles and functions. Figure 10-5 describes these systems.

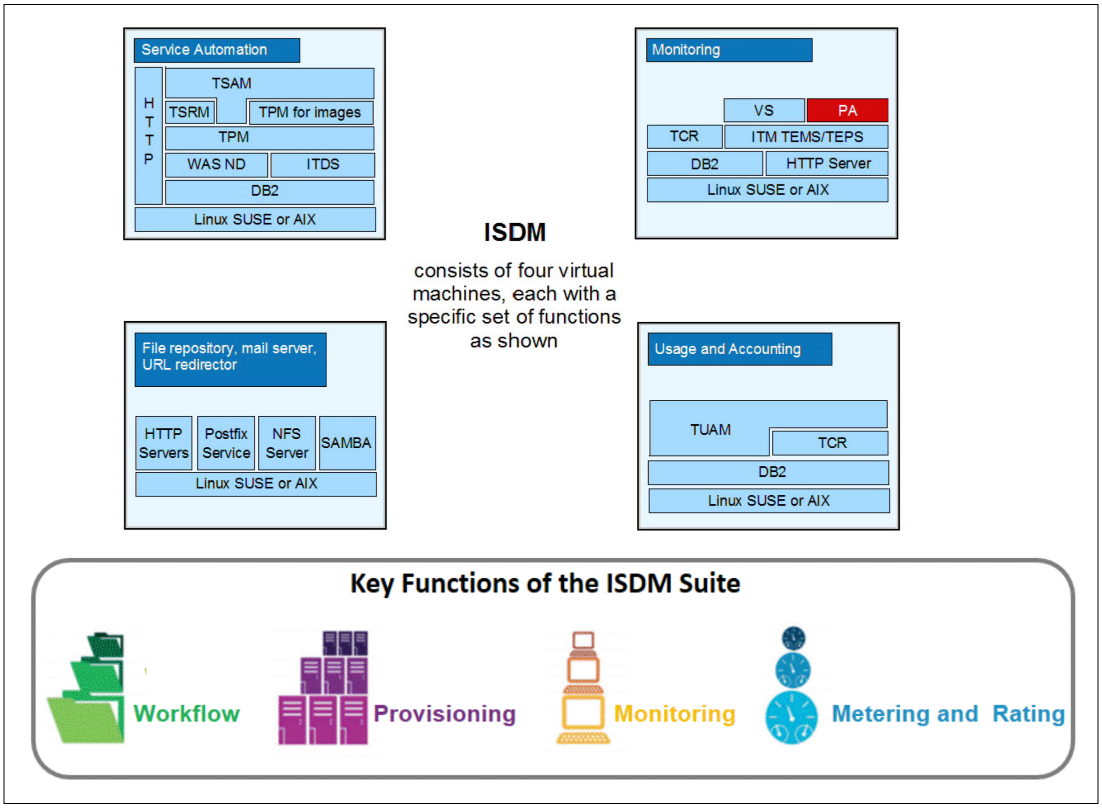


Figure 10-5 ISDM as a set of four VMs and its key functions

N series integration with ISDM

Some N series capabilities are supported as an “out-of-the-box” option in Tivoli® Service Automation Manager (TSAM), which is one of the main components of the ISDM suite.

10.4.4 IBM SmartCloud Orchestrator

IBM SmartCloud® Orchestrator provides an open and extensible cloud management platform for managing heterogeneous hybrid environments. IBM SmartCloud software integrates provisioning, metering, usage. and accounting as well as monitoring and capacity management of cloud services. IBM SmartCloud Orchestrator provides the following features and benefits:

- Standardization and automation of cloud services through a flexible orchestration engine and a self-service portal
- Reusable workload patterns to enable dynamic cloud service delivery
- Built on open standards, including OpenStack, for unparalleled interoperability

SmartCloud Orchestrator is built on open standards and leverages open technologies such as OpenStack to build an interoperable infrastructure foundation to provision workloads, provide multi-tenancy, and enable administration. It offers simple ways to create and manage services, thanks to its comprehensive interfaces and a solid underlying application engine and logic.

Figure 10-6 below shows the self-service portal of SmartCloud Orchestrator. Cloud admin can create a service catalog that will be shown to the users based on their access level.

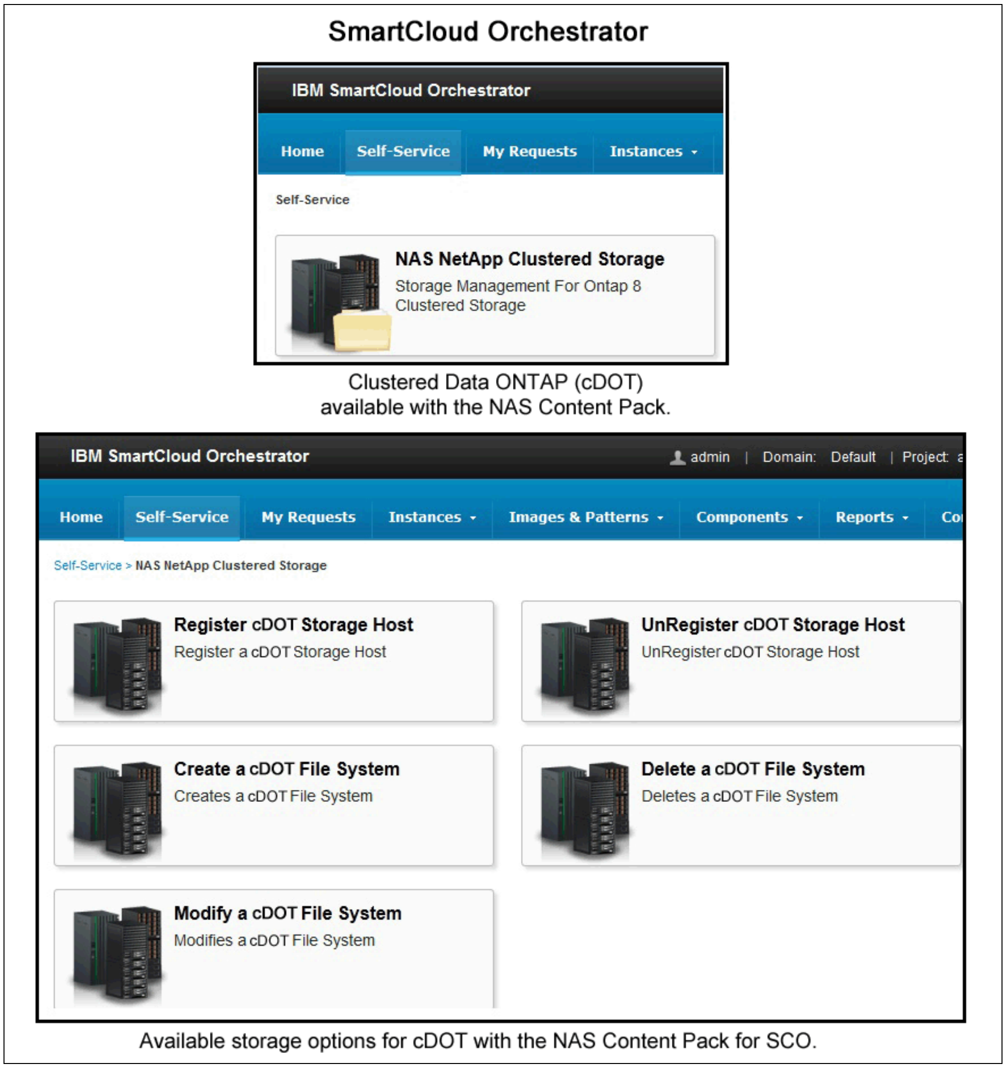


Figure 10-6 Self-service portal of SmartCloud Orchestrator

N series and SmartCloud Orchestrator

SmartCloud Orchestrator is one of the most flexible orchestrator tools in the sense that it offers many ways client can implement services, from creating workflows that triggers advances scripts or by leveraging a simple GUI where no programming is required for the common and built-in flows. It is also integrated with other cloud management elements that controls the inventory, monitoring, provisioning, and so on, so it has solid reach to the entire platform.

N series has a wide range of APIs options that are available to storage administrators. Together with cloud architects and business representatives, a simple workflow can be deployed that will include storage services as part of the catalog. APIs are available for the storage hardware as well as for other management tools such as the workflow automation and other OnCommand modules, SnapCreator, and VSC. Details about the APIs of N series are provided later on in this chapter.

Examples of services with storage options

Storage services can be a simple allocation of NAS based storage for file repository for a project. The workflow can be easily structured to request the service based on storage size and other attributes such as whether or not the data has to be protected and also the class of performance (leveraging different underlying storage models or disk types as well as QoS). Workflows can be set to archive the content after the project has been completed or to delete it and free the storage space that will immediately become available back at the shared pool.

10.4.5 OpenStack

OpenStack is a cloud operating system that is based on open source software and distributed under the Apache License and it is aimed at the level of IaaS models of cloud-based solutions.

IBM is the third contributor to the OpenStack projects with 250 developers. IBM has made its commitment to OpenStack, and Smartcloud Orchestrator is based on OpenStack.

The components of OpenStack

OpenStack is made of several well defined modules, each of which is also a project under the OpenStack open source development and involved communities. Each of the following main component is worked on as a project within the OpenStack community:

- Compute: OpenStack has multiple use cases, including Big Data solutions such as Hadoop and High Performance Computing (HPC). The use cases that are aligned with the context of this book are to cloud-based services for organizations and IaaS for service providers. The compute resources are accessible via APIs which offers flexibility to design the desired models of cloud-based services.
- Networking: Also API-driven and beyond the basic standard networking (DHCP, VLANs, and so on) capabilities it is extended to security aspects such as firewalls, intrusion detection systems ((IDS) and so on. It can be used for multi-tenancy settings by leveraging other software-defined networking OpenFlow.
- Storage: There are N series drivers for OpenStack, these drivers were developed by NetApp that is also contributing member in the OpenStack community.

  The drivers allow the provisioning of Clustered Data ONTAP storage through OpenStack Block storage. In addition, it enables the use of NFS for mounting individual hypervisors and files are in turn provided as virtual block devices to the hypervisor.

A sample of OpenStack using Data ONTAP Storage provisioning flow is shown in Figure 10-7.

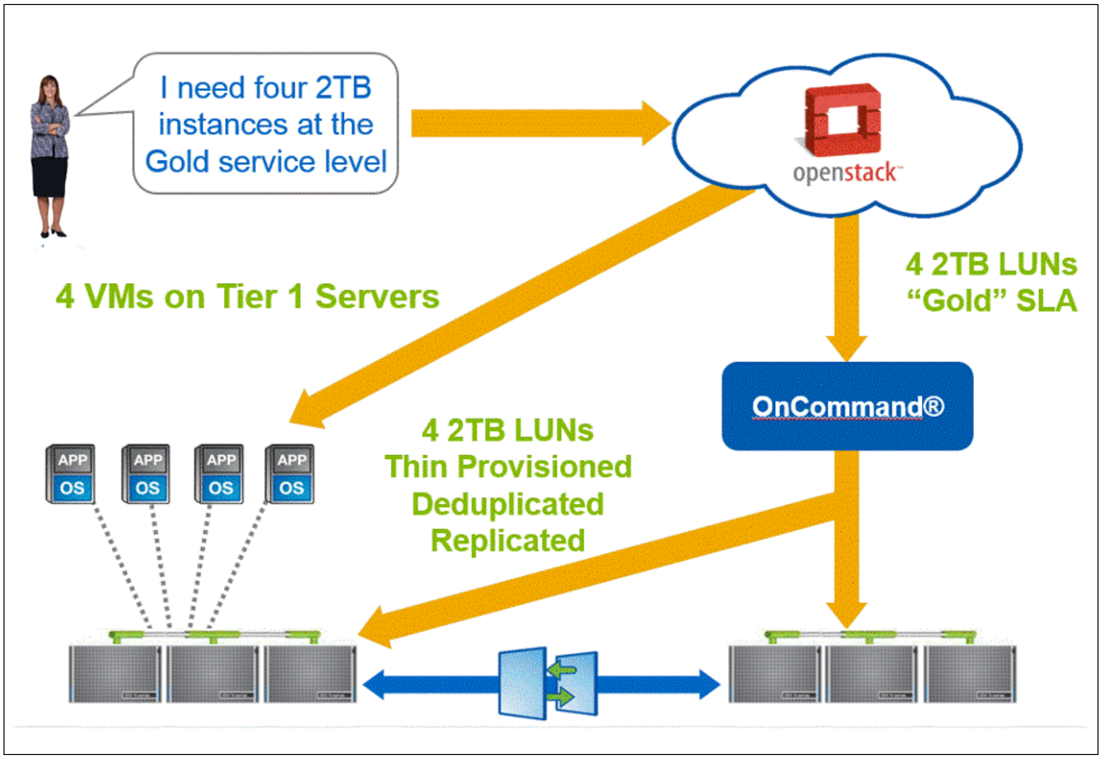


Figure 10-7 OpenStack - Data ONTAP Storage provisioning flow

Part 2

Deployment

This part of the book describes the deployment of a RAVE infrastructure.

In this part of the book, we provide information about the following topics:

- Data protection and disaster recovery
- Easy-step setup guide

11

Data protection and disaster recovery

This chapter provides brief information about various use cases associated with data protection and disaster recovery for solutions that include IBM System Storage N series.

The following topics are covered:

- Introduction
- Approach and considerations
- Common use cases

11.1 Introduction

This chapter focuses on use cases that benefit from cloud services and for simplification it focuses only on the storage system. The term *data protection* is used here plainly in its broadest meaning and not just as a backup and restore solution. So, although brief, this section covers backup and restore, data replication for disaster recovery and business continuity, high availability and redundancy, and security measures and capabilities in terms of access, roles, data encryption, and other similar aspects.

11.2 Approach and considerations

The IBM System Storage N series product line is replete with features that improve availability, performance, and data protection. Most of the features and capabilities were discussed in previous chapters and are not repeated in this section, other than listing them as a quick reference and classifying them according to their main functions. The approach taken in this section of the book is to leverage terminologies, features, and capabilities that were introduced earlier and explain how they can be used in the context of a real environment based on a common set of use cases that are typical for the topic of data protection.

11.2.1 List of data protection features

As mentioned, N series offers a comprehensive set of features to address data protection requirements. In this section, as a quick reference, we list all of the features and capabilities that take part in protecting the data, its availability, and its usability.

Backup and restore

The following features are included here:

- Snap Manager products
- Snap Creator
- SnapVault
- Snapshot
- NDMP
- Variations when the listed features integrate with other software

High availability and redundancy: Hardware

The following features are included here:

- RAID DP
- Spare disks
- Clustered Data ONTAP: Multiple nodes, interconnect switch
- HA pairs
- Networking redundancy: Multiple cards / ports
- Redundancy in physical connectivities
- SDK and APIs: Integration with other tools

Disaster recovery and business continuity: Off site assumed

The following features are included here:

- SnapMirror
- SDK and APIs: Integration with other tools

Enabling higher data availability and usability

The following features are included here:

- Clustered Data ONTAP non-disruptive operation, Data Motion
- LIFs
- SVM
- QoS
- OnCommand Unified - reporting, analysis and monitoring
- OnCommand Workflow Automation
- SNMP
- Unified architecture

Security

The following features are included here:

- Disk encryption
- SVM
- LIFs
- RBAC - storage HW and SW modules

11.3 Common use cases

This section provides a brief overview of the common use cases.

11.3.1 Site or storage failover

In case of a site failure, SnapMirror is the feature that “ships” data from one site to another. SnapMirror can be scheduled and the data replication can take place between similar versions of the Data ONTAP regardless of the actual N series hardware. This is a direct benefit of the unified architecture, which leads to tremendous flexibility when designing and preparing for disaster recovery.

With multiple sites, business functions along with IT can design the data layout in the storage, in a way that data replication can occur automatically and at various levels of granularity. Not all data has to be replicated, and not all the replicated data has to be replicated to the same destination.

In the context of cloud, data replication can be integrated with the servers’ operations and into logic and flow of orchestration tools.

Often, small companies cannot afford to have another site for disaster recovery, in some cases, even a second storage is too expensive. A simple solution can be implemented by classifying the data and organizing it in the storage according to business priority. Replication can occur on a very small subset of the data and the destination can be a service offering from one of the cloud providers.

For cloud providers, N series offers great flexibility for various business and operational models around data protection. In the context of disaster recovery, N series supports data replication from multiple nodes and storage clusters, into a single cluster (different volumes and/or SVMs). By designing the storage carefully, one storage cluster can be the destination to many data replication session; each session is isolated and the data sets can be completely segregated from one another.

Upon the restoration of the site or the storage cluster, data replication can be reversed.

11.3.2 Single node failure

This use case is probably the first one that most IT teams are preparing for, hardware redundancy. The N series can be configured with two nodes that together act as one storage entity, which is called an HA pair. HA configurations. are discussed in great detail in Chapter 2, “Architecture and design” on page 7, Chapter 3, “Introduction to Clustered Data ONTAP 8.2” on page 23, and Chapter 8, “Storage” on page 101.

Remember that if one node fails, the second node needs to serve the entire amount of data and the required IOPS. Chapter 3, “Introduction to Clustered Data ONTAP 8.2” on page 23 and Appendix A, “N series Clustered Data ONTAP 8.2 sizing considerations” on page 179 provide details on options that can help IT teams increase the utilization yet keep the risk low, by leveraging the capabilities of Clustered Data ONTAP with multiple nodes. This includes DataMotion as a key feature that enables “always on” capabilities and, also very important, the proper configuration of the QoS feature.

12

Easy-step setup guide

This chapter is an easy-step setup guide that provides quick basic instructions for integrating the N series storage system with the virtualized server environments from VMware and Microsoft to enable the storage layer of the infrastructure.

The following topics are covered:

- Preparation
- N series management tools
- Integration with VMware
- Integration with Microsoft Hyper-V

12.1 Preparation

The easy-step setup guide only covers the integration of the N series storage system with the hypervisors and the storage management tools. This approach is based on the premise that all hardware and software components are already installed and the end-to-end infrastructure is ready for the actual integration with the storage. It also assumes that networking, security, and other common elements were also already configured according to preferred practices. Reference to installation documents of the N series storage, servers, hypervisors, and the various other software components is provided at the end of this chapter.

12.1.1 Intended audience

This easy-step setup guide is intended for storage administrators, professional service engineers, and IT delivery specialists, as well as other IT professionals who have several years of experience and are familiar with common tasks of setting up, connecting to, supporting, and maintaining key elements of IT infrastructures. Considering IT professionals as the audience for this section, the authors of this book did not cover each and every step in the integration process, and common steps that are obvious were excluded, so this chapter is not a typical step-by-step guide.

12.1.2 Preferred practices

This setup guide contains screen captures of suggested versions of the software packages that were used in the lab environment during the period of writing this book. While the general flow and sequence of the steps may remain similar in the future, when newer versions of the software packages are released, it is likely that the current provided screen captures will be less useful. IT professionals should rely on their own discretion regarding when to follow the instructions step-by-step, as-is, or when to skip certain steps and just stay on course with the general flow, while making the necessary modifications required for newer versions of the software modules.

Prior to starting the integration, users should check with each vendor that the versions of the hardware and software they are intending to use are compatible and supported. Users should also understand the prerequisites described in this section, and validate that all the components are available, accessible, and are functioning properly.

The listed IP addresses, host name, and other network settings used throughout the setup guide are unique to the lab environment that was used for creating this section of the book, and are being provided for context and reference. It is preferred practice to prepare checklists for the configurations and worksheet to capture relevant details such as network settings, cabling information, and so on. The authors also advise that this section of the book needs to be reviewed once prior to following the actual steps of the integration. Doing this will help with the preparation, because it is likely that the actual environment will be slightly different than the one depicted in this section.

Important: Certain collaboration between members in IT teams is often required when working on integration projects. The authors of this book strongly advise to approach this effort as a project, with careful and thorough planning, proper communication between the involved parties, including business stakeholders, to use test environment prior to deploying in a production environment, and to follow change management protocols where applicable.

12.1.3 Prerequisites

Since this setup guide focuses on the integration aspects of the storage with other infrastructure components, including storage management tools, all other non-storage components have to be installed and be functioning properly.

Storage

The N series storage system requires a two-node Clustered Data ONTAP version 8.2.x. The appropriate protocol license has to be installed. In this guide, *NFS* is used for the integration with VMware and *SMB/CIFS* is used for the integration with Microsoft Hyper-V.

> **Note:** Since all steps described in this setup guide are applicable to all the N series storage models running Clustered Data ONTAP 8.2.x, there is no reference to a specific N series model.

The following N series storage features are preferred:

- *SnapVault* and *SnapMirror* for data protection and replication
- *FlexClone* for thin provisioning of VMs based on the cloning capabilities of the storage
- *Deduplication* for eliminating duplicated data and reducing storage consumption

Note that these storage features are not required for the steps described in this guide, but are commonly used in most production and test environments, hence they are mentioned.

Storage management tools are critical for successful operation. This guide includes references to these two required storage management tools:

- System Manager 3.0
- OnCommand Unified Manager (OCUM) 6.1

Both System Manager and OCUM are installed on the same VM.

There are more storage prerequisites that are unique either to the Microsoft or to the VMware environments, which will be mentioned in the respective sections.

VMware environment

Table 12-1 lists the different servers and storage entities that are part of the VMware environment for the storage integration, as used in the lab environment.

Table 12-1 Key server and storage elements in the VMware environment

Host	Software / storage components	Role / function
vcenter5GA-1	Windows 2008 R2, vCenter 5.0, vSphere Client 5.0, VSC 4.2.1	VMware management platform, vSphere client, N series storage plug-in for vCenter
OC-CORE	Windows 2008 R2, OnCommand Unified Manager (OCUM) 6.1, System Manager 3.0	Storage management tools
DC	Windows 2008 R2	Domain Controller for ibmdemo.local
svm-nfs-vmware1	ESXi 5.1	Main Hypervisor
cluster1	Main two-node storage cluster	Cluster management
cluster1-01	cluster 1, node 1	Management LIF
cluster1-02	cluster 1, node 2	Management LIF
cluster2	2nd two-node storage cluster	cluster management
cluster2-01	cluster 2, node 1	Management LIF
cluster2-02	cluster 2, node 2	Management LIF

Important: The list in Table 12-1only includes the essential components of the environment that are required for the storage integration. Servers and storage components for applications, data, non-storage management tools, security, and other elements are not listed.

Figure 12-1 provides an architectural diagram of the N series storage as part of the VMware environment.

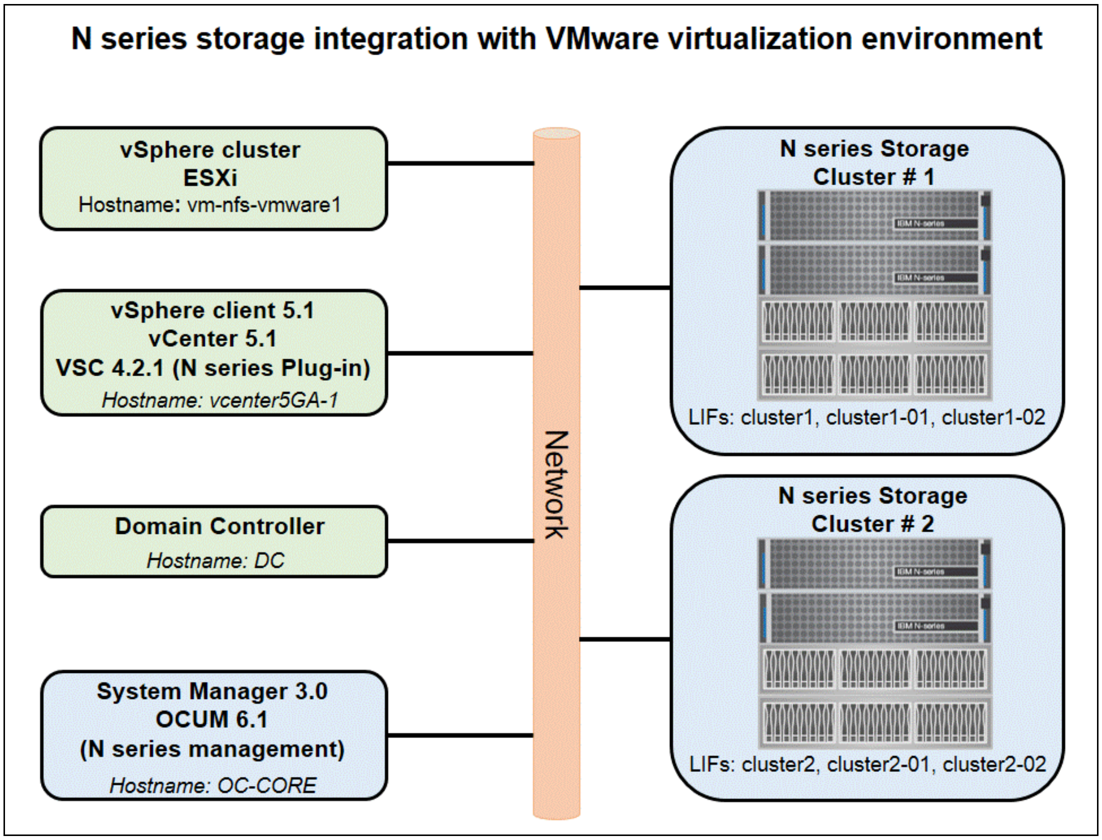


Figure 12-1 VMware server virtualization with N series storage

Microsoft environment

Table 12-2 lists the different servers and storage entities that are part of the Microsoft environment for the storage integration.

Table 12-2 Key server and storage elements in the Microsoft environment

Host name	Operating system / software	Role / function
Hyperv1	Windows 2012 - 64bit	Hyper-V cluster node 1
Hyperv2	Windows 2012 - 64bit	Hyper-V cluster node 2
DC	Windows 2008 R2	Domain Controller for demo.com
SCVMM	Windows 2012 - 64bit	System Center Virtual Machine Manager
SCOM	Windows 2012 - 64bit	System Center Operations Manager
SMIS	Windows 2012 - 64bit	SMIS and PowerShell (storage integration)
OC-CORE	Windows 2008 R2, OCUM 6.1, System Manager Windows 3.0	Storage management
cluster1	Four-node N series cluster	Storage cluster management
cluster1-01	N series storage node # 1	Node 1, management LIF
cluster1-02	N series storage node # 2	Node 2, management LIF
cluster1-03	N series storage node # 3	Node 3, management LIF
cluster1-04	N series storage node # 4	Node 4, management LIF

Important: The list in Table 12-2 only includes the essential components of the environment that are required for the storage integration. Servers and storage components for applications, data, non-storage management tools, security, and other elements are not listed.

Figure 12-2 provides architectural diagram of the N series storage as part of the Microsoft environment.

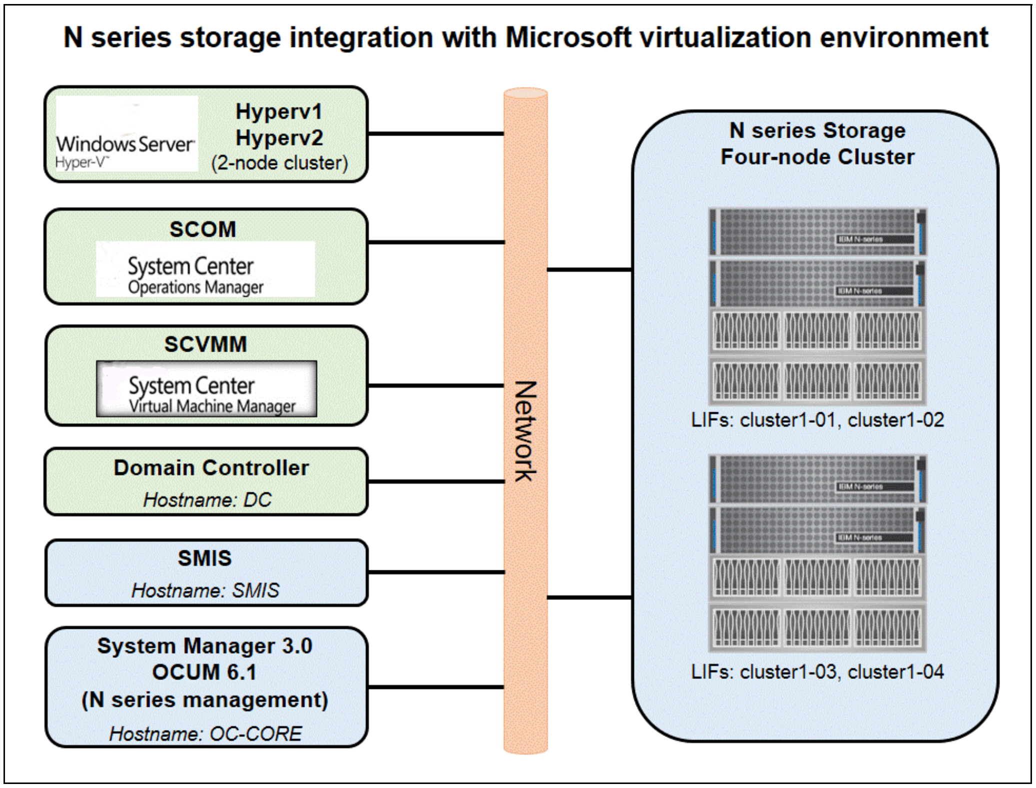


Figure 12-2 Microsoft virtualization environment with N series storage

12.2 N series management tools

This section provides instructions on how to add the N series storage unit to the System Manager and OnCommand Unified Manager (OCUM).

12.2.1 System Manager

System Manager 3.0 for Windows is used in this guide. In its latest version, System Manager is referred to as *OnCommand System Manager* and is becoming part of the OnCommand suite. As with the other various components, it is assumed that System Manager is already installed.

The N series storage needs to be added by providing a hostname or IP address. The process requires the storage credentials in order to establish the connection. Figure 12-3 includes the two steps of adding a new storage to be managed by System Manager.

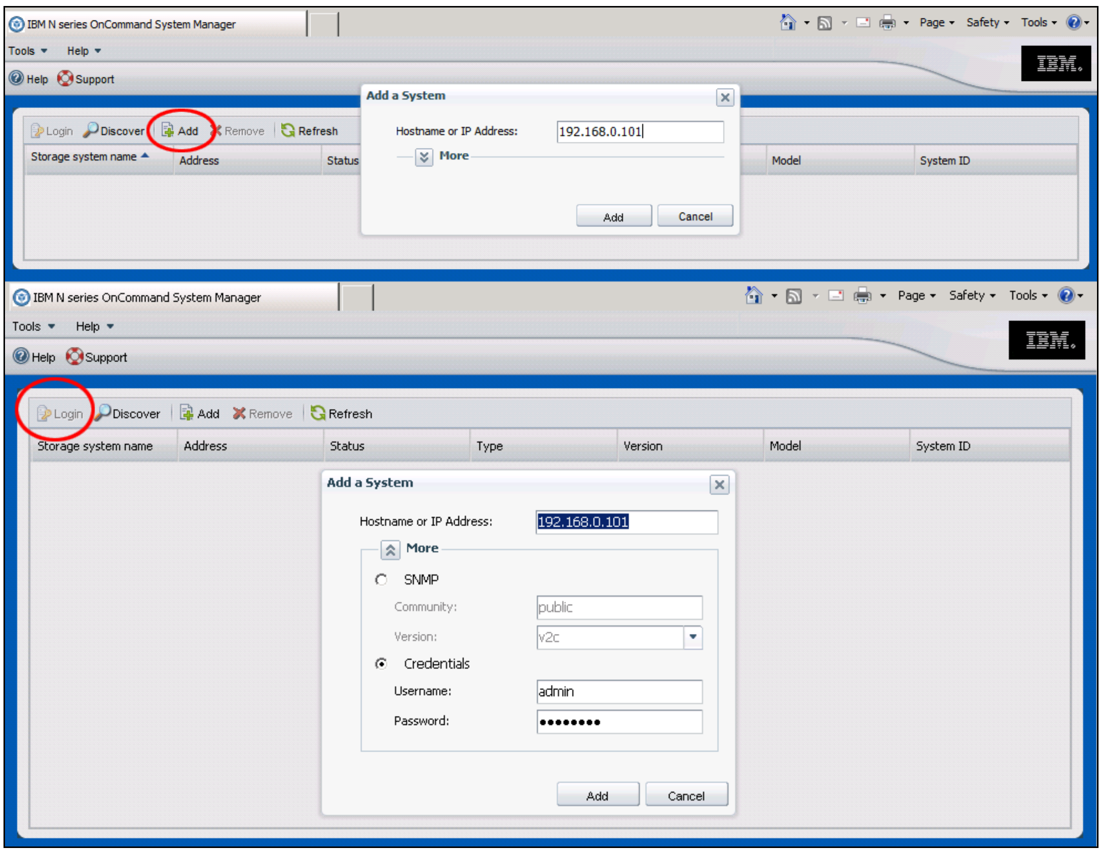


Figure 12-3 Adding N series storage to System Manager 3.0

After System Manager establishes the connection, it will list the storage unit with its essential information. Managing the listed storage entities requires an additional login, which then brings up the dashboard window as illustrated in Figure 12-4. The dashboard shown in this figure provides high level information about the storage, and includes alerts, alarms, and basic utilization information. The left side of the dashboard window provides access to specific management tasks.

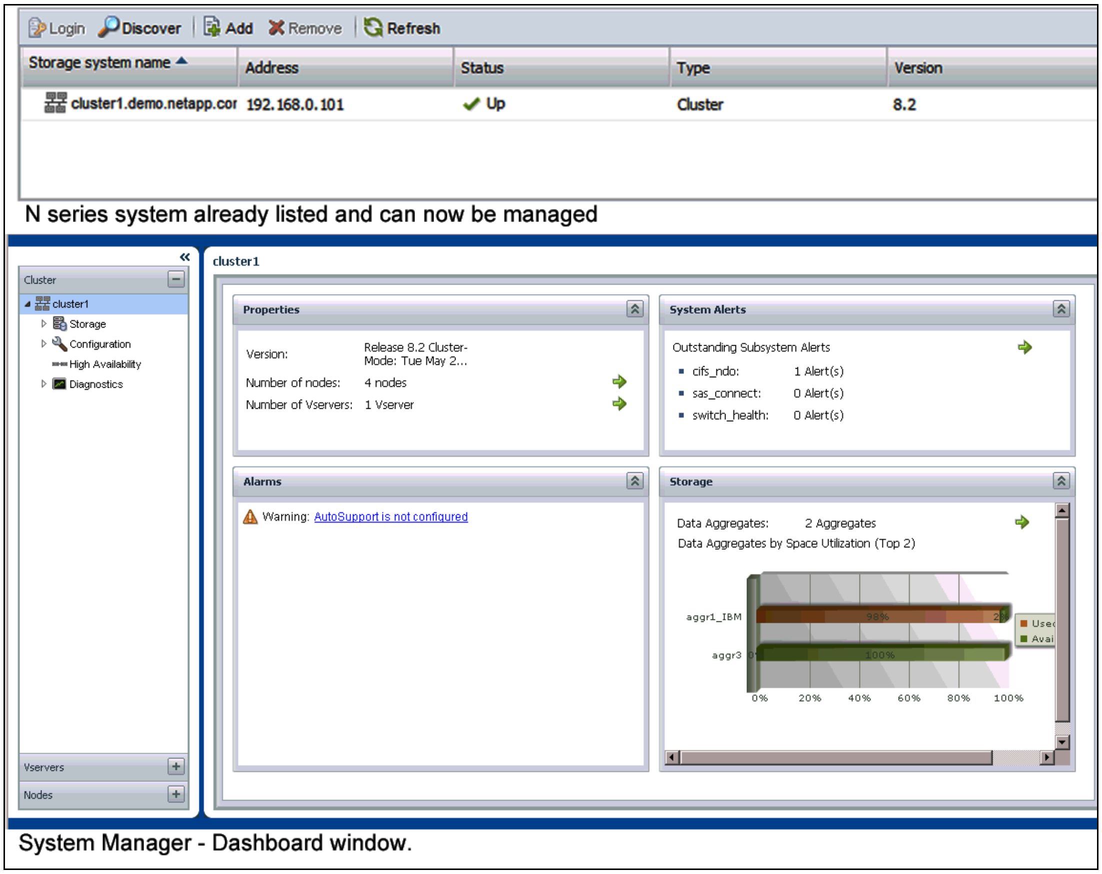


Figure 12-4 Storage added and can be managed

12.2.2 OnCommand Unified Manager (OCUM)

This section provides instructions on how to add the N series storage to the OnCommand Unified Manager (OCUM), which in our case is running on the same host as the System Manager on a Windows 2008 R2 OS.

In previous versions, OCUM was named *OnCommand Core, Operations Manager*, or *DFM* (Manager). Despite the fact that some of the provided screen captures look similar to previous versions of the product, only OCUM version 6.1 and higher supports N series with the Clustered Data ONTAP operating system.

The lab setting in this guide requires access via http port 8080, and login is required with an account that has admin privileges on the host where OCUM is installed (OC-CORE as indicated in Figure 12-1 on page 157 or Figure 12-2 on page 159).

Connecting to OCUM and adding the N series storage

As shown in Figure 12-5, we point the browser to: `http://oc-core.demo.ibm.com:8080` to access the OnCommand Console.

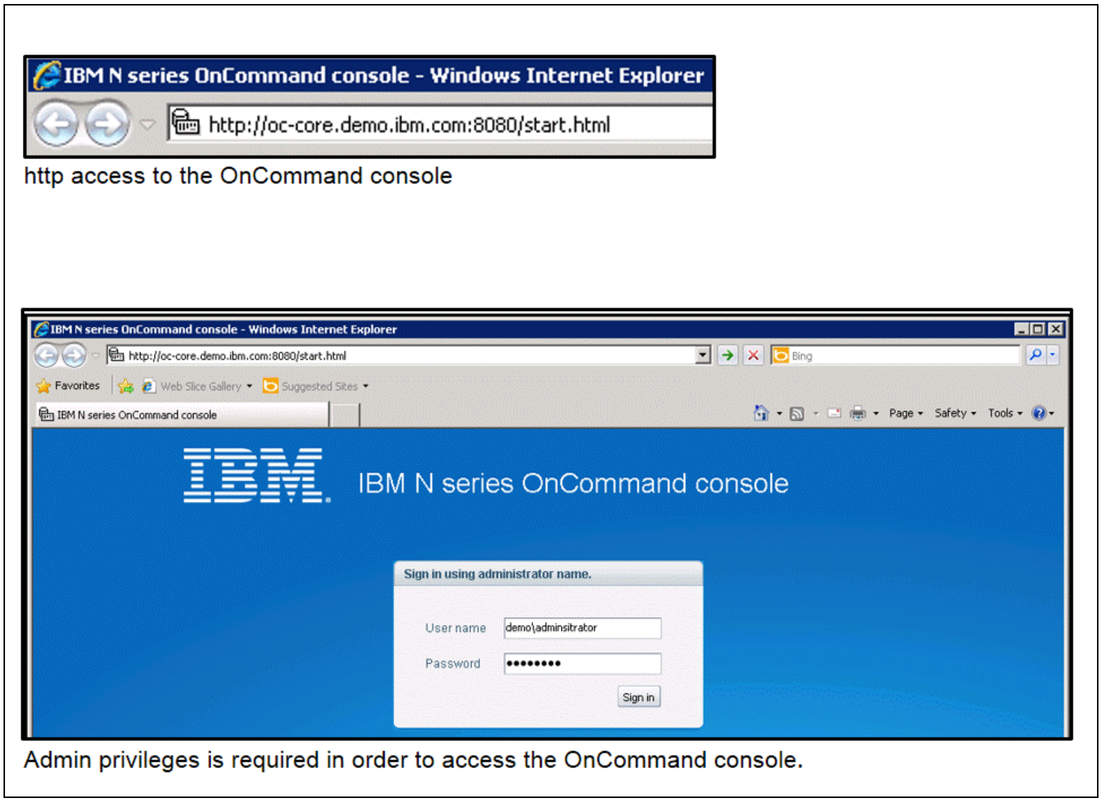


Figure 12-5 Accessing OCUM

Next we add the N series storage, which is done in the **Storage** tab (Figure 12-6).

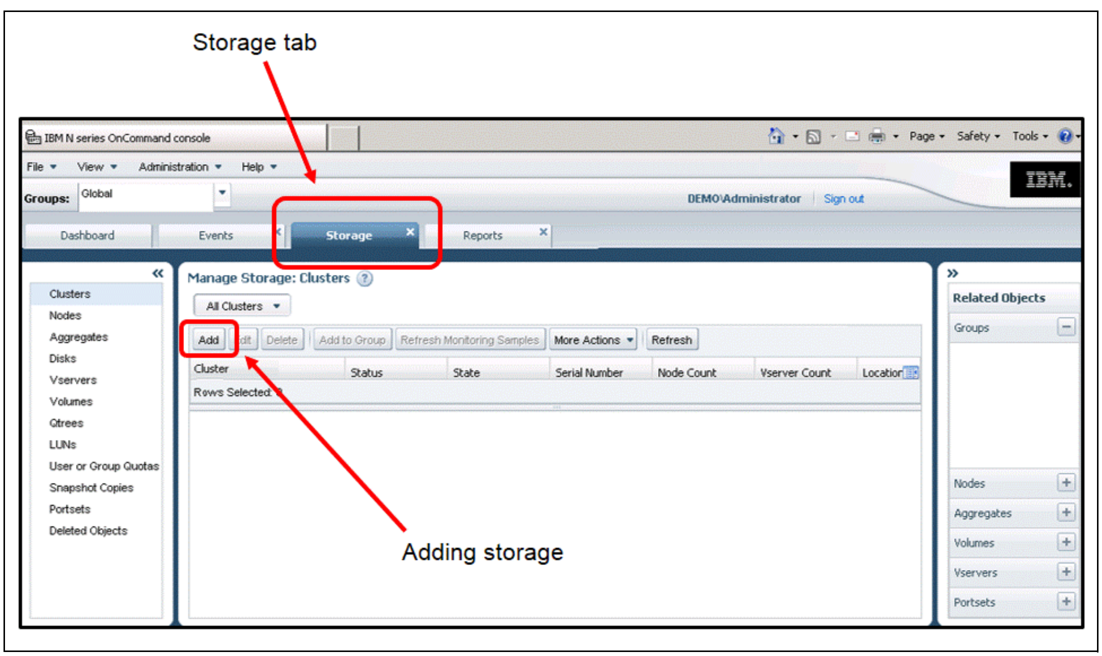


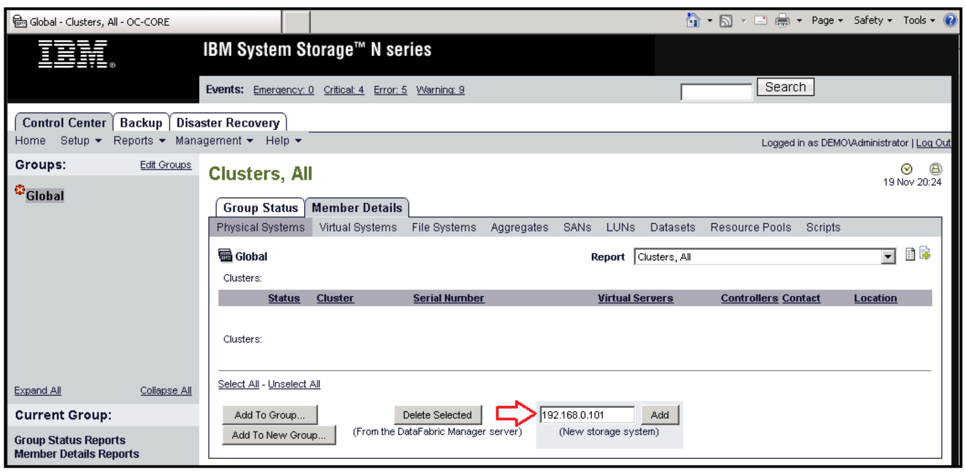
Figure 12-6 Adding the N series cluster to OCUM

The process requires the hostname or IP address of the N series system. The storage in the lab environment has the IP address: `192.168.0.101`. Adding the unit will bring up the OnCommand Operations Manager interface, which is a module that operates now within OCUM and is responsible for some of the functionality.

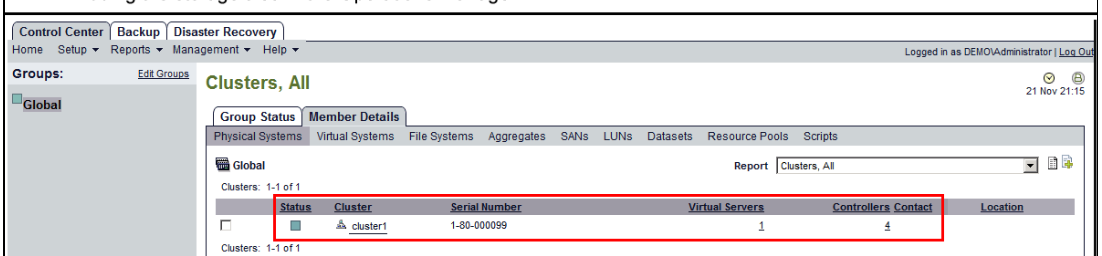
The required steps are as follows:

1. Enter the IP address or hostname of the N series in the (New storage system) box and click Add
2. This will bring up the OnCommand Operations Manager
3. Enter the IP address or hostname of the N series and add it.
4. Verify that the cluster storage was added successfully.

Figure 12-7 illustrates the steps mentioned before, for adding the N series via the Operations Manager interface.



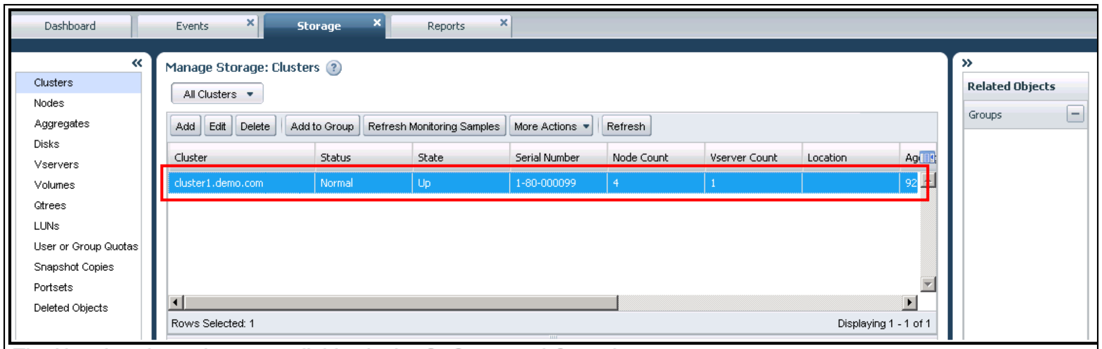
Adding the storage also in the Operations Manager.



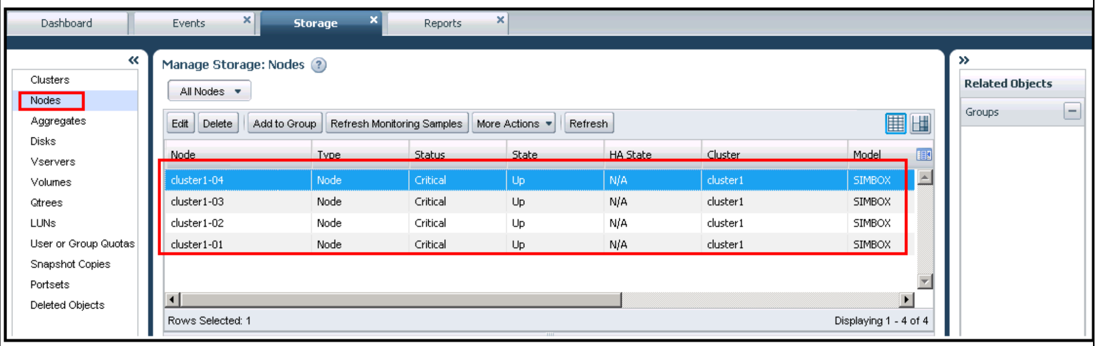
Storage is now listed and indicating 4 nodes.

Figure 12-7 Adding the N series storage in Operations Manager

Now the storage cluster is available also in the OnCommand console and is ready to be managed. This is indicated in Figure 12-8.



The N series cluster is now available via the OnCommand Console.



Information about the cluster’s nodes is available by selecting ***Nodes*** at the left section of the ***Storage*** tab.

Figure 12-8 The N series storage cluster (4 nodes) can now be managed from the console

OCUM: Dashboard

Now that the storage is available and can be managed, we can look at the Dashboard tab for a quick view of the storage status, as shown in Figure 12-9.

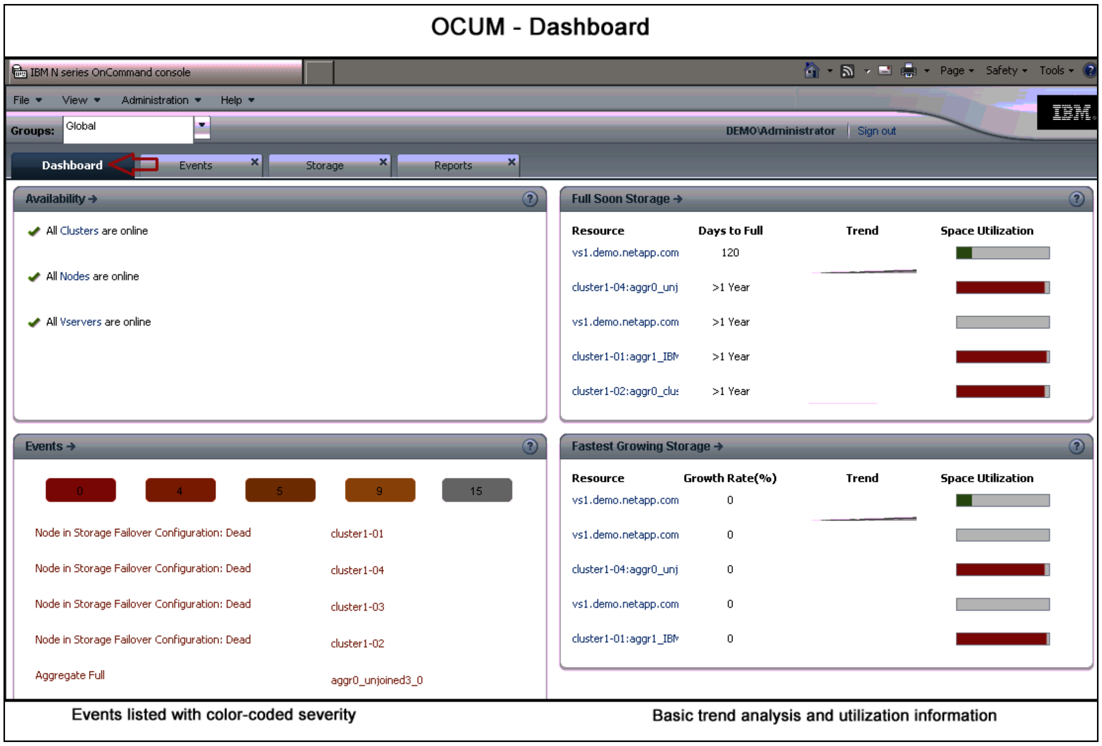


Figure 12-9 OCUM - Dashboard

12.3 Integration with VMware

This section provides instructions on how to integrate the N series storage with the VMware management components.

12.3.1 Creating Storage Virtual Machine (SVM) with NFS file sharing

SVMs are managed by the vServer command. For simplicity and consistency, we will refer to the SVM as vServer in this section.

Our objective is to create an NFS datastore that will be used for virtual machines. Prior to creating the NFS volume, we will need to create a vServer that will contain the NFS volume. Here we list the steps and the exact commands (to be run from a console):

1. Create a vServer:

```
vserver create -vserver vs1 -rootvolume vs_nfs -aggregate aggr1_nfs
-rootvolume-security-style unix -ns-switch file -nm-switch file
```

2. Create an NFS configuration for the vServer:

```
vserver nfs create -vserver vs1
```

3. Create a logical interface (LIF) for the vServer:

```
network interface create -vserver vs1 -lif vs_nfs_data -role data
-data-protocol nfs -home-node cluster1-01 -home-port a0a -address 10.1.3.100
-netmask 255.255.255.0
```

4. Create a route to the vServer's NFS IP:

```
network routing-groups route create -server vs_nfs -routing-group d10.1.3.0/24
-gateway 10.1.3.5
```

5. Create an "all open" export policy for the vServer:

```
vserver export-policy rule create -vserver vs1 -policyname default -clientmatch
0.0.0.0/0 -rorule any -rwrule any -anon 0 -superuser any -ruleindex 1
```

6. Allow the NFS protocol for the vServer:

```
vserver modify -vserver vs1 -allowed-protocols nfs
```

7. Create a volume attached to the vServer:

```
vol create -vserver vs1 -volume nfsvol1 -aggregate aggr1_nfs -size 50GB -policy
default -unix-permissions 777
```

8. Mount the volume to a junction path:

```
volume mount -volume nfsvol1 -vserver vs1 -junction-path /nfsvol1
```

9. Assign the export policy to the vServer root volume:

```
volume modify -vserver vs1 -policy default -volume vs_nfs
```

It will be useful to capture the important parameters and add them to our worksheet:

- The name of the Storage Virtual Machine (SVM), also referred to as vServer, is: **vs1**
- The operation was done on storage node **cluster1-01** with **IP Address 10.1.3.100**
- Export policy "all open" is not preferred practice and proper policy based on the current topology and the components of the infrastructure will be required. For example, the ESXi server needs to have access to the storage.
- The NFS volume created is named: **nfsvol1** and is in aggregate: **aggr1**
- The volume size created is: **50GB**

12.3.2 Creating NFS type datastore

In this section, we will add the NFS volume we created in 12.3.1, "Creating Storage Virtual Machine (SVM) with NFS file sharing" on page 165 (nfsvol1) as a NFS type datastore:

1. The first step is to connect with the vSphere client to the desired host.
2. In the Configuration tab, select the Storage from the left Hardware tab.
3. Click **Add Storage** and follow the steps presented by the wizard to add "Network File System" type storage.
4. The required parameters used in our example are as follows:
   a. Server IP: 10.1.3.100 (this is node 1 of the storage cluster cluster1-01)
   b. Folder: /nfsvol1 (this is the NFS volume we have created in section 12.3.1
   c. Datastore Name: NFSVOL1 (to keep simple logical mapping between the datastore that we are about to create and the name of the volume we have already created).

The foregoing steps are depicted in Figure 12-10.

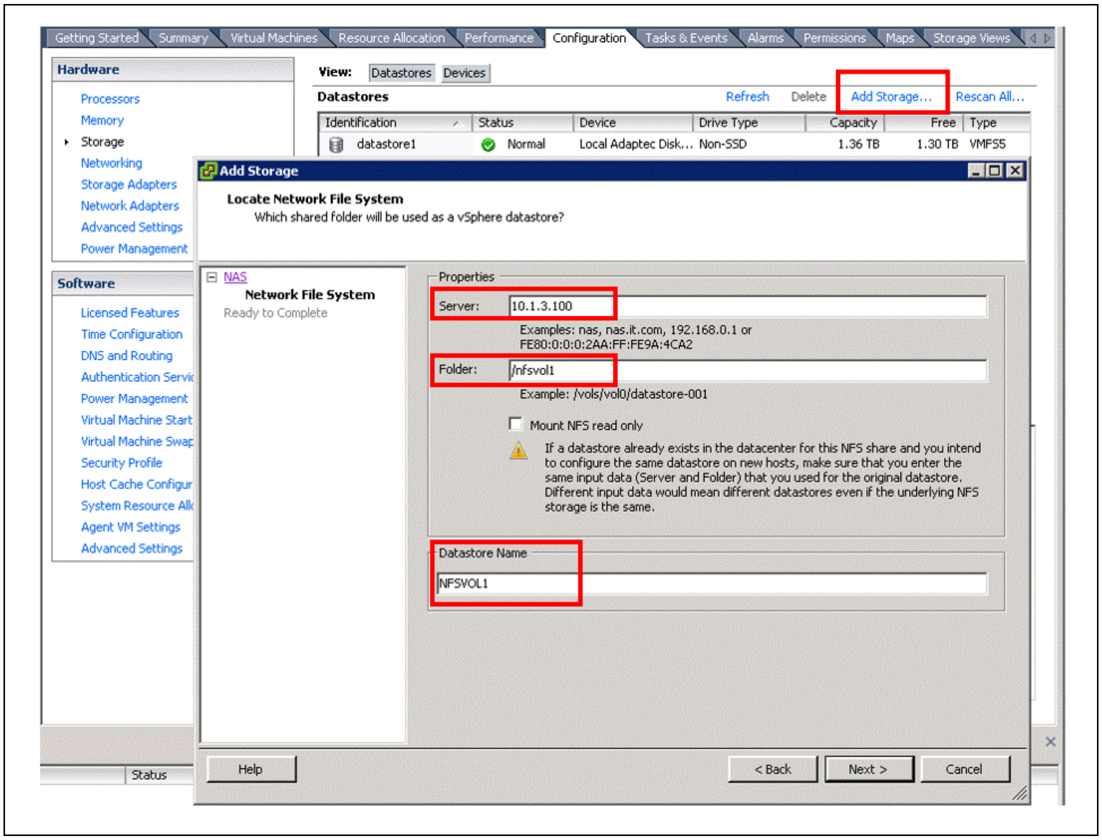


Figure 12-10 Adding NFS type datastore

When the storage has been added, it will be listed as indicated in Figure 12-11.

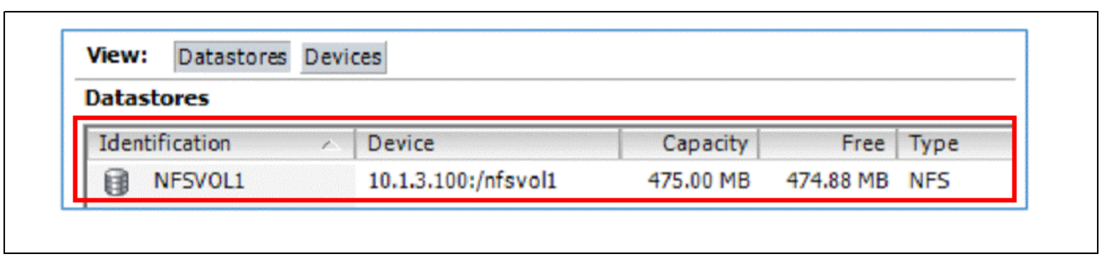


Figure 12-11 NFS datastore added

12.3.3 Virtual Storage Console for VMware (VSC)

Chapter 4, “VMware vSphere integration” on page 41 covers the theoretical part of integrating the N series Clustered Data ONTAP storage with VMware. It includes details about VSC. This section provides a quick overview of the benefits and capabilities of using VSC.

Introduction to SVC

Virtual Storage Console for VMware vSphere software is a single vCenter Server plug-in that provides end-to-end virtual machine lifecycle management for VMware environments with ONTAP storage.

The plug-in provides the following functions:

- Storage configuration and monitoring using the Monitoring and Host Configuration capability
- Datastore provisioning and virtual machine (VM) cloning using the Provisioning and Cloning capability
- Online alignments and single and group migrations of VMs into new or existing datastores using the Optimization and Migration capability
- Backup and recovery of VMs and datastores using the Backup and Recovery capability

As a vCenter Server plug-in, VSC for VMware vSphere is available to all vSphere Clients that connect to the vCenter Server. Unlike a client-side plug-in that must be installed on every vSphere Client, you install the VSC for VMware vSphere software on a Windows server in your data center.

Figure 12-12 provides a reference to where and how the VSC plugs into the VMware management framework under *Solutions and Applications*.

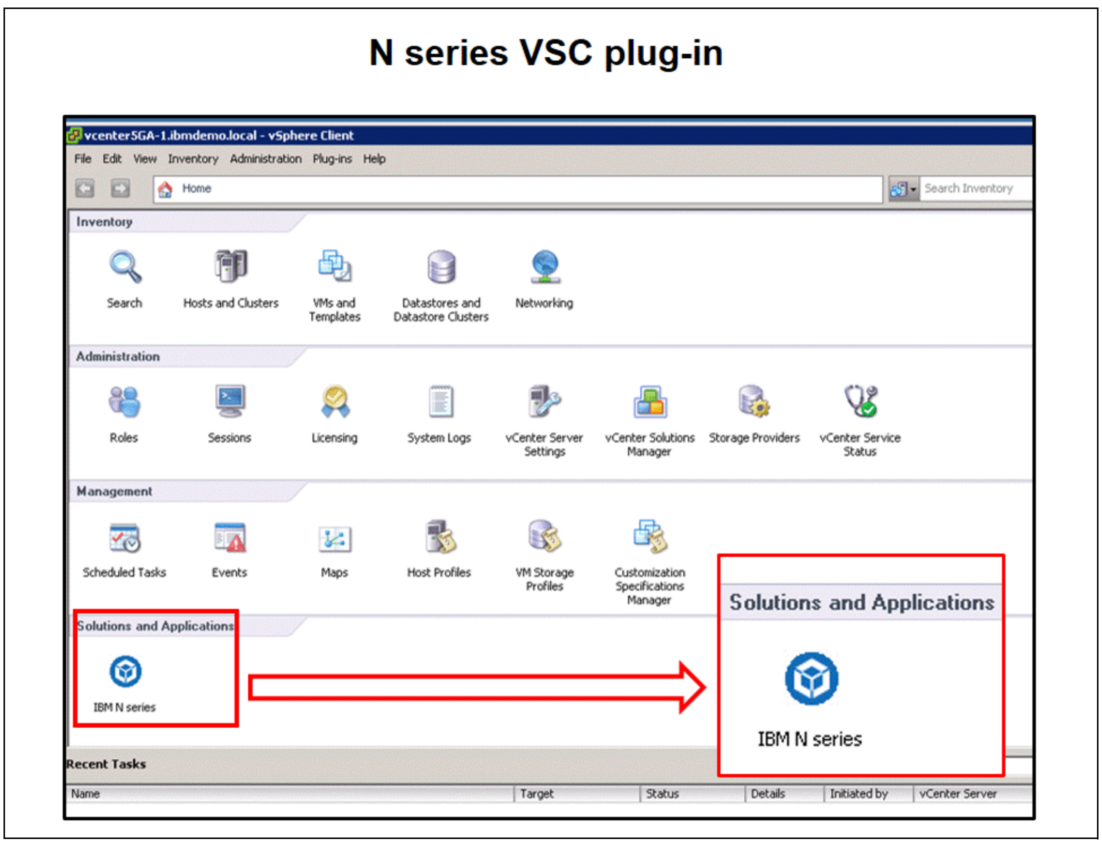


Figure 12-12 N series VSC as a VMware plug-in

Monitoring and Host Configuration capabilities

The Monitoring and Host Configuration capability provides information about your controllers and ESX and ESXi hosts. The following sections provide details on how to use the Monitoring and Host Configuration capability:

- VSC for VMware vSphere configuration:

  You can configure and manage your ESX and ESXi hosts and virtual machines (VMs) by first specifying the physical storage systems on which the active images of the datastores and VMs that are managed by the vCenter Server reside.

- Administering the Monitoring and Host Configuration capability:

  The Monitoring and Host Configuration capability lets you work with hosts and controllers and configure values for them.

- Fields and commands described by the online help:

  In addition to the tasks that this guide has already described, the online help contains explanations for other fields and commands that are available on the Monitoring and Host Configuration capability panels. To provide you with an overview of those additional fields and commands, they are included in the sections that follow.

Figure 12-13 provides visibility to the storage monitoring and host configuration capabilities of the SVC.

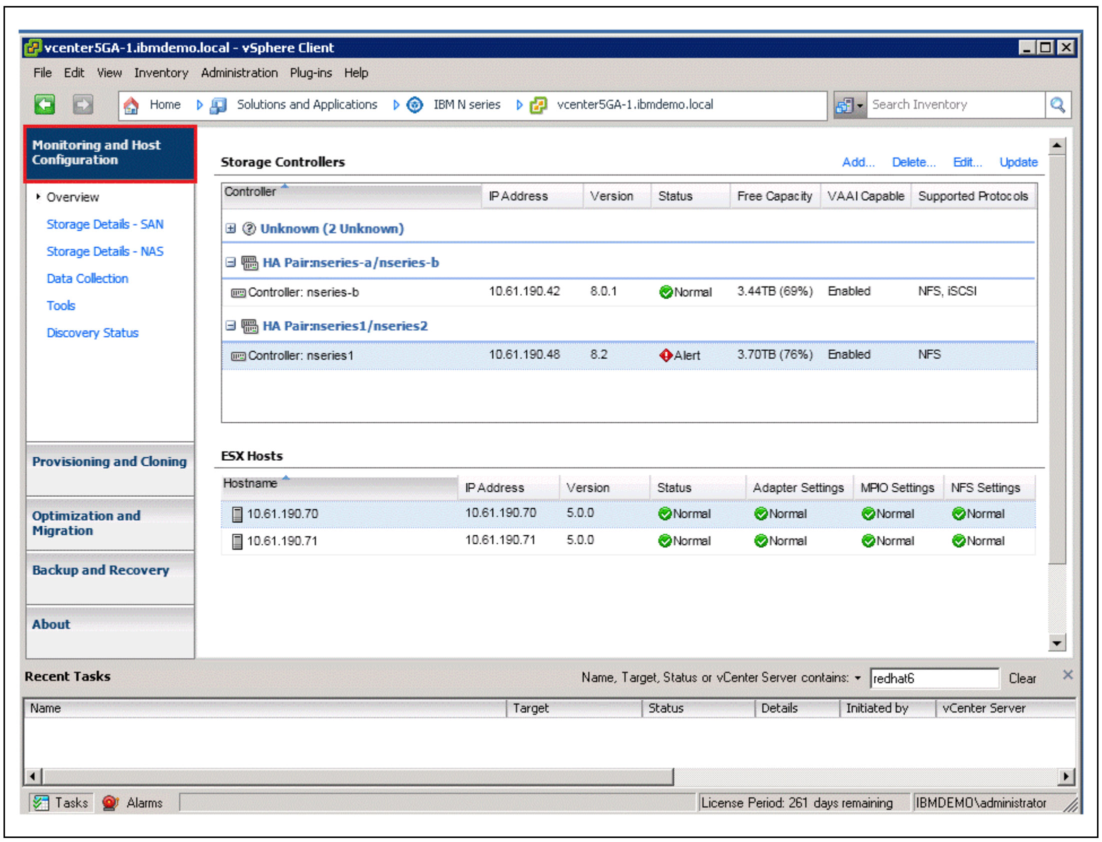


Figure 12-13 Monitoring and Host Configurations capabilities of SVC

Provisioning and Cloning capabilities

The Provisioning and Cloning capability of Virtual Storage Console for VMware vSphere enables you to provision datastores and quickly create multiple clones of virtual machines in the VMware environment. The following sections provide details on how to use the Provisioning and Cloning capability:

- Cloning and managing virtual machines:

  You can use the Provisioning and Cloning capability to clone virtual machines, manage connection brokers, redeploy clones locally, and reclaim unused space on virtual machines.

- Managing storage controllers:

  You can view usage and deduplication statistics, and manage volume settings and network interfaces with the Provisioning and Cloning capability.

- Managing datastores:

  You can use the Provisioning and Cloning capability to replicate datastores to remote sites, provision, mount, resize, and destroy datastores, and manage deduplication on datastores.

- Programmable API:

  This section presents usage and reference information for the Provisioning and Cloning capability programmable API.

- vCenter Privileges:

  Figure 12-14 presents the privileges required to use the Provisioning and Cloning capabilities in vCenter.

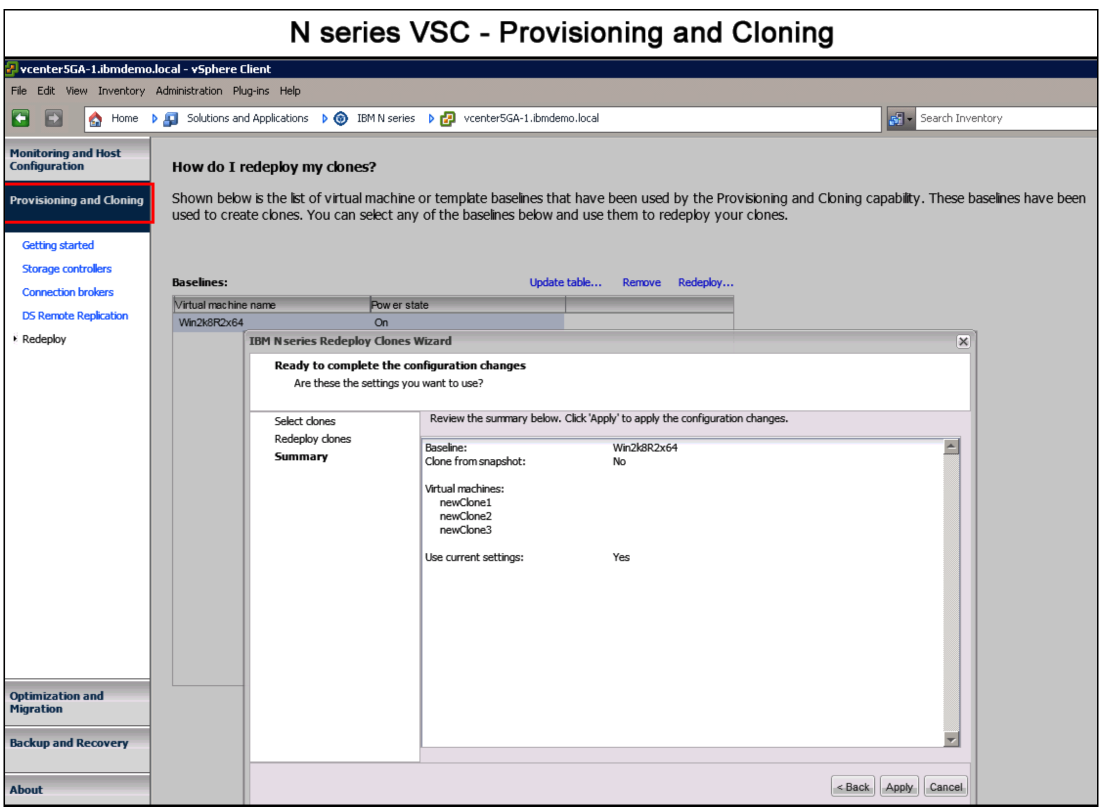


Figure 12-14 VSN - Provisioning and Cloning window

The Optimization and Migration capability provides a simple interface for performing online alignments and migrations of virtual machines (VM). You can align VMFS datastores without having to power down the VM. In addition, you can review the alignment status of VMs and migrate groups of VMs into new or existing datastores.

The interface for the Optimization and Migration capability is integrated with VMware vCenter Server and works in conjunction with the VMware Storage vMotion feature to enable a running VM to be moved between datastores. Having the VMs aligned can improve performance. See Figure 12-15.

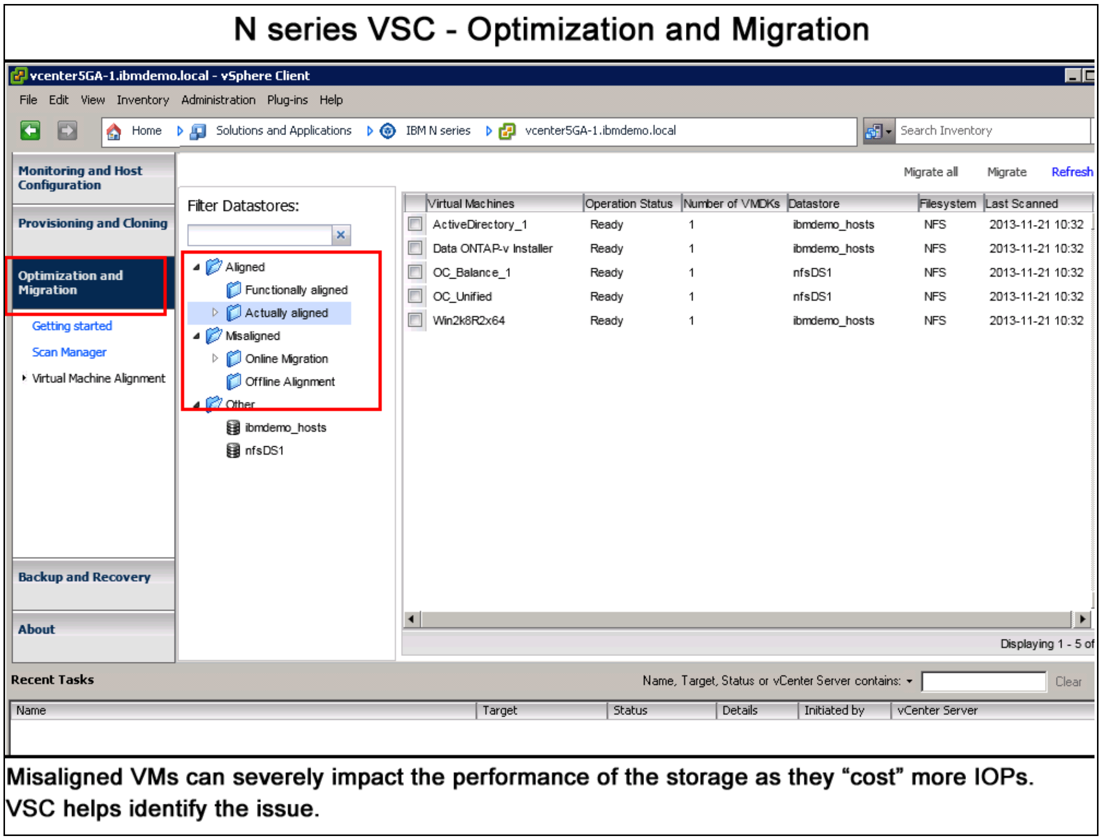


Figure 12-15 VSC - Optimization and Migration window

Backup and Recovery

Using Snapshot technology, Backup and Recovery allows you to back up entire datastores or individual virtual machines, and then restore at any level of granularity, datastore, virtual machine, VMDK, or guest file. Optionally, Backup and Recovery can also trigger SnapMirror updates after a backup job. A SnapMirror relationship must be established prior to running the replication update. See Figure 12-16.

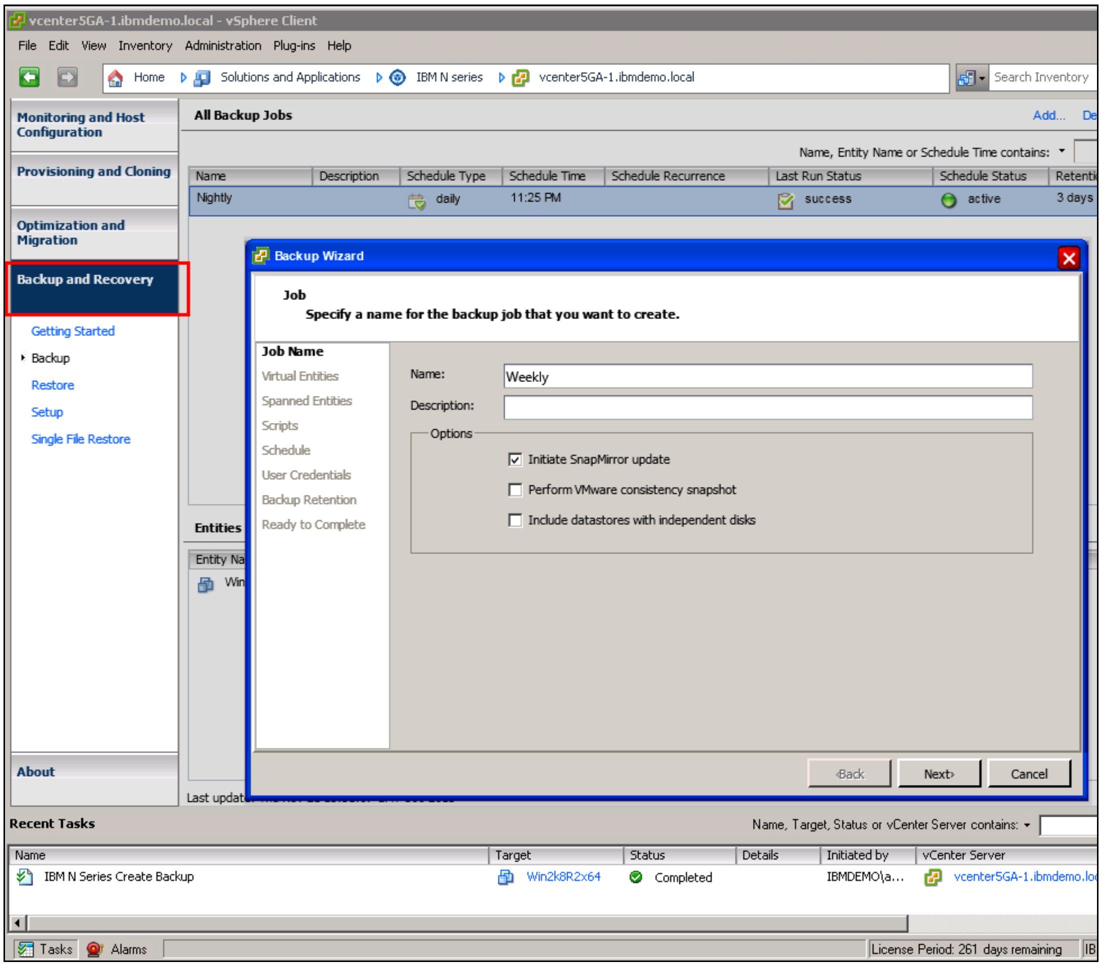


Figure 12-16 Setting a backup job in the VSC

12.4 Integration with Microsoft Hyper-V

The details about the VMs, host names, and storage configuration used in this section are provided in an earlier part of the chapter, under the *Preparation* section. You can use the information in Table 12-2 on page 158 and Figure 12-2 on page 159.

With Clustered Data ONTAP 8.2.x, we have the option to connect the Hyper-V server via FC, FCoE, iSCSI, or Server Message Block (SMB) 3.0. In this instance, we are connecting via a SMB 3.0 share.

When running Hyper-V over SMB on Clustered Data ONTAP, we need to ensure that the Autolocation feature is disabled. Here is a CLI example:

```
vserver cifs options modify -vserver vs1.demo.ibm.com -is-referral-enabled false
```

If creating the file share via *System Manager,* the "Enable Continuous Availability for Hyper-V" option will need to be selected as shown in Figure 12-17.

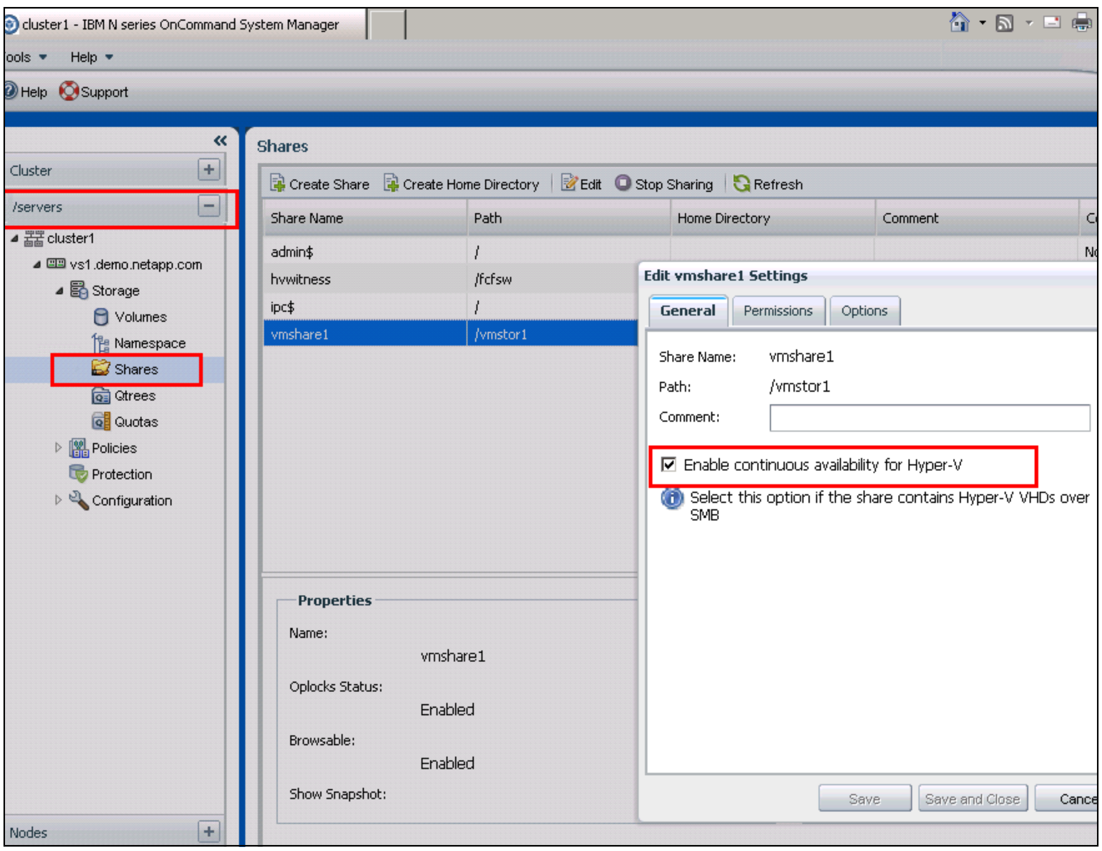


Figure 12-17 Enabling Continuous Availability in System Manager

The next step is to add **Full Control** permissions for the AD group that will allow access for the Hyper-V nodes. See Figure 12-18.

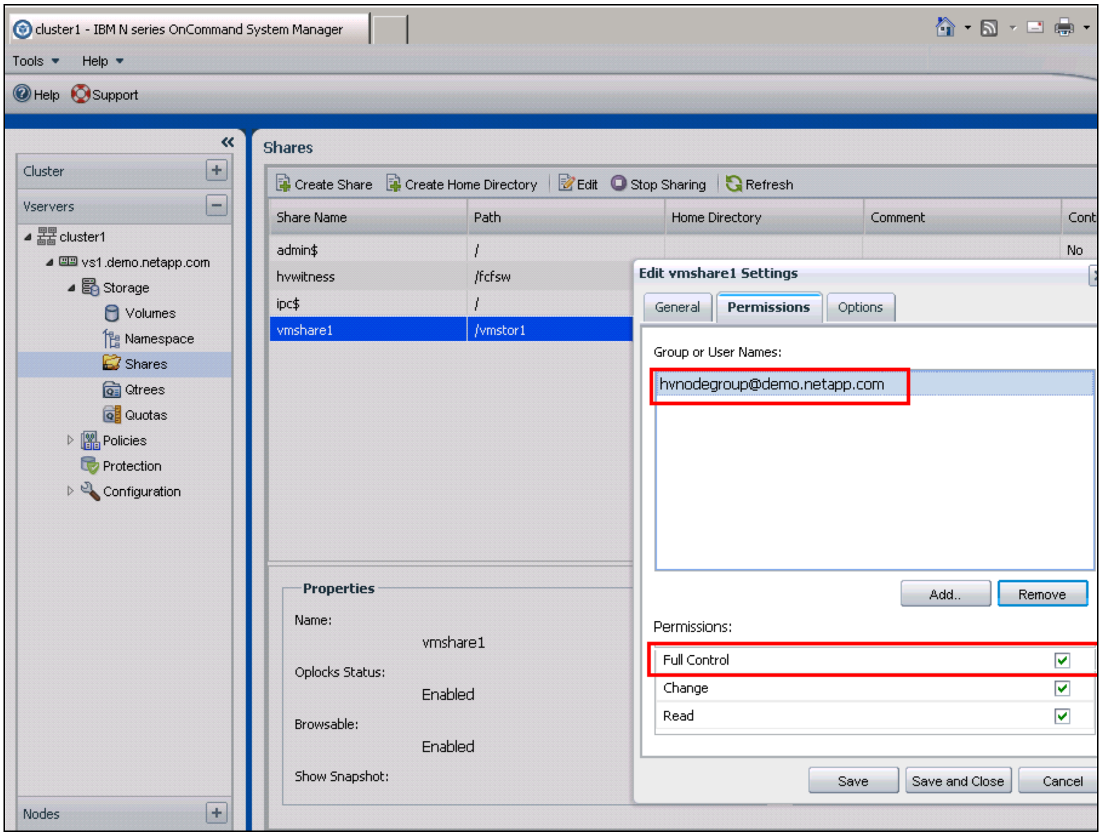


Figure 12-18 Adding Full Control permission

Next, proceed as follows:

1. From the Hyper-V Manager, select new "Virtual Machine" and this will bring up the "New Virtual Machine Wizard".
2. When you are at the "Specify Name and Location" page, specify the share that was created with the "Enable Continuous Availability for Hyper-V" selected and Hyper-V will create the VM on the specified share.
3. Complete the "New Virtual Machine Wizard" with the appropriate VM settings and you will have a VM connected to the NSeries via SMB3.0. You can use Figure 12-19 for reference.

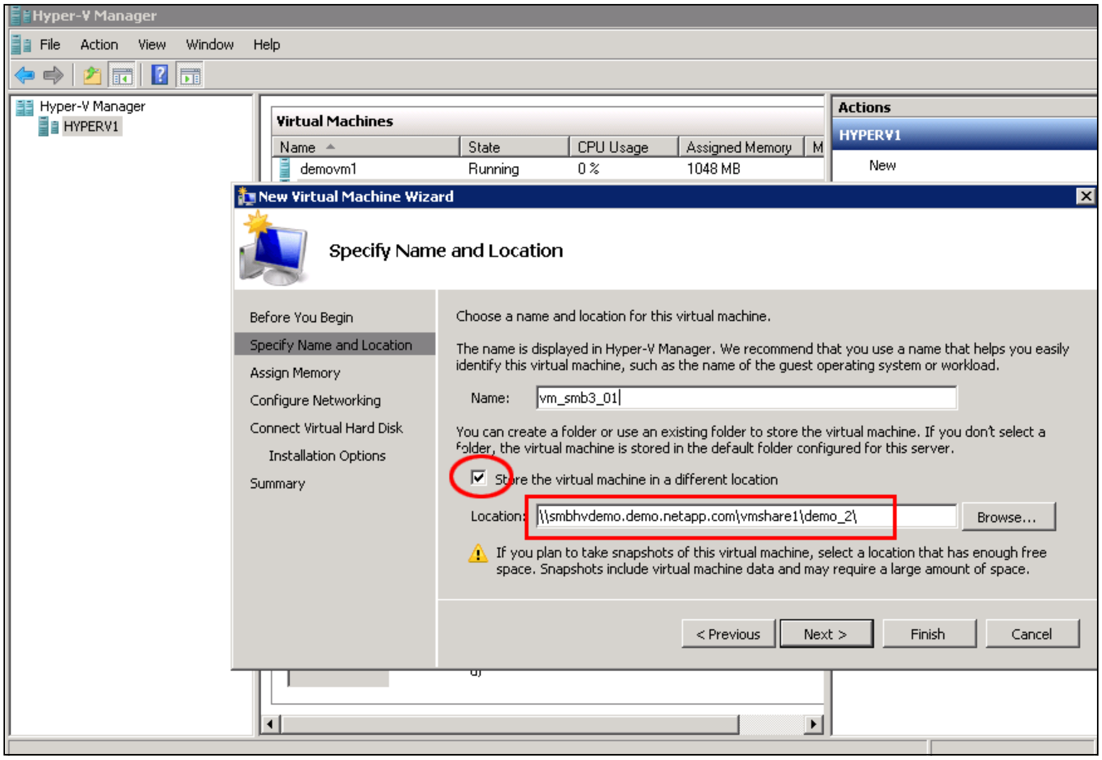


Figure 12-19 Creating a new Virtual Machine.

Provision of storage

Storage pool management of the N series through Microsoft SCVMM (System Center 2012 Virtual Machine Manager) is possible by installing the SMIS agent for Hyper-V. At the time of writing this paper, the latest version of Data ONTAP SMI-S agent is 5.1. Figure 12-20 provides a reference to a provisioned storage.

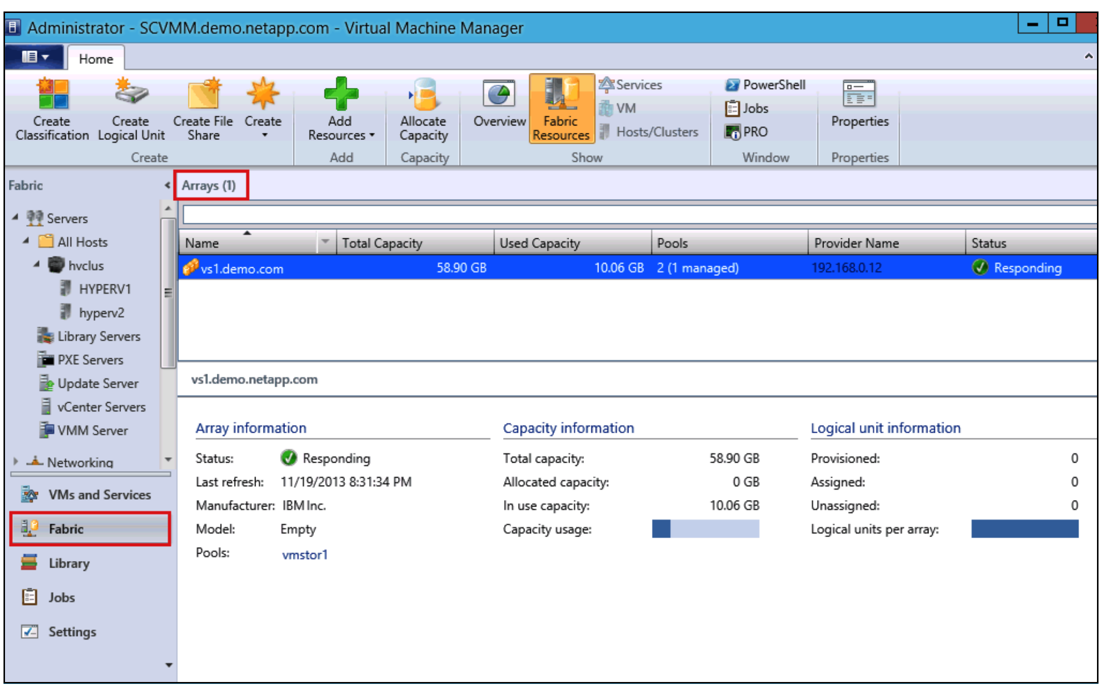


Figure 12-20 Example of provisioned storage

Part 3

Appendixes

In this part of the book, we provide information about the following topics:

- N series Clustered Data ONTAP 8.2 sizing considerations
- Sample configurations

A

N series Clustered Data ONTAP 8.2 sizing considerations

This appendix provides detailed information about the assumptions used when sizing the sample configuration listed in Chapter 2, “Architecture and design” on page 7 under *Entry*, *Mainstream*, and *Advanced*. It also discusses the various sizing considerations, tools, techniques, and approaches for accurate and effective sizing of the N series Clustered Data ONTAP storage system.

The following topics are covered:

- Storage sizing approach and details
- Sizing assumptions for sample configurations

Storage sizing approach and details

Despite the scientific accuracy of sizing calculations and technology that has a clear set of specifications so its performance can be predicted, the end results are measured only by user experience and their expectations. Thus, working closely with the business to understand the requirements is critical, and should be done on a regular basis, also after the solution is already deployed. Business requirements tend to change, so being aware in advance of upcoming changes is part of the responsibility of IT.

Sometimes it is difficult to predict in advance how a new software feature, or adding a few more users will impact the storage infrastructure. These changes are likely to impact usable or consumed capacity and IOPS. If there are bottlenecks in the sense that the extra capacity or IOPS transactions cannot be served without increasing storage CPU and/or disk utilization, the overall latency will increase, and user experience will ultimately suffer. N series OnCommand is a powerful tool that can monitor the utilization of the storage system and generate reports about trends as well as point to sources of potential problems.

General approach

Here is a high level description of the key steps that one should follow in order to design an N series Clustered Data ONTAP storage system:

1. Understand the solution:
   a. General classification and type, for example: VDI or Server VMs
   b. General topology, sites, number of users
   c. Any existing logical and physical diagrams
   d. Business expectations, importance of the solution, any specific SLOs
   e. Data protection requirements
   f. Who or what is accessing the data, how and when
2. Gather preliminary performance requirements (tools can be used as well!):
   a. Types of data
   b. Estimated capacities per data type
   c. If there are servers, what are the roles of each one
   d. Required usable capacity for each of the data type or sets
   e. Required IOPS and latency
   f. Number of users, per location, per time period (business hours per location)
   g. Specific backup information per data type, including RTO and RPO
   h. Specific data replication information, including replication window
3. Prepare the site:
   a. Map the storage systems, servers, data type, and users to all locations
   b. Develop preliminary understanding of data center readiness
4. Process the gathered data:
   a. List all requirements, if possible using sizing templates
   b. Create preliminary logical and physical diagrams
   c. Identify gaps in missing requirements
5. Review and conduct preliminary sizing:
   a. Agree on set of assumptions and models to use if information is not available
   b. Conduct preliminary sizing to validate that all aspects are covered
   c. Identify additional gaps and resolve with the business

6. Conduct full sizing:
   a. Revisit parameters gathered to confirm assumptions and requirements did not change
   b. Use multiple tools and reviews, double check!

When sizing storage, evaluate the following parameters and account for them across all workloads and for each user, application, and type of virtual machine:

- Required (usable) capacity on day one with expected growth
- Thin provisioning and other storage efficiencies should be accounted for
- IOPS and/or KB/s / MB/s
- Workload block size (KB)
- Latency
- Protocols used
- The random and sequential mix of the workloads
- The Read/Write ratio
- Maximum users, concurrent/active users
- Peak hours, possible maintenance windows
- Times to perform data replication and backups knowing RPO and RTO
- Available / allocated network bandwidth for data replication
- Number of storage controllers
- QoS and SLOs to meet
- Priority list of the important business applications
- The knowledge, experience of the IT staff

Sizing assumptions for sample configurations

Chapter 2, “Architecture and design” on page 7 provides a list of configurations that are classified under *Entry*, *Mainstream,* and *Advanced*. This section provides the additional details that explain how the sizing calculation was done.

Maximum utilization and risk assessment

The *Entry*, *Mainstream* and *Advanced* set of configurations includes two or more storage controllers (nodes) working in sets of HA pairs for high availability in an active-active mode. If one of the controllers in a HA pair fails, then the second active controller assumes ownership of all the disks and connections that were owned and managed by the failed node. Thus, it would assume ownership over the total combined workload of the HA pair, which is known as controller failover mode.

For configurations with two nodes cluster, which also means only one HA pair, the sizing was done in a way that the storage can continue to operate and support the entire workload even if one of the controllers fails. The total utilization of each controller is kept at the range just over 50% CPU utilization and is calculated based on all VMs running at the specified number of IOPS.

There is an assumption that in day-to-day operation, 15% of the VMs are only generating a negligible number of very low IOPS at any given time, which then reduces the total required IOPS, and the storage will actually be performing at a lower range than 50% utilization. With the QoS feature and the assumption that some of the VMs can tolerate higher latency during the failover period, then indeed if one node fails, the other active node will be able to sustain the entire workload with minimal to no impact on the users. See Figure A-1.

Configuration Name & #	Number of VMs	Avg IOPS/VM	Total IOPS	VM size (GB) Before Dedupe	VM size (GB) After Dedupe	Total Required Capacity (TB)
Entry # 2	200	75	15,000	60	48	9.6
Entry # 3	450	75	33,750	60	48	21.6
Mainstream # 1	300	75	22,500	70	56	16.8
Mainstream # 2	650	75	48,750	70	56	36.4
Mainstream # 3	1500	75	112,500	70	56	84
Advanced # 1	500	75	37,500	80	64	32
Advanced # 2	1100	75	82,500	80	64	70.4
Advanced # 3	2400	75	180,000	80	64	153.6

Figure A-1 Performance and capacity requirements

After understanding the preliminary information, as shown in Figure A-1, it is possible to assess an average workload per node, which is illustrated in Figure A-2.

Important: In most cases the data will not be distributed evenly between the member nodes. In our example, we are using a model of averages, as the total in either case will be the same. But when operating on a day-to-day basis, it is important to balance the data according to the business requirements and the available resources.

Configuration Name & #	Total Required IOPS	Storage Model	# of Nodes	IOPS/HA Pair	IOPS/Node
Entry # 2	15,000	N3220	2	15,000	7,500
Entry # 3	33,750	N3220	4	16,875	8,438
Mainstream # 1	22,500	N6250	2	22,500	11,250
Mainstream # 2	48,750	N6250	4	24,375	12,188
Mainstream # 3	112,500	N6250	8	28,125	14,063
Advanced # 1	37,500	N7550T	2	37,500	18,750
Advanced # 2	82,500	N7550T	4	41,250	20,625
Advanced # 3	180,000	N7550T	8	45,000	22,500

Figure A-2 Calculating IOPS per each storage node (average)

For configurations with four nodes, the sizing approach was to design the storage so it will operate at around 60% CPU utilization for each node, if 100% of the VMs are working at the specified IOPS. It was assumed that one node out of the four will fail and there will be no impact on user experience. For four-node cluster it is also assumed that in reality, 15% of the VMs are not generating any significant IOPS. With QoS and the ability to move non-disruptively sets of VMs to other nodes that are active, this higher utilization can be achieved without risking the business.

Prior to understanding what are the possible implications of the assumptions mentioned above, it is important to introduce additional set of information regarding the characteristics of the workloads in the various configurations. Figure A-3 provides details about the Read / Write ratios and the percentages of the active working sets. This information is required for some of the sizing tools.

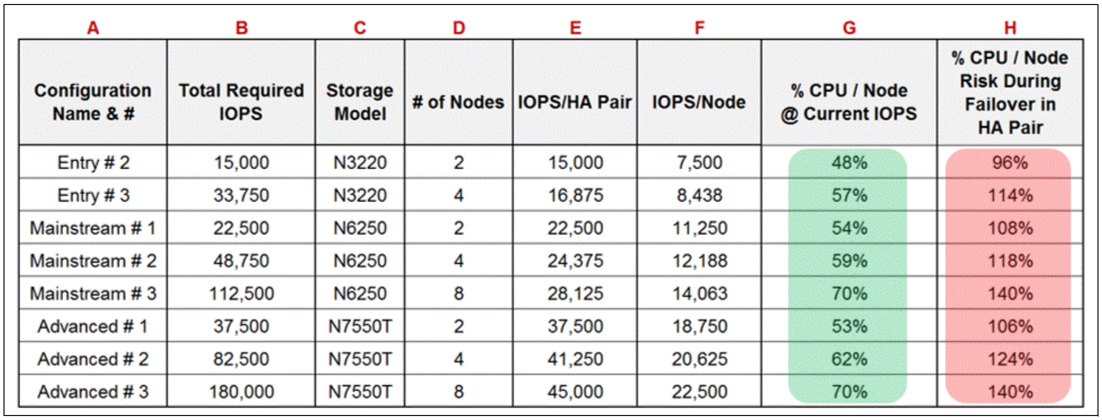
Configuration Name & #	Random Read Latency (ms)	Random Read %	Random Write %	Sequential Read %	Sequential Write %	Active Working Set %
Entry # 2	20	45%	45%	5%	5%	5%
Entry # 3	20	45%	45%	5%	5%	5%
Mainstream # 1	20	45%	45%	5%	5%	5%
Mainstream # 2	20	45%	45%	5%	5%	5%
Mainstream # 3	20	45%	45%	5%	5%	5%
Advanced # 1	18	30%	60%	5%	5%	10%
Advanced # 2	18	30%	60%	5%	5%	10%
Advanced # 3	18	30%	60%	5%	5%	10%

Figure A-3 Workload characteristics in terms of %Read / %Write

The same principle was used for the configurations with eight nodes. In the eight-node configurations the storage is designed in a way that each node is at about 70% CPU utilization if 100% of the VMs are working and generating the specified number of IOPS. Assuming QoS and that some VMs can tolerate higher latency and assuming that IT can move certain groups of VMs, if needed, to other storage nodes, these configurations were design to sustain the entire cluster workload even in the case of 2 failing nodes, and that is of course under the condition that the failing nodes are not in the same HA pair.

From this, it is easy to see that storage utilization can be higher thanks to Clustered Data ONTAP, but it is very important also to be aware of the limitations of the technology, the capabilities of the IT teams and the requirements and expectations of the business. Only after establishing a solid understanding of all the these aspects, it can be decided on the sizing and design of the storage.

At this point there is enough information and the risks can be calculated. The objective it to find the balance that allow reasonably high utilizationj (cost saving), without impacting performance, usability and user experience. This is a joint exercise that the storage teams must conduct with the business. Figure A-4 on page 184 provides details about the exposure if indeed the set of requirements are the actual requirements. 79% utilization per node was established as the value of the maximum acceptable utilization. Column G indicates that when all nodes are working, the utilization is well below the red line. Column H however, indicates that with the current set of assumptions, upon a failure of a single node, the partner node will be way above the red line of the 79% CPU utilization per node.



Configuration Name & #	Total Required IOPS	Storage Model	# of Nodes	IOPS/HA Pair	IOPS/Node	% CPU / Node @ Current IOPS	% CPU / Node Risk During Failover in HA Pair
A	B	C	D	E	F	G	H
Entry # 2	15,000	N3220	2	15,000	7,500	48%	96%
Entry # 3	33,750	N3220	4	16,875	8,438	57%	114%
Mainstream # 1	22,500	N6250	2	22,500	11,250	54%	108%
Mainstream # 2	48,750	N6250	4	24,375	12,188	59%	118%
Mainstream # 3	112,500	N6250	8	28,125	14,063	70%	140%
Advanced # 1	37,500	N7550T	2	37,500	18,750	53%	106%
Advanced # 2	82,500	N7550T	4	41,250	20,625	62%	124%
Advanced # 3	180,000	N7550T	8	45,000	22,500	70%	140%

Figure A-4 Recognizing risks during the sizing and design process

From a storage perspective, common preferred practices suggest not to operate any storage node at a capacity utilization that is higher than 70% when 80% is red line that should not be crossed. It is expected to see spikes in storage CPU utilization, but the storage of course should not be operating long durations of more than few seconds at 100% CPU utilization. In some cases, even couple seconds of 100% utilization can impact user experience and important transactions will suffer. With proper sizing tools and other calculations done by a qualified engineer, the approach will be to work with a model of averages while leaving considerable amount of room for unplanned, yet possible higher utilization. With a model uses averages, the storage can be design to operate at a a specific CPU utilization, which means 100% of the time the average will be X% CPU utilization, as explained in this section with the examples of the *Entry*, *Mainstream* and *Advanced* configurations. Averages still need to account for the maximum expected utilization and other assumptions.

To a degree, the sizing exercise that is explained in this section is done in reverse. What will be shown in Figure A-5, is how much change is needed in the requirements, or how low the threshold needs to be lowered for our configurations to work, which is of course not how things are done in real life. According to the figures in Figure A-5 at the top part, even after reducing the number of concurrent VMs by 25% most of the configurations are still in the red.

Column I assumes that 15% are not active and column J assumes that with QoS, 10% of VMs can tolerate poor performance, or even stop working on certain things until service is restored. The QoS will assure that the important business critical data will get the highest priority hence no risk.

The lower chart in Figure A-5 is the solution and how the features of Clustered Data ONTAP enable higher utilization while keeping the risk low. Column K indicates the missing CPU percentages for that the active partner node is missing in order to sustain the full workload in case of a failure. Column L, provides information about how much total CPU percentages are available within other nodes that are active in the same cluster, and they are also limited by the 79% maximum allowed. If the percentages in column L are higher than those in column K, *DataMotion* can be used to move, non disruptively, SVM from the busy node to other nodes in the cluster and by that, optimize the data layout to accommodate the situation with the failed controller. Once the service is fully restored, the SVMs can be moved back.

A	C	D	F	G	H	I	J
Configuration Name & #	Storage Model	# of Nodes	IOPS/Node	% CPU / Node @ Current IOPS	% CPU / Node Risk During Failover in HA Pair	% CPU / Node 85% Concurrency	Additional 10% Reduction
Entry # 2	N3220	2	7,500	48%	96%	82%	72%
Entry # 3	N3220	4	8,438	57%	114%	97%	87%
Mainstream # 1	N6250	2	11,250	54%	108%	92%	82%
Mainstream # 2	N6250	4	12,188	59%	118%	100%	90%
Mainstream # 3	N6250	8	14,063	70%	140%	119%	109%
Advanced # 1	N7550T	2	18,750	53%	106%	90%	80%
Advanced # 2	N7550T	4	20,625	62%	124%	105%	95%
Advanced # 3	N7550T	8	22,500	70%	140%	119%	109%

A	G	H	I	J	K	L
Configuration Name & #	% CPU / Node @ Current IOPS	% CPU / Node Risk During Failover in HA Pair	% CPU / Node 85% Concurrency	Additional 10% Reduction	Excess Exposure when desired % CPU <= 79%	Available CPU (%) in other Nodes
Entry # 2	48%	96%	82%	72%	NA	NA
Entry # 3	57%	114%	97%	87%	8%	44%
Mainstream # 1	54%	108%	92%	82%	3%	0%
Mainstream # 2	59%	118%	100%	90%	11%	40%
Mainstream # 3	70%	140%	119%	109%	30%	54%
Advanced # 1	53%	106%	90%	80%	1%	0%
Advanced # 2	62%	124%	105%	95%	16%	34%
Advanced # 3	70%	140%	119%	109%	30%	54%

Figure A-5 Reducing risk during the sizing and design process

Other sizing assumptions

For servers, it was assumed that on average, each physical host server will have about 20 running guest VMs.

Sizing tools

The most accurate sizing tools are SPM and Synergy, and they are both required for most configurations. *SPM - System Performance Modeler* can be found at the following link:

https://spm.netapp.com/

Synergy is useful in finding usable capacities from raw capacities, understanding configurations limits, and ultimately used to transform the output from SPM, into a configuration that can be ordered / purchased. Synergy is not an online tool, it needs to be downloaded from this link:

http://synergy.netapp.com/

- Microsoft Exchange calculator can be found here:

  http://gallery.technet.microsoft.com/Exchange-2013-Server-Role-f8a61780

- Microsoft sizing for SharePoint can be found here:

  http://technet.microsoft.com/en-us/library/ff758647(v=office.15).aspx

- Sizing for Microsoft SQL can be found here:

  http://technet.microsoft.com/en-us/library/ee410782(v=sql.100).aspx

B

Sample configurations

This appendix contains five storage configurations that specify the IBM Machine, Model, and Feature numbers that correspond to the items described in the configurations that were introduced in Chapter 2, “Architecture and design” on page 7, as part of the architecture and design discussion. In addition, it includes information about the servers that are part of the solution.

The following topics are covered:

- Sample configurations: Entry
- Sample configurations: Mainstream
- Sample configuration: Advanced
- Further information

Sample configurations: Entry

This section provides the configuration details with the IBM part numbers and quantities for two of the three configurations that are described in Chapter 2, “Architecture and design” on page 7. Configuration *Entry # 2* and configuration *Entry # 3* are listed next. Configuration Entry # 1 is not covered in this section and was described in Chapter 2, “Architecture and design” on page 7 only as an example for a system that is used for development and functional testing.

As a reference, the *Entry* set of configurations is depicted in Figure 2-9 on page 19.

Configuration for Entry # 2

Table B-1 lists the required IBM part numbers and quantities for the configuration *Entry # 2*. The list does not include the following items: Rack, power cords, networking cables, SFP modules, cables for the disk shelves. These items are required for a complete configuration, but since each has multiple part numbers reflecting various features such as cable length, voltage, country specifications, data center limitations and requirements, it will be counterproductive to list them here arbitrarily. Installation and services are within the same category hence also not listed.

Table B-1 Entry - Configuration # 2

Description	Machine	Model	Feature	Qty
N3220, dual-node system in a single chassis	2857	A22		1
10 GbE Mezzanine	2857	A22	2031	2
24 X 600GB 10K RPM SAS Disks	2857	A22	4101	1
EXN3500 24 X 600GB 10K RPM SAS Disks	2857	006	4101	2
Data ONTAP Essentials	2857	A22	A8PH	2
NFS License	2857	A22	A8PM	2

Table B-1 lists the key components of configuration *Entry # 2*. Additional software features are required for integration with VMware or Microsoft, and some software features are not required, yet advised for data protection, and for enabling advanced capabilities such as cloning. Software features for IBM System Storage N series is also available in bundles that include multiple features. In many cases it is less expensive to purchase a software bundle. See “Further information” on page 193 at the end of this appendix for more information about the software options for N series.

Configuration for Entry # 3

Table B-2 lists the required IBM part numbers and quantity for the configuration *Entry # 3*. The list does not include the following items: Rack, power cords, networking cables, SFP modules, cables for the disk shelves. These items are required for a complete configuration, but since each has multiple part numbers reflecting various features such as cable length, voltage, country specifications, data center limitations and requirements, it will be counterproductive and misleading to list them here arbitrarily. Installation and services are within the same category hence also not listed.

Table B-2 Entry - Configuration # 3

Description	Machine	Model	Feature	Qty
N3220, dual-node system in a single chassis	2857	A22		2
10 GbE Mezzanine	2857	A22	2031	4
24 X 600GB 10K RPM SAS Disks	2857	A22	4101	2
EXN3500 24 X 600GB 10K RPM SAS Disks	2857	006	4101	6
Data ONTAP Essentials	2857	A22	A8PH	4
NFS License	2857	A22	A8PM	4
16 Ports Cluster Interconnect	2857	A22	1001	2

Table B-2 lists the key components of configuration *Entry # 3*. Additional software features are required for integration with VMware or Microsoft, and some software features are not required, yet advised for data protection, and for enabling advanced capabilities such as cloning. Software features for IBM System Storage N series is also available in bundles that include multiple features. In many cases it is less expensive to purchase a software bundle. See “Further information” on page 193 at the end of this appendix for more information about the software options for N series.

Server configurations

The advised servers for the configurations *Entry # 2* and *Entry # 3* are the IBM System *x3650 M4*, or *x3550 M4*. For the server sizing, it was assumed that about 20 VMs guests will run on each physical host server. As indicated in Figure 2-9 on page 19, the number of physical servers for configurations # 2 and # 3 is between 8 and 30 for hosting 200 - 450 VMs. Based on the sizing assumptions and calculations, it is advisable to configure each server with the following components:

- Dual Intel Xeon Processor E5-2680 8C 2.7GHz 20MB Cache 1600MHz 130W
- 16 X 16GB (1x16GB, 2Rx4, 1.5V) 1600 MHz LP RDIMM
- Dual Port 10 GbE SFP+ Broadcom NetXtreme or equivalent 10 GbE
- 2 X IBM 300GB 10K 6Gbps SAS 2.5” SFF G2HS HDD
- Dual Power Supply

Sample configurations: Mainstream

This section provides the configuration details with the IBM part numbers and quantities for two of the configurations that are described in chapter 2 under the *Mainstream* set of configurations: *Mainstream # 2* and *Mainstream # 3*.

For a reference, the *Mainstream* set of configurations is captured in Figure 2-10 on page 19.

Configuration for Mainstream # 2

Table B-3 lists the required IBM part numbers and quantities for the configuration *Mainstream # 2*. The list does not include the following items: Rack, power cords, networking cables, SFP modules, cables for the disk shelves. These items are required for a complete configuration, but since each has multiple part numbers reflecting various features such as cable length, voltage, country specifications, data center limitations and requirements, it will be counterproductive to list them here arbitrarily. Installation and services are within the same category hence also not listed.

Table B-3 Mainstream - Configuration # 2

Description	Machine	Model	Feature	Qty
N6250, dual-node system with IOXM	2858	E26		2
Dual port 10 GbE SFP+	2858	E26	1078	8
SFP+ Optical Module	2858	E26	2014	16
EXN3500 24 X 600GB 10K RPM SAS Disks	2857	006	4101	8
Flash Cache II 1TB	2858	E26	1072	4
Data ONTAP Essentials	2858	E26	A8W1	4
NFS License	2858	E26	A8W8	4
16 Ports Cluster Interconnect	2858	E26	1001	2

Table B-3 lists the key components of configuration *Mainstream # 2*. Additional software features are required for integration with VMware or Microsoft, and some software features are not required, yet advised for data protection, and for enabling advanced capabilities such as cloning. Software features for IBM System Storage N series is also available in bundles that include multiple features. In many cases it is less expensive to purchase a software bundle. See “Further information” on page 193 at the end of this appendix for more information about the software options for N series.

Configuration for Mainstream # 3

Table B-4 lists the required IBM part numbers and quantities for the configuration *Mainstream # 3*. The list does not include the following items: Rack, power cords, networking cables, SFP modules, cables for the disk shelves. These items are required for a complete configuration, but since each has multiple part numbers reflecting various features such as cable length, voltage, country specifications, data center limitations and requirements, it will be counterproductive to list them here arbitrarily. Installation and services are within the same category, hence are also not listed.

Table B-4 Mainstream - Configuration # 3

Description	Machine	Model	Feature	Qty
N6250, dual-node system with IOXM	2858	E26		4
Dual port 10 GbE SFP+	2858	E26	1078	16
SFP+ Optical Module	2858	E26	2014	32
EXN3500 24 X 600GB 10K RPM SAS Disks	2857	006	4101	16
Flash Cache II 1TB	2858	E26	1072	8
Data ONTAP Essentials	2858	E26	A8W1	8
NFS License	2858	E26	A8W8	8
16 Ports Cluster Interconnect	2858	E26	1001	2

Tip: Configuration # 3 is essentially twice configuration # 2, however, it does not apply to the Cluster Interconnect switch, as the two switches can support the eight-node storage cluster. In larger node count clusters, a different set of switches will be required for higher port count.

Table B-4 lists the key components of configuration *Mainstream # 3*. Additional software features are required for integration with VMware or Microsoft, and some software features are not required, yet advised for data protection, and for enabling advanced capabilities such as cloning. Software features for IBM System Storage N series is also available in bundles that include multiple features. In many cases it is less expensive to purchase a software bundle. See "Further information" on page 193 at the end of this appendix for more information about the software options for N series.

Server configurations

As indicated in Figure 2-10 on page 19, the number of physical servers for the *Mainstream* configuration can be up to 1500 VMs. Based on the sizing assumptions and calculations, it is advisable to configure each server with the following items:

- Dual Intel Xeon Processor E5-2680 8C 2.7GHz 20MB Cache 1600MHz 130W
- 16 X 16GB (1x16GB, 2Rx4, 1.5V) 1600 MHz LP RDIMM
- Dual Port 10 GbE SFP+ Broadcom NetXtreme or equivalent 10 GbE
- 2 X IBM 300GB 10K 6Gbps SAS 2.5" SFF G2HS HDD
- Dual Power Supply

The above specifications are available on several product lines from IBM, including the *System x3550M4*, *x3650M4*, *x240* as x86 compute node for Flex System and the IBM *BladeCenter HX5* and *HS23* for BladeCenter H chassis. It is difficult to advise as to which product is more suitable because further analysis is required for each individual case. Price consideration will certainly be factored in any decision, but it is also important to understand that the there are differences also when it comes to operational aspects and from a technological perspective, BladeCenter and Flex System offer greater flexibility and in some environments can significantly simplify data center operation and the IT infrastructure.

Sample configuration: Advanced

This section provides the configuration details with the IBM part numbers and quantities for the *Advanced # 2* configuration option that is described in chapter 2.

For a reference, the *Advanced* set of configurations is captured in Figure 2-11 on page 20.

Configuration for Advanced # 2

Table B-5 lists the required IBM part numbers and quantities for the configuration *Advanced # 2*. The list does not include the following items: Rack, power cords, networking cables, SFP modules, cables for the disk shelves. These items are required for a complete configuration, but since each has multiple part numbers reflecting various features such as cable length, voltage, country specifications, data center limitations and requirements, it will be counterproductive to list them here arbitrarily. Installation and services are within the same category hence also not listed.

Table B-5 Advanced - Configuration # 2

Description	Machine	Model	Feature	Qty
N7550T, dual-node system	2867	C20		2
Dual Port 10 GbE SFP+	2867	C20	1078	8
SFP+ Optical Module	2867	C20	2014	16
PCIe 2 port 8Gb FC	2867	C20	1036	4
EXN3500 24 X 600GB 10K RPM SAS Disks	2857	006	4101	8
Flash Cache II 1TB	2867	C20	1072	4
Data ONTAP Essentials	2867	C20	A8W1	4
NFS License	2867	C20	A908	4
FCP License	2867	C20	A904	4
16 Ports Cluster Interconnect	2858	C20	1001	2

Table B-5 lists the key components of configuration *Advanced # 2*. Additional software features are required for integration with VMware or Microsoft, and some software features are not required, yet advised for data protection, and for enabling advanced capabilities such as cloning. Software features for IBM System Storage N series is also available in bundles that include multiple features. In many cases it is less expensive to purchase a software bundle. See “Further information” on page 193 at the end of this appendix for more information about the software options for N series.

Server configurations

The server options for the Advanced configuration x240 compute node as part of the IBM Flex System Enterprise Chassis, or the BladeCenter HX5 and HS23 for BladeCenter H chassis. The server specifications are the same as described for the Mainstream and the Entry configuration in this book.

Further information

This section provides links to additional information about the configuration options, covering both the software and the hardware features of the IBM System Storage N series. It also includes links to useful information about IBM servers.

N series product information

In addition to this list of resources, see “Further information” on page 127.

- Further information about the N3220 and its features:

  http://www-03.ibm.com/systems/storage/network/n3000/appliance/features.html
  http://www-01.ibm.com/common/ssi/rep_ca/1/897/ENUS112-001/ENUS112-001.PDF

- Further information about the N6250 and its features:

  http://www-01.ibm.com/common/ssi/ShowDoc.wss?docURL=/common/ssi/rep_sm/5/877/ENUS2858-_h05/index.html&lang=en&request_locale=en

- Further information about the N7550T and its features:

  http://www-01.ibm.com/common/ssi/ShowDoc.wss?docURL=/common/ssi/rep_sm/6/877/ENUS2867-_h06/index.html&lang=en&request_locale=en

IBM System X, BladeCenter, and Flex System information

In addition to this list of resources, see “Further information” on page 94.

- Further information about x3550 M4:

  http://www-03.ibm.com/systems/xbc/cog/x3550m4_7914/x3550m4_7914aag.html

- Further information about x3650 M4:

  http://www-03.ibm.com/systems/xbc/cog/x3650m4_7915/x3650m4_7915aag.html

- Further information about BladeCenter Chassis H and BladeCenter HS23 and HX5:
  - BladeCenter HX5:

    http://www-03.ibm.com/systems/xbc/cog/bc_hx5_7873/bc_hx5_7873aag.html

  - BladeCenter HS23:

    http://www-03.ibm.com/systems/xbc/cog/bc_hs23_7875/bc_hs23_7875aag.html

  - BladeCenter Chassis H:

    http://www-03.ibm.com/systems/xbc/cog/bc_h_8852/bc_h_8852aag.html

- Further information about Flex System Enterprise Chassis and x240 compute node:
  - *Flex System Enterprise Chassis - Interoperability Guide:*

    http://www.redbooks.ibm.com/redpapers/pdfs/redpfsig.pdf

  - *Flex System Enterprise Chassis - Configurations and Options Guide:*

    http://www-03.ibm.com/systems/xbc/cog/flex_8721/flex_8721aag.html

  - *Flex System Enterprise Chassis - Product Guide:*

    http://www.redbooks.ibm.com/abstracts/tips0863.html

  - *Flex System x240 Compute Node - Configurations and Options Guide:*

    http://www-03.ibm.com/systems/xbc/cog/x240_8737/x240_8737aag.html

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks publications and IBM Redpaper publications

The following IBM Redbooks publications and IBM Redpaper publications provide additional information about the topic in this document. Note that some publications referenced in this list might be available in softcopy only:

- *IBM System Storage N series Hardware Guide*, SG24-7840
- *IBM System Storage N series Software Guide*, SG24-7129
- *IBM System Storage N series Reference Architecture for Virtualized Environments*, REDP-4865
- *Managing Unified Storage with IBM System Storage N series Operation Manager*, SG24-7734
- *Using the IBM System Storage N series with IBM Tivoli Storage Manager*, SG24-7243
- *IBM System Storage N series and VMware vSphere Storage Best Practices,* SG24-7871
- *IBM System Storage N series with VMware vSphere 5*, SG24-8110
- *Designing an IBM Storage Area Network*, SG24-5758
- *Introduction to Storage Area Networks and System Networking*, SG24-5470
- *IP Storage Networking: IBM NAS and iSCSI Solutions*, SG24-6240
- *Storage and Network Convergence Using FCoE and iSCSI,* SG24-7986
- *IBM Data Center Networking: Planning for Virtualization and Cloud Computing*, SG24-7928
- *IBM N Series Storage Systems in a Microsoft Windows Environment*, REDP-4083
- *Using an IBM System Storage N series with VMware to Facilitate Storage and Server Consolidation*, REDP-4211
- *IBM System Storage N series MetroCluster,* REDP-4259
- *IBM System Storage N series with FlexShare*, REDP-4291
- *IBM System Storage N series A-SIS Deduplication Deployment and Implementation Guide*, REDP-4320

You can search for, view, download or order these documents and other Redbooks publications, Redpaper publications, Web Docs, draft and additional materials, at the following website:

ibm.com/redbooks

Other publications

These publications are also relevant as further information sources:

- Network-attached storage:

  http://www.ibm.com/systems/storage/network/
- IBM support documentation:

  http://www.ibm.com/support/entry/portal/Documentation
- IBM Storage – Network Attached Storage: Resources:

  http://www.ibm.com/systems/storage/network/resources.html
- IBM System Storage N series Machine Types and Models (MTM) Cross Reference:

  http://www-304.ibm.com/support/docview.wss?uid=ssg1S7001844
- IBM N Series to NetApp Machine type comparison table:

  http://www-03.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/TD105042
- Interoperability matrix:

  http://www-304.ibm.com/support/docview.wss?uid=ssg1S7003897
- VMware documentation:

  http://www.vmware.com/support/pubs/
- VMware vSphere 5 documentation:

  http://www.vmware.com/support/pubs/vsphere-esxi-vcenter-server-pubs.html
  http://pubs.vmware.com/vsphere-50/index.jsp
- VMware Capacity Planner:

  http://www.vmware.com/products/capacity-planner/
- VMware vSphere 4.1 configurations maximum:

  http://www.vmware.com/pdf/vsphere4/r41/vsp_41_config_max.pdf
- VMware vCloud suite:

  http://www.vmware.com/products/datacenter-virtualization/vcloud-suite/overview.html
- Microsoft Mailbox Server Storage Design:

  http://technet.microsoft.com/en-us/library/dd346703.aspx
- Microsoft Mailbox Server Processor Capacity Planning:

  http://technet.microsoft.com/en-us/library/ee712771.aspx
- Microsoft Planning and architecture for SharePoint Server 2010:

  http://technet.microsoft.com/en-us/library/cc261834.aspx
- Microsoft Hardware and Software Requirements for Installing SQL Server 2012:

  http://technet.microsoft.com/en-us/library/ms143506.aspx

Online resources

These websites are also relevant as further information sources:

- IBM NAS support website:

  http://www.ibm.com/storage/support/nas/

- NAS product information:

  http://www.ibm.com/storage/nas/

- IBM Integrated Technology Services:

  http://www.ibm.com/planetwide/

Help from IBM

IBM Support and downloads:

ibm.com/support

IBM Global Services:

ibm.com/services

IBM Redbooks

IBM System Storage N series Reference Architecture for Virtualized Environments

(0.2"spine)
0.17"<->0.473"
90<->249 pages

IBM System Storage N series Reference Architecture for Virtualized Environments

Understand Clustered Data ONTAP benefits for dynamic cloud solutions

Size the right solution meeting your business requirements

Design scalable cloud solutions using N series storage

This IBM Redbooks publication provides deployment guidelines, workload estimates, and preferred practices for clients who want a proven IBM technology stack for virtualized VMware and Microsoft environments. The result is a Reference Architecture for Virtualized Environments (RAVE) that uses VMware vSphere or Microsoft Hypervisor, IBM System x or IBM BladeCenter server, IBM System Networking, and IBM System Storage N series with Clustered Data ONTAP as a storage foundation. The reference architecture can be used as a foundation to create dynamic cloud solutions and make full use of underlying storage features and functions.

This book provides a blueprint that illustrates how clients can create a virtualized infrastructure and storage cloud to help address current and future data storage business requirements. It explores the solutions that IBM offers to create a storage cloud solution addressing client needs. This book also shows how the Reference Architecture for Virtualized Environments and the extensive experience of IBM in cloud computing, services, proven technologies, and products support a Smart Storage Cloud solution that is designed for your storage optimization efforts.

This book is for anyone who wants to learn how to successfully deploy a virtualized environment. It is also written for anyone who wants to understand how IBM addresses data storage and compute challenges with IBM System Storage N series solutions with IBM servers and networking solutions. This book is suitable for IT architects, business partners, IBM clients, storage solution integrators, and IBM sales representatives.

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