Microsoft

Best Practices for Virtualizing & Managing Exchange 2013

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Windows Server

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Introduction

This guide provides high-level best practices and considerations for deploying and managing Microsoft Exchange 2013 on a Windows Server 2012 Hyper-V-based virtualization infrastructure. The recommendations and guidance in this document aim to:

- Complement the architectural design of an organization's specific environment.
- Help organizations take advantage of the key platform features in Microsoft Exchange 2013 to deliver the highest levels of performance and availability in a virtualized environment.

Executive Summary

To meet demanding and ever-changing business needs, organizations want their Exchange Server-based messaging solution to rapidly scale and to be highly available at all times. As the demand for Exchange Server resources increases within and across organizations, it becomes important for IT to quickly meet those requirements. At the same time, though, IT is challenged with the need to minimize the cost of underlying infrastructure, effectively manage risk, and save time and effort on management activities. One solution to this challenge is virtualization.

Virtualization is now common in organizations of all sizes. Many have moved beyond the nascent stage into being more advanced users of server virtualization for a variety of workloads, including their messaging systems. These organizations have gained benefits in the areas of cost, efficiency, operations, availability, agility, and resiliency.

Windows Server 2012 Hyper-V, with its enhanced capabilities, can be used to effectively virtualize mission-critical workloads such as Exchange 2013. This guide explains these capabilities in the context of:

- How organizations can virtualize Exchange 2013 on Windows Server 2012 Hyper-V.
- How organizations can benefit from managing this virtualized environment with Microsoft System Center 2012 SP1.

Working together, these three industry-leading products deliver an integrated solution that provides low total cost of ownership (TCO) and offers mission-critical scale, performance, and high availability. The solution also provides more enhanced end-to-end security, management, and monitoring capabilities.

Further, many organizations now want to go a step beyond and adopt an IT infrastructure that is optimized for and ready to work in a cloud-based environment. They need an IT infrastructure that can seamlessly span from a private to a public cloud. To achieve this goal, many organizations choose a common virtualization platform across the infrastructure. In this regard, Windows Server 2012 Hyper-V offers the best virtualization platform for Exchange 2013.

Target Audience

This guide is intended for IT professionals and technical decision makers (TDMs), including IT consultants and architects, IT managers, and messaging administrators. With this guide, IT professionals can better understand how to set up an environment for virtualizing Exchange 2013 using an integrated virtualization platform built on some of the latest Microsoft technologies, including Windows Server 2012 Hyper-V and System Center 2012 SP1. In addition, identifying key considerations and best practices can help TDMs effectively plan and deploy Exchange 2013 in a Hyper-V environment. This guide serves the following purposes for these key roles:

- **IT consultants and architects**: Understand how the entire virtualization environment will work as they design the architecture.
- **IT managers**: Design processes to fit the overall virtualization environment so that costs are reduced and efficiency is increased as much as possible.
- **Messaging administrators**: Understand how Exchange 2013 can be set up and function in the virtual environment.

Scope

This guide focuses on providing an understanding of the key considerations for virtualizing Exchange 2013 on a Windows Server 2012 host system or virtual machine, or as part of an on-premises, hybrid, or private cloud deployment. At a broad level, the guide is divided into the following sections:

- **Fabric configuration**: Covers the key requirements, features, and considerations for infrastructure that are necessary to set up the virtualization environment. This includes best practice considerations for physical hosts and requirements for processors, memory, storage, and networks.
- **Fabric/host resiliency**: Provides information related to Hyper-V host clustering and resiliency, and introduces features that enable resiliency on host systems, such as failover clustering and Cluster Shared Volumes.
- **Virtual machine configuration for Exchange 2013 and Exchange 2013 resiliency**: Highlights best practice considerations related to configuring virtual machines for Exchange 2013. Provides information related to Exchange 2013 resiliency in different scenarios, including virtualizing a single Exchange 2013 virtual machine and creating resilient Exchange 2013 deployments across multiple hosts.
- **System Center enhancements**: Provides an overview of how System Center 2012 SP1 supports deploying and managing Exchange 2013 across the infrastructure (that is, on-premises, in the cloud, or hybrid).

Why Virtualize Exchange?

The demand to virtualize tier-1 applications such as Exchange Server continuously increases as IT organizations push toward completely virtualized environments to improve efficiency, reduce operational and capital costs, and improve the management of IT infrastructure. By using Windows Server 2012 Hyper-V to virtualize Exchange application workloads, organizations can overcome potential scalability, reliability, and performance concerns of virtualizing such a workload.

While Windows Server 2012 Hyper-V and System Center 2012 SP1 meet the deployment, manageability, and performance requirements necessary to virtualize an Exchange 2013 environment with confidence, the unique nature of Exchange Server means the choice of whether or not to virtualize Exchange workloads should be considered carefully. According to a February 2013 lab validation report from the Enterprise Strategy Group (ESG), "Capacity planning and performance analysis of existing Exchange deployments is recommended to not only determine if your organization's workload is suitable for virtualization, but also to plan the processor, memory, and network resources that need to be configured within each virtual machine."[1] This guide examines some of these considerations and provides recommendations to enable the best performance, reliability, and manageability when virtualizing Exchange Server.

Why Microsoft Virtualization and Management?

Organizations today want the ability to consistently and coherently develop, deploy, and manage their services and applications across on-premises and cloud environments. Microsoft offers a consistent and integrated platform that spans from on-premises to cloud environments. This platform is based on key Microsoft technologies, including Windows Server 2012 Hyper-V and System Center 2012 SP1.

Windows Server 2012 Hyper-V is an optimal virtualization platform that can be used for deploying demanding and intensive production applications, including Exchange 2013. With Hyper-V, Microsoft has become one of the leading vendors in virtualization technology.[2] This virtualization platform, based on new technologies from Microsoft, offers many features and improvements, including improved scale and performance, a hypervisor in the box, and enterprise features at no additional cost.

Together, Windows Server 2012 Hyper-V and Exchange 2013 deliver improved availability, flexibility, scalability, and manageability. A virtualized Exchange environment offers low input/output (I/O) response times with excellent performance scalability. Deploying a virtualized Exchange 2013 environment is a quick and streamlined process, with helpful scripts and easy-to-follow wizards. In addition, the web-based Exchange Admin Center console simplifies the management of a consolidated Exchange 2013 environment, automates some important tasks, and provides a user-friendly interface.

By combining Windows Server 2012 with System Center 2012 SP1, organizations can comprehensively manage demanding applications, such as Exchange 2013, as well as the infrastructure—including physical and virtual resources—in an integrated and unified manner.[3] The key benefits of this integrated virtualization and management platform by Microsoft include the following:[4]

- **Better scalability**: Higher capacity virtual machines that support up to 64 virtual CPUs (vCPUs) and 1 TB of memory per virtual machine, and greater virtual machine density (up to 1,024 per host and 8,000 per cluster).
- **Better performance**: Hyper-V support for Host and Guest Non-Uniform Memory Access (NUMA), Virtual Fibre Channel (FC), Hardware Offloading, Single Root I/O Virtualization (SR-IOV), and more.
- **Better availability**: Faster and simultaneous live migrations, storage migrations, and shared-nothing live migrations, along with dynamic quorum for more resilient failover clusters.
- **Better manageability**: Comprehensive management tools in System Center 2012 SP1 for Exchange 2013 virtual machines.

Fabric Configuration

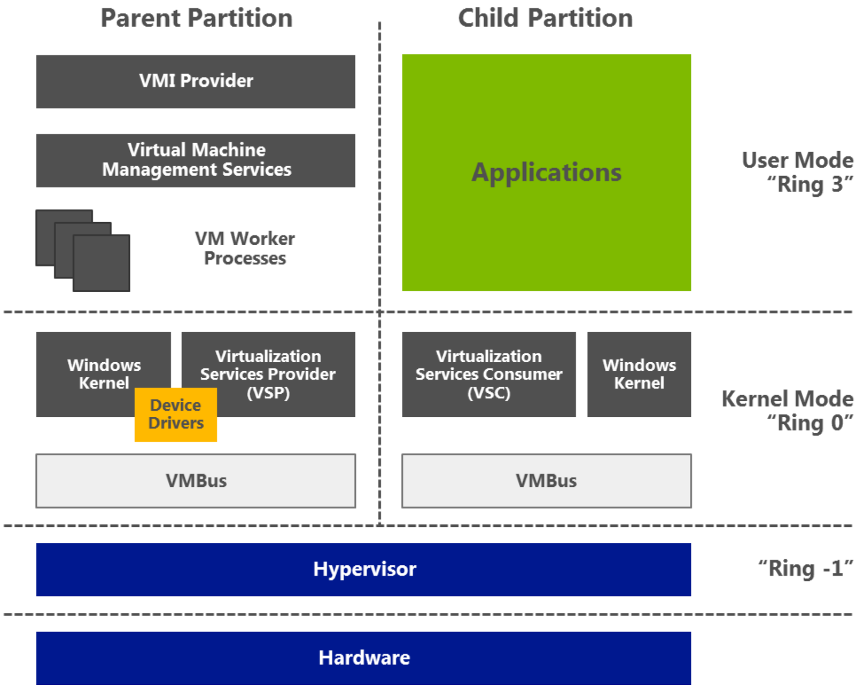
With Windows Server 2012 Hyper-V, customers can make the best use of new and existing server hardware investments by consolidating multiple workloads as separate virtual machines, reducing the number of physical machines in the infrastructure and improving utilization. Windows Server 2012 provides a number of compelling capabilities to help organizations build scalable, high-performing, and reliable virtualized infrastructure for their mission-critical workloads like Exchange 2013. This section covers many of the enhancements in Windows Server 2012 Hyper-V that can help organizations build an optimized virtualized infrastructure.

Hardware Considerations

Hyper-V requires a 64-bit processor that includes hardware-assisted virtualization and hardware-enforced Data Execution Prevention (DEP).

Hardware-assisted virtualization is available in processors that include an option to enable the virtualization of host machines. The Windows Server 2012 Hyper-V role supports hardware-assisted virtualization processers from the Intel VT and AMD-V processor families. Using this feature, WIndows Server 2012 injects the hypervisor layer, Hyper-V, between the processors enabled with hardware-assisted virtualization and the host operating system. This facilitates interaction between guest operating systems and the underlying hardware via the host or main operating system for better performance and control than a system without hardware-assisted virtualization support (Figure 1).

Figure 1: Full virtualization with Hyper-V



Hardware-enforced Data Execution Prevention must be available and enabled. Specifically, you must enable Intel XD bit (*execute disable bit*) or AMD NX bit (*no execute bit*).

The minimum system requirements for Windows Server 2012 are as follows:[5]

- **Processor**: Minimum of 1.4 GHz 64-bit processor
- **Memory**: Minimum of 512 MB
- **Disk**: Minimum of 32 GB

Note

The above are minimum requirements only. The actual requirements will vary based on the system configuration used to create a virtualization environment with Windows Server 2012 Hyper-V and the applications and features installed. Therefore, we recommend carefully considering the intended Exchange 2013 workloads and their requirements when planning for hardware resources.

For an optimal experience and better performance and stability of Windows Server 2012, customers should utilize hardware that is Certified for Windows Server 2012. Windows Server 2012 is compatible with most common hardware and software and has a large list of items from multiple manufacturers that are part of the Microsoft logo testing programs. The Windows Server Catalog lists thousands of hardware and software items compatible with Windows Server 2012. It is important to select the proper hardware to meet your expected performance and power goals because hardware bottlenecks limit the effectiveness of software tuning.

Windows Server 2012 provides multiple deployment options, including a Server Core Installation, Minimal Server Interface, and Server with a GUI.[6] The *Server Core Installation* option reduces the space required on disk, the potential attack surface, and especially the requirements for servicing and restarting the server. The *Minimal Server Interface* option in Windows Server 2012 does not include many aspects of Server Graphical Shell. With this option enabled, you can perform most of the GUI management tasks without requiring Internet Explorer or the full Server Graphical Shell.[7] Minimal Server Interface has more options/features than Server Core Installation, but it lacks the significant GUI components of the full installation. The *Server with a GUI* option is the Windows Server 2012 equivalent of the full installation option available in Windows Server 2008 R2.

Best Practices and Recommendations

Use the Server Core Installation option for setting up Hyper-V hosts in an Exchange virtualization environment. This helps to reduce the servicing footprint and potential attack surface of the host. **The Server Core Installation option, however, cannot be used to host the Exchange 2013 components themselves**. These should be installed on a full GUI installation of Windows Server.

Scalability Maximums of Windows Server 2012 Hyper-V

Windows Server 2012 Hyper-V provides significant scalability improvements over Windows Server 2008 R2 Hyper-V. Hyper-V in Windows Server 2012 greatly expands support for the number of host processors and memory for virtualization—up to 320 logical processors and 4 TB physical memory, respectively. In addition, Hyper-V includes support for up to 64 virtual processors and 1 TB memory per virtual machine, a new VHDX virtual hard disk (VHD) format with a larger disk capacity of up to 64 TB, and additional resiliency and alignment benefits when working with large sector disks. These features help to ensure that Hyper-V as a virtualization platform provides the highest levels of performance for workloads that customers may have previously thought could not be virtualized.

Table 1 highlights additional improvements by comparing the resources supported by Hyper-V in Windows Server 2012 to those supported in Windows Server 2008 R2:[8, 9]

Table 1: Resources available across versions of Windows Server

	Resource	Windows Server 2008 R2 Hyper-V	Windows Server 2012 Hyper-V	Improvement Factor
Host	Logical Processors	64	**320**	**5×**
	Physical Memory	1 TB	**4 TB**	**4×**
	Virtual CPUs per Host	512	**2,048**	**4×**
VM	Virtual CPUs per VM	4	**64**	**16×**
	Memory per VM	64 GB	**1 TB**	**16×**
	Active VMs per Host	384	**1,024**	**2.7×**
	Guest NUMA	No	**Yes**	**-**
Cluster	Maximum Nodes	16	**64**	**4×**
	Maximum VMs	1,000	**8,000**	**8×**

Significant improvements also have been made within Windows Server 2012 Hyper-V to support increased cluster size and a higher number of active virtual machines per host. Windows Server 2012 Hyper-V supports up to 8,000 virtual machines on a 64-node failover cluster. This is eight times and four times, respectively, the support provided by Windows Server 2008 R2.[10] In addition, more advanced performance features, such as in-guest Non-Uniform Memory Access (NUMA), are supported by Windows Server 2012 Hyper-V virtual machines. Providing these enhancements helps to ensure that customers can achieve the highest levels of scalability, performance, and density for their mission-critical workloads.

Microsoft Assessment and Planning Toolkit

IT infrastructure for server virtualization requires proper planning, which includes gathering details related to the hardware that resides in current environments. The Microsoft Assessment and Planning Toolkit provides server utilization data for Hyper-V server virtualization planning; identifies server placements; and performs virtualization candidate assessments, including return on investment (ROI) analysis for server consolidation with Hyper-V.

Compute Considerations

Organizations need virtualization technology that can support the massive scalability requirements of a demanding Exchange 2013 deployment. One of the key requirements to virtualizing such workloads is to have a large amount of processing and memory power. Therefore, when planning to virtualize mission-critical, high-performance workloads, you must properly plan for these compute resources.

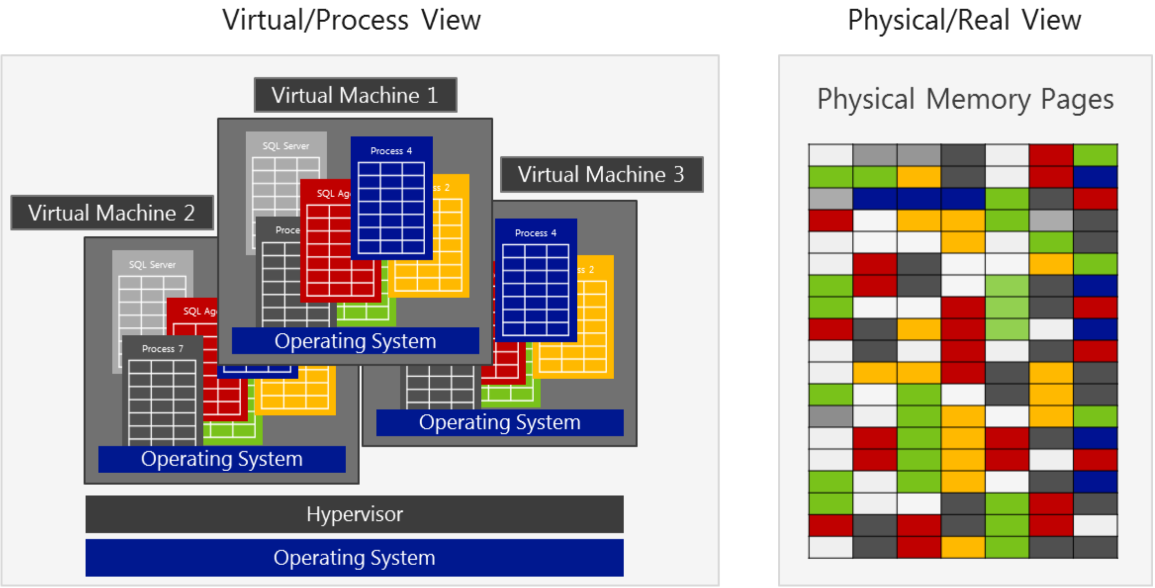
Logical Processors on Hardware

Logical processors are representations or abstractions of a processor's physical cores themselves or of the number of threads that can be handled by a single physical core of a processor. Windows Server 2012 can run on host servers supporting up to 320 logical processors. With Windows Server 2012, there is no enforced limit on the virtual processor to logical processor (VP:LP) ratio. Users can have as many virtual processors associated with a logical processor as the hardware will allow. However, it is better to test the VP:LP ratio compatibility of the workload that needs to be virtualized to a level where the performance is not adversely affected. **For any virtual machine in an Exchange 2013 deployment, we recommend a ratio of 1:1, but a ratio of up to 2:1 is officially supported**. Oversubscribing the CPU on the virtualization host can decrease performance, depending on how much the CPU is oversubscribed.

Hyper-V also benefits from larger processor caches, especially for loads that have a large working set in memory and in virtual machine configurations where the VP:LP ratio is high.[11]

Customers can use processors that support **Second Level Address Translation (SLAT)** technologies (that is, SLAT-based processors). SLAT technologies add a second level of paging functionality under the paging tables of x86/x64 processors. They provide an indirection layer that maps virtual machine memory addresses to physical memory addresses, which reduces load on the hypervisor for address translation (Figure 2).

Figure 2: Virtual memory and SLAT



SLAT technologies also help to reduce CPU and memory overhead, thereby allowing more virtual machines to be run concurrently on a single Hyper-V machine. The Intel SLAT technology is known as *Extended Page Tables* (EPT); the AMD SLAT technology is known as *Rapid Virtualization Indexing* (RVI), formerly *Nested Paging Tables* (NPT).

Best Practices and Recommendations

For optimal performance of demanding workloads like Exchange 2013, run Windows Server 2012 Hyper-V on SLAT-capable processors/hardware. This offers the additional benefits of improved performance, greater virtual machine density per host machine, and reduced overhead as compared to non-SLAT systems.

Virtual Processors

A virtual processor or a virtual CPU (vCPU) is a representation of the physical core of a processor or the threads/logical processors in the core. A virtual machine is configured with at least one vCPU that represents time on the physical CPU resource stack. Hyper-V supports configuring virtual machines with more than one virtual processor from multiple physical or logical processors. In other words, one virtual machine can be configured to use multiple physical processor cores at the same time, and this can increase performance in many cases. Such virtual machines are called Symmetric Multi-Processing (SMP) virtual machines. With SMP functionality, applications can benefit from multi-threading while running virtual machines on Hyper-V, thereby enabling workload performance to be optimally distributed as long as enough cores are available. This can be achieved by monitoring the CPU workload on the host.

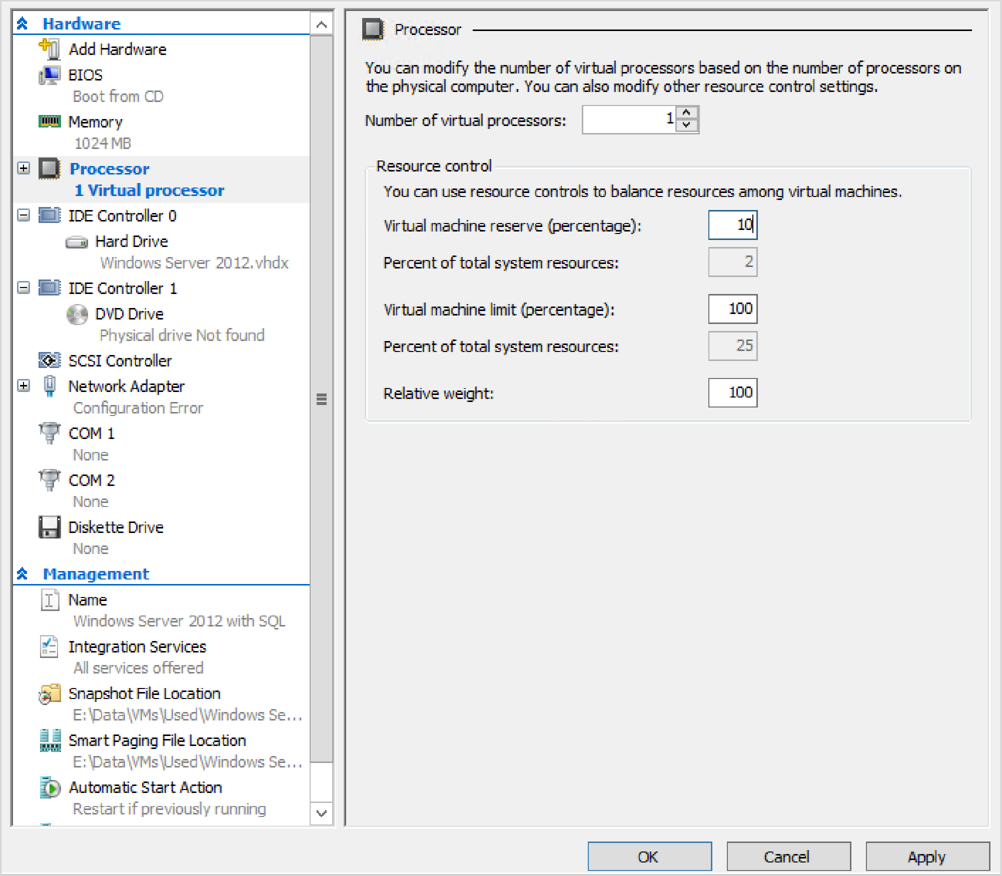
As previously discussed, Windows Server 2012 Hyper-V supports virtual machines with up to 64 virtual processors and 1TB memory. With increased support for 320 logical processors on a host machine, Hyper-V in Windows Server 2012 can now support up to 2,048 virtual processors per host.

Note

Unlike the earlier version of Windows Server, there is no VP:LP ratio imposed by Hyper-V in Windows Server 2012. However, **Exchange 2013 supports a VP:LP ratio of no greater than 2:1—and a ratio of 1:1 is recommended**.

Windows Server 2012 Hyper-V also provides the Weights and Reserves feature (Figure 3). Weights are assigned to a virtual processor to grant it a larger or smaller share of CPU cycles than the average cycle share. Reserves are set for a virtual processor to ensure that it gets at least a specified percentage of the total possible CPU usage of a virtual machine when there is contention for CPU resources. Simply put, if there is higher demand for CPU than is physically available, Hyper-V ensures that a virtual machine needing CPU resources gets at least its CPU reserve when there is contention.[12] This feature is especially beneficial for system administrators who want to prioritize specific virtual machines depending on the load they have or need to handle.

Figure 3: Weights and reserves in Windows Server 2012



Hardware

Add Hardware

BIOS
Boot from CD

Memory
1024 MB

Processor
1 Virtual processor

IDE Controller 0

Hard Drive
Windows Server 2012.vhdx

IDE Controller 1

DVD Drive
Physical drive Not found

SCSI Controller

Network Adapter
Configuration Error

COM 1
None

COM 2
None

Diskette Drive
None

Management

Name
Windows Server 2012 with SQL

Integration Services
All services offered

Snapshot File Location
E:\Data\VMs\Used\Windows Se...

Smart Paging File Location
E:\Data\VMs\Used\Windows Se...

Automatic Start Action
Restart if previously running

Processor

You can modify the number of virtual processors based on the number of processors on the physical computer. You can also modify other resource control settings.

Number of virtual processors: 1

Resource control

You can use resource controls to balance resources among virtual machines.

Virtual machine reserve (percentage): 10

Percent of total system resources: 2

Virtual machine limit (percentage): 100

Percent of total system resources: 25

Relative weight: 100

Best Practices and Recommendations

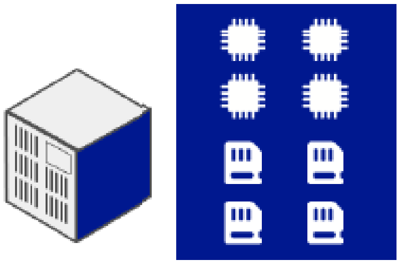
The Weights and Reserves feature, when used properly, can be a great tuning mechanism for Exchange 2013 virtual machines. If CPU resources are overcommitted through other additional workloads, you can set weights and reserves to optimize the way these resources are used so that the Exchange 2013 VMs have priority. Ideally, you should not oversubscribe CPU resources in environments where Exchange 2013 is virtualized.

Non-Uniform Memory Access – Host Perspective

In single system bus architecture, all processors fetch memory from a single pool, and all requests for memory are sent using a single system bus. One problem with this architecture is that as the speed and number of processors increase, it becomes difficult for the system to handle a large number of memory requests. This leads to issues such as memory latency and scalability limitations. While one solution for such issues is to have larger cache size, this helps only to a certain extent. The issues related to memory access can be best resolved with NUMA.[13]

NUMA is a memory design architecture that delivers significant advantages over the single system bus architecture and provides a scalable solution to memory access problems. In a NUMA-supported operating system, CPUs are arranged in smaller systems called *nodes* (Figure 4). Each node has its own processors and memory, and is connected to the larger system through a cache-coherent interconnect bus.[14]

Figure 4: NUMA node (processor and memory grouped together)

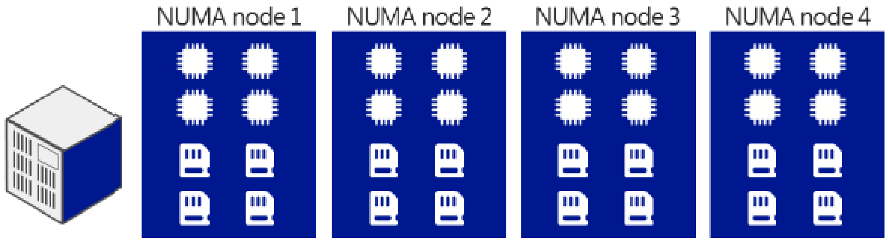


Multiple NUMA nodes can exist in a host system (Figure 5). In the context of multiple nodes:

- Local memory is attached directly to the processor (grouped into a node).
- Remote memory is local to another processor in the system (another node).

This grouping into nodes reduces the time required by a processor to access memory (locally located), as the processor can access local memory faster than remote memory.[15]

Figure 5: Multiple NUMA nodes on a single host



Root/Host Reserve

Root reserve or host reserve is the amount of memory that is reserved for the root partition and is guaranteed to be available to the root partition. It is not allocated to any of the virtual machines running in the child partition. Hyper-V automatically calculates root reserve based on the physical memory available on the host system and system architecture.[16]

Best Practices and Recommendations

The root partition must have sufficient memory to provide services such as I/O virtualization, virtual machine snapshot, and management to support the child partitions. Hyper-V calculates an amount of memory (known as the *root reserve*), which is guaranteed to be available to the root partition. This memory is never assigned to virtual machines. Root reserve is calculated automatically, based on the host's physical memory and system architecture.

Page File Guidance

When a machine runs low on memory and needs more immediately, the operating system uses hard disk space to supplement system RAM through a procedure called *paging*. Too much paging degrades overall system performance. However, you can optimize paging by using the following best practices and recommendations for page file placement.

Best Practices and Recommendations

Let the Windows Server 2012 Hyper-V host operating system handle the page file sizing. It is well optimized in this release.

Isolate the page file on its own storage devices, or at least make sure it does not share the same storage devices as other frequently accessed files. For example, place the page file and operating system files on separate physical disk drives.

Place the page file on a drive that is not fault-tolerant. Note that if the disk fails, a system crash is likely to occur. If you place the page file on a fault-tolerant drive, remember that fault-tolerant systems are often slower to write data because they do so to multiple locations.

Use multiple disks or a disk array if you need additional disk bandwidth for paging. Do not place multiple page files on different partitions of the same physical disk drive.

The following additional best practices and recommendations should be considered while planning and managing host compute (CPU and memory) resources.[17]

Best Practices and Recommendations

While performing capacity planning for virtualizing workloads, always count the number of cores required and not the number of logical processors/threads required.

Note: Dynamic Memory is not supported for Exchange 2013 and is not NUMA-aware. When you are planning how to use the host server's memory, it is important to consider the virtualization-related overhead. Whether you choose to use NUMA and/or Dynamic Memory, both have some overhead related to memory management in the virtualized environment. There may be scenarios when using NUMA and/or Dynamic Memory may not be the best option. For Exchange Server, memory allocations must be statically configured. **Properly plan the memory requirements for running Exchange 2013 workloads on Windows Server 2012, and do not use Dynamic Memory for Exchange 2013 virtual machines**. (For more information, see our NUMA best practices and recommendations).

There is an additional load on root server processors because the root servers manage running guest machines. This overhead varies in different scenarios; however, it is good to consider some percent of overhead when planning/sizing the host processors.[18]

Storage Considerations

Storage configuration is one of the critical design considerations for any Mailbox Server role in Exchange 2013. With a growing number of physical storage devices resulting in increased power use, organizations want to reduce energy consumption and hardware maintenance costs through virtualization. Running Exchange 2013 on hardware that is either underutilized or oversubscribed increases overall operational costs, including the cost of providing power, cooling, and storage infrastructure, as well as the administrative overhead of maintaining storage capacity on this hardware.

Windows Server 2012 Hyper-V has a number of different storage options for storing the virtual disks and related data associated with a virtualized Exchange 2013 infrastructure, providing the administrator with flexibility to choose based on desired levels of performance, resiliency, and budget.

Storage Options for Hyper-V Virtual Machines

Storage virtualization helps administrators perform backup, archiving, and recovery tasks by reducing the complexity of storage devices and the time required to manage them. Windows Server 2012 introduces a class of sophisticated storage virtualization enhancements that can be easily implemented to develop resilient infrastructure. These enhancements use two new concepts: Storage Spaces and Storage Pools.

Storage Spaces

With the Storage Spaces technology, you can achieve a desired level of resiliency through automatic or controlled allocation of heterogeneous storage media presented as one logical entity. Storage Spaces shields the physical disks and presents selected storage capacity as pools, known as *storage pools*, in which a virtual disk, known as a *storage space*, can be created. Storage Spaces supports two optional resiliency modes: mirror and parity. These provide per-pool support for disks that are reserved for replacing failed disks (hot spares), background scrubbing, and intelligent error correction. In case of a power failure or cluster failover, the integrity of data is preserved so that recovery happens quickly and does not result in data loss.

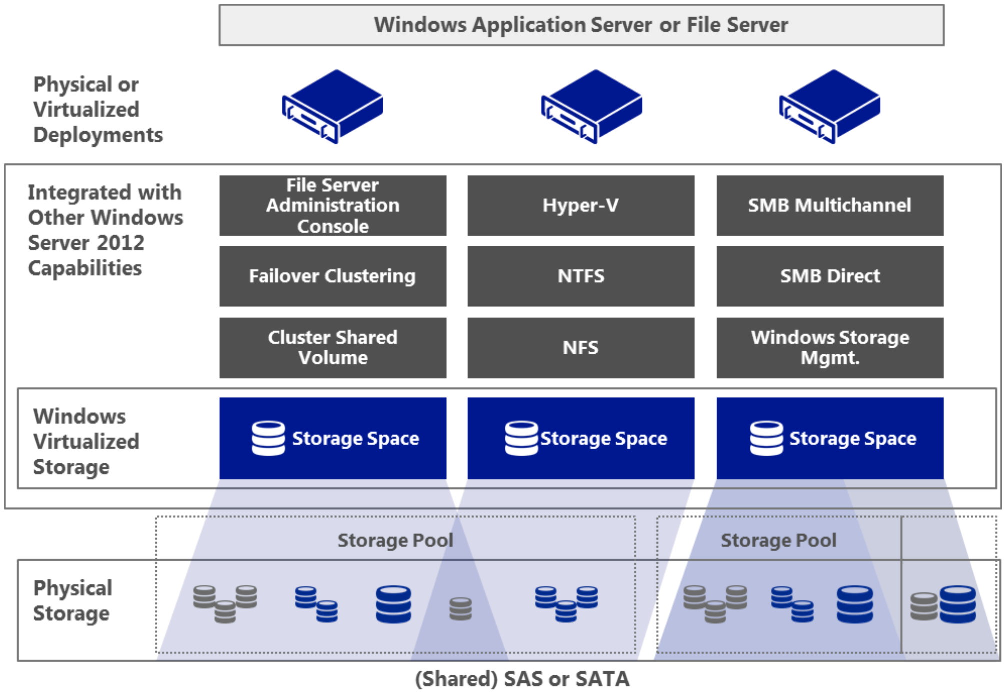
The Storage Spaces technology is fully integrated with failover clustering to enable continuously available service deployments. One or more storage pools can be clustered across multiple nodes within a single cluster. Storage Spaces supports thin provisioning to allow organizations to easily share storage capacity among multiple unrelated data sets, thereby maximizing capacity use. Fully scriptable management is enabled through the Windows Storage Management API, Windows Management Instrumentation (WMI), and Windows PowerShell. Storage Spaces also can be managed through the File and Storage Services role in Server Manager. Finally, Storage Spaces provides notifications when the amount of available capacity in a storage pool hits a configurable threshold.

Storage Pools

Storage pools are a collection of disks used for storing replicas, shadow copies, and transfer logs and are the fundamental building blocks for Storage Spaces (Figure 6). In Windows Server 2012, storage pools are a collection of physical disks grouped together into one or more containers. This allows for storage aggregation, flexible capacity expansion, and delegated administration of storage. Windows Server 2012 maps a storage pool by combining a group of hard disks and/or solid-state drives (SSDs). By simply adding additional drives, storage pools are dynamically expanded to handle the growing size of data.

Thinly provisioned virtual disks can be provisioned from the available capacity. Thin provisioning helps to reserve the actual capacity by reclaiming capacity on the space when files are deleted or no longer in use.

Figure 6: Conceptual deployment model for storage spaces and storage pools



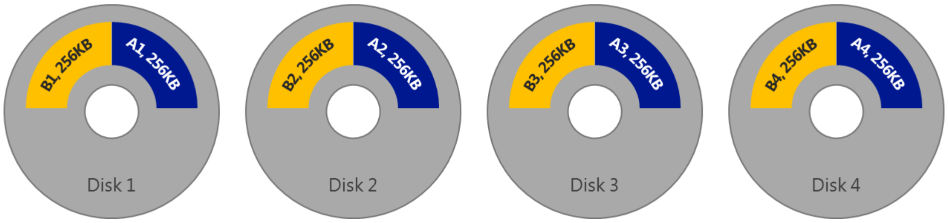
Types of Storage Spaces

There are three key types of storage spaces: simple/striped spaces, mirror spaces, and parity spaces. Each is discussed in more detail below.[19]

Simple spaces/striped spaces: Simple storage spaces are used for storing temporary data because they are non-resilient to disk failures. Striping is the process of writing data across multiple disks to reduce access and response times. Logical blocks of data with a defined size are laid out in a sequential circular manner across multiple disks. This helps in balancing the storage load across all physical drives. Striping provides the overall best performance in terms of reads and writes but, as noted, provides no resiliency.

In Figure 7, there are four disks, and 1 MB of data needs to be written to these disks. In this case, there are two options for writing data to the disks: Either write all of the data to a single disk and access it from there, or write 256 KB to each of the four disks simultaneously. The second option results in a quadruple decrease in write times.[20] The greater the number of disks Storage Spaces can stripe across, the better the performance will be.

Figure 7: Striped storage space across four disks



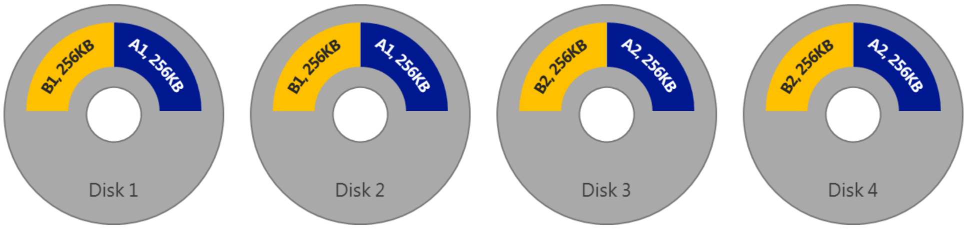
Striped storage spaces can be used for the following:

- Delivering the overall best performance in terms of reads and writes.
- Balancing the overall storage load across all physical drives.
- Backing up disks to increase backup throughput or to distribute the use of space across disks.

Mirror spaces: This data layout process uses the concept of mirroring to create copies of data on multiple physical disks. A logical virtual disk is created by combining two or more sets of mirrored disks. Mirror storage spaces are resilient in nature because in the event of failure, if one copy is lost, the other is still available. To make them resilient from disk failures, mirror spaces are configured to at least one (two-way mirror) or two (three-way mirror) concurrent physical disks.

In Figure 8, 512 KB of data needs to be written to the storage space. For the first stripe of data (A1), Storage Spaces writes 256 KB of data to the first column, which is written in duplicate to the first two disks. For the second stripe of data (A2), Storage Spaces writes 256 KB of data to the second column, which is written in duplicate to the next two disks. The column-to-disk correlation of a two-way mirror is 1:2, while for a three-way mirror, the correlation is 1:3. Reads on mirror spaces are very fast because they are done from either of the two copies of data. If disks 1 and 3 are busy servicing another request, the needed data can be read from disks 2 and 4.

Figure 8: Mirror storage space across four disks



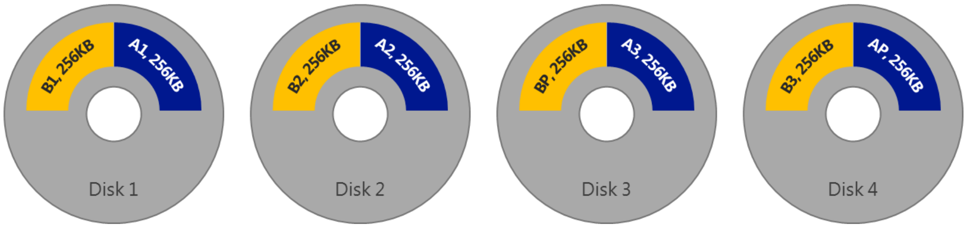
Mirror storage spaces are used for the following:

- Enabling faster reads on data.
- Increasing resiliency and protection from disk failures.

Parity spaces: Parity storage spaces store parity-bit information that helps in reconstructing data from a failed disk. This can be useful in providing data recovery capabilities. Storage Spaces uses rotating parity that stores data and parity information by rotating from stripe to stripe across different disks. Parity spaces tend to have lower write performance than mirror spaces because each parity block takes time in updating itself to the corresponding modified data block. Parity is more cost efficient than mirroring because it requires only one additional disk per virtual disk, instead of double or triple the total number of disks in an array.

In Figure 9, for the first stripe of data, 768 KB is written across disks 1 through 3 (A1, A2, A3), while the corresponding parity bit (AP) is placed on disk 4. For the second stripe of data, Storage Spaces writes the data on disks 1, 2, and 4, thereby rotating the parity to disk 3 (BP). Because parity is striped across all disks, it provides good read performance and resiliency to single disk failure.

Figure 9: Parity storage space across four disks

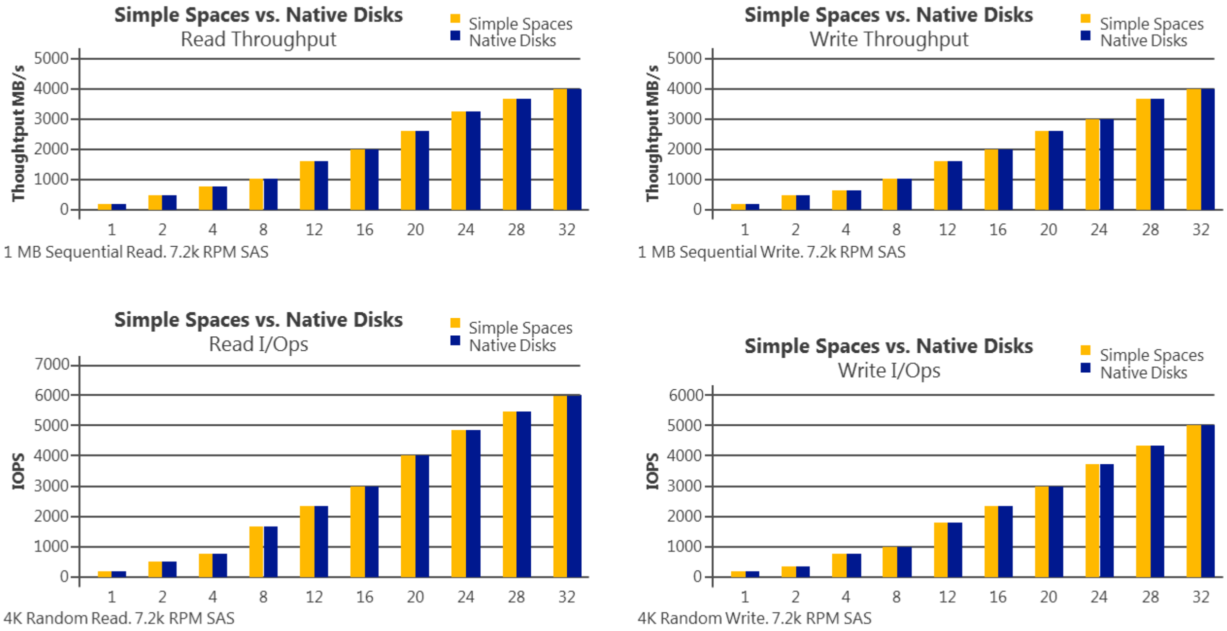


Parity storage spaces are used for the following:

- Providing data recovery of failed disks.
- Offering efficient capacity utilization.
- Delivering faster read operations.
- Providing bulk backups by writing data in large sequential append blocks.

The graphs in Figure 10 show the performance scaling of a simple storage space with up to 32 disks, which resulted in a random read 1.4 million IOPS and 10.9 GB/sec of sequential throughput.[21]

Figure 10: Performance scaling of a simple storage space



Storage Protocols and Additional Features

Various storage protocols can help in virtualizing workloads to connect easily and reliably to existing storage arrays. These storage protocols include a vast number of storage feature enhancements that increase administrative flexibility, efficiency, and control by centralizing management of storage volumes. Apart from storage protocols, Windows Server 2012 allows efficient data movement using intelligent storage arrays and enables rapid provisioning and migration of virtual machines. Some of these storage protocols and features are described below.

Server Message Block 3.0

The Server Message Block (SMB) protocol is a network file sharing protocol that allows applications to read, create, update, and access files or other resources at a remote server. The SMB protocol can be used on top of its TCP/IP protocol or other network protocols. Windows Server 2012 introduces the new 3.0 version of the SMB protocol that greatly enhances the reliability, availability, manageability, and performance of file servers. SMB 3.0 also allows you to create a failover cluster without shared storage or expensive storage area networks (SANs).

Hyper-V over SMB

By enabling Hyper-V to use SMB file shares, you can greatly enhance performance with easy and inexpensive deployments of virtual storage. Hyper-V over SMB can be used to keep virtual storage (.vhd and .vhdx files) on a remote file server rather than requiring the Hyper-V host to manage the storage for its many virtual machines. This allows Hyper-V hosts to provide compute resources with many processors and RAM while using virtual storage resources provided by file servers. Hyper-V over SMB requires:

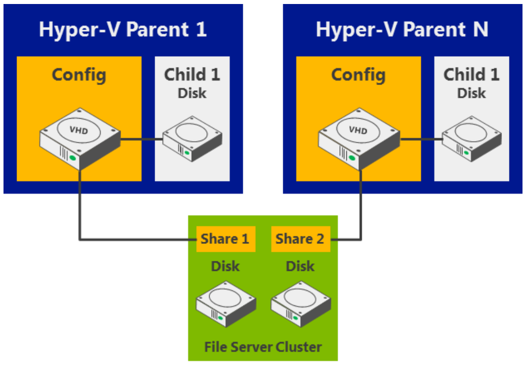
- One or more computers running Windows Server 2012 with the Hyper-V and File and Storage Services roles installed.
- A common Active Directory infrastructure. (The servers running Active Directory Domain Services do not have to run Windows Server 2012.)

Note that failover clustering on the Hyper-V side, the File and Storage Services side, or both is optional.

Hyper-V over SMB supports a variety of flexible configurations that offer different levels of capabilities and availability. These configurations include Single-Node File Server, Dual-Node File Server, and Multi-Node File Server, as shown in the following figures.[22]

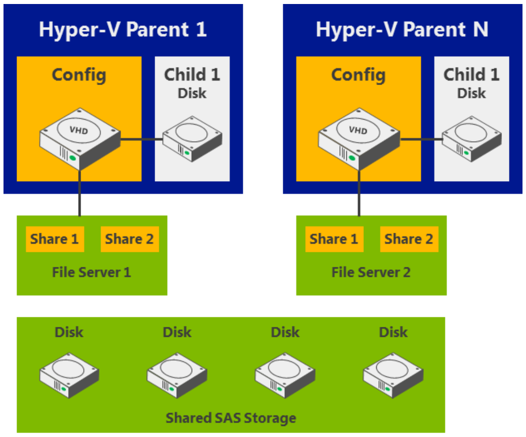
Single-Node File Server: In a Single-Node File Server, Hyper-V shares are used for VHD storage (Figure 11). File servers use standalone and local storage. This configuration provides flexibility for shared storage, as well as low costs for acquisition and operation. It does not provide continuous availability. Storage is not fault-tolerant, and Hyper-V virtual machines are not highly available.

Figure 11: Single-Node File Server



Dual-Node File Server: In a Dual-Node File Server, file servers can be clustered storage spaces, where shares are used for VHD storage (Figure 12). This configuration provides flexibility for shared storage, fault-tolerant storage, and low costs for acquisition and operation. It also offers continuous availability but with limited scalability.

Figure 12: Dual-Node File Server



Multi-Node File Server: A Multi-Node File Server uses clustered Hyper-V file servers and storage spaces, where shares are used for VHD storage (Figure 13). This configuration provides flexibility for shared storage, fault-tolerant storage, and low costs for acquisition and operation. It also provides continuous availability, and Hyper-V virtual machines are highly available.

Figure 13: Multi-Node File Server

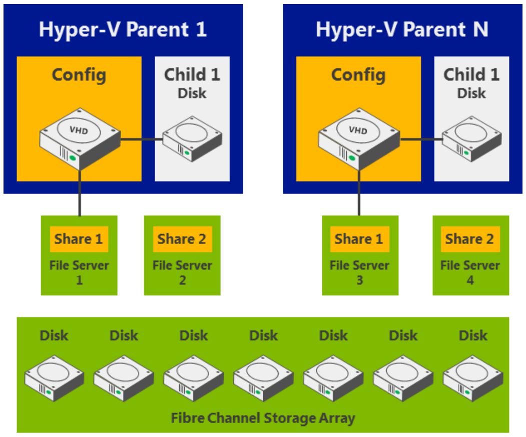


Table 2 compares the cost and availability/scalability of the three configurations for Hyper-V over SMB.

Table 2: Comparison of Hyper-V over SMB configurations

	Single-Node File Server	Dual-Node File Server	Multi-Node File Server
Cost	Lowest cost for shared storage	Low cost for continuously available shared storage	Higher cost, but still lower than connecting all Hyper-V hosts with Fibre Channel (FC)
Availability/ Scalability	Shares not continuously available	Limited scalability (up to a few hundred disks)	Highest scalability (up to thousands of disks)

Best Practices and Recommendations

Fixed of dynamic virtual disks may be stored on SMB 3.0 files that are backed by block-level storage if the guest machine is running on Windows Server 2012 Hyper-V (or a later version of Hyper-V). The only supported usage of SMB 3.0 file shares is for storage of fixed or dynamic virtual disks. Such file shares cannot be used for direct storage of Exchange data. When using SMB 3.0 file shares to store fixed or dynamic virtual disks, configure the storage backing the file share for high availability to ensure the best possible availability of the Exchange virtual machines.

SMB Multichannel

Both the SMB client and SMB server must support SMB 3.0 to take advantage of the SMB Multichannel functionality. SMB Multichannel increases network performance and availability for file servers. SMB Multichannel allows file servers to use multiple network connections simultaneously. This increases throughput by transmitting more data using multiple connections for high-speed network adapters or multiple network adapters. When using multiple network connections at the same time, the clients can continue to work uninterrupted despite the loss of a network connection. SMB Multichannel automatically discovers the existence of multiple available network paths and dynamically adds connections as required.

Best Practices and Recommendations

If you use SMB storage with Hyper-V, use multiple network adapters to take advantage of SMB Multichannel, as this provides increased performance and resiliency.

SMB Direct (SMB over RDMA)

Windows Server 2012 introduces SMB Direct, a feature that provides the ability to use Remote Direct Memory Access (RDMA) network interfaces for high throughput with low latency and CPU utilization. SMB Direct supports the use of network adapters that have RDMA capability. Network adapters with RDMA can function at full speed with very low latency, while using very little CPU. For workloads such as Hyper-V or Exchange Server, this enables a remote file server to resemble local storage. SMB Direct is automatically configured by Windows Server 2012 and includes the following benefits:

- **Increased throughput**: Takes advantage of the full throughput of high-speed networks where the network adapters coordinate the transfer of large amounts of data at line speed.
- **Low latency**: Provides extremely fast responses to network requests and, as a result, makes remote file storage feel as if it is directly attached block storage.
- **Low CPU utilization**: Uses fewer CPU cycles when transferring data over the network, which leaves more power available to server applications.

By supporting mission-critical application workloads, the new SMB server and client cooperate to provide transparent failover to an alternative cluster node for all SMB operations for planned moves and unplanned failures. This results in reduced cost, improved high availability, and increased performance for workloads in a virtualized environment.

Best Practices and Recommendations

SMB Direct works with SMB Multichannel to transparently provide exceptional performance and failover resiliency when multiple RDMA links between clients and SMB file servers are detected. Also, because RDMA bypasses the kernel stack, it does not work with Network Interface Card (NIC) Teaming, but does work with SMB Multichannel (because SMB Multichannel is enabled at the application layer).

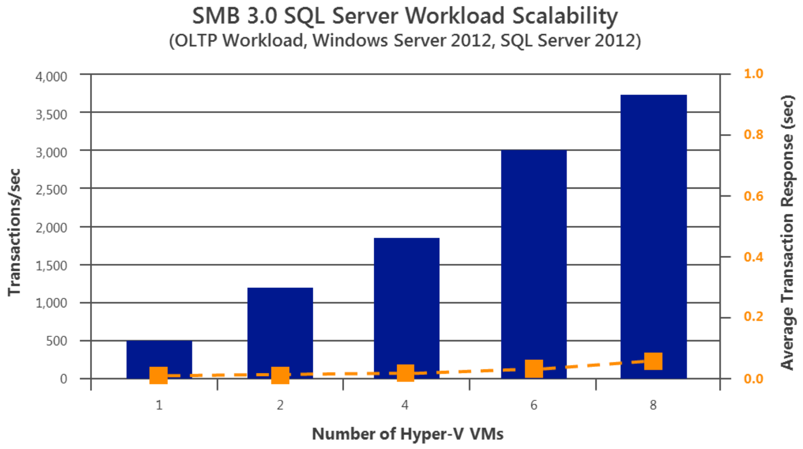
Customers with existing investments in enterprise-class storage arrays that support the SMB 3.0 protocol can connect these arrays directly to the Hyper-V hosts and use them to store the virtual disks (and data) of key applications and workloads.

Loopback configurations are not supported by Hyper-V when the file server is configured on the host where the virtual machines are running.

The ESG Lab tested the SMB 3.0 protocol by using an online transaction processing (OLTP) workload application to simulate the activity of SQL Server users (Figure 14).[23] The goal was to demonstrate the performance, scalability, and efficiency of the SMB protocol, Hyper-V hypervisor, and SQL Server database engine on cost-effective commodity hardware.

A database of 3,000 customers was configured within each of eight SQL Server virtual machines, with a goal of achieving linear scalability for the number of transactions per second as the number of consolidated SQL Server virtual machines increased. The transactions per second and average response time were monitored as the number of customers and virtual machines increased.

Figure 14: Workload scalability with SMB 3.0 and SQL Server



As shown in the graph, as the number of Hyper-V virtual machines increased, the number of transactions per second increased, while recorded average transaction response times were manageably low—even though the virtual machines and respective databases resided on remote file servers accessed using SMB 3.0. The full report and further details are available here.

Internet SCSI

The Internet Small Computer System Interface (iSCSI) protocol is based on a storage networking standard that facilitates data transfers over the Internet and manages storage over long distances, all while enabling hosts to operate as if the disks were attached locally.

An iSCSI target is available as a built-in option in Windows Server 2012; it allows sharing block storage remotely by using the Ethernet network without any specialized hardware. It also provides support for diskless network boot capabilities and continuous availability configurations.

Fibre Channel

Fibre Channel (FC) is a data transmitting technology that enables server-to-storage connectivity at 16 GB and is well suited for connecting storage controllers and drives. Fibre Channel offers point-to-point, switched, and loop interfaces. It is designed to interoperate with SCSI, the Internet Protocol (IP), and other protocols. With the new 16 GB FC, a bi-directional throughput of 3,200 MB/sec can deliver over 1 million IOPS. This enhancement supports deployments of densely virtualized servers, increases scalability, and matches the performance of multicore processors and SSD-based storage infrastructure. 16 GB FC is backward compatible with 8/4 GB FC, allowing them to be seamlessly integrated into expansion segments of existing FC networks.

Windows Server 2012 fully supports FC connectivity for storage of virtual machine files. In addition, Windows Server 2012 Hyper-V provides a new capability for the virtual machines themselves, known as *Hyper-V Virtual Fibre Channel* (VFC). This capability enables connecting to FC storage directly from within virtual machines, opening up new scenarios around guest clustering and providing a more direct path to the underlying FC fabric from within the virtual infrastructure.

Fibre Channel over Ethernet

Fibre Channel over Ethernet (FCoE) offers the benefits of using an Ethernet transport while retaining the advantages of the FC protocol and the ability to use FC storage arrays. This solution helps to reduce costs in several ways, including the elimination of dedicated FC switches and a reduction in cabling (which can be a significant cost in large data center environments). For higher performance and availability, FCoE provides direct connections to the FC host bus adapter (HBA) and SAN fabric from Hyper-V virtual machines.

Best Practices and Recommendations

Some of the vendors supporting FCoE hardware include NetApp, Brocade, Cisco, Intel, QLogic, EMC, and Emulex.

FCoE requires switches that have Data Center Bridging (DCB), which provides the extensions to traditional Ethernet that make it suitable for transporting storage traffic in a lossless way. The DCB capability is available in some 10 GbE switches. Adapters that work with FCoE are known as *converged network adapters* (CNAs). Traditional Ethernet and FC host bus adapter (HBA) vendors provide CNAs and support Ethernet and FC simultaneously over the same wire. These CNAs run at 10 Gbps for both Ethernet and FC.

Best Practices and Recommendations

Standard 10/100, 1 Gb, or 10 GbE do not support FCoE. FCoE runs on versions of Ethernet that have been improved to provide low latency, quality of service, guaranteed delivery, and other functionality traditionally associated with channel interfaces.

Fibre Channel, OM3, and OM4 cabling are suitable for FCoE and 10 GbE.

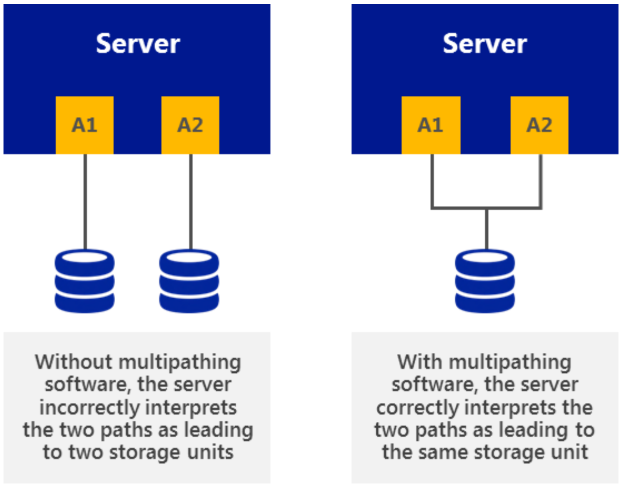
Multipath I/O

Microsoft Multipath I/O (MPIO) is a framework provided by Microsoft for developing multipath solutions that contain hardware-specific information required to enhance connectivity for storage arrays. In other words, MPIO increases the availability of storage resources by providing support for using multiple data paths to a storage device. MPIO uses host-based software, called *device-specific modules* (DSMs), to provide this multipath support. MPIO is protocol-independent and can be used with FC, iSCSI, and Serial Attached SCSI (SAS) interfaces in Windows Server 2012. MPIO in Windows Server 2012 provides the following enhanced features:

- **PowerShell management and configuration**: MPIO can be configured using PowerShell as an alternative to MPCLAIM.exe.
- **Heterogeneous HBA usage with MPIO**: Heterogeneous HBA types now can be used together with non-boot virtual disks only.
- **Support for MPIO with multiport-SAS enclosures**: The use of MPIO with data volumes on a multiport-SAS enclosure is now supported.

An MPIO/multipath driver cannot work effectively until it discovers, enumerates, and configures into a logical group the different devices that the operating system sees through redundant adapters. Figure 15 shows that without any multipath driver, the same devices through different physical paths would appear as different devices, leaving room for data corruption.

Figure 15: The use of multipathing software to correctly identify paths and devices


Server
A1
A2
Without multipathing software, the server incorrectly interprets the two paths as leading to two storage units
Server
A1
A2
With multipathing software, the server correctly interprets the two paths as leading to the same storage unit

With MPIO, Windows Server 2012 efficiently manages up to 32 paths between storage devices and the Windows host operating system, and provides fault-tolerant connectivity to storage. Further, as more data is consolidated on SANs, the potential loss of access to storage resources is unacceptable. To mitigate this risk, high availability solutions like MPIO have become a requirement.

MPIO provides the logical facility for routing I/O over redundant hardware paths connecting servers to storage. These redundant hardware paths are composed of components such as cabling, HBAs, switches, storage controllers, and possibly even power. MPIO solutions logically manage these redundant connections so that I/O requests can be rerouted if a component along one path fails. The MPIO software supports the ability to balance I/O workloads without administrator intervention. MPIO determines which paths to a device are in an active state and can be used for load balancing. Each vendor's load balancing policy setting is set in the DSM. (Individual policy settings may use any of several algorithms—such as Round Robin, Least Queue Depth, Weighted Path, and Least Blocks—or a vendor-unique algorithm.) This policy setting determines how I/O requests are actually routed.

Best Practices and Recommendations

To determine which DSM to use with existing storage, it is important to check with the storage array manufacturer. Multipath solutions are supported as long as a DSM is implemented in line with logo requirements for MPIO. Most multipath solutions for Windows use the MPIO architecture and a DSM provided by the storage array manufacturer. Use the Microsoft DSM provided in Windows Server only if it is also supported by the storage array manufacturer, in lieu of the manufacturer providing its own DSM.

A DSM from the storage array manufacturer may provide additional value beyond the implementation of the Microsoft DSM because the software typically provides auto-configuration, heuristics for specific storage arrays, statistical analysis, and integrated management. We recommend that you use the DSM provided by the storage array manufacturer to achieve optimal performance. This is because storage array manufacturers can make more advanced path decisions in their DSMs that are specific to their arrays, which may result in quicker path failover times.

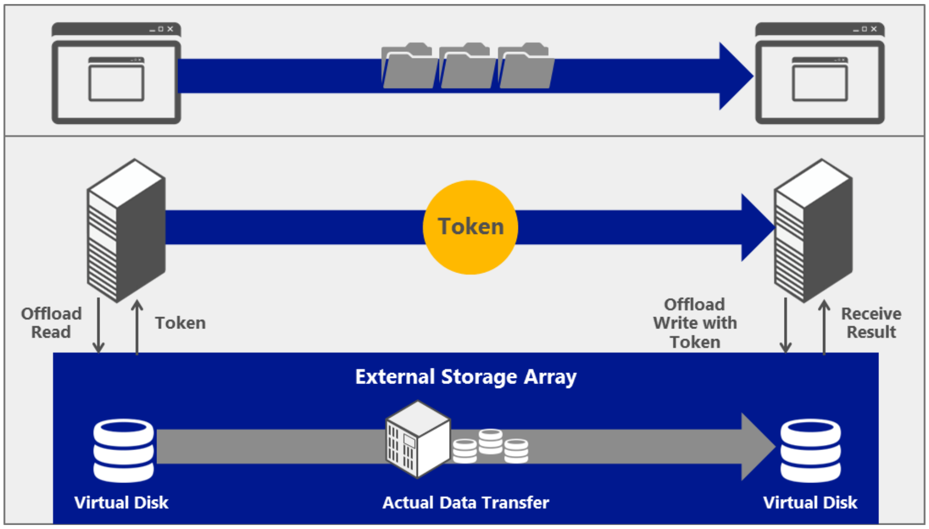
Offloaded Data Transfer

Offloaded Data Transfer (ODX) in Windows Server 2012 enables customers who have invested in storage technologies such as iSCSI or FC SANs to accomplish more with existing external storage arrays. This is because ODX lets you quickly move large files and virtual machines directly between storage arrays, which reduces host CPU and network resource consumption.

ODX enables rapid provisioning and migration of virtual machines and provides significantly faster transfers of large files, such as database or video files. By offloading the file transfer to the storage array, ODX minimizes latencies; maximizes the use of array throughput; and reduces host resource usage, such as CPU and network consumption. File transfers are automatically and transparently offloaded when you move or copy files, regardless of whether you perform drag-and-drop operations in Windows Explorer or use command-line file copy commands. No administrator setup or intervention is needed.

To eliminate the inefficient and unnecessary steps required by traditional host-based file transfers, ODX uses a token-based mechanism for reading and writing data within or between intelligent virtual storage database volumes (Figure 16). Instead of routing the data through the host, a small token is copied between the source and destination. The token serves as a point-in-time representation of the data. For example, when you copy a file or migrate a virtual machine between storage locations, Windows Server 2012 copies the token representing the virtual machine file. This removes the need to copy the underlying data between servers.

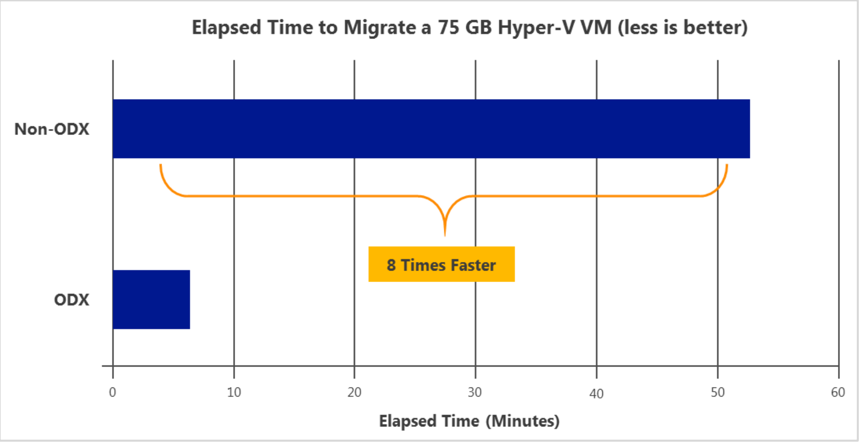
Figure 16: Offloaded Data Transfer in Windows Server 2012



The ESG Lab tested the efficiency and functionality of Offloaded Data Transfer. Two servers were connected to an ODX-compliant Dell EqualLogic storage array.[24] The storage array consisted of 12 SAS drives (600 GB each). A single RAID5 pool was created with two volumes: One contained a 75 GB virtual machine, and the other was empty. Using an intuitive wizard, the ESG Lab configured a virtual machine live migration from one server to another within a SAN. The lab specified the type of move, the server receiving the data, move options, and destination virtual machine options. It then transferred a virtual machine using the traditional non-ODX method and the new ODX method. The lab monitored network utilization and elapsed time for the transfer to complete in both test cases.

The results in Figure 17 show noticeable improvements using ODX. The ODX transfer took approximately 6.5 minutes for the virtual machine to completely migrate to the other server, and the average network bandwidth consumption was around 64 Kb/sec. Conversely, with non-ODX method, moving the 75 GB virtual machine over the network took approximately 52 minutes and consumed 4 Mb/sec of network bandwidth. The ODX method completed eight times faster than the non-ODX method, while consuming virtually no server CPU or network resources.

Figure 17: Faster SAN-attached virtual machine migrations with ODX



Best Practices and Recommendations

If you are using SAS or FC in all clustered servers, all elements of the storage stack should be identical. It is required that the MPIO and DSM software be identical. It is recommended that the mass storage device controllers (that is, the HBA, HBA drivers, and HBA firmware attached to cluster storage) be identical.[25]

If you are using iSCSI, each clustered server should have a minimum of two network adapters or iSCSI HBAs that are dedicated to the cluster storage. The network being used for iSCSI should not be used for network communication. In all clustered servers, the network adapters being used to connect to the iSCSI storage target should be identical, and we recommend that you use Gigabit Ethernet or higher. Network adapter teaming (also called *load balancing and failover*, or LBFO) is not supported for iSCSI. MPIO software should be used instead.

ODX is enabled by default, but check with your storage vendor for support, as upgraded firmware may be required.

Networking Considerations

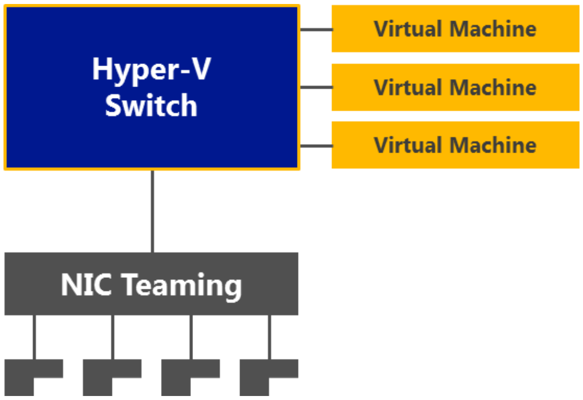
Networking in a virtualized Exchange environment is a critical component for managing traffic in an optimal way. The appropriately architected network seamlessly routes people to their mailboxes while maintaining a consistent end-user experience. Network performance and availability are essential for mission-critical applications like Exchange 2013.

Windows Server 2008 R2 introduced several networking-related features that help to reduce networking complexity while simplifying management tasks. Windows Server 2012 improves on this functionality in several ways, including new and enhanced features for NIC Teaming, the Hyper-V Extensible Switch, virtual LANs (VLANs), and Virtual Machine Queue (VMQ).

Host Resiliency with NIC Teaming

NIC Teaming gives the ability to bond multiple high-speed network interfaces together into one logical NIC to support workload applications that require heavy network I/O and redundancy (Figure 18). Windows Server 2012 offers fault tolerance of network adapters with inbox NIC Teaming. This provides advanced networking capabilities to aggregate bandwidth from multiple network adapters and traffic failovers to prevent connectivity loss (so that failure of one NIC within the team does not affect the availability of the workload).

Figure 18: NIC Teaming in a virtual machine configuration



The built-in NIC Teaming solution in Windows Server 2012:

- Works with all network adapter vendors.
- Eliminates potential problems caused by proprietary solutions.
- Provides a common set of management tools for all adapter types.
- Is supported by Microsoft.

The solution also works within a virtual machine hosted on Hyper-V by allowing virtual network adapters to connect to more than one Hyper-V switch and still have connectivity even if the NIC underlying a certain switch gets disconnected. NIC Teaming uses two basic sets of configuration algorithms to provide better flexibility when designing networking for complex scenarios: switch-dependent mode and switch-independent mode.

Switch-dependent mode: These algorithms require all the network adapters of the team to be connected to the same switch. Two common ways in which the switch-dependent mode can be configured are as follows:

- Generic, or static, teaming (IEEE 802.3ad draft v1) requires configuration on the switch and computer to identify which links form the team.
- Dynamic teaming (IEEE 802.1ax, LACP) uses the Link Aggregation Control Protocol (LACP) to dynamically identify links between the computer and a specific switch.

Switch-independent mode: These algorithms do not require the switch to participate in the teaming. The team network adapters can be connected to different switches because a switch does not know to which network adapter it belongs.

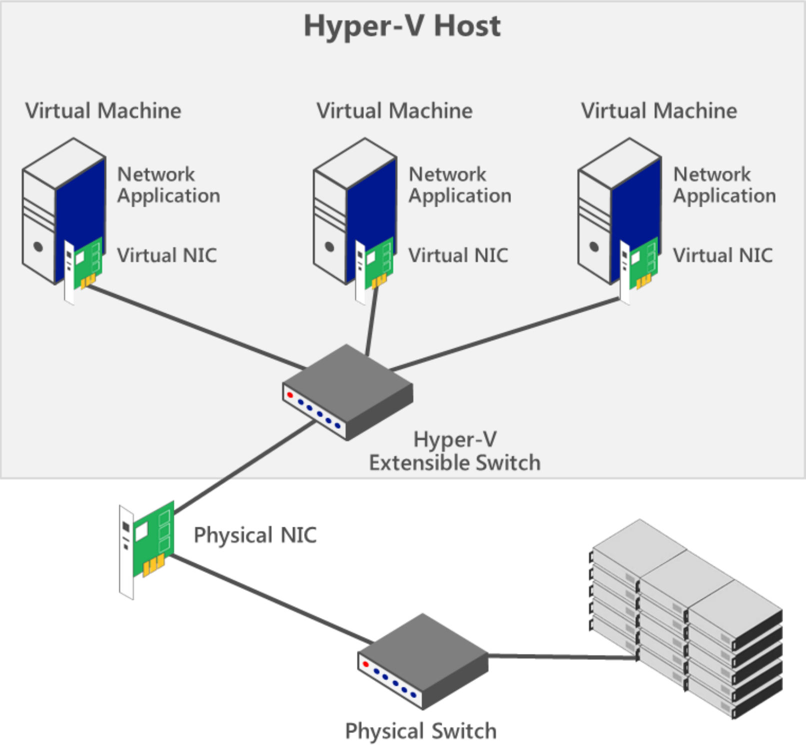
Best Practices and Recommendations

We recommend that you use host-level NIC Teaming to increase resiliency and bandwidth. NIC Teaming supports up to 32 NICs from mixed vendors. It is important to have NICs within a team with the same speed.

Hyper-V Extensible Switch

Shown in Figure 19, the Hyper-V Extensible Switch is a layer-2 virtual interface that provides programmatically managed and extensible capabilities to connect virtual machines to the physical network.[26] With its new features and enhanced capabilities, the Hyper-V Extensible Switch supports tenant isolation, traffic shaping, protection against virtual machines infected with malicious code, and simplified troubleshooting. With built-in support for Network Device Interface Specification (NDIS) filter drivers and Windows Filtering Platform (WFP) callout drivers, the Hyper-V Extensible Switch also enables independent software vendors (ISVs) to create extensible plug-ins (known as *Virtual Switch Extensions*) that can provide enhanced networking and security capabilities.

Figure 19: Hyper-V Extensible Switch



The two public Windows platforms for extending Windows networking functionality are used as follows:

- **NDIS filter drivers**: Used to monitor or modify network packets in Windows.
- **WFP callout drivers**: Used to allow ISVs to create drivers to filter and modify TCP/IP packets, monitor or authorize connections, filter IPsec-protected traffic, and filter RPCs. Filtering and modifying TCP/IP packets provides unprecedented access to the TCP/IP packet processing path.

In this path, the outgoing and incoming packets can be modified or examined before additional processing occurs. By accessing the TCP/IP processing path at different layers, ISVs can easily create firewalls, antivirus software, diagnostic software, and other types of applications and services.

Extensions can extend or replace the following three aspects of the switching process: ingress filtering, destination lookup and forwarding, and egress filtering. Table 3 lists a number of top partners that offer networking extensions for Hyper-V environments, as well as their key extension products.

Table 3: Example options for networking extensions

CISCO	Cisco Nexus® 1000V Series Switches and Cisco Unified Computing System™ Virtual Machine Fabric Extender (VM-FEX)
NEC	NEC ProgrammableFlow PF1000
inMon The Inventors of sFlow®	InMon sFlow Agent
5NINE SOFTWARE	5nine Security Manager for Hyper-V

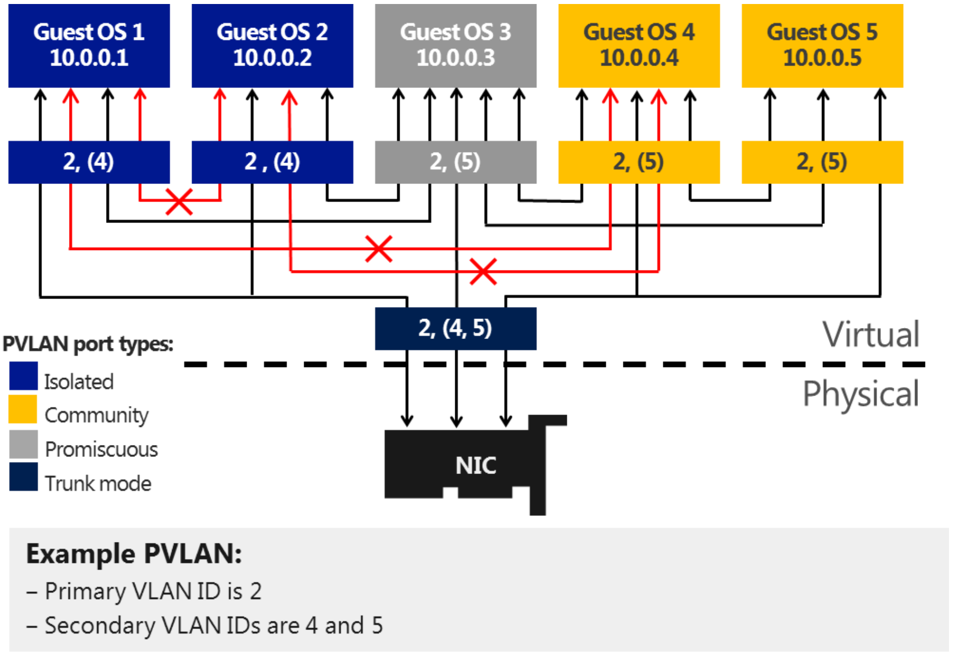
Virtual LANs

Virtual LANs (VLANs) subdivide a network into logical groups that share common physical infrastructure to provide network isolation. A VLAN uses explicit tagging in the Ethernet frames, and relies on Ethernet switches to enforce isolation and restrict traffic to network nodes of the same tag. However, there are some drawbacks with VLANs that limit networking capabilities within a large and complex network that provides communications for mission-critical workloads.

Windows Server 2012 introduces support for private VLANs (PVLANs) that extends the VLAN capabilities by providing isolation between two virtual machines on the same VLAN. Network virtualization in Windows Server 2012 removes the constraints of VLAN and hierarchical IP address assignment for virtual machine provisioning. Windows Server 2012 PVLANs provide scalability and better isolation of workloads. With PVLANs, a VLAN domain can be divided into subdomains that are represented by a pair of VLANs (primary VLAN and secondary VLAN). In such an implementation, every virtual machine in a PVLAN is assigned one primary VLAN ID and one or more secondary VLAN IDs. There are three modes for secondary PVLANs (Figure 20):

- **Isolated**: Isolated ports cannot exchange packets with each other at layer 2. If fact, isolated ports can only talk to promiscuous ports.
- **Community**: Community ports on the same VLAN ID can exchange packets with each other at layer 2. They can also talk to promiscuous ports. They cannot talk to isolated ports.
- **Promiscuous**: Promiscuous ports can exchange packets with any other port on the same primary VLAN ID (secondary VLAN ID makes no difference).

Figure 20: PVLAN in Windows Server 2012



Best Practices and Recommendations

VLANS and PVLANS can be a useful mechanism to isolate different Exchange infrastructures—for instance, a service provider hosting multiple unrelated Exchange infrastructures. For customers with VLAN constraints, PVLANS enable extra levels of isolation granularity within the same VLAN. PVLANS can be configured through PowerShell.

Hardware Offloads – Dynamic Virtual Machine Queue

Virtual Machine Queue (VMQ) allows the host's network adapter to pass DMA packets directly into individual virtual machine memory stacks. Each virtual machine device buffer is assigned a VMQ, which avoids needless packet copies and route lookups in the virtual switch. Essentially, VMQ allows the host's single network adapter to appear as multiple network adapters to the virtual machines, allowing each virtual machine its own dedicated network adapter. The result is less data in the host's buffers and an overall performance improvement to I/O operations.

VMQ is a hardware virtualization technology for the efficient transfer of network traffic to a virtualized host operating system. A VMQ-capable network adapter classifies incoming frames to be routed to a receive queue based on filters that associate the queue with a virtual machine's virtual network adapter. These hardware queues may be affinitized to different CPUs, thereby enabling receive scaling on a per-virtual network adapter basis.

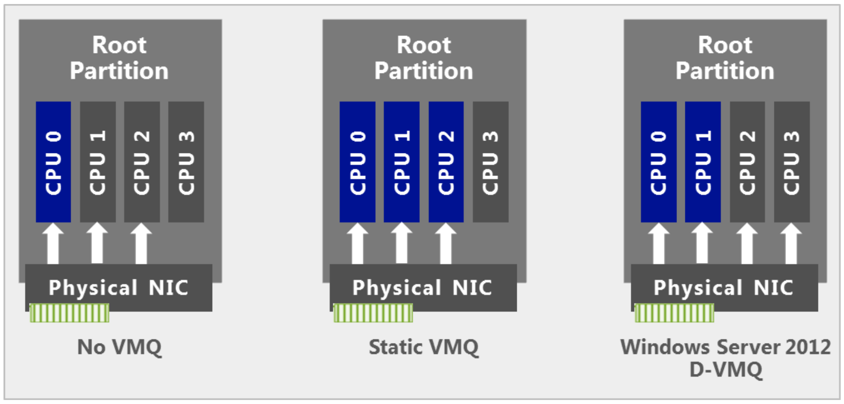
Windows Server 2008 R2 allowed administrators to statically configure the number of processors available to process interrupts for VMQ. Without VMQ, CPU 0 would run hot with increased network traffic. With

VMQ, the interrupts were spread across more processors. However, network load could vary over time. A fixed number of processors may not have be suitable in all traffic regimes.

Windows Server 2012, on the other hand, dynamically distributes the processing of incoming network traffic to host processors, based on processor use and network load. In times of heavy network load, Dynamic VMQ (D-VMQ) automatically uses more processors. In times of light network load, D-VMQ relinquishes those same processors. This helps to ensure that overall performance is optimized.

As shown in Figure 21, without the VMQ technology and RSS, the majority of network processing burdens CPU 0 and ultimately limits the scale of the solution. With D-VMQ, processor cores are dynamically assigned to distribute the workload.

Figure 21: Dynamically distributed workload with D-VMQ for Hyper-V



Best Practices and Recommendations

Some Intel multicore processors may use Intel Hyper-Threading Technology. When Hyper-Threading Technology is enabled, the actual number of cores that are used by D-VMQ should be half the total number of logical processors that are available in the system. This is because D-VMQ spreads the processing across individual physical cores only, and it does not use hyper-threaded sibling cores.

As an example, if the machine has an Intel processor with four physical cores and Hyper-Threading Technology is enabled, it will show a total of eight logical processors. However, only four logical processors are available to VMQ. (VMQ will use cores 0, 2, 4, and 6.)

VMQ provides improved networking performance for the **management operating system as a whole rather than for a specific virtual machine**. For best results, treat queues as a scarce, carefully managed resource. Because queues are allocated to virtual machines on a first-come, first-served basis, making all virtual machines eligible for a queue may result in some queues being given to virtual machines with light traffic instead of those with heavier traffic. **Enable VMQ only for those virtual machines with the heaviest inbound traffic**. Because VMQ primarily improves receive-side performance, providing queues for virtual machines that receive the most packets offers the most benefit for overall performance of the management operating system.

Host Resiliency & VM Agility

For mission-critical workloads, high availability and scalability are becoming increasingly important to ensure that all users can access data and applications whenever they want. Windows Server 2012 Hyper-V provides enhanced capabilities that help to ensure that Exchange 2013 workloads are agile, easy to manage, and highly available at the hypervisor level.

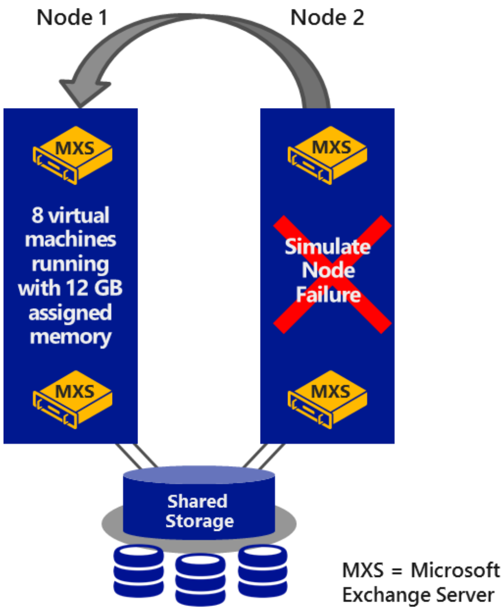
Host Clustering

This subsection discusses the key elements of host clustering, including failover clustering, Cluster Shared Volumes, cluster networking, cluster-aware updating, virtual machine priority, virtual machine affinity, and live migration.

Failover Clustering

Failover clustering allows you to connect physical machines (also called *nodes*) together to provide better scalability and high availability. These clustered nodes work in such a way that if one or more of the active nodes fail, the other nodes in the cluster begin to provide service (Figure 22). Clustered nodes are continuously monitored to ensure that they are working properly. The nodes come to know each other's active status by using a *heartbeat*—a periodic signal between two directly connected machines.

Figure 22: Failover clustering—virtual machines fail over to Node 1 simultaneously


Node 1
Node 2
MXS
MXS
8 virtual machines running with 12 GB assigned memory
Simulate Node Failure
MXS
MXS
Shared Storage
MXS = Microsoft Exchange Server

Best Practices and Recommendations

All hardware should be certified for Windows Server 2012, and the failover cluster solution should pass all tests in the Validate a Configuration Wizard. For more information about validating a failover cluster, see Validate Hardware for a Windows Server 2012 Failover Cluster.

Windows Server 2012 Hyper-V supports scaling clusters up to 64 nodes and 8,000 virtual machines per cluster. Windows Server 2012 also provides Windows PowerShell cmdlets and a snap-in for Failover Cluster Manager, which allows administrators to manage multiple clustered nodes.

The aim of failover clustering is to provide a resilient solution for workloads that are running on top of the cluster. These could be clustered roles such as a file server, a DHCP server, or (as in the case of this paper) a virtual machine. The Windows Server 2012 Failover Clustering capability provides resiliency for a number of other roles or services. Additional information about this capability can be found here.

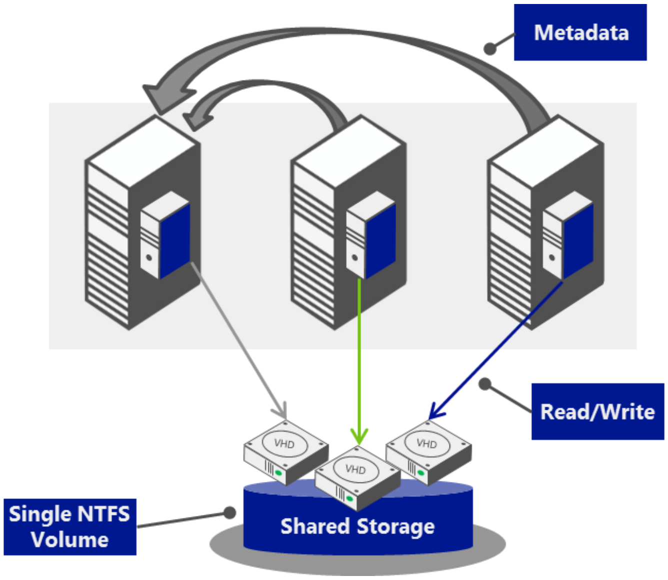
With virtual machines running on top of a Hyper-V cluster, should a Hyper-V cluster node fail, the virtual machines also will experience downtime. However, the remaining cluster nodes immediately start working to bring those virtual machines up again on an alternative node within the cluster—helping to ensure that downtime is minimal and that administrator intervention is not required. This means that the workload—in this case, Exchange 2013—has an extra level of resiliency when compared to a physical implementation. The physical implementation requires the administrator to rely on only application-level resiliency, as opposed to the dual layers of resiliency provided by a clustered Hyper-V implementation. This topic is explored in more detail later in this paper.

Cluster Shared Volumes

With Cluster Shared Volumes (CSV), Windows Server 2012 provides shared storage resources for clustered virtual machines. The CSV technology makes it easy to manage large numbers of LUNs in a failover cluster. CSV allows simultaneous read-write permissions to the same NTFS-provisioned LUN disk from multiple cluster nodes (Figure 23). Due to significant improvements in the CSV design in Windows Server 2012, Cluster Shared Volumes can perform an increased number of operations in direct I/O mode as compared to previous versions of Windows Server. This feature also can be helpful while operating workloads for failover, conducting live migration, or moving workloads. It allows workloads to share the same volume without impacting the other workloads.

- CSV provides better security for mission-critical data by supporting BitLocker Drive Encryption.
- For decrypting data, CSV uses cluster name objects as identity for data decryption.
- CSV provides continuous availability and scalability of file-based server storage for applications or databases using the Scale-Out File Server feature.
- CSV supports two types of snapshots, including application-consistent and crash-consistent Volume Shadow Copy Service (VSS) snapshots.
- CSV supports clustered VHD files for clustered workloads.

Figure 23: Cluster Shared Volumes



Best Practices and Recommendations

To provide high availability, use at least one separate CSV for Exchange 2013 databases/logs so that each mailbox database copy of a particular mailbox database is stored on separate infrastructure. In other words, in a four-copy deployment, a minimum of four CSVs should be used to isolate database copies, and the storage and networking infrastructure used to provide access to those CSVs should be completely isolated, as well.

The following guidelines are recommended for deploying a SAN with a failover cluster:

- Confirm with the manufacturers and vendors whether the storage (including drivers, firmware, and software) being used is compatible with failover clusters in Windows Server 2012. The Windows Server Catalog can be a useful source of guidance for this information.
- Isolate the LUN used for one set of cluster servers from all other servers through LUN masking or zoning.
- Use multipath I/O software for the highest level of redundancy and availability when connecting your hosts to iSCSI or FC storage.

Cluster Networking

Before you begin to construct the failover cluster that will form the resilient backbone for key virtualized workloads, it is important to ensure that the networking is optimally configured. Clusters, as a minimum, require 2 x 1 GbE network adapters; however, for a traditional production Hyper-V failover cluster, it is recommended that a greater number of adapters be used to provide increased performance, isolation, and resiliency.

As a base level for customers using gigabit network adapters, **8 network adapters** are recommended. This provides the following:

- 2 teamed NICs used for **Hyper-V host management** and the **cluster heartbeat**.
- 2 teamed NICs used by a **Hyper-V Extensible Switch** to allow **virtual machine communication**.
- 2 teamed NICs used by **Cluster Shared Volumes** for traffic and communication.
- 2 teamed NICs used for **live migration** of virtual machines.

Moreover, if a customer is using **iSCSI storage**, an **additional 2 NICs** should be included for connectivity from host to storage, and MPIO should be used instead of NIC Teaming. Alternatively, if the customer is using **SMB storage** for the cluster, the hosts should have **2 NICs**, but SMB Multichannel (or SMB Direct, if RDMA is present) should be used to provide enhanced throughput and resiliency. So, in total, 10 NICs as a minimum are mandated for a customer who:

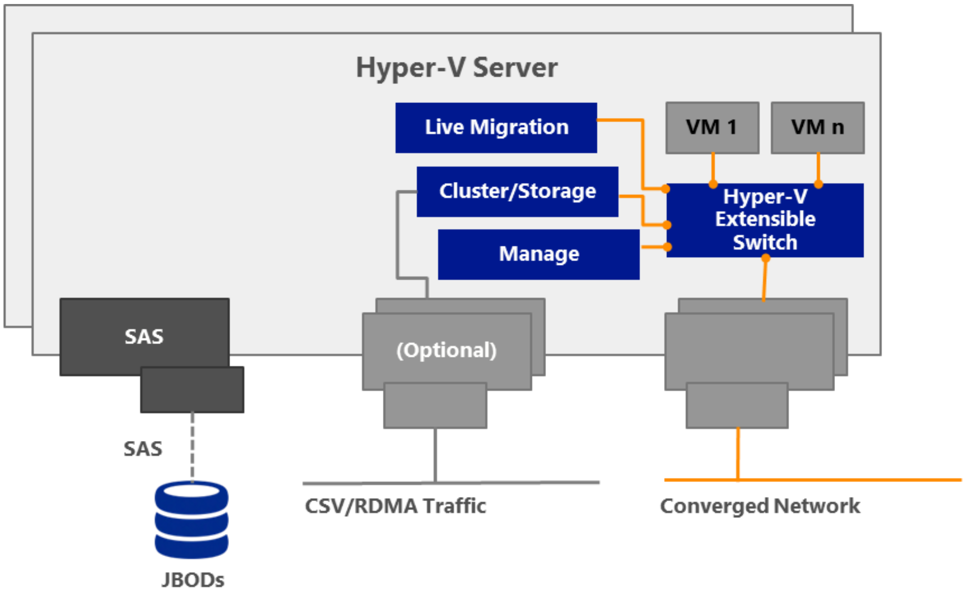
- Needs a cluster that uses Cluster Shared Volumes.
- Wants to use live migration.
- Requires resiliency at the NIC level.

These different networks can be combined onto fewer NICs, but isolation is recommended for optimal performance.

Another option is to use fewer, higher bandwidth NICs, such as 2 x 10 GbE NICs that are combined into a host-level team for an aggregated 20 Gb bandwidth. The question remains, however, how do you isolate the different types of traffic (like CSV and live migration) on what essentially is a single NIC Team presented at the host level? To solve this problem, you can use a converged approach.

Figure 24 provides a high-level example of this converged approach. Here, the Hyper-V cluster node has 2 x 10 GbE NICs, which are configured in a team. For the isolated networks that are required, you can create virtual NICs (vNICs) for the host operating system. Each cluster node member uses a virtual network adapter (for live migration, for CSV, for management, and so on) to connect to the single Hyper-V Extensible Switch, which connects it to the physical network. Each tenant virtual machine is also connected to the same Hyper-V Extensible Switch using a regular virtual network adapter. Windows Server 2012 Hyper-V virtual switch Quality of Service (QoS) is used to ensure that each traffic type (such as live migration, cluster, management, and tenant) has a predictable amount of bandwidth available. Traffic isolation is enabled by 802.1q VLAN tagging so that host traffic is not visible to the tenants. Hyper-V virtual switch port ACLs also can be used for more granular access control at the network level.

Figure 24: High-level overview of cluster member converged networking configuration



This converged approach can significantly reduce the number of physical NICs required in each host and, subsequently, the number of overall switch ports. Yet at the same time, the approach provides resiliency and high levels of bandwidth for key virtual machines and workloads. More information about converged infrastructure options can be found here on TechNet.

Cluster-Aware Updating

In the past, it has been a challenging task for administrators to appropriately update and patch failover clusters. The Cluster-Aware Updating (CAU) feature in Windows Server 2012 simplifies this task. CAU facilitates automated maintenance of cluster nodes/servers. Automating cluster nodes makes the server maintenance process in a cluster faster, easier, more reliable, and more consistent with less downtime. CAU puts each cluster node in maintenance mode, applies required updates/patches, and restores the node to be used again. At a high level, CAU performs the following steps:[27]

- Puts a node of the cluster in maintenance mode and takes it offline transparently.
- Moves clustered roles off the node.
- Installs the updates or patches, and any dependent updates.
- Performs a restart, if needed.
- Brings the node back online and out of maintenance mode.
- Restores clustered roles on the node.
- Moves to the next node and updates/patches it in the same manner.

This increases the availability of servers during the update and patching process in both environments (virtualized and non-virtualized). It also helps to maintain the security and performance of servers in the cluster. Administrators use the Cluster-Aware Updating Wizard for automating the update of a failover cluster (Figure 25).

Figure 25: Cluster-Aware Updating Wizard

CAU can perform the cluster updating process in two different modes: self-updating mode and remote-updating mode. In self-updating mode, the CAU clustered role is configured as a workload on the failover cluster that is to be updated. In remote-updating mode, a remote computer running Windows Server 2012 or Windows 8 is configured with the CAU clustered role. This remote computer is also called the *Update Coordinator* and is not part of the cluster that is updating.

Note that for many clustered roles in a cluster, the automatic updating process triggers a planned failover, which, in turn, can cause a service interruption for a very short time (transient).[28]

Best Practices and Recommendations

Use the CAU feature with continuously available cluster workloads in Windows Server 2012 to perform updates on clusters with no impact on service availability. Examples of continuously available cluster workloads in Windows Server 2012 are file servers (file server with SMB Transparent Failover) and Hyper-V virtual machines with live migration. With CAU, virtualized Exchange Servers experience no downtime, even though underlying hosts are being patched and potentially taken offline for maintenance.

Create *Updating Run Profiles* for different classes of failover clusters, and store and manage them on a centralized file share. This ensures that the CAU deployments consistently apply updates to the clusters throughout the IT organization (even across different departments, line-of-business areas, or administrators).

CAU supports an extensible architecture that helps to update the cluster node with node-updating tools and software updates that are not available from Microsoft or through Windows Update or Microsoft Update. Examples include custom software installers, updates for non-Microsoft device drivers, and network adapter/HBA firmware updating tools. This is beneficial for publishers who want to coordinate the installation of non-Microsoft software updates.

Virtual Machine Priority

IT administrators can configure availability options for virtual machines running on Hyper-V host clusters. An administrator sets priority for the virtual machines in a host cluster, which the host cluster uses to identify the high-priority virtual machines and give them first preference. This ensures that high-priority virtual machines are allocated memory and other resources first upon failover.[29]

In Windows Server 2012, administrators can configure availability options/settings to provide improved and efficient allocation of cluster resources (such as when starting or maintaining nodes) in large physical clusters and Hyper-V failover clusters. The availability options for managing clustered virtual machines and other clustered roles include the following:[30]

- **Priority settings**: This option can be applied to all clustered roles, including clustered virtual machines. A virtual machine can be set to high priority, medium priority, low priority, or No Auto Start. By default, every virtual machine is set to medium priority. Clustered roles with higher priority are started and placed on nodes before those with lower priority. If a No Auto Start priority is assigned, the role does not come online automatically after it fails, which keeps resources available so other roles can start.
- **Preemption of virtual machines based on priority**: This option can be applied to clustered virtual machines. In case of a node failure, if the high-priority virtual machines do not have the necessary memory and other resources to start, the lower priority virtual machines are taken offline to free up resources. When necessary, preemption starts with the lowest priority virtual machines and continues to higher priority virtual machines. Virtual machines that are preempted are later restarted in priority order.

Best Practices and Recommendations

In case of failover, virtualized domain controllers, along with other high-priority workloads like Exchange 2013 virtual machines, should be given the highest priority to start first.

Virtual Machine Affinity

The Virtual Machine Affinity rules in Windows Server 2012 allow administrators to configure partnered virtual machines to migrate simultaneously at failover. For example, imagine two machines are partnered: One virtual machine has front-end applications and the other has a back-end database.

It can also be specified that two particular virtual machines cannot coexist on the same node in a failover scenario. This is the Virtual Machine Anti-Affinity rule. In this case, Windows Server 2012 Hyper-V migrates the partnered virtual machines to different nodes to help mitigate a failure. For example, domain controllers running on the same Hyper-V host can be migrated to different nodes to prevent loss of the domain in case of failure.

Windows Server 2012 Hyper-V provides a cluster group property called *AntiAffinityClassNames* that can be applied to any virtual machine in the Hyper-V cluster group. This property allows preferences to be set to keep a virtual machine off the same node as other virtual machines of a similar kind.

Best Practices and Recommendations

Use Virtual Machine Anti-Affinity rules to keep related Exchange 2013 virtual machines apart on hosts within a Hyper-V Cluster. This ensures that if any host is lost, whole Exchange deployments are not taken down as a result.

Live Migration

Previous sections of this paper have focused on the failover cluster, which provides the solid, resilient foundation for ensuring workloads like virtual machines are as continuously available as possible. Further, with a failover cluster in place, other key capabilities that provide solutions for planned maintenance are unlocked. Live migration is one of these capabilities.

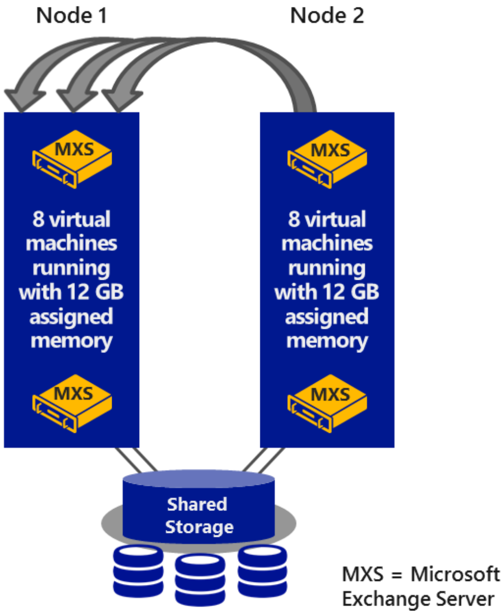
Live migration is a process where running workloads can be moved from a source server to a destination server without impacting the availability of running business applications or critical data. While migrating live virtual machines, there are two major concerns: outage of applications or data, and prevention of data loss.

Windows Server 2012 with Hyper-V provides a better way to migrate running virtual machines from one physical server to another without hampering business availability. Hyper-V 2012 with the enhanced Live Migration feature allows you to execute the live migration of multiple workloads at the same time, all without downtime. During the migration process of any workload, no additional configuration changes are required on the guest operating system.

- Windows Server 2012 with Hyper-V efficiently uses the available network bandwidth on designated Live Migration networks to reduce the time taken for the process.
- Hyper-V now offers functionality to migrate multiple virtualized Exchange 2013 servers simultaneously.

For migrating virtual machines, Hyper-V sets up a TCP connection between source and destination hosts to transfer virtual machine configurations. The memory assigned to the migrating virtual machine is transferred over the network to the destination virtual machine. Hyper-V keeps track of the memory pages being modified during the transfer from the source to the destination server. Once all the modified pages are copied completely to the destination server, Hyper-V takes care of the migration of any associated virtual hard disk files or connectivity to physical storage attached through a virtual FC adapter. After completing all stages of migration, Hyper-V brings up the new destination virtual machine, with no downtime to the workload itself (Figure 26).

Figure 26: Live migration with Hyper-V


Node 1
Node 2
MXS
8 virtual machines running with 12 GB assigned memory
MXS
MXS
8 virtual machines running with 12 GB assigned memory
MXS
Shared Storage
MXS = Microsoft Exchange Server

In addition to improvements made with the Live Migration feature, Windows Server 2012 now allows the live migration of virtual machine storage—independent of the virtual machine itself and without any downtime. This is known as *live storage migration* and can be initiated using the Hyper-V Manager console, Failover Cluster console, Microsoft System Center Virtual Machine Manager (SCVMM) console, or PowerShell. This capability can be used in several scenarios, including the need to redistribute virtual machine storage when disk space runs low or the need to perform maintenance on underlying storage without disrupting the virtual machine. Live storage migration for .vhd and .vhdx disks can be performed on standalone Hyper-V servers and clustered Hyper-V servers. Live storage migrations cannot be used with pass-through disks.

Windows Server 2012 also implements *shared-nothing live migration*, which helps in migrating virtual machines using just a network cable without any downtime. Shared-nothing live migration works in conjunction with live migration and live storage migration. First the storage is live migrated. Once the live storage migration completes, the state of the virtual machines is copied and synchronized between the source and destination servers over the network.

Virtual Machine Configuration

In addition to configuring and establishing the host server as a virtualization server with Hyper-V, it is important to design detailed architecture and system specifications for building virtual machines for expected workloads. It is also necessary to plan for needed resources for the virtual machines. The number of virtual machines you can run on any individual server depends on the server's hardware configuration and the anticipated workloads.

General Supportability

Before you begin to virtualize Exchange 2013, it is important to understand the general supportability of the products, as well as what combinations of products will ensure that if you encounter an issue, Microsoft Customer Support Services will be able to support you through the process fully.

Best Practices and Recommendations

While all efforts have been made to ensure the accuracy of this supported guidance, over time, supported configurations may change. Please refer to the Exchange Virtualization documentation on TechNet **for definitive, up to date clarification**

Hypervisor support for running Exchange 2013 in a virtual machine:

- Windows Server 2008 R2 SP1 Hyper-V | Hyper-V Server 2008 R2 SP1
- Windows Server 2012 Hyper-V and later | Hyper-V Server 2012 and later
- Any third-party hypervisor certified under the Server Virtualization Validation Program

Exchange 2013 is not supported on:

- Virtual Machines running on Windows Azure Infrastructure Services

Guest operating system that is running Exchange 2013 roles must be either:

- Windows Server 2008 R2 SP1
- Windows Server 2012 or 2012 R2

Microsoft Assessment and Planning Toolkit

Consolidating an application's workloads can help to improve the efficiency and agility of that application. It also can provide better control and flexibility over computing resources in terms of their placement, sizing, and overall utilization. Consolidating Exchange workloads requires proper planning because every element of a virtual Exchange Server deployment should comply with Exchange licensing requirements. It is also important to account for other software products that are prerequisites for installing Exchange Server, including Windows Server.

The Microsoft Assessment and Planning (MAP) toolkit can help organizations to properly plan their Exchange 2013 virtualization, speed up migration to a virtual environment (Hyper-V), and start realizing the benefits of virtualization. The MAP toolkit provides a complete software tracker that collects and reports client access and server usage information of Exchange Server deployments. The reports and proposals provided by the MAP toolkit include a server consolidation report, server consolidation proposal, workload discovery report, and cost savings and ROI assessment. The information provided in these reports and proposals can be used to consolidate Exchange workloads, better utilize hardware resources, and determine licensing needs.

Exchange 2013 Server Role Requirements Calculator

Before an Exchange 2013 deployment, whether physical or virtual, accurate capacity planning and sizing is imperative for success. The Exchange Product Team has produced a significant amount of information and guidance to help with the sizing of different Exchange 2013 roles. Using this guidance in conjunction with the best practices and recommendations in this paper can help you to better plan and deploy an Exchange 2013 infrastructure.

Best Practices and Recommendations

For detailed sizing guidance for Exchange 2013, refer to Sizing Exchange 2013 Deployments on the Exchange Team Blog. In addition, the Exchange 2013 Server Role Requirements Calculator can help to accelerate the sizing decisions for Exchange 2013 deployments across both physical and virtual infrastructures.

Exchange 2013 Virtual Machine CPU Considerations

This subsection discusses Non-Uniform Memory Access from the virtual machine perspective.

Best Practices and Recommendations

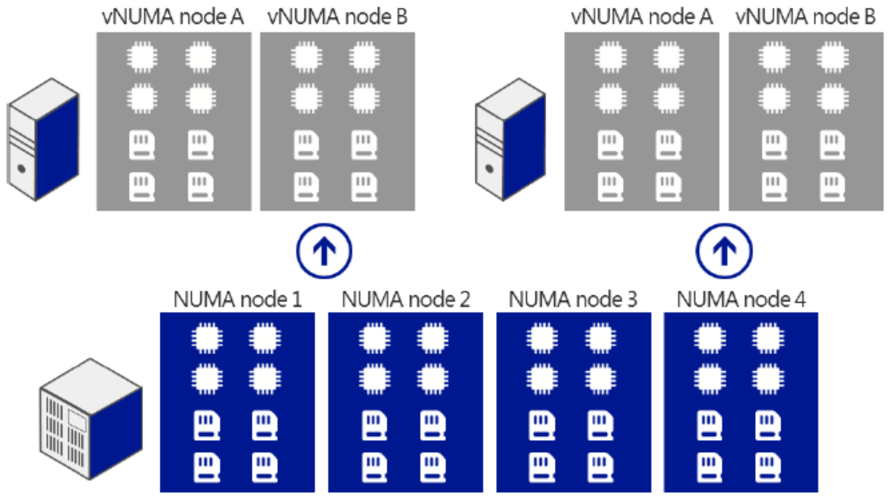
It is important to note that **Exchange 2013 as an application is not NUMA-aware**. However, when sizing a virtual machine, you must still understand the underlying physical NUMA topology to ensure the highest levels of performance at the guest level.

Non-Uniform Memory Access – Virtual Machine Perspective

In Windows Server 2012, NUMA is extended to the virtual environment (virtual NUMA) by making virtual NUMA topology available to the guest operating systems. High-performance applications support NUMA and use the computer’s NUMA topology to increase performance by considering NUMA when scheduling threads or allocating memory. Therefore, by reflecting the underlying NUMA topology into virtual machines, organizations can maximize performance gains from running NUMA-aware workloads in virtualized farm environments on NUMA. **Exchange 2013 is not a NUMA-aware workload, but it appreciates NUMA to the same level as any other non-NUMA-aware application**.

To identify and adapt to the virtual NUMA topology within the virtual machines, the NUMA-aware guest operating system and applications use their inherent NUMA performance optimizations. In this way with Windows Server 2012 Hyper-V, the default virtual NUMA topology is optimized to match the NUMA topology of the host/physical computer, as shown in Figure 27.[31]

Figure 27: Guest NUMA topology by default matching host NUMA topology



The best practices below provide more guidance around managing varying CPU demand, reducing overhead on the CPU, and optimizing processor performance for Exchange workloads.[32, 33]

Best Practices and Recommendations

Hyper-V publishes performance counters like Performance Monitor (Perfmon.exe) and Logman.exe. These performance counters help to characterize the behavior of the virtualization server and report resource usage. To measure CPU usage of the physical host, use the Hyper-V Hypervisor Logical Processor performance counters. The Performance Tuning Guidelines for Windows Server 2012 contain the list of available performance counters.

Do not oversubscribe the CPU for any virtual machine that you use in an Exchange 2013 infrastructure. Use a VP:LP ratio of 1:1 for optimum performance, but 2:1 is supported.

For any virtual machine that is running Exchange 2013 roles, detailed and accurate capacity planning and sizing should be performed. This is to determine the correct amount of processors/cores or, in this case, the minimum number of virtual CPUs that should be assigned to the Exchange virtual machine. This value should be based on published guidance from the Exchange team, such as that found on TechNet or the Exchange Team Blog on Sizing. The Exchange 2013 Server Role Requirements Calculator also provides helpful guidance.

Although Exchange 2013 is not NUMA-aware, it takes advantage of the Windows scheduler algorithms that keep threads isolated to particular NUMA nodes; however, Exchange 2013 does not use NUMA topology information.

Best Practices and Recommendations

Crossing the NUMA boundary can reduce virtual performance by as much as 8 percent. Therefore, configure a virtual machine to use resources from a single NUMA node.[34] For Exchange Server, make sure that allocated memory is equal to or smaller than a NUMA boundary.

While setting NUMA node preferences (NUMA node balancing) for virtual machines, ensure that all virtual machines are not assigned to the same NUMA node. If this happens, the virtual machines may not get enough CPU time or local memory from the assigned NUMA node.[35]

By default, a virtual machine gets its preferred NUMA node every time it runs. However, in due course, an imbalance in the assignment of NUMA nodes to the virtual machines may occur. This may happen because each virtual machine has ad hoc memory requirements or because the virtual machines can be started in any order. Therefore, we recommend that you use Perfmon to check the NUMA node preference settings for each running virtual machine. The settings can be checked with the following: \Hyper-V VM Vid Partition (*)\ NumaNodeIndex counter.

Perform NUMA node balancing to automatically change NUMA node assignments, depending on the requirements of the running virtual machines.

Identify and categorize virtual machines based on the intensity of the loads they bear (high intensity and low intensity). Then set weights and reserves on the virtual processors accordingly. In this way, you can ensure that a large amount of the CPU cycle is available for virtual machines/virtual processors having high-intensity loads.

Install the latest virtual machine Integration Services in each supported guest virtual machine. Virtual machine Integration Services can help to improve I/O throughput and decrease overall CPU usage of guests. This is because it includes enlightened drivers for Hyper-V-specific I/O devices that reduce CPU overhead for I/O.

Exchange 2013 Virtual Machine Memory Considerations

For memory in a virtualized environment, better performance and enhanced support are essential considerations. You must be able to both quickly allocate memory to virtual machines depending on their requirements (peak and off-peak loads) and ensure that the memory is not wasted. New enhancements in Windows Server 2012 help to optimize the utilization of memory allocated to virtual machines.[36] One of these enhancements is known as *Dynamic Memory*, which allows Hyper-V to intelligently give and take memory from a virtual machine while it is running, depending on the demand within that virtual machine at a given time.

Best Practices and Recommendations

Microsoft does not support Dynamic Memory for virtual machines that run any of the Exchange 2013 roles. Exchange 2013 uses in-memory data caching to provide better performance and faster I/O operations. To achieve this, Exchange 2013 needs a substantial amount of memory at all times and full control over the memory. If Exchange 2013 does not have full control of the memory allocated to the physical or virtual machines on which it is running, degraded system performance and a poor client experience can result. Therefore, Dynamic Memory is not supported for Exchange 2013.

Dynamic Memory

While not supported with virtual machines running any Exchange 2013 roles, Dynamic Memory can still provide a valuable and effective solution for optimizing memory usage for other virtualized workloads. **Virtual machines with Dynamic Memory enabled can coexist without issue on hosts with other virtual machines that have Dynamic Memory disabled**. Earlier versions of Hyper-V only allowed administrators to assign a fixed amount of physical memory to a virtual machine on the host machine. Once the memory was assigned, it was not possible to change the memory for that particular virtual machine during its run state.[37, 38] To overcome this problem, Microsoft introduced the concept of Dynamic Memory in Windows Server 2008 R2 SP1.

With Windows Server 2012, Microsoft has enhanced the Dynamic Memory feature to provide increased agility around how memory is allocated and managed between virtual machines running on a host. Dynamic Memory in Windows Server 2012 has introduced two key new enhancements: minimum memory and Hyper-V smart paging.

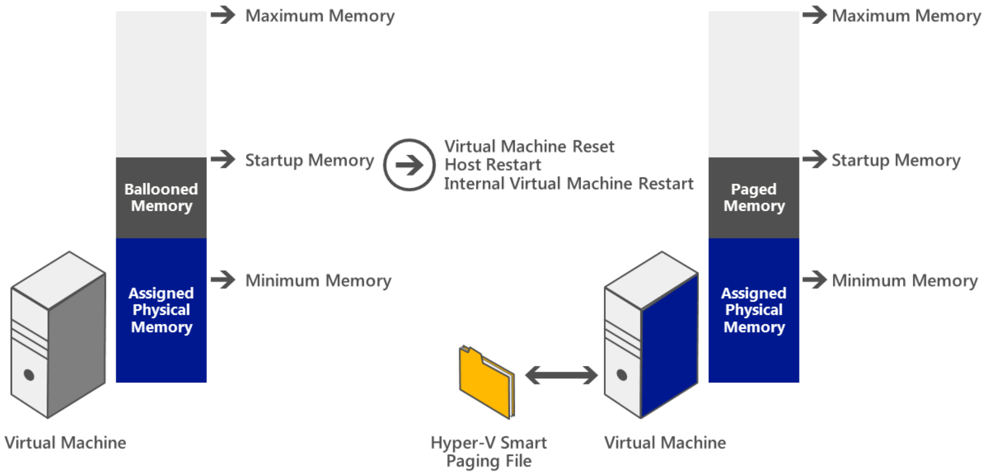
Minimum Memory

Minimum memory allows Hyper-V in Windows Server 2012 to reclaim the unused memory from virtual machines. This results in increased virtual machine consolidation. However, there can be a limitation to this feature. If you must restart one virtual machine and it has less memory than required for its startup memory, Hyper-V needs additional memory to restart the machine. Yet, Hyper-V may not always have additional memory available. Such a situation results in a virtual machine start failure. To overcome this situation, Dynamic Memory in Windows Server 2012 has introduced Hyper-V Smart Paging.

Hyper-V Smart Paging

Hyper-V Smart Paging is a memory management technique that is used to cover the gap between minimum memory and startup memory, enabling reliable restart of virtual machines (Figure 28). It uses disk resources as additional, temporary memory when more physical memory is required to restart a virtual machine than is currently available.[39, 40]

Figure 28: Hyper-V Smart Paging

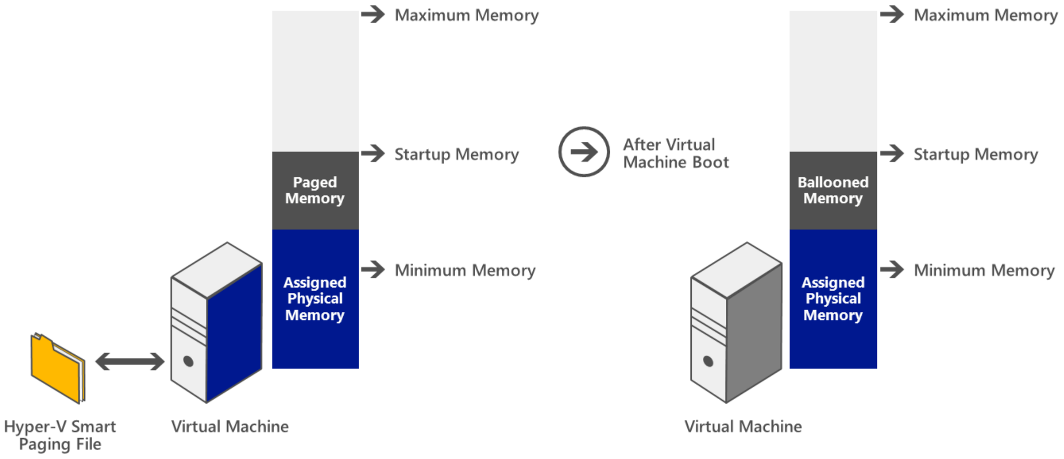


Hyper-V Smart Paging can lead to some performance degradation due to slower disk access speeds. Therefore, to ensure that the performance impact of Smart Paging is minimized, this feature is used only when all of the following are true:

- The virtual machine is being restarted.
- No physical memory is available.
- No memory can be reclaimed from other virtual machines that are running on the host.

Memory ballooning: Memory ballooning is a technique used to further reduce the performance impact of Hyper-V Smart Paging. Once the virtual machine is restarted and the need for memory is less than the startup memory, Hyper-V can stop using Smart Paging. Therefore, Hyper-V removes the temporary memory from the virtual machine by coordinating with Dynamic Memory components inside the guest (a process sometimes referred to as *ballooning*). With this technique, use of Hyper-V Smart Paging is temporary and is not expected to be longer than 10 minutes. Figure 29 shows Hyper-V removing memory from the virtual machine after it completes the startup process.[41]

Figure 29: Removing paged memory after virtual machine restart



The best practices below provide more guidance around planning and managing memory for virtual machines running Exchange 2013 workloads.[42, 43, 44]

Best Practices and Recommendations

For any virtual machine that is running Exchange 2013 roles, detailed and accurate capacity planning and sizing should be performed to determine the correct amount of minimum memory that should be assigned to the Exchange virtual machine. This value should be based on published guidance from the Exchange team, as well as the use of the Exchange 2013 Server Role Requirements Calculator. The following figures are the absolute smallest supported amounts of memory required for an Exchange 2013 deployment:

- Mailbox: **8 GB minimum**
- Client Access: **4 GB minimum**
- Mailbox and Client Access combined: **8 GB minimum**

The page file size minimum and maximum must be set to the operating system's RAM plus 10 MB.

In environments where performance is critical, use SSD for Smart Paging.

Exchange 2013 Virtual Machine Storage Considerations

With an optimal configuration for both CPU and memory, you need to ensure that the underlying disk subsystem is also optimally configured for the Exchange 2013 workload. This subsection discusses two key storage considerations for Exchange 2013: virtual disks and guest storage.

Best Practices and Recommendations

Provide at least 30 GB of space on the drive where you will install Exchange.

Add an additional 500 MB of available disk space for each Unified Messaging (UM) language pack that you plan to install.

Add 200 MB of available disk space on the system drive.

Use a hard disk with at least 500 MB of free space to store the message queue database, which can be co-located on the system drive, assuming you have accurately planned for enough space and I/O throughput.

Virtual Disks

When considering virtual disks, it is important to know the capabilities and limitations of the different types. Discussed below are the VHDX file format, dynamically expanding VHDX versus fixed-size VHDX, and virtual IDE versus virtual SCS.

VHDX File Format

Hyper-V in Windows Server 2012 introduces VHDX, a new version of the virtual hard disk format that is designed to handle current and future workloads. VHDX has a much larger storage capacity than the older VHD format. It also provides protection from data corruption during power failures and optimizes structural alignments to prevent performance degradation on new, large sector physical disks. The main features of the VHDX format are as follows:

- Support for virtual hard disk storage capacity of up to 64 TB.
- Protection against data corruption during power failures by logging updates to the VHDX metadata structures.
- Improved alignment of the virtual hard disk format to work well on large sector disks.
- Larger block sizes for dynamic and differencing disks, which allows these disks to attune to the needs of the workload.
- A 4-KB logical sector virtual disk that allows for increased performance when used by applications and workloads that are designed for 4-KB sectors.
- The ability to store custom metadata about a file that the user might want to record, such as operating system version or patches applied.
- Efficiency in representing data (also known as *trim*), which results in smaller file size and allows the underlying physical storage device to reclaim unused space. (Trim requires physical disks directly attached to a virtual machine or SCSI disks, and trim-compatible hardware.)

Best Practices and Recommendations

When you create virtual machines on Windows Server 2012 Hyper-V, the VHDX file format should be the default choice. While not compatible with previous versions of Hyper-V, its capacity advantage, better alignment with underlying storage, and stronger protection against corruption make VHDX an ideal choice for mission-critical workloads like Exchange 2013.

Dynamically Expanding VHDX vs. Fixed-Size VHDX

Fixed-size VHDX uses the full amount of space specified during virtual hard disk creation. However, the size of a fixed-size VHDX can be increased while the virtual machine is offline by using Hyper-V Manager or running a PowerShell script. Note that reducing the size is not supported. Fixed-size VHDX delivers near native-to-physical performance and slightly higher performance than dynamically expanding VHDX files.

During virtual hard disk creation, dynamically expanding VHDX files only consume physical space based on their actual contents. For instance, an administrator could create a dynamically expanding VHDX with a maximum size of 127 GB. Upon creation, the actual physical size of the VHDX file may only be a few MB, but as files are added to the VHDX inside the guest operating system, the size of the VHDX file in the physical world grows accordingly. The guest operating system always sees the maximum size that the administrator chose upon creation.

Best Practices and Recommendations

Each Exchange guest machine must be allocated sufficient storage space on the host machine for the fixed disk that contains the guest's operating system, any temporary memory storage files in use, and related virtual machine files that are hosted on the host machine. In addition, for each Exchange guest machine, you must also allocate sufficient storage for the message queues and sufficient storage for the databases and log files on Mailbox servers.

The storage used by the Exchange guest machine for storage of Exchange data (for example, mailbox databases and transport queues) can be virtual storage of a fixed size (for example, fixed virtual hard disks (VHD or VHDX) in a Hyper-V environment), dynamic virtual storage when using VHDX files with Hyper-V, SCSI pass-through storage, or Internet SCSI (iSCSI) storage. Pass-through storage is storage that's configured at the host level and dedicated to one guest machine. All storage used by an Exchange guest machine for storage of Exchange data must be block-level storage because Exchange 2013 doesn't support the use of network attached storage (NAS) volumes, other than in the SMB 3.0 scenario outlined below. Also, NAS storage that's presented to the guest as block-level storage via the hypervisor isn't supported.

Fixed or dynamic virtual disks may be stored on SMB 3.0 files that are backed by block-level storage if the guest machine is running on Windows Server 2012 Hyper-V (or a later version of Hyper-V). The only supported usage of SMB 3.0 file shares is for storage of fixed or dynamic virtual disks. Such file shares can't be used for direct storage of Exchange data. When using SMB 3.0 file shares to store fixed or dynamic virtual disks, the storage backing the file share should be configured for high availability to ensure the best possible availability of the Exchange service.

Storage used by Exchange should be hosted in disk spindles that are separate from the storage that's hosting the guest virtual machine's operating system

To reduce disk contention, do not store system files on hard drives dedicated to storing virtual machines.

Do not use snapshots for the virtual machines in an Exchange 2013 production environment. When you create a snapshot, Hyper-V creates a new secondary drive for the virtual machines. Write operations occur on the new drive, and read operations occur on both drives, resulting in reduced performance.

Be aware of underlying disk read/write contention between different virtual machines and their virtual hard disks.

Virtual IDE vs. Virtual SCSI

Virtual machines can be configured to use virtual IDE device controllers or virtual SCSI device controllers to connect virtual storage. When a virtual machine starts, the virtual IDE controller is used with a boot VHD/x file because the virtual SCSI disk requires a driver to be present during boot-up. This driver is only present when booted into the operating system. IDE is limited to 3 connected disks. (One port is retained for the DVD drive, which is required for updating the integration components.) Virtual SCSI, on the other hand, can have 64 connected disks per controller and 4 controllers per virtual machine, giving a total of 256 virtual SCSI disks per virtual machine. Virtual SCSI also supports hot-add/removal of disks, whereas virtual IDE disks do not.

Best Practices and Recommendations

The virtual IDE controller must be used for booting the virtual machine; however, all other drives should be attached to the virtual SCSI controller. This ensures optimal performance, as well as the greatest flexibility. Each virtual machine has a single virtual SCSI controller by default, but three more can be added while the virtual machine is offline.

Guest Storage

In addition to presenting VHD or VHDX files to Exchange 2013 virtual machines, administrators can choose to connect the guest operating system of an Exchange virtual machine directly to existing storage investments. Two methods provided in Windows Server 2012 Hyper-V are In-Guest iSCSI and Virtual Fibre Channel.

In-Guest iSCSI

Deploying an Exchange 2013 virtual machine on iSCSI storage provides a more cost-effective solution for enterprise-level virtual machine installations than an equivalent Fibre Channel solution. Instead of using virtual disks (such as the VHD or VHDX files discussed earlier) and placing them on the iSCSI LUNS presented to the host, the administrator can choose to bypass the host and connect the virtual machines directly to the iSCSI array itself. The iSCSI target, which is part of the storage array, provides storage to the Exchange 2013 virtual machine directly over the virtual machine's network adapters. The Exchange virtual machine uses the in-box iSCSI initiator inside the Windows Server guest operating system to consume the storage over a vNIC that has connectivity on the iSCSI storage network. The respective Exchange Servers can therefore store information, logs, and other critical data directly on iSCSI disk volumes.

To enact this approach, the administrator must create dedicated Hyper-V virtual switches and bind them to appropriate physical NICs in the hosts. This ensures that the virtual machines can communicate with the iSCSI storage on the appropriate network/VLAN. After configuration, the administrator must use the guest operating system IQN from the iSCSI initiator to present the appropriate LUNS directly to the virtual machine over the virtual networks. In addition, vNIC features like jumbo frames and some other offload capabilities can help to increase performance and throughput over the network. It is important to note that if you intend to run the virtual machine with In-Guest iSCSI on top of a Hyper-V cluster, all cluster nodes must have the same iSCSI virtual switches created on the hosts to ensure that when the virtual machine migrates around the cluster, connectivity to the underlying storage is not lost.

For resiliency, the administrator may want to use multiple vNICs to connect the virtual machine to the iSCSI SAN. If this is the case, it is important to enable and configure MPIO, as discussed earlier, to ensure optimal performance and resiliency.

Virtual Fibre Channel

In a similar way to iSCSI, Virtual Fibre Channel for Hyper-V helps to connect to FC storage from within a virtual machine, bypassing the host's operating system. Virtual FC for Hyper-V provides direct SAN access from the guest operating system by using standard World Wide Node Names (WWNN) and Worldwide Port Names (WWPN) associated with a virtual machine. Virtual FC for Hyper-V also helps to run the Failover Clustering feature inside the guest operating system of a virtual machine connected to the underlying, shared FC storage.

For virtualizing Exchange 2013, Virtual FC for Hyper-V allows you to use existing FC investments to drive the highest levels of storage performance access, while also retaining support for virtual machine live migration and MPIO.

Exchange 2013 Virtual Machine Network Considerations

Networking and network access are critical to the success of an Exchange deployment. Windows Server 2012 Hyper-V provides a number of capabilities, technologies, and features that an administrator can use to drive the highest levels of networking performance for the virtualized Exchange infrastructure.

Legacy versus Synthetic Virtual Network Adapters

When creating a virtual machine, the administrator has two choices for virtual network adapters (or vNICs): legacy or synthetic. A legacy adapter emulates an Intel 21140-based PCI Fast Ethernet Adapter, which results in a lower data transfer than the network adapter. Legacy network adapters (also known as *emulated NIC drivers*) should only be used when booting a virtual machine in the Pre-Boot Execution Environment (PXE) or when installing guest operating systems that are not Hyper-V-aware.

Synthetic adapters are the preferred option for most virtual machine configurations because they use a dedicated VMBus to communicate between the virtual NIC and the physical NIC. This results in reduced CPU cycles, as well as much lower hypervisor/guest transitions per operation. The driver for the synthetic adapter is included with the Integration Services that are installed with the Windows Server 2012 guest operating system.

Best Practices and Recommendations

From an Exchange 2013 perspective, there is no reason to use the Legacy vNIC. At minimum, customers should use the default synthetic vNIC to drive higher levels of performance. In addition, should the physical network card support them, the administrator should take advantage of a number of the NIC offloads that can further increase performance.

Single Root I/O Virtualization

The Single Root I/O Virtualization standard was introduced by the PCI-SIG, the special interest group that owns and manages PCI specifications as open industry standards. SR-IOV helps to virtualize demanding workloads like Exchange 2013 that require higher network and I/O performance. It does so by enabling virtual machines to perform I/O directly to the physical network adapter by bypassing the root partition.

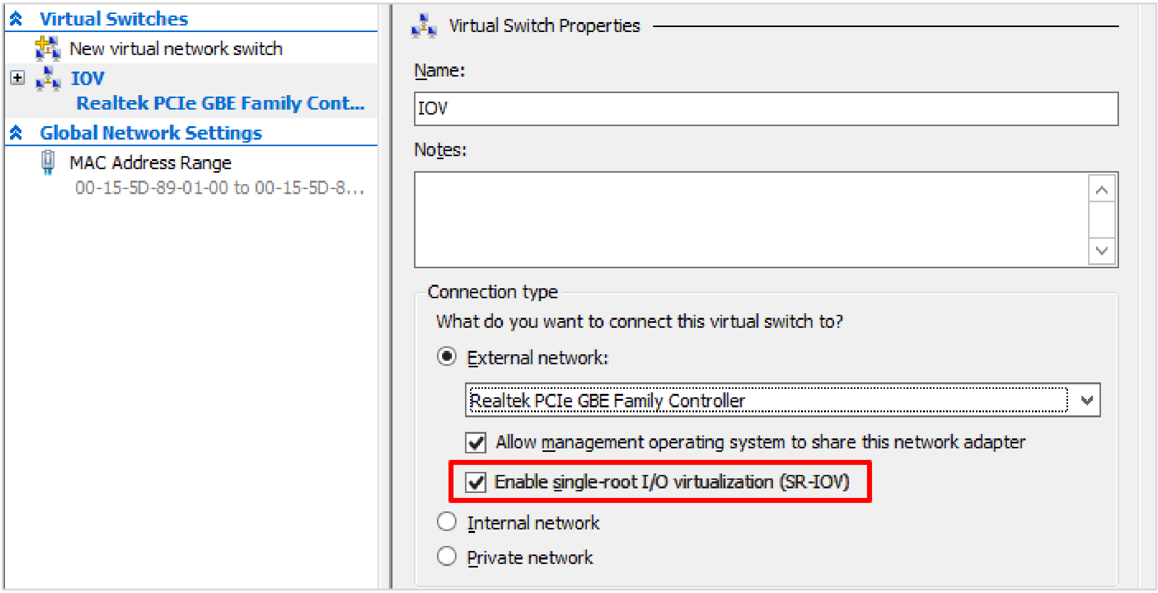
In Windows Server 2012, SR-IOV can be deployed in conjunction with key capabilities such as live migration to enable high network performance with availability.

SR-IOV provides extensions to PCI Express (PCIe) devices like network adapters to separate access to its resources among various PCIe hardware functions. Two of these functions are PCIe Physical Function (PF) and PCIe Virtual Functions (VFs):

- **PCIe Physical Function** is the primary function of the device and advertises its SR-IOV capabilities. The PF is associated with the Hyper-V parent partition in a virtualized environment.
- **PCIe Virtual Functions** are associated with the PF of the device. A VF shares one or more physical resources, such as memory and network ports, with the PF and other VFs on the device. Each VF is associated with a Hyper-V child partition in a virtualized environment.

Using Hyper-V Manager, you can enable SR-IOV in Windows Server 2012 when you create a virtual switch (Figure 30).[45]

Figure 30: Enabling SR-IOV in the Virtual Switch Properties window



Virtual Switches

New virtual network switch

IOV

Realtek PCIe GBE Family Cont...

Global Network Settings

MAC Address Range

00-15-5D-89-01-00 to 00-15-5D-8...

Virtual Switch Properties

Name: IOV

Notes:

Connection type

What do you want to connect this virtual switch to?

● External network:

Realtek PCIe GBE Family Controller

☑ Allow management operating system to share this network adapter

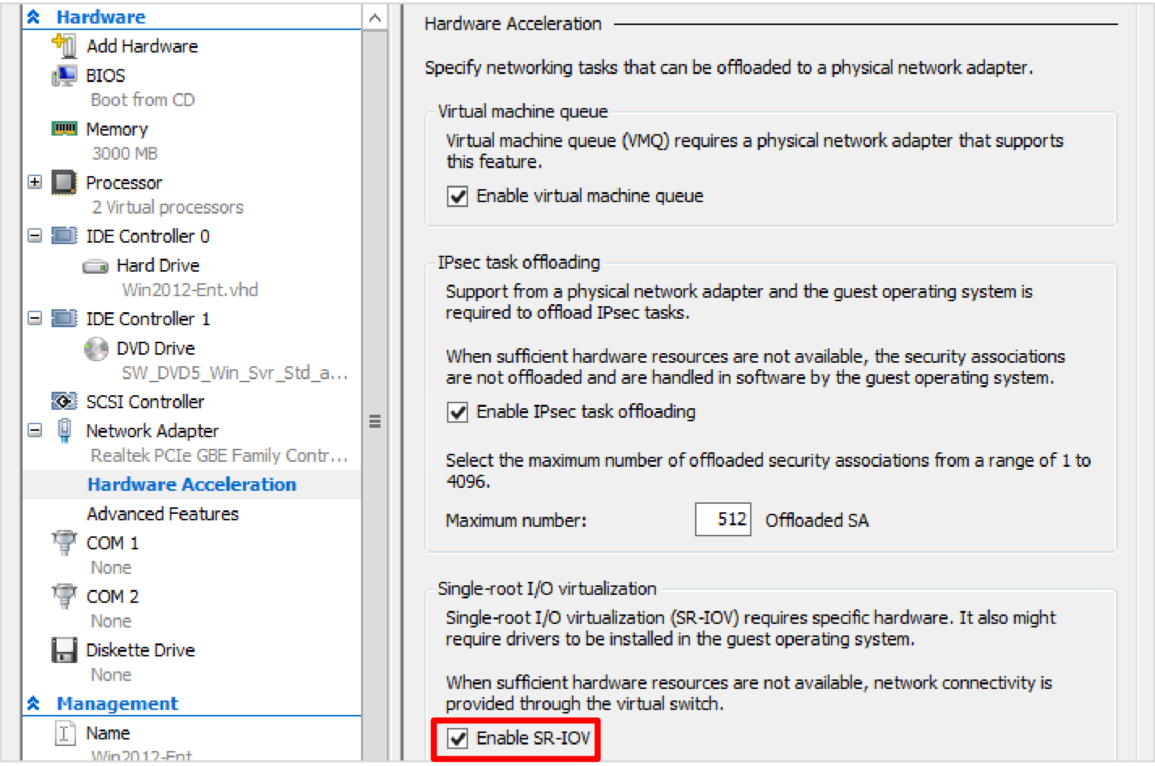
☑ Enable single-root I/O virtualization (SR-IOV)

○ Internal network

○ Private network

Once the virtual switch is created, SR-IOV should also be enabled while configuring a virtual machine in the Hardware Acceleration node (Figure 31).

Figure 31: Enabling SR-IOV in the Virtual Machine Properties window



Hardware Acceleration

Specify networking tasks that can be offloaded to a physical network adapter.

Virtual machine queue

Virtual machine queue (VMQ) requires a physical network adapter that supports this feature.

☑ Enable virtual machine queue

IPsec task offloading

Support from a physical network adapter and the guest operating system is required to offload IPsec tasks.

When sufficient hardware resources are not available, the security associations are not offloaded and are handled in software by the guest operating system.

☑ Enable IPsec task offloading

Select the maximum number of offloaded security associations from a range of 1 to 4096.

Maximum number: 512 Offloaded SA

Single-root I/O virtualization

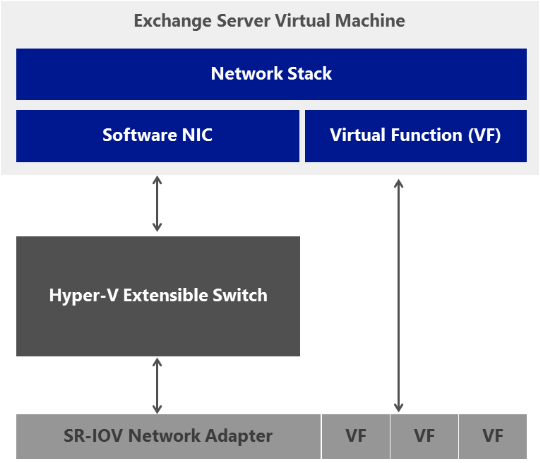
Single-root I/O virtualization (SR-IOV) requires specific hardware. It also might require drivers to be installed in the guest operating system.

When sufficient hardware resources are not available, network connectivity is provided through the virtual switch.

☑ Enable SR-IOV

Figure 32 shows how SR-IOV attaches a physical NIC to an Exchange 2013 virtual machine. This provides the Exchange 2013 virtual machine with a more direct path to the underlying physical network adapter, increasing performance and reducing latency—both of which are important considerations for the Exchange 2013 workload.

Figure 32: SR-IOV support in Hyper-V



With the virtual machine now attached to the physical NIC through the VF, does this mean that this particular virtual machine cannot be live migrated to another physical host? The answer is no—the virtual machine is still free to be live migrated, with no downtime, to another available node in the cluster. This helps to ensure that Hyper-V in Windows Server 2012 not only provides high levels of performance, but also does so without sacrificing agility.

SR-IOV automatically fails over the network traffic from the VF to the synthetic data path of the Hyper-V virtual machine. The transition between the VF and synthetic data paths occurs with minimum loss of packets and prevents the loss of TCP connections. Whenever there is a state transition that requires the hardware state to be saved, the VF is removed from the virtual machine beforehand, falling back to the synthetic path. Once the VF is removed, any operation necessary can be performed on the virtual machine because it is a complete software-based container at that point.

The Hyper-V child partition is being live migrated to a different host at this stage. Once the operation has been completed, assuming hardware resources are available and other dependencies are met, the VF is returned back to the virtual machine. This solves the problem of saving the hardware state of the virtual machine and helps to ensure that workloads receive the highest levels of performance. The high-level process is outlined below.[46, 47, 48] Note that throughout this process, the Exchange virtual machine always has connectivity.

- SR-IOV is enabled for the Exchange virtual machine, and its VF is assigned. Traffic flows down the VF path, not the software stack.
- When live migration starts, connectivity is failed over to the synthetic path, and the VF is removed.
- At this point, live migration of the virtual machine takes place from source to destination. (Traffic is now travelling via the synthetic software stack.)
- Upon arrival, the VF is reassigned and traffic now passes via the VF. Alternatively, if the virtual machine has been migrated to a new host that does not have SR-IOV-capable hardware, the network traffic continues to operate along the synthetic software stack.

If the Exchange virtual machine is configured to use SR-IOV, but the guest operating system does not support it, SR-IOV VFs are not allocated to the virtual machine. We recommend that you disable SR-IOV on all virtual machines that run guest operating systems that do not support SR-IOV.[49]

Best Practices and Recommendations

SR-IOV can provide the highest levels of networking performance for virtualized Exchange virtual machines. Check with your hardware vendor for support because there may be a BIOS and firmware update required to enable SR-IOV.

QoS Bandwidth Management

Quality of Service is a prioritization technique that gives the ability to cost effectively manage network traffic and enhance user experiences in enterprise environments. QoS allows you to meet the service requirements of a workload or application in an Exchange environment by measuring network bandwidth, detecting changing network conditions (such as congestion or availability of bandwidth), and prioritizing or throttling network traffic. QoS provides features like bandwidth management, classification and tagging, priority-based flow control, policy-based QoS, and Hyper-V QoS.[50]

For Hyper-V virtual machines specifically, QoS bandwidth management helps to set a throttling rate for a workload like Exchange 2013. Minimum Bandwidth and Maximum Bandwidth enable organizations to enforce predictable network throughput for the Exchange workload. Apart from bandwidth management, organizations can prioritize and tag traffic so that QoS is enforced from end-to-end across a data center.

Other Key Exchange 2013 Virtual Machine Considerations

In Windows Server 2012, Hyper-V Integration Services include six components that provide performance enhancements to a child partition (that is, virtual machine or guest) and additional interoperability between child and parent partitions. Integrations Services are available in a child partition only after they are installed in a supported guest operating system. It is also possible to update Integration Services after the initial installation, and this is usually recommended when migrating a virtual machine from an older to a newer version of Hyper-V (for example, Windows Server 2008 R2 to Windows Server 2012) or as new versions of the Integrations Services are released.

Best Practices and Recommendations

Running a guest operating system of Windows Server 2012 on a Windows Server 2012 Hyper-V host **does not require an update** of the Integration Services—they automatically have the latest, most optimized versions.

Integration Services are installed as user mode components in the guest operating system and are implemented in the following services:

- Hyper-V Heartbeat Service (vmicheartbeat)
- Hyper-V Guest Shutdown Service (vmicshutdown)
- Hyper-V Data Exchange Service (vmickvpexchange)
- Hyper-V Time Synchronization Service (vmictimesync)
- Hyper-V Remote Desktop Virtualization Service (vmicrdv)
- Hyper-V Volume Shadow Copy Requestor Service (vmicvss)

Integration Services in a child partition communicate over a VMBus with components in the parent partition virtualization stack that are implemented as virtual devices (VDev). The VMBus supports high-speed, point-to-point channels for secure interpartition communication between child and parent partitions. A dedicated VDev manages each of the parent partition Integration Services functions, just as each dedicated service manages the different Integration Services functions in a child partition. Through this architecture, Integration Services components provide enhanced functionality and performance for mouse, keyboard, display, network, and storage devices installed in a virtual machine. More information about Integration Services components is available on the TechNet Wiki.

For each virtual machine, you can configure automatic stop and start behavior if a physical computer shuts down. The options for stop are as follows:

- **Save state**: The current state of the virtual machine is saved. When the virtual machine is started, Hyper-V attempts to restore the virtual machine to the state it was in.
- **Turn off**: This is the equivalent of pulling the power plug on a server.

- **Shut down the guest operating system**: This is the equivalent of shutting down a computer by using the Windows shut down option.

Best Practices and Recommendations

For an Exchange 2013 virtual machine, do not configure the virtual machine to **save state**. We recommend that you configure the virtual machine to use a **shut down** because it minimizes the chance that the virtual machine can be corrupted. When a shut down happens, all jobs that are running can finish, and there will be no synchronization issues when the virtual machine restarts (for example, a Mailbox role server within a DAG replicating to another DAG member).

The opposite of an automatic stop is an automatic start. Hyper-V provides the following options when the physical server restarts:

- **Do nothing**: You must start the virtual machine manually regardless of its state when the physical server shut down.
- **Automatically start**: This option can be used if the virtual machine was running when the service stopped.
- **Always start this virtual machine automatically**: Hyper-V starts the virtual machine regardless of its state when the physical server shut down.

Best Practices and Recommendations

We recommend that you select either of the first two options for automatic start. Both options are acceptable; however, the decision is ultimately up to the IT team that manages and maintains the virtual environment. In addition to the listed start options, you can configure a start time delay for a virtual machine. By doing so, you reduce resource contention on a virtualization host. However, if your start option is to do nothing, this is not an issue.

Exchange 2013 Resiliency

The backbone of business communication, messaging solutions require high availability. Exchange 2013 provides advanced capabilities to deliver a messaging solution that is always available. Moreover, the data in mailbox databases is one of the most critical business elements of any Exchange-based organization. These mailbox databases can be protected by configuring them for high availability and site resilience. With a virtualized Exchange 2013 environment, administrators can combine the built-in, integrated high availability features of Exchange 2013 with the failover clustering capabilities available at the host level to provide higher availability.

Exchange 2013 Roles

Exchange 2013 has just two roles: Client Access Server (CAS) and Mailbox Server. Each provides a unit of high availability and a unit of fault tolerance that are decoupled from one another. Client Access servers make up the CAS array, while Mailbox servers comprise the database availability group (DAG). All of the functionality of the Hub Transport and Unified Messaging roles found in Exchange 2010 now exist within the Mailbox role.

Client Access Server Role

In Exchange 2013, clients (like Microsoft Outlook, Outlook Web App, and Exchange ActiveSync) connect to the Client Access server for mailbox access. The Client Access server authenticates and proxies requests to the appropriate Mailbox server. The Client Access server itself does not render data. The Client Access server is a thin and stateless server; there is never anything queued or stored on it. The Client Access server offers all the usual client access protocols: HTTP, POP and IMAP, UM, and SMTP.

The Client Access server provides high availability using a load balancer. This load balancer can detect when a specific Client Access server has become unavailable and remove it from the set of servers that handle inbound connections.[51]

Mailbox Server Role

Mailbox servers host the databases that contain mailbox and public folder data. The Exchange 2013 Mailbox Server role can be made highly available by configuring a Database Availability Group. The Mailbox Server role uses the DAG concept to provide both high availability and site resilience features. In addition, the new Information Store, known as the *Managed Store*, helps to perform failover much faster.

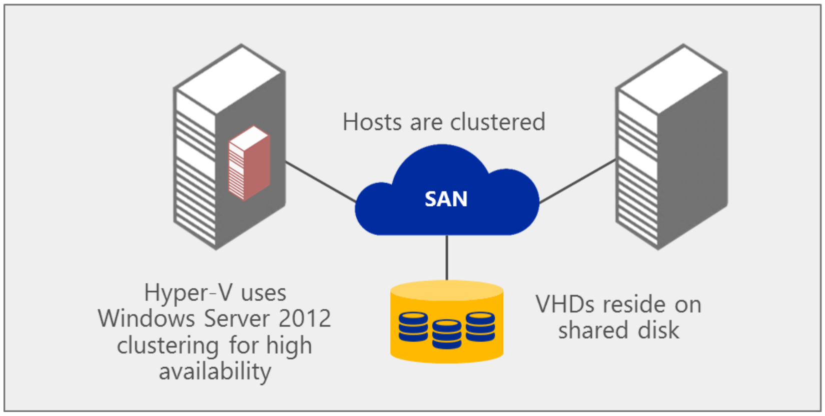
Data is replicated between DAG members using log shipping. Multiple copies of databases are supported in the same site and across sites, as are automatic failovers or manual switchovers. Finally, up to 16 copies of a database are supported across multiple servers.

Single Exchange 2013 Virtual Machine on a Hyper-V Cluster

For smaller organizations that require only a single Exchange 2013 server but still need a high level of availability, a good option is to run the Exchange 2013 server as a virtual machine on top of a Hyper-V physical cluster. Figure 33 shows two Hyper-V cluster nodes connected, in this case, to some centralized SAN storage. Note that this storage could be iSCSI or FC, or with Windows Server 2012 Hyper-V, it could also be SMB 3.0-based storage.

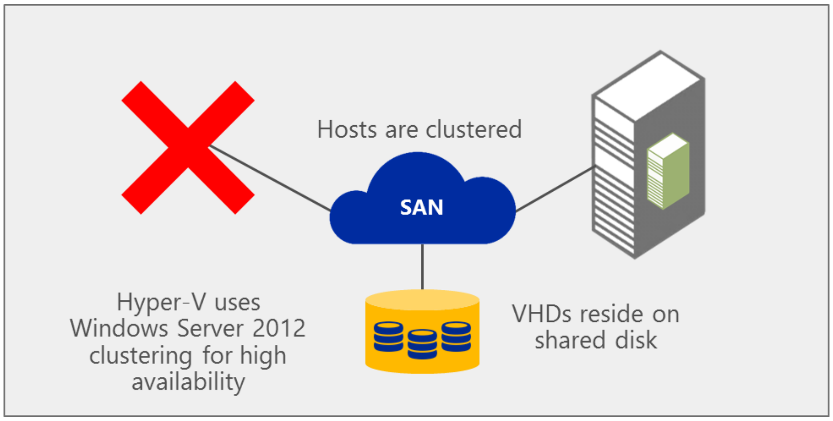
The Exchange 2013 virtual machine has a number of virtual disks to store data and other relevant Exchange information—which is further stored on different LUNs and spindles in the underlying disk subsystem. If one of the physical cluster nodes fails, any virtual machines currently running on that now-failed node will experience some downtime.

Figure 33: Virtual machine guests failing over from one node to another (active node failing)


Hosts are clustered
SAN
Hyper-V uses Windows Server 2012 clustering for high availability
VHDs reside on shared disk

The virtual machines, however, will restart automatically on another node in that cluster—without administrator intervention and with minimal downtime (Figure 34). Remember one key consideration, though: If there are multiple virtual machines on Node 1, they all now have experienced downtime.

Figure 34: Virtual machine guests failing over from one node to another


Hosts are clustered
SAN
Hyper-V uses Windows Server 2012 clustering for high availability
VHDs reside on shared disk

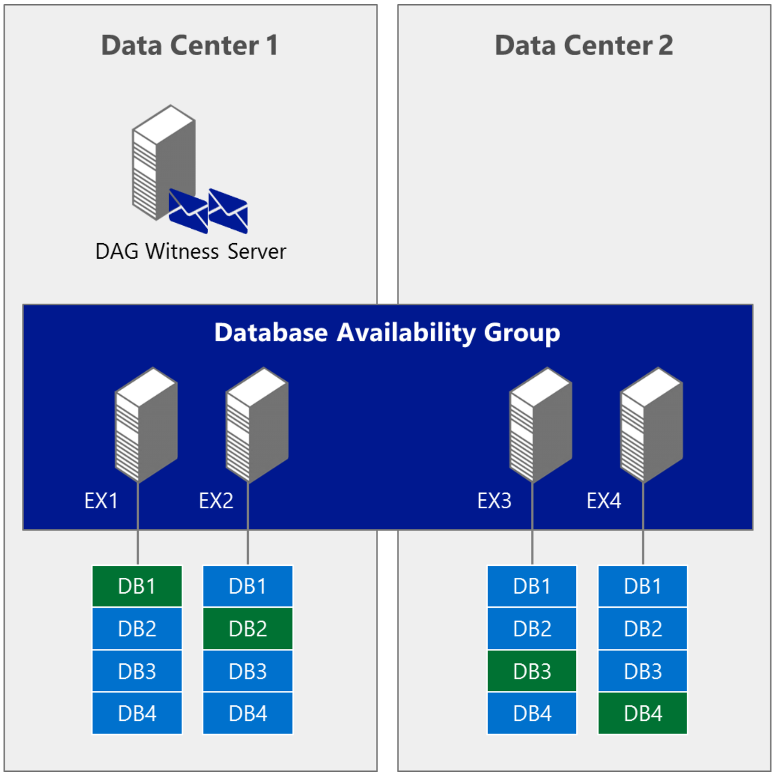
The cluster wants to start these virtual machines again on another available cluster node as quickly as possible, but you may want to ensure that the Exchange 2013 virtual machine starts first. With this in mind, you can set the **Failover Priority** setting for the Exchange 2013 virtual machine to **high**. This ensures that even under contention, the Exchange 2013 virtual machine, upon failover, will successfully start and receive the resources it needs to perform at the desired levels—taking resources from other currently running virtual machines, if required.

Resilient Exchange Configuration on a Hyper-V Cluster

A Database Availability Group is the base component of the high availability and site resilience framework built into Exchange 2013. A group of up to 16 Mailbox servers, a DAG hosts a set of databases and provides automatic and database-level recovery from failures. Any server in a DAG can host a copy of a mailbox database from any other server in the same DAG. When a server is added to a DAG, it works with the other servers in the DAG to provide automatic recovery from failures that affect the mailbox databases, such as a disk or server failure.

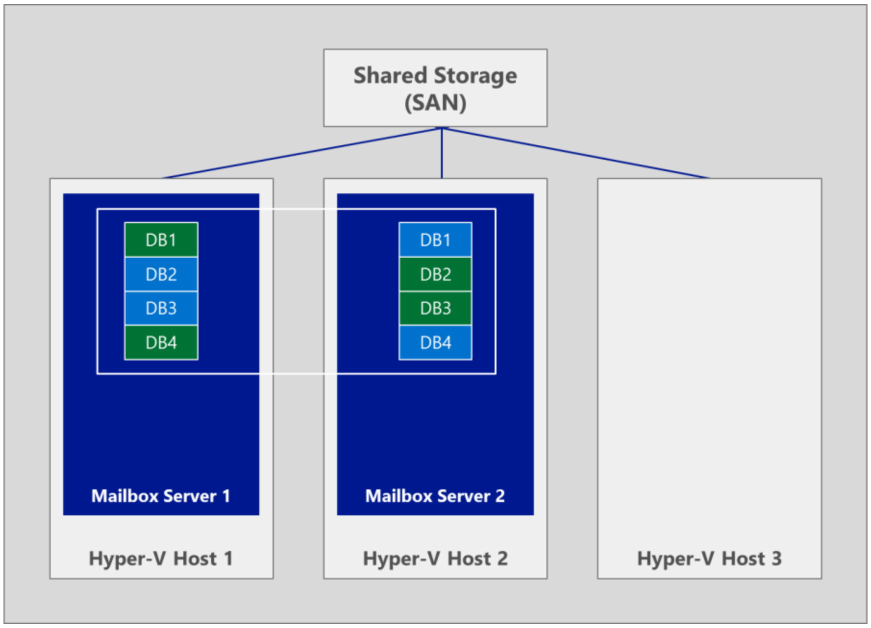
When two or more virtual machines running Exchange 2013 are configured as a DAG solution, one virtual machine will take over if any of the others fails (Figure 35).

Figure 35: Exchange virtual machines running as a DAG solution across data centers



With DAGs, Exchange 2013 can work as a cluster-aware application to provide better availability and resiliency for Exchange 2013 mailboxes in a virtualized environment (Figure 36). (For more information, see the Mailbox Server Role subsection above.)

Figure 36: Creating Exchange 2013 Mailbox servers



In this example, a three-node Hyper-V cluster is connected to some shared storage. This storage could be an iSCSI or FC SAN, or with Windows Server 2012 Hyper-V, it could be an SMB 3.0 file share on which the Exchange 2013 VHDX files are stored. Exchange 2013 as an application or workload has no requirement for shared storage; however, the Hyper-V layer itself, for resiliency through failover clustering, requires some form of shared storage to store the virtual disks of the virtual machines.

On top of this Hyper-V cluster are two virtual machines, hosting the Mailbox role and are configured in a DAG. The virtual machines are split across the hosts, with Mailbox Server 1 on Hyper-V Host 1, and Mailbox Server 2 on Hyper-V Host 2. This is currently optimal in the sense that if you were to lose either of the Hyper-V hosts running the Exchange 2013 virtual machines, the entire Exchange 2013 DAG would not be taken down.

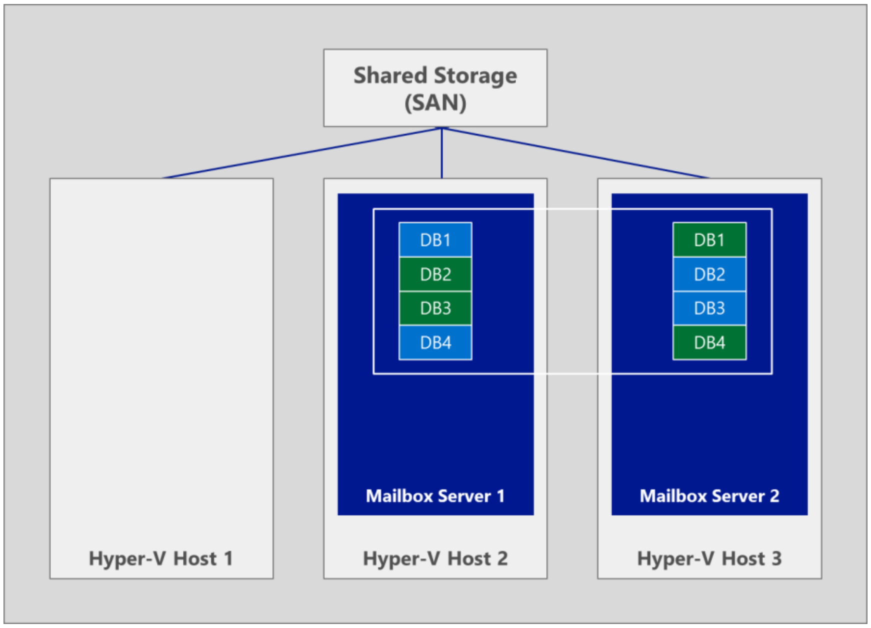
As an example, say you were to lose Hyper-V Host 1. Mailbox Server 1 also would be temporarily lost, but would automatically restart on another available node on the cluster. When restarting the virtual machines, Failover Cluster Manager looks at the available resources in the cluster and places the restarting virtual machines on the most appropriate host—again, all without administrator intervention.

Best Practices and Recommendations

Use the **Failover Priority** setting to ensure that, upon failover, the Exchange 2013 virtual machines start in advance of other, less important virtual machines.

Continuing this example, even though Mailbox Server 1 was down for a short period of time, the level of built-in high availability in Exchange 2013, at the DAG level, ensures that users are still able to access information and connect to their mailboxes via Mailbox Server 2, which was still running during the outage of Hyper-V Host 1 (Figure 37).

Figure 37: Reestablishing the DAG after failing over Mailbox Server 1 on another host



This dual layer of availability—specifically, combining Exchange-level availability with host-level availability—means that within a few minutes, both VMs will be fully online and the administrator can then rebalance the databases within the DAG, thereby restoring the highest levels of availability that were experienced before the outage. Whilst we've focused on the DAG here, the information is equally applicable to the CAS Array to distribute the CAS functionality across multiple VMs.

With the Exchange 2013 virtual machines now stored on a Hyper-V cluster, individual virtual machines can be moved around the cluster using live migration.

Best Practices and Recommendations

When performing live migration of DAG members, follow these key points:[52]

- If the server offline time exceeds five seconds, the DAG node will be evicted from the cluster. **Ensure that the hypervisor and host-based clustering use the Live Migration technology** in Hyper-V to help migrate resources with no perceived downtime.
- If you are raising the heartbeat timeout threshold, perform testing to ensure that migration succeeds within the configured timeout period.
- On the Live Migration network, enable jumbo frames on the network interface for each host. In addition, verify that the switch handling network traffic is configured to support jumbo frames.

- Deploy as much bandwidth as possible for the Live Migration network to ensure that the live migration completes as quickly as possible.

In the prior example, placing Mailbox Server 1 on a separate host from Mailbox Server 2 was ideal because it ensured that if a host were lost, the entire DAG would not be lost as well. To help enforce this kind of configuration, you can use some of the features within the Hyper-V cluster, such as **Preferred** and **Possible Owners**. Importantly, to ensure that certain virtual machines stay apart on different hosts, you also can use the **AntiAffinityClassNames** property of the failover cluster.

Best Practices and Recommendations

In this example, the administrator can create two Anti-Affinity Groups:

```
$CASAntiAffinity = New-Object System.Collections.Specialized.StringCollection
$CASAntiAffinity.Add("CAS Array")

$DAGAntiAffinity = New-Object System.Collections.Specialized.StringCollection
$DAGAntiAffinity.Add("DAG")
```

With the affinity class names defined, the administrator can assign them to the cluster groups. Once again, the *Get-ClusterGroup* cmdlet can be used to update the value of this property for each virtual machine:

```
(Get-ClusterGroup -Name EXCH-CAS1).AntiAffinityClassNames = $CASAntiAffinity
(Get-ClusterGroup -Name EXCH-CAS2).AntiAffinityClassNames = $CASAntiAffinity
(Get-ClusterGroup -Name EXCH-DAG1).AntiAffinityClassNames = $DAGAntiAffinity
(Get-ClusterGroup -Name EXCH-DAG2).AntiAffinityClassNames = $DAGAntiAffinity
```

In addition, customers can take advantage of the **Failover Priority** setting to help control the start order of virtual machines upon failover.

These settings and configuration options can help to ensure that as you scale out an Exchange 2013 infrastructure on Hyper-V hosts, you are ensuring the highest levels of both performance and resiliency by combining Exchange and Hyper-V high availability solutions.

System Center 2012 SP1

System Center 2012 SP1 provides several components that give IT the ability to streamline infrastructure management and—as discussed in this guide specifically—to better deploy, manage, maintain, and protect Exchange 2013 in a virtualized environment.

Comprehensive Management Capabilities

Cloud computing is transforming the way organizations provide and consume IT services with the promise of more productive infrastructure and more predictable applications. System Center 2012 SP1 delivers on this promise by enabling your enterprise to benefit from private, hosted, and public cloud computing while still supporting your unique business needs. It helps to organize your IT assets—network, storage, and compute—into a hybrid cloud model spanning private cloud and public cloud services from a single console view.

Infrastructure management: System Center 2012 SP1 provides a common management toolset to help you configure, provision, monitor, and operate your IT infrastructure. If your infrastructure is like that of most organizations, you have physical and virtual resources running heterogeneous operating systems. The integrated physical, virtual, private, and public cloud management capabilities in System Center 2012 SP1 can help you ensure efficient IT management and optimized ROI of those resources.

Service delivery and automation: System Center 2012 SP1 helps you simplify and standardize your data center with flexible service delivery and automation. Using the Service Manager and Orchestrator components of System Center 2012 SP1, you can automate core organizational process workflows like incident management, problem management, change management, and release management. You can also integrate and extend your existing toolsets and build flexible workflows (or runbooks) to automate processes across your IT assets and organizations.

Application management: System Center 2012 SP1 offers unique application management capabilities that can help you deliver agile, predictable application services. Using the App Controller, Operations Manager, and Virtual Machine Manager components of System Center 2012 SP1, you can provide *Applications as a Service*—where a "service" is a deployed instance of a cloud-style application along with its associated configuration and virtual infrastructure.

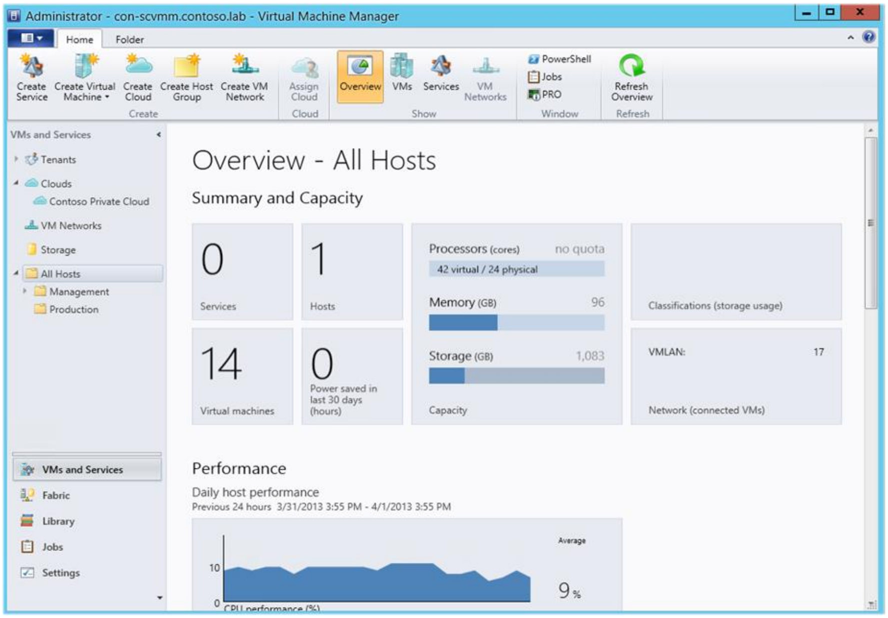
Virtual Machine Manager

System Center 2012 SP1 Virtual Machine Manager (VMM) is the control center of a virtualized Exchange 2013 deployment. This subsection takes a deeper dive into VMM by discussing the following topics: centralized fabric configuration, virtual machine creation, virtual machine deployment, Dynamic Optimization, virtual machine priority and affinity, availability sets, and private clouds.

Centralized Fabric Configuration

System Center 2012 SP1 Virtual Machine Manager (VMM) enables the IT administrator to quickly and easily configure and manage virtualization hosts, networking, and storage resources in order to create and deploy virtual machines to host key Exchange 2013 components (Figure 38).

Figure 38: System Center 2012 SP1 Virtual Machine Manager - Overview



In addition to managing Hyper-V, VMM also provides management for Citrix XenServer and VMware ESX/i hosts and host clusters on which virtual machines and services can be deployed. To help organize hosts and the deployment of virtual machines, the IT administrator can create host groups based on considerations such as physical site location or resource allocation.

In terms of networking, VMM manages resources such as logical networks, IP address pools, and load balancers that are used to deploy virtual machines and services. VMM also manages storage resources like storage classifications, LUNs, and storage pools that are made available to Hyper-V hosts and host clusters.

Virtual Machine Creation

The VMM management console provides a number of capabilities and features that can be used to accelerate and optimize the deployment of virtual machines to be used for Exchange 2013.

Physical-to-Virtual Conversions

VMM offers an inbox physical-to-virtual (P2V) capability to quickly and efficiently convert physical Exchange Servers to virtual Exchange Servers that run on Hyper-V. VMM offers two methods for conversion of physical machines: online and offline.

With an **online conversion**, the source computer continues to perform normal operations during the conversion, and it is available throughout the process. VMM creates a copy of local NTFS volumes and data from VSS-aware applications. VMM uses the Volume Shadow Copy Service (VSS) to ensure that data is backed up consistently while the server continues to service user requests. VMM uses this read-only snapshot to create a VHD.

For a busy Exchange Server, however, the point-in-time local copy for the online P2V will be out of date very quickly. Therefore, an automated **offline conversion** may be more appropriate. Here, the source computer restarts into the Windows Preinstallation Environment (Windows PE), and then VMM clones the volume to a VHD. Offline P2V conversion is the only method to reliably migrate FAT volumes, and it is the recommended method for converting domain controllers. In addition, offline P2V conversion can be the most reliable way to ensure data consistency.

Virtual Machine Profiles and Templates

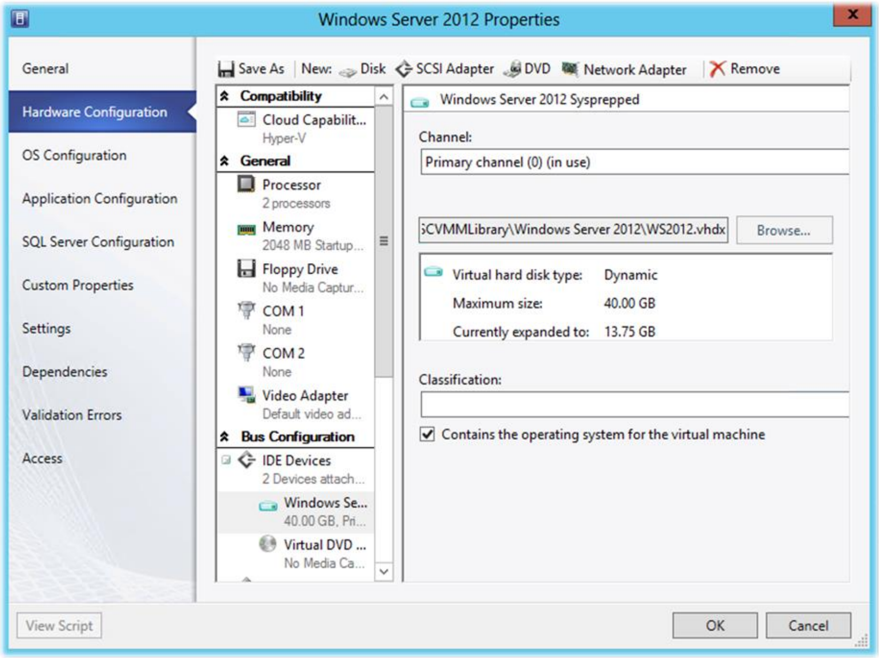
In VMM, a **profile** is a library resource containing specifications that can be applied to a new virtual machine or virtual machine template. A **template** encapsulates a standard set of configuration settings that can be used when creating a virtual machine. Templates can help you to quickly create virtual machines with consistent hardware and operating system settings. This can be extremely useful for the rapid deployment of Exchange Server virtual machines into an infrastructure. Templates also can be used to restrict the virtual machine settings available to self-service users creating new virtual machines.

Profiles are used when creating templates. A template typically consists of a hardware profile, an operating system profile, and a VHD that will be used by the virtual machine created with the template. The VHD/X might be stored in the VMM library, or it might be a disk from an existing virtual machine.

The hardware and operating system profiles are discussed in more detail below:

- **Hardware profile**: A hardware profile defines hardware configuration settings such as CPU, memory, network adapters, video adapter, DVD drive, floppy drive, COM ports, and the priority given the virtual machine when allocating resources on a virtual machine host (Figure 39).

Figure 39: System Center 2012 SP1 Virtual Machine Manager – Hardware Profile



Windows Server 2012 Sysprepped

Channel:
Primary channel (0) (in use)

;CVMMLibrary\Windows Server 2012\WS2012.vhdx

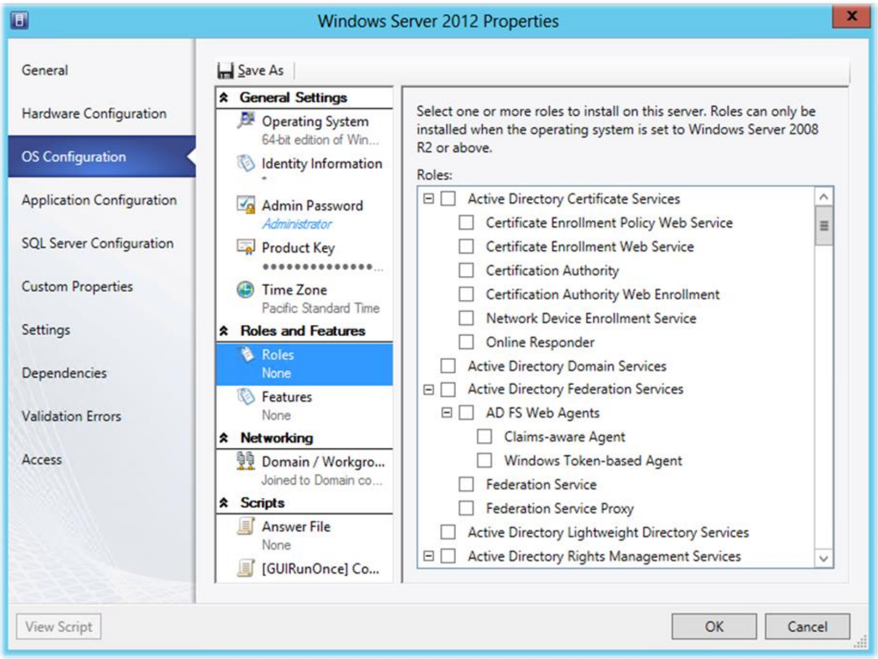
Virtual hard disk type: Dynamic
Maximum size: 40.00 GB
Currently expanded to: 13.75 GB

Classification:

☑ Contains the operating system for the virtual machine

- **Guest operating system profile**: A guest operating system profile defines operating system-configured settings that will be applied to a virtual machine created with the template. This profile defines common operating system settings, including type of operating system, roles and features to be enabled, computer name, administrator password, domain name, product key, time zone, answer file, and run-once file (Figure 40).

Figure 40: System Center 2012 SP1 Virtual Machine Manager – Guest Operating System Profile



General Settings

Operating System
64-bit edition of Win...

Identity Information
*

Admin Password
Administrator

Product Key
••••••••••••••...

Time Zone
Pacific Standard Time

Roles and Features

Roles
None

Features
None

Networking

Domain / Workgro...
Joined to Domain co...

Scripts

Answer File
None

[GUIRunOnce] Co...

Select one or more roles to install on this server. Roles can only be installed when the operating system is set to Windows Server 2008 R2 or above.

Roles:

- ⊟ □ Active Directory Certificate Services
  - □ Certificate Enrollment Policy Web Service
  - □ Certificate Enrollment Web Service
  - □ Certification Authority
  - □ Certification Authority Web Enrollment
  - □ Network Device Enrollment Service
  - □ Online Responder
- □ Active Directory Domain Services
- ⊟ □ Active Directory Federation Services
  - ⊟ □ AD FS Web Agents
    - □ Claims-aware Agent
    - □ Windows Token-based Agent
  - □ Federation Service
  - □ Federation Service Proxy
- □ Active Directory Lightweight Directory Services
- ⊟ □ Active Directory Rights Management Services

On their own, however, these profiles are not enough to be classified as a template. A template contains a number of other key elements that help to accelerate the deployment of new virtual machines into the infrastructure. It is important to note that templates are database objects stored in the library catalog of the VMM database; they are not represented by physical configuration files. Templates can be created as follows:

- From an existing virtual hard disk or template stored in the library.
- From an existing virtual machine deployed on a host.

Best Practices and Recommendations

One of the easiest ways to create a new template is to generate a new, blank virtual machine with the desired hardware settings; install the chosen Windows operating system; install any relevant updates or patches; and, once complete, shut the virtual machine down.

An administrator can then use the VMM Template Creation wizard to transform this “gold virtual machine” into a new template. (If you want to keep the original, **make a clone** of the gold virtual machine before the template creation process.) Once VMM has finished creating the template, it will store the relevant files in the library. The administrator can then begin deploying new virtual machines from this template.

Once the template is created, you can start to use some other profiles to enhance the template and accelerate deployment of virtual machines that have specific applications within them. One such key profile is the application profile. Application profiles provide instructions for installing Microsoft Application Virtualization (Server App-V) applications, Microsoft Web Deploy applications, and Microsoft SQL Server data-tier applications (DACs). For Exchange 2013, scripts could also be included as part of the application profile; scripts can be used to automate an unattended installation of Exchange 2013 once the virtual machine has been deployed. Additional information can be found on TechNet to help to guide administrators through this process.

Service Templates

"Regular" templates, like the gold virtual machine template, can be deployed as they are, without further modification. However, with the power of **service templates**, administrators (specifically Exchange administrators) can deploy multiple virtual machines simultaneously to host Exchange.

In VMM, a service is a set of virtual machines that are configured and deployed together and are managed as a single entity (for example, a deployment of a multi-tier line-of-business application). In the VMM management console, you can use the Service Template Designer to create a service template, which defines the configuration of the service. The service template includes information about what virtual machines to deploy as part of the service, which applications to install on the virtual machines, and what networking configuration to use for the service (including the use of a load balancer, if required). The service template can make use of existing virtual machine templates, or you can define the service from the ground up.

After the service template is created, you can deploy the service to a private cloud or to virtual machine hosts. After the service is deployed, you can update the service template and then deploy those changes to the existing service. Alternatively, you can deploy additional virtual machines to an existing service in order to provide other resources for the service.

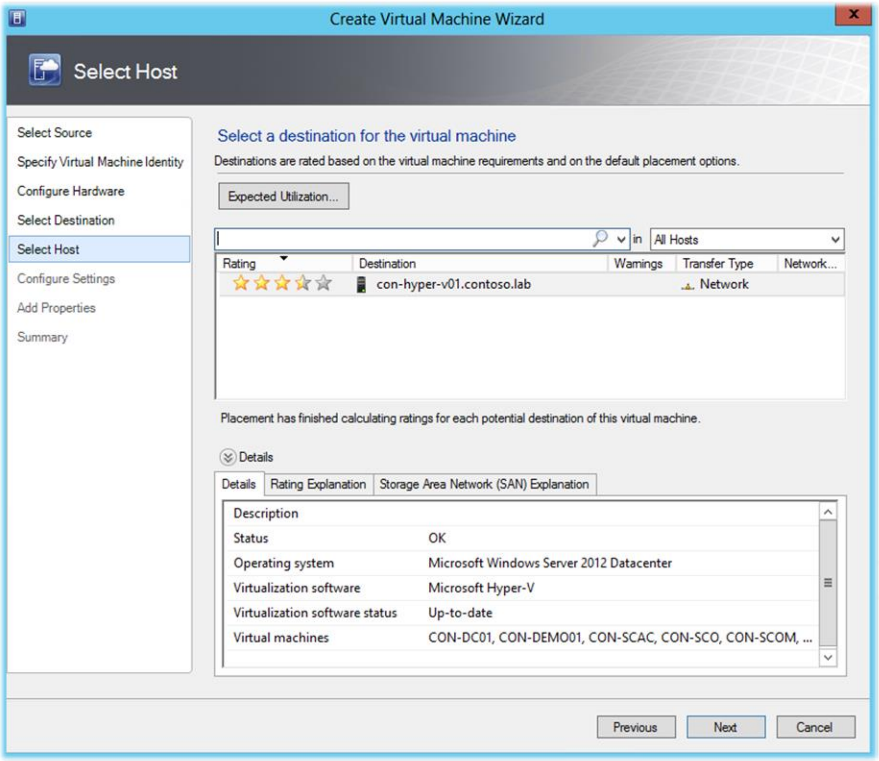
Virtual Machine Deployment

Thus far, this section has discussed how the template process can accelerate deployment of virtual machines to host Exchange 2013, as well as how a template can contain scripts to install Exchange 2013 in an unattended way. However, VMM also provides guidance on deployment: It can decide where to place the virtual machine, and can move the virtual machine around the infrastructure if better performance for that workload can be delivered elsewhere.

Intelligent Placement

VMM can help to identify the most appropriate physical host servers for virtualized Exchange Server workloads. This Intelligent Placement technology not only can make administrative tasks easier, but also can help to ensure that data center resources are deployed properly and align with business goals (Figure 41).

Figure 41: System Center 2012 SP1 Virtual Machine Manager – Intelligent Placement



Select a destination for the virtual machine

Destinations are rated based on the virtual machine requirements and on the default placement options.

Rating	Destination	Warnings	Transfer Type	Network...
★★★★☆	con-hyper-v01.contoso.lab		Network	

Placement has finished calculating ratings for each potential destination of this virtual machine.

Description	
Status	OK
Operating system	Microsoft Windows Server 2012 Datacenter
Virtualization software	Microsoft Hyper-V
Virtualization software status	Up-to-date
Virtual machines	CON-DC01, CON-DEMO01, CON-SCAC, CON-SCO, CON-SCOM, ...

Intelligent Placement in VMM inputs host system data, workload performance history, and administrator-defined business requirements into sophisticated algorithms. This provides easy-to-understand, ranked results that can take the guesswork out of the placement task and help to ensure that workloads are spread across physical resources for optimal performance.

This placement also takes into account situations where a virtual machine requires specific hardware offload capabilities, such as SR-IOV, as defined in the template. If these capabilities are not available on a particular host, that host will not receive a star ranking as part of the Intelligent Placement destinations.

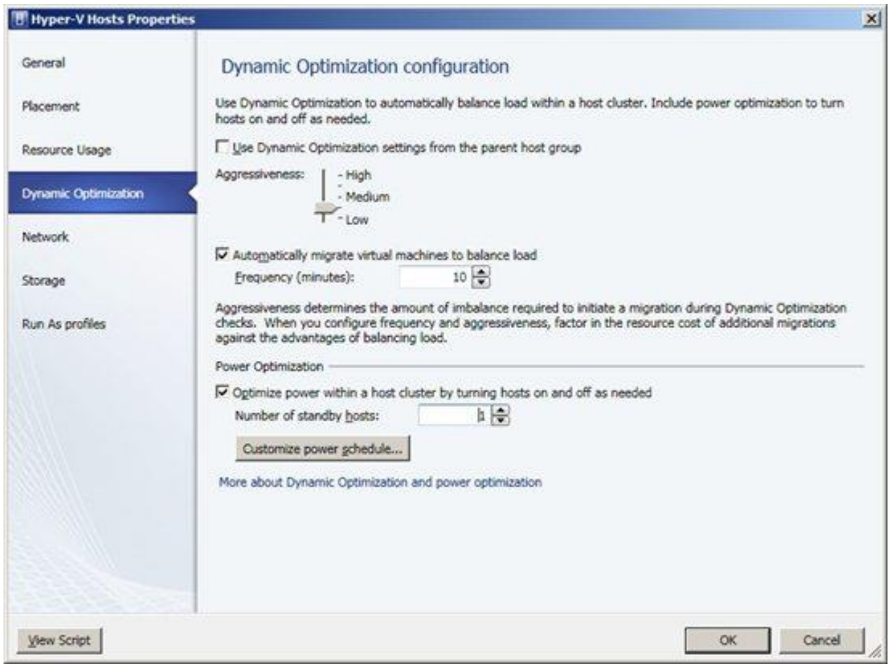
Storage Classification

VMM also provides the ability for an administrator to apply simple classifications to storage, which can be used for storing and running Exchange Server virtual machines. Storage can be classified in any way that the administrator wants, but common examples include terms such as “Bronze,” “Silver,” and “Gold,” which may represent I/O characteristics, capacity, performance, and redundancy of the underlying storage array. For example, consider the storage options and requirements for the Mailbox Server role in Exchange 2013: Bronze might be low-capacity solid-state drives in an older SAN; Silver might be SAS drives in a newer array; and Gold might be high-capacity SATA drives. These storage classifications can be used in an Exchange 2013 virtual machine template so that VMM automatically ensures that a chosen type of storage will be used for a particular deployment.[53]

Dynamic Optimization

Once Exchange 2013 virtual machines have been deployed onto the Hyper-V cluster, VMM actively monitors key cluster and host metrics—such as CPU, Memory, Disk, and Network—to see if it can better balance the virtual machine workloads across different hosts (Figure 42). For example, you may have a number of hosts in a cluster, and one of the hosts has some Exchange 2013 virtual machines that are exhibiting higher levels of demand than some others on other hosts. VMM can recognize this, and automatically live migrate, with no downtime, some of the other virtual machines on that busy host to less-busy hosts, freeing up valuable resources. This helps to ensure that workloads such as Exchange 2013, inside the virtual machines always receive the resources they need to meet demand, without impacting other workloads running on the cluster.

Figure 42: System Center 2012 SP1 Virtual Machine Manager – Dynamic Optimization



Dynamic Optimization configuration

Use Dynamic Optimization to automatically balance load within a host cluster. Include power optimization to turn hosts on and off as needed.

□ Use Dynamic Optimization settings from the parent host group

Aggressiveness: - High - Medium - Low

☑ Automatically migrate virtual machines to balance load

Frequency (minutes): 10

Aggressiveness determines the amount of imbalance required to initiate a migration during Dynamic Optimization checks. When you configure frequency and aggressiveness, factor in the resource cost of additional migrations against the advantages of balancing load.

Power Optimization

☑ Optimize power within a host cluster by turning hosts on and off as needed

Number of standby hosts: 1

Customize power schedule...

More about Dynamic Optimization and power optimization

Best Practices and Recommendations

Dynamic Optimization can be configured on a host group to migrate virtual machines within host clusters with a specified frequency and aggressiveness. Aggressiveness determines the amount of load imbalance that is required to initiate a migration during Dynamic Optimization. By default, virtual machines are migrated every 10 minutes with medium aggressiveness. When configuring frequency and aggressiveness for Dynamic Optimization, you should factor in the resource cost of additional migrations against the advantages of balancing load among hosts in a host cluster. By default, a host group inherits Dynamic Optimization settings from its parent host group.

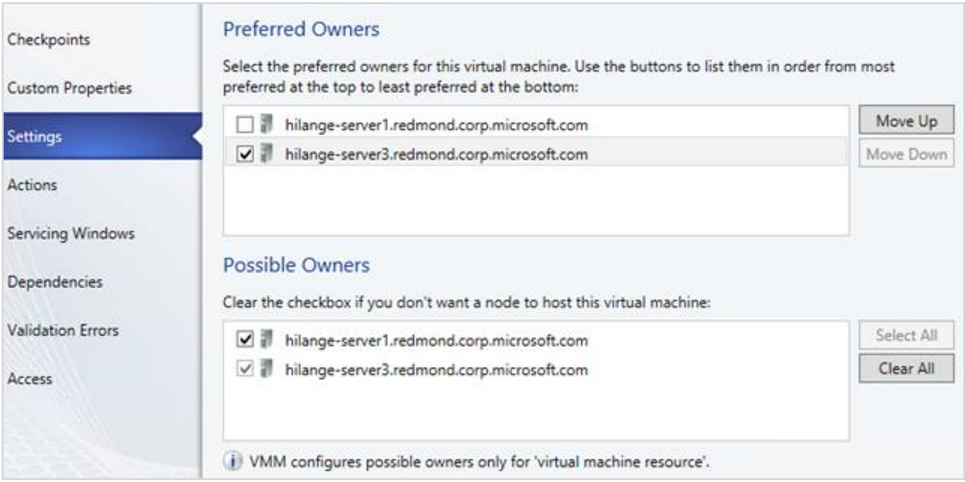
Virtual Machine Priority and Affinity

If you deploy virtual machines on a host cluster, you can use VMM to configure **priority settings** for them. With these settings, the cluster *starts or places high-priority virtual machines before medium-priority or low-priority virtual machines*. This ensures that the high-priority virtual machines, like those running Exchange Server, are allocated memory and other resources first, for better performance. Also, after a node failure, if the high-priority virtual machines do not have the necessary memory and other resources to start, the lower priority virtual machines will be taken offline to free up the necessary resources for the high-priority machines. Virtual machines that are preempted are later restarted in priority order.

You can also configure priority settings in a virtual machine template so that any virtual machines created with that template will have the specified virtual machine priority.

VMM also provides the ability for an administrator to influence the placement of virtual machines on the nodes of the host cluster. As an administrator, you can do this by defining **Preferred Owners** and **Possible Owners** for the virtual machines—ensuring that certain virtual machines can only run on certain hosts, or certain virtual machines will never run on a particular host (Figure 43).

Figure 43: System Center 2012 SP1 Virtual Machine Manager – Preferred and Possible Ownership



Preferred Owners

Select the preferred owners for this virtual machine. Use the buttons to list them in order from most preferred at the top to least preferred at the bottom:

□ hilange-server1.redmond.corp.microsoft.com
☑ hilange-server3.redmond.corp.microsoft.com

Possible Owners

Clear the checkbox if you don't want a node to host this virtual machine:

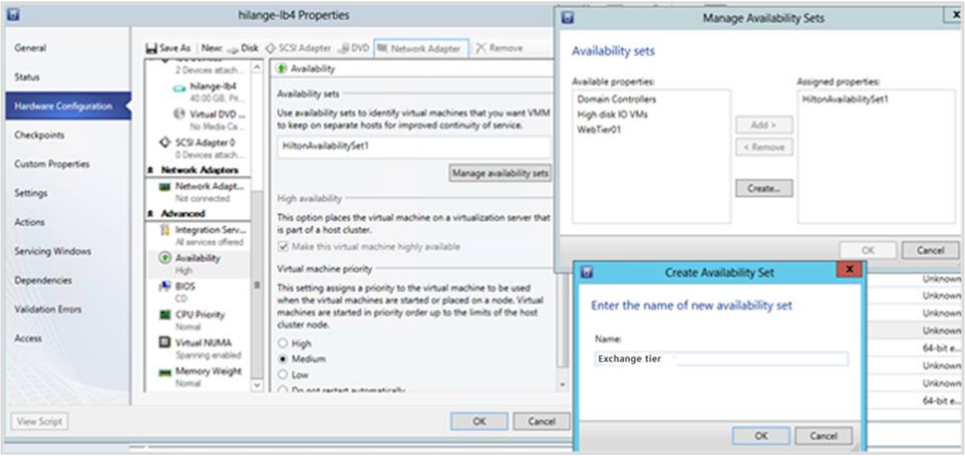
☑ hilange-server1.redmond.corp.microsoft.com
☑ hilange-server3.redmond.corp.microsoft.com

VMM configures possible owners only for 'virtual machine resource'.

Availability Sets

When you place multiple virtual machines in an **availability set**, VMM attempts to keep those virtual machines on separate hosts whenever possible (Figure 44). This helps to improve continuity of service. Another way to configure this setting is to use Windows PowerShell commands for failover clustering. In this context, the setting appears in the *Get-ClusterGroup* listing and is called *AntiAffinityClassNames*. Note that you can also configure availability sets in a service template to specify how virtual machines created with that template should be placed on hosts.

Figure 44: System Center 2012 SP1 Virtual Machine Manager – Availability Set for Exchange Virtual Machines



Availability sets

Use availability sets to identify virtual machines that you want VMM to keep on separate hosts for improved continuity of service.

HiltonAvailabilitySet1

High availability

This option places the virtual machine on a virtualization server that is part of a host cluster.

☑ Make this virtual machine highly available

Virtual machine priority

This setting assigns a priority to the virtual machine to be used when the virtual machines are started or placed on a node. Virtual machines are started in priority order up to the limits of the host cluster node.

○ High
● Medium
○ Low
○ Do not restart automatically

Availability sets

Available properties:
Domain Controllers
High disk IO VMs
WebTier01

Assigned properties:
HiltonAvailabilitySet1

Enter the name of new availability set

Name: Exchange tier

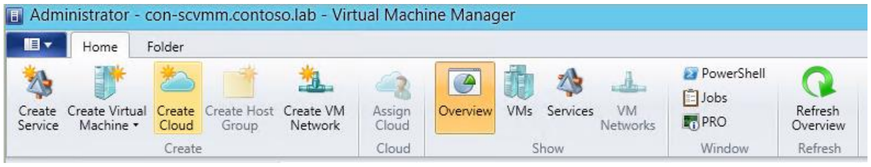
Best Practices and Recommendations

When creating a DAG or CAS array virtualized on top of a Hyper-V host cluster, consider keeping the individual Exchange 2013 roles on separate hosts. If one physical host is lost, it will only take down a single node of the DAG or CAS array because the **availability set** within VMM will have ensured that the DAG/CAS array nodes are running on separate hosts on the Hyper-V cluster.

Private Clouds

A **cloud** can be defined as the set of hardware, networks, storage, services, and interfaces that combine to deliver aspects of computing as a service. Cloud services include the delivery of software, infrastructure, and storage over the Internet (as either separate components or a complete platform) based on user demand. A private cloud is a cloud infrastructure that is provisioned and managed on-premises or off-premises by an organization or a third party. The private cloud is deployed using the organization's own hardware to capitalize on the advantages of the private cloud model. Through VMM, an organization can quickly and easily manage the private cloud definition, access to the private cloud, and the underlying physical resources (Figure 45). It also can provide granular, role-based access to end users, application owners, or in the case of this white paper, Exchange administrators.

Figure 45: System Center 2012 SP1 Virtual Machine Manager – Create Cloud Wizard



In VMM, a private cloud provides the following benefits:

- **Resource pooling**: Through the private cloud, administrators can collect and present an aggregate set of resources, such as storage and networking resources. Resource usage is limited by the capacity of the private cloud and by user role quotas.
- **Opacity**: Self-service users have no knowledge of the underlying physical resources.

- **Self-service**: Administrators can delegate management and use of the private cloud while retaining the opaque usage model. Self-service users do not need to ask the private cloud provider for administrative changes beyond increasing capacity and quotas.
- **Elasticity**: Administrators can add resources to a private cloud to increase capacity.
- **Optimization**: Use of underlying resources is continually optimized without affecting the overall private cloud user experience.

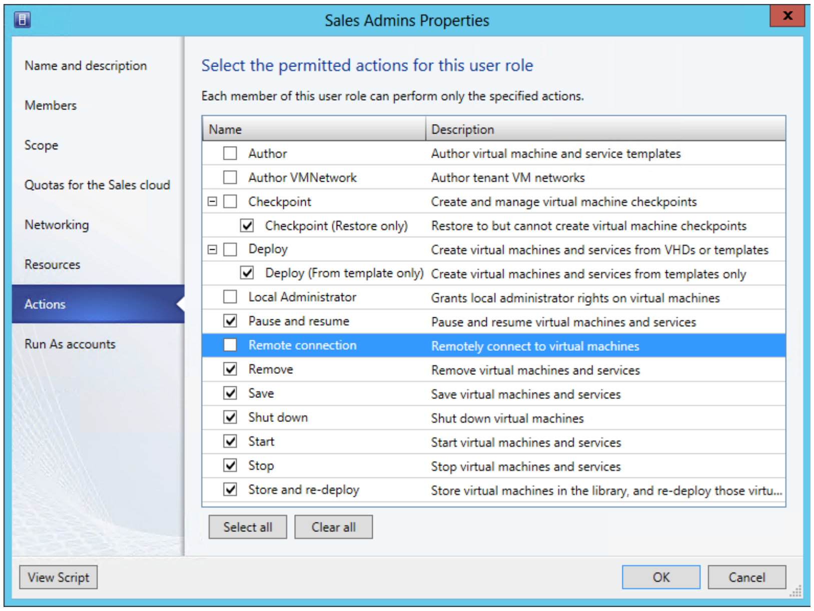
Best Practices and Recommendations

From an Exchange 2013 perspective, an IT administrator can define a cloud to be used exclusively with Exchange 2013 virtual machines. The IT organization would define the capacity of the cloud, which can use elements such as storage classifications to ensure that all virtual machines placed in the Exchange cloud use a certain tier of storage. In addition, specific virtual machine templates and service templates can be assigned to the Exchange 2013 cloud, helping to ensure that the only virtual machines deployed into this cloud are those that have been sized a certain way and will host Exchange 2013 once deployed. The templates also can contain the appropriate unattend scripts to install Exchange 2013 virtual machines.

During the creation process, you select the underlying fabric resources to be available in the private cloud, configure library paths for users, and set the capacity for the private cloud. Therefore, before you create a private cloud, you should configure the fabric resources, such as storage, networking, library servers and shares, host groups, and hosts.

Once the Exchange private cloud is created, an IT administrator can delegate access to certain users and groups within the IT infrastructure, such as the Exchange administrators (Figure 46). The IT administrator can determine—through rich, granular role-based controls—who can see what inside the cloud, and who can perform which tasks associated with it.

Figure 46: System Center 2012 SP1 Virtual Machine Manager – User Roles



Select the permitted actions for this user role

Each member of this user role can perform only the specified actions.

Name	Description
☐ Author	Author virtual machine and service templates
☐ Author VMNetwork	Author tenant VM networks
⊟ ☐ Checkpoint	Create and manage virtual machine checkpoints
☑ Checkpoint (Restore only)	Restore to but cannot create virtual machine checkpoints
⊟ ☐ Deploy	Create virtual machines and services from VHDs or templates
☑ Deploy (From template only)	Create virtual machines and services from templates only
☐ Local Administrator	Grants local administrator rights on virtual machines
☑ Pause and resume	Pause and resume virtual machines and services
☐ Remote connection	Remotely connect to virtual machines
☑ Remove	Remove virtual machines and services
☑ Save	Save virtual machines and services
☑ Shut down	Shut down virtual machines
☑ Start	Start virtual machines and services
☑ Stop	Stop virtual machines and services
☑ Store and re-deploy	Store virtual machines in the library, and re-deploy those virtu...

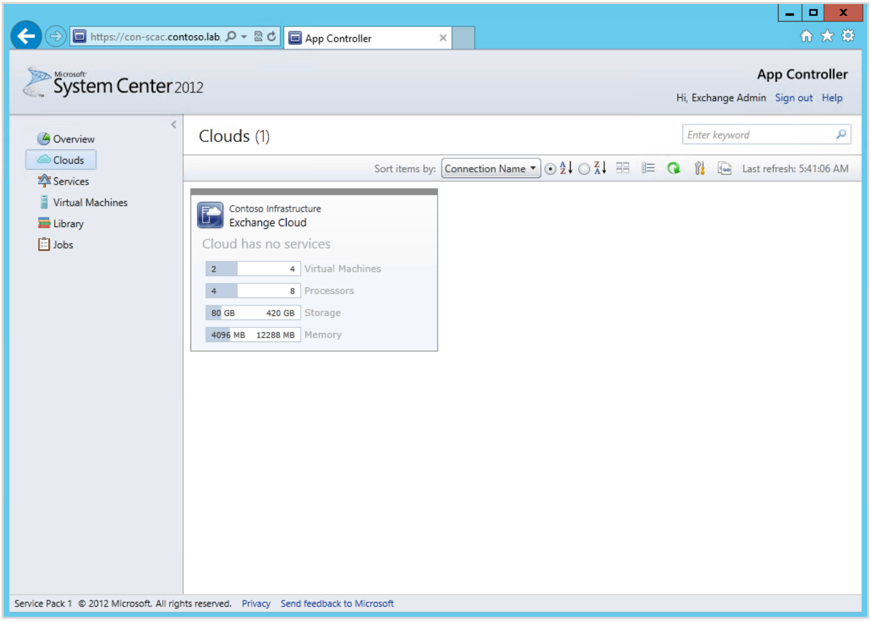
Users who are part of the newly created group can then access the cloud and associated virtual machine templates and service templates through the VMM console or, for a true self-service experience, through System Center 2012 SP1 App Controller.

App Controller

Among the advantages of a private cloud is the ability to quickly provision and deprovision compute, networking, and storage resources through virtual machines. With System Center 2012 SP1 App Controller, IT administrators in your organization can give certain users (such as Exchange administrators) the ability to access and consume private and public cloud infrastructure by self-provisioning standardized virtual machines in a controlled environment. This helps to reduce administrative overhead and improve time to market.

When an Exchange administrator logs on to the App Controller interface, an overview screen is dynamically generated based on identity and shows what the administrator can access (Figure 47). By selecting the **Clouds** option, as shown, the Exchange administrator sees accessible clouds. Note that the Exchange administrator has access to the Exchange cloud, of which a significant amount of capacity has already been used.

Figure 47: Using App Controller to access an Exchange private cloud as the Exchange administrator

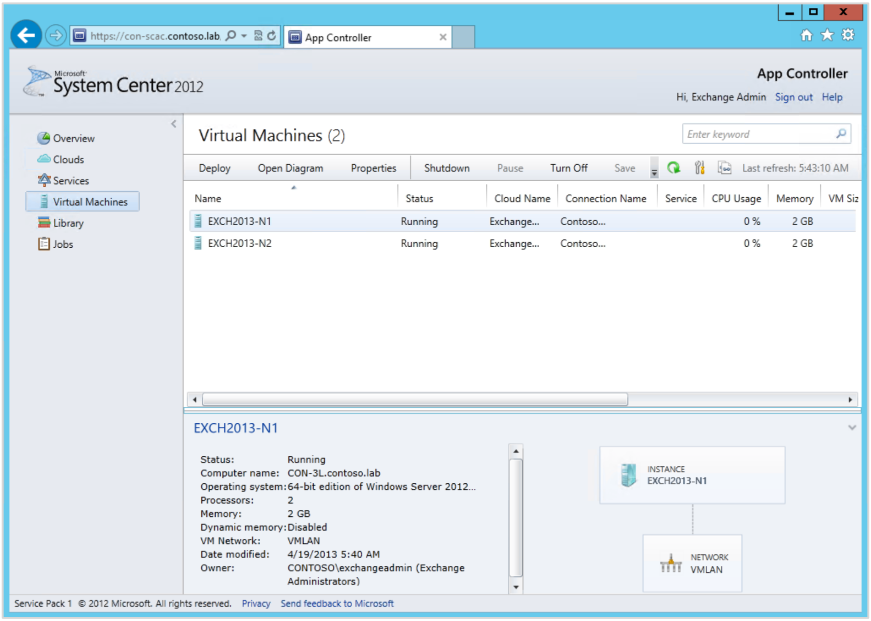


Contoso Infrastructure
Exchange Cloud
Cloud has no services

2	4	Virtual Machines
4	8	Processors
80 GB	420 GB	Storage
4096 MB	12288 MB	Memory

In Figure 48, when **Virtual Machines** is selected, a list appears of the current virtual machines that are visible to this particular Exchange administrator. It is important to note here that the Exchange administrator sees only the virtual machines that the IT administrator has specifically provided and enabled for consumption. The Exchange administrator does not see the rest of the virtual machines on a particular host or cluster, even though this person's own virtual machines may be running on those hosts or clusters. In addition, the Exchange administrator can perform only certain tasks on the virtual machine; in this example, the Exchange administrator cannot pause or save virtual machines, but can start, stop, shutdown, and deploy new virtual machines.

Figure 48: Virtual machine view in App Controller for an Exchange administrator



Virtual Machines (2)

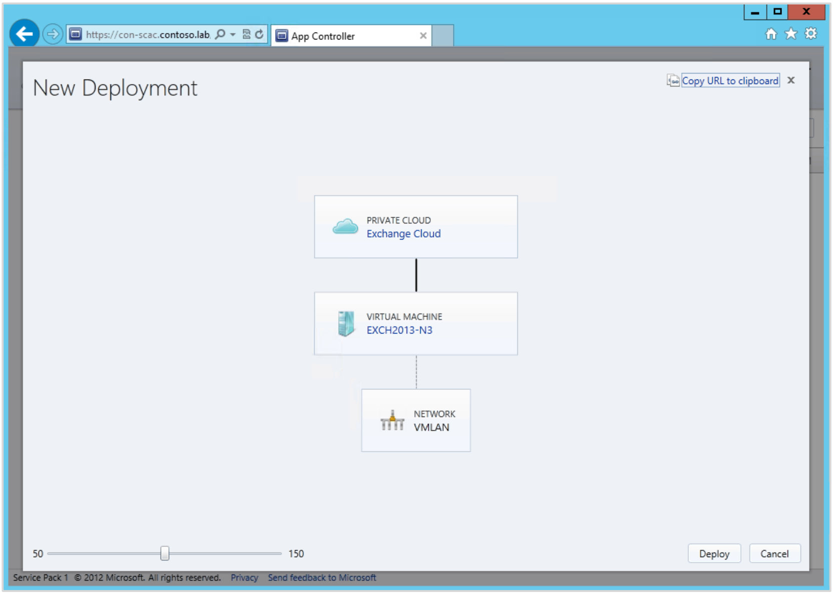
Name	Status	Cloud Name	Connection Name	Service	CPU Usage	Memory	VM Siz
EXCH2013-N1	Running	Exchange...	Contoso...		0 %	2 GB	
EXCH2013-N2	Running	Exchange...	Contoso...		0 %	2 GB	

EXCH2013-N1

Status: Running
Computer name: CON-3L.contoso.lab
Operating system: 64-bit edition of Windows Server 2012...
Processors: 2
Memory: 2 GB
Dynamic memory: Disabled
VM Network: VMLAN
Date modified: 4/19/2013 5:40 AM
Owner: CONTOSO\exchangeadmin (Exchange Administrators)

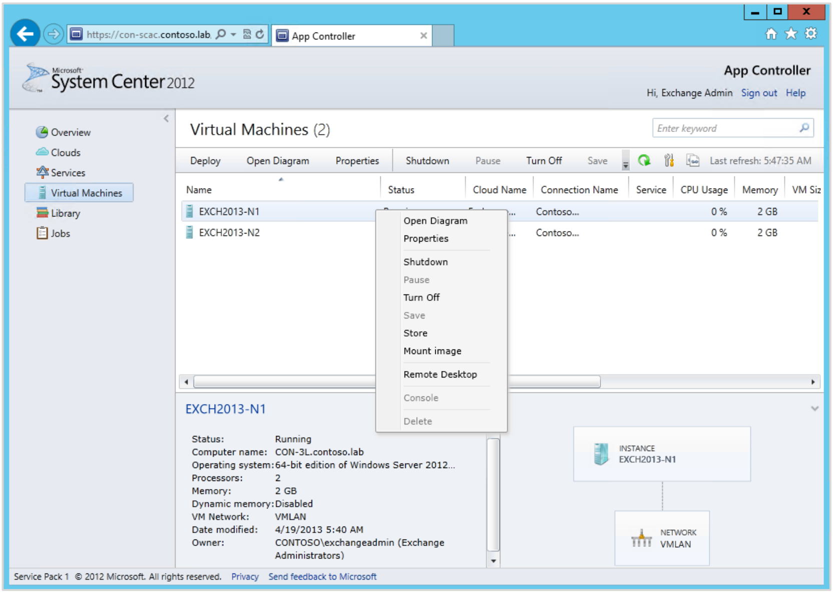
In Figure 49, the Exchange administrator chooses a particular cloud. From here, the Exchange administrator can choose from a list of provided virtual machine templates and service templates to determine the final pieces of configuration (such as Service Name, VM Name, and OS Name) for a customized deployment. When the Exchange administrator clicks **Deploy**, the virtual machine provisioning process starts, and VMM automatically orchestrates the deployment and placement of the new virtual machine, which subsequently can be used to run Exchange 2013.

Figure 49: Deploying a virtual machine with App Controller



Once the virtual machine is deployed, the Exchange administrator can access it through App Controller and perform the tasks and actions that the IT administrator has enabled (Figure 50). The Exchange administrator also can connect to the virtual machine through remote desktop to perform Exchange-specific actions.

Figure 50: Connecting to a virtual machine through App Controller



Name	Status	Cloud Name	Connection Name	Service	CPU Usage	Memory	VM Siz
EXCH2013-N1		...	Contoso...		0 %	2 GB	
EXCH2013-N2		...	Contoso...		0 %	2 GB	

EXCH2013-N1

Status: Running
Computer name: CON-3L.contoso.lab
Operating system: 64-bit edition of Windows Server 2012...
Processors: 2
Memory: 2 GB
Dynamic memory: Disabled
VM Network: VMLAN
Date modified: 4/19/2013 5:40 AM
Owner: CONTOSO\exchangeadmin (Exchange Administrators)

Service Manager and Orchestrator

To review, the subsections above have discussed:

- How IT administrators can define a private cloud within VMM, generate templates, and assign users/groups.
- How, from that point forward, Exchange administrators can access the rich web interface of App Controller to deploy into that cloud virtual machines that can be used to install and run Exchange Server.

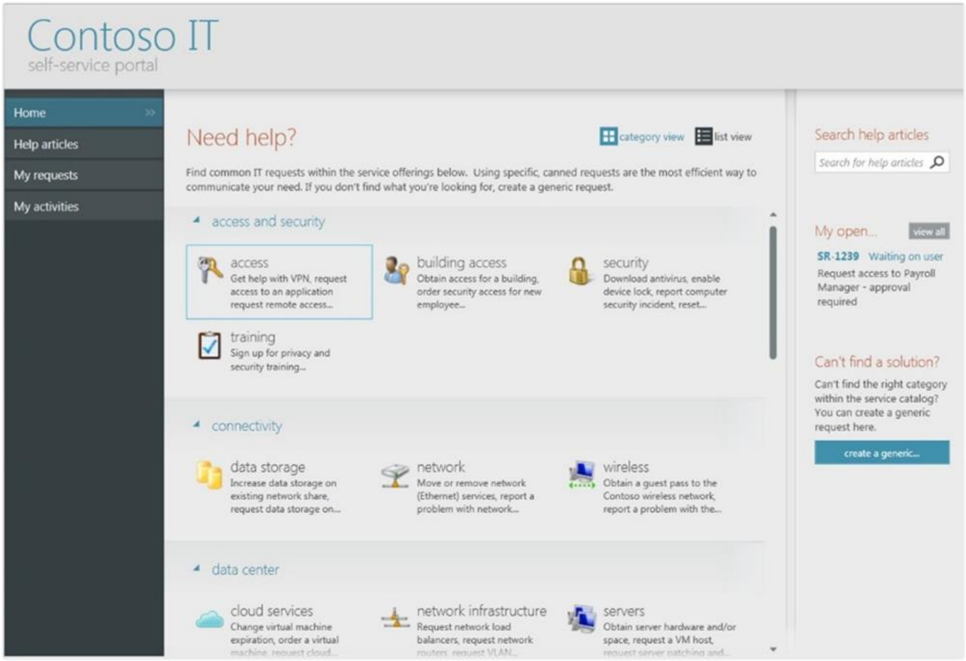
Now consider the scenario where IT administrators want to use App Controller for Exchange administrators to access their virtual machines, but also want to enact a mechanism through which the Exchange administrators must request new virtual machines, as needed, instead of creating them at will. To manage this scenario, your organization needs the Service Manager and Orchestrator components of System Center, as well as the free Cloud Services Process Pack download. Together, these elements, along with other System Center components like VMM, deliver a self-service infrastructure-as-a-service (IaaS) platform that is managed by IT and consumed by end users, application owners, and Exchange administrators.

Before examining how the components work together, it is important to understand what they provide individually. Each component is discussed below in more detail.

Service Manager

- **IT service management**: System Center 2012 SP1 Service Manager provides an integrated platform for automating and adapting your organization’s IT service management best practices, such as those found in Microsoft Operations Framework (MOF) and Information Technology Infrastructure Library (ITIL). It provides built-in processes for incident and problem resolution, change control, and asset lifecycle management.
- **ITaaS**: Service Manager enables a rich self-service portal that provides role-based access to the service catalog (Figure 51). The Self-Service Portal in System Center 2012 is a SharePoint website that is accompanied by a set of Microsoft Silverlight applications. The SharePoint environment provides a foundation on which the portal can be customized. It also provides a set of building blocks for extending the features that users can access through a web browser.

Figure 51: Self-service portal in Service Manager



Find common IT requests within the service offerings below. Using specific, canned requests are the most efficient way to communicate your need. If you don't find what you're looking for, create a generic request.

access
Get help with VPN, request access to an application request remote access...

building access
Obtain access for a building, order security access for new employee...

security
Download antivirus, enable device lock, report computer security incident, reset...

training
Sign up for privacy and security training...

data storage
Increase data storage on existing network share, request data storage on...

network
Move or remove network (Ethernet) services, report a problem with network...

wireless
Obtain a guest pass to the Contoso wireless network, report a problem with the...

cloud services
Change virtual machine expiration, order a virtual machine, request cloud...

network infrastructure
Request network load balancers, request network routers, request VLAN...

servers
Obtain server hardware and/or space, request a VM host, request server patching and...

SR-1239 Waiting on user
Request access to Payroll Manager - approval required

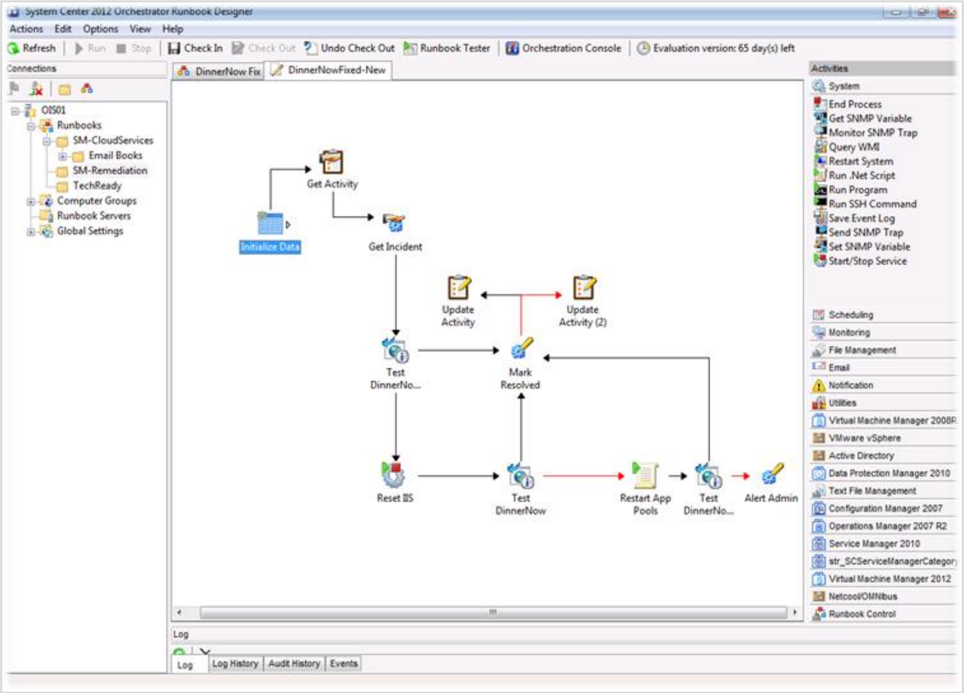
Can't find the right category within the service catalog? You can create a generic request here.

- **Integration**: Connectors simplify and streamline integration between Service Manager and other System Center components. You can use Service Manager connectors to import data as configuration items from Active Directory Domain Services, Configuration Manager, Orchestrator, VMM, and Operations Manager. In addition, you can import alerts from Operations Manager and configure them to automatically generate incidents in Service Manager. You can also import data from comma-separated value (CSV) files into the Service Manager database.
- **Business intelligence**: Service Manager delivers a powerful data warehouse for rich, integrated reporting. Service Manager reports enable you to collect and view data and trends from across the business environment. For example, you can generate a report that shows the number of incidents that occur in a specific time frame. You can then use that information to calculate the cost of each incident (in hours) and to identify trends and take preventative measures to reduce the cost and occurrence of incidences.

Orchestrator

- **Custom automation**: System Center 2012 SP1 Orchestrator provides tools to build, test, debug, deploy, and manage automation in your environment. These automated procedures, called *runbooks*, can function independently or start other runbooks (Figure 52). The standard activities defined in every installation of Orchestrator provide a variety of monitors, tasks, and runbook controls, which you can integrate with a wide range of system processes. Each activity in a runbook publishes data that is available to any subsequent activity in that runbook. You can use this published data to provide dynamic decision-making capabilities (like creating emails, alerts, log files, accounts, and more).

  Figure 52: Sample runbook in Orchestrator



  Your IT organization can use Orchestrator to improve efficiency and reduce operational costs to support cross-departmental objectives. Orchestrator provides an environment with shared access to common data. By using Orchestrator, you can evolve and automate key processes between groups and consolidate repetitive manual tasks. You can automate cross-functional team processes and enforce best practices for incident, change, and service management by creating runbooks that are customized for your requirements. Through automation, regularly recurring tasks reduce the number of manual and error-prone activities in your environment, helping to improve reliability and predictability.

- **Cross-platform integration**: Orchestrator integrates with System Center, other Microsoft products, and non-Microsoft products to enable interoperability across the data center. Orchestrator improves efficiency across multiple tools, systems, and departments by eliminating or crossing technology and organizational process structures. You can extend the capabilities of Orchestrator with integration packs that include additional functionality for both Microsoft and non-Microsoft products and technologies. Orchestrator activities and integration packs reduce unanticipated errors and shorten service delivery time by automating the common tasks associated with enterprise tools and products.

- **End-to-end orchestration**: *Orchestration* is the collective name for the automated arrangement, coordination, and management of systems, software, and practices. It enables the management of complex cross-domain processes. Orchestrator provides the tools for orchestration to combine software, hardware, and manual processes into a seamless system. These tools let you connect and automate workflows.

  Just as manufacturing companies have automated common and repeatable tasks from their production processes, you can adopt this same efficiency in the IT environment by using Orchestrator to seamlessly perform and monitor your IT processes. Orchestrator can handle routine tasks, ensure process enforcement, and reliably meet the demands of the largest enterprises. Orchestrator interoperates with other System Center products to integrate IT administrative tasks from start to finish.
- **Extensible structure**: If you have a custom in-house solution, Orchestrator provides extensible integration to any system through the Orchestrator Integration Toolkit. You can create custom integrations that allow Orchestrator to connect to any environment. Orchestrator uses a Representational State Transfer (REST)-based web service that can perform processes like start and stop runbook jobs and get reporting information in Open Data protocol (OData) format. The web service lets you develop applications that can use live data from Orchestrator.

Cloud Services Process Pack

- **Infrastructure as a service**: IaaS is a service-centric model for requesting and provisioning data center resources. The System Center Cloud Services Process Pack is the Microsoft IaaS solution built on the System Center platform. With the Cloud Services Process Pack, your organization can realize the benefits of IaaS while simultaneously using your existing investments in Service Manager, Orchestrator, VMM, and Operations Manager.

  Corporate data centers are in transition. The recent shift from physical to virtual environments is now being replaced by an interest in moving to the cloud—specifically both private and public cloud infrastructures. Private cloud management assets are being delivered with Service Manager, and a key part of this solution is the self-service experience. This experience is now significantly enhanced by the Cloud Services Process Pack.

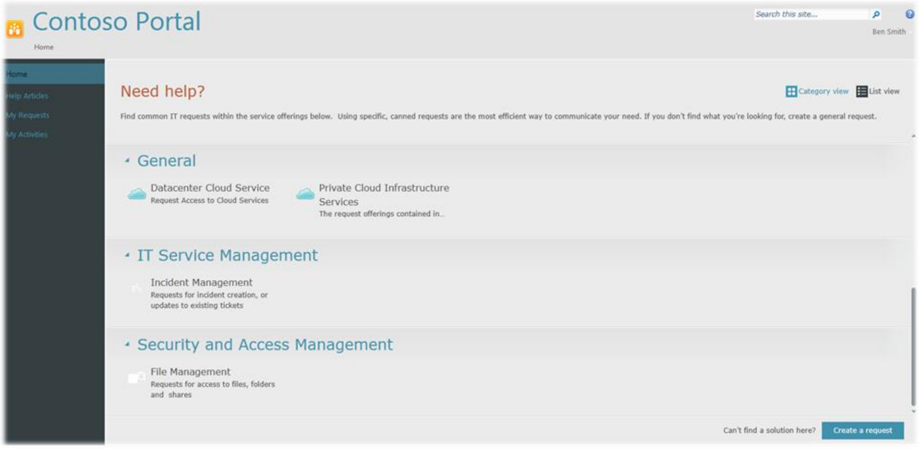
  Moreover, IT organizations considering IaaS need to examine and adapt their existing tools, processes, workflows, and automation to meet the requirements of an effective cloud services implementation. While it is critical that the underlying features (such as the Self-Service Portal, ticketing infrastructure, notifications, workflows, and automation) integrate well with each other and account for industry-wide best practices, the work involved to ensure an effective cloud services implementation can be daunting and time-consuming. The Cloud Services Process Pack addresses these concerns by enabling IaaS while incorporating domain expertise and best practices from organizations that have successfully deployed IaaS.

Implications for Exchange Server

The Service Manager, Orchestrator, and Cloud Services Process Pack components work together to form a powerful IaaS solution. With this solution, designated users like Exchange administrators can request infrastructure; once the request is approved, integrated automation orchestrates delivery of and access to the infrastructure—reducing the need for IT involvement and accelerating time to market.

Using the key components of System Center and the Cloud Services Process Pack, IT administrators can define a rich self-service experience for Exchange administrators who want to request infrastructure to run their Exchange workloads. In Figure 53, when the Exchange administrator logs on to the Contoso Portal, the portal recognizes who the user is. Role-based access is key to the Service Manager self-service experience, and the portal dynamically generates content based on the specific user.

Figure 53: Self-service portal in Service Manager



Need help?

Find common IT requests within the service offerings below. Using specific, canned requests are the most efficient way to communicate your need. If you don't find what you're looking for, create a general request.

General

Datacenter Cloud Service
Request Access to Cloud Services

Private Cloud Infrastructure Services
The request offerings contained in...

IT Service Management

Incident Management
Requests for incident creation, or updates to existing tickets

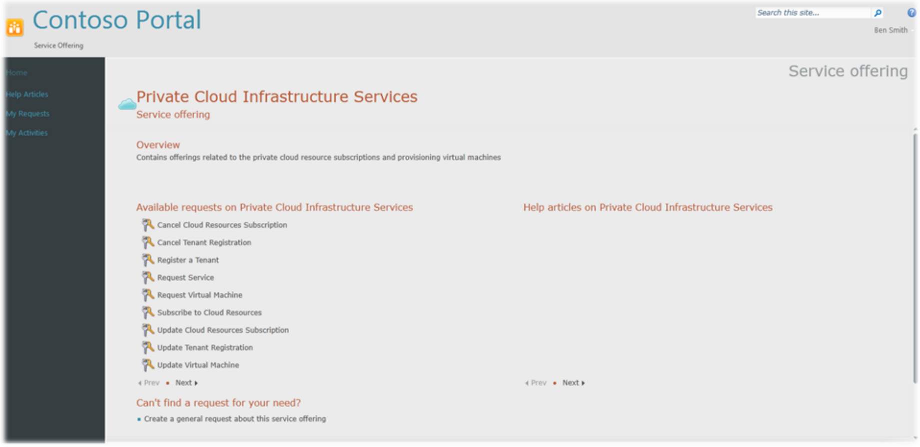
Security and Access Management

File Management
Requests for access to files, folders and shares

Can't find a solution here?

Figure 54 shows the Service Offerings page of the portal. Service Offerings essentially group together requests that the specific user can make. In this example, the Exchange administrator selects the Service Offering entitled *Private Cloud Infrastructure Services* to be presented with available requests.

Figure 54: Service Offerings page and related requests in Service Manager



Private Cloud Infrastructure Services
Service offering

Overview
Contains offerings related to the private cloud resource subscriptions and provisioning virtual machines

Available requests on Private Cloud Infrastructure Services

- Cancel Cloud Resources Subscription
- Cancel Tenant Registration
- Register a Tenant
- Request Service
- Request Virtual Machine
- Subscribe to Cloud Resources
- Update Cloud Resources Subscription
- Update Tenant Registration
- Update Virtual Machine

Help articles on Private Cloud Infrastructure Services

Can't find a request for your need?

- Create a general request about this service offering

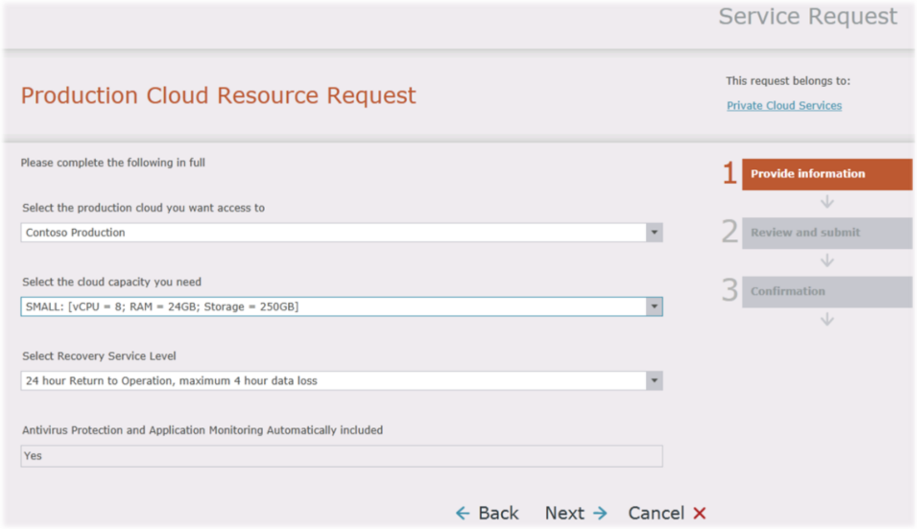
The available requests are essentially the menu of choices that IT has provided for the DBA. The Cloud Services Process Pack provides all of these in the box, and they can be used as templates for further customization by IT. Example requests include:

- Tenant Registration
- Tenant Update Registration

- Cloud Resources Subscription
- Cloud Resources Update Subscription
- Virtual Machine
- Virtual Machine Update
- Tenant Registration Cancellation
- Cloud Resources Subscription Cancellation

From an Exchange perspective, IT can define specific requests that relate to Exchange Server. These requests can be general or specific—for example, a request for IT to create a pool of resources for Exchange administrators, or a request for a specific virtual machine to host a new installation of Exchange Server. Remember the previous example where the Exchange administrator used App Controller to deploy a virtual machine from a service template. In the current example, the same process is taking place, but the Exchange administrator is making a request to have the activity performed (Figure 55). If the request is approved, Orchestrator works in conjunction with Service Manager and VMM to create and deliver the virtual machine. From there, the Exchange administrator can interact with the virtual machine through App Controller.

Figure 55: Making a cloud resource request in Service Manager



Service Request

Production Cloud Resource Request

This request belongs to:
Private Cloud Services

Please complete the following in full

Select the production cloud you want access to
Contoso Production

Select the cloud capacity you need
SMALL: [vCPU = 8; RAM = 24GB; Storage = 250GB]

Select Recovery Service Level
24 hour Return to Operation, maximum 4 hour data loss

Antivirus Protection and Application Monitoring Automatically included
Yes

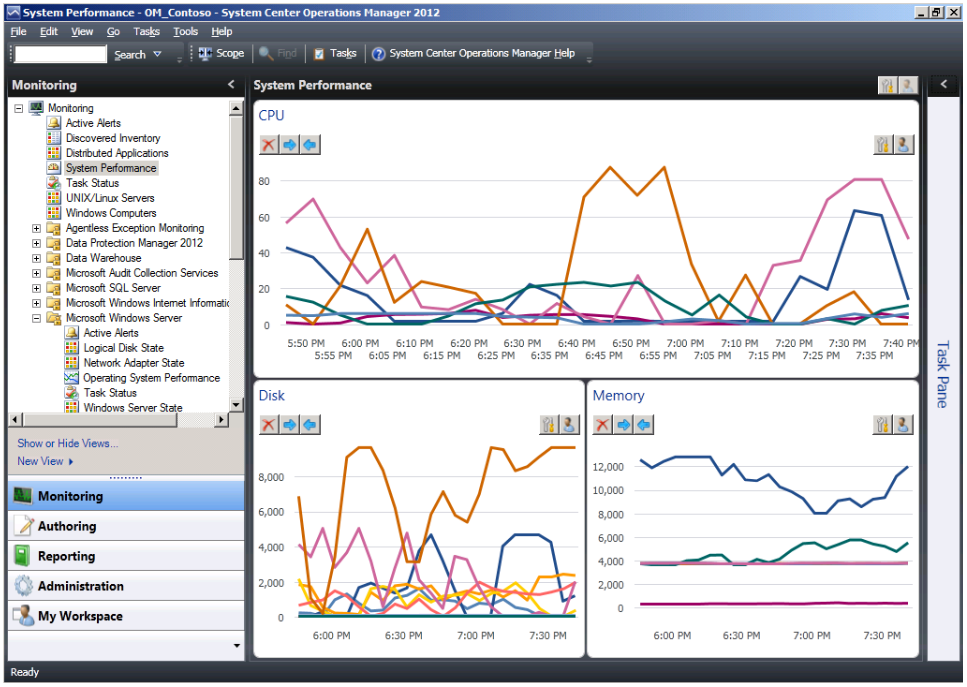
Note that the Exchange administrator can request a private cloud and specify its capacity, recovery service level, and antivirus and monitoring status. Once the request is submitted, the appropriate IT administrator is notified to initiate approval. Upon approval, Orchestrator, as part of the integrated CSPP runbooks, plugs in the relevant information from the form; orchestrates the creation of the cloud with VMM; and sets up the relevant monitoring and protection with Operations Manager and Data Protection Manager. The Exchange administrator receives notification upon completion and then is able to access the resources with App Controller or through remote desktop directly into the virtual machine.

Operations Manager

Microsoft has a long history of defining and refining monitoring capabilities for its products. System Center 2012 SP1 Operations Manager continues this tradition as a solution with a deeper level of insight and improved scalability. With Operations Manager, your organization can gain levels of visibility into its infrastructure at every level of the stack, helping to ensure that the infrastructure is optimized and running efficiently. Fundamentally, Operations Manager provides infrastructure monitoring that is flexible and cost effective, better ensures the predictable performance and availability of vital applications, and offers comprehensive oversight of your data center and cloud—both private and public.

Operations Manager enables IT administrators to monitor services, devices, and operations for many computers in a single console (Figure 56). Operations Manager includes numerous views that show state, health, and performance information, as well as alerts generated for availability, performance, configuration, and security situations. With these tools, you can gain rapid insight into the state of the IT environment and the IT services running across different systems and workloads.

Figure 56: Dashboard in Operations Manager



Exchange 2013 Management Pack

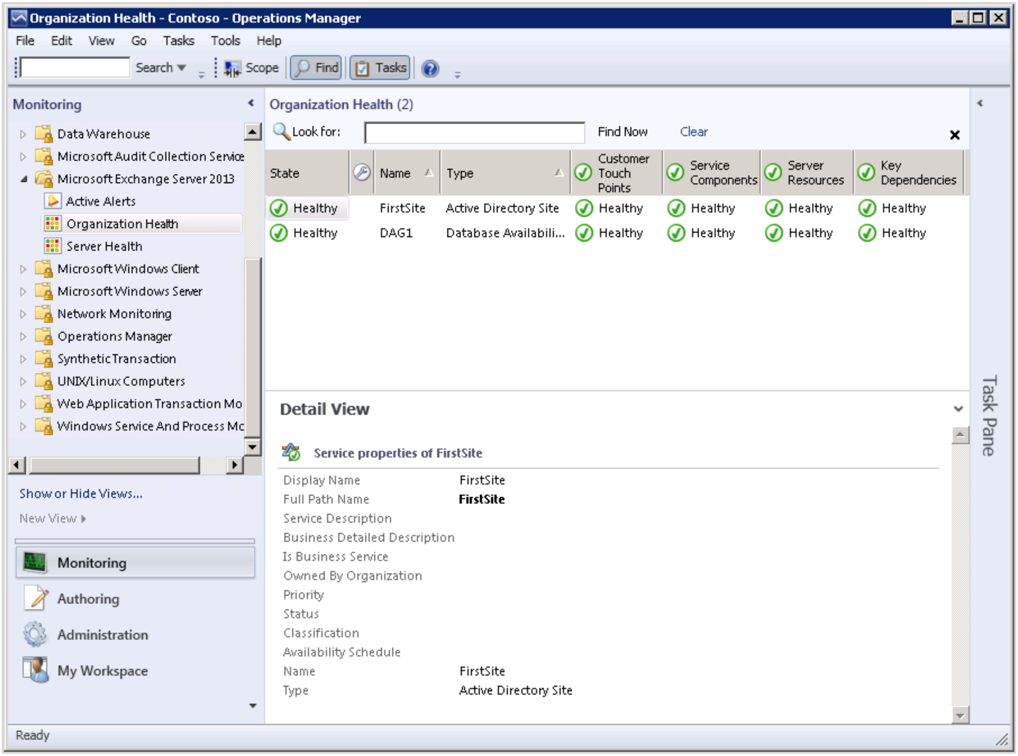
The ability to provide end-to-end management across infrastructure is a critical step in ensuring the health of the hosts and clusters, virtual machines, and private cloud itself. Further, Operations Manager can be used to monitor mission-critical Exchange Server workloads using the Exchange 2013 Management Pack.

The Microsoft Exchange 2013 Management Pack provides comprehensive service health information for an Exchange infrastructure and has been engineered for organizations that include servers running Exchange 2013. The key feature of this management pack is user-focused monitoring. The simplified dashboard focuses on the user experience and makes it easier for an administrator to quickly determine exactly what users are experiencing.

The management pack provides a number of useful views to help an Exchange 2013 administrator understand the health of the Exchange 2013 infrastructure. The **Active Alerts** view shows you all the alerts that are raised and currently active in your Exchange organization. You can click on any alert and see more information about it in the details pane. This view essentially provides you with a yes/no answer to the basic question, “Is there anything wrong in my Exchange deployment?” Each alert corresponds to one or more issues for a particular health set. Also, depending on the particular issue, there may be more than one alert raised.

If you see an alert in the Active Alerts view, your first step is to check the **Organization Health** view (Figure 57). This is the primary source of information for the overall health of your organization. It shows you specifically what is impacted in your organization, like Active Directory Sites and Database Availability Groups.

Figure 57: Exchange 2013 Organization Health view in Operations Manager



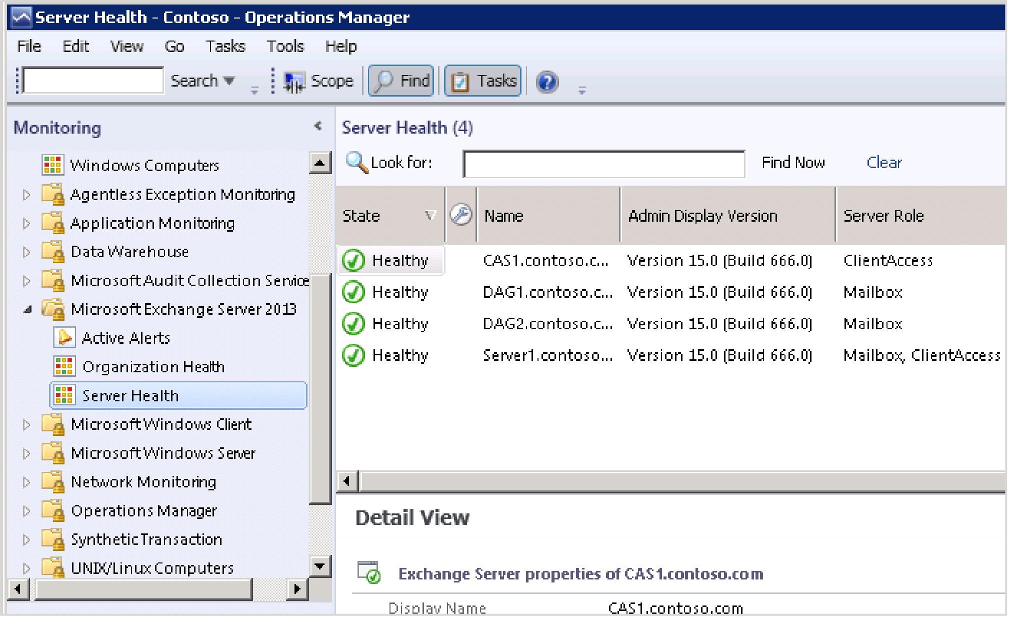
State	Name	Type	Customer Touch Points	Service Components	Server Resources	Key Dependencies
✓ Healthy	FirstSite	Active Directory Site	✓ Healthy	✓ Healthy	✓ Healthy	✓ Healthy
✓ Healthy	DAG1	Database Availabili...	✓ Healthy	✓ Healthy	✓ Healthy	✓ Healthy

Service properties of FirstSite

Display Name	FirstSite
Full Path Name	**FirstSite**
Service Description	
Business Detailed Description	
Is Business Service	
Owned By Organization	
Priority	
Status	
Classification	
Availability Schedule	
Name	FirstSite
Type	Active Directory Site

The **Server Health** view provides details about individual servers in your organization. Here, in Figure 58, you can see the individual health of all your servers. Using this view, you can narrow down any issues to a particular server.

Figure 58: Exchange 2013 Server Health view in Operations Manager



State	Name	Admin Display Version	Server Role
✓ Healthy	CAS1.contoso.c...	Version 15.0 (Build 666.0)	ClientAccess
✓ Healthy	DAG1.contoso.c...	Version 15.0 (Build 666.0)	Mailbox
✓ Healthy	DAG2.contoso.c...	Version 15.0 (Build 666.0)	Mailbox
✓ Healthy	Server1.contoso...	Version 15.0 (Build 666.0)	Mailbox, ClientAccess

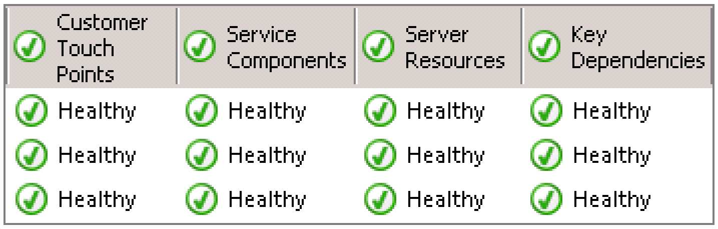
Exchange Server properties of CAS1.contoso.com

Display Name CAS1.contoso.com

While going through the three views in the Exchange 2013 dashboard, you will notice that in addition to the **State** column, you have four additional health indicators (Figure 59). Each of these health indicators provides an overview of specific aspects of your Exchange deployment.

- **Customer Touch Points**: Shows you what your users are experiencing. If the indicator is healthy, it means that the problem is probably not impacting your users. For example, assume that a DAG member is having problems, but the database failed over successfully. In this case, you will see unhealthy indicators for that particular DAG, but the Customer Touch Points indicator will show as healthy because users are not experiencing any service interruption.
- **Service Components**: Shows you the state of the particular service associated with the component. For example, the Service Components indicator for Microsoft Outlook Web Access (OWA) indicates whether the overall OWA service is healthy.
- **Server Resources**: Shows you the state of physical resources that impact the functionality of a server.
- **Key Dependencies**: Shows you the state of the external resources that Exchange depends on, like network connectivity, DNS, and Active Directory.

Figure 59: Health indicators in Operations Manager



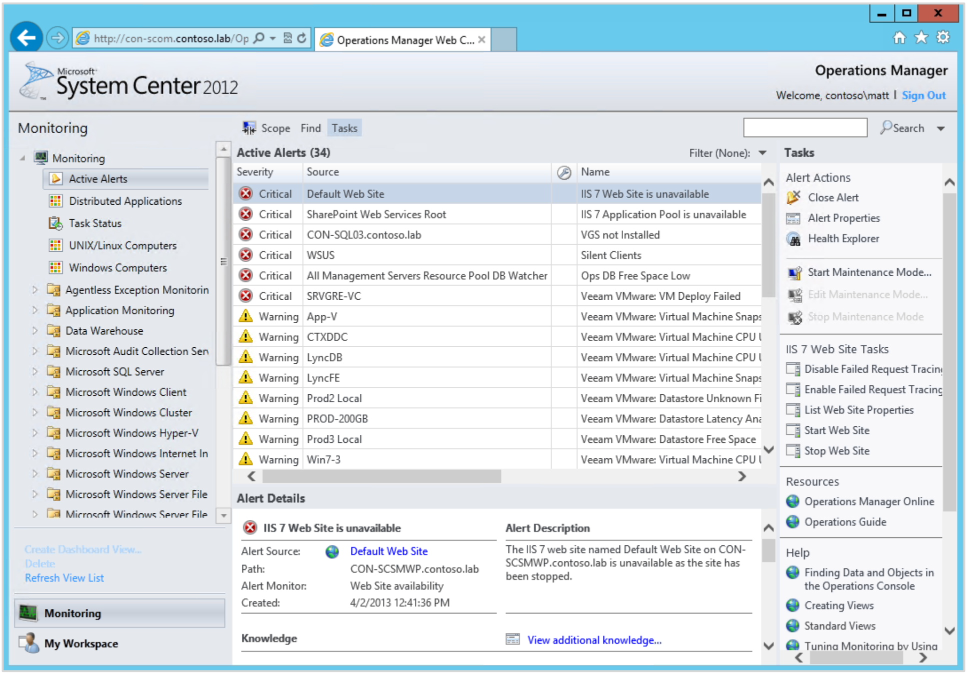
✓ Customer Touch Points	✓ Service Components	✓ Server Resources	✓ Key Dependencies
✓ Healthy	✓ Healthy	✓ Healthy	✓ Healthy
✓ Healthy	✓ Healthy	✓ Healthy	✓ Healthy
✓ Healthy	✓ Healthy	✓ Healthy	✓ Healthy

The Exchange 2013 Management Pack provides simple but powerful views that makes it easy and fast to determine if your organization is healthy. However, the views are also robust and structured in a way to quickly guide you to the root of the problem, should an alert be triggered.

Best Practices and Recommendations

If the Exchange administrator does not want to install the full Operations Manager console on a local machine or if IT is not comfortable providing that level of access, the Operations Manager web console is a good option (Figure 60). The web console can be accessed through a browser and offers near-parity with the full console. This allows the Exchange administrator to access key information, alerts, dashboards, and views focused on specific areas (such as Exchange 2013).

Figure 60: Web console for Operations Manager



Active Alerts (34)

Severity	Source	Name
Critical	Default Web Site	IIS 7 Web Site is unavailable
Critical	SharePoint Web Services Root	IIS 7 Application Pool is unavailable
Critical	CON-SQL03.contoso.lab	VGS not Installed
Critical	WSUS	Silent Clients
Critical	All Management Servers Resource Pool DB Watcher	Ops DB Free Space Low
Critical	SRVGRE-VC	Veeam VMware: VM Deploy Failed
Warning	App-V	Veeam VMware: Virtual Machine Snaps
Warning	CTXDDC	Veeam VMware: Virtual Machine CPU U
Warning	LyncDB	Veeam VMware: Virtual Machine CPU U
Warning	LyncFE	Veeam VMware: Virtual Machine Snaps
Warning	Prod2 Local	Veeam VMware: Datastore Unknown Fi
Warning	PROD-200GB	Veeam VMware: Datastore Latency Ana
Warning	Prod3 Local	Veeam VMware: Datastore Free Space
Warning	Win7-3	Veeam VMware: Virtual Machine CPU U

Alert Details

IIS 7 Web Site is unavailable

Alert Source: Default Web Site
Path: CON-SCSMWP.contoso.lab
Alert Monitor: Web Site availability
Created: 4/2/2013 12:41:36 PM

Alert Description

The IIS 7 web site named Default Web Site on CON-SCSMWP.contoso.lab is unavailable as the site has been stopped.

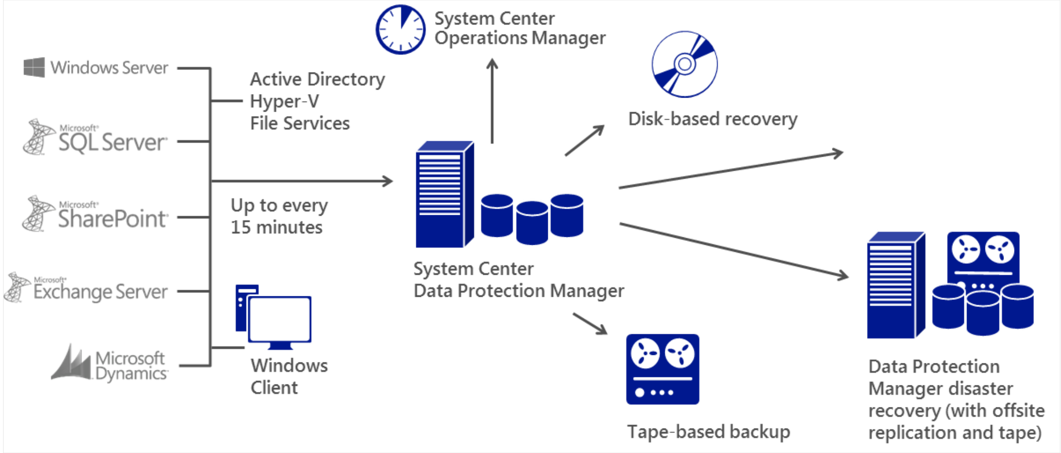
Knowledge

View additional knowledge...

Data Protection Manager

Data Protection Manager (DPM) has been part of the System Center family since the 2006 version was launched, and since then, it has continued to evolve with more enhanced capabilities around backup and workload protection. With the 2012 SP1 release, there have been further incremental improvements in DPM that make it an excellent companion for Hyper-V, offering granular, efficient protection of virtual machines and key Microsoft workloads like Exchange, SQL, and SharePoint (Figure 61).

Figure 61: Key capabilities of Data Protection Manager



DPM provides continuous data protection for Exchange Server. DPM performs replication, synchronization, and recovery point creation to provide reliable protection and rapid recovery of Exchange data by both system administrators and end users. DPM also allows users to exclude virtual machine page files from incremental backups to improve storage usage and backup performance.

Organizations can back up and restore critical data using Exchange-aware applications that also support VSS Writer for Exchange 2013. The VSS component of Windows Server coordinates the activities of providers, writers, and requesters for applications that create and use shadow copies. These applications consist of a background service that performs the backup, a scheduling service that times the backup, and a Windows GUI application console that controls and configures the backup and restore system. [54, 55]

DPM protects databases for Exchange 2013 that are contained in a DAG. DPM also can be used to recover Exchange 2013 mailboxes and mailbox databases.[56] DPM supports the following types of recovery for Exchange 2013 mailboxes:

- **Recover to an Exchange Server database**: Recover only to Exchange Server recovery databases.
- **Recover to a network location**: Copy the database to a network folder.
- **Copy to tape**: Create an on-tape copy of the database.

Likewise, DPM supports the following five types of recovery for Exchange 2013 mailbox databases:

- **Recover the database to its original location**: Overwrite the existing copy of the database.
- **Recover the database to an alternate database**: Restore to another database on an Exchange Server.
- **Recover to an Exchange Recovery database**: Recover to an Exchange Recovery database instead of a standard mailbox database.
- **Recover to network location**: Copy the database to a network folder.
- **Copy to tape**: Create an on-tape copy of the database.

With System Center 2012 SP1, DPM now can back up data from the DPM server to offsite storage that is managed by the Windows Azure Backup service. (Your organization must sign up for the service, and you must download and install the Windows Azure Backup agent on the DPM server, which is used to transfer the data between the server and the service.) With the new online backup capabilities in DPM, you can expect the following benefits:

- **Reduced TCO**: The Windows Azure Backup service can help to reduce TCO by providing scalability, elasticity, and simplified storage management.
- **Peace of mind**: The Windows Azure Backup service provides a reliable, secure, and robust offsite solution for backup and recovery that is highly available. It also provides uninterrupted protection for migrated virtual machines.
- **Simplicity**: Windows Azure Backup workflows are seamlessly integrated into the existing DPM backup, recovery, and monitoring workflows. The service also facilitates recovery of data from individual mailboxes.

Conclusion

Windows Server 2012 Hyper-V is a great fit for virtualizing Exchange 2013 workloads. As demand for virtualization technology grows, Microsoft has continued to make it easier for organizations to choose to virtualize workloads that were not previously considered good candidates. Virtualization of Exchange 2013 is a valid option for organizations looking to address the impact of any wasted resources from Exchange deployments on underutilized hardware. In addition, Exchange virtualization delivers other significant benefits, including increased dual-levels of resiliency, along with significant overall power and space savings, improved server utilization, rapid server provisioning, and increased performance and manageability. With Hyper-V technology, Microsoft provides a platform with flexible and robust virtualization capabilities. Whether in your data center, with a service provider, or in a private cloud, Microsoft provides flexibility and control to consume IT as a service—in whatever way best meets your unique business needs.

Proper planning is required before virtualizing business-critical workloads like Exchange 2013, and it is beneficial to understand the best practices and recommendations discussed in this guide. At a high level, the fabric considerations can help you to effectively plan the physical infrastructure, including processors, memory, storage, and network. Likewise, the agility and resiliency considerations can help you to configure virtual machines using Exchange 2013 and Windows Server 2012 Hyper-V settings, depending on various requirements.

Both Exchange 2013 roles (Client Access Server and Mailbox Server) are supported for virtualization. Combining Exchange Mailbox servers that are part of a DAG with host-based failover clustering and migration technology is also now supported. As a best practice, spend adequate time designing the virtualized environment to avoid consequences later. For organizations that have high availability or site resiliency needs, it is important to determine these requirements as a first step. For high availability, you must deploy the same Exchange roles (for example, Client Access Server) across multiple physical Hyper-V hosts to allow for load balancing and high availability. Therefore, never deploy either of the following on the same Hyper-V host: Mailbox servers that are members of the same DAGs or all Client Access servers. To optimize high availability and resiliency, Windows Server 2012 Hyper-V even lets you prioritize virtual machines in a failover situation.

The Virtual Machine Configuration section provides a guide to design detailed architecture and system specifications for building virtual machines for Exchange workloads. Remember that it is also necessary to plan for needed resources for the virtual machines, including CPU, memory, storage, and network. Windows Server 2012 Hyper-V offers increased virtual machine resource densities of up to 64 virtual processors and 1 TB of RAM per virtual machine; this is a significant boost to virtualizing mission-critical, heavy-duty workloads like Exchange Mailbox Server roles and multi-role servers.

Virtualizing Exchange 2013 with Windows Server 2012 gives organizations flexible deployment options, both on-premises and in the cloud. System Center 2012 SP1 enables these organizations to deploy, manage, maintain, and protect Exchange 2013 in a virtualized environment. System Center 2012 SP1 Virtual Machine Manager and Operations Manager provide a highly capable set of tools to manage and deploy virtual machines to host the key Exchange 2013 components. Likewise, System Center 2012 SP1 Data Protection Manager provides continuous data protection and rapid data recovery for Exchange Server using replication, synchronization, and recovery point creation.

Additional Resources

For more information, please visit the following links:

Exchange 2013 for IT Pros
http://technet.microsoft.com/en-us/exchange/fp179701.aspx

Exchange 2013 Virtualization
http://technet.microsoft.com/en-us/library/jj619301(v=exchg.150).aspx

Windows Server 2012
http://www.microsoft.com/en-us/server-cloud/windows-server/default.aspx

Windows Server 2012 TechNet
http://technet.microsoft.com/en-us/windowsserver/hh534429.aspx

Microsoft System Center 2012
http://www.microsoft.com/en-us/server-cloud/system-center/default.aspx

Microsoft System Center 2012 TechNet
http://technet.microsoft.com/en-us/systemcenter/bb980621.aspx

What’s New in System Center 2012 SP1
http://technet.microsoft.com/en-us/systemcenter/bb980621.aspx

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