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Successfully Virtualizing Microsoft SQL Server for High Availability on Azure VMware Solutions BEST PRACTICES GUIDE



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Introduction

This document describes the steps and tasks involved in design and configuring a sample Azure VMware solution infrastructure to optimally support a virtualized production Microsoft SQL Server workload. It is intended to provide a representative list of configuration options, architectural guidelines and operational considerations based on the standard practices documented in VMware's published best practices for virtualizing Microsoft SQL Server workloads on the Vmware vSphere® platform.

To provide a broader view of these options, this document describes a 3-node cluster of Microsoft SQL Server instances configured as follows:

- A 2-node failover clustering instance (FCI) configuration consisting of two Windows Server 2019 VMs hosting an instance of Microsoft SQL Server and configured for high availability.
- A 2-node always on availability group (AG) consisting of two Windows Server 2019 VMs hosting a high-availability configuration of a database.
- One of the VMs in both scenarios described above is simultaneously participating as a node in the configurations.

Always refer to the following architectural and best practices guides for the latest and most comprehensive information when designing your VMware vSphere-based hybrid cloud infrastructure. These documents (individually and collectively) will remain the authoritative sources for information related to running Microsoft SQL Server workloads on the vSphere platform and any hybrid- or public-cloud based derivative:

- o SQL Server on vSphere Best Practices Guide
- <u>Planning Highly Available, Mission Critical SQL Server Deployments with VMware</u> <u>vSphere</u>
- o <u>Considerations for running Microsoft SQL server workloads on VMware vSAN</u>
- o Architecting Microsoft SQL Server on VMware vSphere Best Practices Guide

Target Audience

This document assumes a knowledge and understanding of VMware vSphere and Microsoft SQL Server. Other than in passing, this document does not describe features, architecture, management or administration of VMware vSphere or Microsoft's Azure Platform and components. Where necessary, this document includes links to existing references and screenshots for the purpose of illustration only.

Architectural staff can use this document to gain an understanding of how the system will work as a whole as they design and implement various components. Engineers and administrators can use this document as a catalog of technical capabilities. Database administrator (DBA) staff can use this document to gain an understanding of how Microsoft SQL Server might fit into a virtual infrastructure. Management staff and process owners can use this document to help model business processes to take advantage of the savings and operational efficiencies achieved with virtualization and hybrid cloud.



Architectural Guidelines and Operational Considerations for Running SQL Server on Azure VMware Solutions

<u>Azure VMware Solutions (AVS)</u> allows users to create vSphere-based data centers (SDDCs) on AVS. Each deployed SDDC includes VMware ESXi™ hosts, VMware vCenter Server®, VMware vSAN™, VMware NSX® components and other software. The same HTML5-based vSphere client is used to manage a SDDC once deployed. This approach allows seamless migration of demanding application workloads without the need to adopt new toolsets or refactor application components.

The planning and designing phase is very important to ensure that migrations of mission-critical application workloads to Azure VMware Solution complete without negatively impacting application SLAs or affecting the performance, availability, manageability and scalability of the workloads. This document summarizes architectural guidelines which will help enterprises when planning a migration.

Use Case Definition

The following uses cases have been identified as the most frequently employed for SQL Server workloads on Azure VMware Solutions:

- Data center extension, like cloud-bursting and test/dev
- Workloads health and performance
- Workload high availability
- Data center evacuation
- Disaster recovery with site resilience
- Application migration and modernization

Each particular use case, or combination of use cases, influences general solution design and necessitates appropriate requirements gathering. This document focuses on use cases specific to workloads health, performance and high availability. We address the health and performance aspects of our objectives by providing a checklist of the common configuration options and recommendations required to avoid common performance bottlenecks in a typical virtualized Microsoft SQL Server infrastructure. We believe that, instead of repeating the usual exercise of providing performance metrics (which we continue to do in separate documents), it is more beneficial that we provide you with actionable configuration tips and recommendation to make your virtualization experience enjoyable.

Rightsizing

Before considering where to place SQL Server workloads on a cloud platform, ensure that your virtual machine is right-sized. A workload's performance profile should be collected over a sufficient period of time to reflect applications steady state, peaks and spikes in resource utilizations. While defining the required time range to collect time series data, consult with DBAs and application owners to understand the workload profile. At least a full month of "non-rolled up" time series data is recommended prior to executing the performance analysis.

Utilizing the <u>VMware vRealize® Suite</u> <u>Management Pack for Microsoft SQL Server (vmware.com)</u> is proven to be very helpful in this preparation phase. While analyzing captured data, make sure your rightsizing approach has been agreed upon by administrators, application owners and business



owners, and that it encompasses both spikes (i.e., high performance) and average utilization (i.e., higher density).

Microsoft's <u>AVS Assessment with Azure Migrate</u> is also a very useful tool to employ at this phase of your planning, sizing and assessment.

The following should be considered while sizing SQL Server workloads:

- For CPU and memory resources allocation, check <u>Common questions about Azure VMware</u> <u>Solution</u> to become familiar with the host's compute maximums and to verify the workload will fit and not overcommit host resources.
- Account for differences in physical CPU architectures between your current environment and the <u>host instances</u> used in Azure VMware Solution.
- Always size the CPU resource based on the actual workload, as vCPU can be easily added later.
 - Unnecessarily over-allocating compute resources to a VM can have an adverse performance impact on the workloads.
 - Hot-adding CPUs to a VM running Microsoft SQL Server instances is not recommended.
 Software Subject Control Software Soft

urces. To use the additional CPU resources, either add the new CPUs to the soft-NUMA

- Source spid53 Message Online addition of CPU resources cannot be completed. A software nor NUMA confugation and restart SQL Server.
- O
- Enabling vCPU HotAdd creates fake NUMA nodes on Windows (83980) (vmware.com)
- <u>CPU HotAdd for Windows VMs: How BADLY Do You Want It? Virtualize Applications</u> (vmware.com)
- Note that the storage layer in Azure VMware Solution is provided by hyperconverged infrastructure (HCI) solutions VMware vSAN. Adding storage will require the addition of compute resources (i.e., hosts) as well. You can use Azure storage services (e.g., storage accounts, table storage, blob storage) to augment storage for workloads running in your Azure VMware Solution environment.

Requirements

A crucial part of a successful migration is collecting business and technical requirements, allowing you to properly design a cloud platform. For guidance, review <u>Preparing for Azure VMware Solutions</u> before beginning your requirements gathering.

Business requirements are an important part of the requirements gathering process. Input examples include:

- RTO/RPO targets
- Business SLAs for the applications workloads based on SQL Server databases
- Licensing considerations
- Azure Hybrid Benefit
- Security and data-management considerations

Technical requirements will directly influence logical design and should be collected and validated with care. Pay special attention to the following bullet points:



- Performance requirements of the workload (e.g., transactions-per-second, number of user connections, expected future workloads changes)
- Capacity requirements (e.g., future growth, other projects to be served)
- Scalability requirements (e.g., method for increasing capacity of a SDDC, scale-out versus scalein approach)
- Application requirements (e.g., type of workloads [e.g., OLTP/data warehouse], dependencies between on-premises components and network flow between them)
- Manageability requirements (e.g., providing access to a SDDC to appropriate user groups, reconfiguring monitoring tools, backup solution in use, modifying scripting, vRealize Operations workflows)
- Availability requirements (e.g., SQL Server high-availability solutions in use, DRS groups, hostisolation response, number of availability zones required)

NOTE: Manageability and Availability are two important considerations we will discuss in greater details in this document. This is because, due to its hosted and managed-services nature, AVS provides restricted administrative access to the underlying infrastructure. This level of access limits certain configurations that require assisted support and which cannot ordinarily be performed by the customer.

Risks, Assumptions and Constraints

Ensure that risks, assumptions and constraints are identified and documented and that the riskmitigation plan has been agreed by all groups involved.

- An example of an assumption: Do you have a *software assurance* agreement for Microsoft SQL Server licensing?
- An example of a constraint: available network bandwidth between on-premises and SDDC (e.g., is ExpressRoute available?)
 - The scenario described in this document assumes that there is connectivity between the on-premises VMware vSphere infrastructure and the Azure VMware Solution environment
 - The examples shown in this document present a stretched-network scenario in which one network subnet is in use across both environments.
- An example of a risk: different CPU generations between on-premises ESXi hosts and hosts in an SDDC (can you enable EVC to ensure migrating running workloads from on-premises to AVS without impacting service?)

High-Level Architecture

A high-level solution architecture should include enough information to capture the on-premises environment hosting the SQL Server workloads and planned SDDC(s) with multiple availability zones (AZ) while also providing enough details to work on logical design.

Deploying and operating an Azure VMware Solution SDDC involves several simplified processes which are described in the following quick steps:

- Planning the Deployment
- Deploying the Azure VMware Solution



- <u>Connecting to on-premises</u>
- Deploying and Configuring VMware HCX

Logical Design

A logical design describes all technical decisions made and addresses identified technical requirements while minimizing risk. The level of detail included should be sufficient to create an implementation guide for the solution. While specifics of each logical design are unique, it's important to ensure all technical prerequisites are met. The following prerequisites have been identified as crucial to the successful migration of SQL Server workloads to Azure VMware Solutions:

• For on-premises-located VMs, ESXi hosts, and/or vSphere clusters hosting SQL server workloads, check and document all advanced settings configured. Ensure corresponding options are available in Azure VMware Solutions. For example, DRS anti-affinity groups and rules must be re-created in an SDDC as they cannot be migrated.

IMPORTANT:

- a. As at the time of this writing, VM-VM anti-affinity rule is not supported in AVS
- b. As at the time of this writing, creating the necessary anti-affinity rules required to separate clustered VMs in AVS requires that you open a support request with the Microsoft AVS support team. This task is assumed to have been completed and is, therefore, not covered in this document.

<u>UPDATE:</u> Microsoft has added support for creating DRS Rules into Azure VMware Solution (AVS). Using the "Placement Policy" option available in the VPC, a Customer can create one of four DRS Rules:

- VM-Host Affinity
- VM-Host Anti-Affinity
- VM-VM Affinity
- VM-VM Anti-Affinity



Keep-VMs-Separate

VM-Host affinity

VM-Host anti-affinity

Decide which hosts certain VMs do not run on. Useful when certain capabilities such as GPU or IOPS control requires avoiding certain hosts.

VM-VM affinity

Decide which VMs run together on same host. Useful when VMs benefit from locality of data reference or when placement on the same host simplify auditing.

VM-VM anti-affinity

Decide which VMs run apart on different hosts. Useful when VMs benefit from running on different hosts and if a problem occurs with one host, not all virtual machines would be placed at risk.

- Conduct an assessment of your current infrastructure using <u>AVS Assessment with Azure Migrate</u> to ensure that all requirements are met.
- Determine whether or not <u>Azure Migrate</u> is appropriate as the migration tool for existing moving workloads to AVS.
- Where applicable, <u>Deploy and Configure VMware HCX for Azure VMware Solution</u> to enable you to move existing workloads from your existing VMware infrastructure to AVS.
 - a. Hybrid coexistence using L2 VPN between the on-premises and the SDDC is currently not supported for AVS.
- Configure <u>Hybrid Linked Mode</u> to allow managing both on-premises and public SDDCs within a single vSphere Client interface. Verify that all required user accounts are added to the appropriate group.

Operational Considerations

Post-implementation maintenance and operation guidelines are a key component of any well-prepared infrastructure architecture. While incorporating Azure VMware Solution SDDCs in an existing infrastructure, it's critical that *Day 2* operational routines are updated accordingly, including:

- Backup configurations
- Monitoring configurations
- Operational documentations



If <u>vRealize Operations</u> is used to monitor the environment, confirm that all SDDCs are added to vRealize Operations-managed resources and configured using vCenter Adapter with the **Public Cloud** option.

Configuration Checklist for Hosting Microsoft SQL Server Workloads on AVS

The purpose of this section is to document the specific configuration options for successfully and optimally hosting Microsoft SQL Server instances on the Azure VMware Solution. These are explained in detail in the SQL Server on *vSphere Virtualization Best Practices Guide* mentioned at the beginning of this document. We will therefore not discuss this in great detail.

Memory Allocation

How much memory to allocate to a VM on the vSphere platform is strictly a function of the actual utilization threshold, as determined through administrative due diligence. While Microsoft SQL Server Administrators typically prefer to allocate the maximum possible RAM to their Microsoft SQL Server workloads (in anticipation of peak or worst-case consumption scenarios), it is very important to resist this practice. Virtualization imposes certain optimization and functionality considerations that may (counter-intuitively) induce performance penalties for an over-sized VM if over-allocation of resources results in sustained resource wastage. Right-sizing VMs is a sound administrative practice and we encourage applications and virtualization team members to engage in the necessary due diligence to avoid allocating compute resources to a VM on a whim. Memory should be allocated to a Microsoft SQL Server VM strictly based on empirical and historical usage trends.

Memory Hot-Add: Memory hot-add is a feature which allows Administrators to allocate *just-enough* memory to a VM (without incurring over-allocation penalties) and to adjust this allocation upwards when load increases without having to restart the VM or interrupt running tasks and processes. Modern Windows Server OS, Microsoft SQL Server and VMware vSphere support this feature, so we recommend that, when in doubt, it should be enabled as a compromise, rather than the alternative option of anticipatory over-allocation.

Memory Reservation

One of the tenets and benefits of virtualization is the cost-beneficial opportunity to utilize physical compute resources more densely and fully than is otherwise possible in a physical server environment. At a very high level, the cost benefits come from the ability to pool these resources together and share them more broadly among more OS instances on one physical server.



✓ Memory *	
Reservation	64 GB ~
	✓ Reserve all guest memory (All locked
Limit	Unlimited • MB
Shares	Normal ~ 655360
Manager Hat Dive	

Conversely, one of the challenges of virtualization is the likelihood that, in attempting to share pooled resources among as many OS instances as possible to achieve this density, Administrators run the risk of unintentionally creating the opposite effect, at least for some of the OS instances sharing the pooled resources.

As an example, imagine an ESXi host with 128GB of RAM and 10 VMs, each with 20GB RAM allocated. In normal operating conditions, it is unlikely that all 10 VMs will need their 20GB allocation at the same time. In that scenario, the VMs can all happily coexist without inducing performance bottleneck.

What if all VMs were to suddenly need their full allocation, though? Obviously, we are 72GB of memory short. Since virtualization itself does not manufacture non-existent compute resources, the hypervisor has to resort to various mechanisms (e.g., swapping, ballooning) to try to satisfy the VM's demands. In the process, some (if not all) of the VMs and the applications they host will experience performance degradation, leading to negative impact on business processes and overall user experience.

Here is where the Memory Reservation feature of VMware vSphere can come into play. In most network environments, workloads are not created equal. Some servers (physical or VMs) host applications which are more critical to business operations and revenue than others. These are called the Business (or Mission) Critical Applications. Supposing that five of the VMs in our example above are considered *"Business Critical"* (aka Tier 1) and the other five are considered not so critical. Memory Reservation would allow us to give each of the five Tier-1 VMs all their allocated memory even as the other five gasp for air.

If you are mixing VMs of different critical importance in your AVS environment, *and* you anticipate over-allocating available physical memory resources in the ESXi cluster, it is recommended that you reserve ALL the memories you are allocating to the VMs hosting the most critical application in the mix. By doing this, you ensure that your important VMs will always be entitled (and have access) to the allocated memory resources. As a little bonus, because vSphere won't create a swap file for VMs whose memory have been fully reserved, you also save on storage.



CPU Allocation

Starting with vSphere 6.5, VMware has changed its prescriptive guidance for allocating compute resources to a VM. Please see <u>Virtual Machine vCPU and vNUMA Rightsizing - Guidelines - VROOM!</u> <u>Performance Blog (vmware.com)</u> for all the background and pertinent information around this.

In summary, for wide VMs (i.e., VMs which require more vCPU counts than are available in one physical socket in the ESXi host), the recommendation to *leave cores-per-socket at 1* no longer applies. The simplified rule of thumb is to allocate vCPUs to a VM in a way that mirrors the physical NUMA topology of the ESXI host.

CPU Reservation: This is not recommended, so we will not spend much time discussing this.

CPU Hot-Add: While Microsoft SQL Server is one of the few modern applications which can dynamically adapt to (and utilize) hot-added CPUs, VMware does not recommend enabling hot-add CPUs for VMs running any version of the Windows Server Operating System at this time. Please see the following for more detailed discussion:

- <u>CPU HotAdd for Windows VMs: How BADLY Do You Want It? Virtualize Applications</u> (vmware.com)
- Enabling vCPU HotAdd creates fake NUMA nodes on Windows (83980) (vmware.com)
- <u>CPU Hot Add Performance in vSphere 6.7 VROOM! Performance Blog (vmware.com)</u>

Edit Settings Avs-vmw-sql	01	
Virtual Hardware VM Options		
		ADD NEW DE'
✓ CPU *	24	
Cores per Socket	12 × Sockets: 2	
CPU Hot Plug	Enable CPU Hot Add	
Reservation	0 MHz V	
Limit	Unlimited	MHz ~

Beware of "Limit"

As you have likely noticed in the previous two images above, vSphere provides Administrators an easy option to prevent unnecessary resource wastage by imposing a limit on the Memory and CPU resources allocated to a VM. VMware strongly recommends that Administrators leave this option unconfigured in both cases. It is better to right-size and allocate as much resources to a Microsoft SQL



Server VM as it requires rather than over-allocating resources and then consciously imposing a restriction on the VM's access to the allocated resources.

One of the most challenging problems with configuring Limits on VMs is that such configuration is easily forgotten and then missed during a performance troubleshooting exercise. The standard administrative response when a VM is perceived to be resource-constrained is to increase its allocation. Sadly, however much one increases the allocation, the VM will never be able to utilize anything beyond what has been set in Limit.

Network Card Configuration

When you create a Windows VM on vSphere, the default vNIC type assigned to the VM is the E1000E vNIC. This is not a suitable vNIC type a Windows VM running Microsoft SQL Server workloads. VMware highly recommends that you always assign the VMXNet3 virtual network card type to any Windows VMs which have more than one vCPU allocated. This is primarily because the VMXNet3 vNIC type is the only vNIC type in vSphere which supports the Windows Receive Side Scaling (RSS) feature. No other vNIC has this capability.

✓ New Network *	Deji-Segment ~
Status	✓ Connect At Power On
Adapter Type	VMXNET 3
DirectPath I/O	E1000E SR-IOV passthrough
Shares	VMXNET 3

So, why would should you care about RSS for your MS SQL Server VMs? Here is why: <u>Introduction to</u> <u>Receive Side Scaling - Windows drivers | Microsoft Docs</u>. Briefly, RSS is the Windows feature which allows Windows to distribute the handling of network packets/requests/interrupts over multiple CPUs in the OS. Without this feature, only one CPU (out of however many you have allocated to Windows) will be doing the heavy lifting. On a busy Windows OS instance, this invariably leads to packet drops, performance degradation and (eventually) instability.



Choosing VMXNet3 vNIC for the VM is just one step. Because VMXNet3 is not native to Windows, it is unusable until you have installed the VMTools on the VM. It is very important that you always keep VMTools up-to-date on your VMs because this is the mechanism through which VMware delivers updated drivers

and fixes to the VM and its components.



By default, RSS is not enabled on the vNIC inside Windows, so you must make enabling it a core part of your standard administrative or deployment procedures (better yet, enable it in your Windows VM Templates).



NOTE: Please disregard any counter recommendation you may come across. If it's a Windows VM, and it has multiple processors and it's likely to generate, receive, or transmit network traffic, VMXNet3 is your only choice for virtual network card.

SCSI Controller Configuration

The default virtual SCSI controller type assigned to a Windows VM on vSphere is the LSI Logic SAS. This choice is driven largely by the need to simplify the VM deployment process, allowing the Administrator to install Windows as quickly and seamlessly as possible.

However, the LSI Logic SAS SCSI controller is inadequate for the data throughput and disk IO patterns of a typical Microsoft SQL Server workload, which expects an optimal and fast storage IO send/receive rate for its queries and transactions. The LSI Logic SAS vSCSI controller is limited to 32 IO queue depth, which is insufficient for most modern Microsoft SQL Server workloads.

The VMware Paravirtualized Controller (PVSCSI), on the other hand, has a configurable queue depth of 64, which can be increased to 254 (per device) and 1024 (per Adapter). In addition, PVSCSI has a lighter CPU footprint, which makes it even that much more performant than the default LSI Logic SAS.



> SCSI controller 0	LSI Logic SAS	
✓ New SCSI controller *	VMware Paravirtual	
Change Type	VMware Paravirtual 🗸	
SCSI Bus Sharing	BusLogic Parallel	
> Network adapter 1	LSI Logic SAS	Connected
	VMware Paravirtual	

VMware highly recommends PVSCSI for all Data, Transaction logs and TempDB disks of a Microsoft SQL Server VM. If you have multiple disks (VMDKs) for these disk types, VMware recommends that customers add additional PVSCSI controllers and distribute the disks as evenly as possible over all the controllers.

> SCSI controller 0	USU ogic SAS OS Backup (etc) Volumes
 SCSI controller 1 	VMware Paravirtual
Change Type	VMware Paravirtual 🗸
SCSI Bus Sharing	Physical Volumes (for WSFC)
✓ SCSI controller 2	VMware Paravirtual
Change Type	VMware Paravirtual 🗸
SCSI Bus Sharing	Physical Volumes (for WSFC)
 SCSI controller 3 	VMware Paravirtual
Change Type	VMware Paravirtual 🗸
SCSI Bus Sharing	None V Non-Shared Volumes

As with the VMXNet3 vNIC, PVSCSI is not native to Windows and is, therefore, unusable until you have installed VMTools. After installing the VMTools on a Windows VM which has PVSCSI controllers attached, a new Windows Registry key becomes available and configurable. This key is where the controller can be configured to support larger queue depth.

It is highly recommended that customers configure this option in order to increase IO performance for the workloads. The following two-line PowerShell command can be used to accomplish this task:

New-Item -Path "HKLM:\SYSTEM\CurrentControlSet\services\pvscsi\Parameters\Device"



Set-ItemProperty -Path "HKLM:\SYSTEM\CurrentControlSet\services\pvscsi\Parameters\Device" -name DriverParameter -value "RequestRingPages=32,MaxQueueDepth=254" | Out-Null Administrator: Windows PowerShell Windows PowerShell opyright (C) Microsoft Corporation. All rights reserved. Viev PS C:\Windows\system32> New-Item -Path "HKLM:\SYSTEM\Cu Hive: HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\pvscsi\Parameters Q 2 lame Property)evice -Path "HKLM:\SYSTEM\CurrentContr 23 MayOueueDepth=254" | Out-Null PS C:\Windows\system32> Set-ItemProperty DriverParameter S C:\Windows\system32> 📑 Registry Editor File Edit View Favorites Help $Computer \verb|HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\pvscsi\Parameters\Device$ pla > Name Туре Data PlugPlay ab (Default) REG SZ (value not set) pmem 💩 DriverParameter REG SZ RequestRingPages=32,MaxQueueDepth=254 PNPMEM PolicyAgent PortProxy Power PptpMiniport PrintNotify PrintWorkflowUserSv PrintWorkflowUserSv(Processor ProfSvc Psched PushToInstall pvscsi Enum Parameters Device PnpInterface

Disk Allocation and Configuration

VMware vSphere allows you to create VMDKs as large as 62TB each. While this is generally a good thing, Administrators should resist the temptation to misuse this capability. As with the SCSI controllers, VMDKs have queue depth limits, too. See <u>Large-scale workloads with intensive I/O</u> patterns might require queue depths significantly greater than Paravirtual SCSI default values (2053145) (vmware.com) for additional information.

A device (in this case, a VMDK) has a queue depth of 64. The queue depth controls the maximum parallel IO that could be passed through the device at one time. Once this maximum is reached, IOs begin to queue up. If you create a large (62TB) VMDK, slice it up into multiple volumes inside the Guest OS, and assign these to, say, a few Transaction Logs, TempDB and Data disks, all of the IOs generated by these different disks will have to pass through the one VMDK, increasing your chances of reaching



the 64 queue depth threshold very frequently and quickly. The end result is storage IO performance degradation.

For performance and availability reasons, VMware recommends that Administrators consciously avoid putting too many high-transactional volumes or disks in one VMDK.

What about Eager-Zero Thick disk provisioning? This is an artefact that is not relevant for our purposes.

We have one more important performance-improvement related disk tuning task to check off, but since it is application-specific, we will discuss it at a later point in this document.

Power Setting Configuration

Most modern hardware and Operating Systems default to power conservation in consideration of the impact of power consumption on the environment. Unfortunately, conserving power leads to CPU throttling, which leads to severe negative impact on application performance and throughput. In Windows, for example, the default Power Scheme is **Balanced**. Balanced Power Scheme results in Windows putting some CPUs to sleep when it determines that they are not in active use, and then waking them up when it deems it necessary. This behavior invariably results in suboptimal performance for Microsoft SQL Server queries and tasks.



VMware recommends that Administrators change the default **Balanced** power setting to **High Performance** as a standard administrative procedure for all VMs hosting Microsoft SQL Server workloads.

The following PowerShell command will toggle Windows Power cheme from **Balanced** to **High Performance:**

Powercfg -setacvalueindex 8c5e7fda-e8bf-4a96-9a85-a6e23a8c635c sub_processor bc5038f7-23e0-4960-96da-33abaf5935ec 100



Powercfg -setacvalueindex 8c5e7fda-e8bf-4a96-9a85-a6e23a8c635c sub_processor 893dee8e-2bef-41e0-89c6-b55d0929964c 100

Powercfg -setactive 8c5e7fda-e8bf-4a96-9a85-a6e23a8c635c



This concludes the high-level performance tuning checklist required to get our VMs ready for an optimal and satisfactory virtualization experience on the Azure VMware Solution platform.

We will now proceed through setting up and configuring a representative use-case scenario, showing how to successfully deploy and configure Microsoft SQL Server workloads to satisfy high-availability requirements.

The configuration shown in the following example is highly simplified. This is intentionally so because we want to focus on the specific considerations for achieving our objectives solely from a virtualization perspective as opposed to offering a tutorial on how to install, configure or cluster Microsoft SQL Server. We assume that you are already familiar with most of the tasks involved in installing, running and operating Microsoft SQL Server.



For specific Application-level performance tuning option, please see <u>SQL Server Configuration here</u> and in Section 4.3 (SQL Server Configuration) of <u>SQL-Server-on-VMware-Best-Practices.</u>



Deploying and Preparing a VM for Windows Server Failover Clustering

Overview

As described earlier, we will use three VMs in our example. They are named:

- AVS-VMW-SQL01
- AVS-VMW-SQL02
- AVS-VMW-SQL03

Two of the VMs (AVS-VMW-SQL01 and AVS-VMW-SQL02) will host a clustered instance of Microsoft SQL Server in Always On failover clustering instance (FCI) mode.

We will also create a Database on this Instance (AVSVMW-DemoAGDB) and configure it for high availability in Always On Availability Aroup (AG) mode.

AVS-VMW-SQL03 will be configured to host an asynchronous replica of AVSVMW-DemoAGDB.

We'll henceforth refer to these VMs as SQL01, SQL02, and SQL03.

Deployment Steps

- We create the VMs, following the configuration options described earlier in this document.
- We create one or more VMDKs on SQL01 which will be used as shared disks for our FCI. In our simplified example, we're using only one shared VMDK.
- We attach this VMDK to Bus 0 on PVSCSI Controller 1 (SCSI1:0). Remember that the SCSI bussharing mode has to be set to **Physical** when used for shared disk.
- We are done with SQL01 now, so we move on to SQL02
- On SQL02, we add this VMDK we just configured on SQL01 to SQL02. We do this by selecting the **Existing Hard Disk** option in the **Add New Device** menu.

Edit Settings AVS-VM	W-SQL02		
Virtual Hardware VM Options			
			ADD NEW DEVICE
> CPU	4 ~		CD/DVD Drive Host USB Device
> Memory	16	GB 🗸	Hard Disk
> Hard disk 1	120	GB 🗸	RDM Disk Existing Hard Disk
			Network Adapter

• We browse to where we have stored the shared VMDK and select it.



Datastores Contents vsanDatastore · i.vsan.stats · i.vsan.stats	Select File		
✓ SanDatastore ▲ > ∴.vsan.stats ▲ > ∴ AVS-VMW-CL01 ▲ > ∴ AVS-VMW-DC01 ▲ ✓ △ AVS-VMW-SQL01 ▲	Datastores		Contents
> □.vsan.stats ▲ AVS-VMW-SQL01_1.vmdk > □ AVS-VMW-CL01 → > □ AVS-VMW-DC01 → > □ AVS-VMW-SQL01 →	∨ 🗐 vsanDatastore	^	AVS-VMW-SQL01.vmdk
 AVS-VMW-CL01 AVS-VMW-DC01 AVS-VMW-SQL01 	> 🛅 .vsan.stats		AVS-VMW-SQL01_1.vmdk
> AVS-VMW-DC01	> 🗖 AVS-VMW-CL01		
V AVS-VMW-SQL01	> 🗖 AVS-VMW-DC01		
	V 🗖 AVS-VMW-SQL01		

• We create a new PVSCSI controller and attach the disk to it.

200 GB 🗸	
43.18 TB	
vSAN Default Storage Policy \sim	
Unspecified ~	
[vsanDatastore] 657c0861-545a-20e1-518 SQL01_1.vmdk	e-1c34da421504/AVS-VMW-
Normal ~ 1000	
Unlimited $$	
0 MB ~	
Dependent v	
SCSI controller 0 V SCSI(0:1) Ne	w Hard disk $$
IDE 0	
IDE 1 SCSI controller 0 SATA controller 0	
	43.18 FB vSAN Default Storage Policy Unspecified [vsanDatastore] 657c0861-545a-20e1-518 SQL01_1.vmdk Normal 1000 Unlimited 0 Dependent × SCSI controller 0 SCSI(0:1) Ne IDE 0 IDE 1 SCSI controller 0 SATA controller 0



• We verify that the disk and SCSI controllers are configured identically on both VMs.

Edit Settings		Edit Settings	
Virtual Hardware VM Options		Virtual Hardware VM Options	
			C
> Hard disk 1	120 GB 🗸	> Hard disk 1	120 <u>GB v</u>
Hard disk 2	200 GB 🗸	V Hard disk 2	200 GB
Maximum Size	43.34 TB	Maximum Size	43.34 TB
VM storage policy	vSAN Default Storage Policy 🗸 🗸	VM storage policy	vSAN Default Storage Porcy 🗸 🗸
Туре	As defined in the VM storage policy	Туре	As defined in the VM storagy policy
Sharing	No sharing 🗸	Sharing	No sharing 🗸
Disk File	[vsanDatastore] 657c0861-545a-20e1-518e-1c34d	Disk File	[vsanDatastore] 657c0861-541a-20e1-518e-1c34da4215
	SQL01_1.vmdk		SQL01_1.vmdk
Shares	Normal V 1000	Shares	Normal V 1000
Limit - IOPs	Unlimited ~	Limit - IOPs	Unlimited ~
Virtual flash read cache	0 <u>MB ~</u>	Virtual flash read cache	0 <u>MB ~</u>
Disk Mode	Dependent v	Disk Mode	Dependent ~
Virtual Device Node	SCSI controller 1 V SCSI(1:0) Hard disk 2	Virtual Device Node	SCSI controller 1 V SCSI(1:0) Hard disk 2 V

• The End.

Really. That is all we need to do on the vSphere side to assign a shared disk to VMs for use in FCI configuration.

Now, we power on the VMs and let them boot into Windows.

Installing Windows Server Failover Clustering

Installing WSFC on VMs in AVS with vSphere is not in any way different from doing so on physical servers or any other platform, so we won't spend time describing it in this document. In fact, nothing in the rest of this document is peculiar to AVS or vSphere – we are including them only for guidance.

The newly-added disk is currently offline, according to Windows File and Storage Services. So, let's make it available and ready for WSFC's use (we will perform this task only on one of the nodes. There is no need to repeat the steps on any other node sharing the disk):

	i KS disks 2 total		0		_			
Number	Virtual Disk	Status	Capacity	Unallocated	Partition	Read Only	Clustered	Subs
AVS-	-VMW-SQL0)1 (2)						



• We bring the disk online.

iii	Servers Volumes	DISKS All disks 2 total
Ξ.	Disks	
	Storage Pools	Number Virtual Disk Status Capacity Unallocated Partition Read Only (
		AVS-VMW-SQL01 (2)
		New Volume
		GB 0.00 B GPT
		Take Offline
		Reset Disk
_		DISKS
	Servers	All disks 2 total
	Volumes	Filter
ii.	Disks	
	Storage Pools	Number Virtual Disk Status Capacity Unallocated Partition Read Only Cluster
		AVS-VMW-SQL01 (2)
		1 Offline 200 GB 200 GB Unknown
		0 Online 120 GB 0.00 B GPT
		Bring Disk Online ×
		If this disk is already online on another server, bringing the disk online on this server can cause data loss. Are you sure
		you want to bring this disk online on this server?
		Last refreshe Yes No
		VOLUMES STORAGE POOL
		TASKS VMware Virtual disk on AVS-

- Yes, we know what we are doing. Right?
- Now, we create a volume on it (standard Windows stuff, please feel free to skip ahead).



 Servers Volumes Disks Storag	s je Pools		Filter Number AV	r Virtu	ual Disl	al k Status 2L01 (2) New Volume Bring Online Take Offline	Сара	(III acity B B	 Unalloca 200 GB 0.00 B 	R ▼ ated Pa U G	artition Inknown PT	Rea	id Onț
Servers Volumes Disks Storage Poo	New Volume With Before you B	DISKS All disks zard DU De egin isk rr Folder ettings	egin	This wiza system. You can o more phy disks can To contin	ard helps create a nysical dis n increase nue, click	nitialize Reset Disk you create a volur volume on a physi ks from a previous e the reliability and Next.	me, assign it cal disk or a ly created s l performan	t a drive a virtual storage scce of th	e letter or fol disk. A virtur pool. The lay le volume.	Ider, and th al disk is a yout of dat	en format collection o a across th	it with a f of one or e physica	TAS X iile

• Next



ī	Servers Volumes	All disks 2 tota	al							TAS	SI
	Disks	🚘 New Volume Wizard						— (×	
File and S	Storage Poo Storage Services	Select the server a	and disk							Т	Ту
		Before You Begin	Server:	-						_	
		Server and Disk	Provision to	Stat	tus	Cluster Rol	e Destinati	on			
		Size	AVS-VMW-SQLUT	On	line	Not Cluste	red Local			-	
			Disk:				Refresh	F	Rescan	ī	_
			Disk	Virtual Disk	Capacity	Free Space Su	ubsystem				
			Disk 1		200 GB	200 GB				AS NO	SI
			Disks with insuffice	ent free space o	or read-onl Previous	y access are not Next >	shown. Activa Go to Se Create	te Win	ndow Gancel	/s	Vi

• Next

	Servers	All disks	2 total							
ii I	Volumes Disks	New Volume Wizard		0		<u></u>			_	
ir d	Storage Poo									
	_	Select the serve	er a	nd disk						
		Before You Begin		Server:						
		Server and Disk		Provision to		Status	Cluster	Role	Destination	
		Size Off	line or	Uninitialized Disk				× ªd	Local	
		Drive Letter or Fold								
		File System Settings	A	The selected disk will GPT disk, To continue.	be brought or click OK. or to	nline and initializ	ed as a t disk or			
		Confirmation	$\mathbf{\overline{v}}$	create a new virtual d	sk, click Cance	el.				
		Results								
						ОК	Cancel			-
				100.00					Refresh	Resca
				Disk:						
				Disk:	Virtual Di	sk Capacity F	ree Space	Subsy	/stem	

• OK



∎	Servers Volumes	DISKS All disks 2 total	TAS
ii:	Disks	🔁 New Volume Wizard	- 🗆 ×
ir ⊳	Storage Poo	Specify the size of the volume	Ţ
		Before You Begin Available Capacity: 200 GB Server and Disk Minimum size: 8.00 MB Size Volume size: 200 GB Drive Letter or Folder GB	
		File System Settings Confirmation Results	_
			Activate Windows
		< Previous	Next > Create Cancel

• Next



Servers	ile and Storage Sel	rvices • Volumes • Disks • 🕝 🍢 Manage Tools Vie
Volumes Disks Storage Poo	New Volume Wizard Assign to a drive Before You Begin Server and Disk Size Drive Letter or Folder File System Settings Confirmation Results	 × e letter or folder Select whether to assign the volume to a drive letter or a folder. When you assign a volume to a folder, the volume appears as a folder within a drive, such as D:\UserData. Assign to: Drive letter: The following folder: Browse Don't assign to a drive letter or folder.
		Activate Windows

• Next



Servers Volumes Disks Storage Poo	ile and Storage Ser DISKS All disks 2 to Rew Volume Wizard Select file system	vices > Volumo	es • Disks • 😨	Manage Tools Vi TAS
	Before You Begin Server and Disk Size Drive Letter or Folder File System Settings Confirmation Results	File system: Allocation unit size: Volume label: Generate short file Short file names (8 applications runnit	NTFS	e required for some 16-bit tions slower.
			< Previous Next >	Activate Windows

• Next



\mathbf{E}	€ •• F	ile and Storage Ser	vices • Volum	es 🕨 Disks 🛛 🗸 🤕) 🚩 Manage Tools Vi
	Servers Volumes Disks Storage Poo	DISKS All disks 2 to All disks 2 to New Volume Wizard Select file system Before You Begin	settings	NTFS *	
		Server and Disk Size Drive Letter or Folder File System Settings Confirmation Results	Allocation unit size: Volume label: Generate short fil Short file names (i applications runni	Default	are required for some 16-bit erations slower.
				< Previous Next >	Activate Windows

- Let's give it a fancy name and click **Next**.
- We're almost done now.

Volumes Disks Tel New Volume Wizard - Storage Poo - -	× □
Disks New Volume Wizard Storage Poo	Т
Storage Poo	т
Confirm selections	
Before You Begin Confirm that the following are the correct settings, and then click C	Sreate.
Server and Disk VOLUME LOCATION	
Size Server: AVS-VMW-SQL01	
Drive Letter or Folder Disk: Disk 1	
File System Settings Free space: 200 GB	
Confirmation VOLUME PROPERTIES	
Results Volume size: 200 GB	
Drive letter or folder: E:\	
Volume label: Shared-Disk	
FILE SYSTEM SETTINGS	
File system: NTFS	45
Short file name creation: Disabled	
Allocation unit size: Default	
Activate	Windows
	in os to activa te W
< Previous Next > Create	Cancel

• Just hit Create, then Next



Servers	DISKS All disks 2 total	
Volumes Disks Storage Poo	New Volume Wizard	>
	Before You Begin You have successfully completed the Server and Disk Task Progress Size Gather information Create new partition File System Settings Format volume Add access path Confirmation Update cache	e New Volume Wizard. Status Completed Completed Completed Completed Completed
	< Previou	Activate Window us Next > Go to Settings to active Close

• Hit that **Close** button and let's get this over with.

All disks 7 to	tal							TASKS
Filter		\$	•	•				۲
Number Virtual Di	sk Status	Capacity	Unallocated	Partition	Read Only	Clustered	Subsystem	Bus Type
AVS-VMW-S	QL01 (2)							
0	Online	120 GB	0.00 B	GPT				SAS
1	Online	200 GB	0.00 B	GPT		\checkmark		SAS

• There. Our shared disk is now ready for WSFC.

Windows Server Failover Clustering Configuration

Installing Windows Server Failover Clustering (WSFC) on a VM in AVS is not different from doing it in any other Windows Server OS Environment.

• Add WSFC as a feature in Windows.



Se Se	rver Manager • Dasl	nboard	🕶 🧭 🏴 Manage Tools View	Help
Dashboard Local Server All Servers File and Storage Servers	WELCOME TO SER	VER MANAGER		
	Before You Begin Installation Type Server Selection Server Roles Features Confirmation Results	Select one or more features to install o Features	Add Koles and Peatures wizard Add features that are required for Failover Clustering? The following tools are required to manage this feature, but do not have to be installed on the same server. Remote Server Administration Tools Remote Server Administration Tools Remote Server Administration Tools Remote Server Administration Tools Remote Administration Tools Remote Administration Tools Remote Administration Tools Remote Administration Tools Remote Administration Tools Remote Administration Tools	he >

• Let's click through the process, remembering to check the option to auto-reboot upon completion.

Before You Begin	To install the following roles, role services, or features on selected server, click Install.
Installation Type	Restart the destination server automatically if required
Server Selection	Optional features (such as administration tools) might be displayed on this page because they have
Server Roles	been selected automatically. If you do not want to install these optional features, click Previous to clear their check boxes
Features	
Confirmation	Failover Clustering
Results	Remote Server Administration Tools
	Feature Administration Tools
	Failover Clustering Tools
	Failover Cluster Management Tools
	Failover Cluster Module for Windows PowerShell
	Export configuration settings Specify an alternate source path
	< Previous Next > Cancel





Now, we have successfully installed WSFC. It's time to get to work.

WELCOME TO SERVER MANAGER			Component Services Computer Management
			Defragment and Optimize Drives
	1 Configure this local ser 2 Add roles and features		Disk Cleanup
			Event Viewer
OUTCK START			Failover Cluster Manager
QUICK START			iSCSI Initiator
			Local Security Policy
			Minner & Anne Considera

• We begin by launching the Cluster Validation Wizard.



• We'll let the wizard run all recommended tests, just for completeness.



	over clusters, validate naroware for potential failover clusters, and perform configuration changes to	
🦉 Validate a Configu	uration Wizard	<
Tosting (Intions	
Testing C		
Before You Begin	Choose between running all tests or running selected tests.	
Select Servers or a Cluster	The tests examine the Cluster Configuration, Hyper-V Configuration, Inventory, Network, Storage, and System Configuration.	
Testing Options	Microsoft supports a cluster solution only if the complete configuration (servers, network, and storage) can	
Confirmation	pass all tests in this wizard. In addition, all hardware components in the cluster solution must be "Certified for Windows Server 2019."	
Validating		
Summary		
	Run all tests (recommended)	
	Run only tests I select	
	More about cluster validation tests	
	< Previous Next > Cancel	
		_

We'll add the nodes we want to join into a cluster.

💐 Validate a Config	uration Wizard		×
Select Se	ervers or a Cluster		
Before You Begin Select Servers or a Cluster	To validate a set of serve To test an existing cluster	ers, add the names of all the servers. r, add the name of the cluster or one of its nodes.	
Testing Options	Enter name:	Browse.	
Confirmation	Selected servers:	AVS-VMW-SQL01.avsvmw.loc Add	
Summary		Remove	
		< Previous Next > Cancel	



• Let's check the **Create the cluster now** box but, before we hit **Finish**, we'll take a look at the result of the tests by clicking the **View Report** button.

💐 Validate a Configu	uration Wizard		\times
Summary			
Before You Begin Select Servers or a Cluster	Testing has completed for the tests you selected cluster solution is supported by Microsoft only if y succeed (with or without warnings).	. You should review the warnings in the Report ou run all cluster validation tests, and all tests	Α
Testing Options	Node		^
Confirmation	AVS-VMW-SQL01.avsvmw.loc	Validated	
Validating	AVS-VMW-SQL02.avsvmw.loc	Validated	
Summany	Result		
Summary	List BIOS Information	Success	
	List Disks	Success	
	List Disks To Be Validated	Success	
	List Environment Variables	Success	
	List Fibre Chappel Heat Rue Adaptors	Success	~
	Create the cluster now using the validated nodes		
	To view the report created by the wizard, click View Rep To close this wizard, click Finish.	View Report.	
		Finish	

• Look at that! Some WARNINGS!!! Yes, we can safely ignore these warnings because they're from a check specific only to <u>Microsoft's Storage Spaces subsystems and is, therefore, irrelevant in our AVS environment.</u>





• We can close the Report and click **Finish** on the Wizard to complete our validation test and proceed to setting up the cluster.



Create Cluster Wi	Point for Administering the Cluster	×
Before You Begin Access Point for Administering the Cluster Confirmation Creating New Cluster	Type the name you want to use when administering the cluster. Cluster Name: AVSVMW-Clus01 Image: The NetBIOS name is limited to 15 characters. One or more IPv4 addresses could not be configured automatically. For each network to be used, make sure the network is selected, and then type an address.	
Summary	Networks Address Image: 192.168.100.0/24 192 . 168 . 100 . 101 Image: 100 - 101 192 . 168 . 100 . 101 Image: 100 - 101 Image: 100 . 101 Image: 100 - 101	

- We give the cluster's administrative access point a name and its corresponding IP.
 - <u>NOTE</u>: As mentioned previously, we assume familiarity with all of these steps, so we won't describe how to do most of the Active Directory, DNS preparatory tasks related to configuring a Windows Server Failover Cluster

🚏 Create Cluster Wiz	zard	×
Confirmat	tion	
Before You Begin Access Point for Administering the	You are ready to create a cluster. The wizard will create your cluster with the following settings:	
Cluster	Cluster	^
Confirmation	AVSVMW-Clus01	
Creating New Cluster	Node	
Summary	AVS-VMW-SQL01.avsvmw.loc	
	AVS-VMW-SQL02.avsvmw.loc	
	Cluster registration	
	DNS and Active Directory Domain Services	~
	Add all eligible storage to the cluster. To contend of the cluster. (Previous Next > Cancel	

• Checking the Add all eligible storage to the cluster option is not recommended because, among other things, it can lead to WSFC making the wrong choice for you about the available disks and



what you intend to do with them. For example, as shown in the next image, WSFC has added our Shared Disk and assigned it to the Cluster as our Witness Disk.

• **NOTE:** Do not place the File Share Witness folder on any of the nodes participating in the Cluster. The Witness gets a vote in the Quorum, so if you put it on one of the nodes and the node becomes unavailable, you've lost two votes in the Quorum.



- This is definitely NOT what we want, so let's correct this quickly.
- We are going to change the Quorum setting to use a File Share Witness (FSW) instead. FSW (which is simply a folder on any server on the network, shared and made accessible to the clustered nodes and the Cluster Network Object CNO]) is easier to configure and maintain and works well for our purposes.

💐 Failover Cluster N	lanager					
File Action View	Help					
🗢 🔿 🖄 📰 🕻	2					
📲 Failover Cluster M	anager Disks (1))				
V AVSVMW-Clus	Configure Role				🔎 Querie	s 🕶 🔐 💌 😒
Node	Validate Cluster		Status	Assigned To	Owner Node	Disk Number
✓ <u>ề</u> Storac ≞ Di	View Validation Report		() Online	Disk Witness in Quorum	AVS-VMW-SQL01	1
Pc Er Netwo	Add Node					
	Close Connection					
📓 Cluste	Reset Recent Events					
	More Actions	>	Configure Cluster Que	orum Settings		
	Refresh		Copy Cluster Roles			
	Properties		Shut Down Cluster			
	Help		Destroy Cluster	stroy Cluster		
			Move Core Cluster Re	sources >		
		_	Cluster-Aware Updati	ng		
	<					>

• This involves a series of Next, Next clicks...



Configure Cluste	r Quorum Wizard	×
Before You Begin Select Quorum Configuration Option Configure Cluster Quorum Settings Summary	This wizard guides you through configuring the quorum for your failover cluster. The relevant cluster elements are the nodes and, in some quorum configurations, a disk witness or file share witness. The quorum configuration affects the availability of your cluster. A sufficient number of cluster elements must be online, or the cluster loses quorum and must stop running. Note that the full function of a cluster depends not only on the quorum, but also on the capacity of each node to support the clustered roles. Important: Run this wizard only if you have determined that you need to change the quorum configuration for your cluster. When you create a cluster, the cluster software automatically chooses a quorum configuration that will provide the highest availability for your cluster. To continue, click Next. Failover Cluster Quorum and Witness Configuration Options Do not show this page again	

• Click Next.

Configure Cluster	Quorum Wizard	×
Select Qu	Jorum Configuration Option	
Before You Begin Select Quorum	Select a quorum configuration for your cluster.	
Configuration Option Select Quorum Witness	 Use default quorum configuration The cluster determines quorum management options, including the quorum witness. 	
Configure Storage Witness Confirmation	 Select the quorum witness You can add or change the quorum witness. The cluster determines the other quorum management options. 	
Configure Cluster Quorum Settings	 Advanced quorum configuration You determine the quorum management options, including the quorum witness. 	
Summary		
	Failover Cluster Quorum and Witness Configuration Options	
	< Previous Next > Cancel]

• Choose the Select Quorum Witness option, then click Next.



Configure Cluster	體 Configure Cluster Quorum Wizard				
Select Qu	uorum Witness				
Before You Begin Select Quorum Configuration Option	Select a quorum witness option to add or change the quorum witness for your cluster configuration. As a best practice, configure a quorum witness to help achieve the highest availability of the cluster.				
Select Quorum Witness	Configure a disk witness Adds a quorum vote of the disk witness				
Configure File Share Witness Confirmation Configure Cluster Quorum Settings Summary	 Configure a file share witness Adds a quorum vote of the file share witness Configure a cloud witness Adds a quorum vote of the cloud witness Do not configure a quorum witness Failover Cluster Quorum and Witness Configuration Options 				
	< Previous Next > Cancel				

- We want the File Share Witness option, so check that and click Next.
- Browse to where the share is located, then select it.

Browse for Shared Folders	—		×
Server:			
AVS-VMW-DC01		Browse	t
Show Shared Folders			
Shared folders:			



Configure Cluster	r Quorum Wizard e File Share Witness	×
Before You Begin Select Quorum Configuration Option	Please select a file share that will be used by the file share witness resource. This file share must not be hosted by this cluster. It can be made more available by hosting it on another cluster.	
Witness	File Share Path:	
Configure File Share Witness	\\AVS-VMW-DC01\SQL-FSW Browse	J
Confirmation		
Configure Cluster Quorum Settings		
Summary		
	< Previous Next > Cancel	

• We confirm that we have selected the correct share, then we click **Next**.



Configure Cluster	Quorum Wizard	×
Before You Begin Select Quorum Configuration Option	You are ready to configure the quorum settings of the	cluster.
Select Quorum	Configure Cluster Quorum Settings	^
Witness	File Share Witness	\\AVS-VMW-DC01\SQL
Configure File Share Witness	Cluster Managed Voting	Enabled
Confirmation	Voting Nodes:	
Configure Cluster Quorum Settings Summary	All nodes are configured to have quorum votes	
		~
	To continue, click Next.	
		< Previous Next > Cancel

• One more **Next**



Configure Cluste	r Quorum Wizard	×
Summary	,	
Before You Begin Select Quorum	You have successfully configured the quorum settings for the cluster.	
Select Quorum Witness Configure File Share Witness Confirmation Configure Cluster Quorum Settings Summary	Cluster Managed Voting Enabled Witness Type File Share Witness Witness Resource \\AVS-VMW-DC01\SQL-FSW	
	To view the report created by the wizard, click View Report. To close this wizard, click Finish.	

• And, we wrap it up with a Finish (unless you'd like to read the Report, of course).

📲 Failover Cluster Manager						
File Action View Help						
🗢 🔿 🞽 🖬 🚺						
📲 Failover Cluster Manager	Disks (1)					
 AVSVMW-Clus01.avsvmw.lc Roles 	Search P Queries 🔻 📘					
Nodes	Name	Status	Assigned To	Owner Node	Disk Number	
 Storage Disks Pools Enclosures Networks Cluster Events 	문공 Cluster Disk 1	(Online	Available Storage	AVS-VMW-SQL01		

• Now, our Shared Disk is recognized by WSFC as we intended for it to be – **"Available Storage**. We can now use it for our Microsoft SQL Server FCI-clustering purposes.



But, before we do that, why don't we confirm that the disk is actually a clustered resource and can survive the failure of one of the nodes we just clustered? This would give us the peace of mind we need before laying our SQL Server bits on top.

Here is how both nodes see the shared disk after we've completed the cluster setup.



• Both nodes see that SQL01 currently owns the disk, which is fine.

But what happens if SQL01 were to become suddenly unavailable?

📌 AVS-VMW-SQL01 - VMware Remote Console	AVS-VMW-SQL02 - VMware Ren	note Console				
<u>y</u> mrc • <mark> </mark> • 母 [0]	⊻MRC - 🖬 - 🛱 🔲					
	🐘 Failover Cluster Manager					
	File Action View Help					
	🗢 🤿 🖄 📷 🚺 🖬					
	Hailover Cluster Manager	Disks (1)			<u> </u>	
	 AVSVMW-ClusULavsvmw.li Roles 	Search			P Que	ries 🔻 🔛 🕯
	Nodes 📲	Name	Status	Assigned To	Owner Node	Disk Num
	V Storage	Cluster Disk 1	💿 Online	Available Storage	AVS-VMW-SQL0	2
	Pools					
	Enclosures					
	E Cluster Events					
Restarting						
		<				

• WSFC does what it's supposed to do – it lets SQL02 take ownership of the clustered resource.

At this point, we have completed our demonstration of clustering shared resources (disk) for multiple Windows Server Failover Clustering nodes on Azure VMware Solutions. As you can see, the actual WSFC installation and configuration procedures are similar, regardless of the platform.

We are now going to simulate and document layering Microsoft SQL Server instances and databases on top of the clustered infrastructure.

NOTE: As before, we assume prior knowledge of the administrative steps and tasks involved in setting up FCI and availability group in a typical Microsoft SQL Server environment, so we will not be describing these in detail.



Installing and Configuring Microsoft SQL Server Always On Failover Clustering Instance on AVS We will install Microsoft SQL Server first on SQL01, then on SQL02. The major difference in the installation process is that we will select the **New SQL Server Failover Cluster installation** option for SQL01 and the **Add node to a SQL Server Failover Cluster** option for SQL02 as shown below:



The install process wants to remind us that we did ignore some warnings during the WSFC validation test. We know this already, so we will ignore the reminder and proceed with our installation.



📸 Install a SQL Server Failover Clus	ter					\times
Install Failover Cluster	Rules					
Setup rules identify potential can continue.	problems that	might occur while running Setup. Failures must be corrected b	efore S	etup		
Install Failover Cluster Rules Feature Selection Feature Rules Feature Configuration Rules Ready to Install	Operation Hide det	completed. Passed: 18. Failed 0. Warning 2. Skipped 0. ails << iled report			Re-n	un
Complete	Result	Rule Microsoft Cluster Service (MSCS) cluster verification warnings Remote registry service i) Domain controller i) Result X Rule "Microsoft Cluster Service (MSCS) cluster verification varings" generated a warning. X Nule "Microsoft Cluster Service (MSCS) cluster verification varings" generated a warning. X In the MSCS cluster validation report, or some tests were kipped while running the validation. To continue, run alidation from the Windows Cluster Administration tool to insure that the MSCS cluster validation report does not contain more.	Sta Wa Pas Pas Wa Pas Pas Pas Pas	atus arning assed sseed		
		ОК	N	ext >. Activate	Cancel	ows.

• After successfully installing SQL Server on SQL01, we can see in Cluster Manager that SQL Server (MSSQLServer) has become a clustered role in WSFC.

鶡 Failover Cluster Manager								_		Х
File Action View Help										
🗢 🔿 🙍 📰										
Failover Cluster Manager	Roles (1)						Acti	ons		
✓ Modes AVSVMW-Clus01.avsvmw.k	Search			P Qu	ieries 🔻 🔒	• •	Role	25		-
Nodes	Name	Status	Туре	Owner Node	Priority	Inform	20	Configure Ro	le	
V 📇 Storage	SQL Server (MSSQLSE	🕜 Running	Other	AVS-VMW-SQL01	Medium			Virtual Machi	nes	•
							1	Create Empty	Role	
Enclosures								View		•
Networks							Q	Refresh		
							?	Help		

We can now install SQL Server on the second Node (SQL02), joining it in as a part of the SQL Server cluster we just installed on node 1 (SQL01). But, before we do so, we have some housekeeping tasks to take care of. One is related to improving disk IO for Microsoft SQL Server workloads in vSphere-based



hybrid cloud environments, and the other is maintaining availability and resilience for WSFC-based clustered resources generally.

Enable (Persistent) Trace Flag 1800

Disk IO misalignment is a very common cause of severe suboptimal performance of Microsoft SQL Server queries, synchronization and transactions. Although Microsoft has long released patches to address the specific Sector misalignment issues, an administrative action is still required in order for the fixes to apply to a given SQL Server instance. Please see <u>KB3009974 - FIX: Slow synchronization when</u> <u>disks have different sector sizes for primary and secondary replica log files in SQL Server AG and</u> <u>Logshipping environments (microsoft.com)</u> for more detailed information.

So, let's go ahead and do this for our environment.

The TraceFlag will be global and persistent (it needs to remain in place, even after a service restart or server reboot), so we will do this inside the SQL Server Configuration Manager (SSCM).

- Open SSCM and navigate to the Startup Parameters tab.
- Type in -T1800 (TraceFlags trace flags are preceded by "-T"), then click Add.

		- IVIGITUU			
L Server (MSSQLSERVE	R) Properties	;		?	
Log On	Service		FI	ESTREAM	
Always On Availability G	roups	Startup Pa	arameters	Advar	nced
Specify a startup parame	ter:				
-T1800				Add	
Existing parameters:					
-dE: WSSQL15.MSSQLSE -eE: WSSQL15.MSSQLSE	RVER (MSSQL)	DATA (ma	ster.mc DRLOG		
-dE: WSSQL 15.MSSQLSE -eE: WSSQL 15.MSSQLSE -lE: WSSQL 15.MSSQLSE	RVER (MSSQL) RVER (MSSQL) RVER (MSSQL)	\DATA \ma \Log \ERR(DATA \mas	ster.mc DRLOG stlog.ld1		
-dE: WSSQL 15.MSSQLSE -eE: WSSQL 15.MSSQLSE -lE: WSSQL 15.MSSQLSEF	RVER (MSSQL) RVER (MSSQL) RVER (MSSQL)	\DATA \ma \Log \ERR(DATA \mas	ster.mc ORLOG stlog.ldf		
-dE: WSSQL 15.MSSQLSE -eE: WSSQL 15.MSSQLSE -lE: WSSQL 15.MSSQLSEF	RVER (MSSQL) RVER (MSSQL) RVER (MSSQL)	\DATA \ma \Log \ERR(DATA \mas	ster.mc DRLOG stlog.ldt	Remove	
-dE: WSSQL 15.MSSQLSE -eE: WSSQL 15.MSSQLSE -lE: WSSQL 15.MSSQLSE	RVER (MSSQL) RVER (MSSQL) RVER (MSSQL)	VDATA (ma Log (ERRO DATA (mas	ster.mc DRLOG stlog.ld1	Remove	

• Click OK.



LOg On	Ser	vice	FILE	STREAM	
Always On Availability	Groups	Startup Par	ameters	Advand	ed
pecify a startup para	meter:				
				Add	
					_
xisting parameters:					
-dE: MSSQL 15.MSSQI	LSERVER MSS	SQL\DATA\mas	ter.mc		
-eE: MSSQL 15.MSSQL	LSERVER MSS	SQL Log ERRO	RLOG		
-T1800	SERVER	QLIDATA mast	log.idi		
				Remove	1
<			>		
<			>		
<			>		
<			>		

Yes, yes, we have to restart the service for this to take effect, so let's do so now.

Existing pa	rameters:		
-dE:\MSSC -eE:\MSSC	QL 15.MSSQLSERVER \MSSQL \DATA \master. JL 15.MSSQLSERVER \MSSQL \Log \ERRORLC	.mc DG	
Warning			×
i	Any changes made will be saved; howev effect until the service is stopped and re	/er, esta	they will not take arted.
			OK
<		>	8



	Name	State text Filte Running	Start Mode Manual	Log On As NT Service\!
	💦 SQL Serv	Chard .	Manual	AVSVMW\sc
t	🖏 SQL Serv	Start	Automatic	NT AUTHOF
	SQL Serv	Stop	Manual	AVSVMW\sc
		Pause		
		Resume		
		Restart		
		Properties		

That's it.

But, was all that worth the effort? Let's take a look at *before* and *after*.

Here is a sample insert job we ran on a server without the trace flag:

% Results Image: Messages (No column name)	No TraceFlag 1800 286K Inserts
285899	

Here is the same job, with trace flag 1800 enabled on the same server:



Using a tool like Procmon, you can get a peek into the root cause of the performance bottleneck and see how it resolves after the TraceFlag trace flag is added.

Here is our IO and block size pattern prior to enabling -T1800 (the yellow highlight):



4:40:13.5754222 PM IIII solservr exe	6684 Ht WriteFile	1 \Program Files\Microsoft SQL Server\MSSQL15.MSSQLSER_ER\MS	SSQL\Data\LoadDB_logJdf SUCCESS	Offset: /04,252,928, Length: 4,608,	I/O Hags: Non-d
4:40:13.579094		Program Files\Microsoft SQL Server\MSSQL15.MSSQLSER	SSQL\Data\LoadDB_log.ldf SUCCESS	Offset: 704,257,536, Length: 6,144,	I/O Flags: Non-c
4:40:13.583065		Program Files\Microsoft SQL Server\MSSQL15.MSSQLSER ER\MS	SSQL\Data\LoadDB_log.ldf SUCCESS	Offset: 704,263,680, Length: 4,608,	I/O Flags: Non-d
4:40:13.5868612 NO Trace	Flad 1800	Program Files\Microsoft SQL Server\MSSQL15.MSSQLSERVER\MS	SSQL\Data\LoadDB_log.ldf SUCCESS	Offset: 704,268,288, Length: 5,632,	I/O Flags: Non-o
4:40:13.5911185		Program Files\Microsoft SQL Server\MSSQL15.MSSQLSERVER\MS	SSQL\Data\LoadDB log.ldf SUCCESS	Offset: 704.273.920, Length: 4.608,	I/O Flags: Non-d
4:40:13.5954452		Program Files\Microsoft SQL Server\MSSQL15.MSSQLSERVER\MS	SSQL\Data\LoadDB log.ldf SUCCESS	Offset: 704.278.528. Length: 5.632.	I/O Flags: Non-d
4:40:13.5961322 PM salservr.exe	6684 WriteFile	L:\Program Files\Microsoft SQL Server\MSSQL15.MSSQLSERVER\MS	SSQL\Data\LoadDB log.ldf SUCCESS	Offset: 704.284.160, Length: 4.608,	I/O Flags: Non-d
4:40:13.6002419 PM Isolservr exe	6684 WriteFile	L:\Program Files\Microsoft SQL Server\MSSQL15.MSSQLSER_ER\MS	SSQL\Data\LoadDB_log.ldf SUCCESS	Offset: 704 288 768, Length: 5.632	I/O Flags: Non-d
4:40:13.6045122 PM Isolservr.exe	6684 WriteFile	L:\Program Files\Microsoft SQL Server\MSSQL15.MSSQLSERVER\MS	SSQL\Data\LoadDB_log.ldf SUCCESS	Offset: 704.294.400, Length: 4.608,	I/O Flags: Non-d
4:40:13.6083530 PM Isolservr.exe	6684 WriteFile	L:\Program Files\Microsoft SQL Server\MSSQL15.MSSQLSER_ER\MS	SSQL\Data\LoadDB log.ldf SUCCESS	Offset: 704.299.008. Length: 5.632.	I/O Flags: Non-d
4:40:13.6091008 PM Isolservr.exe	6684 WriteFile	L:\Program Files\Microsoft SQL Server\MSSQL15.MSSQLSER ER\MS	SSQL\Data\LoadDB log.ldf SUCCESS	Offset: 704.304.640, Length: 4.608,	I/O Flags: Non-d
4:40:13 6102964 PM	6684 WriteFile	L:\Program Eles\Microsoft SQL Server\MSSQL15 MSSQLSER_ER\MS	SSQL\Data\LoadDB_log.ldf SUCCESS	Offset: 704 309 248 Length: 5 632	I/O Flags: Non-d
4:40:13 6114625 PM	6684 WriteFile	L:\Program Eles\Microsoft SQL Server\MSSQL15 MSSQLSER EB\MS	SSQL\Data\LoadDB_log.ldfSUCCESS	Offset: 704 314 880 Length: 4 608	I/O Flags: Non-c
4:40:13 6126892 PM	6684 WriteFile	I \Program Eles\Microsoft SQL Server\MSSQL15 MSSQLSER EB\MS	SSQL\Data\LoadDB_log.ldf SUCCESS	Offset: 703 037 440 Length: 4 608	I/O Flags: Non-d

Here is how it improved and stabilized with -T1800:

4:48:07.0660802 PM	sqlservr.exe	9072 🛃 WitteFile	L:\Program Files\I	Aicrosoft SQ	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,547,968, Length: 8,192	I/O Flags: Non-cached
4:48:07.0666139 PM	sqlservr.exe	9072 🗟 WriteFile	L:\Program Files\#	Acrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,556,160, Length: 8,192	I/O Flags: Non-cached
4:48:07.0671033 PM	1 s			ficrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,564,352, Length: 8,192	I/O Flags: Non-cached
4:48:07.0675913 PM	1 s			licrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,572,544, Length: 8,192	I/O Flags: Non-cached
4:48:07.0680639 PM	Te \A/ith	TracoElac	1000	licrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,580,736, Length: 8,192	I/O Flags: Non-cached
4:48:07.0685865 PM	Te VVILII	Traceriay	1000	licrosoft SQ	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,588,928, Length: 8,192	I/O Flags: Non-cached
4:48:07.0690233 PM	-s			licrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,597,120, Length: 8,192	I/O Flags: Non-cached
4:48:07.0694995 PM	Tr s			licrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,605,312, Length: 8,192	I/O Flags: Non-cached
4:48:07.0699635 PM	sqlservr.exe	9072 🛃 WriteFile	L:\Program Files\#	Acrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,613,504, Length: 8,192	I/O Flags: Non-cached
4:48:07.0704725 PM	sqlservr.exe	9072 📴 WriteFile	L:\Program Files\I	Aicrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,621,696, Length: 8,192	I/O Flags: Non-cached
4:48:07.0708106 PM	sqlservr.exe	9072 🛃 WriteFile	L:\Program Files\#	Aicrosoft SQ	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,629,888, Length: 8,192	I/O Flags: Non-cached
4:48:07.0712911 PM	sqlservr.exe	9072 🛃 WriteFile	L:\Program Files\/	Aicrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,638,080, Length: 8,192	I/O Flags: Non-cached
4:48:07.0717344 PM	sqlservr.exe	9072 📴 WriteFile	L:\Program Files\I	Acrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,646,272, Length: 8,192	I/O Flags: Non-cached
4:48:07.0722424 PM	sqlservr.exe	9072 🛃 WriteFile	L:\Program Files\#	Acrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,654,464, Length: 8,192	I/O Flags: Non-cached
4:48:07.0726918 PM	sqlservr.exe	9072 🛃 WriteFile	L:\Program Files\I	Aicrosoft SQI	L Server\MSSQL	15.MSSQLSER	ER\MSSQL\Data\Lo	adDB_log.ldf	SUCCESS	Offset: 30,662,656, Length: 8,192	I/O Flags: Non-cached

Adjust WSFC Cluster Heartbeat Thresholds:

One of the standard configuration checks you'd want to perform after completing your clustered SQL Server installation on AVS is the **Cluster Heartbeat Threshold** setting. You can do this by issuing the following PowerShell command:

Get-Cluster | fl *subnetthreshold*

You should get an output similar to that shown below:



Why is this necessary? It's a long story, but long documented in many places, including in various *VMware's Best Practices for Virtualizing Microsoft SQL Server* guides. Here's a brief overview:

Clustered Windows nodes exchange periodic heartbeats with each other. This is how they verify that their peers are available, responsive and still participating in the cluster. They send these heartbeats every second. Historically, if one node fails to respond to five (for nodes in the same network subnet) or



ten (for nodes in different subnets) consecutive heartbeat probes, its peers will consider it unresponsive and will be compelled to try and take over whatever clustered resource is hosted on the nonresponsive node. This means that a node has a grace period of 5 or 10 seconds to respond to heartbeat probes before it's deemed to no longer be fit to own a clustered resource.

These numbers were considered good enough until freezing (or quiescing) a Windows OS instance became a feature of Windows and a standard practice for many operations (e.g., in-Guest backup). When a clustered Windows OS instance is quiesced for longer than the tolerable threshold, unexpected clustered resource failover events begin to occur.

To help mitigate this potential for unintended failovers, Microsoft recommended that customers adjust the threshold. Microsoft has now since increased the default to 20, for both **SameSubnetThreshold** and **CrossSubnetThreshold** for more modern Windows versions.

In AVS (indeed, in all VMware vSphere platforms), when you perform a vMotion operation on a Windows VM, the VM will be quiesced at a point during the process. Although vMotion tries to exist the quiesced state as quickly as possible, some external factors could cause the process to take longer than 5 or 10 seconds in some versions of Windows. For clustered workloads, this is not desirable. This is why you must check and adjust the thresholds. If you need to adjust the threshold, use the following PowerShell commands:

- (get-cluster).SameSubnetThreshold = 20
- (get-cluster).CrossSubnetThreshold = 20
- (get-cluster).RouteHistoryLength = 40

We now have a 2-node SQL Server instance configured in FCI clustering mode in our AVS. Let see what it looks like.

🌄 192.168.100.21 - Remote Desktop (Connection						퉣 192.168.100.22 - Remote Desktop	o Connection					
📲 Failover Cluster Manager						i	🍓 Failover Cluster Manager						
File Action View Help							File Action View Help						
							🗢 🔿 🙍 📰 🔢 🖬						
File Action View Help	Roles (1) Search Name SQL Server (MSSQLSE SQL Server (MSSQLSE Server (MSSQLSE Server Name Berrer Statumer (NSSR) Norder Statumer (NSSR) Nor	Status Status SQLSERVER) ee of 200 GB 01 68.100 102	Type Other	Owner Node AVS-VMW-SQL Pr Status Online Online	Gueres V Lu V Protty 11 Medum Afened Owness: Any Information	Info	File Action View Help File Action View Help Fallow Club Anager Nodes Nodes Nodes Nodes Cluster Events	Roles (1) Sourch Nene SOL Server (MSSQLSE ▼ ● SQL Server (MSSQLSE ▼ ● SQL Server (MSSQLSE ■ Storage ■ Storage ■ Storage ■ ■ <td>Status • Running • SSQLSERVER) •) • new of 200 GB • 168: 100.102</td> <td>Type Other</td> <td>P Owner Node AVS-VMW-SQLD P Status @ Online @ Online @ Online @ Online @ Online @ Online</td> <td>Pionty Pionty 1 Medum</td> <td>L V V Irformat</td>	Status • Running • SSQLSERVER) •) • new of 200 GB • 168: 100.102	Type Other	P Owner Node AVS-VMW-SQLD P Status @ Online @ Online @ Online @ Online @ Online @ Online	Pionty Pionty 1 Medum	L V V Irformat
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Roles: Cluster Disk 1							Roles: SOL Server (MSSOLSERVER)						



Node 1 (SQL01) currently owns the resource. Let's see what happens if SQL01 were to suddenly become unavailable.



As expected, the resource automatically fails over to node 2 (SQL02). Nothing to see here.

Installing and Configuring Microsoft SQL Server Always On Availability Group on AVS Unlike FCI, installing and configuring Microsoft SQL Server Always On availability group (AG) on Azure VMware Solution is a much more simplified process. This is chiefly because shared-disk SCSI3 PR command and disk ownership arbitration among two or more clustered VMs is the major challenge with successfully configuring Windows Server Failover Clustering in a VMware vSphere-based platform such as AVS. In AG, the nodes do not share disks or resources. Each node has ownership of its own set of resources.

We will now describe the tasks and activities involved in successfully creating and configuring a sample Availability Group cluster in our AVS environment. We will attempt to make this section more interesting by adding the AG configuration on top of our existing FCI configuration. This is a fairly common configuration in production environment and it's our hope that, in using this example, administrators will get a more detailed picture of the various configuration options available in clustering Microsoft SQL Server on AVS.

NOTE: As usual, we expect you are familiar with the administrative tasks and preparations required for some of the tasks we show in this example. We will not be describing this in detail, except to the extent that the tasks are either unique to AVS or help paint a clearer picture.



For example, we have added a separate, non-shared VMDK to SQL01 which will contain the data and files for the Database that we're going to configure in AG. We have also added a similar (but separate and unshared) VMDK to SQL03 for the same purpose.

We will now proceed by adding a third MS SQL Server node (i.e., AVS-VMW-SQL03, hereafter simply referred to as SQL03) to the existing WSFC cluster we created in the previous exercise.



Using Cluster Manager, expand the cluster, right click on Nodes, and choose Add Node.
 Add Node Wizard

Before Yo	ou Begin
Before You Begin Select Servers Validation Warning Confirmation Configure the Cluster Summary	 This wizard adds one or more nodes (servers) to an existing cluster. All nodes in a cluster should use the same hardware, firmware, and software (including drivers and operating system updates) as other nodes in the cluster. Before you run this wizard, we strongly recommend that you run the Validate a Configuration wizard for both the existing cluster nodes and the new node or nodes. The Validate a Configuration wizard helps ensure that your hardware and hardware settings are compatible with failover clustering. Microsoft supports a cluster solution only if the complete configuration (servers, network, and storage) can pass all tests in the Validate a Configuration wizard. To continue, click Next. Do not show this page again
	Next > Cancel

• Click Next.



Add Node Wizard	ervers		×
Before You Begin Select Servers Validation Warning	Select the servers to ad	ld to the cluster:	
Confirmation	Enter server name:		Browse
Configure the Cluster	Selected servers:	AVS-VMW-SQL03.avsvmw.loc	Add
Summary			Remove
		C Previous Next >	Cancel

• We'll add SQL03 and click **Next**.

Add Node Wizard	I		×
Validation	n Warni	ing	
Before You Begin Select Servers Validation Warning Confirmation Configure the Cluster	<u>^</u>	For the servers you selected for this cluster, the reports from cluster configuration validation tests appear to be missing or incomplete. Microsoft supports a cluster solution only if the complete configuration (servers, network and storage) can pass all the tests in the Validate a Configuration wizard. Do you want to run configuration validation tests before continuing?	
Summary	◯ Yes nod ● No. valie	a. When I click Next, run configuration validation tests, and then return to the process of adding le(s) to the cluster. I do not require support from Microsoft for this cluster, and therefore do not want to run the dation tests. When I click Next, continue adding the node(s) to the cluster.	
	More ab	bout cluster validation tests	
		< Previous Next > Cancel	

• We've already run the validation test and passed, so, let's skip it this time.



Add Node Wizard		×
Summary		
Before You Begin Select Servers Validation Warning	You have successfully added one or more nodes to the cluster.	
Confirmation	Node	
Configure the Cluster	AVS-VMW-SQL03.avsvmw.loc	
Summary		
Commeny		
	To view the report created by the wizard, click View Report View Report View Report	
	Finish	
	Fillist	

• One more click and we are done with adding SQL03 to our WSFC cluster. Here is what we have now:

📲 Failover Cluster Manager					
File Action View Help					
🗢 🔿 🙍 🖬					
📲 Failover Cluster Manager	Nodes (3)				
V AVSVMW-Clus01.avsvmw.lo	Search			Q.	Queries 💌
Nodes	Name	Status	Assigned Vote	Current Vote	Site
> 📙 Storage	AVS-VMW-SQL01	🕥 Up	1	1	
Networks	AVS-VMW-SQL02	🕥 Up	1	1	
	AVS-VMW-SQL03	🕥 Up	1	1	

Now, we move onto configuring a Database for Always On AG.

• Let's connect to the SQL instances on SQL01 and SQL03.



No. 192.168.100.21 - Remote Desktop Connection				192.168.100.23 - Remote Desktop Con	nection		
😣 Microsoft SQL Server Management Studio				🧏 Microsoft SQL Server Management	t Studio		Quick Launch
File Edit View Tools Window Help				File Edit View Tools Window	Help		
0-0 🕅 - 🔁 - 🖕 🔛 🖉 💭 Ne	w Query 🗯 🔊 🚮 🚮 🕅	≵ ♂ ☆ ♡ • ♥ • ⊠ • ♬		0-0 🔯 - 🖞 - 🗳 🗎 📲	🗎 New Query 🔒 🗟 🗟	☆☆ × ♂ ☆ ♡ - ♡ - ♡ - ☞ ♪	
- P	Execute 🔳 🗸 📅 🗐 🚽	19 18 빠 비 웹 翻 町 코 丞 근 관 @ 후	_	₩ ¥	→ Execute III √ ^{D+O} / ₀	8 8 Y X 2 A B A A	E 10 -
Object Explorer	Connect to Server		×	Object Explorer 👻	무 × 교통 Connect to Serv	er	×
Connect → ¥ × = Y C →		SQL Server		Connect ▼ ¥ ? ₩ ■ ▼ O →		SQL Server	
	Server type :	Database Engine	-		Server type:	Database Engine	~
	Server name:	AVSVMW-NET01	2		Server name:	AVS-VMW-SQL03	~
	Authentication:	Windows Authentication	-		Authentication:	Windows Authentication	~
	User name:	AVSVMW\deji			User name:	AVSVMW\deji	~
	Password:				Password:		
		Remember password				Remember password	
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	Connection				₿ 192.168.100.23 - Re	mote Desktop Connection	
	ent Studio			Quick Launch	🧏 Microsoft SQL S	erver Management Studio	
File Edit View Tools Wind	ow Help				File Edit View	Tools Window Help	
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😑 🐻 AVSVMW-NET01 (SQL Server 1	5.0.2000.5 - AVSVMW\d	eji)			🖃 🔂 AVS-VMW-SQ	L03 (SQL Server 15.0.2000.5 - AVSVMW\de	ji)
🖃 🛑 Databases					😑 📁 Databases		
🕀 📕 System Databases					🕀 🛑 System	Databases	
Database Snapshots					🕀 🛑 Databa	se Snapshots	
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Tables					Benlication	1	
🗄 🛑 Views					PolyBase	•	
😥 💼 External Resources					🗉 🛑 Always On	High Availability	
😥 🛑 Synonyms					😥 🗐 Manageme	ent .	
😥 🛑 Programmability					🗉 🛑 Integration	Services Catalogs	
😥 💼 Service Broker					💂 SQL Server	Agent (Agent XPs disabled)	

There is currently one Database on SQL01. This is the Database in our default instance which is configured in FCI and paired with SQL02. There is currently no Database on SQL03 because this node is not a part of the FCI configuration.

We will now configure our target nodes to participate in Always On Availability Group configuration.

• On each node, click the SQL Server Services properties in SQL Server Configuration Manager.



🗉 💼 Service Broker 🕀 📕 Storage

🗄 💼 Security 🕀 📕 Security Server Obiects



Check the Enable Always On Availability Groups box on the Always On Availability Groups tab.



SQL Server (MSSQLSERV	?	×					
Log On	Log On Service FILESTR						
Always On Availability	Groups	Startup Pa	arameters	Advan	ced		
Windows Server Failover Cluster:							
Enable Always On A	vailability G	roups					
Allow this instance of SQL Server to use availability groups for high availability and disaster recovery.							

• Click **OK** to confirm that we know what we are doing.

Warning		×
Í	Any changes made will be saved; however, they will not take effect until the service is stopped and restarted.	
	ОК	

• Now, we create the Database we're going to use for AG on SQL01.





n 192.168.100.21 - Remote Desktop Connection							-
🔀 Microsoft SQL Server Management Studio					Q	uick Launch (Ctrl+Q)	P
File Edit View Tools Window Help	BOOOO	الم حر ال	0 0				
	New Database					- 0	×
Object Explorer	eneral	🖵 Script 🔻 😮	Help				
Connect → ¥ ¥ = ▼ C → P Or AVSVMW-NET01 (SQL Server 15.0.200	otions egroups	Database name: Owner:		AVSVMW-	DemoAGDB		
 Databases System Databases Database Snapshots 		Use full-text in	ndexing				
AVSVMW-DemoDB		Database files:					
		Logical Name	File Type	Filegroup	Initial Size (MB	 Autogrowth / Maxsize 	Pa
Server Objects		AVSVMW	ROWS	PRIMARY	20480	By 10 percent, Unlimited	E:
Replication PolyBase		AVSVMW	LOG	Not Applicable	1024	By 10 percent, Unlimited	E:
 Always On High Availability 							

For our purposes, we will set it to **"Full"** Recovery model. •

Solution 192.168.100.21 - Remote Desktop Connection				
🧏 Microsoft SQL Server Management Studio			Quick La	unch (
File Edit View Tools 🗃 Database Properties - AVSV	MW-DemoAGDB		_	
G + O 10 + 10 + Select a page	🖵 Script 🔻 😯 Help			
Object Explorer	Collation:	SQL_Latin1_General_CP1_CI_AS		
Connect - + + + = - Change Tracking	Recovery model:	Full		
🖃 🐻 AVSVMW-NET01 (SQ 🔌 Permissions	Compatibility level:	SQL Server 2019 (150)		
 Databases Extended Properties Mirroring 	Containment type:	None		
	Other options:			
AVSVMW-Der				

To help speed up the process, we will take a backup of both the Database and Transaction Logs • files. - v |

Back Up Database - AVSVMW-DemoAGDB

Back Up Database - Avsviviv-DemoAGDB					
Select a page	🖵 Script 🔻 😯 Help				
 Media Options Backup Options 	Source				
	Database:	AVSVMW-DemoAGDB			\sim
	Recovery model:	FULL			
	Backup type:	Full			\sim
	Copy-only backup				
🗑 Back Up Database - AVS\	/MW-DemoAGDB		_		×
Select a page	🖵 Script 🔻 😯 Help				
Backup Options	Source				
	Database:	AVSVMW-DemoAGDB			\sim
	Recovery model:	FULL			
	Backup type:	Transaction Log			\sim
	Copy-only backup				



Microsoft SQL Server Management Studio	×
The backup of database 'AVSVMW-DemoAGD	B' completed successfully.
Copy message	ОК

We'll copy the backup file manually from SQL01 to SQL03.
 192.168.100.23 - Remote Desktop Connection

📙 🛛 🔁 📕 🖛 🛛 Backup			— 🗆 🗙 h (Ctrl+
File Home Share V	ïew		~ 😮
\leftarrow \rightarrow \checkmark \uparrow \square \ll ES \Rightarrow M2	SSQL15.MSSQLSERVER > MSSQL > Backup	Search Backup	٩
🛄 Desktop 🛷 ^ 🗌	Name	Date modified 🛛 Y Type	Size
🕂 Downloads 🖈 🖂	AVSVMW-DemoAGDB.bak	8/5/2021 12:44 PM BAK File	24,756 KB
🟥 Documents 🖈			
📕 📙 🖓 📑 🖛 Backup			- 🗆 🗙
💻 File Home Shar	e View		~ 😮
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E Desktop 🖈 ^	Name ^	Date modified Type	Size
📕 🦊 Downloads 🖈	AVSVMW-DemoAGDB.bak	8/5/2021 12:44 PM BAK File	24,756 KB
🚆 Documents 🖈			
📕 💽 Pictures 🖈			

• Next, we restore the backed-up database to SQL03. This helps us avoid lengthy re-seed and synchronization, especially for large and highly active Databases





• We select our .bak file.

₱ 192.168.100.2	No. 192.168.100.23 - Remote Desktop Connection					
🛃 Micros 🔮	🔀 Restore Database -					
File Edit 🐼	No backupset selected to be restore	d.				
G - O Se	elect a page	🗊 Script 👻 😯 Help				
_ # ¥ _ ▲	General Files					
Object Explor	Options	Source				
Connect -		O Database:				
🖃 🔂 AVS-		Device:				
🖃 🛑 D.		 Select backup devices 	– – × –			
		Constitution benchman and the loss				
🕀 💼 Se		Specify the backup media and its lo	location for your restore operation.			
		Backup media type:	File ~			
		Backup media:				
🕀 💼 AI		🛢 Locate Backup File - AVS-VI	VMW-SQL03			
		Backup File location:	ASSQL15 MSSQLSERVER\MSSQL\Backup			
🚽 SC						
		□ ■···■ C: ■···■ D:	AVSVMW-DemoAGDB.bak			
		Brogram Files				
		ia i Microsoft SQL Ser				
Co	AVS-VMW-SQL03					
Y1	[AVSVMW\deji]	Backu				



•	We verify	that all	looks	good.
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192.168.100.23 - Remote Desktop Cor	nnection						
🛃 Micros 💀 Restore Database - AV	/SVMW-DemoAGDB					-	
File Edit 🕦 Ready							
G - O Select a page	💭 Script 👻	😮 Help					
Image: Second state sta	Source — O Data O Devi Destination Databas	abase: ice: Database: n se:	F:\Program Files\Microsoft S AVSVMW-DemoAGDB AVSVMW-DemoAGDB	QL Server\MS	SQL15.MSSQLSER	VER\MSSQL\Backu	P
🕀 📕 Se	Restore	to:	The last backup taken (Thur	sday, August 5	, 2021 12:44:42 PM)	Timeline
± ■ N	Restore pla	an					
🕀 💼 A	Backup s	ets to restore:					
🗄 📕 M	Restore	Name		Component	Туре	Server	Database
		AVSVMW-Der	moAGDB-Full Database Backup	Database	Full	AVSVMW-NET01	AVSVMW
×× ×× ⊕ XI		AVSVMW-Der	noAGDB-Full Database Backup	Log	Transaction Log	AVSVMW-NET01	AVSVMW

• We choose the **Restore with NoRecovery** option and *OK* the choices.

<u></u>			
No. 22 - Remote Desktop Connection			_
🧏 Micros 💀 Restore Database - AVSVMW-D	emoAGDB	- 0	×
File Edit 🕦 Ready			
G - O Select a page	🗊 Script 👻 🕜 Help		
General Files Object Explor	Restore options		
Connect -	Overwrite the existing d	atabase (WITH REPLACE)	
□ 🔂 AVS-' □ 💼 D	Restrict access to the r	estored database (WITH RESTRICTED_USER)	
• •	Recovery state:	RESTORE WITH NORECOVERY	\sim
	Standby file:	F:\Program Files\Microsoft SQL Server\MSSQL15.MSSQLSERVER\MSSQL	
₩ = Se ₩ = R	Leave the database non-op	verational and do not roll back uncommitted transactions. Additional transaction logs can be re	estored.

• Depending on the size of the Database, the restore process may take some time to complete.



192.168.100.23 - Remote Desktop Connection	
🔀 Microsoft SQL Server Management Studio	
File Edit View Tools Window Help	
🌀 - 🌀 🏠 - 🛅 - 🊔 🔛 🚰 月 New Query	🛢 🗟 🗟 🐨 🕹 🗅 🗂 ಶ - 🤍 - 🞯 👘
🕴 🕆 🍸 📄 🕞 Execute	■ ✓ 認 目 智 認 部 目 翻 品 目 注 通 平
Object Explorer	▼ ╄ ×
Connect - 🛱 🏹 🗏 🝸 🖒 🚸	
😑 🐻 AVS-VMW-SQL03 (SQL Server 15.0.2000.5 - AVSVN	1W∖deji)
🖃 💼 Databases	
🕀 🛑 System Databases	
🕀 📕 Database Snapshots	
🕀 👕 AVSVMW-DemoAGDB (Restoring)	
🕀 📕 Security	

- Now that we have a stub copy of the Database on the second node, we are ready to configure it for high availability, using the Microsoft SQL Server Availability Group option.
- From the Always On Availability Group menu on the Active node (SQL01), select New Availability Group Wizard.



VMWal

by Broadcom



• We give the AG a name.

-	state 192.168.100.21 - Remote Desktop Connection						
	×	Micr	osoft	👸 New Availability Group		_	
Fi 2002 2003	le ⊖ ₽	Edit • ©	Vie t	Specify Availability	r Group Options		
0	bject	t Exp	lorer	Introduction			C
C	Conn	ect •	Ť	Specify Options	6 K 11 H		
•	•	AV	SVMW Datab	Select Databases	Specify availability grou	p options	
L		÷	📕 Sy	Specify Replicas	Availability group name:	AVSVMW-AG01	
L		±	Da A	Select Data Synchronization	Cluster type:	Windows Server Failover Cluster \sim	
	Ŧ	±	A Secur	Validation		Database Level Health Detection	
	Đ		Serve	Summary		Per Database DTC Support	

• We want our Replica copy of the AG to be in Asynchronous mode, so be sure to toggle the **Availability Mode** from **Synchronous Commit** to **Asynchronous Commit**.

New Availability Group	-					— C	X
Introduction Specify Options Select Databases	Specify an instance o	f SQL Server to	host a secondary	y replica.			🕢 Help
Specify Replicas	Replicas Endpoints	Backup Prefere	ences Listener	Read-Only Routing			
Select Data Synchronization	Availability Replicas:		1				
Validation	Server Instance	Initial Role	Automatic Failover (Up to 5)	Availability Mode	1	Readable Secondary	
Summary	AVSVMW-NET01	Primary		Synchronous commit	~ Y	/es	~
Results	AVS-VMW-SQL03	Secondary	\checkmark	Synchronous commit	ו _≺ γ	'es	~
				X			

• Here is what we want our **Availability Mode** to look like for our AG Database configuration.



👸 Availability Group Properties	s - AVSVMW-AG01						_		\times
Select a page	🖵 Script 👻 😮 Help								
 Backup Preferences Permission Read-Only Routing 	Availability group name: Cluster type: Required synchronized Database level healt Per database DTC s Basic Availability Gro Availability Databases Database Name AVSVMW-DemoAGDB	secondari th detection support bup	AVSVM Window on	IW-,/ ws S	AG01 ierver Failov	er Clu	ister		>
Connection									
Server: AVSVMW-NET01	Availability Replicas —						Add	Remove	е
Connection: AVSVMW\deji	Server R	Role	Availability Mode		Failover Mode		Connect Role	ions in Prima	ny
Y ₩ <u>View connection properties</u>	AVSVMW-NET01 Pr	imary	Synchronous commit	~	Manual	\sim	Allow all d	connections	~
	AVS-VMW-SQL03 Se	econdary	Asynchronous commit	~	Manual	~	Allow all d	connections	~
Progress									
Ready	<						Add	Remove	> e
							ок	Cance	el



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• Choose the **Join Only** option – remember, we have already copied the Database manually to the Secondary node.

new Availability Group	– 🗆 X
Select Initial Data	Synchronization
Introduction	Welp
Specify Options Select Databases	Select your data synchronization preference.
Specify Replicas Select Data Synchronization	O Automatic seeding SQL Server automatically creates databases for every selected secondary replica. Automatic seeding requires that the data and log file paths are the same on every SQL Server instance participating in the availability group.
Validation	○ Full database and log backup
Summary Results	Starts data synchronization by performing full database and log backups for each selected database. These databases are restored to each secondary and joined to the availability group. Make sure the file share is accessible to all replicas and is mounted to the same directory on all Linux replicas.
	Specify the file share path in Windows format:
	Browse
	Specify the file share location in Linux format:
	 Join only Starts data synchronization where you have already restored database and log backups to each secondary server. The selected databases are joined to the availability group on each secondary. Skip initial data synchronization
	Choose this option if you want to perform your own database and log backups of each primary database.

• We skipped the option to configure the Listener for now. We will come back to that later.





• We're almost done. Let's click Finish.

👸 New Availability Group	- 🗆 X
Summary	
Introduction	🕡 Help
Specify Options	Varify the choicer made in this winard
Select Databases	Click Einish to perform the following actions:
Specify Replicas	
Select Data Synchronization	Primary replica: AVSVMW-AGOT
Validation	
Summary	- Database health trigger: False
Results	Required synchronized secondaries to commit: 0 Per database DTC support enabled: False Databases Initial data synchronization: Join only Replicas Server instance name: AVSVMW-NET01 Availability mode: Synchronous commit
	Script 💌
	Activate Windows < Previous Setting Finishictivate WCantelws.



- The wizard skips several of the steps because we've already completed them in previous step.
- Note the state of the Database on SQL03. We're cooking with gas now.



The process takes a while, but, eventually, here is the result of our effort.

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Now, we are ready to configure our Listener.

<u>NOTE:</u> In our simplified configuration, we have a stretched/extended/flat network segment between our on-premises SQL Servers and AVS. We're using the same subnet for both sides. In this configuration, we need only one Listener. If this were routed or disjointed segments, we would have needed to create a Listener for each segment where we have the clustered VMs.

• In SQL Server Manager, expand Always On High Availability and navigate to the Availability Group Listeners section. Right click and select Add Listener.





📱 New Availability Group List	ner	_	×	
Select a page	🖵 Script 🔻 😮 Help			
	Listener DNS Name: AVSVMW-AG01-L			
	Port: 1433			
	Network Mode: Static IP		~	
	Subnet IP Address			
	Sector Add IP Address		_	
	Subnet: 192.168.100.0/24			
	Address			
	IPv4 Address: 192.168.100.105			
	Subnet Mask 255.255.255.0			
	IPv6 Address			
Connection				

- Give the Listener a name and an IP Address. ٠
 - As you can see, the Listener has a **DNS Name**. This is part of the administrative pre-tasks not covered in this document because it is not peculiar to virtualization.
 - Also note that we left the port at the default **1433**.

📱 New Availability Group List	ener		-	
Select a page General	Script ▼ 3 Help			
	Listener DNS Name:	AVSVMW-AG01-L		
	Port:	1433		
	Network Mode:	Static IP		
	Subnet		IP Address	
	192.168.100.0/24		192.168.100.105	

Click **Next** and let's wrap up the setup. •





• There it is.

If we look in Windows Cluster Manager, we can now see that we have two clustered Microsoft SQL Server resources (Roles).

One is our newly clustered, share-nothing Availability Group Database

퉣 192.168.100.23 - Remote Desktop	Connection					
📲 Failover Cluster Manager						
File Action View Help						
🗢 🔿 🖄 🖬 🚺						
📲 Failover Cluster Manager	Roles (2)					
 AVSVMW-Clus01.avsvmw.le Roles 	Search			PG	Queries 🔻 🔚	•
Nodes	Name	Status	Туре	Owner Node	Priority	Informat
> 📇 Storage	RVSVMW-AG01	Running	Other	AVS-VMW-SQL01	Medium	
Cluster Events	SQL Server (MSSQLSE	💿 Running	Other	AVS-VMW-SQL01	Medium	
1-1						
	<					>
	V AVSVMW-AG01	l		Preferred	Owners: <u>User</u>	Settings
	Name			Status Inf	ormation	
	Other Resources					
	AVSVMW-AG01)		💿 Online		
	Server Name			0		
	Mame: AVSVMW-AG	01-L		(1) Online		
	IP Address: 192.1	168.100.105		(한 Online		

And the other is the shared-disk Failover Cluster Instance.



- S ISENDONIONES Remote Desktop	Connection					
🍓 Failover Cluster Manager						
File Action View Help						
🔶 🄿 📩 🖬 👔 🖬						
📲 Failover Cluster Manager	Roles (2)					
V Clus01.avsvmw.lc	Search			R	Queries 🔻 🖡	-
Roles		a .	-			
I Nodes	Name	Status	Type	Owner Node	Priority	Inform
Networks	AVSVMW-AG01	(1) Running	Other	AVS-VMW-SQL01	Medium	
Cluster Events	SQL Server (MSSQLSE	(1) Running	Other	AVS-VMW-SQL01	Medium	
	<			_		3
	V SQL Server (MS	Pref	ferred Owners:	Any node		
	Name			0		
	Name			Status	Information	
	Storage			Status	Information	
	Storage			Online	Information	
	Storage	\sum		Online	Information	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr	ree of 200 GB		Online	Information	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr Server Name	ee of 200 GB		Online	ntomation	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr Server Name Name: AVSVMW-Net	ee of 200 GB		Online Online Online	Intormation	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr Server Name Name: AVSVMW-Net IP Address: 192.1	ee of 200 GB 01 168.100.102		Online Online Online Online Online	ntomation	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr Server Name Name: AVSVMW-Net IP Address: 192.1 Other Resources	ee of 200 GB 01 168.100.102		Online Online Online Online Online	ntomation	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr Server Name Name: AVSVMW-Net IP Address: 192.1 Other Resources SQL Server	ee of 200 GB 01 168.100.102		Online Online Online Online Online Online Online Online	Intormation	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr Server Name Name: AVSVMW-Net IP Address: 192.1 Other Resources SQL Server SQL Server Agent	ee of 200 GB 01 168.100.102		Online	Intormation	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr Server Name Name: AVSVMW-Net IP Address: 192.1 Other Resources SQL Server SQL Server SQL Server Agent Roles	ee of 200 GB 01 168.100.102		Online Online Online Online Online Online Online Online Online	Intormation	
	Storage Cluster Disk 1 Shared-Disk (E) NTFS 157 GB fr Server Name Name: AVSVMW-Net IP Address: 192.1 Other Resources SQL Server SQL Server SQL Server Agent Roles SQL Server CEIP (MS	ee of 200 GB 01 168.100.102 SSQLSERVER)		Online Online	Intormation	

Conclusion

Mission accomplished. We have successfully configured a functioning, production-ready, highlyavailable Microsoft SQL Server farm on our Azure VMware Solution platforms, using a mixture of the two most common application-level HA options.

At its core, Azure VMware Solution is a VMware vSphere-base hybrid cloud platform, allowing administrators to seamlessly and easily extend their on-premises infrastructure to the public cloud, using the familiar, true-and-tested vSphere technologies they are already familiar and comfortable with, without unnecessarily re-factoring their applications or re-learning complex processes and ways of doing things.







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