Revisions

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1 Preface

1.1 Audience
The audience for this document is storage and systems administrators who are responsible for the setup and maintenance of Windows servers and associated storage. Readers should have a working knowledge of Windows Server 2012/R2 and the Dell Compellent Storage Center.

1.2 Purpose
This document provides an overview of Microsoft Windows Server 2012/R2 and introduces best practice guidelines when integrating Windows Server 2012/R2 with the Dell Compellent Storage Center.

1.3 Disclaimer
The information contained within this document provides general recommendations only. Configurations may need to vary in customer environments for many reasons, such as individual circumstances, budget constraints, service level agreements, applicable industry-specific regulations, and other business needs.

1.4 Customer support
Dell Compellent provides live support 1-866-EZSTORE (866.397.8673), 24 hours a day, 7 days a week, 365 days a year. For additional support, email Dell Compellent at support@compellent.com. Dell Compellent responds to emails during normal business hours.
2 Introduction

2.1 Dell Compellent Storage Center overview
The Dell Compellent Storage Center is an enterprise-class storage area network (SAN) that significantly lowers capital expenditures, reduces storage management and administration time, provides continuous data availability and enables storage virtualization. Storage Center’s Fluid Data Architecture manages data dynamically at the block-level, maximizing utilization, automating tiered storage, simplifying replication and speeding data recovery.

2.2 Microsoft Windows Server 2012/R2 overview
Initially released in September of 2012, Windows Server 2012 offered a new user interface, and significant improvements and new features aimed at improving the user and cloud experience. Dubbed "the cloud OS" by Microsoft, Server 2012 was designed to be dynamic, scalable, resilient, and to be the core of the data center.

With a focus on offering an enterprise-class cloud platform and a better user experience, Windows Server 2012 R2 was released in October 2013. Server 2012 R2 brought back the Windows start button, and added additional enhancements and features to networking, storage, failover clustering, data deduplication, Hyper-V and more.

As they relate to integration with Dell Compellent Storage Center, the following features and improvements will be covered throughout this document:

- Hyper-V
- Clustering
- SMB 3.0
- Offloaded Data Transfer (ODX)
- Thin Provisioning and Trim Support
- Resilient File System (ReFS)
- Windows Storage Spaces
- Data Deduplication
- PowerShell 4.0

For a complete list of new features and improvements in Windows Server 2012 R2, please refer to the references listed at the end of this document under Additional Resources.
Multipath I/O

Windows Server 2012/R2 natively supports Multipath I/O (MPIO) by way of a Device Specific Module (DSM). MPIO is setup as a feature in the OS and must be enabled to work with the specific volumes that have multiple paths to the SAN. The process is very straightforward and simple to implement.

The main purpose of Multipath I/O is to provide redundant paths for a server to access storage. With multipath, if one path goes down, another path is able to provide connectivity to prevent a service outage. MPIO also allows for load-balancing so that the I/O is spread across the available paths.

For more information on how to install and configure MPIO on Windows Server 2012/R2, Windows Server 2016 (including Nano Server), and SC Series volumes, refer to the guide, Dell Storage SC Series: Microsoft Multipath I/O Best Practices.

Note: The changes specified in the Dell Storage SC Series: Microsoft Multipath I/O Best Practices guide must be applied to all Windows Servers that access storage on SC Series arrays, regardless of whether they are using single-path I/O (SPIO) or multipath I/O (MPIO), in order to ensure optimal performance and proper behavior. This is particularly important for servers that use iSCSI NICs.
4 iSCSI VLAN tagging overview

Storage Center front-end ports are categorized into fault domains that identify allowed port movement when a controller or port fails. Ports that belong to the same fault domain can fail over to each other because they have connectivity to the same resources. Storage Center 6.5.1 includes support for configuring iSCSI ports in a fault domain to use a VLAN (Virtual LAN) ID. A VLAN allows separation of a single physical network interface into multiple distinct domains. The benefit of this configuration is it provides isolation of a virtual interface on a single physical link. The process of assigning a VLAN ID to a network interface is referred to as “tagging”.

For detailed information on Storage Center Multi-VLAN support, please refer to the Dell Compellent Enterprise Manager 2014 R2 Administrator’s Guide located on Knowledge Center.

4.1 Configuring VLAN tags on Windows Server 2012/R2

As mentioned above, Storage Center MVLAN is supported on iSCSI interfaces only. The Microsoft iSCSI Initiator does not include the ability to specify a VLAN tag. Instead, VLAN tagging must be configured on
the specific network adaptor specified in the iSCSI initiator. On a physical server, Windows Server 2012/R2’s NIC Teaming feature can be used to set a VLAN tag on a single NIC, or on a NIC team. Setting a VLAN tag on a Hyper-V virtual machine can be done through Hyper-V Manager.

Note: NIC manufacturers such as Intel and Broadcom offer the ability to set VLAN tags through software programs provided by the manufacturer. Because NIC manufacturers and models vary, this section focuses only on using built-in Windows features to set VLAN tags.

To utilize a VLAN tagged network adapter for iSCSI traffic, it must be specified in iSCSI Initiator properties. For information on setting iSCSI Initiator properties, please refer to the Windows Server MPIO Best Practices for Dell Compellent Storage Center Guide located on Dell TechCenter.

4.1.1 Configuring a VLAN tag on a physical server

Without specific software and drivers from the NIC manufacturer, the only way to set a VLAN tag on a NIC is by using Windows Server 2012/R2’s built in NIC Teaming feature.

To configure a VLAN tag on a physical server:

1. Log on as an administrator to the Windows 2012/R2 server.
2. Open Server Manager by going to Start→Apps→Administrative Tools→Server Manager or by clicking the icon on the Windows desktop.
3. On the left-hand menu, select Local Server.
4. In the Properties pane, locate the entry for NIC teaming and click Disabled.

5. In the NIC Teaming window right-click the adaptor to be used, and select Add to New Team.
1. In the New team window, assign a descriptive name to the team, and click the Additional properties drop down.

**Note:** Once a VLAN is set, - VLAN xxx will be appended to the team name. This will be the name of the adapter displayed in Network Connections.

2. Under Additional properties, leave the options for Teaming mode and Load balancing mode set to the defaults, and click link next to Primary team interface.
8. In the **New team interface** window under **VLAN membership** select **Specific VLAN**: and enter the VLAN number to use for iSCSI traffic.

9. Click **OK** twice to return to the main NIC Teaming window.
10. The new team will show under the Teams pane.

![New team created](image)

**Figure 6**  New team created

11. The new team will also show as a new adapter in Network Connections in Control Panel.

![Network connections](image)

**Figure 7**  Network connections

12. Should the need exist to further segment iSCSI traffic, additional VLAN tags can be assigned to the team adapter. To assign an additional VLAN tag to the team adapter:
   a. In the **NIC Teaming** window, click the **Team Interfaces** tab under the **Adapters and Interfaces** pane:
b. Highlight the adapter, and then select Add Interface from the Tasks drop-down:

c. Enter the VLAN to be used, and click OK.
d. The new interface will appear in the Adapters and Interfaces pane as well as under Network Connections in Control Panel.
4.1.2 Configuring a VLAN tag on a Hyper-V virtual machine

As with physical machines, a dedicated NIC should be used on a virtual machine for iSCSI traffic.

**Note:** Clustered Hyper-V guests can be configured to use a VLAN tag in either Failover Cluster Manager or Hyper-V Manager. The guest settings screen is the same in both tools, and NIC settings created in one tool will transfer to the other.

To configure a VLAN tag on a Hyper-V virtual machine:

1. Log on as an administrator to the Windows 2012/R2 server.
2. Open Hyper-V Manager by going to **Start** ➔ **Apps** ➔ **Hyper-V Manager**
3. If the guest is running, shut it down by right-clicking on the guest and selecting **Shut Down**...
4. When the guest is turned off, right-click on the guest and select settings.

![Figure 14 Guest settings](image)

5. Select the network adapter to be used for iSCSI traffic. Under VLAN ID, check the box to enable virtual LAN identification, and then enter the VLAN to be used.
Figure 15  Enable VLAN support

6. Click OK.
7. When the guest is turned back on all traffic for the specific network adapter will only travel over the VLAN specified in the guest settings.

**Note:** Unlike physical adapters, multiple VLANs cannot be assigned to a single virtual network adapter. A separate virtual network adapter is required for each VLAN to be used in the guest.

4.2 Jumbo frame support

Standard Ethernet communications transmit frames with the Maximum Transmission Unit (MTU) size of 1500 bytes of payload. The standard MTU size holds true in both 1 Gb and 10 Gb networks. Jumbo frames are classified as any Ethernet frame with a MTU payload bigger than 1500 bytes. The benefit of using jumbo frames to transfer data is reduced CPU utilization and increased throughput. Storage Center supports a MTU of 9000 bytes.

**Note:** In order to utilize jumbo frames in an iSCSI environment, every component in the network (NICs, switches, routers, etc...) must support jumbo frames and be set to the same MTU size.
Storage Center MTU size is set individually on iSCSI Fault Domains. One Fault Domain could have a MTU of 1500 bytes (standard) and another Fault Domain could have a MTU of 9000 bytes (jumbo).

For detailed information on setting MTU size in Storage Center, please refer to the *Dell Compellent Enterprise Manager 2014 R2 Administrator’s Guide* located on Knowledge Center.

4.2.1 Enabling jumbo frame support on a physical Windows Server 2012/R2 server

On physical servers, jumbo frame support is enabled on a per-NIC basis.

**Note:** As a best practice, do not enable jumbo frame support on NICs that do not require the functionality. Enabling jumbo frames on unsupported networks can cause performance degradation.

On a server with 2 NICs (1 for management traffic and 1 for iSCSI traffic), only the NIC used for iSCSI traffic should be configured for jumbo frame support.

In section 4.1.1 above, a single NIC was used to create a team in order to create a virtual interface with an assigned VLAN tag. In this scenario, jumbo frame support needs to be enabled on the underlying physical NIC used for the network team. Note that if multiple VLAN tagged interfaces are hosted in the team, enabling jumbo frames on the NIC enables jumbo frames on all associated interfaces.

To enable jumbo frame support on a physical NIC:

1. Log on as an administrator to the Windows Server 2012/R2 server.
2. Open Network Connections by going to **Start** ➔ **Control Panel** ➔ **Network and Sharing Center** ➔ **Change adapter settings**
3. Right-click the NIC and click **Properties**.

![NIC properties](image)
4. Click the **Configure** button, then click the **Advanced** tab.

![Adapter properties](image17)

**Figure 17** Adapter properties

5. Click the entry for **Jumbo Packet** (depending on the NIC manufacturer, this setting could also be called Jumbo Frames, Packet Size, or something else).

6. Click the drop down and select the MTU size to use for jumbo frames. This value varies depending on NIC manufacturer, and should be set closest to the MTU value set in Storage Center.

![Enable jumbo frames](image18)

**Figure 18** Enable jumbo frames

7. Click **OK** to close the NIC properties window.
4.2.2 Enabling jumbo frame support on a Windows Server 2012/R2 Hyper-V guest

In order for a Hyper-V guest to utilize jumbo frames, jumbo frame support must be enabled on the physical NIC that hosts the Hyper-V virtual switch that the guest network adapter connects to, and also within the guest itself.

**Note:** No configuration of the Hyper-V virtual switch is necessary to enable jumbo frame support on a guest.

The physical NIC can be identified through Virtual Switch Manager within Hyper-V Manager. To access Virtual Switch Manager:

1. Log on as an administrator to the Windows Server 2012/R2 Hyper-V server.
2. Open Hyper-V Manager by going to **Start**:Apps:**Hyper-V Manager**.
3. In Hyper-V Manager in the Actions pane, click **Virtual Switch Manager**.

![Hyper-V Manager](image)

**Figure 19** Hyper-V manager

4. In Virtual Switch Manager click the virtual switch that will be used for iSCSI traffic.
5. In the Virtual Switch Properties, identify the physical NIC connection under Connection type:
6. Click **OK** to close Virtual Switch Manager.

Follow the procedure in section 4.2.1 above to configure jumbo frame support on the physical NIC that hosts the Hyper-V virtual switch.

To enable jumbo frame support within a Windows Server 2012/R2 Hyper-V guest, the virtual network adapter used for iSCSI traffic must be configured to enable jumbo frame support. The same procedure as used in section 4.2.1 above also applies here, although the configuration properties for the virtual network adapter will be consistent in all guests regardless of the manufacturer of the underlying NIC associated with the Hyper-V virtual switch. In the configuration properties of the virtual NIC the property to be set will be named Jumbo Packet, and the values available will be disabled, 4088 Bytes, or 9014 Bytes. Select the value that is closest to MTU size set on the Storage Center.
For more information on Hyper-V and virtual switch configuration, please refer to the *Hyper-V 2012 R2 Best Practices for Dell Compellent Storage Center Guide* located on [Dell TechCenter](https://www.dell.com/techcenter).

### 4.2.3 Testing jumbo frames

To test if jumbo frames are configured properly:

1. Open a command prompt by going to **Start** → **Apps** → **Command Prompt** and type in the following command:

   ```
   Ping -f -l <packet size> <Storage Center iSCSI Fault Domain IP address> <enter>
   ```

**Note:** Due to TCP/IP overhead, sending a packet size of 9000 bytes will most likely fail. Maximum packet size depends on a number of factors, and could be higher on one system than another.

Failure to send a jumbo packet results in a message that the packet needs to be fragmented because the packet size is too large. (The –f option in the ping command above specifies that the packet not be fragmented)
A failed ping could be the result of trying to send too large of a packet. It could also be the result of jumbo frame support not configured on a switch located between the server and the Storage Center.

A successful ping will result in transfer of the jumbo packet without fragmentation or errors:
Hyper-V

Hyper-V is a layer of software that sits between the physical server's hardware layer and the Hyper-V guest virtual machines (VMs). Hyper-V presents hardware resources in a virtualized manner from the host server to the guest VMs. Hyper-V hosts (also referred to as nodes or virtualization servers) can host multiple Hyper-V guest VMs, which are isolated from each other but share the same underlying hardware resources (e.g. processors, memory, networking, and other I/O devices).

Microsoft Hyper-V in Windows Server 2012 contained numerous new features and improvements from the previous version in Window Server 2008 R2. Some of the new features include a new virtual hard disk format (VHDX), virtual fibre channel support, support for guest VMs on shared file storage, Offloaded Data Transfer (ODX) support, live migration of multiple guests, live storage migration, 150 built-in PowerShell Cmdlets, and better guest resource allocations.

Windows Server 2012 R2 adds additional features and improvements to Hyper-V. New features include Live Migration with compression, shared virtual disks for guest clustering, storage quality of service (QoS), virtual machine generation settings, enhanced session mode, and automatic virtual machine activation.

For a complete listing of new and improved features in Windows Server 2012 R2 Hyper-V, please refer to Microsoft TechNet.

For detailed information on Dell Compellent integration with Windows Server 2012/R2 Hyper-V, please refer to the Dell Compellent Storage Center Best Practices Guide for Microsoft Hyper-V located on Knowledge Center.
6  Windows failover clustering and SMB 3.0

6.1  Windows failover clustering overview

Window Server 2012/R2 Failover Clustering provides the capability to tie multiple servers together to offer high availability and scalability for business-critical applications such as Microsoft Exchange, Hyper-V, Microsoft SQL Server, and file servers. Clustering is designed to maintain data integrity and provide failover support. Windows Server 2012/R2 failover clustering can scale up 64 nodes in a single cluster.

The initial release of Windows Server 2012 failover clustering included new and changed functionality from the prior release included in Windows Server 2008 R2. This functionality supported increased scalability, continuously available file-based server application storage, easier management, faster failover, and more flexible architectures for failover clusters.

Windows Server 2012 R2 adds additional functionality to Failover Clustering by adding support for shared virtual hard disks (for Hyper-V guest clustering), improved handling of virtual machines in a Hyper-V cluster, Cluster Shared Volume (CSV) improvements, and new and improved cluster quorum handling. For a complete list of changes and new features included in Windows Server 2012 R2 Failover Clustering, please refer to Microsoft TechNet.

Failover Clustering is included in both the Standard and Datacenter versions of Windows Server 2012/R2.

6.2  Server message block (SMB) 3.0 overview

One of the biggest improvements/updates in Windows Server 2012 was the inclusion of SMB 3.0. SMB is a Microsoft-developed file sharing protocol. Compared to the previous version (2.1, included in Windows Server 2008 R2), SMB 3.0 offers improved performance, fault tolerance, scaling, backup and restore, and PowerShell integration.

The majority of improvements and new features in SMB 3.0 are fully utilized on a failover cluster. For instructions on how to setup a Windows Server 2012/R2 Failover Cluster with Dell Compellent Storage Center, please refer to the Configuring a Microsoft Windows Server 2012/R2 Failover Cluster with Storage Center Guide located on Knowledge Center.

**Note:** A non-clustered Windows 2012/R2 server running the File Server role can host file shares and utilize some of the new features of SMB 3.0.

**Note:** SMB 3.0 connections can only be established between Windows 2012/R2 servers, or between a Windows 8/8.1 client and Windows 2012/R2 server. For SMB version and compatibility information, please refer to Microsoft TechNet.
6.2.1 Scale-out file server and continuous availability

Introduced with Windows Server 2012, a Scale-Out File Server (SoFS) allows the storage of server application data, such as Hyper-V virtual machine files, on SMB file shares. All file shares are online on all nodes simultaneously. This configuration is commonly referred to as an active-active cluster configuration.

**Note:** SoFS does not support the NFS protocol, Data Deduplication, DFS Replication, or File Server Resource Manager.

A SoFS allows for continuously available file shares. Continuous availability tracks file operations on a highly available file share so that clients can fail over to another node of the cluster without interruption. This is also known as Transparent Failover.

6.3 Cluster shared volumes (CSVs)

Originally introduced in Windows Server 2008 R2 Failover Clustering, CSVs allow all nodes in a cluster to simultaneously have read-write access to the same LUN that is formatted as an NTFS or ReFS (2012 R2 only) volume. Using CSVs, clustered roles can fail over quickly from one node to another node without requiring a change in drive ownership, or dismounting and remounting a volume. In Windows Server 2008 R2, only Hyper-V workloads were supported on CSVs. Windows Server 2012 expanded CSV functionality, allowing CSVs to be utilized as file shares with the Scale-Out File Server role. Scale-out file shares can host application data, such as Microsoft SQL Server and Hyper-V guests.

**Note:** While not a requirement for a clustered file server, a CSV is required for a Scale-Out File Server with a continuously available file share.

CSVs in Windows Server 2012 R2 now support data deduplication. For detailed information about data deduplication please refer to chapter 10 in this document.

**Note:** CSVs formatted with ReFS do not support the data deduplication feature, TRIM/unmap, or ODX.

As previously mentioned, Windows Server 2012 R2 Hyper-V introduced the ability to use shared virtual disks to allow for guest clustering. A shared virtual disk presented to a guest cluster can be formatted as a CSV.
6.4 SMB multichannel and SMB direct

6.4.1 SMB multichannel
SMB Multichannel allows multiple connections to a single SMB session over multiple NICs, enabling bandwidth aggregation of the multiple NICs and multiple CPUs involved. The result is greatly improved performance, giving SMB access comparable performance to directly accessed storage (when used with SMB direct). While providing increased throughput to SMB shares, SMB Multichannel provides fault tolerance in the case of the loss of a network connection. SMB Multichannel will automatically detect and utilize multiple network paths.

SMB Multichannel is enabled by default.

For more information about SMB Multichannel, please refer to Microsoft TechNet.

6.4.2 SMB direct
SMB Direct allows for the use of Remote Direct Memory Access (RDMA) network interfaces for high throughput with low latency and low CPU utilization. This is particularly useful for Hyper-V and SQL server workloads that reside on remote file shares, as the file shares resemble local storage.

**Note:** To fully utilize SMB Direct and remote file shares as storage for Hyper-V or SQL Server, a Windows failover cluster hosting a Scale-out File Server for Applications must be used.

SMB Multichannel is responsible for detecting RDMA capabilities of network adapters to enable SMB Direct.

For more information on SMB Direct, please refer to Microsoft TechNet.
Offloaded data transfer (ODX)

Offloaded Data Transfer (ODX) is a feature developed by Microsoft for copying and moving SAN data. The work of copying or moving data is offloaded to the SAN, bypassing the need for the Windows server to handle the data movement. By offloading operations to the SAN, ODX can provide significant performance improvements for copy and read operations.

ODX is enabled by default on Windows Server 2012/R2 and Storage Center 6.3. ODX requires both the source and destination volumes be formatted with NTFS.

**Note:** ODX only works between volumes that are hosted on the same Storage Center (single or dual controller). Even if two volumes from different Storage Centers are mapped to the same server, data transfers will take place using the traditional buffered copy operation between the two volumes.

ODX operations can be initiated from a physical server or a virtual machine. The source and destination volumes can be physical disks, VHDs, or SMB shared disks (the share must be hosted on a volume located on the same Storage Center as the source/destination volume).

Within Hyper-V, ODX is used to speed up the virtualization platform layer. This allows Hyper-V to achieve native-like performance when virtual machines read and write to Storage Center. ODX also allows for rapid deployment of guests.

Additionally, ODX can be utilized when creating a fixed-size virtual hard drive (VHD). Without ODX enabled, Windows will explicitly zero-out all the disk space assigned to the new VHD file. Depending on the size of the VHD file, this can be a slow, time consuming process. With ODX enabled, Windows issues the Storage Center a command to write all zeros to the blocks that represent the new VHD file. This process takes seconds to complete. Windows reads the newly created VHD file as the full size, but with thin provisioning on the Storage Center, the file is not consuming any actual space until data is written to it.

ODX operations on virtual machines (VMs) require the VMs be running Windows Server 2012/R2 or Windows 8/8.1, and the VM’s virtual hard drive(s) be in the VHDX format. Transferring data between VMs require that both VMs’ virtual hard drives be housed on volumes hosted on the same Storage Center. VMs can use ODX to transfer data to other guests, physical pass-through volumes, virtual fibre channel volumes, and SMB shared disks.

For more information about using ODX on Storage Center, please refer to the *Dell Compellent Storage Center and Windows Server 2012/R2 ODX Technical Overview* on [Knowledge Center](http://technet.microsoft.com/en-us/library/jj200627.aspx).

For information on how to enable or disable ODX, and how to establish performance benchmarks, please see this Microsoft reference:

8 Thin provisioning and Trim/unmap

Windows Server 2012/R2 automatically identifies thin provisioned LUNs and will reclaim unused space (aka Trim) in real time. When files and folders are moved or deleted from a volume, Trim automatically reclaims that space on the SAN. Thin provisioning and Trim are enabled by default in Windows Server 2012/R2.

Dell Compellent Storage Center supports Trim/Unmap as of the 6.3.1 release of the Storage Center OS. With the Trim/Unmap feature, the Dell Compellent Server Agent will no longer be required to recover deleted disk space from server volumes and return it to the SAN’s free disk space pool to be used elsewhere. The Dell Compellent Server Agent can still be installed on a 2012/R2 Server, but the disk space recovery feature, since it is no longer needed, will be disabled by default.

Trim/Unmap will be supported with the following types of volumes and disks:

- Dell Compellent SAN volumes mapped to physical Server 2012/R2 hosts using iSCSI or fiber channel, and to guest VMs as pass-through or direct-attached disks using iSCSI or virtual fiber channel:
  - SAN volumes must be “basic” disks and formatted as NTFS (other formats such as FAT and ReFS do not support Trim/Unmap).
- Dell Compellent SAN volumes mapped to Server 2012/R2 Hyper-V nodes as cluster shared volumes (CSVs):
  - CSVs must be “basic” disks and formatted as NTFS
    - CSVs formatted with ReFS (Windows Server 2012 R2 only) do not support Trim/Unmap
- Virtual Hard Disks:
  - The virtual hard disk must be formatted as a .VHDX file (dynamic or fixed). Trim/Unmap is not supported with the .VHD virtual hard disk format.
  - The guest VM OS must support Trim/Unmap. When the guest VM OS is Server 2012/R2, from the perspective of the guest, the VHDX must be a “basic” disk, formatted as NTFS. Trim/Unmap is not supported on a .VHDX when the guest VM’s OS is Server 2008 R2 or earlier.
9 Resilient file system (ReFS)

Introduced with the initial release of Windows Server 2012, ReFS is a file system that is specifically intended for managing extremely large data volumes. Using a new file system design, ReFS can auto-detect data corruption and automatically perform needed repairs without taking a volume offline. ReFS eliminates the need to run CHKDSK against large volumes.

ReFS volumes can scale exponentially in size, and a single volume can store 18 quintillion (18 million million) files.

9.1 Using ReFS on Dell Compellent volumes

A Dell Compellent Volume mapped to a Windows 2012/R2 Server can be formatted with ReFS.

Things to keep in mind with ReFS:

- Replays and restores of ReFS volumes function in the same manner as NTFS volumes.
- ReFS cannot be used on boot/OS volumes.
- ReFS is not compatible with Windows Server 2012/R2 data deduplication.
- ReFS does not support the following features (must use NTFS):
  - File Compression
  - Disk Quotas
  - EFS Encryption
  - Short Filenames
  - Object IDs
  - Named Streams
  - Extended Attributes
  - User Data Transactions
  - Hard links
  - ODx
  - TRIM/unmap

**Note:** Windows Server 2012 R2 supports the use of ReFS on CSVs.

It is recommended to use ReFS on very large data volumes on Windows Server 2012/R2 file servers. Because of the reduced feature set of ReFS, NTFS is recommended for all other applications.
10 Windows storage spaces

Windows Storage Spaces was introduced as a new feature in the initial release of Windows Server 2012. Storage Spaces provides storage virtualization capabilities using readily-available non-enterprise class hard disks. Storage Spaces allows for the creation of storage pools using two or more heterogeneous physical hard drives. A Storage Space (logical drive) can be created from a storage pool, which can be formatted, partitioned, and used just as a physical disk would be. A Storage Space can be assigned redundancy, such as mirroring or parity. Windows Storage Spaces is not a SAN replacement. Instead, it offers some SAN-like features using disparate disks in a JBOD configuration.

10.1 Compatibility and limitations

Windows Storage Spaces is not compatible with SAN disks, and therefore not compatible with Storage Center. Mapped Storage Center volumes appear to Windows Server as logical disks. Windows Storage Spaces is compatible only with physical disks attached to the server.

As compared to Dell Compellent Storage Center, the limitations of Storage Spaces include:

- No active hardware monitoring
- Lack of monitoring tools
- No support for boot or system volumes
- No support for fibre channel and iSCSI
- No ability to replicate data
- Existing data is not rebalanced when a new drive is added to a pool
- No Replays
- No Live Volume
11 Data deduplication

Previously only available with Windows Storage Server and known as Single Instance Storage (SIS), data deduplication is now included in Windows Server 2012/R2. Data deduplication on Windows Server 2012/R2 works at the block level, whereas SIS worked at the file level. Block-based deduplication is more efficient than file-based deduplication because changes in files only require saving the changed blocks between one version of the file and the next. File-based deduplication requires the entire file to be saved a second time.

The primary goal of data deduplication is to store more data in less space. Microsoft accomplishes this by segmenting files into small variable-sized chunks (32-128 KB), identifying duplicate chunks, and preserving one copy of each chunk. Duplicate copies of the chunk are replaced by a link to the single copy. The single copy chunks are compressed and placed into special container files in the sysvol folder.

Once a volume has been optimized for deduplication, it contains the following:

- **Unoptimized files**: Any file that has not been deduplicated. Files that don’t meet deduplication policy settings, encrypted files, system files, files in use by applications, and files smaller than 32 KB fall into this category.
- **Optimized files**: Files that are stored as reparse points that contain links to the data chunks in order to restore the file.
- **Chunk store**: The location of optimized data.
- **Additional free space**: The chunk store and optimized files occupy considerably less space than prior to deduplication.

11.1 Enhancements to data deduplication in Windows Server 2012 R2

Windows Server 2012 R2 includes the following enhancements to data deduplication:

- Improved performance
  - Faster read/write of optimized files
  - Improved optimization speed
- Deduplication can now be used on open virtual hard disks (VHD and VHDX), providing real-time deduplication of virtual machines.
- Deduplication is now supported on Cluster Shared Volumes (CSVs) that are formatted as NTFS volumes (ReFS is not supported).

**Note:** Although Windows Server 2012 R2 data deduplication can be used on open VHD and VHDX files, this functionality was designed to be implemented in a Virtual Desktop Infrastructure (VDI) scenario where the storage and compute nodes are connected remotely. Microsoft does not support using data deduplication for Hyper-V VMs in a non-VDI scenario.

For more information regarding using data deduplication with VDI workloads, please refer to [Microsoft TechNet](#).
11.2 Installing the data deduplication feature

Data Deduplication is not enabled by default on Windows Server 2012/R2. The feature can be installed through the GUI or through PowerShell.

11.2.1 Installing the data deduplication feature with Server Manager

1. Open Server Manager.

![Server Manager GUI](image)

Figure 24 Server Manager GUI

2. From the Dashboard, click on Add roles and features.

![Add roles and features wizard](image)

Figure 25 Add roles and features wizard
3. When the Add Roles and Features Wizard window opens, click **Next** on the Before you begin screen.

4. Select **Role-based or feature-based installation** and click **Next**.

![Figure 26 Role-based or feature-based installation](image)

5. Choose the local server from the **Select destination server** screen and click **Next**.

6. Expand **File and iSCSI Services**, and select **Data Deduplication**. Click **Next**.

![Figure 27 Select server roles](image)

7. Click **Next** on the Select features screen (do not select any features to install).
8. Click **Install** on the confirmation screen.

9. Click **Close** when installation has completed.
11.2.2 Installing the Data Deduplication feature with PowerShell

1. Open a PowerShell window with elevated (administrator) privileges.
2. At the PowerShell prompt, execute the following commands:
   a. `Import-Module ServerManager [Enter]`
   b. `Add-WindowsFeature -name FS-Data-Deduplication [Enter]`
   c. `Import-Module Deduplication [Enter]`

11.3 Enabling data deduplication

Although the feature has been installed, data deduplication needs to be configured on a per-volume basis. The following sections detail configuring data deduplication through Server Manager and PowerShell.
11.3.1 Enabling data deduplication on a volume with Server Manager

1. Open Server Manager.

![Server Manager](image1)

Figure 32 Server Manager

2. Click File and Storage Services, then click Volumes.

![Volumes](image2)

Figure 33 Volumes

3. Right-click a volume and select Configure Data Deduplication.
4. By default, data deduplication is set to disabled. Click the drop down box and select an option for deduplication: **General purpose file server** or **Virtual Desktop Infrastructure (VDI) server** (In this example General purpose file server will be used). Enter the number of days that should elapse from the date of file creation until files are deduplicated. Enter the extensions of any file types that should not be deduplicated, and then click **Add** to browse any folders with files that should not be deduplicated.

Figure 35  Deduplication settings
5. Click **Set Deduplication Schedule**.

6. Select optimization options and schedule. Click **OK**.

7. Click **OK** to exit the Deduplication Settings window.

11.3.2 Enabling data deduplication on a volume with PowerShell

The following example is to enable deduplication on the F: drive.

1. Open an elevated PowerShell window.
2. At the PowerShell prompt, type in the following command:
   
a. **Enable-DedupVolume F:** [Enter]

![Enable deduplication](image)

3. **Optional** – Set the minimum number of days that must pass before a file is deduplicated by typing in the following command:
   
a. **Set-DedupVolume F:** -MinimumFileAgeDays 20 [Enter]
Figure 38  Set minimum file age

**Note:** The default minimum number of days is 5.

11.4  **Viewing deduplication statistics**

Deduplication statistics can be viewed from Server Manager or PowerShell.

11.4.1  **Viewing deduplication statistics with Server Manager**

1. Open Server Manager.

![Server Manager](image)

Figure 39  Server Manager

2. Click **File and Storage Services** then click **Volumes**.

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3. Select a volume. The volume’s deduplication statistics are displayed:

4. Deduplication statistics can also be viewed by right-clicking on the volume and selecting properties.
11.4.2 Viewing deduplication statistics with PowerShell

1. Open a PowerShell window with elevated (administrator) privileges.
2. At the PowerShell prompt, type in the following command:
   
   ```powershell
   Get-DedupStatus [Enter]
   ```

3. Detailed information about each volume can be obtained by typing in the following command:
   
   ```powershell
   Get-DedupVolume | format-list [Enter]
   ```
Figure 44  Detailed deduplication information

For further information about Windows Server 2012/R2 Data Deduplication, please refer to the references listed at the end of this document under Additional Resources.
PowerShell 4.0

PowerShell 4.0 is included in Windows Server 2012 R2. PowerShell 4.0 introduces many new features, bug fixes, and new Cmdlets for systems administration. Along with the over 2300 Cmdlets that were included in PowerShell 3.0 (included with the initial release of Windows Server 2012), PowerShell 4.0 can be used to control and configure just about every aspect of Windows Server.

For a complete listing of all PowerShell 4.0 Cmdlets, please refer to Microsoft TechNet.

Dell Compellent offers the Storage Center Command Set version 7.0 for Windows PowerShell. Available on Dell Compellent Knowledge Center, this free download contains 99 Cmdlets for streamlining SAN management, including administration, snapshot schedules and data recovery. Complete instructions for installing and using the Storage Center Command Set are found in the Administrator’s Guide included with the Command Set download.
Additional resources

Support.dell.com is focused on meeting your needs with proven services and support.

DellTechCenter.com is an IT Community where you can connect with Dell Customers and Dell employees for the purpose of sharing knowledge, best practices, and information about Dell products and installations.

**Referenced or recommended Dell Compellent publications on Knowledge Center:**
http://kc.compellent.com
- Dell Compellent Storage Center Users Guide
- Dell Compellent Storage Center Microsoft Multipath I/O (MPIO) Best Practices Guide
- How to Configure a Windows Server 2012/R2 Failover Cluster
- Dell Compellent Storage Center ODX Overview
- Dell Compellent Storage Center Best Practices for Hyper-V

**Referenced or recommended Microsoft publications:**
- Microsoft TechNet Windows Server 2012 and Server 2012 R2 document collection:
- Install and Deploy Windows Server 2012 R2:
- What’s new in Windows Server 2012 R2:
- Microsoft Multipath I/O (MPIO) Users Guide for Windows Server 2012 (applies for R2)
- Offloaded Data Transfers (ODX):
- SMB Direct – Remote Direct Memory Access (RDMA):
- Resilient File System (ReFS) Overview:
- Data Deduplication Overview: