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About the Author

Anthony Sequeira (CCIE #15626) began his IT career in 1994 with IBM in Tampa, Florida. He quickly formed his own computer consultancy, Computer Solutions, and then discovered his true passion—teaching and writing about Microsoft and Cisco technologies. Anthony has lectured to massive audiences around the world while working for Mastering Computers. He has never been happier in his career than he is now as a full-time trainer for CBT Nuggets. He is an avid tennis player, a private pilot, and a semi-professional poker player, and he enjoys getting beaten up by women and children at the martial arts school he attends with his daughter.
Dedication

This book is dedicated to all my fellow employees at CBT Nuggets. Thank you for your tireless efforts in enriching the lives of students all over the world.
Acknowledgments

Thanks so much to my technical reviewer, Vince Averello. Vince carefully stepped through the hefty contents of this book to ensure that the information is as accurate as possible. Thanks also to Michelle Newcomb for her patience with me as I struggled to get this book completed on time. Finally, as always, thanks to Chris Cleveland for his incredible work to ensure that this book is as awesome as possible!
About the Technical Reviewer

Vince Averello has been a professional geek for more than 30 years. During those often funny, sometimes frightening but always interesting years, he’s worked for more than 10 organizations, lending his expertise to a variety of projects. Every one of them has been a learning experience, so now he knows a little bit about a lot of things, ranging from the Internet to garment trucking. Vince lives in lovely midtown Bayonne, New Jersey with his loving wife, daughter, and two cats with delusions of grandeur.
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As the reader of this book, you are our most important critic and commentator. We value your opinion and want to know what we’re doing right, what we could do better, what areas you’d like to see us publish in, and any other words of wisdom you’re willing to pass our way.

We welcome your comments. You can email or write to let us know what you did or didn’t like about this book—as well as what we can do to make our books better.

Please note that we cannot help you with technical problems related to the topic of this book.

When you write, please be sure to include this book’s title and author as well as your name and email address. We will carefully review your comments and share them with the author and editors who worked on the book.

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Introduction

Congratulations! If you are reading this, you have in your possession a powerful tool that can help you do the following:

- Install Windows Servers in host and compute environments
- Implement storage solutions
- Implement Hyper-V
- Implement Windows containers
- Implement high availability
- Maintain and monitor server environments
- Prepare for the Exam 70-740 Installation, Storage, and Compute with Windows Server 2016 certification exam from Microsoft

Whether you are preparing for the MCSA or MCSE certifications from Microsoft or changing careers to server administration, this book will help you gain the knowledge to get started and prepared.

This text covers every single objective the 70-740 exam has to offer and also provides the step-by-step guidance you need in production server environments.

The Exam 70-740 Installation, Storage, and Compute with Windows Server 2016 exam is required for the MCSA and MCSE certifications from Microsoft. This book covers all the topics listed in Microsoft’s exam blueprint, and each chapter includes key topics and preparation tasks to assist you in mastering this information. Reviewing tables and practicing test questions will help you practice your knowledge in all subject areas.

About the 70-740 Installation, Storage, and Compute with Windows Server 2016 Exam

This exam focuses primarily on the installation, storage, and compute features and functionality available in Windows Server 2016. It covers general installation tasks and considerations and the installation and configuration of Nano Server, in addition to the creation and management of images for deployment. It also covers local and server storage solutions, including the configuration of disks and volumes, data deduplication, high availability, disaster recovery, Storage Spaces Direct, and Failover Clustering solutions. The exam also covers Hyper-V and containers, along with the maintenance and monitoring of servers in physical and compute environments. For a complete review of the exam structure and types of questions you will face, visit www.ajsnetworking.com/70-740-review.

You can take the exam at Pearson VUE testing centers. Register with VUE at www.vue.com.
# 70-740 Exam Topics

Table I-1 lists the topics of the 70-740 exam and indicates the chapter in the book where each is covered.

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<td>Create, manage, and maintain images for deployment</td>
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<td><strong>Implement storage solutions</strong></td>
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<td><strong>Implement Hyper-V</strong></td>
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About the MCSA 70-740 Cert Guide

This book maps to the topic areas of the 70-740 exam and uses a number of features to help you understand the topics and prepare for the exam.

Objectives and Methods

This book uses several key methodologies to help you discover for which exam topics you need more review, to help you fully understand and remember those details, and to help you prove to yourself that you have retained your knowledge of those topics. This book does not try to help you pass the exams only by memorization but by truly learning and understanding the topics. This book is designed to help you pass the 70-740 exam by using the following methods:

- Helping you discover which exam topics you have not yet mastered
- Providing explanations and information to fill in your knowledge gaps
- Supplying exercises that enhance your ability to recall and deduce the answers to test questions
- Providing practice exercises on the topics and the testing process via test questions on the companion website

Book Features

To help you customize your study time using this book, the core chapters have several features that help you make the best use of your time:

- “Do I Know This Already?” quiz: Each chapter begins with a quiz that helps you determine how much time you need to spend studying that chapter.
- Foundation Topics: These are the core sections of each chapter. They explain the concepts for the topics in that chapter.
- Exam Preparation Tasks: After the “Foundation Topics” section of each chapter, the “Exam Preparation Tasks” section lists a series of study activities that you should do at the end of the chapter. Each chapter includes the activities that make the most sense for studying the topics in that chapter.
- Review All the Key Topics: The Key Topic icon appears next to the most important items in the “Foundation Topics” section of the chapter. The Review All the Key Topics activity lists the key topics from the chapter, along with their page numbers. Although the contents of the entire chapter could be on the exam, you should definitely know the information listed in each key topic, so you should be sure to review these.
Complete the Tables and Lists from Memory: To help you memorize some lists of facts, many of the most important lists and tables from the chapter are included in a document on the companion website. This document lists only partial information, allowing you to complete the table or list.

Define Key Terms: Although the exam may be unlikely to ask a question such as “How do you define the term x?” the 70-740 exam does require that you learn and know a lot of networking terminology. This section lists the most important terms from the chapter, asking you to write a short definition and compare your answer against the glossary at the end of the book.

Q&A: This section helps you confirm that you understand the content that you just covered.

Web-based practice exam: The companion website includes the Pearson Test Prep practice test software, which allows you to take practice exam questions. Use them to prepare with a sample exam and to pinpoint topics for which you need more study.

How This Book Is Organized

This book contains 20 core chapters:

Chapter 1, “Installing, Upgrading, and Migrating,” covers installation requirements and methods as well as upgrade scenarios and migration approaches.

Chapter 2, “Installing and Configuring Nano,” covers how to determine appropriate usage scenarios and requirements for Nano Server as well as how to install Nano Server, including the implementation of roles and features on Nano Server. The chapter also covers the management and configuration of Nano Server, including the use of Windows PowerShell.

Chapter 3, “Working with Images,” covers the important planning and implementation steps involved in virtualization.

Chapter 4, “Disks and Volumes,” covers basic and advanced disk and volume creation and management, including the use of NFS and SMB shares for a network.

Chapter 5, “Server Storage,” covers more advanced storage topics such as storage pools and Storage Area Network (SAN)–related topics.

Chapter 6, “Data Deduplication,” covers implementation of data deduplication.

Chapter 7, “Installing Hyper-V,” covers requirements for Hyper-V as well as its implementation and management.

Chapter 8, “Working with Virtual Machines,” covers advanced topics in VM creation and management.
Introduction

Chapter 9, “Hyper-V Storage,” covers the ins and outs of VHDs and VHDX files.

Chapter 10, “Hyper-V Networking,” covers networking concepts from virtual NICs to RDMA.

Chapter 11, “Deploying Containers,” covers container basics and their creation.

Chapter 12, “Managing Containers,” covers container management, including the use of Docker in the Windows Server 2016 environment.

Chapter 13, “High Availability in Hyper-V,” covers important high-availability topics such as Hyper-V Replica, live migration, and shared-nothing live migration.

Chapter 14, “Failover Clustering,” covers the creation of various Failover Clustering models that are possible in Windows Server 2016.

Chapter 15, “Managing Failover Clustering,” moves deeper into the subject of failover cluster management, including advanced topics such as VM monitoring and node fairness.


Chapter 17, “Managing VM Movement,” includes features such as Live Migration; Quick Migration; Storage Migration; importing, exporting, and copying; and VM Network Health Protection, and Drain on Shutdown.


Companion Website

Register this book to get access to the Pearson Test Prep practice test software and other study materials plus additional bonus content. Check this site regularly for new and updated postings written by the author that provide further insight into the most troublesome topics on the exam. Be sure to check the box indicating that you would like to hear from us to receive updates and exclusive discounts on future editions of this product or related products.

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Please note that many of our companion content files can be very large, especially image and video files.

**Pearson Test Prep Practice Test Software**

As noted previously, this book comes complete with the Pearson Test Prep practice test software, containing two full exams. These practice tests are available to you either online or as an offline Windows application. To access the practice exams that were developed with this book, please see the instructions in the card inserted in the sleeve in the back of the book. This card includes a unique access code that enables you to activate your exams in the Pearson Test Prep software.

**Accessing the Pearson Test Prep Software Online**

The online version of this software can be used on any device that has a browser and connectivity to the Internet, including desktop machines, tablets, and smartphones. To start using your practice exams online, simply follow these steps:

2. Select Pearson IT Certification as your product group.
3. Enter your email/password for your account. If you don’t have an account on PearsonITCertification.com or CiscoPress.com, you need to establish one by going to PearsonITCertification.com/join.
4. In the My Products tab, click the Activate New Product button.
5. Enter the access code printed on the insert card in the back of your book to activate your product.
6. The product is now listed in your My Products page. Click the Exams button to launch the exam settings screen and start your exam.
Accessing the Pearson Test Prep Software Offline

If you wish to study offline, you can download and install the Windows version of the Pearson Test Prep software. There is a download link for this software on the book’s companion website, or you can just enter this link in your browser: www.pearsonitcertification.com/content/downloads/pcpt/engine.zip.

To access the book’s companion website and the software, simply follow these steps:

2. Respond to the challenge questions.
3. Go to your account page and select the Registered Products tab.
4. Click the Access Bonus Content link under the product listing.
5. Click the Install Pearson Test Prep Desktop Version link under the Practice Exams section of the page to download the software.
6. When the software finishes downloading, unzip all the files on your computer.
7. Double-click the application file to start the installation and follow the onscreen instructions to complete the registration.
8. When the installation is complete, launch the application and click the Activate Exam button on the My Products tab.
9. Click the Activate a Product button in the Activate Product Wizard.
10. Enter the unique access code found on the card in the sleeve in the back of your book and click the Activate button.
11. Click Next and then click Finish to download the exam data to your application.
12. You can now start using the practice exams by selecting the product and clicking the Open Exam button to open the exam settings screen.

Note that the offline and online versions sync together, so saved exams and grade results recorded on one version are available to you on the other as well.

Customizing Your Exams

Once you are in the exam settings screen, you can choose to take exams in one of three modes:

- **Study mode:** Study mode allows you to fully customize your exams and review answers as you are taking the exam. This is typically the mode you use first to assess your knowledge and identify information gaps.
■ **Practice Exam mode:** Practice Exam mode locks certain customization options in order to present a realistic exam experience. Use this mode when you are preparing to test your exam readiness.

■ **Flash Card mode:** Flash Card mode strips out the answers and presents you with only the question stem. This mode is great for late-stage preparation, when you really want to challenge yourself to provide answers without the benefit of seeing multiple-choice options. This mode does not provide the detailed score reports that the other two modes provide, so you should not use it if you are trying to identify knowledge gaps.

In addition to these three modes, you can select the source of your questions. You can choose to take exams that cover all the chapters, or you can narrow your selection to just a single chapter or the chapters that make up specific parts in the book. All chapters are selected by default. If you want to narrow your focus to individual chapters, simply deselect all the chapters and then select only those on which you wish to focus in the Objectives area.

You can also select the exam banks on which to focus. Each exam bank comes complete with a full exam of questions that cover topics in every chapter. The two exams printed in the book are available to you, along with two additional exams of unique questions. You can have the test engine serve up exams from all four banks or just from one individual bank by selecting the desired banks in the exam bank area.

There are several other customizations you can make to your exam from the exam settings screen, such as the time of the exam, the number of questions served up, whether to randomize questions and answers, whether to show the number of correct answers for multiple-answer questions, and whether to serve up only specific types of questions. You can also create custom test banks by selecting only questions that you have marked or questions on which you have added notes.

### Updating Exams

If you are using the online version of the Pearson Test Prep software, you should always have access to the latest version of the software as well as the exam data. If you are using the Windows desktop version, every time you launch the software, it will check to see if there are any updates to your exam data and automatically download any changes made since the last time you used the software. This happens only if you are connected to the Internet at the time you launch the software.

Sometimes, due to many factors, the exam data may not fully download when you activate your exam. If you find that figures or exhibits are missing, you may need to manually update your exams.

To update a particular exam you have already activated and downloaded, simply select the **Tools** tab and click the **Update Products** button. Again, this is only an issue with the desktop Windows application.
To check for updates to the Pearson Test Prep exam engine software, Windows desktop version, simply select the **Tools** tab and click the **Update Application** button. This way, you can ensure that you are running the latest version of the software engine.
This chapter covers the following subjects:

- **Storage Spaces:** Windows Server 2016 makes it simple to combine multiple physical disks into whatever logical storage scheme you might need. The industry term for this is storage virtualization. Of course, this section details this technology for you.

- **Storage Area Networks:** Windows Server 2016 can integrate very well with Fibre Channel and related Storage Area Network (SAN) technologies. This part of the chapter covers topics like the creation of iSCSI targets and initiators as well as advanced topics like DCB and MPIO.

- **Storage Replica:** A great new feature of Windows Server 2016 is the replication of data between storage locations. This section describes the various options available, and when they are right for your design.
Server Storage

Microsoft offers many rich storage features in Windows Server 2016. This chapter covers some of the most important ones, including Storage Spaces, Storage Area Network (SAN) features, and Storage Replica capabilities.

“Do I Know This Already?” Quiz

The “Do I Know This Already?” quiz allows you to assess whether you should read the entire chapter. Table 5-1 lists the major headings in this chapter and the “Do I Know This Already?” quiz questions covering the material in those headings so you can assess your knowledge of these specific areas. The answers to the “Do I Know This Already?” quiz appear in Appendix A, “Answers to the ‘Do I Know This Already?’ Quizzes and Q&A Questions.”

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<tr>
<td>Storage Area Networks</td>
<td>3, 4</td>
</tr>
<tr>
<td>Storage Replica</td>
<td>5, 6</td>
</tr>
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</table>

CAUTION  The goal of self-assessment is to gauge your mastery of the topics in this chapter. If you do not know the answer to a question or are only partially sure of the answer, you should mark your answer as incorrect for purposes of the self-assessment. Giving yourself credit for an answer you correctly guess skews your self-assessment results and might provide you with a false sense of security.
1. What Storage Spaces layout choice is similar to RAID 5?
   a. Simple
   b. Three-way mirror
   c. Parity
   d. Two-way mirror

2. How many disks are needed for three-way mirroring?
   a. Two
   b. Three
   c. Four
   d. Five

3. What SAN technology is critical for lossless connectivity in a converged network?
   a. iSNS
   b. DCB
   c. MPIO
   d. MCS

4. What SAN technology is critical for resiliency for the connectivity of iSCSI targets?
   a. DCB
   b. iSNS
   c. MPIO
   d. FC

5. In what scenarios could Storage Replica be critical? Choose two.
   a. File Server
   b. SYSVOL
   c. SQL Server
   d. Microsoft Exchange

6. What PowerShell cmdlet do you use to configure Storage Replica?
   a. New-Replica
   b. New-SRPartnership
   c. New-SReplica
   d. New-SReplicaPeer
Foundation Topics

Storage Spaces

Storage Spaces offers a nice alternative to a potentially expensive and complex Storage Area Network (SAN). Storage Spaces allows you to use multiple physical disks attached to a Windows Server 2016 system and present them to users in a flexible manner. For example, you can pool together physical disks with Storage Spaces and present them to users as one large logical disk.

NOTE The Datacenter Edition of Windows Server 2016 offers a new feature called Storage Spaces Direct. This feature can use local, unshared storage to create highly available storage for hosting virtual machine files. Chapter 16, “Storage Spaces Direct,” discusses this feature.

Configuring Storage Pools and Storage Spaces

Storage Spaces storage virtualization technology in Windows Server 2016 consists of two components:

- **Storage Pools**: A collection of physical disks presented as logical disks (for example, one large logical disk).

- **Storage Spaces**: Virtual disks created from free space in a Storage Pool. These virtual disks are like LUNs (logical unit numbers) in a Storage Area Network (SAN) environment.

Storage management is extremely flexible and offers many options, including the following:

- The Windows Storage Management API (Application Programming Interface) in Windows Management Instrumentation (WMI)
- PowerShell
- The File and Storage Services role in Server Manager

You can format your Storage Spaces virtual disk as either of the following:

- NTFS
- ReFS
Remember, as discussed in Chapter 4, “Disks and Volumes,” that various needs often dictate your choice of formatting. For example, data deduplication needs NTFS as the file system technology.

To configure Storage Spaces, you need to consider the following:

- **Disk-sector size**: If you can use only 512 and/or 512e drives, your pool defaults to 512e; remember that the 512e disks use 4096-byte sectors that emulate 512-byte sectors. If there is one or more 4K drives, the pool defaults to 4K. You can define the sector size for Storage Spaces, but remember that it forces you into the type of disks that you can add.

- **Drive allocation**: This dictates how a pool distributes drives; options include automatic by the OS (the default), manual, or hot spare.

- **Provisioning scheme**: Options are thin provisioned or fixed provisioning space.

### Implementing Simple, Mirror, and Parity Storage Layout Options for Disks or Enclosures

Storage layout is obviously a critical choice for Storage Spaces. Valid options include the following:

- **Simple**: Simple features striping but no parity for resiliency; remember that striping means segments of data are written across multiple physical disks. Why would you choose Simple? The answer lies in performance improvements.

- **Two-way and three-way mirrors**: These spaces support two- or three-way copies of the data they host; note that mirror spaces also stripe data across multiple physical disks.

- **Parity**: This Storage Spaces technology is like RAID 5: Data is striped, along with parity information, across multiple physical drives; the parity information permits resiliency.

**NOTE** You can use Storage Spaces with Failover Clustering, as described in Chapter 14, “Failover Clustering.”

It is critical to remember these rules regarding the physical disks of your Storage Spaces configuration:

- To create a storage pool, you need at least one physical disk.

- If you want to create a resilient mirror virtual disk, you need a minimum of two physical disks.
To create a resilient virtual disk with parity, you need a minimum of three physical disks.

- For three-way mirroring resiliency, you need at least five physical disks.
- Your disks must be blank and unformatted, with no volumes on any disk.
- Failover Clustering cannot use SATA, USB, or SCSI disks.

Follow these steps to configure the Storage Spaces functionality in various configurations:

**Step 1.** In Server Manager, select **File and Storage Services** and then **Storage Pools**, as shown in Figure 5-1.

**Figure 5-1** Configuring a New Storage Pool

- **Step 2.** Create a new Storage Pool by using the Tasks drop-down menu.
- **Step 3.** Provide values for **Storage Pool Name** and **Available Disk Group**, and choose **Physical Disks** for the pool.
Step 4. Create a new virtual disk and specify the following values:
- Storage Pool
- Virtual Disk Name
- Enclosure Awareness
- Storage Layout
- Resiliency Settings
- Provisioning Type
- Size of the Virtual Disk

Step 5. When the virtual disk is created, select Create a volume when this wizard closes.

Step 6. In the New Volume Wizard, complete the following:
- Virtual Disk
- Volume Size
- Drive Letter
- File System
- Volume Label

Expanding Storage Pools

Expanding a Storage Pool is simple. Follow these steps:

Step 1. Add a new virtual disk by navigating to iSCSI in Server Manager.

Step 2. Create a new iSCSI virtual disk by specifying the following values:
- Storage location
- Disk name
- Size
- ISCSI target

Step 3. In Server Manager, click the Refresh button and wait for all the panes to refresh.

Step 4. In the STORAGE POOLS pane, right-click your Storage Pool and then add the new physical disk to the Storage Pool.

Step 5. In the VIRTUAL DISKS pane, right-click Mirrored vDisk and then extend your virtual disk to the desired size.
Configuring Tiered Storage

Tiered Storage Spaces is an exciting feature in Windows Server 2016. It allows you to mix the types of disks you use in a Storage Space and use them efficiently. For example, you might use slow, large mechanical disks in conjunction with small, fast SSD (solid state drive) disks. Windows Server can dynamically move data based on the frequency of access.

When you add HDDs and SSDs to a Storage Space, Windows Server 2016 registers each type of disk and automatically creates two tiers. By default, each night at 1 a.m., optimization of the disks can occur.

To manually run the optimization, use the following PowerShell command:

```
Get-ScheduledTask -TaskName "Storage Tiers Optimization" | Start-ScheduledTask
```

You can pin files to certain tiers by using the PowerShell cmdlet `Set-FileStorageTier`. Here is the complete syntax for this cmdlet:

```
Set-FileStorageTier -DesiredStorageTierFriendlyName <String> -FilePath <String> [-CimSession <CimSession[]>] [-ThrottleLimit <Int32>] [-Confirm] [-WhatIf] [ <CommonParameters>] [<WorkflowParameters>]
```

Storage Area Networks

Storage Area Network (SAN) technologies now integrate with Windows Server 2016 more seamlessly than ever before. The sections that follow detail this integration.

Configuring iSCSI Target and Initiator

iSCSI storage provides an inexpensive and simple way to configure a connection to remote disks. An iSCSI SAN implementation typically includes the following:

- **An IP network**: IP is the glue holding the various parts of the datacenter together
- **iSCSI targets**: iSCSI targets advertise storage, just like controllers for hard disk drives of locally attached storage.
- **iSCSI initiators**: iSCSI targets display storage to the iSCSI initiator.
- **iSCSI qualified name (IQN)**: IQNs are unique identifiers that iSCSI uses to address initiators and targets on an iSCSI network.
The iSCSI Target Server role service supports a software-based and hardware-independent iSCSI disk subsystem. You can use the iSCSI Target Server to create iSCSI targets and iSCSI virtual disks, and then you can use Server Manager to manage your iSCSI targets and virtual disks. In Windows Server 2016, the iSCSI Target Server is available as a role service under the File and Storage Services role in Server Manager.

The following Windows PowerShell cmdlets exist for managing the iSCSI Target Server:

- **Install-WindowsFeature** `FS-iSCSITarget-Server`
- **New-IscsiVirtualDisk**
  ```powershell
  ```
- **New-IscsiServerTarget**
  ```powershell
  [-TargetName] <String> [-ClusterGroupName] [-ComputerName <String>] [-Credential <PSCredential>] [-InitiatorIds <InitiatorId>][] [ <CommonParameters>] 
  ```
- **Add-IscsiVirtualDiskTargetMapping**
  ```powershell
  [-TargetName] <String> [-Path] <String> [-ComputerName <String>] [-Credential <PSCredential>] [ <CommonParameters>] 
  ```

Windows Server 2016 installs the iSCSI initiator by default. To connect your computer to an iSCSI target, you only need to start the service and configure it. The following Windows PowerShell cmdlets allow management of the iSCSI initiator:

- **Start-Service** `msiscsi`
- **Set-Service** `msiscsi` -StartupType "Automatic"
- **New-IscsiTargetPortal**
  ```powershell
  ```
- **Connect-IscsiTarget**
  ```powershell
Configuring iSNS

You use the Internet Storage Name Service (iSNS) protocol for interaction between iSNS servers and iSNS clients. iSNS clients are initiators that are trying to discover targets on an Ethernet network. iSNS eases automated discovery, management, and configuration of iSCSI and Fibre Channel devices (using iFCP gateways) on a TCP/IP network.

**NOTE**  Windows Server 2016 only supports the discovery of iSCSI devices, not Fibre Channel devices.

Adding iSNS simply installs as a feature in Server 2016, as shown in Figure 5-2.

![Figure 5-2 Installing the iSNS Feature](image-url)
Configuring Datacenter Bridging (DCB)

Data Center Bridging (DCB) is a suite of Institute of Electrical and Electronics Engineers (IEEE) standards that enables Converged Fabrics in the data center. This is an environment where storage, data networking, cluster IPC, and management traffic all share the same Ethernet network infrastructure.

DCB offers hardware-based bandwidth allocation to a specific type of traffic and enhances Ethernet transport reliability with the use of priority-based flow control. Hardware-based bandwidth allocation is essential if traffic bypasses the operating system and offloads to a converged network adapter. This adapter might support Internet Small Computer System Interface (iSCSI), Remote Direct Memory Access (RDMA) over Converged Ethernet, or Fiber Channel over Ethernet (FCoE). Priority-based flow control is essential if the upper-layer protocol, such as Fiber Channel, assumes a lossless underlying transport.

You install DCB as a feature in a Windows Server 2016 system as shown in Figure 5-3.

![Figure 5-3 Installing DCB](image)
Configuring Multipath IO (MPIO)

Creating a single connection to iSCSI storage makes that storage available. There is an issue, however, because this configuration does not make the storage highly available. If iSCSI loses the connection, the server loses access to its storage. Therefore, you should make most iSCSI storage connections redundant through one of two high-availability technologies—Multiple Connected Session (MCS) and Multipath I/O (MPIO).

MCS is an iSCSI protocol feature that does the following:

- Enables multiple TCP/IP connections from the initiator to the target for the same iSCSI session
- Supports automatic failover
- Needs explicit support by iSCSI SAN devices

MPIO offers redundancy in a different fashion:

- If you have multiple network interface cards in an iSCSI initiator and iSCSI Target Server, you can use MPIO to provide failover redundancy during network outages.
- MPIO needs a device-specific module (DSM) if you want to connect to a third-party SAN device connected to the iSCSI initiator.
- MPIO is widely supported.
- MPIO is more complex to configure and is not as fully automated during failover as MCS.

**NOTE** Our exam blueprint requires knowledge of the MPIO approach to SAN redundancy. This text presents MCS here for the sake of completeness.

You install MPIO in the Add Roles and Features Wizard, as shown in Figure 5-4.
Figure 5-4  Installing MPIO

You can then carry out MPIO policy in the Properties dialog of your storage device (see Figure 5-5).

Figure 5-5  Configuring MPIO Policy
Storage Replica

Another exciting new data storage feature in Windows Server 2016 is Storage Replica. This technology permits storage and agnostic data replication between clusters or servers.

Remember these key points about Storage Replica:

- Synchronous and asynchronous replication choices exist; as the administrator, you can choose based on network latency and geographic distances.
- Storage Replica requires GPT initialized disks.
- Supported replication scenarios include Server-to-Server, Cluster-to-Cluster, and Stretch Cluster.
- Only one-to-one replication is supported; a third replica is not an option.
- Storage Replica performs replication at the block level, and therefore you should not consider it for branch office scenarios with slow WAN links.
- Storage Replica can replicate data involving open files.

Determining Usage Scenarios for Storage Replica

While Storage Replica is not application specific, you should note that some replication technologies are better suited for some implementations. Table 5-2 shows appropriate usage scenarios for the Storage Replica feature. Note that this table also helps you determine the appropriate application-specific replication technology.

Table 5-2  Determining Usage Scenarios for Storage Replica

<table>
<thead>
<tr>
<th>Feature</th>
<th>Virtual Machine</th>
<th>SYSVOL</th>
<th>File Server</th>
<th>Microsoft Exchange</th>
<th>SQL Server</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyper-V Replica</td>
<td>Yes</td>
<td>Not applicable</td>
<td>Yes (VMs)</td>
<td>No</td>
<td>Yes (VMs)</td>
</tr>
<tr>
<td>Storage Replica</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>SQL Server AlwaysOn Failover Cluster Instance</td>
<td>No</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Yes</td>
</tr>
<tr>
<td>SQL Server AlwaysOn Availability Groups</td>
<td>No</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Yes</td>
</tr>
<tr>
<td>Microsoft Exchange Database Availability Groups</td>
<td>No</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Yes</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Distributed File System Replication</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Implementing Storage Replica for Server-to-Server, Cluster-to-Cluster, and Stretch Cluster Scenarios

As described earlier in this section, there are three scenarios available with Storage Replica:

- Server-to-Server
- Cluster-to-Cluster
- Stretch Cluster

Server-to-Server

You use PowerShell to implement Server-to-Server replication, which involves the following requirements:

- The servers must be participants in a domain.
- Each storage set must have two volumes—one for data and one for logs. The two data volumes must be the same size, and their sector size must also be the same.
- Each file server needs at least a 1 GB connection.
- You need 4 GB of RAM in each server with at least two CPU cores.
- Firewalls must allow ICMP, SMB, and WS-MAN bidirectional traffic.
- You need a network between servers of at least 1 Gbps and 5 ms round-trip latency.
- Both server nodes must have local admin permissions.

Here is sample syntax for a PowerShell configuration:

```
New-SRPartnership -SourceComputerName SVR1 -SourceRGName RepGroup01
-SourceVolumeName F: -SourceLogVolumeName G:
-DestinationComputerName SVR2
-DestinationRGName RepGroup02
-DestinationVolumeName F: -DestinationLogVolumeName G:
-LogSizeInBytes 8GB
```

Here is the complete cmdlet syntax:

```
```
Cluster-to-Cluster

You use PowerShell to implement Cluster-to-Cluster replication. The requirements for Cluster-to-Cluster replication are identical to those for Server-to-Server.

Here are the steps for PowerShell Cluster-to-Cluster configuration:

**Step 1.** Grant the first cluster full access to the other cluster by running the `Grant-ClusterAccess` cmdlet on any node in the first cluster or remotely:

```
Grant-SRAccess -ComputerName SRV01 -Cluster SRVCLUSB
```

**Step 2.** Grant the second cluster full access to the other cluster by running the `Grant-ClusterAccess` cmdlet on any node in the second cluster or remotely:

```
Grant-SRAccess -ComputerName SRV03 -Cluster SRVCLUSA
```

**Step 3.** Configure the Cluster-to-Cluster replication, specifying the source and destination disks, the source and destination logs, the source and destination cluster names, and the log size. You can perform this command locally on the server or using a remote management computer:

```
New-SRPartnership -SourceComputerName SRVCLUSA -SourceRGName rg01
-SourceVolumeName c:\ClusterStorage\Volume2
-SourceLogVolumeName f: -DestinationComputerName SRVCLUSB
-DestinationRGName rg02 -DestinationVolumeName c:\ClusterStorage\Volume2
-DestinationLogVolumeName f:
```

Stretch Cluster

Stretch Cluster is a configuration that features one Hyper-V cluster with nodes in two locations and storage in both locations. It allows failover of virtual machines from one cluster to the other. Requirements are identical to those for Server-to-Server and Cluster-to-Cluster.

You configure Stretch Cluster using Failover Cluster Manager or Windows PowerShell. To use the Failover Cluster Manager, follow these steps:

**Step 1.** Add a source data disk to a role or CSV.

**Step 2.** Enable replication on that source data disk.

**Step 3.** Select a destination data disk.

**Step 4.** Select a source log disk.

**Step 5.** Select a destination log disk.
To use PowerShell, follow these steps:

**Step 1.** Add the source data storage only to the cluster as CSV. To get the size, partition, and volume layout of the available disks, use the following commands:

```
Move-ClusterGroup -Name "available storage" -Node sr-srv01

$DiskResources = Get-ClusterResource | Where-Object { $_.ResourceType -eq 'Physical Disk' -and $_.State -eq 'Online' }
$DiskResources | foreach { $resource = $_;
    $DiskGuidValue = $resource | Get-ClusterParameter DiskIdGuid
    Get-Disk | where { $_.Guid -eq $DiskGuidValue.Value } | Get-Partition | Get-Volume |
    Select @{N="Name"; E={$resource.Name}}, @{N="Status"; E={$resource.State}}, DriveLetter, FileSystemLabel, Size, SizeRemaining
} | ft -AutoSize

Move-ClusterGroup -Name "available storage" -Node sr-srv03

$DiskResources = Get-ClusterResource | Where-Object { $_.ResourceType -eq 'Physical Disk' -and $_.State -eq 'Online' }
$DiskResources | foreach { $resource = $_;
    $DiskGuidValue = $resource | Get-ClusterParameter DiskIdGuid
    Get-Disk | where { $_.Guid -eq $DiskGuidValue.Value } | Get-Partition | Get-Volume |
    Select @{N="Name"; E={$resource.Name}}, @{N="Status"; E={$resource.State}}, DriveLetter, FileSystemLabel, Size, SizeRemaining
} | ft -AutoSize
```

**Step 2.** Set the correct disk to CSV:

```
Add-ClusterSharedVolume -Name "Cluster Disk 4"
Get-ClusterSharedVolume
Move-ClusterSharedVolume -Name "Cluster Disk 4" -Node sr-srv01
```

**Step 3.** Configure the Stretch Cluster, as in this example:

```
New-SRPartnership -SourceComputerName sr-srv01
    -SourceRGName rg01 -SourceVolumeName "C:\ClusterStorage\Volume1" -SourceLogVolumeName e: -DestinationComputerName sr-srv03 -DestinationRGName rg02 -DestinationVolumeName d: -DestinationLogVolumeName e:
```
Exam Preparation Tasks

As mentioned in the section “How to Use This Book” in the Introduction, you have a couple choices for exam preparation: the exercises here, Chapter 21, “Final Preparation,” and the exam simulation questions in the Pearson Test Prep Software Online.

Review All Key Topics

Review the most important topics in this chapter, noted with the Key Topics icon in the outer margin of the page. Table 5-3 lists these key topics and the page number on which each is found.

Table 5-3  Key Topics for Chapter 5

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<th>Key Topic Element</th>
<th>Description</th>
<th>Page Number</th>
</tr>
</thead>
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</tr>
<tr>
<td>Steps</td>
<td>Storage Pool expansion</td>
<td>88</td>
</tr>
<tr>
<td>Command</td>
<td>Manually optimizing tiered storage</td>
<td>89</td>
</tr>
<tr>
<td>List</td>
<td>PowerShell cmdlets for iSCSI targets</td>
<td>90</td>
</tr>
<tr>
<td>List</td>
<td>Storage Replica key points</td>
<td>95</td>
</tr>
</tbody>
</table>

Complete Tables and Lists from Memory

Print a copy of Appendix B, “Memory Tables” (found on the book website), or at least the section for this chapter, and complete the tables and lists from memory. Appendix C, “Memory Tables Answer Key,” also on the website, includes completed tables and lists you can use to check your work.

Define Key Terms

Define the following key terms from this chapter and check your answers against the glossary:

- Storage Spaces
- Storage Pool
- Tiered Storage
- iSCSI Target
- iSCSI Initiator
- iSNS
- DCB
- MPIO
- Storage Replica
Q&A

The answers to these questions appear in Appendix A. For more practice with exam format questions, use the Pearson Test Prep Software Online.

1. What two tiers of disk types are used with tiering inside Storage Spaces?
2. What PowerShell command can you use to connect an iSCSI target in a Windows Server 2016 environment?
3. What type of partition system does Storage Replica require on disks? What edition of Windows Server 2016 does it require?
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