



# Microsoft Azure Security Technologies

Exam Ref AZ-500

Yuri Diogenes  
Orin Thomas

FREE SAMPLE CHAPTER

SHARE WITH OTHERS



# Exam Ref AZ-500

## Microsoft Azure Security Technologies

Yuri Diogenes  
Orin Thomas

# Exam Ref AZ-500 Microsoft Azure Security Technologies

Published with the authorization of Microsoft Corporation by  
Pearson Education, Inc.  
Hoboken, NJ

Copyright © 2021 by Yuri Diogenes and Orin Thomas

All rights reserved. This publication is protected by copyright, and permission must be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. For information regarding permissions, request forms, and the appropriate contacts within the Pearson Education Global Rights & Permissions Department, please visit [www.pearson.com/permissions](http://www.pearson.com/permissions). No patent liability is assumed with respect to the use of the information contained herein. Although every precaution has been taken in the preparation of this book, the publisher and author assume no responsibility for errors or omissions. Nor is any liability assumed for damages resulting from the use of the information contained herein.

ISBN-13: 978-013-678893-5

ISBN-10: 0-136-78893-9

Library of Congress Control Number: 2020948249

ScoutAutomatedPrintCode

## TRADEMARKS

Microsoft and the trademarks listed at <http://www.microsoft.com> on the "Trademarks" webpage are trademarks of the Microsoft group of companies. All other marks are property of their respective owners.

## WARNING AND DISCLAIMER

Every effort has been made to make this book as complete and as accurate as possible, but no warranty or fitness is implied. The information provided is on an "as is" basis. The author, the publisher, and Microsoft Corporation shall have neither liability nor responsibility to any person or entity with respect to any loss or damages arising from the information contained in this book.

## SPECIAL SALES

For information about buying this title in bulk quantities, or for special sales opportunities (which may include electronic versions; custom cover designs; and content particular to your business, training goals, marketing focus, or branding interests), please contact our corporate sales department at [corpsales@pearsoned.com](mailto:corpsales@pearsoned.com) or (800) 382-3419.

For government sales inquiries, please contact [governmentsales@pearsoned.com](mailto:governmentsales@pearsoned.com).

For questions about sales outside the U.S., please contact [intlcs@pearson.com](mailto:intlcs@pearson.com).

## CREDITS

### EDITOR-IN-CHIEF

Brett Bartow

### EXECUTIVE EDITOR

Loretta Yates

### ASSISTANT SPONSORING EDITOR

Charvi Arora

### DEVELOPMENT EDITOR

Rick Kughen

### MANAGING EDITOR

Sandra Schroeder

### SENIOR PROJECT EDITOR

Tracey Croom

### COPY EDITOR

Rick Kughen

### INDEXER

Cheryl Lenser

### PROOFREADER

Charlotte Kughen

### TECHNICAL EDITOR

Mike Martin

### EDITORIAL ASSISTANT

Cindy Teeters

### INTERIOR DESIGNER

Tricia Bronkella

### COVER DESIGNER

Twist Creative, Seattle

### GRAPHICS

Tammy Graham

*In memory of Chris Jackson, Chief Awesomeologist at Microsoft. Chris was passionate about security, and he was always enthusiastic when he had to speak about this topic. Chris left us way too early, but his enthusiasm, leadership, and friendship will never be forgotten. Rest in peace, friend.*



# Contents at a glance

	<i>Introduction</i>	xv
<b>CHAPTER 1</b>	<b>Manage identity and access</b>	<b>1</b>
<b>CHAPTER 2</b>	<b>Implement platform protection</b>	<b>89</b>
<b>CHAPTER 3</b>	<b>Manage security operations</b>	<b>179</b>
<b>CHAPTER 4</b>	<b>Secure data and applications</b>	<b>243</b>
	<i>Index</i>	<i>311</i>



# Contents

<b>Introduction</b>	<b>xv</b>
Organization of this book .....	xvi
Preparing for the exam .....	xvi
Microsoft certifications .....	xvi
Quick access to online references.....	xvii
Errata, updates, & book support.....	xvii
Stay in touch .....	xvii
<b>Chapter 1 Manage identity and access</b>	<b>1</b>
Skill 1.1: Manage Azure Active Directory identities .....	1
Configure security for service principals	2
Manage Azure AD directory groups	6
Manage Azure AD users	13
Configure password writeback	15
Configure authentication methods including password hash and Pass Through Authentication (PTA), OATH, and passwordless authentication	30
Transfer Azure subscriptions between Azure AD tenants	36
Skill 1.2: Configure secure access by using Azure AD .....	38
Monitor privileged access for Azure AD Privileged Identity Management (PIM)	38
Configure access reviews	40
Activate and configure PIM	43
Implement conditional access policies including multifactor authentication	46
Administer MFA users	54
Configure Azure AD Identity Protection	60
Skill 1.3: Manage application access.....	64
Create app registrations	64
Configure app registration permission scopes	70

Manage app registration permission consent	71
Manage API access to Azure subscriptions and resources	73
Skill 1.4: Manage access control . . . . .	74
Configure subscription and resource permissions	74
Configure resource group permissions	79
Identify the appropriate role	81
Apply the principle of least privilege	81
Configure custom RBAC roles	81
Interpret permissions	84
Check access	84
Thought experiment answers . . . . .	86
Chapter summary . . . . .	87
<b>Chapter 2 Implement platform protection</b>	<b>89</b>
Skill 2.1: Implement advanced network security . . . . .	89
Overview of Azure network components	89
Secure the connectivity of virtual networks	104
Configure network security groups and Application Security Groups	109
Create and configure Azure Firewall	117
Configure Azure Front Door service as an application gateway	126
Configure Web Application Firewall (WAF) on Azure Application Gateway	133
Configure Azure Bastion	135
Configure resource firewall	138
Implement service endpoint	145
Implement DDoS	147
Skill 2.2: Configure advanced security for compute . . . . .	151
Configure endpoint security within the VM	151
Configure system updates for VMs in Azure	156
Configure authentication for containers	159
Configure security for different types of containers	161
Implement vulnerability management	164
Configure isolation for AKS	166



<b>Chapter 4</b>	<b>Secure data and applications</b>	<b>243</b>
	Skill 4.1: Configure security for storage . . . . .	243
	Configure access control for storage accounts	244
	Configure key management for storage accounts	247
	Create and manage Shared Access Signatures (SAS)	251
	Create a stored access policy for a blob or blob containers	255
	Configure Azure AD authentication for Azure Storage	255
	Configure Azure AD Domain Services authentication for Azure Files	256
	Configure Storage Service Encryption	262
	Advanced Threat Protection for Azure Storage	267
	Skill 4.2: Configure security for databases . . . . .	268
	Enable database authentication	268
	Enable database auditing	270
	Configure Azure SQL Database Advanced Threat Protection	273
	Implement database encryption	276
	Implement Azure SQL Database Always Encrypted	279
	Skill 4.3: Configure and manage Key Vault . . . . .	281
	Manage access to Key Vault	282
	Key Vault firewalls and virtual networks	282
	Manage permissions to secrets, certificates, and keys	285
	Configure RBAC usage in Azure Key Vault	287
	Manage certificates	288
	Manage secrets	296
	Configure key rotation	298
	Backup and restore of Key Vault items	303
	Thought experiment answers . . . . .	308
	Chapter summary . . . . .	308
	<b>Index</b>	<b>311</b>

# About the Authors

---

**Yuri Diogenes, MsC** has a Master's of Science in cybersecurity intelligence and forensics investigation (UTICA College) and is a Principal Program Manager for the Microsoft CxE Azure Security Center Team. Primarily, Yuri helps customers onboard and deploy Azure Security Center and works with the ASC Engineering Team for continuous improvement of the product. Yuri has been working for Microsoft since 2006 in different positions, including five years as Senior Support Escalation Engineer for the CSS Forefront Edge Team, and from 2011 to 2017 as a member of the content development team, where he also helped create the Azure Security Center content experience after its launch in 2016. Yuri has published a total of 23 books, mostly about information security and Microsoft technologies. Yuri also holds an MBA and many IT/Security industry certifications, such as CISSP, E|CND, E|CEH, E|CSA, E|CHFI, CompTIA Security+, CySA+, Cloud Essentials Certified, Mobility+, Network+, CASP, CyberSec First Responder, MCSE, and MCTS. You can follow Yuri on Twitter at *@yuridiogenes*.

**Orin Thomas** is a Principal Cloud Operations Advocate at Microsoft and has written more than three dozen books for Microsoft Press on topics including Windows Server, Windows Client, Azure, Microsoft 365, Office 365, System Center, Exchange Server, Security, and SQL Server. He has authored Azure Architecture courses at Pluralsight, has authored multiple Microsoft Official Curriculum and EdX courses on a variety of IT Pro topics, and is completing a Doctorate of Information Technology on cloud computing security and compliance at Charles Sturt University. You can follow him on twitter at *@orinthomas*.

# Acknowledgments

---

The authors would like to thank Loretta Yates and the entire Microsoft Press/Pearson team for their support in this project. We would also like to thank Mike Martin (Microsoft MVP) for reviewing this book and Rick Kughen for the editorial review.

From Yuri: Thanks to my wife and daughters for their endless support; my great God for giving me strength and guiding my path on each step of the way; my friend and co-author Orin Thomas for the great partnership on this project; my manager Rebecca Halla for always encourage me to go above and beyond; and my teammates Safeena, Kerinne, Fernanda, Future, Tom, and Lior. Last but not least, thanks to my parents for working hard to give me an education, which is the foundation I use every day to keep moving forward in my career.

From Orin: Thanks to Yuri for being very supportive in this project and forgiving when life has gotten in the way of my writing schedule. I'd like to thank my son, Rooslan, for keeping his nose to the grindstone and not giving up under extraordinary conditions. I'd also like to thank the usual suspects for their support (Rick Claus, Donovan Brown, Sonia Cuff, Anthony Bartolo, Pierre Roman, Phoummala Schmitt, Sarah Lean, Thomas Maurer, and the cat that Thomas will have (or should be) buying Isidora Katanic.

# Introduction

---

The AZ-500 exam deals with advanced topics that require candidates to have an excellent working knowledge of Azure security technologies. Portions of the exam cover topics that even experienced Azure security administrators might rarely encounter unless they work with all aspects of Azure on a regular basis. To be successful in taking this exam, candidates not only need to understand how to manage Azure identity and access, they need to understand how to implement Azure platform protection, manage Azure security operations, and secure Azure data and applications. Candidates also need to be able to keep up to date with new developments in Azure security technologies, including expanded features and changes to the interface.

Candidates for this exam should have subject matter expertise with implementing security controls and threat protection; managing identity and access; and protecting data, applications, and networks in cloud and hybrid environments as part of an end-to-end infrastructure.

Responsibilities for an Azure Security Engineer include maintaining the security posture, identifying and remediating vulnerabilities by using a variety of security tools, implementing threat protection, and responding to security incident escalations. Azure Security Engineers often serve as part of a larger team dedicated to cloud-based management and security of hybrid environments as part of an end-to-end infrastructure.

A candidate for this exam should be familiar with scripting and automation and should have a deep understanding of networking and virtualization. A candidate should also have a strong familiarity with cloud capabilities, Azure products and services, and other Microsoft products and services. To pass, candidates require a thorough theoretical understanding of the technologies involved, as well as meaningful practical experience implementing the same.

This edition of this book covers Azure and the AZ-500 exam objectives as of late 2020. As Azure's security functionality evolves, so do the AZ-500 exam objectives, so you should check carefully to determine whether any changes have occurred since this edition of the book was authored, and you should study accordingly.

This book covers every major topic area found on the exam, but it does not cover every exam question. Only the Microsoft exam team has access to the exam questions, and Microsoft regularly adds new questions to the exam, making it impossible to cover specific questions. You should consider this book a supplement to your relevant real-world experience and other study materials. If you encounter a topic in this book that you do not feel completely comfortable with, use the "Need more review?" links you'll find in the text to find more information and take the time to research and study the topic. Great information is available on [docs.microsoft.com](https://docs.microsoft.com) and in blogs and forums.

## Organization of this book

---

This book is organized by the “Skills measured” list published for the exam. The “Skills measured” list is available for each exam on the Microsoft Learn website: <http://aka.ms/examlist>. Each chapter in this book corresponds to a major topic area in the list, and the technical tasks in each topic area determine a chapter’s organization. If an exam covers six major topic areas, for example, the book will contain six chapters.

## Preparing for the exam

---

Microsoft certification exams are a great way to build your resume and let the world know about your level of expertise. Certification exams validate your on-the-job experience and product knowledge. Although there is no substitute for on-the-job experience, preparation through study and hands-on practice can help you prepare for the exam. This book is *not* designed to teach you new skills.

We recommend that you augment your exam preparation plan by using a combination of available study materials and courses. For example, you might use the Exam Ref and another study guide for your “at home” preparation and take a Microsoft Official Curriculum course for the classroom experience. Choose the combination that you think works best for you. Learn more about available classroom training and find free online courses and live events at <http://microsoft.com/learn>. Microsoft Official Practice Tests are available for many exams at <http://aka.ms/practicetests>.

Note that this Exam Ref is based on publicly available information about the exam and the author’s experience. To safeguard the integrity of the exam, authors do not have access to the live exam.

## Microsoft certifications

---

Microsoft certifications distinguish you by proving your command of a broad set of skills and experience with current Microsoft products and technologies. The exams and corresponding certifications are developed to validate your mastery of critical competencies as you design and develop, or implement and support, solutions with Microsoft products and technologies both on-premises and in the cloud. Certification brings a variety of benefits to the individual and to employers and organizations.

### **MORE INFO ALL MICROSOFT CERTIFICATIONS**

For information about Microsoft certifications, including a full list of available certifications, go to <http://www.microsoft.com/learn>.

## Quick access to online references

---

Throughout this book are addresses to webpages that the author has recommended you visit for more information. Some of these links can be very long and painstaking to type, so we've shortened them for you to make them easier to visit. We've also compiled them into a single list that readers of the print edition can refer to while they read.

Download the list at *MicrosoftPressStore.com/ExamRefAZ500/downloads*

The URLs are organized by chapter and heading. Every time you come across a URL in the book, find the hyperlink in the list to go directly to the webpage.

## Errata, updates, & book support

---

We've made every effort to ensure the accuracy of this book and its companion content. You can access updates to this book—in the form of a list of submitted errata and their related corrections—at

*MicrosoftPressStore.com/ExamRefAZ500/errata*

If you discover an error that is not already listed, please submit it to us at the same page.

For additional book support and information, please visit

*http://www.MicrosoftPressStore.com/Support*

Please note that product support for Microsoft software and hardware is not offered through the previous addresses. For help with Microsoft software or hardware, go to

*http://support.microsoft.com*

## Stay in touch

---

Let's keep the conversation going! We're on Twitter: *http://twitter.com/MicrosoftPress*.



# Implement platform protection

One of the main aspects of cloud computing is the shared responsibility model, where the cloud solution provider (CSP) and the customer share different levels of responsibilities, depending on the cloud service category. When it comes to platform security, Infrastructure as a Service (IaaS), customers will have a long list of responsibilities. However, in a Platform as a Service (PaaS) scenario there are still some platform security responsibilities, they are not as extensive as when using IaaS workloads.

Azure has native platform security capabilities and services that should be leveraged to provide the necessary level of security for your IaaS and PaaS workloads while maintaining a secure management layer.

### Skills in this chapter:

- Skill 2.1: Implement advanced network security
- Skill 2.2: Configure advanced security for compute

## Skill 2.1: Implement advanced network security

---

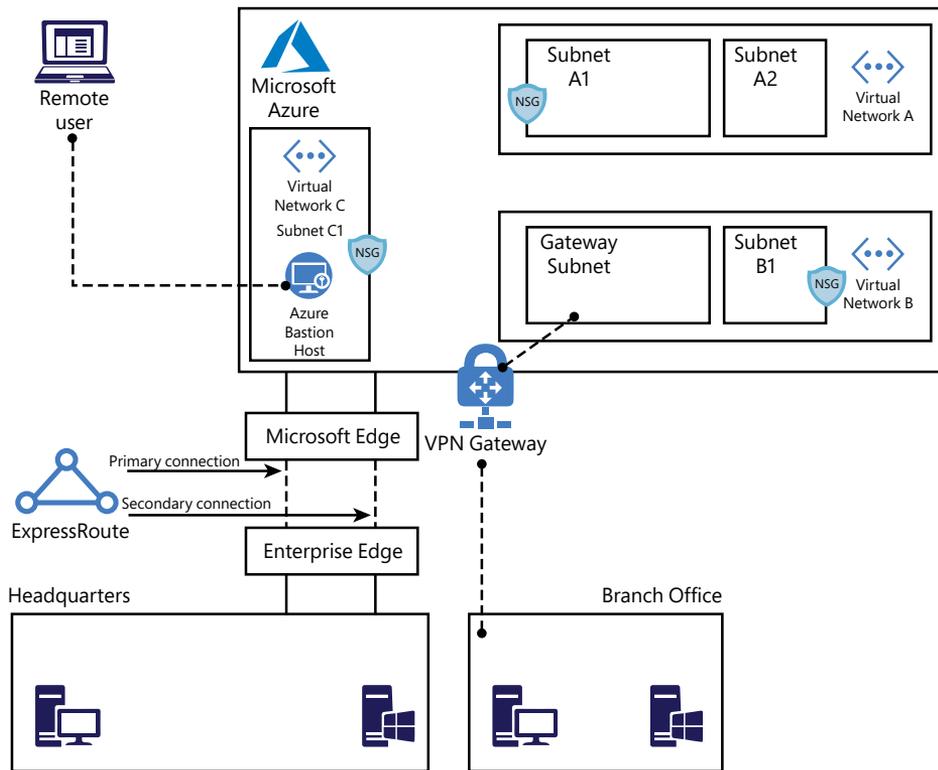
To implement an Azure network infrastructure, you need to understand the different connectivity options available in Azure. These options will enable you to implement a variety of scenarios with different requirements. This section of the chapter covers the skills necessary to implement advanced network security.

### Overview of Azure network components

Azure networking provides built-in capabilities to enable connectivity between Azure resources, connectivity from on-premises networks to Azure resources, and branch office to branch office connectivity in Azure.

While those skills are not directly called out in the AZ-500 exam outline, it is important for you to understand these concepts. If you're already comfortable with your skill level, you can skip to "Secure the connectivity of virtual networks," later in this chapter.

To better understand the different components of an Azure network, let's review Contoso's architecture diagram shown in Figure 2-1.



**FIGURE 2-1** Contoso network diagram

In Figure 2-1, you can see Azure infrastructure (on top), with three virtual networks. Contoso needs to segment its Azure network in different virtual networks (VNETs) to provide better isolation and security. Having VNETs in its Azure infrastructure allows Contoso to connect Azure Virtual Machines (VMs) to securely communicate with each other, the Internet, and Contoso's on-premises networks.

If you think about the traditional physical network on-premises where you operate in your own data center, that's basically what VNET is, but with its additional benefits of Azure's infrastructure, which includes scalability, availability, and isolation. When you are creating a VNET, you must specify a custom private IP address that will be used by the resources that belong to this VNET. For example, if you deploy a VM in a VNET with an address space of 10.0.0.0/24, the VM will be assigned a private IP, such as 10.0.0.10/24.

**IMPORTANT MULTIPLE VNETS AND VIRTUAL NETWORK PEERING**

An Azure VNET is scoped to a single region/location. If you need to connect multiple virtual networks from different regions, you can use Virtual Network Peering.

Notice in Figure 2-1 that there are subnets in each VNet in Contoso's network. Contoso needs to segment the virtual network into one or more subnetworks and allocate a portion of the virtual network's address space to each subnet. With this setup, Contoso can deploy Azure resources in a specific subnet, just like it used to do in its on-premises network. From an organizational and structure perspective, subnets have allowed Contoso to segment its VNet address space into smaller segments that are appropriate for its internal network. By using subnets, Contoso also was able to improve address allocation efficiency.

Another important trio of component is shown in Figure 2-1: subnets A1, B1, and C1. Each one of these subnets has a network security group (NSG) bound to it, which provides an extra layer of security based on rules that allow or deny inbound or outbound network traffic.

NSG security rules are evaluated by their priority, and each is identified with a number between 100 and 4096, where the lowest numbers are processed first. The security rules use 5-tuple information (source address, source port, destination address, destination port, and protocol) to allow or deny the traffic. When the traffic is evaluated, a flow record is created for existing connections and the communication is allowed or denied based on the connection state of the flow record. You can compare this type of configuration to the old VLAN segmentation that was often implemented with on-premises networks.

**IMPORTANT TRAFFIC INTERRUPTIONS MIGHT NOT BE INTERRUPTED**

Existing connections might not be interrupted when you remove a security rule that enabled the flow. An interruption of traffic occurs when connections are stopped, and no traffic is flowing in either direction for at least a few minutes.

Contoso is headquartered in Dallas, and it has a branch office in Sydney. Contoso needs to provide secure and seamless RDP/SSH connectivity to its virtual machines directly from the Azure portal over TLS. Contoso doesn't want to use jumpbox VMs and instead wants to allow remote access to back-end subnets through the browser. For this reason, Contoso implemented Azure Bastion, as you can see in the VNet C, subnet C1 in Figure 2-1.

Azure Bastion is a platform-managed PaaS service that can be provisioned in a VNet.

For Contoso's connectivity with Sydney's branch office, it is using a VPN gateway in Azure. A virtual network gateway in Azure is composed of two or more VMs that are deployed to a specific subnet called gateway subnet. The VMs that are part of the virtual network gateway contain routing tables and run specific gateway services. These VMs are automatically created when you create the virtual network gateway, and you don't have direct access to those VMs to make custom configurations to the operating system.

When planning your VNets, consider that each VNet may only have one virtual network gateway of each type, and the gateway type may only be VPN or ExpressRoute. Use VPN when you need to send encrypted traffic across the public Internet to your on-premises resources.



**EXAM TIP IP ADDRESS CONFIGURATION**

When taking the exam, pay extra attention to scenarios that include IP addresses for different subnets and potential connectivity issues because of incorrect IP configuration.

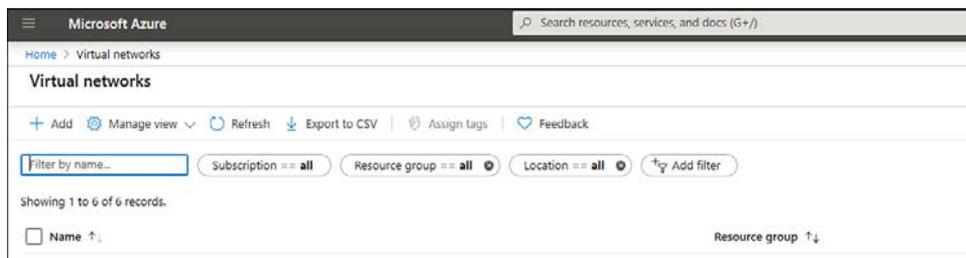
For example, let's say that Contoso needs a faster, more reliable, secure, and consistent latency to connect its Azure network to its headquarters in Dallas. Contoso decides to use ExpressRoute, as shown in Figure 2-1. ExpressRoute allows Contoso to extend its on-premises networks into the Microsoft cloud (Azure or Office 365) over a private connection because ExpressRoute does not go over the public Internet.

In Figure 2-1, notice that the ExpressRoute circuit consists of two connections, both of which are Microsoft Enterprise Edge Routers (MSEEs) at an ExpressRoute Location from the connectivity provider or your network edge. While you might choose not to deploy redundant devices or Ethernet circuits at your end, the connectivity providers use redundant devices to ensure that your connections are handed off to Microsoft in a redundant manner. This Layer 3 connectivity redundancy is a requirement for Microsoft SLA to be valid.

Network segmentation is important in many scenarios, and you need to understand the design requirements to suggest the implementation options. Let's say you want to ensure that Internet hosts cannot communicate with hosts on a back-end subnet but can communicate with hosts on the front-end subnet. In this case, you should create two VNets: one for your front-end resources and another for your back-end resources.

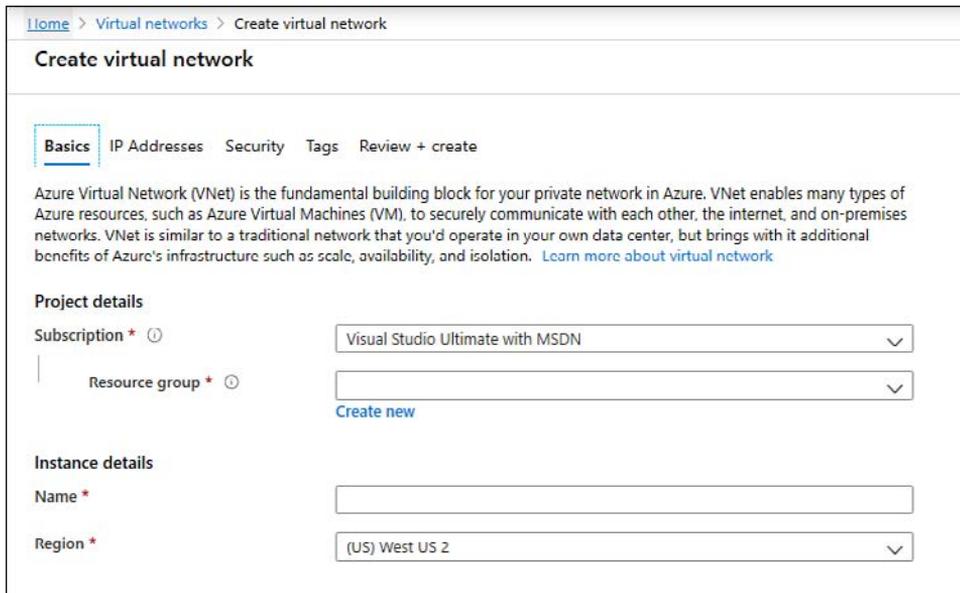
When configuring your virtual network, also take into consideration that the resources you deploy within the virtual network will inherit the capability to communicate with each other. You can also enable virtual networks to connect to each other, or you can enable resources in either virtual network to communicate with each other by using virtual network peering. When connecting virtual networks, you can choose to access other VNets that are in the same or in different Azure regions. Follow the steps below to configure your virtual network using the Azure portal:

1. Navigate to the Azure portal at <https://portal.azure.com>.
2. In the search bar type **virtual networks** and under **Services**, click **Virtual Networks**. The **Virtual Networks** page appears, as shown in Figure 2-2.



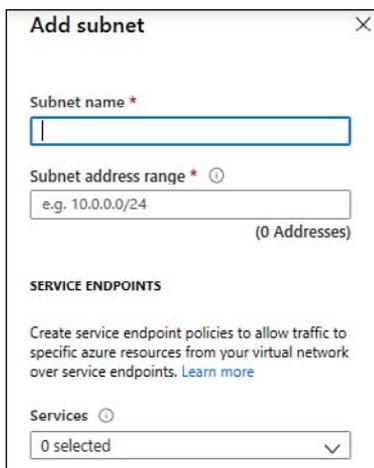
**FIGURE 2-2** Azure Virtual Networks page

3. Click the **Add** button and the **Create Virtual Network** page appears, as shown in Figure 2-3.



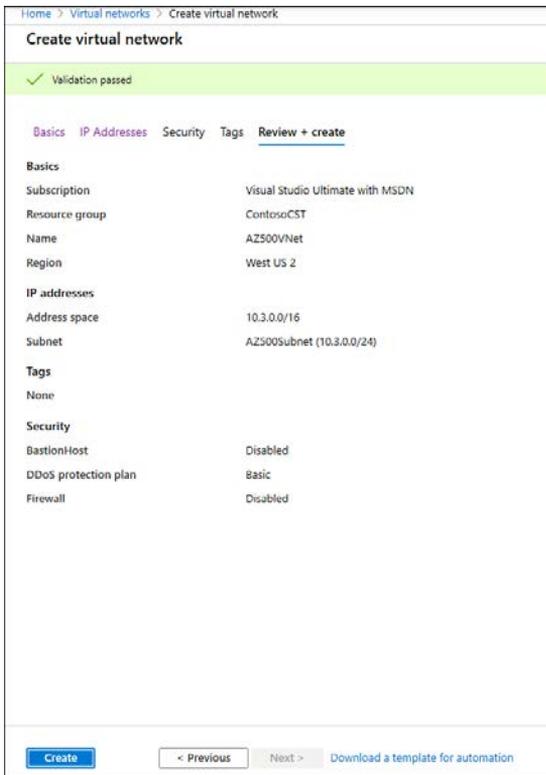
**FIGURE 2-3** The Create Virtual Network page allows you to customize your VNet deployment

4. On the **Basics** tab, select the **Subscription** for the VNet and the **Resource Group**.
5. In the **Name** field, type a comprehensive name for the VNet, and in the **Region** field, select the Azure region in which the VNet is going to reside. Finally, click the **IP Addresses** tab.
6. On the **IP Addresses** page, in the **IPv4** field, type the address space in classless inter-domain routing (CIDR) format; for example, you could enter **10.3.0.0/16**.
7. Click the **Add Subnet** button. The **Add Subnet** blade appears, as shown in Figure 2-4.



**FIGURE 2-4** Add Subnet blade

8. In the **Subnet Name** field, type a name for this subnet.
9. In the **Subnet Address Range**, type the IP range for this subnet in CIDR format, such as **10.3.0.0/16**. Keep in mind that the smallest supported IPv4 subnet is /29, and the largest is /8.
10. Click the **Add** button; the subnet that you just created appears under the **Subnet Name** section.
11. Leave the default selections for now and click the **Review + Create** button. The validation result appears, which is similar to the one shown in Figure 2-5.



**FIGURE 2-5** Summary of the selections with the validation results

12. Click the **Create** button.
13. The **Overview** page appears with the deployment final status. On this page, click the **Go To Resource** button and review these options on the left navigation pane: **Overview**, **Address Space**, and **Subnets**.

Notice that the parameters you configured during the creation of your VNet will be distributed among the different options on the VNet page. As you saw in the previous steps, creating a VNet using the Azure portal is a straightforward process, though in some circumstances, you might need to automate the creation process, and you can use PowerShell to do just that.

When you are creating your virtual network, you can use any IP range that is part of RFC 1918, which includes

- 224.0.0.0/4 (multicast)
- 255.255.255.255/32 (broadcast)
- 127.0.0.0/8 (loopback)
- 169.254.0.0/16 (link-local)
- 168.63.129.16/32 (internal DNS)

Also consider the following points:

- Azure reserves x.x.x.0 as a network address and x.x.x.1 as a default gateway.
- x.x.x.2 and x.x.x.3 are mapped to the Azure DNS IPs to the VNet space.
- x.x.x.255 is reserved for a network broadcast address.

To automate that, you can either use PowerShell on your client workstation (using `Connect-AzAccount` to connect to your Azure subscription) or by using Cloud Shell directly from <https://shell.azure.com>. To create a virtual network using PowerShell, you need to use the `New-AzVirtualNetwork` cmdlet, as shown here:

```
$AZ500Subnet = New-AzVirtualNetworkSubnetConfig -Name AZ500Subnet -AddressPrefix "10.3.0.0/24"
New-AzVirtualNetwork -Name AZ500VirtualNetwork -ResourceGroupName ContosoCST -Location centralus -AddressPrefix "10.3.0.0/16" -Subnet $AZ500Subnet
```

In this example, you have the `$AZ500Subnet` variable, which configures a new subnet for this VNet using the `New-AzVirtualNetworkSubnetConfig` cmdlet. Next, the `New-AzVirtualNetwork` cmdlet is used to create the new VNet, and it calls the `$AZ500Subnet` variable at the end of the command line to create the subnet.

After creating your VNet, you can start connecting resources to it. In an IaaS scenario, it is very common to connect your virtual machines (VMs) to the VNet. Assuming you have Virtual Machine Contributor privileges in the subscription, you can quickly deploy a new VM the `New-AzVM` PowerShell cmdlet, as shown here:

```
New-AzVm `
  -ResourceGroupName "ContosoCST" `
  -Location "East US" `
  -VirtualNetworkName "AZ500VirtualNetwork" `
  -SubnetName "AZ500Subnet" `
  -Name "AZ500VM" `
```

## Routing

In a physical network environment, you usually need to start configuring routes as soon as you expand your network to have multiple subnets. In Azure, the routing table is automatically created for each subnet within an Azure VNet. The default routes created by Azure and assigned to each subnet in a virtual network can't be removed. The default route that is created contains an address prefix and the next hop (where the package should go). When traffic leaves the

subnet, it goes to an IP address within the address prefix of a route; the route that contains the prefix is the route used by Azure.

When you create a VNet, Azure creates a route with an address prefix that corresponds to each address range that you defined within the address space of your VNet. If the VNet has multiple address ranges defined, Azure creates an individual route for each address range. You don't need to worry about creating routes between subnets within the same VNet because Azure automatically routes traffic between subnets using the routes created for each address range. Also, differently from your physical network topology and routing mechanism, you don't need to define gateways for Azure to route traffic between subnets. In an Azure routing table, this route appears as:

- **Source** Default
- **Address prefix** Unique to the virtual network
- **Next hop type** Virtual network

If the destination of the traffic is the Internet, Azure leverages the system-default route 0.0.0.0/0 address prefix, which routes traffic for any address not specified by an address range within a virtual network to the Internet. The only exception to this rule is if the destination address is for one of Azure's services. In this case, instead of routing the traffic to the Internet, Azure routes the traffic directly to the service over Azure's backbone network. The other scenarios in which Azure will add routes are as follows:

- **When you create a VNet peering** In this case, a route is added for each address range within the address space of each virtual network peering that you created.
- **When you add a Virtual Network Gateway** In this case, one or more routes with a virtual network gateway listed as the next hop type are added.
- **When a VirtualNetworkServiceEndpoint is added** When you enable a service endpoint to publish an Azure service to the Internet, the public IP addresses of the services are added to the route table by Azure.

You might also see None in the **Next Hop Type** column, in the routing table. Traffic routed to this hop is automatically dropped. Azure automatically creates default routes for 10.0.0.0/8, 192.168.0.0/16 (RFC 1918), and 100.64.0.0/10 (RFC 6598).



---

**EXAM TIP**

The exam might include scenarios that involve routing-related problems. Make sure to pay close attention to the details about the routing configuration and whether any routing configurations are missing.

---

At this point, you might ask: "If all these routes are created automatically, in which scenario should I create a custom route?" You should do this only when you need to alter the default routing behavior. For example, if you add an Azure Firewall or any other virtual appliance, you can change the default route (0.0.0.0/0) to point to this virtual appliance. This will enable the appliance to inspect the traffic and determine whether to forward or drop the traffic. Another example is when you want to ensure that traffic from hosts doesn't go to the Internet; you can control the routing rules to accomplish that.

To create a custom route that is effective for your needs, you need to create a custom routing table, create a custom route, and associate the routing table to a subnet, as shown in the PowerShell sequence that follows.

1. Create the routing table using `New-AzRouteTable` cmdlet, as shown here:

```
$routeTableAZ500 = New-AzRouteTable `
  -Name 'AZ500RouteTable' `
  -ResourceGroupName ContosoCST `
  -Location EastUS
```

2. Create the custom route using multiple cmdlets. First, you retrieve the route table information using `Get-AzRouteTable`, and then you create the route using `Add-AzRouteConfig`. Lastly, you use the `Set-AzRouteTable` to write the routing configuration to the route table:

```
Get-AzRouteTable `
  -ResourceGroupName "ContosoCST" `
  -Name "AZ500RouteTable" `
  | Add-AzRouteConfig `
  -Name "ToAZ500Subnet" `
  -AddressPrefix 10.0.1.0/24 `
  -NextHopType "MyVirtualAppliance" `
  -NextHopIpAddress 10.0.2.4 `
  | Set-AzRouteTable
```

3. Now that you have the routing table and the custom route, you can associate the route table with the subnet. Notice here that you first write the subnet configuration to the VNet using the `Set-AzVirtualNetwork` cmd. After that you use `Set-AzVirtualNetworkSubnetConfig` to associate the route table to the subnet:

```
$virtualNetwork | Set-AzVirtualNetwork
Set-AzVirtualNetworkSubnetConfig `
  -VirtualNetwork $virtualNetwork `
  -Name 'CustomAZ500Subnet' `
  -AddressPrefix 10.0.0.0/24 `
  -RouteTable $routeTableAZ500 | `
Set-AzVirtualNetwork
```

## Virtual network peering

When you have multiple VNets in your Azure infrastructure, you can connect those VNets using VNet peering. You can use VNet peering to connect VNets within the same Azure region or across Azure regions; doing so is called global VNet peering.

When the VNets are on the same region, the network latency between VMs that are communicating through the VNet peering is the same as the latency within a single virtual network. It's also important to mention that the traffic between VMs in peered virtual networks is not through a gateway or over the public Internet; instead, that traffic is routed directly through the Microsoft backbone infrastructure. To create a VNet peering using the Azure portal, follow these steps:

1. Navigate to the Azure portal at <https://portal.azure.com>.
2. In the search bar type **virtual networks**, and under **Services**, click **Virtual Networks**.

3. Click the VNet that you want to peer, and on the left navigation pane, click **Peerings** (see Figure 2-6).

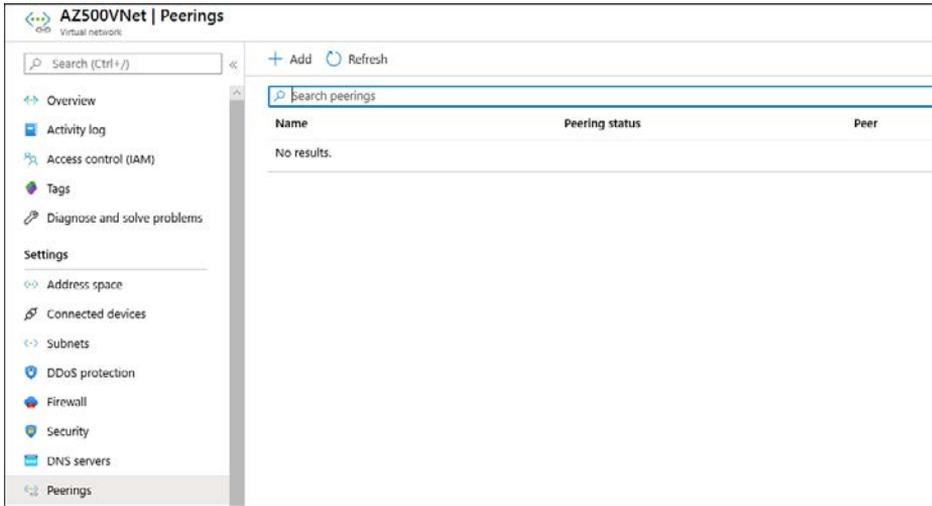


FIGURE 2-6 Configuring VNet peering

4. Click the **Add** button, and the **Add Peering** page appears, as shown in Figure 2-7.

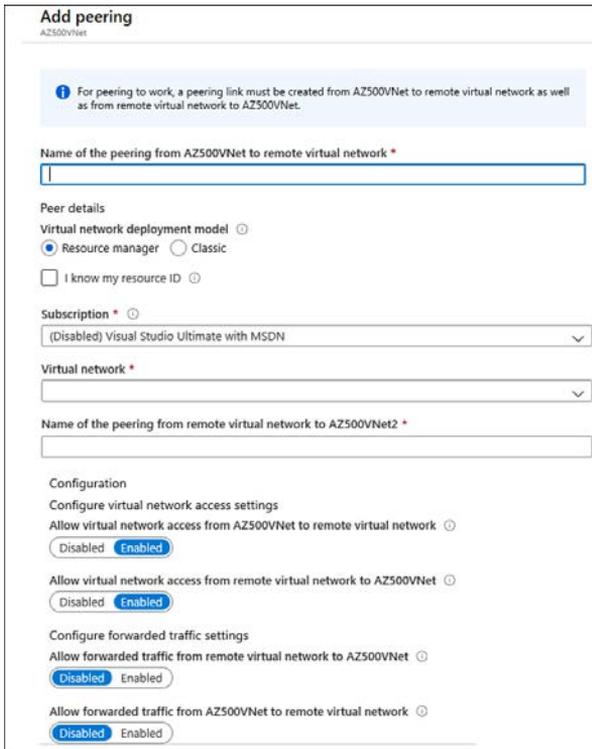


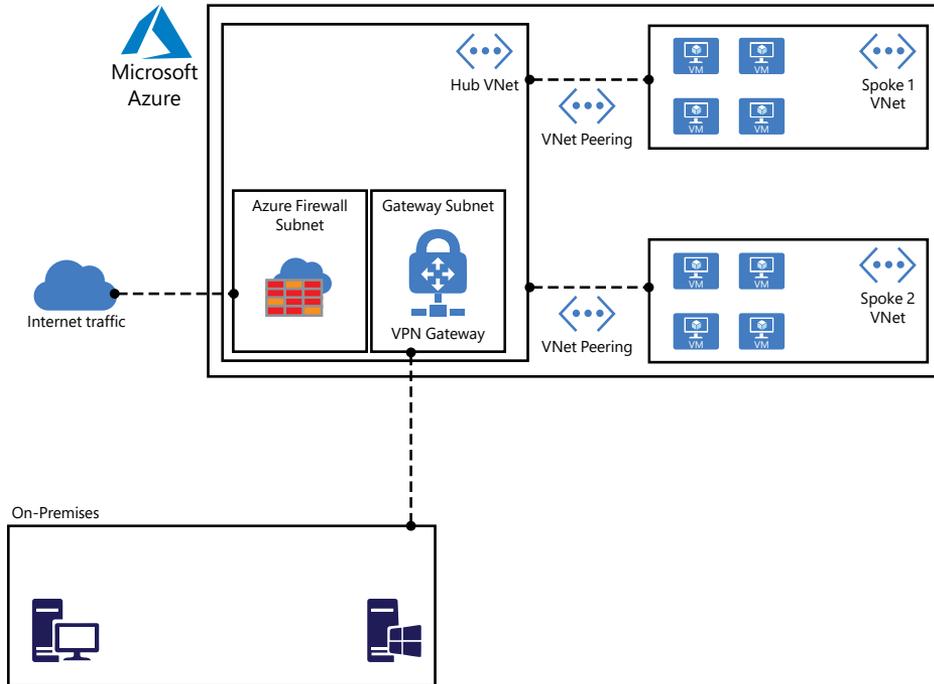
FIGURE 2-7 Adding a new peering

5. In the **Name** field, type a name for this peering.
6. In the **Subscription** field, select the subscription that has the VNet to which you want to connect.
7. In the **Virtual Network** field, click the drop-down menu and select the VNet that you want to peer.
8. In the **Name Of The Peering From Remote Virtual Network** field, type the name that you want this peering connection to appear on the other VNet.
9. The next two options—**Allow Virtual Network Access From [VNet name] To Remote Virtual Network** and **Allow Virtual Network Access From Remote Virtual To [VNet name]**—are used to control the communication between those VNets. If you want full connectivity from both directions, make sure to leave the **Enabled** option selected (default selection) for both. Enabling communication between virtual networks allows resources connected to either virtual network to communicate with each other with the same bandwidth and latency as if they were connected to the same virtual network.
10. The next two options—**Allow Forwarded Traffic From Remote Virtual Network To [VNet name]** and **Allow Forwarded Traffic From [VNet name] To Remote Virtual Network**—are related to allowing forwarded traffic. You should select **Enable** for both settings only when you need allow traffic that didn't originate from the VNet to be forwarded by a network virtual appliance through a peering. For example, consider three virtual networks named VNetTX, VNetWA, and MainHub. A peering exists between each spoke VNet (VNetTX and VNetWA) and the Hub virtual network, but peerings don't exist between the spoke VNets. A network virtual appliance is deployed in the Hub VNet, and user-defined routes can be applied to each spoke VNet to route the traffic between the subnets through the network virtual appliance. If this option is disabled, there will be no traffic flow between the two spokes through the hub.
11. Click **OK** to finish the configuration.

To configure a VNet peering using PowerShell, you just need to use the `Add-AzVirtualNetworkPeering` cmdlet, as shown here:

```
Add-AzVirtualNetworkPeering -Name 'NameOfTheVNetPeering' -VirtualNetwork SourceVNet  
-RemoteVirtualNetworkId RemoteVNet
```

A peered VNet can have its own gateway, and the VNet can use its gateway to connect to an on-premises network. One common use of VNet peering is when you are building a hub-spoke network. In this type of topology, the hub is a VNet that acts as a central hub for connectivity to your on-premises network. The spokes are VNets that are peering with the hub, allowing them to be isolated, which increases their security boundaries. An example of this topology is shown in Figure 2-8.



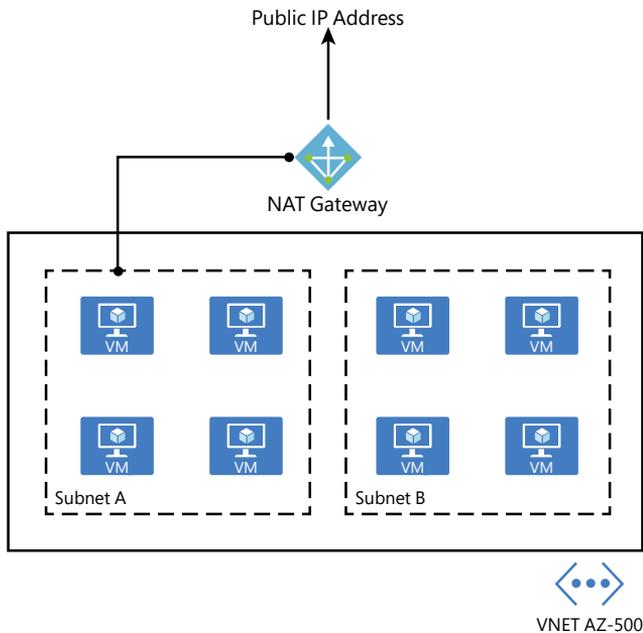
**FIGURE 2-8** Hub-spoke network topology using VNet peering

A hybrid network uses the hub-spoke architecture model to route traffic between Azure VNets and on-premises networks. When there is a site-to-site connection between the Azure VNet and the on-premises data center, you must define a gateway subnet in the Azure VNet. All the traffic from the on-premises data center would then flow via the gateway subnet.

## Network address translation

Azure has a Virtual Network NAT (network address translation) capability that enables out-bound-only Internet connectivity for virtual networks. This is a common scenario when you want that outbound connectivity to use a specified static public IP address (static NAT) or you want to use a pool of public IP addresses (Dynamic NAT).

Keep in mind that outbound connectivity is possible without the use of an Azure load balancer or a public IP address directly attached to the VM. Figure 2-9 shows an example of the topology with a NAT Gateway.



**FIGURE 2-9** NAT Gateway topology

You can implement NAT by using a public IP prefix directly, or you can distribute the public IP addresses of the prefix across multiple NAT gateway resources. NAT also changes the network route because it takes precedence over other outbound scenarios, and it will replace the default Internet destination of a subnet. From an availability standpoint (which is critical for security), NAT always has multiple fault domains, which means it can sustain multiple failures without service outage.

**IMPORTANT NAT GATEWAY BILLING**

A NAT gateway is billed with two separate meters: resource hours and data processed. Consult the Azure NAT pricing page for the latest pricing.

To create a NAT Gateway for your subnet, you first need to create a public IP address and a public IP prefix. Follow the steps below to perform these tasks:

1. Navigate to the Azure portal at <https://portal.azure.com>.
2. In the main dashboard, click the **Create A Resource** button.
3. On the **New** page, type **Public IP** and click the **Public IP Address** option that appears in the list.
4. On the **Public IP Address** page, click the **Create** button; the **Create Public IP Address** page appears, as shown in Figure 2-10.

**FIGURE 2-10** Creating a public IP address to be used by NAT Gateway

5. Type the name for this public IP address and select the subscription, resource group, and the Azure location. For this example, you can leave all other options with their default selections. Once you finish, click the **Create** button.
6. Now you should repeat steps 1 and 2. In the third step, type **public IP prefix** and click the **Public IP Prefix** option that appears in the drop-down menu.
7. On the **Create A Public IP Prefix** page, configure the following relevant options:
  - Select the appropriate **Subscription**.
  - Select the appropriate **Resource Group**.
  - Type the **Prefix Name**.
  - Select the appropriate **Azure Region**.
  - In the **Prefix Size** drop-down menu, select the appropriate size for your deployment.
8. Once you finish configuring these options, click the **Review + Create** button and click **Create** to finish.
9. Now that you have the two requirements fulfilled, you can create the NAT Gateway.
10. Navigate to the Azure portal at <https://portal.azure.com>.
11. In the main dashboard, click the **Create A Resource** button.

12. On the New page, type **NAT Gateway** and click the **NAT Gateway** option in the list.
13. On the **NAT Gateway** page, click **Create**. The **Create Network Address Translation (NAT) Gateway** page appears, as shown in Figure 2-11.
14. On the **Basics** tab, make sure to configure the following options:
  - Select the appropriate **Subscription** and **Resource Group**.
  - Type the **NAT Gateway Name**.
  - Select the appropriate **Azure Region** and **Availability Zone**.
15. Move to the next tab, **Outbound IP**, and select the Public IP Address and Prefix Name that you created previously.
16. Next, on the **Subnet** tab, you will configure which subnets of a VNet should use this NAT gateway.
17. The **Tags** tab is optional, and you should use it only when you need to logically organize your resources in a particular taxonomy to easily identify them later.
18. You can review a summary of the selections in the **Review + Create** tab. Once you finish reviewing it, click the **Create** button.

The screenshot shows the 'Create network address translation (NAT) gateway' page in Azure. The page has a title bar and a navigation bar with tabs: Basics, Outbound IP, Subnet, Tags, and Review + create. The 'Basics' tab is active. Below the navigation bar, there is a brief description of Azure NAT gateway and a link to learn more. The main content area is divided into two sections: 'Project details' and 'Instance details'. In the 'Project details' section, there are two dropdown menus: 'Subscription' (set to 'CONTOSO-Managed-Subscription') and 'Resource group' (empty). Below the 'Resource group' dropdown is a 'Create new' link. In the 'Instance details' section, there are four fields: 'NAT gateway name' (empty text box), 'Region' (dropdown set to '(US) East US'), 'Availability zone' (dropdown set to 'None'), and 'Idle timeout (minutes)' (text box set to '4'). At the bottom of the page, there is a navigation bar with a 'Review + create' button, a '< Previous' button, a 'Next : Outbound IP >' button, and a 'Download a template for automation' link.

**FIGURE 2-11** Creating a NAT Gateway in Azure

You can also use the `New-AzNatGateway` cmdlet to create a NAT Gateway using PowerShell, as shown:

```
New-AzNatGateway -ResourceGroupName "AZ500RG" -Name "nat_gt" -IdleTimeoutInMinutes 4  
-Sku "Standard" -Location "eastus2" -PublicIpAddress PublicIpAddressName
```

## Secure the connectivity of virtual networks

With organizations migrating to the cloud, virtual private networks (VPNs) are constantly used to establish a secure communication link between on-premises and cloud network infrastructure. While this is one common scenario, there are many other scenarios where a VPN can be used. You can use Azure VPN to connect two different Azure regions or different subscriptions.

Azure natively offers a service called VPN gateway, which is a specific type of virtual network gateway that is used to send encrypted traffic between an Azure virtual network and on-premises resources. You can also use a VPN gateway to send encrypted traffic between Azure virtual networks. When planning your VPN Gateway implementation, be aware that each virtual network can have only one VPN gateway, and you can create multiple connections to the same VPN gateway. Depending on the scenario, you can select from different types of VPN connectivity. The available options are

- **Site-to-Site (S2S) VPN** This type of VPN is used in scenarios where you need to connect on-premises resources to Azure. The encrypted connection tunnel uses IPsec/IKE (IKEv1 or IKEv2).
- **Point-to-Site (P2S) VPN** This type of VPN is used in scenarios where you need to connect to your Azure VNet from a remote location. For example, you would use P2S when you are working remotely (hotel, home, conference, and the like) and you need to access resources in your VNet. This VPN uses SSTP (Secure Socket Tunneling Protocol) or IKE v2 and does not require a VPN device.
- **VNet-to-VNet** As the name states, this VPN is used in scenarios where you need to encrypt connectivity between VNets. This type of connection uses IPsec (IKE v1 and IKE v2).
- **Multi-Site VPN** This type of VPN is used in scenarios where you need to expand your site-to-site configuration to allow multiple on-premises sites to access a virtual network.

ExpressRoute is another option that allows connectivity from your on-premises resources to Azure. This option uses a private connection to Azure from your WAN, instead of a VPN connection over the Internet.

## VPN authentication

The Azure VPN connection is authenticated when the tunnel is created. Azure generates a pre-shared key (PSK), which is used for authentication. This pre-shared key is an ASCII string character no longer than 128 characters. This authentication happens for policy-based (static routing) or routing-based VPN (dynamic routing). You can view and update the pre-shared key for a connection with these PowerShell cmdlets:

- **Get-AzVirtualNetworkGatewayConnectionSharedKey** This command is used to show the pre-shared key.
- **Set-AzVirtualNetworkGatewayConnectionSharedKey** This command is used to change the pre-shared key to another value.

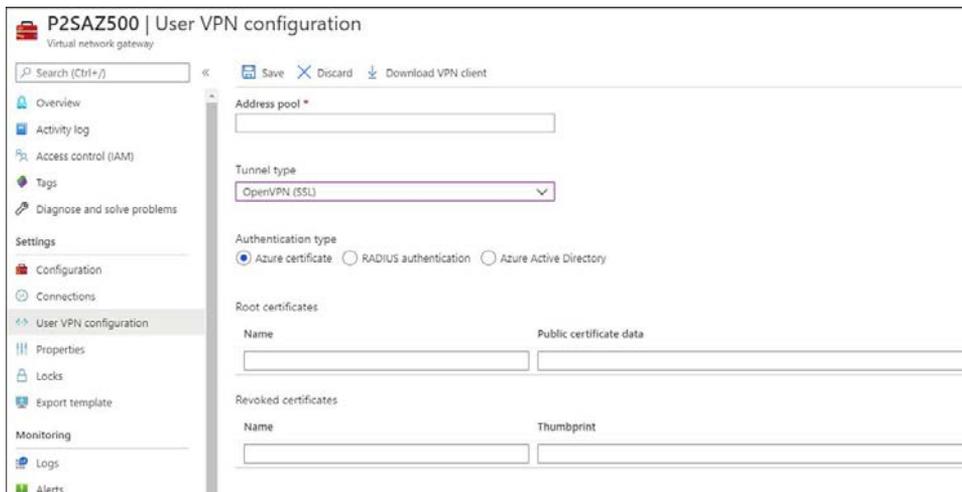
For point-to-site (P2S) VPN scenarios, you can use native Azure certificate authentication or Azure AD authentication. For native Azure certificate authentication, a client certificate is presented on the device, which is used to authenticate the users who are connecting. The certificate can be one that was issued by an enterprise certificate authority (CA), or it can be a self-signed root certificate. For native Azure AD, you can use the native Azure AD credentials. Keep in mind that native Azure AD is only supported for the OpenVPN protocol and Windows 10. (Windows 10 requires the use of the Azure VPN Client.)

If your scenario requires the enforcement of a second factor of authentication before access to the resource is granted, you can use Azure Multi-Factor Authentication (MFA) with conditional access. Even if you don't want to implement MFA across your entire company, you can scope the MFA to be employed only for VPN users using conditional access capability.

#### **MORE INFO** CONFIGURING MFA FOR VPN ACCESS

You can see the steps for configuring MFA for VPN access at <http://aka.ms/az500mfa>.

Another option available for P2S is the authentication using RADIUS (which also supports IKEv2 and SSTP VPN). Keep in mind that RADIUS is only supported for VpnGw1, VpnGw2, and VpnGw3 SKUs. For more information about the latest VPN SKUs, visit <http://aka.ms/az-500vpnsku>. Figure 2-12 shows an example of the options that appear when you are configuring a P2S VPN and you need to select the authentication type.



**FIGURE 2-12** Authentication options for VPN

The options that appear right under the **Authentication Type** section will vary according to the Authentication Type you select. In Figure 2-12, **Azure Certificate** is chosen, and the page shows options to enter the **Name** and **Public Certification Data** for the **Root Certificates** and the **Name** and **Thumbprint** for the **Revoked Certificates**. If you select **RADIUS authentication**, you will need to specify the **Server IP Address** and the **Server Secret**. Lastly, if you select the **Azure Active Directory** option, you will need to specify the **Tenant's URL**; the **Audience** (which identifies the recipient resource the token is intended for); and the **Issuer** (which identifies the Security Token Service (STS) that issued the token). Lastly, choose the Azure AD tenant.

Your particular scenario will dictate which option to use. For example, Contoso's IT department needs to implement a VPN solution that can integrate with a certificate authentication infrastructure that it already has through RADIUS. In this case, you should use RADIUS certificate authentication. When using the RADIUS certificate authentication, the authentication request is forwarded to a RADIUS server, which handles the certificate validation. If the scenario requires that the certificate authentication be performed by the Azure VPN gateway, the right option would be to use the Azure native certificate authentication.

## ExpressRoute encryption

If your connectivity scenario requires a higher level of reliability, faster speeds, consistent latencies, and higher security than typical connections over the Internet, you should use ExpressRoute, which provides layer 3 connectivity between your on-premises network and the Microsoft Cloud.

ExpressRoute supports two different encryption technologies to ensure the confidentiality and integrity of the data that is traversing from on-premises to Microsoft's network. The options are

- Point-to-point encryption by MACsec
- End-to-end encryption by IPSec

MACsec encrypts the data at the media access control (MAC) level or at network layer 2. When you enable MACsec, all network control traffic is encrypted, which includes the border gateway protocol (BGP) data traffic, and your (customer) data traffic. This means that you can't encrypt only some of your ExpressRoute circuits.

If you need to encrypt the physical links between your network devices and Microsoft's network devices when you connect to Microsoft via ExpressRoute Direct, MACsec is preferred. MACsec also allows you to bring your own MACsec key for encryption and store it in Azure Key Vault. If this is the design choice, remember that you will need to decide when to rotate the key.

### **TIP** EXPRESSROUTE DIRECT

Although MACsec is only available on ExpressRoute Direct, it comes disabled by default on ExpressRoute Direct ports.

Keep in mind that when you update the MACsec key, the on-premises resources will temporarily lose connectivity to Microsoft over ExpressRoute. This happens because MACsec configuration only supports pre-shared key mode, so you must update the key on both sides. In other words, if there is a mismatch, traffic flow won't occur. Plan the correct maintenance window to reduce the impact on production environments.

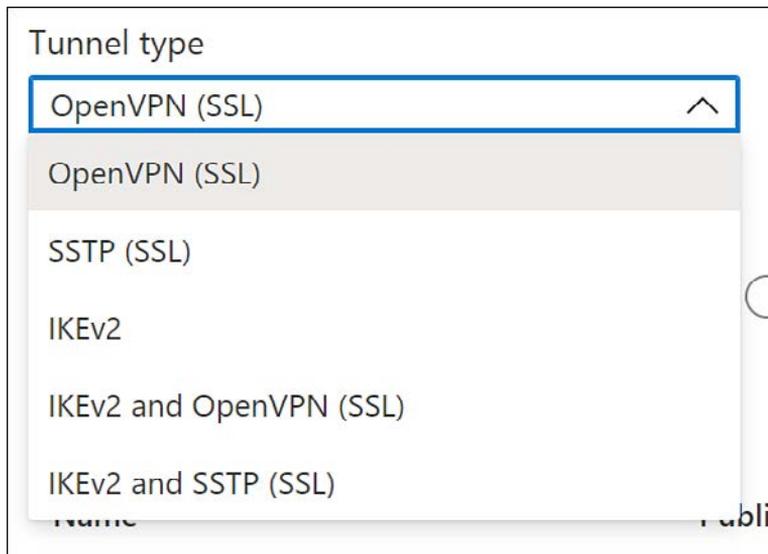
The other option is to use end-to-end encryption with IPSec, which encrypts data at the Internet protocol (IP)-level or at network layer 3. A very common scenario is to use IPSec to encrypt the end-to-end connection between on-premises resources and your Azure VNet. In a scenario where you need to encrypt layer 2 and layer 3, you can enable MACsec and IPSec.

#### **MORE INFO** CREATE IPSEC OVER EXPRESSROUTE

You can learn how to create IPsec over ExpressRoute for Virtual WAN at <http://aka.ms/az-500vpnexpressroute>.

## Point-to-site

To implement a point-to-site (P2S) VPN in Azure, you first need to decide what authentication method you will use based on the options that were presented earlier in this section. The authentication method will dictate how the P2S VPN will be configured. When configuring the P2S VPN, you will see the options available under **Tunnel Type**, as shown in Figure 2-13.



**FIGURE 2-13** Different options for the VPN tunnel

- Another important variable to select is the protocol that will be used. Use Table 2-1 to select the most-appropriate protocol based on the advantages and limitations:

**TABLE 2-1** Advantages and limitations

Protocol	Advantages	Limitations
OpenVPN Protocol	This is a TLS VPN-based solution that can traverse most firewalls on the market. Can be used to connect from a variety of operating systems, including Android, iOS (versions 11.0 and above), Windows, Linux, and Mac devices (OSX versions 10.13 and above).	Basic SKU is not supported. Not available for the classic deployment model.
Secure Socket Tunneling Protocol (SSTP)	Can traverse most firewalls because it uses TCP port 443.	Only supported on Windows devices. Supports up to 128 concurrent connections, regardless of the gateway SKU.
IKEv2	Standard-based IPsec VPN solution. Can be used to connect to Mac devices (OSX versions 10.11 and above).	Basic SKU is not supported. Not available for the classic deployment model. Uses nonstandard UDP ports, so you need to ensure that these ports are not blocked on the user's firewall. The ports in use are UDP 500 and 4500.



**EXAM TIP**

For the AZ-500 exam, make sure to carefully read the scenarios because there will be indications of what the company wants to accomplish, and those indications will be used to decide which protocol to implement or which protocol is not an option for the specified scenario.

## Site-to-site

A site-to-site (S2S) VPN is used in most scenarios to allow the communication from one location (on-premises) to another (Azure) over the Internet. To configure a S2S, you need the following prerequisites fulfilled before you start:

- A VPN device on-premises that is compatible with Azure VPN policy-based configuration or route-based configuration. See the full list at <https://aka.ms/az500s2sdevices>.
- Externally-facing public IPv4 address.
- IP address range from your on-premises network that will be utilized to allow Azure to route to your on-premises location.

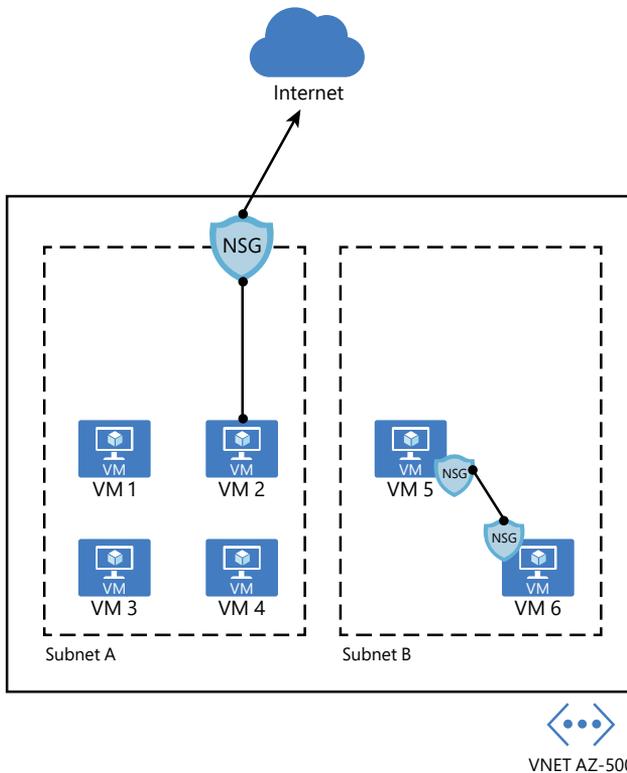
**MORE INFO CREATING AN S2S VPN**

Once you have those requirements, you can create your S2S VPN. For more information on the steps, see <https://aka.ms/az500s2svpn>. If your VPN connection is over IPsec (IKE v1 and IKE v2), you need to have a VPN device or an RRAS.

# Configure network security groups and Application Security Groups

Network security groups (NSG) in Azure allow you to filter network traffic by creating rules that allow or deny inbound network traffic to or outbound network traffic from different types of resources. For example, you could configure an NSG to block inbound traffic from the Internet to a specific subnet that only allows traffic from a network virtual appliance (NVA).

Network security groups can be enabled on the subnet or to the network interface in the VM, as shown in Figure 2-14.



**FIGURE 2-14** Different NSG implementations

In the diagram shown in Figure 2-14, you have two different uses of NSG. In the first case, the NSG is assigned to the subnet A. This can be a good way to secure the entire subnet with a single set of NSG rules. However, there will be scenarios where you might need to control the NSG on the network interface level, which is the case of the second scenario (subnet B), where VM 5 and VM 6 have a NSG assigned to the network interface.

When inbound traffic is coming through the VNet, Azure processes the NSG rules that are associated with the subnet first—if there are any—and then it processes the NSG rules that are associated with the network interface. When the traffic is leaving the VNet (outbound traffic), Azure processes the NSG rules that are associated with the network interface first, followed by the NSG rules that are associated to the subnet.

When you create an NSG, you need to configure a set of rules to harden the traffic. These rules use the following parameters:

- **Name** The name of the rule.
- **Priority** The order in which the rule will be processed. Lower numbers have high priority, which means that a rule priority 100 will be evaluated before rule priority 300. Once the traffic matches the rule, it will stop moving forward to evaluate other rules. When configuring the priority, you can assign a number between 100 and 4096.
- **Source** Define the source IP, CIDR Block, Service Tag, or Application Security Group.
- **Destination** Define the destination IP, CIDR Block, Service Tag, or Application Security Group.
- **Protocol** Define the TCP/IP protocol that will be used, which can be set to **TCP**, **UDP**, **ICMP**, or **Any**.
- **Port Range** Define the port range or a single port.
- **Action** This determines the action that will be taken once this rule is processed. This can be set to **Allow** or **Deny**.

Before creating a new NSG and adding new rules, it is important to know that Azure automatically creates default rules on NSG deployments. Following is a list of the inbound rules that are created:

- **AllowVNetInBound**
  - **Priority** 6500
  - **Source** VirtualNetwork
  - **Source Ports** 0-65535
  - **Destination** VirtualNetwork
  - **Destination Ports** 0-65535
  - **Protocol** Any
  - **Access** Allow
- **AllowAzureLoadBalancerInBound**
  - **Priority** 6501
  - **Source** AzureLoadBalancer
  - **Source Ports** 0-65535
  - **Destination** 0.0.0.0/0
  - **Destination Ports** 0-65535
  - **Protocol** Any
  - **Access** Allow
- **DenyAllInbound**
  - **Priority** 6501
  - **Source** AzureLoadBalancer

- **Source Ports** 0-65535
- **Destination** 0.0.0.0/0
- **Destination Ports** 0-65535
- **Protocol** Any
- **Access** Deny

Below is a list of outbound rules that are created:

- **AllowVnetOutBound**
  - **Priority** 6501
  - **Source** VirtualNetwork
  - **Source Ports** 0-65535
  - **Destination** VirtualNetwork
  - **Destination Ports** 0-65535
  - **Protocol** Any
  - **Access** Allow
- **AllowInternetOutBound**
  - **Priority** 6501
  - **Source** 0.0.0.0/0
  - **Source Ports** 0-65535
  - **Destination** Internet
  - **Destination Ports** 0-65535
  - **Protocol** Any
  - **Access** Allow
- **DenyAllOutBound**
  - **Priority** 6501
  - **Source** 0.0.0.0/0
  - **Source Ports** 0-65535
  - **Destination** 0.0.0.0/0
  - **Destination Ports** 0-65535
  - **Protocol** Any
  - **Access** Deny

**IMPORTANT** DEFAULT RULES CANNOT BE REMOVED

Keep in mind that these default rules cannot be removed, though if necessary, you can override them by creating rules with higher priorities.

Follow the steps below to create and configure an NSG, which in this example, will be associated with a subnet:

1. Navigate to the Azure portal by opening <https://portal.azure.com>.
2. In the search bar, type **network security**, and under **Services**, click **Network Security Groups**; the **Network Security Groups** page appears.
3. Click the **Add** button; the **Create Network Security Group** page appears, as shown in Figure 2-15.

The screenshot shows the 'Create network security group' page in the Azure portal. The breadcrumb navigation at the top reads 'Home > Network security groups > Create network security group'. The main heading is 'Create network security group'. Below this, there are three tabs: 'Basics' (selected), 'Tags', and 'Review + create'. Under the 'Basics' tab, there are two sections: 'Project details' and 'Instance details'. In the 'Project details' section, there are two dropdown menus: 'Subscription \*' with the value 'Contoso Hotels' and 'Resource group \*' which is empty. Below the 'Resource group \*' dropdown is a 'Create new' link. In the 'Instance details' section, there are two text input fields: 'Name \*' which is empty and 'Region \*' with the value '(US) South Central US'.

**FIGURE 2-15** Initial parameters of the network security group

4. In the **Subscription** field, select the subscription where this NSG will reside.
5. In the **Resource Group** field, select the resource group in which this NSG will reside.
6. In the **Name** field, type the name for this NSG.
7. In the **Region** field, select the Azure region in which this NSG will reside.
8. Click **Review + Create** button, review the options, and click the **Create** button.
9. Once the deployment is complete, click the **Go To Resource** button. The NSG page appears.

At this point, you have successfully created your NSG, and you can see that the default rules are already part of it. The next step is to create the custom rules, which can be inbound or outbound. (This example uses inbound rules.) The same operation could be done using the `New-AzNetworkSecurityGroup` PowerShell cmdlet, as shown in the following example:

```
New-AzNetworkSecurityGroup -Name "AZ500NSG" -ResourceGroupName "AZ500RG" -Location "westus"
```

Follow these steps to create an inbound rule that allows FTP traffic from any source to a specific server using Azure portal:

1. On the NSG page, under **Settings** in the left navigation pane, click **Inbound Security Rules**.
2. Click the **Add** button; the **Add Inbound Security Rule** blade appears, as shown in Figure 2-16.

The screenshot shows the 'Add inbound security rule' blade in Azure. The form is titled 'Add inbound security rule' and includes a 'Basic' tab. The fields are as follows:

- Source \***: A dropdown menu with 'Any' selected.
- Source port ranges \***: A text box containing '\*'.
- Destination \***: A dropdown menu with 'Any' selected.
- Destination port ranges \***: A text box containing '21'.
- Protocol \***: Radio buttons for 'Any', 'TCP', 'UDP', and 'ICMP'. 'Any' is selected.
- Action \***: Radio buttons for 'Allow' and 'Deny'. 'Allow' is selected.
- Priority \***: A text box containing '101'.
- Name \***: A text box containing 'AZ500NSGRule\_FTP'.
- Description**: An empty text box.

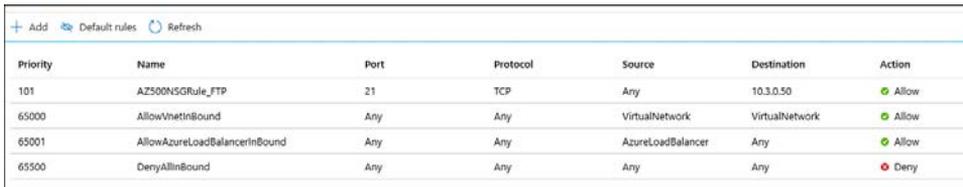
An 'Add' button is located at the bottom left of the form.

**FIGURE 2-16** Creating an inbound security rule for your NSG

3. On this blade, you start by specifying the source, which can be an IP address, a service tag, or an ASG. If you leave the default option (**Any**), you are allowing any source. For this example, leave this set to **Any**.
4. In the **Source Port Ranges** field, you can harden the source port. You can specify a single port or an interval. For example, you can allow traffic from ports 50 to 100. Also, you can use comma to add another condition to the range, such as 50-100, 135, which specifies ports 50 through 100 and 135. Leave the default selection (\*), which allows any source port.
5. In the **Destination** field, the options are nearly the same as the **Source** field. The only difference is that you can select the VNet as the destination. For this example, change this option to **IP Addresses** and enter the internal IP address of the VM that you created at the beginning of this chapter.

6. In the **Destination Port Ranges** field, specify the destination port that will be allowed. The default port is 8080; for this example, change it to 21.
7. In the **Protocol** field, you can select which protocol you are going to allow; in this case, change it to **TCP**.
8. Leave the **Action** field set to **Allow**, which is the default selection.
9. You can also change the **Priority** of this rule. Remember that the lowest priority is evaluated first. For this example, change it to **101**.
10. In the **Name** field, change it to **AZ500NSGRule\_FTP** and click the **Add** button.

The NSG will be created, and a new rule will be added to the inbound rules. At this point, your inbound rules should look like the rules shown in Figure 2-17.



Priority	Name	Port	Protocol	Source	Destination	Action
101	AZ500NSGRule_FTP	21	TCP	Any	10.3.0.50	Allow
65000	AllowVnetInbound	Any	Any	VirtualNetwork	VirtualNetwork	Allow
65001	AllowAzureLoadBalancerInBound	Any	Any	AzureLoadBalancer	Any	Allow
65500	DenyAllInBound	Any	Any	Any	Any	Deny

**FIGURE 2-17** List of inbound rules

While these are the steps to create the inbound rule, this NSG has no use if it is not associated with a subnet or a virtual network interface. For this example, you will associate this NSG to a subnet. The intent is to block all traffic to this subnet and only allow FTP traffic to this specific server. Use the following steps to create this association:

1. In the left navigation pane of the **NSG Inbound Security Rules** page under **Settings**, click **Subnets**.
2. Click the **Associate** button, and in the **Virtual Network** drop-down menu, select the VNet where the subnet resides.
3. After this selection, you will see that the **Subnet** drop-down menu appears; select the subnet and click the **OK** button.

You could also use PowerShell to create an NSG and then associate the NSG to a subnet. To create an NSG using PowerShell, use the `New-AzNetworkSecurityRuleConfig` cmdlet, as shown in the following example:

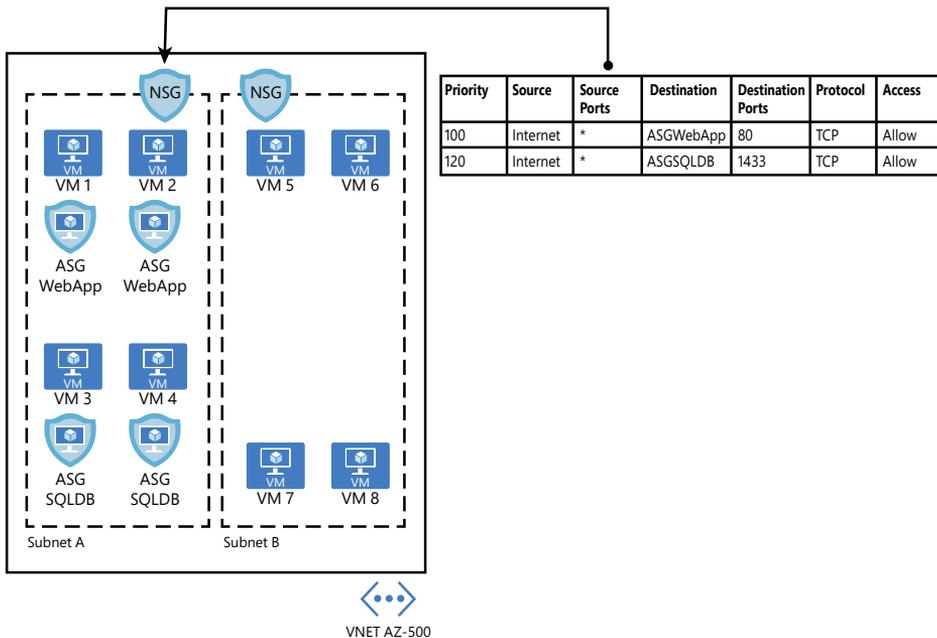
```
$MyRule1 = New-AzNetworkSecurityRuleConfig -Name ftp-rule -Description "Allow FTP"
-Access Allow -Protocol Tcp -Direction Inbound -Priority 100 -SourceAddressPrefix *
-SourcePortRange * -DestinationAddressPrefix * -DestinationPortRange 21
```

## Application security group

If you need to define granular network security policies based on workloads that are centralized on application patterns instead of explicit IP addresses, you need to use the application security group (ASG). An ASG allows you to group VMs and secure applications by

filtering traffic from trusted segments of your network, which adds an extra level of micro-segmentation.

You can deploy multiple applications within the same subnet and isolate traffic based on ASGs. Another advantage is that you can reduce the number of NSGs in your subscription. For example, in some scenarios, you can use a single NSG for multiple subnets of your virtual network and perform the micro-segmentation on the application level by using ASG. Figure 2-18 shows an example of how ASG can be used in conjunction with NSG.



**FIGURE 2-18** ASG used as the destination in the NSG routing table

In the example shown in Figure 2-18, two ASGs have been created to define the application pattern for a web application and another ASG to define the application pattern for a SQL database. Two VMs are part of each group, and the ASG is used in the routing table of the NSG located in subnet A. In the NSG routing table, you can specify one ASG as the source and destination, but you cannot specify multiple ASGs in the source or destination.

When you deploy VMs, you can make them members of the appropriate ASGs. In case your VM has multiple workloads (Web App and SQL, for example), you can assign multiple ASGs to each application. This will allow you to have different types of access to the same VM according to the workload. This approach also helps to implement a zero-trust model by limiting access to the application flows that are explicitly permitted. Follow these steps to create an ASG:

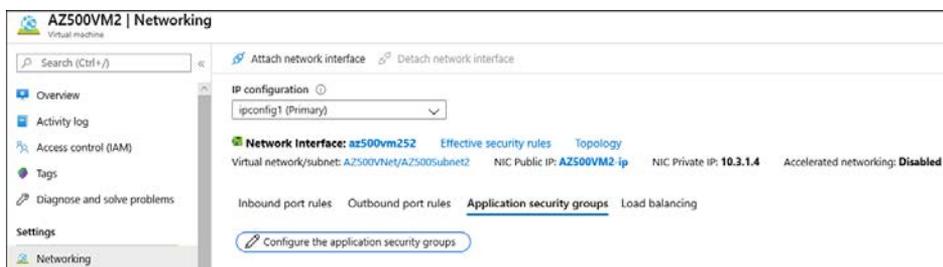
1. Navigate to the Azure portal at <https://portal.azure.com>.
2. In the search bar, type **application security** and under **Services**, click **Application Security Groups**.
3. In the **Application Security Groups** dashboard, click the **Add** button, which makes the **Create An Application Security Group** page appear, as shown in Figure 2-19.

**FIGURE 2-19** Create An Application Security Group

4. In the **Subscription** drop-down menu, select the appropriate subscription for this ASG.
5. In the **Resource Group** drop-down menu, select the resource group in which this ASG will reside.
6. In the **Name** field, type a name for this ASG.
7. In the **Region** drop-down menu, select the appropriate region for this ASG and click the **Review + Create** button.
8. On the **Review + Create** button page, click the **Create** button.

Now that the ASG is created, you need to associate this ASG to the network interface of the VM that has the workload you want to control. Follow these steps to perform this association:

1. Navigate to the Azure portal at <https://portal.azure.com>.
2. In the search bar, type **virtual** and under **Services**, click **Virtual Machines**.
3. Click in the VM that you want to perform this association.
4. On the VM's page, in the **Settings** section, click the **Networking** option.
5. Click the **Application Security Group** tab, and the page shown in Figure 2-20 appears.



**FIGURE 2-20** Associating the ASG to the virtual network interface card

6. Click the **Configure The Application Security Groups** button and the **Configure The Application Security Groups** blade appears, as shown in Figure 2-21.



**FIGURE 2-21** Selecting the ASG

7. Select the appropriate ASG and click the **Save** button.

You can also use the `New-AzApplicationSecurityGroup` cmdlet to create a new ASG, as shown in the following example:

```
New-AzApplicationSecurityGroup -ResourceGroupName "MyRG" -Name "MyASG" -Location "West US"
```

Now when you create your new NSG rule for inbound or outbound traffic, you can select the ASG as source or destination.

## Create and configure Azure Firewall

While NSG provides stateful package flow and custom security rules, you will need a more robust solution when you need to protect an entire virtual network. If your company needs a fully stateful, centralized network firewall as a service (FWaaS) that provides network and application-level protection across different subscriptions and virtual networks, you should choose Azure Firewall.

Also, Azure Firewall can be used in scenarios where you need to span multiple availability zones for increased availability. Although there's no additional cost for an Azure Firewall deployed in an availability zone, there are additional costs for inbound and outbound data transfers associated with Availability Zones. Figure 2-22 shows an Azure Firewall in its own VNet and subnet, allowing some traffic and blocking other traffic based on a series of evaluations.

# Index

## A

- access control, 38-63, 74-85
  - access reviews, 40-42
  - activating/configuring PIM, 43-45
  - administering MFA users, 54-60
    - account lockout settings, 57
    - blocking/unblocking users, 58
    - fraud alert settings, 58
    - OATH tokens, 59
    - phone call settings, 59
    - reporting utilization, 60
  - application access, 64-73
    - API management policies, 73
    - assigning, 66-70
    - permission consent, 71-73
    - permission scopes, 70-71
    - registering applications, 64-66
  - for Azure Key Vault, 282-285
  - best practices, 81
  - conditional access policies, 46-54
    - creating, 47-49
    - implementing MFA, 49-54
    - types of, 46-47
  - configuring identity protection, 60-63
  - custom roles, 81-84
  - identifying roles, 81
  - interpreting permissions, 84
  - monitoring privileged access, 38-40
  - principle of least privilege, 81
  - RBAC roles
    - assigning, 245-247
    - levels of, 244
    - list of, 245
  - resource group permissions, 79-80
  - subscription and resource permissions, 74-79
  - viewing user resource permissions, 84-85
  - for VMs (virtual machines), 155
- accessing
  - Azure Activity Log, 182
  - Azure AD administrative console, 6
- access keys for storage accounts, 247
  - rotating keys, 247-250
  - viewing keys, 248-249
- access reviews, 40-42
- account lockout settings for MFA, 57
- account SAS, 251-254
- ACR (Azure Container Registry)
  - security configuration, 167-168
  - vulnerability management, 164-165
- action groups for Azure Monitor alerts, 185-186
- Active Directory Federation Services (AD FS) in Azure AD Connect, 28
- activity logs in Azure Monitor, 180
  - accessing, 182
- Add-AzKeyVaultCertificate cmdlet, 293
- Add-AzKeyVaultCertificateContact cmdlet, 293
- Add-AzKeyVaultKey cmdlet, 300
- Add-AzRouteConfig cmdlet, 97
- Add-AzureADDirectoryRoleMember cmdlet, 79
- Add-AzureADGroupMember cmdlet, 8
- Add-AzureADGroupOwner cmdlet, 8
- Add-AzVirtualNetworkPeering cmdlet, 99
- adding
  - certificates to Azure Key Vault, 289-293
  - compliance standards to Regulatory Compliance dashboard, 210-211
  - group members, 10
- ADE (Azure Disk Encryption), 168-169
- ad hoc SAS, 251
- administrative console (Azure AD), accessing, 6
- ADS (Advanced Data Security), 199
- Advanced Threat Protection (ATP) for Azure Storage, 267-268
- AKS (Azure Kubernetes Service)
  - authentication, 159-161
  - isolation configuration, 166-167
  - security configuration, 161-164

## alerts

- alerts
  - in Azure Monitor
    - creating/customizing, 183-189
    - viewing/changing, 188
  - in Azure Sentinel, creating/customizing, 217-224
- Always Encrypted, 279-281
- analytics in Azure Sentinel, 213
- API management policies, 73
- application access, 64-73
  - API management policies, 73
  - assigning, 66-70
  - permission consent, 71-73
  - permission scopes, 70-71
  - registering applications, 64-66
- Application Administrator role, 75
- Application Developer role, 75
- application gateways
  - Azure Front Door, 126-133
    - capabilities, 126
    - configuring, 127-133
    - topology, 127
  - WAF (Web Application Firewall) configuration, 133-135
- application objects, 2
- application permissions, 71
- application rules, creating, 120-122
- applications
  - assigning roles, 3-6
  - registering, 2, 64-66
- application security groups (ASGs), 114-117
- app passwords, 32
- ArcDelete ACR role, 167
- ArcImageSigner ACR role, 167
- ArcPull ACR role, 167
- ArcPush ACR role, 167
- ASGs (application security groups), 114-117
- assigning
  - application access, 66-70
  - permissions to service principals, 3-6
  - RBAC roles, 245-247
  - roles to applications, 3-6
  - users to roles, 78-79
- ATP (Advanced Threat Protection) for Azure Storage, 267-268
- auditing databases, 270-273
- audit logs, viewing, 271-273
- authentication, 30-36
  - in Azure App Service, configuring, 174-176
  - for Azure Files, 256-261
    - enabling, 257-261
    - file and folder permissions, 260
    - share-level permissions, 259
  - certificate-based, 33
  - for containers, 159-161
  - for databases, 268-269
  - MFA (multifactor authentication), 49, 54
    - administering users, 54-60
      - enabling, 50-54
      - passwordless, 33-36
    - for storage accounts, 255-256
    - types of, 31-32
    - for VPN gateways, 104-106
- Authentication Administrator role, 75
- authorization in Azure App Service, configuring, 174-176
- Azure Active Directory (Azure AD)
  - access control, 38-63, 74-85
  - access reviews, 40-42
  - activating/configuring PIM, 43-45
  - administering MFA users, 54-60
  - best practices, 81
  - conditional access policies, 46-54
  - configuring identity protection, 60-63
  - custom roles, 81-84
  - identifying roles, 81
  - interpreting permissions, 84
  - monitoring privileged access, 38-40
  - principle of least privilege, 81
  - resource group permissions, 79-80
  - subscription and resource permissions, 74-79
  - viewing user resource permissions, 84-85
- administrative console, accessing, 6
- application access, 64-73
  - API management policies, 73
  - assigning, 66-70
  - permission consent, 71-73
  - permission scopes, 70-71
  - registering applications, 64-66
- applications, registering, 2
- authentication methods, 30-36
  - certificate-based, 33
  - passwordless, 33-36
  - for storage accounts, 255-256
  - types of, 31-32
- container authentication, 159-161
- identities
  - configuring identity protection, 60-63
  - groups, 6-12
  - service principals, 2-6
  - types of, 1
  - users, 13-15
- password writeback, 15-30
  - enabling self-service password reset, 28-30
  - installing/configuring Azure AD Connect, 15-28
  - transferring subscriptions, 36-37
- Azure Active Directory Connect, 15-28
  - connectivity requirements, 16
  - deployment account requirements, 17
  - installing, 17-25
  - sign-in options, 27-28
  - SQL Server requirements, 16-17
  - system requirements, 15-16
  - UPN suffixes and nonroutable domains, 25-27
- Azure Active Directory Domain Services (Azure AD DS), authentication for Azure Files, 256-261
  - enabling, 257-261
  - file and folder permissions, 260
  - share-level permissions, 259
- Azure Active Directory logs in Azure Monitor, 181
- Azure Activity Log, accessing, 182

- Azure App Service
    - firewalls, 143-144
    - security configuration, 170-176
      - authentication, 174-176
      - software updates, 176
      - SSL/TLS certificates, 172-174
  - Azure Application Gateway
    - as load balancer, 126
    - WAF (Web Application Firewall) configuration, 133-135
  - Azure Automation Update Management, 156-159
  - Azure Bastion, 135-137
  - Azure Blueprint security settings, configuring, 236-240
  - Azure Container Registry (ACR)
    - security configuration, 167-168
    - vulnerability management, 164-165
  - Azure DDoS, 147-151
  - Azure Disk Encryption (ADE), 168-169
  - Azure Files authentication, 256-261
    - enabling, 257-261
    - file and folder permissions, 260
    - share-level permissions, 259
  - Azure Firewall
    - application rules, 120-122
    - configuring, 119-120
    - logging, 123-125
    - network rules, 122-123
    - topology, 117-118
  - Azure Front Door, 126-133
    - capabilities, 126
    - configuring, 127-133
    - topology, 127
    - WAF (Web Application Firewall) integration, 133
  - Azure Key Vault
    - access control, 282-285
    - with ADE (Azure Disk Encryption), 168
    - backup and restore, 303-307
    - certificate management, 288-296
    - firewalls, 142-143
    - key rotation, 298-303
    - network access, 282-285
    - permissions management, 285-287
    - RBAC usage, 287-288
    - secrets management, 296-298
    - secrets rotation, 302-303
    - storage account encryption keys, 264
  - Azure Kubernetes Service (AKS)
    - authentication, 159-161
    - isolation configuration, 166-167
    - security configuration, 161-164
  - Azure Logic Apps playbooks, configuring, 224-228
  - Azure Monitor, 179-196
    - activity logs, 180
    - alerts
      - creating/customizing, 183-189
      - viewing/changing, 188
    - Azure Active Directory logs, 181
    - enabling, 179
    - layers in, 180-181
    - log collecting
      - IaaS VM logs, 192-194
      - searching events in Log Analytics workspace, 195-196
      - Security and Audit solution, 194-195
    - metrics in, 181-184
    - operational overview, 180-183
    - resource (diagnostic) logs, 180
      - configuring settings, 189-192
    - resources in, 181
  - Azure Policy
    - centralized policy management in Azure Security Center, 206-209
    - security settings, configuring, 232-236
  - Azure Resources layer (Azure Monitor), 180
  - Azure Security Center, 196-211
    - for AKS (Azure Kubernetes Service), 163-164
    - Azure App Service security recommendations in, 171-172
    - centralized policy management, 206-209
    - JIT (Just In Time) VM access, 201-205
    - Regulatory Compliance dashboard, 209-211
    - viewing endpoint protection, 151-154
  - VM threat detection, 155-156
  - vulnerability assessment, 196-200
  - vulnerability management, 164-165
- Azure Sentinel, 212-232
  - alerts, creating/customizing, 217-224
  - components of, 212-213
  - data connectors, configuring, 213-217
  - playbooks, configuring, 224-228
  - results, evaluating, 228-232
- Azure SQL Database Advanced Threat Protection, 273-276
- Azure SQL databases. *See* databases
- Azure Storage. *See* storage accounts
- Azure Subscription layer (Azure Monitor), 180
- Azure Tenant layer (Azure Monitor), 181
- ## B
- backing up Azure Key Vault items, 303-307
  - Backup-AzKeyVaultCertificate cmdlet, 293
  - Backup-AzKeyVaultKey cmdlet, 300
  - Backup-AzKeyVaultSecret cmdlet, 297
  - Backup-AzureKeyVaultCertificate cmdlet, 306
  - Backup-AzureKeyVaultKey cmdlet, 306
  - Backup-AzureKeyVaultSecret cmdlet, 306
  - best practices
    - access control, 81
    - for SAS (Shared Access Signatures), 251-252
  - Billing Administrator role, 75
  - blobs
    - authentication, 255-256
    - encryption, viewing status, 262-263
    - stored access policies, 255
  - BlobStorage accounts, 244
  - BlockBlobStorage accounts, 244
  - blocking MFA users, 58

blueprints, 236-240  
BYOK (Bring Your Own Key), 276

## C

cases in Azure Sentinel, 212  
CDS (Common Data Service), 176  
centralized policy management in  
  Azure Security Center, 206-209  
certificate authorities for Azure Key  
  Vault, 289-292  
certificate policies, elements of,  
  288-289  
certificate-based authentication, 33  
certificates  
  in Azure Key Vault  
    adding, 289-293  
    backup and restore, 303-307  
    importing, 289-293  
    managing, 288-296  
    permissions, 286  
  contacts information, 289  
  SSL/TLS, configuring, 172-174  
changing Azure Monitor alerts, 188  
Cloud Application Administrator  
  role, 75  
Cloud Device Administrator role, 75  
Common Data Service (CDS), 176  
Community page in Azure Sentinel,  
  213  
Compliance Administrator role, 75  
compliance policies in Azure Se-  
  curity Center, 209-211  
compute security  
  for ACR (Azure Container  
    Registry), 167-168  
  authentication for containers,  
    159-161  
  for Azure App Service, 170-176  
  container security, 161-164  
  disk encryption, 168-169  
  endpoint security, 151-156  
  isolation, 166-167  
  system updates for VMs, 156-159  
  vulnerability management,  
    164-165  
Conditional Access Administrator  
  role, 75

conditional access policies, 46-54  
  creating, 47-49  
  implementing MFA, 49-54  
  types of, 46-47  
Connect-AzAccount cmdlet, 95  
connectivity requirements for Azure  
  AD Connect, 16  
connectors. *See* data connectors  
containers  
  authentication, 159-161  
  isolation configuration, 166-167  
  security configuration, 161-164  
Contributor ACR role, 167  
Contributor role, 77  
Customer Lockbox access approver  
  role, 75  
custom roles, 81-84  
custom routes, creating, 97

## D

dashboards in Azure Sentinel, 212  
databases  
  auditing, 270-273  
  authentication, 268-269  
  Azure SQL Database Advanced  
    Threat Protection, 273-276  
  encryption  
    Always Encrypted, 279-281  
    TDE (transparent data en-  
      ryption), 276-279  
  firewalls for, 140-142  
data connectors in Azure Sentinel,  
  213-217  
data plane for Key Vault access  
  control, 282  
data plane logs, 192  
DDoS (distributed denial of service)  
  protection, 147-151  
Debug-AzStorageAccountAuth  
  cmdlet, 259  
delegated permissions, 71  
deleting  
  group members, 10  
  nested groups, 12  
  users, 14  
deployment account requirements  
  for Azure AD Connect, 17  
Destination Network Address Trans-  
  lation (DNAT), 118

detection mode (WAF on Appli-  
  cation Gateway), 134  
deterministic encryption, 279  
Device Administrators role, 75  
diagnostic logs in Azure Monitor, 180  
  configuring settings, 189-192  
Directory Readers role, 75  
Directory Synchronization Accounts  
  role, 75  
Directory Writers role, 75  
distributed denial of service (DDoS)  
  protection, 147-151  
DNAT (Destination Network Address  
  Translation), 118  
dynamic group membership, 7  
Dynamics 365 Administrator/CRM  
  Administrator role, 75

## E

email addresses for authentication, 32  
email scope (application access), 71  
enabling  
  AD DS authentication, 257-259  
  Azure AD DS authentication,  
    260-261  
  Azure Monitor, 179  
  database auditing, 270-273  
  database authentication,  
    268-269  
  firewall logging, 124-125  
  MFA (multifactor authentication),  
    50-54  
  passwordless authentication,  
    34-35  
  self-service password reset,  
    28-30  
  sign-in risk policies, 61-63  
  user-risk policies, 61-63  
encryption  
  of databases  
    Always Encrypted, 279-281  
    TDE (transparent data en-  
      ryption), 276-279  
  ExpressRoute, 106-107  
  of storage accounts, 262-267  
  infrastructure encryption, 264  
  key management, 263-264  
  scopes, 264-267  
  viewing status, 262-263

- types of, 279-280
- for VMs (virtual machines), 156
- encryption at rest, 168-169
- endpoint security within VMs, 151-156
- evaluating results in Azure Sentinel, 228-232
- events, searching in Log Analytics workspace (Azure Monitor), 195-196
- Exchange Administrator role, 76
- ExpressRoute, 92, 104-107
- external connectors in Azure Sentinel, 214

## F

- FIDO2 Security keys, 34
- file and folder permissions, 260
- FileStorage accounts, 244
- firewalls
  - Azure Firewall
    - application rules, 120-122
    - configuring, 119-120
    - logging, 123-125
    - network rules, 122-123
    - topology, 117-118
  - for Azure Key Vault, 283-285
  - resource firewalls, 138-144
    - in Azure App Service, 143-144
    - in Azure Key Vault, 142-143
    - in Azure SQL databases, 140-142
    - in Azure Storage, 138-140
  - WAF (Web Application Firewall)
    - Azure Front Door integration, 133
    - configuring on Azure Application Gateway, 133-135
    - inbound HTTP/S protection, 118, 122
- fraud alert settings for MFA, 58
- Front Door. *See* Azure Front Door

## G

- General-Purpose V2 accounts, 244
- Get-ADOrganizationalUnit cmdlet, 258
- Get-AdUser cmdlet, 257

- Get-AzAdServicePrincipal cmdlet, 3
- Get-AzKeyVaultCertificate cmdlet, 293
- Get-AzKeyVaultCertificateContact cmdlet, 293
- Get-AzKeyVaultCertificateIssuer cmdlet, 293
- Get-AzKeyVaultCertificateOperation cmdlet, 293
- Get-AzKeyVaultCertificatePolicy cmdlet, 293
- Get-AzKeyVaultKey cmdlet, 300
- Get-AzKeyVaultSecret cmdlet, 297
- Get-AzRouteTable cmdlet, 97
- Get-AzureADDirectoryRole cmdlet, 78
- Get-AzureADDirectoryRoleMember cmdlet, 78
- Get-AzureADGroup cmdlet, 8
- Get-AzureKeyVaultSecret cmdlet, 296
- Get-AzVirtualNetworkGatewayConnectionSharedKey cmdlet, 105
- Get-AzVmDiskEncryptionStatus cmdlet, 169
- Global Administrator/Company Administrator role, 76
- groups, 6-12
  - adding/removing members, 10
  - assigning application access, 67-70
  - assigning roles to, 244
  - creating, 8-10
  - dynamic membership, 7
  - naming, 9
  - nested, 10-12
  - types of, 6-7
- Guest Inviter role, 76

## H-I

- HSM (hardware secure module) key protection, 299
- hunting in Azure Sentinel, 212, 231-232
- IaaS (Infrastructure as a Service) VM security logs, collecting with Azure Monitor, 192-194
- identities
  - configuring identity protection, 60-63
  - groups, 6-12
    - adding/removing members, 10
    - creating, 8-10

- dynamic membership, 7
- naming, 9
- nested, 10-12
- types of, 6-7
- service principals, 2-6
  - assigning permissions, 3-6
  - components of, 3
  - creating, 3
  - viewing list of, 3
- types of, 1
- users, 13-15
  - creating, 13-14
  - deleting, 14
  - recovering, 14
- identity providers for Azure App Service, 176
- Import-AzKeyVaultCertificate cmdlet, 293
- importing certificates to Azure Key Vault, 289-293
- inbound rules for NSGs (network security groups), 110
- incidents in Azure Sentinel, 230-231
- Information Protection Administrator role, 76
- Infrastructure as a Service (IaaS) VM security logs, collecting with Azure Monitor, 192-194
- infrastructure encryption, 264
- installing Azure AD Connect, 17-25
- Intune Administrator role, 76
- IPSec encryption, 107
- isolation configuration, 166-167

## J-K

- JIT (Just In Time) VM access, 201-205
- key management for storage accounts, 247. *See also* Azure Key Vault
  - encryption, 263-264
  - rotating keys, 247-250
  - viewing keys, 248-249
- Key Vault. *See* Azure Key Vault
- Key Vault Administrator role, 288
- Key Vault Certificates Officer role, 288
- Key Vault Contributor role, 288
- Key Vault Crypto Officer role, 288

## Key Vault Crypto Service Encryption role

- Key Vault Crypto Service Encryption role, 288
- Key Vault Crypto User role, 288
- Key Vault Reader role, 288
- Key Vault Secrets Officer role, 288
- Key Vault Secrets User role, 288
- keys in Azure Key Vault
  - backup and restore, 303-307
  - permissions, 286
  - rotating, 298-303
- KQL (Kusto Query Language), 125
- Kubernetes. *See* AKS (Azure Kubernetes Service)

## L

- layers in Azure Monitor, 180-181
- least privilege, principle of, 81, 155, 166
- License Administrator role, 76
- license requirements, PIM (Privileged Identity Management), 45
- load balancers, Azure Application Gateway as, 126
- locks in Azure Blueprint, 240
- Log Analytics workspace (Azure Monitor), searching events, 195-196
- Log Analytics workspace (Azure Sentinel), 228-229
- log collecting with Azure Monitor
  - IaaS VM logs, 192-194
  - searching events in Log Analytics workspace, 195-196
  - Security and Audit solution, 194-195
- log retention in Azure Monitor, configuring, 189-192
- logging in Azure Firewall, 123-125
- logical isolation, 166
- Logic Apps. *See* Azure Logic Apps

## M

- MACsec, 106-107
- management plane for Key Vault access control, 282
- Message Center Reader role, 76

- metrics in Azure Monitor, 181-183
  - creating alerts from, 184
- MFA (multifactor authentication), 49-60
  - administering users, 54-60
    - account lockout settings, 57
    - blocking/unblocking users, 58
    - fraud alert settings, 58
    - OATH tokens, 59
    - phone call settings, 59
    - reporting utilization, 60
  - enabling, 50-54
  - for VPN gateways, 105
- Microsoft Authenticator app, 32-34
- Microsoft incident creation rules in Azure Sentinel, 217, 223-224
- Microsoft Threat Intelligence, 119
- mobile phone numbers for authentication, 32
- Monitor. *See* Azure Monitor
- monitoring privileged access, 38-40
- multifactor authentication. *See* MFA (multifactor authentication)
- multi-site VPNs, 104

## N

- naming groups, 9
- NAT (network address translation), 100-103
- NAT Gateway
  - billing, 101
  - creating, 101-103
  - topology, 100-101
- nested groups, 10-12
- network access for Azure Key Vault, 282-285
- network components, 89-103
  - NAT (network address translation), 100-103
  - peering, 97-100
  - routing, 95-97
  - subnets, 91
  - virtual network gateways, 91
  - VNets (virtual networks), configuring, 90-95
- network rules, creating, 122-123
- network security
  - ASGs (application security groups), 114-117
  - Azure Bastion, 135-137
  - Azure Firewall, 117-125
  - DDoS (distributed denial of service) protection, 147-151
  - NSGs (network security groups), 91, 109-114, 201
  - resource firewalls, 138-144
  - service endpoints, 145-147
  - VPN gateways, 104-108
    - authentication, 104-106
    - ExpressRoute encryption, 106-107
    - point-to-site (P2S), 107-108
    - site-to-site (S2S), 108
    - types of, 104
  - WAF (Web Application Firewall), 133-135
- network security groups (NSGs), 91, 109-114, 201
- New-AzADServicePrincipal cmdlet, 3
- New-AzFirewallApplicationRule cmdlet, 122
- New-AzFirewall cmdlet, 120
- New-AzFirewallNetworkRule cmdlet, 123
- New-AzKeyVaultCertificateOrganizationDetail cmdlet, 294
- New-AzKeyVaultCertificatePolicy cmdlet, 294
- New-AzNatGateway cmdlet, 104
- New-AzNetworkSecurityGroup cmdlet, 112
- New-AzNetworkSecurityRuleConfig cmdlet, 114
- New-AzRoleAssignment cmdlet, 5
- New-AzRouteTable cmdlet, 97
- New-AzureADGroup cmdlet, 8
- New-AzVaultCertificateAdministratorDetail cmdlet, 294
- New-AzVirtualNetwork cmdlet, 95
- New-AzVM cmdlet, 95
- nonroutable domains, UPN suffixes and, 25-27
- notebooks in Azure Sentinel, 213
- NSGs (network security groups), 91, 109-114, 201

## O

- OATH tokens, 32
  - for MFA users, 59
- OAuth, 32
- Office 365 groups, 6-7
- offline access scope (application access), 71
- open scope (application access), 71
- operating systems supported on VMs, 197
- outbound rules for NSGs (network security groups), 111
- Owner ACR role, 167
- Owner role, 77

## P

- P2S (point-to-site) VPNs, 104, 107-108
- pass-through authentication in Azure AD Connect, 27-28
- Password Administrator/Helpdesk Administrator role, 76
- password authentication, 31
- passwordless authentication, 33-36
- password synchronization in Azure AD Connect, 27
- password writeback, 15-30
  - Azure AD Connect, 15-28
    - connectivity requirements, 16
    - deployment account requirements, 17
    - installing, 17-25
    - sign-in options, 27-28
    - SQL Server requirements, 16-17
    - system requirements, 15-16
    - UPN suffixes and non-routable domains, 25-27
    - enabling self-service password reset, 28-30
- peering virtual networks, 97-100
- permission consent for application access, 71-73
- permission scopes for application access, 70-71
- permissions, 74-85
  - assigning to service principals, 3-6
  - for Azure Key Vault, 285-287
  - custom roles, 81-84
  - file and folder, 260
  - identifying roles, 81
  - interpreting, 84
  - principle of least privilege, 81
  - resource group permissions, 79-80
  - share-level, 259
  - subscription and resource permissions, 74-79
  - viewing user resource permissions, 84-85
- phone call settings for MFA, 59
- physical isolation, 167
- PIM (Privileged Identity Management)
  - access reviews, 40-42
  - activating/configuring, 43-45
  - license requirements, 45
  - viewing resource audit history, 38-40
- playbooks in Azure Sentinel, 213
  - configuring, 224-228
- point-to-site (P2S) VPNs, 104, 107-108
- policies
  - blueprints versus, 236
  - centralized policy management in Azure Security Center, 206-209
  - policy definitions, 206
  - policy effect, 206
  - policy enforcement, configuring in Azure Blueprint, 236-240
  - in Azure Policy, 232-236
- Power BI Administrator role, 76
- prevention mode (WAF on Application Gateway), 135
- pricing tiers, ACR (Azure Container Registry), 167
- principle of least privilege, 81, 155, 166
- private endpoint connections for Azure Key Vault, 284
- privileged access, monitoring, 38-40
- Privileged Identity Management (PIM)
  - access reviews, 40-42
  - activating/configuring, 43-45

- license requirements, 45
  - viewing resource audit history, 38-40

- Privileged Role Administrator role, 76
- profile scope (application access), 71
- protocols for P2S (point-to-site) VPNs, 108

## Q-R

- Qualys extension, 196-198
- queue storage authentication, 255-256

- RADIUS, 105-106
- randomized encryption, 279
- RBAC (role-based access control)
  - with Azure Key Vault, 287-288
  - configuring, 77
  - container authentication, 159-161
  - custom roles, 81-84
  - identifying roles, 81
  - interpreting permissions, 84
  - principle of least privilege, 81
  - resource group permissions, 79-80
- roles
  - assigning, 245-247
  - for blob and queue storage, 256
  - levels of, 244
  - list of, 245
  - subscription and resource permissions, 74-79
  - viewing user resource permissions, 84-85
- Reader ACR role, 167
- Reader role, 77
- recovering users, 14
- registering applications, 2, 64-66
- Regulatory Compliance dashboard (Azure Security Center), 209-211
- Remove-AzKeyVaultCertificate cmdlet, 294
- Remove-AzKeyVaultCertificate-Contact cmdlet, 294
- Remove-AzKeyVaultCertificateIssuer cmdlet, 294

## Remove-AzKeyVaultCertificateOperation cmdlet

- Remove-AzKeyVaultCertificateOperation cmdlet, 294
- Remove-AzKeyVaultKey cmdlet, 300
- Remove-AzKeyVaultSecret cmdlet, 297
- Remove-AzureADDDirectoryRoleMember cmdlet, 79
- Remove-AzureADGroup cmdlet, 8
- Remove-AzureADGroupMember cmdlet, 8
- Remove-AzureADGroupOwner cmdlet, 8
- Remove-AzureKeyVaultSecret cmdlet, 296
- removing
  - group members, 10
  - nested groups, 12
  - users, 14
- reports, MFA utilization, 60
- Reports Reader role, 76
- requirements
  - Azure AD Connect
    - connectivity requirements, 16
    - deployment account requirements, 17
    - SQL Server requirements, 16-17
    - system requirements, 15-16
  - certificate-based authentication, 33
  - PIM (Privileged Identity Management), license requirements, 45
- resource audit history, viewing, 38-40
- resource firewalls, 138-144
  - in Azure App Service, 143-144
  - in Azure Key Vault, 142-143
  - in Azure SQL databases, 140-142
  - in Azure Storage, 138-140
- resource group permissions, 79-80
- resource logs in Azure Monitor, 180
  - configuring settings, 189-192
- resource permissions, 74-79
  - viewing, 84-85
- resources in Azure Monitor, 181
- Restore-AzKeyVaultCertificate cmdlet, 294
- Restore-AzKeyVaultKey cmdlet, 300

- Restore-AzKeyVaultSecret cmdlet, 297
- Restore-AzureKeyVaultCertificate cmdlet, 306
- Restore-AzureKeyVaultKey cmdlet, 306
- Restore-AzureKeyVaultSecret cmdlet, 306
- restoring Azure Key Vault items, 303-307
- results, evaluating in Azure Sentinel, 228-232
- revoking user delegation SAS, 252-253
- role-based access control. *See* RBAC (role-based access control)
- roles
  - assigning
    - to applications, 3-6
    - users to, 78-79
  - custom, 81-84
  - defined, 74
  - identifying, 81
  - list of, 75-76
  - RBAC
    - assigning, 245-247
    - for blob and queue storage, 256
    - levels of, 244
    - list of, 245
    - viewing assignments, 77-78
  - rotating
    - keys in Azure Key Vault, 298-303
    - secrets in Azure Key Vault, 302-303
    - storage account access keys, 247-250
  - routing, 95-97
  - rule of least privilege, 244
  - rules, creating
    - application rules, 120-122
    - network rules, 122-123

## S

- S2S (site-to-site) VPNs, 104, 108
- SAS (Shared Access Signatures), 251-254
  - account SAS, 253-254
  - best practices, 251-252

- tokens, 253-254
  - types of, 251
  - user delegation SAS, 252-253
- scheduled query rules in Azure Sentinel, 217-223
- scope
  - for permissions, 74
  - for storage account encryption, 264-267
- searching events in Log Analytics workspace (Azure Monitor), 195-196
- secrets in Azure Key Vault
  - backup and restore, 303-307
  - managing, 296-298
  - permissions, 286
  - rotating, 302-303
- security
  - Azure Front Door, 126-133
  - compute security
    - for ACR (Azure Container Registry), 167-168
    - authentication for containers, 159-161
    - for Azure App Service, 170-176
    - container security, 161-164
    - disk encryption, 168-169
    - endpoint security, 151-156
    - isolation, 166-167
    - system updates for VMs, 156-159
    - vulnerability management, 164-165
  - network security
    - ASGs (application security groups), 114-117
    - Azure Bastion, 135-137
    - Azure Firewall, 117-125
    - Azure Front Door, 126-133
    - DDoS (distributed denial of service) protection, 147-151
    - NSGs (network security groups), 91, 109-114, 201
    - resource firewalls, 138-144
    - service endpoints, 145-147
    - VPN gateways, 104-108
    - WAF (Web Application Firewall), 133-135

- Security Administrator role, 76
- Security and Audit solution (Azure Monitor), 194-195
- Security Center. *See* Azure Security Center
- security groups, 6-7
- Security Information and Event Management (SIEM), 212
- security key sign-in, 34
- Security Orchestration, Automation, and Response (SOAR), 212
- security principals, 74, 285
- security questions, 31-32
- Security Reader role, 76
- security services configuration. *See* Azure Monitor
- security settings, configuring
  - with Azure Blueprint, 236-240
  - with Azure Policy, 232-236
- self-service password reset (SSPR), 15
  - enabling, 28-30
- service endpoints, 145-147
- service principal objects, 2
- service principals, 2-6
  - assigning permissions, 3-6
  - components of, 3
  - creating, 3
  - viewing list of, 3
- service SAS, 251
- Service Support Administrator role, 76
- Set-ACL cmdlet, 260
- Set-AzDiagnosticSetting cmdlet, 125
- Set-AzKeyVaultAccessPolicy cmdlet, 286
- Set-AzKeyVaultCertificateIssuer cmdlet, 294
- Set-AzKeyVaultCertificatePolicy cmdlet, 294
- Set-AzKeyVaultSecret cmdlet, 296, 298
- Set-AzRouteTable cmdlet, 97
- Set-AzStorageAccount cmdlet, 261
- Set-AzureADGroup cmdlet, 8
- Set-AzVirtualNetwork cmdlet, 97
- Set-AzVirtualNetworkGatewayConnectionSharedKey cmdlet, 105
- Set-AzVirtualNetworkSubnetConfig cmdlet, 97
- Set-AzVmDiskEncryptionExtensions cmdlet, 169
- Shared Access Signatures (SAS), 251-254
  - account SAS, 253-254
  - best practices, 251-252
  - tokens, 253-254
  - types of, 251
  - user delegation SAS, 252-253
- shared responsibility model, 89
- share-level permissions, 259
- SharePoint Administrator role, 76
- SIEM (Security Information and Event Management), 212
- sign-in options in Azure AD Connect, 27-28
- sign-in risk policies, 61-63
- single sign-on, 15
- site-to-site (S2S) VPNs, 104, 108
- Skype for Business/Lync Administrator role, 76
- SOAR (Security Orchestration, Automation, and Response), 212
- software-protected keys, 299
- software updates in Azure App Service, 176
- SQL databases. *See* databases
- SQL Server requirements, Azure AD Connect, 16-17
- SQL Servers, vulnerability assessment, 199-200
- SSL/TLS certificates, configuring, 172-174
- SSPR (self-service password reset), 15
  - enabling, 28-30
- Stop-AzKeyVaultCertificateOperation cmdlet, 294
- Storage account Contributor role, 245
- Storage account Key Operator Service Role, 245
- storage accounts
  - ATP (Advanced Threat Protection) for Azure Storage, 267-268
  - authentication with Azure AD, 255-256
  - Azure Files authentication, 256-261
  - encryption, 262-267
    - infrastructure encryption, 264
    - key management, 263-264
    - scopes, 264-267
    - viewing status, 262-263
  - firewalls, 138-140
  - key management, 247
    - rotating keys, 247-250
    - viewing keys, 248-249
  - RBAC roles
    - assigning, 245-247
    - levels of, 244
    - list of, 245
  - SAS (Shared Access Signatures), 251-254
    - account SAS, 253-254
    - best practices, 251-252
    - types of, 251
    - user delegation SAS, 252-253
  - stored access policies, 255
    - types of, 244
- Storage Blob Data Contributor role, 245, 256
- Storage Blob Data Owner role, 245, 256
- Storage Blob Data Reader role, 245, 256
- Storage Blob Delegator role, 245, 256
- Storage File Data SMB Share Contributor role, 259
- Storage File Data SMB Share Elevated Contributor role, 245, 259
- Storage File Data SMB Share Reader role, 245, 259
- Storage File SMB Share Contributor role, 245
- Storage Queue Data Contributor role, 245, 256
- Storage Queue Data Message Processor role, 245, 256
- Storage Queue Data Message Sender role, 245, 256
- Storage Queue Data Reader role, 245, 256
- stored access policies
  - for blob containers, 255
  - with service SAS, 251

## subnets

- subnets, 91
- subscription permissions, 74-79
- subscriptions (Azure), transferring, 36-37
- system requirements, Azure AD Connect, 15-16
- system updates for VMs, 156-159

## T

- TDE (transparent data encryption), 276-279
- Teams Administrator role, 76
- Teams Communications Administrator role, 76
- Teams Communications Support Engineer role, 76
- Teams Communications Support Specialist role, 76
- templates for scheduled query rules in Azure Sentinel, 222-223
- tenants (Azure), transferring subscriptions, 36-37
- threat detection for VMs (virtual machines), 155-156
- threat hunting in Azure Sentinel, 231-232
- threat protection for SQL, 199
- traffic interruptions, 91
- transferring subscriptions (Azure), 36-37
- transparent data encryption (TDE), 276-279
- troubleshooting JIT (Just In Time) VM access, 205

## U

- unblocking MFA users, 58
- Undo-AzKeyVaultCertificateRemoval cmdlet, 294
- Undo-AzKeyVaultKeyRemoval cmdlet, 300
- Undo-AzKeyVaultSecretRemoval cmdlet, 298
- Update-AzKeyVaultCertificate cmdlet, 294
- Update-AzKeyVaultKey cmdlet, 300

- Update-AzKeyVaultSecret cmdlet, 298
- Update-AzStorageAccountADOjectPassword cmdlet, 259
- Update-AzStorageAccountNetworkRuleSet cmdlet, 140
- Update-AzureKeyVaultSecret cmdlet, 296
- Update Management (in Azure Automation), 156-159
- updates
  - software updates in Azure App Service, 176
  - system updates for VMs, 156-159
- UPN suffixes, nonroutable domains and, 25-27
- User Access Administrator role, 77
- User Account Administrator role, 76
- user delegation SAS, 251-253
- user principal objects, 2
- user resource permissions, viewing, 84-85
- user-risk policies, 61-63
- users, 13-15
  - assigning application access, 67-70
  - assigning to roles, 78-79
  - creating, 13-14
  - deleting, 14
  - recovering, 14
  - viewing role assignments, 77-78

## V

- viewing
  - audit logs, 271-273
  - Azure Monitor alerts, 188
  - blob encryption status, 262-263
  - endpoint protection, 151-154
  - resource audit history, 38-40
  - service principal list, 3
  - storage account access keys, 248-249
  - user resource permissions, 84-85
  - user role assignments, 77-78
- virtual network gateways, 91, 104-108
  - authentication, 104-106
  - ExpressRoute encryption, 106-107

- point-to-site (P2S), 107-108
- site-to-site (S2S), 108
- types of, 104
- VMs (virtual machines)
  - disk encryption, 168-169
  - endpoint security, 151-156
  - system updates, 156-159
- VNets (virtual networks)
  - for Azure Key Vault, 283-285
  - configuring, 90-95
  - NAT (network address translation), 100-103
  - peering, 97-100
  - routing, 95-97
  - security, 104-108
  - service endpoints, 145-147
- VNet-to-VNet VPNs, 104
- VPN gateways, 91, 104-108
  - authentication, 104-106
  - ExpressRoute encryption, 106-107
  - point-to-site (P2S), 107-108
  - site-to-site (S2S), 108
  - types of, 104
- vulnerability assessment with Azure Security Center, 196-200
- vulnerability management, 164-165

## W-Z

- WAF (Web Application Firewall)
  - Azure Front Door integration, 133
  - configuring on Azure Application Gateway, 133-135
  - inbound HTTP/S protection, 118, 122
- Windows Hello for Business, 34
- workbooks in Azure Sentinel, 229-230
- workspaces in Azure Sentinel, 213
- x509 certificates, managing in Azure Key Vault, 288-296