Contents

[Azure Virtual Machines 14](#_Toc141866568)

[Create a Windows virtual machine in the Azure portal 14](#_Toc141866569)

[Create a Linux Virtual Machine in the Azure Portal 15](#_Toc141866570)

[Availability Options for Azure Virtual Machines 17](#_Toc141866571)

[Availability zones 17](#_Toc141866572)

[Virtual Machines Scale Sets 17](#_Toc141866573)

[Availability sets 17](#_Toc141866574)

[Load balancer 18](#_Toc141866575)

[Azure Storage redundancy 18](#_Toc141866576)

[Azure Site Recovery 18](#_Toc141866577)

[What are Azure Regions and Availability Zones? 18](#_Toc141866578)

[Regions 19](#_Toc141866579)

[Availability zones 19](#_Toc141866580)

[What are Virtual Machine Scale Sets? 20](#_Toc141866581)

[Why use Virtual Machine Scale Sets? 20](#_Toc141866582)

[Availability Sets Overview 21](#_Toc141866583)

[What is an availability set? 21](#_Toc141866584)

[How do availability sets work? 21](#_Toc141866585)

[Create Virtual Machines in a Scale Set using Azure Portal 23](#_Toc141866586)

[Azure Resource Groups 26](#_Toc141866587)

[Manage Azure Resource Groups by using the Azure Portal 26](#_Toc141866588)

[What is a resource group 26](#_Toc141866589)

[Create resource groups 26](#_Toc141866590)

[List resource groups 26](#_Toc141866591)

[Open resource groups 26](#_Toc141866592)

[Delete resource groups 27](#_Toc141866593)

[Grant a user access to Azure resources using the Azure portal 27](#_Toc141866594)

[Create a resource group 27](#_Toc141866595)

[Grant access 27](#_Toc141866596)

[Remove access 28](#_Toc141866597)

[Clean up 28](#_Toc141866598)

[Azure App Service 29](#_Toc141866599)

[Why use App Service? 29](#_Toc141866600)

[App Service on Linux 30](#_Toc141866601)

[Built-in languages and frameworks 30](#_Toc141866602)

[Azure App Service Plan 31](#_Toc141866603)

[How does my app run and scale? 32](#_Toc141866604)

[How much does my App Service plan cost? 32](#_Toc141866605)

[Deploy an ASP.NET Core Web App using Visual Studio 32](#_Toc141866606)

[Deploy an ASP.NET Core Web App using Visual Studio Code 33](#_Toc141866607)

[Prerequisites 33](#_Toc141866608)

[Create an ASP.NET web app 33](#_Toc141866609)

[Publish your web app 33](#_Toc141866610)

[Update the app and redeploy 34](#_Toc141866611)

[Manage the Azure app 35](#_Toc141866612)

[Clean up resources 35](#_Toc141866613)

[Deploy an ASP.NET Core and Azure SQL Database app to Azure App Service 35](#_Toc141866614)

[Azure Virtual Network (VNet) 36](#_Toc141866615)

[What is Azure Virtual Network? 36](#_Toc141866616)

[Why use an Azure Virtual network? 36](#_Toc141866617)

[Advantages of Using Azure Virtual Network 38](#_Toc141866618)

[Elements of Azure Virtual Network 38](#_Toc141866619)

[Subnets 38](#_Toc141866620)

[Routing 39](#_Toc141866621)

[Network Security Groups 39](#_Toc141866622)

[Getting Familiar with IP Addressing 39](#_Toc141866623)

[What is IP Address? 39](#_Toc141866624)

[IPv4 Overview 40](#_Toc141866625)

[What is IP Subnetting? 40](#_Toc141866626)

[CIDR (Classless Inter-Domain Routing) 41](#_Toc141866627)

[CIDR Available Hosts 41](#_Toc141866628)

[IP Address in Azure 42](#_Toc141866629)

[IP Allocation 42](#_Toc141866630)

[Azure Virtual Network 42](#_Toc141866631)

[Azure Subnet 43](#_Toc141866632)

[Azure Network Interface 43](#_Toc141866633)

[Network Security 43](#_Toc141866634)

[Network Security Group (NSG) 43](#_Toc141866635)

[Service Endpoints 44](#_Toc141866636)

[Web Application Firewall (WAF) 44](#_Toc141866637)

[Azure Network Models 44](#_Toc141866638)

[VNet Peering 45](#_Toc141866639)

[Virtual WAN (Wide Area Network) 45](#_Toc141866640)

[Use the Azure portal to create a virtual network 46](#_Toc141866641)

[Create a virtual network 46](#_Toc141866642)

[Create virtual machines 47](#_Toc141866643)

[Connect to a VM 47](#_Toc141866644)

[Communicate between VMs 48](#_Toc141866645)

[Clean up resources 48](#_Toc141866646)

[NAT Gateway 48](#_Toc141866647)

[What is Azure NAT Gateway? 48](#_Toc141866648)

[Create a NAT gateway using the Azure portal 49](#_Toc141866649)

[Azure SQL 54](#_Toc141866650)

[What is Azure SQL? 54](#_Toc141866651)

[Service comparison 54](#_Toc141866652)

[Azure SQL Database 55](#_Toc141866653)

[Azure SQL Managed Instance 55](#_Toc141866654)

[SQL Server on Azure VM 56](#_Toc141866655)

[Comparison table 56](#_Toc141866656)

[Administration 58](#_Toc141866657)

[Create a single database - Azure SQL Database 58](#_Toc141866658)

[Create a single database 58](#_Toc141866659)

[Query the database 59](#_Toc141866660)

[Clean up resources 60](#_Toc141866661)

[Create a server-level firewall rule in Azure portal 60](#_Toc141866662)

[Prerequisites 60](#_Toc141866663)

[Create a server-level IP-based firewall rule 60](#_Toc141866664)

[Clean up resources 61](#_Toc141866665)

[Use the Azure portal query editor to query Azure SQL Database 62](#_Toc141866666)

[Prerequisites 62](#_Toc141866667)

[Connect to the query editor 62](#_Toc141866668)

[Query the database 62](#_Toc141866669)

[Connect to and query Azure SQL Database using .NET and Entity Framework Core 64](#_Toc141866670)

[Prerequisites 64](#_Toc141866671)

[Configure the database server 64](#_Toc141866672)

[Create the project 66](#_Toc141866673)

[Add Entity Framework Core to the project 66](#_Toc141866674)

[Add the code to connect to Azure SQL Database 66](#_Toc141866675)

[Run the migrations to create the database 69](#_Toc141866676)

[Test the app locally 69](#_Toc141866677)

[Deploy to Azure App Service 70](#_Toc141866678)

[~~Connect the App Service to Azure SQL Database~~ 71](#_Toc141866679)

[Test the deployed application 73](#_Toc141866680)

[Connect to and query Azure SQL Database using .NET and the Microsoft.Data.SqlClient library 73](#_Toc141866681)

[Prerequisites 73](#_Toc141866682)

[Configure the database 73](#_Toc141866683)

[Create the project 75](#_Toc141866684)

[Add the Microsoft.Data.SqlClient library 75](#_Toc141866685)

[Configure the connection string 75](#_Toc141866686)

[Add the code to connect to Azure SQL Database 76](#_Toc141866687)

[Run and test the app locally 78](#_Toc141866688)

[Deploy to Azure App Service 78](#_Toc141866689)

[Connect the App Service to Azure SQL Database 79](#_Toc141866690)

[Test the deployed application 81](#_Toc141866691)

[Secure a database in Azure SQL Database 82](#_Toc141866692)

[Design a relational database in Azure SQL Database using SSMS 82](#_Toc141866693)

[Prerequisites 82](#_Toc141866694)

[Create a blank database in Azure SQL Database 82](#_Toc141866695)

[Create a server-level IP firewall rule 83](#_Toc141866696)

[Connect to the database 84](#_Toc141866697)

[Create tables in your database 85](#_Toc141866698)

[Load data into the tables 86](#_Toc141866699)

[Query data 87](#_Toc141866700)

[Design a relational database in Azure SQL Database using Azure Data Studio (ADS) 87](#_Toc141866701)

[What is Azure SQL Managed Instance (MI)? 87](#_Toc141866702)

[What is SQL Server on Windows Azure Virtual Machines? 87](#_Toc141866703)

[Azure Storage 88](#_Toc141866704)

[Introduction to Azure Storage – Compare Core Storage Services 88](#_Toc141866705)

[Azure Storage redundancy 88](#_Toc141866706)

[Storage Explorer 88](#_Toc141866707)

[Prerequisites 88](#_Toc141866708)

[Download and install 89](#_Toc141866709)

[Connect to a storage account or service 89](#_Toc141866710)

[Create a Storage Account 96](#_Toc141866711)

[Basics tab 96](#_Toc141866712)

[Advanced tab 98](#_Toc141866713)

[Networking tab 102](#_Toc141866714)

[Data protection tab 103](#_Toc141866715)

[Encryption tab 105](#_Toc141866716)

[Tags tab 107](#_Toc141866717)

[Review + create tab 107](#_Toc141866718)

[Delete a storage account 107](#_Toc141866719)

[Azure Blobs Storage 107](#_Toc141866720)

[About Blob Storage 107](#_Toc141866721)

[Upload, download, and list blobs with the Azure portal 108](#_Toc141866722)

[Use Azure Storage Explorer to create a blob 111](#_Toc141866723)

[Azure Blob Storage client library for .NET 111](#_Toc141866724)

[Host a static website on Blob Storage 119](#_Toc141866725)

[Azure Queue Storage 119](#_Toc141866726)

[Queue Storage concepts 119](#_Toc141866727)

[Create a queue and add a message with the Azure portal 120](#_Toc141866728)

[Azure Queue Storage client library for .NET Core 120](#_Toc141866729)

[Get started with Azure Queue Storage using .NET Framework 127](#_Toc141866730)

[Work with Azure Queue Storage queues in .NET 127](#_Toc141866731)

[Azure Table Storage 128](#_Toc141866732)

[What is Table storage 128](#_Toc141866733)

[Table storage concepts 128](#_Toc141866734)

[Understanding the Table service data model 129](#_Toc141866735)

[Create a table in the Azure portal 133](#_Toc141866736)

[Azure Cosmos DB for Table for .NET 134](#_Toc141866737)

[Choose Table Storage or Azure CosmosDB for Table 141](#_Toc141866738)

[Tables, Blobs, Queues & File Storage in Microsoft Azure 141](#_Toc141866739)

[Azure Files Storage 141](#_Toc141866740)

[Create and use an Azure file share 141](#_Toc141866741)

[Create an SMB Azure file share and connect it to a Windows VM using the Azure portal 141](#_Toc141866742)

[Mount SMB Azure file share on Windows 141](#_Toc141866743)

[Azure CosmosDB 142](#_Toc141866744)

[Create an Azure Cosmos DB account, database, container, and items from the Azure portal 142](#_Toc141866745)

[Prerequisites 142](#_Toc141866746)

[Create an Azure Cosmos DB account 142](#_Toc141866747)

[Add a database and a container 144](#_Toc141866748)

[Add data to your database 145](#_Toc141866749)

[Query your data 145](#_Toc141866750)

[Clean up resources 146](#_Toc141866751)

[Azure Cosmos DB for NoSQL client library for .NET 146](#_Toc141866752)

[Azure Cosmos DB for Table for .NET 146](#_Toc141866753)

[Develop an ASP.NET web application with Azure Cosmos DB for NoSQL 147](#_Toc141866754)

[Develop a .NET console application with Azure Cosmos DB for NoSQL 147](#_Toc141866755)

[Getting started with Azure Cosmos DB – end to end example 147](#_Toc141866756)

[Azure Functions 148](#_Toc141866757)

[Scenarios 148](#_Toc141866758)

[Development lifecycle 148](#_Toc141866759)

[Differences between in-process and isolated worker process .NET Azure Functions 149](#_Toc141866760)

[Execution mode comparison table 149](#_Toc141866761)

[Create Azure Function using Visual Studio 150](#_Toc141866762)

[Create a function app project 150](#_Toc141866763)

[Rename the function 151](#_Toc141866764)

[Run the function locally 152](#_Toc141866765)

[Publish the project to Azure 152](#_Toc141866766)

[Verify your function in Azure 154](#_Toc141866767)

[Clean up resources 154](#_Toc141866768)

[Create Azure Function using Visual Studio Code 154](#_Toc141866769)

[Connect Functions to Azure Storage using Visual Studio 155](#_Toc141866770)

[Prerequisites 155](#_Toc141866771)

[Download the Function App Settings 155](#_Toc141866772)

[Register Binding Extensions 156](#_Toc141866773)

[Add An Output Binding 156](#_Toc141866774)

[Add Code that Uses the Output Binding 157](#_Toc141866775)

[Run the Function Locally 158](#_Toc141866776)

[Connect Storage Explorer to Your Account 159](#_Toc141866777)

[Examine the Output Queue 159](#_Toc141866778)

[Redeploy and Verify the Updated App 159](#_Toc141866779)

[Create Azure Function with Queue Trigger using Visual Studio 159](#_Toc141866780)

[Connect Azure Functions to Azure SQL Database using Visual Studio 161](#_Toc141866781)

[Prerequisites 161](#_Toc141866782)

[Create a Server-Level Firewall Rule in Azure Portal 162](#_Toc141866783)

[Get Connection Information 163](#_Toc141866784)

[Set the Connection String 163](#_Toc141866785)

[Add the SqlClient package to the project 165](#_Toc141866786)

[Add a timer triggered function 165](#_Toc141866787)

[Connect Azure Functions to Azure SQL Database using Visual Studio Code 167](#_Toc141866788)

[Http Trigger with Blob Input 167](#_Toc141866789)

[Durable Functions 169](#_Toc141866790)

[Supported languages 169](#_Toc141866791)

[Application patterns 169](#_Toc141866792)

[Pattern #1: Function chaining 170](#_Toc141866793)

[Pattern #2: Fan out/fan in 171](#_Toc141866794)

[Pattern #3: Async HTTP APIs 172](#_Toc141866795)

[Pattern #4: Monitor 173](#_Toc141866796)

[Pattern #5: Human interaction 175](#_Toc141866797)

[Pattern #6: Aggregator (stateful entities) 178](#_Toc141866798)

[Create a Durable Function in C# Using Visual Studio 179](#_Toc141866799)

[Prerequisites 180](#_Toc141866800)

[Create a function app project 180](#_Toc141866801)

[Add functions to the app 180](#_Toc141866802)

[Test the function locally 181](#_Toc141866803)

[Publish the project to Azure 183](#_Toc141866804)

[Test your function in Azure 185](#_Toc141866805)

[Create a Durable Function in C# Using Visual Studio Code 185](#_Toc141866806)

[Prerequisites 185](#_Toc141866807)

[Create your local project 186](#_Toc141866808)

[Add functions to the app 186](#_Toc141866809)

[Test the function locally 187](#_Toc141866810)

[Sign in to Azure 188](#_Toc141866811)

[Create the function app in Azure 189](#_Toc141866812)

[Deploy the project to Azure 190](#_Toc141866813)

[Test your function in Azure 191](#_Toc141866814)

[Function chaining in Durable Functions - Hello sequence sample 191](#_Toc141866815)

[Fan-out/fan-in scenario in Durable Functions - Cloud backup example 191](#_Toc141866816)

[Azure Logic Apps 192](#_Toc141866817)

[Create an example Consumption workflow in multi-tenant Azure Logic Apps with the Azure portal 192](#_Toc141866818)

[Create automated integration workflows with multi-tenant Azure Logic Apps and Visual Studio 192](#_Toc141866819)

[Create an example Standard workflow in single-tenant Azure Logic Apps with the Azure portal 192](#_Toc141866820)

[Create a Standard logic app workflow for single-tenant Azure Logic Apps using Visual Studio Code 192](#_Toc141866821)

[Azure Event Grid 193](#_Toc141866822)

[Overview 193](#_Toc141866823)

[Capabilities 194](#_Toc141866824)

[MQTT messaging (preview) 194](#_Toc141866825)

[Event messaging (HTTP) 194](#_Toc141866826)

[Use cases: 195](#_Toc141866827)

[MQTT messaging 195](#_Toc141866828)

[Push delivery of discrete events 196](#_Toc141866829)

[Pull delivery of discrete events 198](#_Toc141866830)

[How much does Event Grid cost? 199](#_Toc141866831)

[Subscribe to Storage Events 199](#_Toc141866832)

[Use Azure Event Grid to Route Blob Storage Events to Web Endpoint (Azure portal) 199](#_Toc141866833)

[Create a storage account 200](#_Toc141866834)

[Create a message endpoint 201](#_Toc141866835)

[Register the Event Grid resource provider 203](#_Toc141866836)

[Subscribe to the Blob storage 203](#_Toc141866837)

[Send an event to your endpoint 207](#_Toc141866838)

[Clean up resources 208](#_Toc141866839)

[Route custom events to web endpoint with the Azure portal and Azure Event Grid 208](#_Toc141866840)

[Route Custom Events to an Azure Function with Event Grid 208](#_Toc141866841)

[Create Azure function app 208](#_Toc141866842)

[Create a function 209](#_Toc141866843)

[Create a custom topic 209](#_Toc141866844)

[Subscribe to custom topic 210](#_Toc141866845)

[Send an event to your topic 211](#_Toc141866846)

[Clean up resources 214](#_Toc141866847)

[Route Custom Events to Azure Queue storage via Event Grid using Azure CLI 214](#_Toc141866848)

[Route Custom Events to Azure Event Hubs with Azure CLI and Event Grid 214](#_Toc141866849)

[Email when VM Changes 214](#_Toc141866850)

[Resize Uploaded Images 214](#_Toc141866851)

[Step 1: Upload image data in the cloud with Azure Storage 214](#_Toc141866852)

[Step 2: Automate resizing uploaded images using Event Grid 214](#_Toc141866853)

[Azure API Management 215](#_Toc141866854)

[Create a new Azure API Management service instance by using the Azure portal 215](#_Toc141866855)

[1. Import and Publish your First API 215](#_Toc141866856)

[2. Create and Publish a Product 215](#_Toc141866857)

[3. Mock API Responses 215](#_Toc141866858)

[4. Transform and Protect your API 215](#_Toc141866859)

[5. Monitor Published APIs 215](#_Toc141866860)

[6. Debug your APIs using Request Tracing 215](#_Toc141866861)

[7. Add Revisions – Use Revisions to make Non-Breaking API changes safely 215](#_Toc141866862)

[8. Add Multiple Versions – Publish Multiple Versions of your API 216](#_Toc141866863)

[9. Access and Customize the Developer Portal 216](#_Toc141866864)

[10. Manage APIs in VS Code – Use the API Management Extension for Visual Studio Code to import and manage APIs 216](#_Toc141866865)

[Create a new Azure API Management service instance using Visual Studio Code 216](#_Toc141866866)

[Introduction to Azure API Management - Training 216](#_Toc141866867)

[Azure Service Bus 217](#_Toc141866868)

[Overview 217](#_Toc141866869)

[Concepts 218](#_Toc141866870)

[Queues 218](#_Toc141866871)

[Topics 218](#_Toc141866872)

[Namespaces 219](#_Toc141866873)

[Advanced features 219](#_Toc141866874)

[Message sessions 219](#_Toc141866875)

[Auto-forwarding 219](#_Toc141866876)

[Dead-lettering 219](#_Toc141866877)

[Scheduled delivery 220](#_Toc141866878)

[Message deferral 220](#_Toc141866879)

[Transactions 220](#_Toc141866880)

[Filters and actions 220](#_Toc141866881)

[Auto-delete on idle 220](#_Toc141866882)

[Duplicate detection 220](#_Toc141866883)

[Security 220](#_Toc141866884)

[Geo-disaster recovery 220](#_Toc141866885)

[Integration 221](#_Toc141866886)

[Azure Service Bus Queues 221](#_Toc141866887)

[Create a Service Bus Queue Namespace and Queue using the Azure Portal 221](#_Toc141866888)

[QuickStart: Send and Receive Messages from an Azure Service Bus Queue (.NET) 223](#_Toc141866889)

[Azure Service Bus Topics and Subscriptions 241](#_Toc141866890)

[Create Service Bus Topics and Subscriptions using the Azure Portal 241](#_Toc141866891)

[Create a Namespace in the Azure Portal 241](#_Toc141866892)

[Create a Topic using the Azure Portal 242](#_Toc141866893)

[Create Subscriptions to the Topic 242](#_Toc141866894)

[Publish and Subscribe for Messages (.NET) 243](#_Toc141866895)

[Prerequisites 243](#_Toc141866896)

[Create a Namespace in the Azure Portal 244](#_Toc141866897)

[Create a topic using the Azure portal 244](#_Toc141866898)

[Create a Subscription to the Topic 244](#_Toc141866899)

[Authenticate the app to Azure 244](#_Toc141866900)

[Launch Visual Studio and sign-in to Azure 246](#_Toc141866901)

[Send messages to the topic 247](#_Toc141866902)

[Receive messages from a subscription 251](#_Toc141866903)

[Respond to Azure Service Bus events received via Azure Event Grid by using Azure Logic Apps 259](#_Toc141866904)

[Respond to Azure Service Bus events received via Azure Event Grid by using Azure Functions 259](#_Toc141866905)

[Azure Monitor 260](#_Toc141866906)

[Getting Started with Azure Monitor 260](#_Toc141866907)

[Monitor Azure Resources with Azure Monitor 260](#_Toc141866908)

[Analyze Metrics for an Azure resource 260](#_Toc141866909)

[Collect and Analyze Resource Logs from an Azure Resource 260](#_Toc141866910)

[Create a Metric Alert for an Azure Resource 260](#_Toc141866911)

[Azure Application Insights 261](#_Toc141866912)

[Application Insights Overview 261](#_Toc141866913)

[Application Insights for ASP.NET Core applications 261](#_Toc141866914)

[ILogger: Application Insights Logging with .NET 261](#_Toc141866915)

[Enable Application Insights for ASP.NET Core applications 261](#_Toc141866916)

[Azure DevOps 262](#_Toc141866917)

[Creating a Service Connection 262](#_Toc141866918)

[Classic 262](#_Toc141866919)

[Variable Scope in Release Pipeline 262](#_Toc141866920)

[YAML 263](#_Toc141866921)

[Prerequisites 263](#_Toc141866922)

[Create Your Pipeline 263](#_Toc141866923)

[Make configuration changes 268](#_Toc141866924)

[Deploying conditionally 269](#_Toc141866925)

[Add Unit Test and Code Coverage to the YAML Pipeline 269](#_Toc141866926)

[Run Basic Unit Tests 269](#_Toc141866927)

[Run Unit Tests with VSTest and Output Unit Test and Code Coverage Results Files 269](#_Toc141866928)

[Configure dotnet test to Output Unit Test Results 270](#_Toc141866929)

[Configure dotnet test to Output Code Coverage Results 270](#_Toc141866930)

[Full DotNetCoreCLI@2 Task to Output Unit Test and Code Coverage Results 271](#_Toc141866931)

[Publish VSTest Unit Test Result to Azure Pipeline 271](#_Toc141866932)

[Publish Coverlet and Cobertura Code Coverage Results to Azure Pipeline 272](#_Toc141866933)

[Azure Pipeline Display of Unit Test and Code Coverage Results 273](#_Toc141866934)

[Full YAML 274](#_Toc141866935)

[Deploy an Azure Function App using Azure DevOps 276](#_Toc141866936)

[YAML 276](#_Toc141866937)

[Classic 276](#_Toc141866938)

[Terraform on Azure 277](#_Toc141866939)

[What is Infrastructure as Code with Terraform? 277](#_Toc141866940)

[Terraform providers for Azure infrastructure 277](#_Toc141866941)

[Benefits of Terraform with Azure 277](#_Toc141866942)

[Common IaC tool 278](#_Toc141866943)

[Automate infrastructure management 278](#_Toc141866944)

[Understand infrastructure changes before being applied 278](#_Toc141866945)

[Terraform Benefits – In General 278](#_Toc141866946)

[Manage any infrastructure 278](#_Toc141866947)

[Standardize your deployment workflow 278](#_Toc141866948)

[Track your infrastructure 279](#_Toc141866949)

[Collaborate 279](#_Toc141866950)

[Install Terraform 279](#_Toc141866951)

[Manual Installation 279](#_Toc141866952)

[Homebrew on OS X 280](#_Toc141866953)

[Chocolatey on Windows 281](#_Toc141866954)

[Linux 281](#_Toc141866955)

[Verify the installation 282](#_Toc141866956)

[Troubleshoot 282](#_Toc141866957)

[Enable tab completion 282](#_Toc141866958)

[Quick start tutorial 282](#_Toc141866959)

[Build Infrastructure - Terraform Azure Example 285](#_Toc141866960)

[Prerequisites 285](#_Toc141866961)

[Install the Azure CLI tool 285](#_Toc141866962)

[Authenticate using the Azure CLI 285](#_Toc141866963)

[Create a Service Principal 286](#_Toc141866964)

[Set your environment variables 286](#_Toc141866965)

[Write Configuration 286](#_Toc141866966)

[Initialize your Terraform configuration 288](#_Toc141866967)

[Format and validate the configuration 289](#_Toc141866968)

[Apply your Terraform Configuration 289](#_Toc141866969)

[Inspect your state 290](#_Toc141866970)

[Change Infrastructure 291](#_Toc141866971)

[Create a new resource 291](#_Toc141866972)

[Apply your changes 291](#_Toc141866973)

[Modify an existing resource 292](#_Toc141866974)

[Apply your changes 292](#_Toc141866975)

[Review updates to state 293](#_Toc141866976)

[Destroy Infrastructure 293](#_Toc141866977)

[Define Input Variables 295](#_Toc141866978)

[Query Data with Output Variables 298](#_Toc141866979)

[Store Remote State 299](#_Toc141866980)

# Cloud Services Comparison



# Azure Virtual Machines

<https://learn.microsoft.com/en-us/azure/virtual-machines/overview>

Azure virtual machines are one of several types of [on-demand, scalable computing resources](https://learn.microsoft.com/en-us/azure/architecture/guide/technology-choices/compute-decision-tree) that Azure offers. Typically, you choose a virtual machine when you need more control over the computing environment than the other choices offer. This article gives you information about what you should consider before you create a virtual machine, how you create it, and how you manage it.

An Azure virtual machine gives you the flexibility of virtualization without having to buy and maintain the physical hardware that runs it. However, you still need to maintain the virtual machine by performing tasks, such as configuring, patching, and installing the software that runs on it.

## Create a Windows virtual machine in the Azure portal

<https://learn.microsoft.com/en-us/azure/virtual-machines/windows/quick-create-portal>

* Sign in to Azure

Sign in to the Azure portal at [https://portal.azure.com](https://portal.azure.com/).

* Create virtual machine

1. Enter virtual machines in the search.
2. Under **Services**, select **Virtual machines**.
3. In the **Virtual machines** page, select **Create** and then **Azure virtual machine**. The **Create a virtual machine** page opens.
4. Under **Instance details**, enter myVM for the **Virtual machine name** and choose Windows Server 2019 Datacenter - Gen 2 for the **Image**. Leave the other defaults.
5. Under **Administrator account**, provide a username, such as azureuser and a password. The password must be at least 12 characters long and meet the [defined complexity requirements](https://learn.microsoft.com/en-us/azure/virtual-machines/windows/faq#what-are-the-password-requirements-when-creating-a-vm-).
6. Under **Inbound port rules**, choose **Allow selected ports** and then select **RDP (3389)** and **HTTP (80)** from the drop-down.
7. Leave the remaining defaults and then select the **Review + create** button at the bottom of the page.
8. After validation runs, select the **Create** button at the bottom of the page.
9. After deployment is complete, select **Go to resource**.

* Connect to virtual machine

Create a remote desktop connection to the virtual machine. These directions tell you how to connect to your VM from a Windows computer. On a Mac, you need an RDP client such as this [Remote Desktop Client](https://apps.apple.com/app/microsoft-remote-desktop/id1295203466?mt=12) from the Mac App Store.

1. On the overview page for your virtual machine, select the **Connect** > **RDP**.
2. In the **Connect with RDP** tab, keep the default options to connect by IP address, over port 3389, and click **Download RDP file**.
3. Open the downloaded RDP file and click **Connect** when prompted.
4. In the **Windows Security** window, select **More choices** and then **Use a different account**. Type the username as **localhost**\username, enter the password you created for the virtual machine, and then click **OK**.
5. You may receive a certificate warning during the sign-in process. Click **Yes** or **Continue** to create the connection.

* Install web server

To see your VM in action, install the IIS web server. Open a PowerShell prompt on the VM and run the following command:

Install-WindowsFeature -name Web-Server -IncludeManagementTools

When done, close the RDP connection to the VM.

* View the IIS welcome page

In the portal, select the VM and in the overview of the VM, hover over the IP address to show **Copy to clipboard**. Copy the IP address and paste it into a browser tab.

* Clean up resources

When no longer needed, you can delete the resource group, virtual machine, and all related resources.

1. On the Overview page for the VM, select the **Resource group** link.
2. At the top of the page for the resource group, select **Delete resource group**.
3. A page will open warning you that you are about to delete resources. Type the name of the resource group and select **Delete** to finish deleting the resources and the resource group.

## Create a Linux Virtual Machine in the Azure Portal

<https://learn.microsoft.com/en-us/azure/virtual-machines/linux/quick-create-portal?tabs=ubuntu>

* Sign in to Azure

Sign in to the [Azure portal](https://portal.azure.com/).

* Create virtual machine

1. Enter virtual machines in the search.
2. Under **Services**, select **Virtual machines**.
3. In the **Virtual machines** page, select **Create** and then **Virtual machine**. The **Create a virtual machine** page opens.
4. In the **Basics** tab, under **Project details**, make sure the correct subscription is selected and then choose to **Create new** resource group. Enter myResourceGroup for the name.\*.
5. Under **Instance details**, enter myVM for the **Virtual machine name**, and choose Ubuntu 18.04 LTS - Gen2 for your **Image**. Leave the other defaults. The default size and pricing is only shown as an example. Size availability and pricing are dependent on your region and subscription.
6. Under **Administrator account**, select **SSH public key**.
7. In **Username** enter azureuser.
8. For **SSH public key source**, leave the default of **Generate new key pair**, and then enter myKey for the **Key pair name**.
9. Under **Inbound port rules** > **Public inbound ports**, choose **Allow selected ports** and then select **SSH (22)** and **HTTP (80)** from the drop-down.
10. Leave the remaining defaults and then select the **Review + create** button at the bottom of the page.
11. On the **Create a virtual machine** page, you can see the details about the VM you are about to create. When you are ready, select **Create**.
12. When the **Generate new key pair** window opens, select **Download private key and create resource**. Your key file will be download as **myKey.pem**. Make sure you know where the .pem file was downloaded; you will need the path to it in the next step.
13. When the deployment is finished, select **Go to resource**.
14. On the page for your new VM, select the public IP address and copy it to your clipboard.

* Connect to virtual machine

Create an [SSH connection](https://learn.microsoft.com/en-us/azure/virtual-machines/linux-vm-connect) with the VM.

1. If you are on a Mac or Linux machine, open a Bash prompt and set read-only permission on the .pem file using chmod 400 ~/Downloads/myKey.pem. If you are on a Windows machine, open a PowerShell prompt.
2. At your prompt, open an SSH connection to your virtual machine. Replace the IP address with the one from your VM, and replace the path to the .pem with the path to where the key file was downloaded.

ssh -i ~/Downloads/myKey.pem azureuser@10.111.12.123

**Tip**: The SSH key you created can be used the next time your create a VM in Azure. Just select the **Use a key stored in Azure** for **SSH public key source** the next time you create a VM. You already have the private key on your computer, so you won't need to download anything.

* Install web server (on Ubuntu)

To see your VM in action, install the NGINX web server. From your SSH session, update your package sources and then install the latest NGINX package.

sudo apt-get -y update

sudo apt-get -y install nginx

When done, type exit to leave the SSH session.

* View the web server in action

Use a web browser of your choice to view the default NGINX welcome page. Type the public IP address of the VM as the web address. The public IP address can be found on the VM overview page or as part of the SSH connection string you used earlier.

* Clean up resources

When no longer needed, you can delete the resource group, virtual machine, and all related resources. To do so, select the resource group for the virtual machine, select **Delete**, then confirm the name of the resource group to delete.

## Availability Options for Azure Virtual Machines

<https://learn.microsoft.com/en-us/azure/virtual-machines/availability>

### Availability zones

[Availability zones](https://learn.microsoft.com/en-us/azure/availability-zones/az-overview?context=/azure/virtual-machines/context/context) expands the level of control you have to maintain the availability of the applications and data on your VMs. An Availability Zone is a physically separate zone, within an Azure region. There are three Availability Zones per supported Azure region.

Each Availability Zone has a distinct power source, network, and cooling. By designing your solutions to use replicated VMs in zones, you can protect your apps and data from the loss of a data center. If one zone is compromised, then replicated apps and data are instantly available in another zone.

### Virtual Machines Scale Sets

[Azure virtual machine scale sets](https://learn.microsoft.com/en-us/azure/virtual-machines/flexible-virtual-machine-scale-sets) let you create and manage a group of load balanced VMs. The number of VM instances can automatically increase or decrease in response to demand or a defined schedule. Scale sets provide high availability to your applications, and allow you to centrally manage, configure, and update many VMs. There is no cost for the scale set itself, you only pay for each VM instance that you create.

Virtual machines in a scale set can also be deployed into multiple availability zones, a single availability zone, or regionally. Availability zone deployment options may differ based on the [orchestration mode](https://learn.microsoft.com/en-us/azure/virtual-machine-scale-sets/virtual-machine-scale-sets-orchestration-modes?context=/azure/virtual-machines/context/context).

### Availability sets

An [availability set](https://learn.microsoft.com/en-us/azure/virtual-machines/availability-set-overview) is a logical grouping of VMs that allows Azure to understand how your application is built to provide for redundancy and availability. We recommended that two or more VMs are created within an availability set to provide for a highly available application and to meet the [99.95% Azure SLA](https://azure.microsoft.com/support/legal/sla/virtual-machines/). There is no cost for the Availability Set itself, you only pay for each VM instance that you create.

### Load balancer

Combine the [Azure Load Balancer](https://learn.microsoft.com/en-us/azure/load-balancer/load-balancer-overview) with availability zones and scale sets to get the most application resiliency. The Azure Load Balancer distributes traffic between multiple virtual machines. For our Standard tier virtual machines, the Azure Load Balancer is included. Not all virtual machine tiers include the Azure Load Balancer. For more information about load balancing your virtual machines, see the Load Balancer quickstarts using the [CLI](https://learn.microsoft.com/en-us/azure/load-balancer/quickstart-load-balancer-standard-public-cli) or [PowerShell](https://learn.microsoft.com/en-us/azure/load-balancer/quickstart-load-balancer-standard-public-powershell).

### Azure Storage redundancy

Azure Storage always stores multiple copies of your data so that it is protected from planned and unplanned events, including transient hardware failures, network or power outages, and massive natural disasters. Redundancy ensures that your storage account meets its availability and durability targets even in the face of failures.

When deciding which redundancy option is best for your scenario, consider the tradeoffs between lower costs and higher availability. The factors that help determine which redundancy option you should choose include:

* How your data is replicated in the primary region
* Whether your data is replicated to a second region that is geographically distant to the primary region, to protect against regional disasters
* Whether your application requires read access to the replicated data in the secondary region if the primary region becomes unavailable for any reason

For more information, see [Azure Storage redundancy](https://learn.microsoft.com/en-us/azure/storage/common/storage-redundancy)

### Azure Site Recovery

As an organization you need to adopt a business continuity and disaster recovery (BCDR) strategy that keeps your data safe, and your apps and workloads online, when planned and unplanned outages occur.

[Azure Site Recovery](https://learn.microsoft.com/en-us/azure/site-recovery/site-recovery-overview) helps ensure business continuity by keeping business apps and workloads running during outages. Site Recovery replicates workloads running on physical and virtual machines (VMs) from a primary site to a secondary location. When an outage occurs at your primary site, you fail over to secondary location, and access apps from there. After the primary location is running again, you can fail back to it.

Site Recovery can manage replication for:

* Azure VMs replicating between Azure regions.
* On-premises VMs, Azure Stack VMs, and physical servers.

## What are Azure Regions and Availability Zones?

<https://learn.microsoft.com/en-us/azure/reliability/availability-zones-overview?context=%2Fazure%2Fvirtual-machines%2Fcontext%2Fcontext>

Locations are multiple [geographical regions](https://azure.microsoft.com/regions/) around the world where you can create Azure resources. Usually, the region is called **location** when you create a virtual machine. For a virtual machine, the location specifies where the virtual hard disks will be stored.

Azure regions and availability zones are designed to help you achieve reliability for your business-critical workloads. Azure maintains multiple geographies. These discrete demarcations define disaster recovery and data residency boundaries across one or multiple Azure regions. Maintaining many regions ensures customers are supported across the world.

### Regions

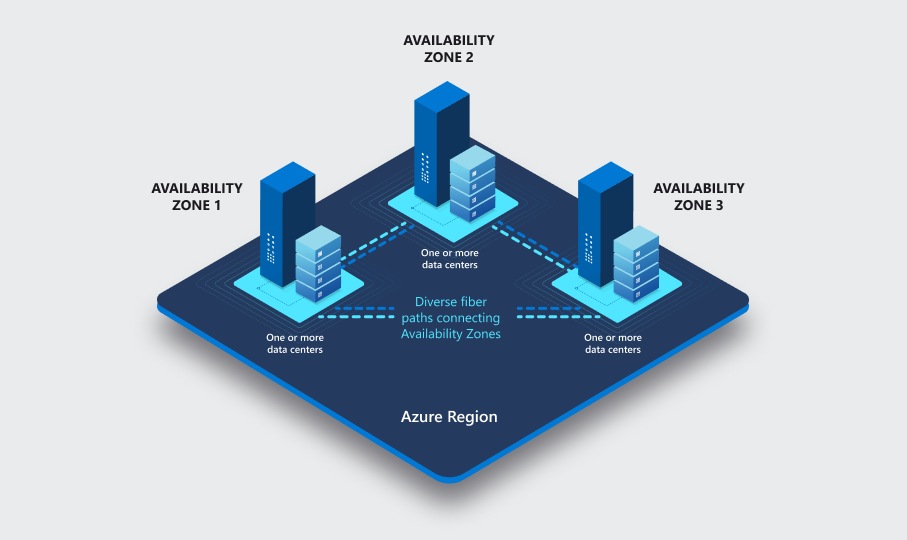
Each Azure region features datacenters deployed within a latency-defined perimeter. They're connected through a dedicated regional low-latency network. This design ensures that Azure services within any region offer the best possible performance and security.

### Availability zones

[**Availability Zones**](https://learn.microsoft.com/en-us/azure/availability-zones/az-overview) are physically separated zones within an Azure region. Availability zones guarantee virtual machine connectivity to at least one instance at least 99.99% of the time when you've two or more instances deployed across two or more Availability Zones in the same Azure region.

Failures can range from software and hardware failures to events such as earthquakes, floods, and fires. Tolerance to failures is achieved because of redundancy and logical isolation of Azure services. To ensure resiliency, a minimum of three separate availability zones are present in all availability zone-enabled regions.

Azure availability zones are connected by a high-performance network with a round-trip latency of less than 2ms. They help your data stay synchronized and accessible when things go wrong. Each zone is composed of one or more datacenters equipped with independent power, cooling, and networking infrastructure. Availability zones are designed so that if one zone is affected, regional services, capacity, and high availability are supported by the remaining two zones.



## What are Virtual Machine Scale Sets?

<https://learn.microsoft.com/en-us/azure/virtual-machine-scale-sets/overview>

[**Virtual Machine Scale Sets**](https://learn.microsoft.com/en-us/azure/virtual-machine-scale-sets/overview) let you create and manage a group of load balanced virtual machines. The number of virtual machine instances can automatically increase or decrease in response to demand or a defined schedule. Scale sets provide high availability to your applications, and allow you to centrally manage, configure, and update many virtual machines. Virtual machines in a scale set can also be deployed into multiple availability zones, a single availability zone, or regionally.

Azure Virtual Machine Scale Sets let you create and manage a group of load balanced VMs. The number of VM instances can automatically increase or decrease in response to demand or a defined schedule. Scale sets provide the following key benefits:

* Easy to create and manage multiple VMs.
* Provides high availability and application resiliency by distributing VMs across availability zones or fault domains.
* Allows your application to automatically scale as resource demand changes.
* Works at large-scale.

### Why use Virtual Machine Scale Sets?

To provide redundancy and improved performance, applications are typically distributed across multiple instances. Customers may access your application through a load balancer that distributes requests to one of the application instances. If you need to perform maintenance or update an application instance, your customers must be distributed to another available application instance. To keep up with extra customer demand, you may need to increase the number of application instances that run your application.

Azure Virtual Machine Scale Sets provide the management capabilities for applications that run across many VMs, automatic scaling of resources, and load balancing of traffic. Scale sets provide the following key benefits:

* **Easy to create and manage multiple VMs**
  + When you have many VMs that run your application, it's important to maintain a consistent configuration across your environment. For reliable performance of your application, the VM size, disk configuration, and application installs should match across all VMs.
  + With scale sets, all VM instances are created from the same base OS image and configuration. This approach lets you easily manage hundreds of VMs without extra configuration tasks or network management.
  + Scale sets support the use of the [Azure load balancer](https://learn.microsoft.com/en-us/azure/load-balancer/load-balancer-overview) for basic layer-4 traffic distribution, and [Azure Application Gateway](https://learn.microsoft.com/en-us/azure/application-gateway/overview) for more advanced layer-7 traffic distribution and TLS termination.
* **Provides high availability and application resiliency**
  + Scale sets are used to run multiple instances of your application. If one of these VM instances has a problem, customers continue to access your application through one of the other VM instances with minimal interruption.
  + For more availability, you can use [Availability Zones](https://learn.microsoft.com/en-us/azure/availability-zones/az-overview) to automatically distribute VM instances in a scale set within a single datacenter or across multiple datacenters.
* **Allows your application to automatically scale as resource demand changes**
  + Customer demand for your application may change throughout the day or week. To match customer demand, scale sets can automatically increase the number of VM instances as application demand increases, then reduce the number of VM instances as demand decreases.
  + Autoscale also minimizes the number of unnecessary VM instances that run your application when demand is low, while customers continue to receive an acceptable level of performance as demand grows and additional VM instances are automatically added. This ability helps reduce costs and efficiently create Azure resources as required.
* **Works at large-scale**
  + Scale sets support up to 1,000 VM instances for standard marketplace images and custom images through the Azure Compute Gallery (formerly known as Shared Image Gallery). If you create a scale set using a managed image, the limit is 600 VM instances.

## Availability Sets Overview

<https://learn.microsoft.com/en-us/azure/virtual-machines/availability-set-overview>

**Note:** We recommend that customers choose [**virtual machine scale sets with flexible orchestration mode**](https://learn.microsoft.com/en-us/azure/virtual-machine-scale-sets/overview) for high availability with the widest range of features. Virtual machine scale sets allow VM instances to be centrally managed, configured, and updated, and will automatically increase or decrease the number of VM instances in response to demand or a defined schedule. Availability sets only offer high availability.

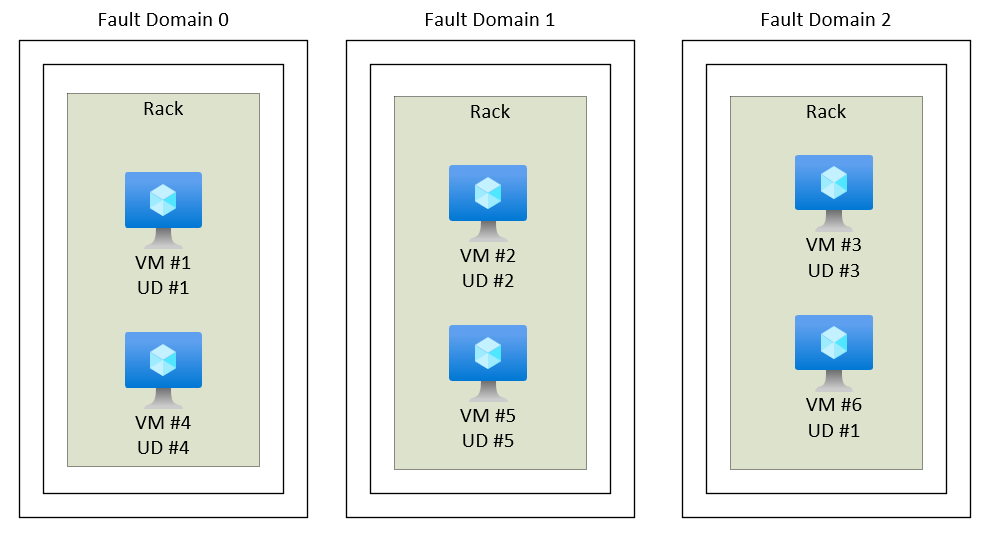
### What is an availability set?

An availability set is a logical grouping of VMs that allows Azure to understand how your application is built to provide for redundancy and availability. We recommended that two or more VMs are created within an availability set to provide for a highly available application and to meet the [99.95% Azure SLA](https://azure.microsoft.com/support/legal/sla/virtual-machines/). There is no cost for the Availability Set itself, you only pay for each VM instance that you create.

### How do availability sets work?

Each virtual machine in your availability set is assigned an **update domain** and a **fault domain** by the underlying Azure platform. Each availability set can be configured with up to three fault domains and twenty update domains. These configurations can't be changed once the availability set has been created. Update domains indicate groups of virtual machines and underlying physical hardware that can be rebooted at the same time. When more than five virtual machines are configured within a single availability set with five update domains, the sixth virtual machine is placed into the same update domain as the first virtual machine, the seventh in the same update domain as the second virtual machine, and so on. The order of update domains being rebooted may not proceed sequentially during planned maintenance, but only one update domain is rebooted at a time. A rebooted update domain is given 30 minutes to recover before maintenance is initiated on a different update domain.

Fault domains define the group of virtual machines that share a common power source and network switch. By default, the virtual machines configured within your availability set are separated across up to three fault domains. While placing your virtual machines into an availability set doesn't protect your application from operating system or application-specific failures, it does limit the impact of potential physical hardware failures, network outages, or power interruptions.



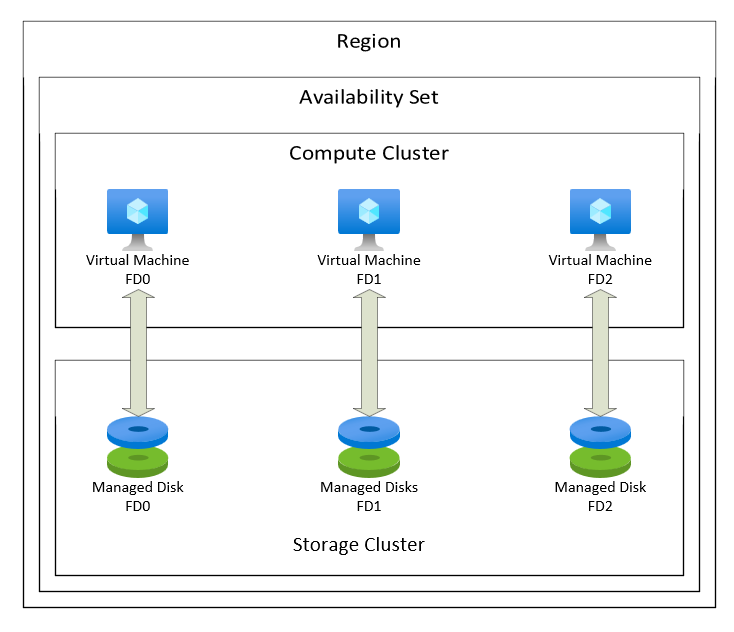
VMs are also aligned with disk fault domains. This alignment ensures that all the managed disks attached to a VM are within the same fault domains.

Only VMs with managed disks can be created in a managed availability set. The number of managed disk fault domains varies by region - either two or three managed disk fault domains per region.

Under certain circumstances, two VMs in the same availability set might share a fault domain. You can confirm a shared fault domain by going to your availability set and checking the Fault Domain column. A shared fault domain might be caused by the completing following sequence when you deployed the VMs:

1. Deploy the first VM.
2. Stop/deallocate the first VM.
3. Deploy the second VM.

Under these circumstances, the OS disk of the second VM might be created on the same fault domain as the first VM, so the two VMs will be on same fault domain. To avoid this issue, we recommend that you don't stop/deallocate VMs between deployments.



## Create Virtual Machines in a Scale Set using Azure Portal

<https://learn.microsoft.com/en-us/azure/virtual-machine-scale-sets/flexible-virtual-machine-scale-sets-portal?toc=%2Fazure%2Fvirtual-machines%2Ftoc.json>

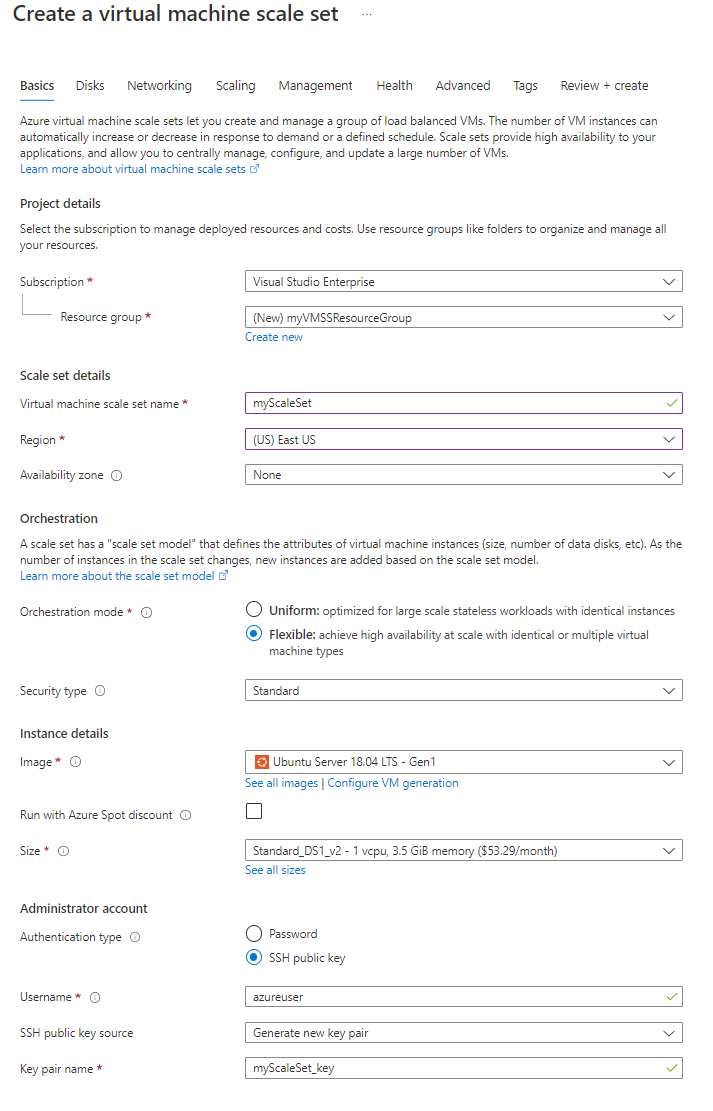
* Log in to Azure

Log in to the Azure portal at [https://portal.azure.com](https://portal.azure.com/).

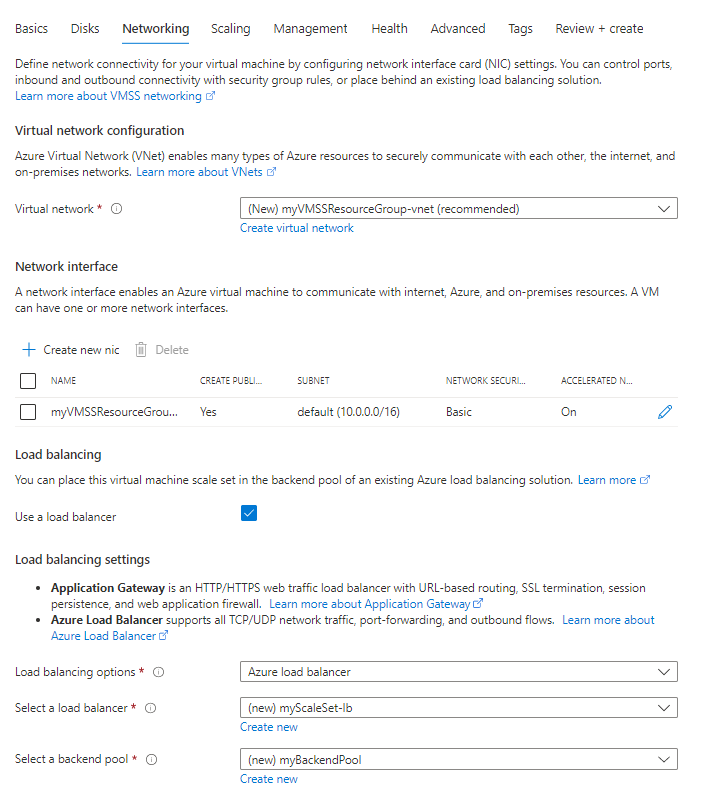
* Create a Virtual Machine Scale Set

You can deploy a scale set with a Windows Server image or Linux image such as RHEL, CentOS, Ubuntu, or SLES.

1. In the Azure portal search bar, search for and select **Virtual Machine Scale Sets**.
2. Select **Create** on the **Virtual Machine Scale Sets** page.
3. In the **Basics** tab, under **Project details**, make sure the correct subscription is selected and create a new resource group called myVMSSResourceGroup.
4. Under **Scale set details**, set myScaleSet for your scale set name and select a **Region** that is close to your area.
5. Under **Orchestration**, select Flexible.
6. Under **Instance details**, select a marketplace image for **Image**. Select any of the Supported Distros.
7. Under **Administrator account** configure the admin username and set up an associated password or SSH public key.
   * A **Password** must be at least 12 characters long and meet three out of the four following complexity requirements: one lower case character, one upper case character, one number, and one special character. For more information, see [username and password requirements](https://learn.microsoft.com/en-us/azure/virtual-machines/windows/faq#what-are-the-password-requirements-when-creating-a-vm-).
   * If you select a Linux OS disk image, you can instead choose **SSH public key**. You can use an existing key or create a new one. In this example, we will have Azure generate a new key pair for us. For more information on generating key pairs, see [create and use SSH keys](https://learn.microsoft.com/en-us/azure/virtual-machines/linux/mac-create-ssh-keys).



1. Select **Next: Disks** to move the disk configuration options. For this quickstart, leave the default disk configurations.
2. Select **Next: Networking** to move the networking configuration options.
3. On the **Networking** page, under **Load balancing**, select the **Use a load balancer** checkbox to put the scale set instances behind a load balancer.
4. In **Load balancing options**, select **Azure load balancer**.
5. In **Select a load balancer**, select a load balancer or create a new one.
6. For **Select a backend pool**, select **Create new**, type myBackendPool, then select **Create**.



1. Select **Next: Scaling** to move to the scaling configurations.
2. On the **Scaling** page, set the **initial instance count** field to 5. You can set this number up to 1000.
3. For the **Scaling policy**, keep it Manual.
4. When you're done, select **Review + create**.
5. After it passes validation, select **Create** to deploy the scale set.

* Clean up resources

When no longer needed, delete the resource group, scale set, and all related resources. To do so, select the resource group for the scale set and then select **Delete**.

# Azure Resource Groups

## Manage Azure Resource Groups by using the Azure Portal

<https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/manage-resource-groups-portal>

## What is a resource group

A resource group is a container that holds related resources for an Azure solution. The resource group can include all the resources for the solution, or only those resources that you want to manage as a group. You decide how you want to allocate resources to resource groups based on what makes the most sense for your organization. Generally, add resources that share the same lifecycle to the same resource group so you can easily deploy, update, and delete them as a group.

The resource group stores metadata about the resources. Therefore, when you specify a location for the resource group, you are specifying where that metadata is stored. For compliance reasons, you may need to ensure that your data is stored in a particular region.

## Create resource groups

1. Sign in to the [Azure portal](https://portal.azure.com/).
2. Select **Resource groups**
3. Select **Add**.
4. Enter the following values:
   * **Subscription**: Select your Azure subscription.
   * **Resource group**: Enter a new resource group name.
5. **Region**: Select an Azure location, such as **Central US**.
6. Select **Review + Create**
7. Select **Create**. It takes a few seconds to create a resource group.
8. Select **Refresh** from the top menu to refresh the resource group list, and then select the newly created resource group to open it. Or select **Notification**(the bell icon) from the top, and then select **Go to resource group** to open the newly created resource group

## List resource groups

1. Sign in to the [Azure portal](https://portal.azure.com/).
2. To list the resource groups, select **Resource groups**
3. To customize the information displayed for the resource groups, select **Edit columns**. The following screenshot shows the additional columns you could add to the display:

## Open resource groups

1. Sign in to the [Azure portal](https://portal.azure.com/).
2. Select **Resource groups**.
3. Select the resource group you want to open.

## Delete resource groups

1. Open the resource group you want to delete. See [Open resource groups](https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/manage-resource-groups-portal#open-resource-groups).
2. Select **Delete resource group**.

## Grant a user access to Azure resources using the Azure portal

<https://learn.microsoft.com/en-us/azure/role-based-access-control/quickstart-assign-role-user-portal>

[Azure role-based access control (Azure RBAC)](https://learn.microsoft.com/en-us/azure/role-based-access-control/overview) is the way that you manage access to Azure resources. In this tutorial, you grant a user access to create and manage virtual machines in a resource group.

## Create a resource group

1. Sign in to the Azure portal at [https://portal.azure.com](https://portal.azure.com/).
2. In the navigation list, click **Resource groups**.
3. Click **New** to open the **Create a resource group** page.
4. Select a subscription.
5. For **Resource group** name, enter **example-group** or another name.
6. Click **Review + create** and then click **Create** to create the resource group.
7. Click **Refresh** to refresh the list of resource groups.

The new resource group appears in your resource groups list.

## Grant access

In Azure RBAC, to grant access, you assign an Azure role.

1. In the list of **Resource groups**, open the new **example-group** resource group.
2. In the navigation menu, click **Access control (IAM)**.
3. Click the **Role assignments** tab to see the current list of role assignments.
4. Click **Add** > **Add role assignment**.

If you don't have permissions to assign roles, the Add role assignment option will be disabled.

1. On the **Role** tab, select the **Virtual Machine Contributor** role.
2. On the **Members** tab, select yourself or another user.
3. On the **Review + assign** tab, review the role assignment settings.
4. Click **Review + assign** to assign the role.

After a few moments, the user is assigned the Virtual Machine Contributor role at the example-group resource group scope.

## Remove access

In Azure RBAC, to remove access, you remove a role assignment.

1. In the list of role assignments, add a checkmark next to the user with the Virtual Machine Contributor role.
2. Click **Remove**.
3. In the remove role assignment message that appears, click **Yes**.

## Clean up

1. In the navigation list, click **Resource groups**.
2. Click **example-group** to open the resource group.
3. Click **Delete resource group** to delete the resource group.
4. On the **Are you sure you want to delete** pane, type the resource group name and then click **Delete**.

# Azure App Service

<https://learn.microsoft.com/en-us/azure/app-service/overview>

Azure App Service is an HTTP-based service for hosting web applications, REST APIs, and mobile back ends. You can develop in your favorite language, be it .NET, .NET Core, Java, Ruby, Node.js, PHP, or Python. Applications run and scale with ease on both Windows and [Linux](https://learn.microsoft.com/en-us/azure/app-service/overview#app-service-on-linux)-based environments.

App Service adds the power of Microsoft Azure to your application, such as security, load balancing, autoscaling, and automated management. Additionally, you can take advantage of its DevOps capabilities, such as continuous deployment from Azure DevOps, GitHub, Docker Hub, and other sources, package management, staging environments, custom domain, and TLS/SSL certificates.

With App Service, you pay for the Azure compute resources you use. The compute resources you use are determined by the App Service plan that you run your apps on. For more information, see [Azure App Service plans overview](https://learn.microsoft.com/en-us/azure/app-service/overview-hosting-plans).

## Why use App Service?

Azure App Service is a fully managed platform as a service (PaaS) offering for developers. Here are some key features of App Service:

* **Multiple languages and frameworks** - App Service has first-class support for ASP.NET, ASP.NET Core, Java, Ruby, Node.js, PHP, or Python. You can also run [PowerShell and other scripts or executables](https://learn.microsoft.com/en-us/azure/app-service/webjobs-create) as background services.
* **Managed production environment** - App Service automatically [patches and maintains the OS and language frameworks](https://learn.microsoft.com/en-us/azure/app-service/overview-patch-os-runtime) for you. Spend time writing great apps and let Azure worry about the platform.
* **Containerization and Docker** - Dockerize your app and host a custom Windows or Linux container in App Service. Run multi-container apps with Docker Compose. Migrate your Docker skills directly to App Service.
* **DevOps optimization** - Set up [continuous integration and deployment](https://learn.microsoft.com/en-us/azure/app-service/deploy-continuous-deployment) with Azure DevOps, GitHub, BitBucket, Docker Hub, or Azure Container Registry. Promote updates through [test and staging environments](https://learn.microsoft.com/en-us/azure/app-service/deploy-staging-slots). Manage your apps in App Service by using [Azure PowerShell](https://learn.microsoft.com/en-us/powershell/azure/) or the [cross-platform command-line interface (CLI)](https://learn.microsoft.com/en-us/cli/azure/install-azure-cli).
* **Global scale with high availability** - Scale [up](https://learn.microsoft.com/en-us/azure/app-service/manage-scale-up) or [out](https://learn.microsoft.com/en-us/azure/azure-monitor/autoscale/autoscale-get-started) manually or automatically. Host your apps anywhere in Microsoft's global datacenter infrastructure, and the App Service [SLA](https://azure.microsoft.com/support/legal/sla/app-service/) promises high availability.
* **Connections to SaaS platforms and on-premises data** - Choose from [many hundreds of connectors](https://learn.microsoft.com/en-us/connectors/connector-reference/connector-reference-logicapps-connectors) for enterprise systems (such as SAP), SaaS services (such as Salesforce), and internet services (such as Facebook). Access on-premises data using [Hybrid Connections](https://learn.microsoft.com/en-us/azure/app-service/app-service-hybrid-connections) and [Azure Virtual Networks](https://learn.microsoft.com/en-us/azure/app-service/overview-vnet-integration).
* **Security and compliance** - App Service is [ISO, SOC, and PCI compliant](https://www.microsoft.com/trustcenter). Authenticate users with [Azure Active Directory](https://learn.microsoft.com/en-us/azure/app-service/configure-authentication-provider-aad), [Google](https://learn.microsoft.com/en-us/azure/app-service/configure-authentication-provider-google), [Facebook](https://learn.microsoft.com/en-us/azure/app-service/configure-authentication-provider-facebook), [Twitter](https://learn.microsoft.com/en-us/azure/app-service/configure-authentication-provider-twitter), or [Microsoft account](https://learn.microsoft.com/en-us/azure/app-service/configure-authentication-provider-microsoft). Create [IP address restrictions](https://learn.microsoft.com/en-us/azure/app-service/app-service-ip-restrictions) and [manage service identities](https://learn.microsoft.com/en-us/azure/app-service/overview-managed-identity). [Prevent subdomain takeovers](https://learn.microsoft.com/en-us/azure/app-service/reference-dangling-subdomain-prevention).
* **Application templates** - Choose from an extensive list of application templates in the [Azure Marketplace](https://azure.microsoft.com/marketplace/), such as WordPress, Joomla, and Drupal.
* **Visual Studio and Visual Studio Code integration** - Dedicated tools in Visual Studio and Visual Studio Code streamline the work of creating, deploying, and debugging.
* **API and mobile features** - App Service provides turn-key CORS support for RESTful API scenarios, and simplifies mobile app scenarios by enabling authentication, offline data sync, push notifications, and more.
* **Serverless code** - Run a code snippet or script on-demand without having to explicitly provision or manage infrastructure, and pay only for the compute time your code actually uses (see [Azure Functions](https://learn.microsoft.com/en-us/azure/azure-functions/)).

Besides App Service, Azure offers other services that can be used for hosting websites and web applications. For most scenarios, App Service is the best choice. For microservice architecture, consider [Azure Spring Apps](https://learn.microsoft.com/en-us/azure/spring-apps/) or [Service Fabric](https://learn.microsoft.com/en-us/azure/service-fabric/). If you need more control over the VMs on which your code runs, consider [Azure Virtual Machines](https://learn.microsoft.com/en-us/azure/virtual-machines/). For more information about how to choose between these Azure services, see [Azure App Service, Virtual Machines, Service Fabric, and Cloud Services comparison](https://learn.microsoft.com/en-us/azure/architecture/guide/technology-choices/compute-decision-tree).

## App Service on Linux

App Service can also host web apps natively on Linux for supported application stacks. It can also run custom Linux containers (also known as Web App for Containers).

### Built-in languages and frameworks

App Service on Linux supports a number of language specific built-in images. Just deploy your code. Supported languages include: Node.js, Java (8, 11, and 17), Tomcat, PHP, Python, .NET Core, and Ruby. Run [az webapp list-runtimes --os linux](https://learn.microsoft.com/en-us/cli/azure/webapp#az-webapp-list-runtimes) to view the latest languages and supported versions. If the runtime your application requires is not supported in the built-in images, you can deploy it with a custom container.

Outdated runtimes are periodically removed from the Web Apps Create and Configuration blades in the Portal. These runtimes are hidden from the Portal when they are deprecated by the maintaining organization or found to have significant vulnerabilities. These options are hidden to guide customers to the latest runtimes where they will be the most successful.

When an outdated runtime is hidden from the Portal, any of your existing sites using that version will continue to run. If a runtime is fully removed from the App Service platform, your Azure subscription owner(s) will receive an email notice before the removal.

If you need to create another web app with an outdated runtime version that is no longer shown on the Portal see the language configuration guides for instructions on how to get the runtime version of your site. You can use the Azure CLI to create another site with the same runtime. Alternatively, you can use the **Export Template** button on the web app blade in the Portal to export an ARM template of the site. You can reuse this template to deploy a new site with the same runtime and configuration.

## Azure App Service Plan

<https://learn.microsoft.com/en-us/azure/app-service/overview-hosting-plans>

An app service always runs in an App Service plan. In addition, [Azure Functions](https://learn.microsoft.com/en-us/azure/azure-functions/dedicated-plan) also has the option of running in an App Service plan. An App Service plan defines a set of compute resources for a web app to run. These compute resources are analogous to the [server farm](https://wikipedia.org/wiki/Server_farm) in conventional web hosting. One or more apps can be configured to run on the same computing resources (or in the same App Service plan).

When you create an App Service plan in a certain region (for example, West Europe), a set of compute resources is created for that plan in that region. Whatever apps you put into this App Service plan run on these compute resources as defined by your App Service plan. Each App Service plan defines:

* Operating System (Windows, Linux)
* Region (West US, East US, etc.)
* Number of VM instances
* Size of VM instances (Small, Medium, Large)
* Pricing tier (Free, Shared, Basic, Standard, Premium, PremiumV2, PremiumV3, Isolated, IsolatedV2)

The pricing tier of an App Service plan determines what App Service features you get and how much you pay for the plan. The pricing tiers available to your App Service plan depend on the operating system selected at creation time. There are a few categories of pricing tiers:

* **Shared compute**: **Free** and **Shared**, the two base tiers, runs an app on the same Azure VM as other App Service apps, including apps of other customers. These tiers allocate CPU quotas to each app that runs on the shared resources, and the resources cannot scale out.
* **Dedicated compute**: The **Basic**, **Standard**, **Premium**, **PremiumV2**, and **PremiumV3** tiers run apps on dedicated Azure VMs. Only apps in the same App Service plan share the same compute resources. The higher the tier, the more VM instances are available to you for scale-out.
* **Isolated**: The **Isolated** and **IsolatedV2** tiers run dedicated Azure VMs on dedicated Azure Virtual Networks. It provides network isolation on top of compute isolation to your apps. It provides the maximum scale-out capabilities.

**Note**: App Service Free and Shared (preview) service plans are base tiers that run on the same Azure virtual machines as other App Service apps. Some apps might belong to other customers. These tiers are intended to be used only for development and testing purposes.

Each tier also provides a specific subset of App Service features. These features include custom domains and TLS/SSL certificates, autoscaling, deployment slots, backups, Traffic Manager integration, and more. The higher the tier, the more features are available. To find out which features are supported in each pricing tier, see [App Service plan details](https://azure.microsoft.com/pricing/details/app-service/plans/).

### How does my app run and scale?

In the **Free** and **Shared** tiers, an app receives CPU minutes on a shared VM instance and cannot scale out. In other tiers, an app runs and scales as follows.

When you create an app in App Service, it is put into an App Service plan. When the app runs, it runs on all the VM instances configured in the App Service plan. If multiple apps are in the same App Service plan, they all share the same VM instances. If you have multiple deployment slots for an app, all deployment slots also run on the same VM instances. If you enable diagnostic logs, perform backups, or run WebJobs, they also use CPU cycles and memory on these VM instances.

In this way, the App Service plan is the scale unit of the App Service apps. If the plan is configured to run five VM instances, then all apps in the plan run on all five instances. If the plan is configured for autoscaling, then all apps in the plan are scaled out together based on the autoscale settings.

### How much does my App Service plan cost?

This section describes how App Service apps are billed. For detailed, region-specific pricing information, see [App Service Pricing](https://azure.microsoft.com/pricing/details/app-service/).

Except for **Free** tier, an App Service plan carries a charge on the compute resources it uses.

* In the **Shared** tier, each app receives a quota of CPU minutes, so each app is charged for the CPU quota.
* In the dedicated compute tiers (**Basic**, **Standard**, **Premium**, **PremiumV2**, **PremiumV3**), the App Service plan defines the number of VM instances the apps are scaled to, so each VM instance in the App Service plan is charged. These VM instances are charged the same regardless of how many apps are running on them. To avoid unexpected charges, see [Clean up an App Service plan](https://learn.microsoft.com/en-us/azure/app-service/app-service-plan-manage#delete).
* In the **Isolated** and **IsolatedV2** tiers, the App Service Environment defines the number of isolated workers that run your apps, and each worker is charged. In addition, in the **Isolated** tier there's a flat Stamp Fee for running the App Service Environment itself.

You don't get charged for using the App Service features that are available to you (configuring custom domains, TLS/SSL certificates, deployment slots, backups, etc.). The exceptions are:

* App Service Domains - you pay when you purchase one in Azure and when you renew it each year.
* App Service Certificates - you pay when you purchase one in Azure and when you renew it each year.
* IP-based TLS connections - There's an hourly charge for each IP-based TLS connection, but some **Standard** tier or above gives you one IP-based TLS connection for free. SNI-based TLS connections are free.

## Deploy an ASP.NET Core Web App using Visual Studio

<https://learn.microsoft.com/en-us/azure/app-service/quickstart-dotnetcore?tabs=net60&pivots=development-environment-vs>

## Deploy an ASP.NET Core Web App using Visual Studio Code

<https://learn.microsoft.com/en-us/azure/app-service/quickstart-dotnetcore?tabs=net60&pivots=development-environment-vscode>

In this quickstart, you'll learn how to create and deploy your first ASP.NET web app to [Azure App Service](https://learn.microsoft.com/en-us/azure/app-service/overview). App Service supports various versions of .NET apps, and provides a highly scalable, self-patching web hosting service. ASP.NET web apps are cross-platform and can be hosted on Linux or Windows. When you're finished, you'll have an Azure resource group consisting of an App Service hosting plan and an App Service with a deployed web application.

Alternatively, you can deploy an ASP.NET web app as part of a [Windows or Linux container in App Service](https://learn.microsoft.com/en-us/azure/app-service/quickstart-custom-container).

### Prerequisites

* .NET 6.0
* An Azure account with an active subscription. [Create an account for free](https://azure.microsoft.com/free/dotnet).
* [Visual Studio 2022](https://www.visualstudio.com/downloads) with the **ASP.NET and web development** workload.

If you've already installed Visual Studio 2022:

1. Install the latest updates in Visual Studio by selecting **Help** > **Check for Updates**.
2. Add the workload by selecting **Tools** > **Get Tools and Features**.

### Create an ASP.NET web app

1. Open Visual Studio and then select **Create a new project**.
2. In **Create a new project**, find, and select **ASP.NET Core Web App**, then select **Next**.
3. In **Configure your new project**, name the application MyFirstAzureWebApp, and then select **Next**.
4. Select **.NET 6.0 (Long-term support)**.
5. Ensure **Authentication Type** is set to **None**. Select **Create**.
6. From the Visual Studio menu, select **Debug** > **Start Without Debugging** to run the web app locally.

### Publish your web app

To publish your web app, you must first create and configure a new App Service that you can publish your app to.

As part of setting up the App Service, you'll create:

* A new [resource group](https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/overview#terminology) to contain all of the Azure resources for the service.
* A new [Hosting Plan](https://learn.microsoft.com/en-us/azure/app-service/overview-hosting-plans) that specifies the location, size, and features of the web server farm that hosts your app.

Follow these steps to create your App Service resources and publish your project:

1. In **Solution Explorer**, right-click the **MyFirstAzureWebApp** project and select **Publish**.
2. In **Publish**, select **Azure** and then **Next**.
3. Choose the **Specific target**, either **Azure App Service (Linux)** or **Azure App Service (Windows)**. Then, select **Next**.

**Important**: When targeting ASP.NET Framework 4.8, use **Azure App Service (Windows)**.

1. Your options depend on whether you're signed in to Azure already and whether you have a Visual Studio account linked to an Azure account. Select either **Add an account** or **Sign in** to sign in to your Azure subscription. If you're already signed in, select the account you want.
2. To the right of **App Service instances**, select **+**.
3. For **Subscription**, accept the subscription that is listed or select a new one from the drop-down list.
4. For **Resource group**, select **New**. In **New resource group name**, enter myResourceGroup and select **OK**.
5. For **Hosting Plan**, select **New**.
6. In the **Hosting Plan: Create new** dialog, enter the values specified in the following table:

| **Setting** | **Suggested value** | **Description** |
| --- | --- | --- |
| **Hosting Plan** | MyFirstAzureWebAppPlan | Name of the App Service plan. |
| **Location** | West Europe | The datacenter where the web app is hosted. |
| **Size** | Free | [Pricing tier](https://azure.microsoft.com/pricing/details/app-service/?ref=microsoft.com&utm_source=microsoft.com&utm_medium=docs&utm_campaign=visualstudio) determines hosting features. |

1. In **Name**, enter a unique app name that includes only the valid characters are a-z, A-Z, 0-9, and -. You can accept the automatically generated unique name. The URL of the web app is http://<app-name>.azurewebsites.net, where <app-name> is your app name.
2. Select **Create** to create the Azure resources.
3. Once the wizard completes, the Azure resources are created for you and you're ready to publish your ASP.NET Core project.
4. In the **Publish** dialog, ensure your new App Service app is selected in **App Service instance**, then select **Finish**. Visual Studio creates a publish profile for you for the selected App Service app.
5. In the **Publish** page, select **Publish**. If you see a warning message, select **Continue**.

Visual Studio builds, packages, and publishes the app to Azure, and then launches the app in the default browser.

### Update the app and redeploy

Follow these steps to update and redeploy your web app:

1. In **Solution Explorer**, under your project, open Index.cshtml.
2. Replace the first <div> element with the following code:

<div class="jumbotron">

<h1>.NET 💜 Azure</h1>

<p class="lead">Example .NET app to Azure App Service.</p>

</div>

Save your changes.

1. To redeploy to Azure, right-click the **MyFirstAzureWebApp** project in **Solution Explorer** and select **Publish**.
2. In the **Publish** summary page, select **Publish**.

When publishing completes, Visual Studio launches a browser to the URL of the web app.

You'll see the updated ASP.NET Core 6.0 web app displayed in the page.

### Manage the Azure app

* To manage your web app, go to the [Azure portal](https://portal.azure.com/), and search for and select **App Services**.
* On the **App Services** page, select the name of your web app.
* The **Overview** page for your web app, contains options for basic management like browse, stop, start, restart, and delete. The left menu provides further pages for configuring your app.

### Clean up resources

In the preceding steps, you created Azure resources in a resource group. If you don't expect to need these resources in the future, you can delete them by deleting the resource group.

1. From your web app's **Overview** page in the Azure portal, select the **myResourceGroup** link under **Resource group**.
2. On the resource group page, make sure that the listed resources are the ones you want to delete.
3. Select **Delete**, type **myResourceGroup** in the text box, and then select **Delete**.

## Deploy an ASP.NET Core and Azure SQL Database app to Azure App Service

<https://learn.microsoft.com/en-us/azure/app-service/tutorial-dotnetcore-sqldb-app>

Sample app: <https://github.com/Azure-Samples/msdocs-app-service-sqldb-dotnetcore>

# Azure Virtual Network (VNet)

<https://k21academy.com/microsoft-azure/solution-architect/azure-networking/>

<https://erikberg.com/notes/networks.html>

<https://learn.microsoft.com/en-us/azure/virtual-network/virtual-networks-overview>

<https://learn.microsoft.com/en-us/azure/virtual-network/quick-create-portal>

<https://www.youtube.com/watch?v=tv49WXZOAWM>

<https://learn.microsoft.com/en-us/azure/virtual-network/tutorial-filter-network-traffic>

<https://learn.microsoft.com/en-us/troubleshoot/azure/virtual-machines/troubleshoot-rdp-nsg-problem>

<https://learn.microsoft.com/en-us/azure/virtual-network/quick-create-cli?toc=%2Fazure%2Fvirtual-machines%2Ftoc.json>

## What is Azure Virtual Network?

Azure Virtual Network (VNet) is the fundamental building block for your private network in Azure. VNet enables many types of Azure resources, such as Azure Virtual Machines (VM), to securely communicate with each other, the internet, and on-premises networks. VNet is similar to a traditional network that you'd operate in your own data center, but brings with it additional benefits of Azure's infrastructure such as scale, availability, and isolation.

### Why use an Azure Virtual network?

Azure virtual network enables Azure resources to securely communicate with each other, the internet, and on-premises networks. Key scenarios that you can accomplish with a virtual network include - communication of Azure resources with the internet, communication between Azure resources, communication with on-premises resources, filtering network traffic, routing network traffic, and integration with Azure services.

#### Communicate with the internet

All resources in a VNet can communicate outbound to the internet, by default. You can communicate inbound to a resource by assigning a public IP address or a public Load Balancer. You can also use public IP or public Load Balancer to manage your outbound connections. To learn more about outbound connections in Azure, see [Outbound connections](https://learn.microsoft.com/en-us/azure/load-balancer/load-balancer-outbound-connections), [Public IP addresses](https://learn.microsoft.com/en-us/azure/virtual-network/ip-services/virtual-network-public-ip-address), and [Load Balancer](https://learn.microsoft.com/en-us/azure/load-balancer/load-balancer-overview).

**Note**: When using only an internal [**Standard Load Balancer**](https://learn.microsoft.com/en-us/azure/load-balancer/load-balancer-overview), outbound connectivity is not available until you define how you want [**outbound connections**](https://learn.microsoft.com/en-us/azure/load-balancer/load-balancer-outbound-connections) to work with an instance-level public IP or a public Load Balancer.

#### Communicate between Azure resources

Azure resources communicate securely with each other in one of the following ways:

* **Through a virtual network**: You can deploy VMs, and several other types of Azure resources to a virtual network, such as Azure App Service Environments, the Azure Kubernetes Service (AKS), and Azure Virtual Machine Scale Sets. To view a complete list of Azure resources that you can deploy into a virtual network, see [Virtual network service integration](https://learn.microsoft.com/en-us/azure/virtual-network/virtual-network-for-azure-services).
* **Through a virtual network service endpoint**: Extend your virtual network private address space and the identity of your virtual network to Azure service resources, such as Azure Storage accounts and Azure SQL Database, over a direct connection. Service endpoints allow you to secure your critical Azure service resources to only a virtual network. To learn more, see [Virtual network service endpoints overview](https://learn.microsoft.com/en-us/azure/virtual-network/virtual-network-service-endpoints-overview).
* **Through VNet Peering**: You can connect virtual networks to each other, enabling resources in either virtual network to communicate with each other, using virtual network peering. The virtual networks you connect can be in the same, or different, Azure regions. To learn more, see [Virtual network peering](https://learn.microsoft.com/en-us/azure/virtual-network/virtual-network-peering-overview).

#### Communicate with on-premises resources

You can connect your on-premises computers and networks to a virtual network using any of the following options:

* **Point-to-site virtual private network (VPN):** Established between a virtual network and a single computer in your network. Each computer that wants to establish connectivity with a virtual network must configure its connection. This connection type is great if you're just getting started with Azure, or for developers, because it requires little or no changes to your existing network. The communication between your computer and a virtual network is sent through an encrypted tunnel over the internet. To learn more, see [Point-to-site VPN](https://learn.microsoft.com/en-us/azure/vpn-gateway/point-to-site-about?toc=/azure/virtual-network/toc.json).
* **Site-to-site VPN:** Established between your on-premises VPN device and an Azure VPN Gateway that is deployed in a virtual network. This connection type enables any on-premises resource that you authorize to access a virtual network. The communication between your on-premises VPN device and an Azure VPN gateway is sent through an encrypted tunnel over the internet. To learn more, see [Site-to-site VPN](https://learn.microsoft.com/en-us/azure/vpn-gateway/design?toc=/azure/virtual-network/toc.json#s2smulti).
* **Azure ExpressRoute:** Established between your network and Azure, through an ExpressRoute partner. This connection is private. Traffic does not go over the internet. To learn more, see [ExpressRoute](https://learn.microsoft.com/en-us/azure/expressroute/expressroute-introduction?toc=/azure/virtual-network/toc.json).

#### Filter network traffic

You can filter network traffic between subnets using either or both of the following options:

* **Network security groups:** Network security groups and application security groups can contain multiple inbound and outbound security rules that enable you to filter traffic to and from resources by source and destination IP address, port, and protocol. To learn more, see [Network security groups](https://learn.microsoft.com/en-us/azure/virtual-network/network-security-groups-overview#network-security-groups) or [Application security groups](https://learn.microsoft.com/en-us/azure/virtual-network/network-security-groups-overview#application-security-groups).
* **Network virtual appliances:** A network virtual appliance is a VM that performs a network function, such as a firewall, WAN optimization, or other network function. To view a list of available network virtual appliances that you can deploy in a virtual network, see [Azure Marketplace](https://azuremarketplace.microsoft.com/marketplace/apps/category/networking?page=1&subcategories=appliances).

#### Route network traffic

Azure routes traffic between subnets, connected virtual networks, on-premises networks, and the Internet, by default. You can implement either or both of the following options to override the default routes Azure creates:

* **Route tables:** You can create custom route tables with routes that control where traffic is routed to for each subnet. Learn more about [route tables](https://learn.microsoft.com/en-us/azure/virtual-network/virtual-networks-udr-overview#user-defined).
* **Border gateway protocol (BGP) routes:** If you connect your virtual network to your on-premises network using an Azure VPN Gateway or ExpressRoute connection, you can propagate your on-premises BGP routes to your virtual networks. Learn more about using BGP with [Azure VPN Gateway](https://learn.microsoft.com/en-us/azure/vpn-gateway/vpn-gateway-bgp-overview?toc=/azure/virtual-network/toc.json) and [ExpressRoute](https://learn.microsoft.com/en-us/azure/expressroute/expressroute-routing?toc=/azure/virtual-network/toc.json#dynamic-route-exchange).

#### Virtual network integration for Azure services

Integrating Azure services to an Azure virtual network enables private access to the service from virtual machines or compute resources in the virtual network. You can integrate Azure services in your virtual network with the following options:

* Deploying [dedicated instances of the service](https://learn.microsoft.com/en-us/azure/virtual-network/virtual-network-for-azure-services) into a virtual network. The services can then be privately accessed within the virtual network and from on-premises networks.
* Using [Private Link](https://learn.microsoft.com/en-us/azure/private-link/private-link-overview) to access privately a specific instance of the service from your virtual network and from on-premises networks.
* You can also access the service using public endpoints by extending a virtual network to the service, through [service endpoints](https://learn.microsoft.com/en-us/azure/virtual-network/virtual-network-service-endpoints-overview). Service endpoints allow service resources to be secured to the virtual network.

## Advantages of Using Azure Virtual Network

Some of the foremost advantages of using Microsoft Azure VNet are as follows:

* It provides an isolated environment for your applications
* A subnet in a very VNet can access the general public internet by default
* We can easily direct traffic from resources
* It is a highly secure network
* It has high network connectivity
* It builds sophisticated network topologies in a very simple manner

## Elements of Azure Virtual Network

Azure networking components provide a large range of functionalities that may help companies build efficient cloud applications that meet their requirements.

The components of Azure Networking are listed below, and we have explained each of those components in an exceedingly detailed manner:

1. Subnets
2. Routing
3. Network Security Groups

### **Subnets**

Subnets let users segment the virtual network into one or more sub-networks.  
These sub-networks may be separated logically, and every subnet consists of a server.  
We can further divide a subnet into two types:

1. **Private –** Instances can access the web with NAT (Network Address Translation) gateway that’s present within the public subnet.
2. **Public –** Instances can directly access the net.

### Routing

* It delivers the information by choosing an appropriate path from source to destination.
* For each subnet, the virtual network automatically routes traffic and creates a routing table.

### Network Security Groups

* It is a firewall that protects the virtual machine by limiting network traffic.
* It restricts inbound and outbound network traffic depending upon the destination IP addresses, port, and protocol.

## Getting Familiar with IP Addressing

Before understanding IP Address, we need to learn the binary numbers. If you are not familiar with binary and decimal conversion, look at the brief explanation below.

In the decimal number system, the combinations are made using only the numbers from 0 to 9. In other words, it is the number system with a base of 10 (0 to 9). Similarly, in the Binary Number System base of 2 (0 and 1) is used. Each value in a binary number is made with 2N (‘N’ is the place value that increases from right to left). The below table shows the basic conversion between binary and decimal.

|  |  |  |
| --- | --- | --- |
| **Binary** | **Conversion** | **Decimal** |
| 000 | 0x22+0x21+0x20 | 0 |
| 001 | 0x22+0x21+1×20 | 1 |
| 010 | 0x22+1×21+0x20 | 2 |
| 011 | 0x22+1×21+1×20 | 3 |
| 100 | 1×22+0x21+0x20 | 4 |
| 101 | 1×22+0x21+1×20 | 5 |

## What is IP Address?

**IANA** is the Internet Assigned Numbers Authority that manages and assigns the IP address in the world. IP Address identifies each device on a network uniquely. There are currently two IP Adress that is IPv4 and IPv6. An **IPv4** address contains a total of 32 binary bits divided into 4 equal octets (8-bit block), whereas **IPv6** is written in hexadecimal notation, separated into 8 groups of 16 **bits** by the colons, thus (8 x 16 = 128) bits in total. We will focus on IPv4 as it is the most used. Each octet of an IP Address is separated by a decimal and ranges from 0 to 255. You will clearly understand the binary number, octets, and IP address formation in the below table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **IP Address** | **Octet 1** | **Octet 2** | **Octet 3** | **Octet 4** |
| 10.2.7.4 | 00001010 | 00000010 | 00000111 | 00000100 |
| 192.124.249.161 | 11000000 | 01111100 | 11111001 | 10100001 |
| 255.255.140.40 | 11111111 | 11111111 | 10001100 | 00101000 |

There are two different IP address one is private, and the other is public.

* **Private IP** is accessed only within a network like a simple school network with a LAN connection.
* **Public IP** is accessed globally via the Internet.

The table below shows the Private IP address range assigned by IANA, and the rest are all Public IP address.

|  |
| --- |
| **Private IP Range** |
| **10.0.0.1 – 10.255.255.255** |
| **172.16.0.0 – 172.31.255.255** |
| **192.168.0.0 – 192.168.255.255** |

## IPv4 Overview

An IPv4 address contains 32-bits. It is usually represented in dotted decimal quad notation so it is easier to read and communicate. Computers, of course, read this information in binary form. And in order to calculate subnet masks, network addresses, and broadcast addresses, the binary value must be known.

## What is IP Subnetting?

Subnetting is the process of dividing a network into many smaller networks. There are 5 classes of IP address and each with a unique purpose. Only the first octet is used for dividing an IP Address into different classes. The table below shows the range of IP address of the 5 classes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class** | **Octet 1 Range (in Binary)** | **Octet 1 Range (in Decimal)** | **Start Address** | **End Address** |
| **Class A** | **00000000-01111111** | **0-126** | **0.0.0.0** | **127.255.255.255** |
| **Class B** | **10000000-10111111** | **128-191** | **128.0.0.0** | **191.255.255.255** |
| **Class C** | **11000000-11011111** | **192-223** | **192.0.0.0** | **223.255.255.255** |
| **Class D** | **11100000-11101111** | **224-239** | **224.0.0.0** | **239.255.255.255** |
| **Class E** | **11110000-11110111** | **240-255** | **240.0.0.0** | **255.255.255.255** |

**Class D** is reserved for multitasking and broadcasting purpose, whereas **Class E** is reserved for research and development. So, both these classes are reserved and cannot be used. The below table shows the range of the first octet in an IP address with each class.

**Note:** The IP address with the first octet as 127 (in decimal) is a loopback address to check the network and address of the machine itself.

An IP address can further be divided into small networks depending on the use and purpose. The above classes are not sufficient for real-life use. Only 5 classes cannot hold all the hosts on the same network, and the loss of IP address will be huge. So, the CIDR method was introduced.

## CIDR (Classless Inter-Domain Routing)

CIDR is a method for allocating IP Address. Using this method, we can apply a subnet mask to an IP Address. This mask defines the number of bits used as a network, and the host will use the other bits that left. To understand CIDR better, we will decode a simple IP address with a subnet mask.

Suppose 192.168.1.30/28 is an IP address with 28 as the subnet mask. By comparing with IP address classes in the above table, this IP comes under Class C. Now, 24 bits are made of 3 octets, so the network will take four extra bits from the next octet to complete 28 bits. Using 2N(‘N’ is the number of borrowed bits from the host), a total of 16 subnets is formed. After taking the four bits, the last octet is left with only 4 bits that a host will use. Using 2H(‘H’ is the number of host bits left), each subnet will contain a block of 16 IP address. The first and last IP is reserved for network and broadcast in each subnet, so the total number of hosts will be 2H-2(‘H’ is the number of host bits) equals 14.

Although a total of 16 subnets or network are possible for this example, the table below listed the initial 4 subnets that can be formed using 28 as the subnet mask. Each subnet contains a total of 16 IP address, and the number of hosts will be 14 as the other two are reserved for network and broadcast.

After comparing the IP given in the example that is 192.168.1.30/28 with the table below, it is clearly visible that it belongs to the second subnet ranging from 192.168.1.16 to 192.168.1.31.

**Note:** Every subnet’s first and last address is not allocated to any host as it is reserved for network and broadcast.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SubNet** | **Total IP** | **Network IP** | **Broadcast IP** | **Range of Hosts** | **Total Hosts** |
| 1 | 16 | 192.168.1.0 | 192.168.1.15 | 192.168.1.1-192.168.1.14 | 14 |
| 2 | 16 | 192.168.1.16 | 192.168.1.31 | 192.168.1.17-192.168.1.30 | 14 |
| 3 | 16 | 192.168.1.32 | 192.168.1.47 | 192.168.1.33-192.168.1.46 | 14 |
| 4 | 16 | 192.168.1.48 | 192.168.1.65 | 192.168.1.49-192.168.1.64 | 14 |

### CIDR Available Hosts

The formula to calculate the number of assignable IP address to CIDR networks is similar to classful networking. Subtract the number of network bits from 32. Raise 2 to that power and subtract 2 for the network and broadcast addresses. For example, a /24 network has 232-24 - 2 addresses available for host assignment.

|  |  |  |
| --- | --- | --- |
| CIDR Notation | Host Formula | Available Hosts |
| /8 | 232-8 - 2 | 16,777,214 |
| /9 | 232-9 - 2 | 8,388,606 |
| /10 | 232-10 - 2 | 4,194,302 |
| /11 | 232-11 - 2 | 2,097,150 |
| /12 | 232-12 - 2 | 1,048,574 |
| /13 | 232-13 - 2 | 524,286 |
| /14 | 232-14 - 2 | 262,142 |
| /15 | 232-15 - 2 | 131,070 |
| /16 | 232-16 - 2 | 65,534 |
| /17 | 232-17 - 2 | 32,766 |
| /18 | 232-18 - 2 | 16,382 |
| /19 | 232-19 - 2 | 8,190 |
| /20 | 232-20 - 2 | 4,094 |
| /21 | 232-21 - 2 | 2,046 |
| /22 | 232-22 - 2 | 1,022 |
| /23 | 232-23 - 2 | 510 |
| /24 | 232-24 - 2 | 254 |
| /25 | 232-25 - 2 | 126 |
| /26 | 232-26 - 2 | 62 |
| /27 | 232-27 - 2 | 30 |
| /28 | 232-28 - 2 | 14 |
| /29 | 232-29 - 2 | 6 |
| /30 | 232-30 - 2 | 2 |

## IP Address in Azure

The two different types of IP Address used and allocated in Azure are Public IP and Private IP.

* **Private** – The Private IP address allows communication of resources within the azure resource group. In other words, resources can not access a private IP outside the network. The resources that can be connected using a private address are VM Network Interface, ILB (Internal Load Balancer) and Application Gateway.
* **Public** – The Public IP address allows Azure Resources to communicate with public-facing Azure services via the Internet. In other words, resources can access public IP outside the network. Some resources that can be connected using public address are VM Network Interface, Public Facing ILB, Application Gateway, VPN Gateway and Azure Firewall.

### IP Allocation

* **Dynamic IP** – The default allocation method by which Azure can automatically assign the available and unreserved IP address from the subnet’s address range. Also, the Dynamic IP is not fixed and changes with time.
* **Static IP** – This is the custom allocation method to assign the available and unreserved IP address from the subnet’s address range. The Static IP is fixed and does not vary with time.

## Azure Virtual Network

Azure Network is the interlinking and communication of all the Azure Resources in an organization. Networking leads to efficient resource work with better consistency and coordination.

Virtual Networking is the communication between devices, servers, virtual machines over the internet. Similarly, Azure Virtual Network (VNet) is a private network with interconnected Azure Resources like Azure Virtual Machines, Infrastructure and Network. It enables communication between various Azure Resources via the Internet. In a Virtual Network, a continuous block of IP Address is used to create multiple subnet networks.

### Azure Subnet

As we know, the subnet is a part of a network that covers a range of IP Address. In Azure, VNet can be divided into smaller subnets for organizations. When a VNet is created in Azure, the subnet range and topology needs to be specified. In Subnet, the IP Address range will be a subpart from a big block of IP Address used in Virtual Network (VNet). The Virtual Machines and resources in a network will be assigned the IP Address from these subnets.

### Azure Network Interface

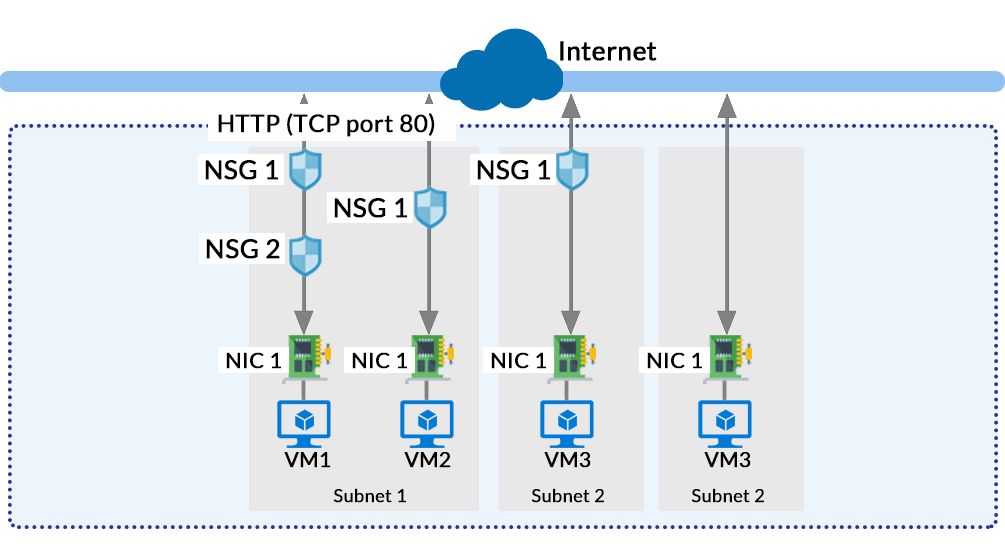
In Azure, NIC is virtual ethernet cards that help communicate the Virtual Machines present in a network. When a Virtual Machine is created in Azure, the NIC with default settings is automatically created. Also, Network Interface settings in Azure can be customized using command tools like Azure CLI and PowerShell.

## Network Security

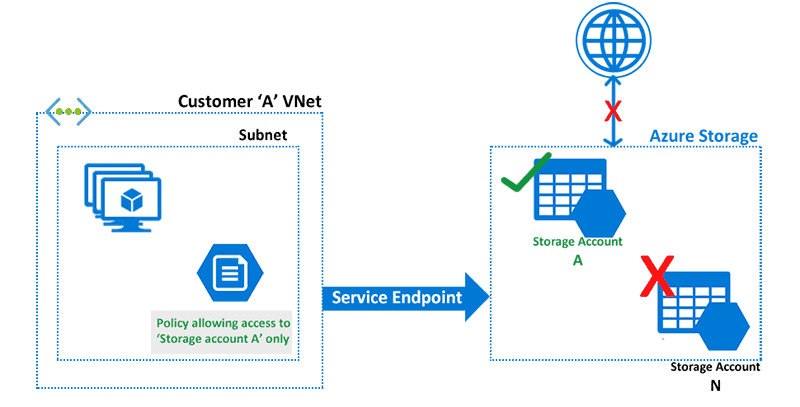
Azure provides various protection methods for securing a service in a network. I have listed down some of the basic network security tools with a short description.

### Network Security Group (NSG)

The Network Security Group in Azure acts like a firewall at the network level. It filters the traffic passing through Azure Resources in a virtual network. NSG is a group of security rules that defines the priority, source or destination, protocol, direction, port range and action. Using these rules, NSG allows or deny inbound and outbound traffic. The rules for entering traffic inside a resource is also called ‘Ingress‘, and the rules for exiting the traffic or going out of the resource is called ‘Egress‘. When all the rules are created, the NSG can be used in a Virtual Machine that will interact with a network.

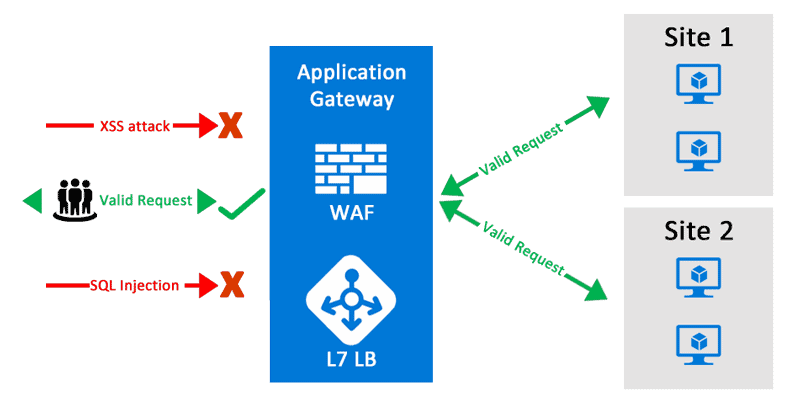


## Service Endpoints



Service Endpoints in Azure provides secure connectivity over the optimized route of the Azure Network. Without needing a public IP address, Service Endpoints allows Private IP address in a VNet to reach the endpoint of an Azure Service. It is simple to set up and improves security for the Azure resources in a network. The services here can be Azure Storage, Azure Database, etc.

## Web Application Firewall (WAF)

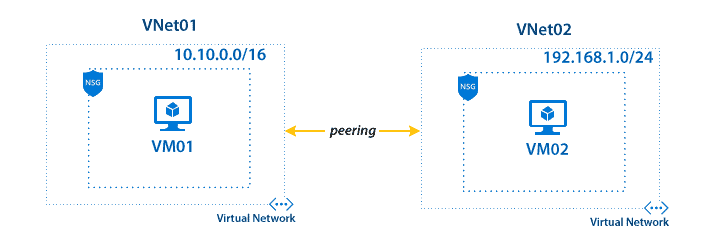


Web applications are a common target for hackers to steal user information. So, protection from the most common attacks like SQL injection, cross-site scripting, etc., is a must. Web Application Firewall by Azure is a firewall for protecting the web application from these common threats. It provides an easy setup for applying various protection of layers that results in better security management. A user can deploy the WAF with other services like Azure Application Gateway, Azure Content Delivery Network (CDN) and Azure Front Door.

## Azure Network Models

Network Models are the representation and methods of connecting multiple networks. In Azure also, Microsoft enables some ways to connect multiple networks. I have listed down some of the most used network models.

### VNet Peering



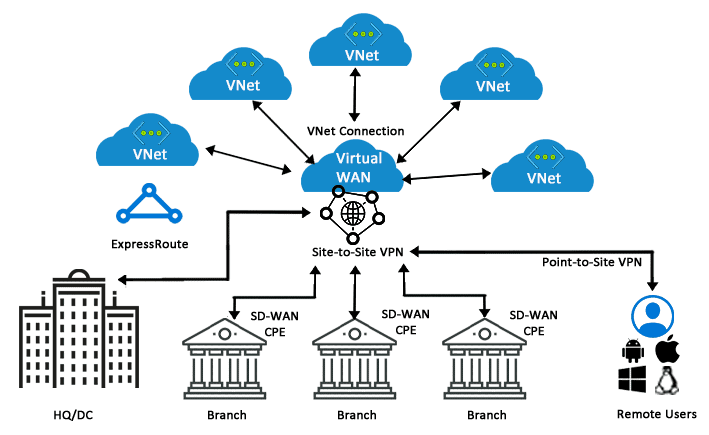
Virtual Network peering enables to connect the two or more Virtual Networks in Azure. It also allows transferring data between deployment models, Azure Subscriptions, Azure Active Directory Tenants and Azure regions without downtime and failure. The traffic between the peered virtual networks use  Microsoft’s backbone infrastructure and is routed through a private network. Thus, gateways, encryption and public internet are not required.

There are two types of Virtual Network Peering:

1. **Regional VNet Peering** – When the two networks needed to peer are in the same region, the peering is called Regional VNet Peering.
2. **Global VNet Peering** – When the two networks are from different regions, the peering is called Global VNet Peering.

### Virtual WAN (Wide Area Network)

Virtual WAN in Azure allows creating a web of multiple networks that are interconnected to each other. It brings multiple networking, security, and routing functionalities together to provide a new single operational interface.



In the above diagram, a Virtual WAN at the centre acts as a single operational hub to manage all the traffic coming from multiple resources in a VNet. Instead of contacting the multiple branches separately, a VNet can contact the central hub to connect with all the branches connected to it.

## Use the Azure portal to create a virtual network

<https://learn.microsoft.com/en-us/azure/virtual-network/quick-create-portal>

This quickstart shows you how to create a virtual network by using the Azure portal. You then create two virtual machines (VMs) in the network, deploy Azure Bastion to securely connect to the VMs from the internet, and communicate privately between the VMs.

A virtual network is the fundamental building block for private networks in Azure. Azure Virtual Network enables Azure resources like VMs to securely communicate with each other and the internet.

### Create a virtual network

The following procedure creates a virtual network with a resource subnet, an Azure Bastion subnet, and an Azure Bastion host.

1. Sign in to the [Azure portal](https://portal.azure.com/).
2. In the portal, search for and select **Virtual networks**.
3. On the **Virtual networks** page, select **Create**.
4. On the **Basics** tab of the **Create virtual network** screen, enter or select the following information:

* **Subscription**: Keep the default or select a different subscription.
* **Resource group**: Select **Create new**, and then name the resource group TestRG.
* **Virtual network name**: Enter VNet.
* **Region**: Keep the default or select a different region for the network and all its resources.

1. Select **Next: IP Addresses** at the bottom of the page.
2. On the **IP Addresses** tab, under **IPv4 address space**, select the garbage can icon to remove any address space that already appears, and then enter *10.0.0.0/16*.
3. Select **Add subnet**.
4. On the **Add subnet** screen, enter the following information, and then select **Add**:

* Subnet name: *default*
* Subnet address range: *10.0.0.0/24*.

1. Select **Next: Security** at the bottom of the page.
2. On the **Security** tab, next to **BastionHost**, select **Enable**.

Azure Bastion uses your browser to connect to VMs in your virtual network over secure shell (SSH) or remote desktop protocol (RDP) by using their private IP addresses. The VMs don't need public IP addresses, client software, or special configuration. For more information about Azure Bastion, see [Azure Bastion](https://learn.microsoft.com/en-us/azure/bastion/bastion-overview).

1. Enter the following information:

* **Bastion name**: VNet-Bastion
* **AzureBastionSubnet address space**: 10.0.1.0/26. Azure automatically creates the AzureBastionSubnet subnet.
* **Public IP address**: Select **Create new**, then enter VNet-bastion-publicIp under **Name** and select **OK**.

1. Select **Review + create** at the bottom of the screen, and when validation passes, select **Create**.

### Create virtual machines

Create two VMs named VM1 and VM2 in the virtual network.

1. In the portal, search for and select **Virtual machines**.
2. On the **Virtual machines** page, select **Create**, and select **Azure virtual machine**.
3. On the **Basics** tab of the **Create a virtual machine** screen, enter or select the following values:

* **Resource group**: Select **TestRG** if not already selected.
* **Virtual machine name**: Enter VM1.
* **Region**: Select the same region as your resource group and virtual network if not already selected.
* **Availability options**: Select **No infrastructure redundancy required**.
* **Image**: Select **Windows Server 2019 Datacenter - x64 Gen2**.
* **Size**: Accept the default, or drop down and select a size.
* **Username**, **Password**, and **Confirm password**: Enter an admin username and password for the VM.
* **Public inbound ports**: Select **None**.

1. Select the **Networking** tab at the top of the page.
2. On the **Networking** page, enter or select the following values:

* **Virtual network**: Select **VNet** if not already selected.
* **Subnet**: Select **default** if not already selected.
* **Public IP**: Select **None**.

1. Accept the other settings, and select **Review + create**. Review the settings, and then select **Create**.
2. After the VM creation finishes, you can select **Create another VM** to create the second VM. Name the VM VM2, with all the same settings.

**Note**: VMs in a virtual network with a Bastion host don't need public IP addresses. Bastion provides the public IP, and the VMs use private IPs to communicate within the network. You can remove the public IPs from any VMs in Bastion-hosted virtual networks. For more information, see [**Dissociate a public IP address from an Azure VM**](https://learn.microsoft.com/en-us/azure/virtual-network/ip-services/remove-public-ip-address-vm).

### Connect to a VM

1. In the portal, search for and select **Virtual machines**.
2. On the **Virtual machines** page, select **VM1**.
3. At the top of the **VM1** page, select the dropdown arrow next to **Connect**, and then select **Bastion**.
4. On the **Bastion** page, enter the username and password you created for the VM, and then select **Connect**.

### Communicate between VMs

1. From the desktop of VM1, open PowerShell.
2. Enter ping myVM2. You get a reply similar to the following message:

PS C:\Users\VM1> ping VM2

The ping fails because it uses the Internet Control Message Protocol (ICMP). By default, ICMP isn't allowed through Windows firewall.

1. To allow ICMP to inbound through Windows firewall on this VM, enter the following command:

New-NetFirewallRule –DisplayName "Allow ICMPv4-In" –Protocol ICMPv4

1. Close the Bastion connection to VM1.
2. Repeat the steps in [Connect to a VM](https://learn.microsoft.com/en-us/azure/virtual-network/quick-create-portal#connect-to-a-vm) to connect to VM2.
3. From PowerShell on VM2, enter ping VM1.

This time you get a success reply similar to the following message, because you allowed ICMP through the firewall on VM1.

PS C:\Users\VM2> ping VM1

1. Close the Bastion connection to VM2.

### Clean up resources

When you're done using the virtual network and VMs, you can delete the resource group and all its resources.

1. In the Azure portal, search for and select **Resource groups**.
2. On the **Resource groups** page, select the **TestRG** resource group.
3. On the **TestRG** page, note all the resources the resource group contains. At the top of the page, select **Delete resource group**.
4. On the **Delete a resource group** page, under **Enter resource group name to confirm deletion**, enter TestRG, and then select **Delete**.
5. Select **Delete** again.

## NAT Gateway

### What is Azure NAT Gateway?

<https://learn.microsoft.com/en-us/azure/nat-gateway/nat-overview>

Azure NAT Gateway is a fully managed and highly resilient Network Address Translation (NAT) service. Azure NAT Gateway simplifies outbound Internet connectivity for virtual networks. When configured on a subnet, all outbound connectivity uses the NAT gateway's static public IP addresses.

#### Azure NAT Gateway benefits

##### Security

With a NAT gateway, individual VMs or other compute resources, don't need public IP addresses and can remain private. Resources without a public IP address can still reach external sources outside the virtual network with NAT gateway's static public IP addresses or prefixes. You can associate a public IP prefix to ensure that a contiguous set of IPs will be used for outbound. Destination firewall rules can be configured based on this predictable IP list.

##### Resiliency

Azure NAT Gateway is a fully managed and distributed service. It doesn't depend on individual compute instances such as VMs or a single physical gateway device. A NAT gateway always has multiple fault domains and can sustain multiple failures without service outage. Software defined networking makes a NAT gateway highly resilient.

##### Scalability

NAT gateway is scaled out from creation. There isn't a ramp up or scale-out operation required. Azure manages the operation of NAT gateway for you.

A NAT gateway resource can be associated to a subnet and can be used by all compute resources in that subnet. All subnets in a virtual network can use the same NAT gateway resource. Outbound connectivity can be scaled out by assigning up to 16 IP addresses to NAT gateway. When a NAT gateway is associated to a public IP prefix, it automatically scales to the number of IP addresses needed for outbound.

##### Performance

Azure NAT Gateway is a software defined networking service. A NAT gateway won't affect the network bandwidth of your compute resources. Learn more about [NAT gateway's performance](https://learn.microsoft.com/en-us/azure/nat-gateway/nat-gateway-resource#performance).

### Create a NAT gateway using the Azure portal

<https://learn.microsoft.com/en-us/azure/virtual-network/nat-gateway/quickstart-create-nat-gateway-portal>

This quickstart shows you how to use the Azure NAT Gateway service. You'll create a NAT gateway to provide outbound connectivity for a virtual machine in Azure.

#### Create a NAT gateway

Before you deploy the NAT gateway resource and the other resources, a resource group is required to contain the resources deployed. In the following steps, you'll create a resource group, NAT gateway resource, and a public IP address. You can use one or more public IP address resources, public IP prefixes, or both.

For information about public IP prefixes and a NAT gateway, see [Manage NAT gateway](https://learn.microsoft.com/en-us/azure/nat-gateway/manage-nat-gateway?tabs=manage-nat-portal#add-or-remove-a-public-ip-prefix).

1. Sign in to the [Azure portal](https://portal.azure.com/).
2. In the search box at the top of the portal, enter **NAT gateway**. Select **NAT gateways** in the search results.
3. Select **+ Create**.
4. In **Create network address translation (NAT) gateway**, enter or select this information in the **Basics** tab:

| **Setting** | **Value** |
| --- | --- |
| **Project Details** |  |
| Subscription | Select your Azure subscription. |
| Resource Group | Select **Create new**.  Enter **myResourceGroupNAT**. Select **OK**. |
| **Instance details** |  |
| NAT gateway name | Enter **myNATgateway** |
| Region | Select **West Europe** |
| Availability Zone | Select **No Zone**. |
| TCP idle timeout (minutes) | Enter **10**. |

1. For information about availability zones and NAT gateway, see [NAT gateway and availability zones](https://learn.microsoft.com/en-us/azure/nat-gateway/nat-availability-zones).
2. Select the **Outbound IP** tab, or select the **Next: Outbound IP** button at the bottom of the page.
3. In the **Outbound IP** tab, enter or select the following information:

| **Setting** | **Value** |
| --- | --- |
| Public IP addresses | Select **Create a new public IP address**.  In **Name**, enter **myPublicIP**.  Select **OK**. |

1. Select the **Review + create** tab, or select the blue **Review + create** button at the bottom of the page.
2. Select **Create**.

#### Virtual network

Before you deploy a virtual machine and can use your NAT gateway, you need to create the virtual network. This virtual network will contain the virtual machine created in later steps.

1. In the search box at the top of the portal, enter **Virtual network**. Select **Virtual networks** in the search results.
2. Select **+ Create**.
3. In **Create virtual network**, enter or select this information in the **Basics** tab:

| **Setting** | **Value** |
| --- | --- |
| **Project Details** |  |
| Subscription | Select your Azure subscription |
| Resource Group | Select **myResourceGroupNAT**. |
| **Instance details** |  |
| Name | Enter **myVNet** |
| Region | Select **(Europe) West Europe** |

1. Select the **Security** tab or select the **Next: Security** button at the bottom of the page.
2. Under **Azure Bastion**, select **Enable Azure Bastion**. Enter this information:

| **Setting** | **Value** |
| --- | --- |
| Azure Bastion name | Enter **myBastionHost** |
| Azure Bastion public IP address | Select **New(myVNet-publicipAddress1)** |

1. Select the **IP Addresses** tab or select the **Next: IP Addresses** button at the bottom of the page.
2. Accept the default IPv4 address space of **10.0.0.0/16**.
3. In the subnet section in **Subnet name**, select the **default** subnet, then select **Save**.
4. In **Edit subnet**, enter this information:

| **Setting** | **Value** |
| --- | --- |
| Name | Enter **mySubnet** |
| Starting address | Enter **10.0.0.0** |
| Subnet size | Select **/24** |
| **Security** |  |
| NAT gateway | Select **myNATgateway**. |

1. Select **Add a subnet** and enter the following information, then select **Add**.

| **Setting** | **Value** |
| --- | --- |
| Subnet template | Select **Azure Bastion** |
| Starting address | Enter **10.0.1.0** |
| Subnet size | Select **/26** |

1. Select the **Review + create** tab or select the **Review + create** button.
2. Select **Create**.

It can take a few minutes for the deployment of the virtual network to complete. Proceed to the next steps when the deployment completes.

#### Virtual machine

In this section, you'll create a virtual machine to test the NAT gateway and verify the public IP address of the outbound connection.

1. In the search box at the top of the portal, enter **Virtual machine**. Select **Virtual machines** in the search results.
2. Select **+ Create** > **Azure virtual machine**.
3. In the **Create a virtual machine** page in the **Basics** tab, enter, or select the following information:

| **Setting** | **Value** |
| --- | --- |
| **Project details** |  |
| Subscription | Select your subscription. |
| Resource group | Select **myResourceGroupNAT**. |
| **Instance details** |  |
| Virtual machine name | Enter **myVM**. |
| Region | Select **(Europe) West Europe**. |
| Availability options | Select **No infrastructure redundancy required**. |
| Security type | Select **Standard**. |
| Image | Select **Windows Server 2022 Datacenter: Azure Edition - Gen2**. |
| Size | Select a size. |
| **Administrator account** |  |
| Username | Enter a username for the virtual machine. |
| Password | Enter a password. |
| Confirm password | Confirm password. |
| **Inbound port rules** |  |
| Public inbound ports | Select **None**. |

1. Select the **Disks** tab, or select the **Next: Disks** button at the bottom of the page.
2. Leave the default in the **Disks** tab.
3. Select the **Networking** tab, or select the **Next: Networking** button at the bottom of the page.
4. In the **Networking** tab, enter or select the following information:

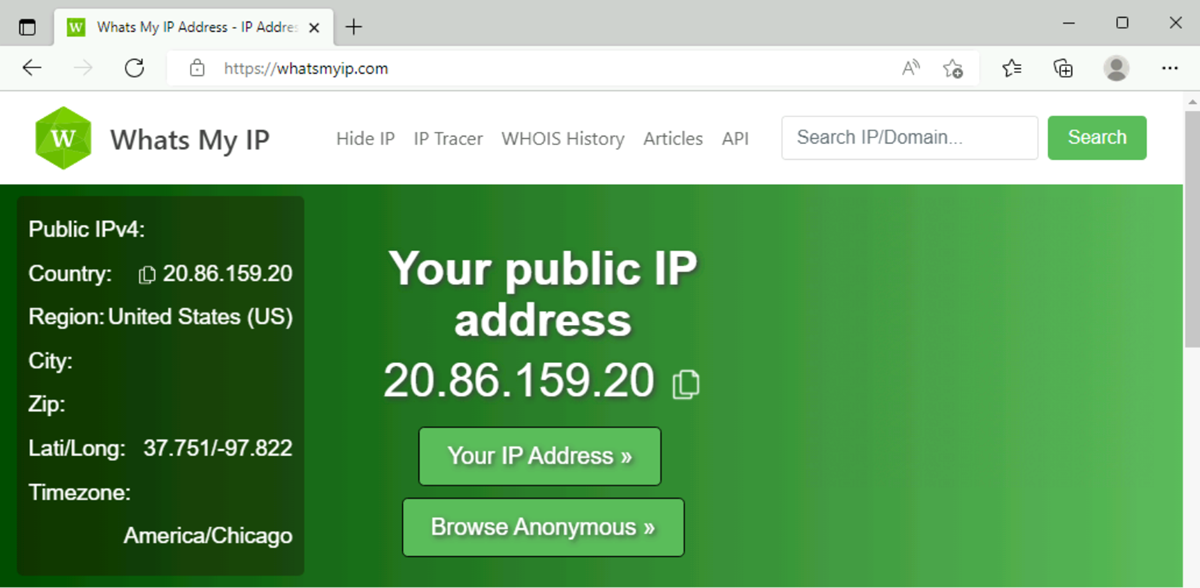
| **Setting** | **Value** |
| --- | --- |
| **Network interface** |  |
| Virtual network | Select **myVNet**. |
| Subnet | Select **mySubnet (10.1.0.0/24)**. |
| Public IP | Select **None**. |
| NIC network security group | Select **Basic**. |
| Public inbound ports | Select **None**. |

1. Select the **Review + create** tab, or select the blue **Review + create** button at the bottom of the page.
2. Select **Create**.

#### Test NAT gateway

In this section, you'll test the NAT gateway. You'll first discover the public IP of the NAT gateway. You'll then connect to the test virtual machine and verify the outbound connection through the NAT gateway.

1. In the search box at the top of the portal, enter **Public IP**. Select **Public IP addresses** in the search results.
2. Select **myPublicIP**.
3. Make note of the public IP address:
4. In the search box at the top of the portal, enter **Virtual machine**. Select **Virtual machines** in the search results.
5. Select **myVM**.
6. On the **Overview** page, select **Connect**, then **Bastion**.
7. Enter the username and password entered during VM creation. Select **Connect**.
8. Open **Microsoft Edge** on **myTestVM**.
9. Enter [**https://whatsmyip.com**](https://whatsmyip.com/) in the address bar.
10. Verify the IP address displayed matches the NAT gateway address you noted in the previous step:



#### Clean up resources

If you're not going to continue to use this application, delete the virtual network, virtual machine, and NAT gateway with the following steps:

1. From the left-hand menu, select **Resource groups**.
2. Select the **myResourceGroupNAT** resource group.
3. Select **Delete resource group**.
4. Enter **myResourceGroupNAT** and select **Delete**.

# Azure SQL

<https://learn.microsoft.com/en-us/training/paths/azure-sql-fundamentals/>

<https://learn.microsoft.com/en-us/azure/azure-sql/azure-sql-iaas-vs-paas-what-is-overview?view=azuresql>

## What is Azure SQL?

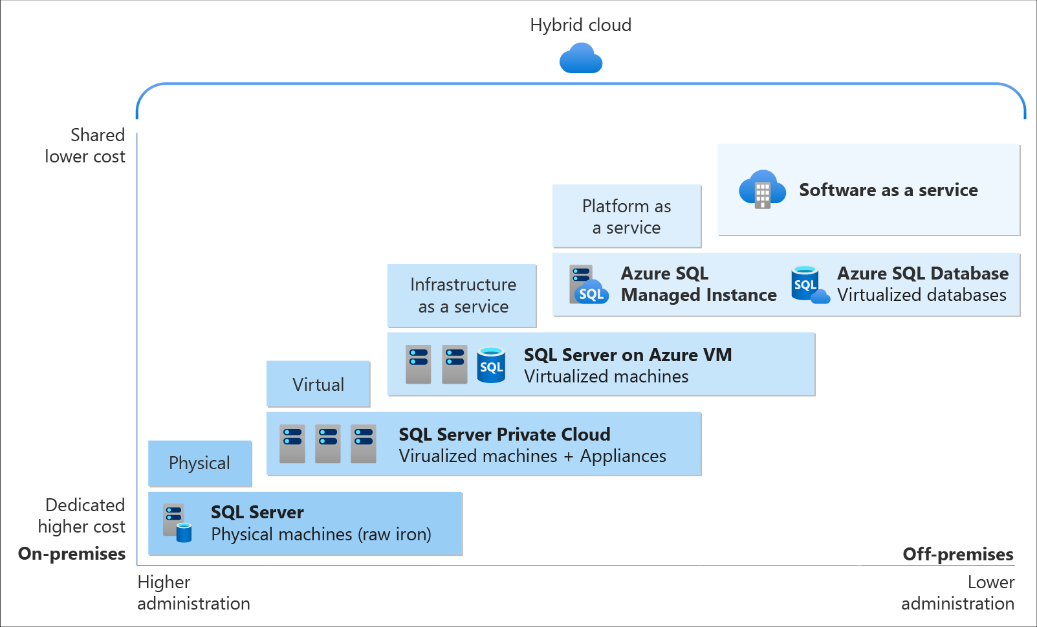
Azure SQL is a family of managed, secure, and intelligent products that use the SQL Server database engine in the Azure cloud.

* **Azure SQL Database**: Support modern cloud applications on an intelligent, managed database service, that includes serverless compute.
* **Azure SQL Managed Instance**: Modernize your existing SQL Server applications at scale with an intelligent fully managed instance as a service, with almost 100% feature parity with the SQL Server database engine. Best for most migrations to the cloud.
* **SQL Server on Azure VMs**: Lift-and-shift your SQL Server workloads with ease and maintain 100% SQL Server compatibility and operating system-level access.

Azure SQL is built upon the familiar SQL Server engine, so you can migrate applications with ease and continue to use the tools, languages, and resources you're familiar with. Your skills and experience transfer to the cloud, so you can do even more with what you already have.

Learn how each product fits into Microsoft's Azure SQL data platform to match the right option for your business requirements. Whether you prioritize cost savings or minimal administration, this article can help you decide which approach delivers against the business requirements you care about most.

### Service comparison



As seen in the diagram, each service offering can be characterized by the level of administration you have over the infrastructure, and by the degree of cost efficiency.

In Azure, you can have your SQL Server workloads running as a hosted service ([PaaS](https://azure.microsoft.com/overview/what-is-paas/)), or a hosted infrastructure ([IaaS](https://azure.microsoft.com/overview/what-is-iaas/)) supporting the software layer, such as Software-as-a-Service (SaaS) or an application. Within PaaS, you have multiple product options, and service tiers within each option. The key question that you need to ask when deciding between PaaS or IaaS is do you want to manage your database, apply patches, and take backups, or do you want to delegate these operations to Azure?

### Azure SQL Database

[Azure SQL Database](https://learn.microsoft.com/en-us/azure/azure-sql/database/sql-database-paas-overview?view=azuresql) is a relational database-as-a-service (DBaaS) hosted in Azure that falls into the industry category of Platform-as-a-Service (PaaS).

* Best for modern cloud applications that want to use the latest stable SQL Server features and have time constraints in development and marketing.
* A fully managed SQL Server database engine, based on the latest stable Enterprise Edition of SQL Server. SQL Database has two deployment options built on standardized hardware and software that is owned, hosted, and maintained by Microsoft.

With SQL Server, you can use built-in features and functionality that requires extensive configuration (either on-premises or in an Azure virtual machine). When using SQL Database, you pay-as-you-go with options to scale up or out for greater power with no interruption. SQL Database has some additional features that are not available in SQL Server, such as built-in high availability, intelligence, and management.

Azure SQL Database offers the following deployment options:

* As a [single database](https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-overview?view=azuresql) with its own set of resources managed via a [logical SQL server](https://learn.microsoft.com/en-us/azure/azure-sql/database/logical-servers?view=azuresql). A single database is similar to a [contained database](https://learn.microsoft.com/en-us/sql/relational-databases/databases/contained-databases) in SQL Server. This option is optimized for modern application development of new cloud-born applications. [Hyperscale](https://learn.microsoft.com/en-us/azure/azure-sql/database/service-tier-hyperscale?view=azuresql) and [serverless](https://learn.microsoft.com/en-us/azure/azure-sql/database/serverless-tier-overview?view=azuresql) options are available.
* An [elastic pool](https://learn.microsoft.com/en-us/azure/azure-sql/database/elastic-pool-overview?view=azuresql), which is a collection of databases with a shared set of resources managed via a [logical server](https://learn.microsoft.com/en-us/azure/azure-sql/database/logical-servers?view=azuresql). Single databases can be moved into and out of an elastic pool. This option is optimized for modern application development of new cloud-born applications using the multi-tenant SaaS application pattern. Elastic pools provide a cost-effective solution for managing the performance of multiple databases that have variable usage patterns.

### Azure SQL Managed Instance

[Azure SQL Managed Instance](https://learn.microsoft.com/en-us/azure/azure-sql/managed-instance/sql-managed-instance-paas-overview?view=azuresql) falls into the industry category of Platform-as-a-Service (PaaS), and is best for most migrations to the cloud. SQL Managed Instance is a collection of system and user databases with a shared set of resources that is lift-and-shift ready.

* Best for new applications or existing on-premises applications that want to use the latest stable SQL Server features and that are migrated to the cloud with minimal changes. An instance of SQL Managed Instance is similar to an instance of the [Microsoft SQL Server database engine](https://learn.microsoft.com/en-us/sql/database-engine/sql-server-database-engine-overview) offering shared resources for databases and additional instance-scoped features.
* SQL Managed Instance supports database migration from on-premises with minimal to no database change. This option provides all of the PaaS benefits of Azure SQL Database but adds capabilities that were previously only available in SQL Server VMs. This includes a native virtual network and near 100% compatibility with on-premises SQL Server. Instances of SQL Managed Instance provide full SQL Server access and feature compatibility for migrating SQL Servers to Azure.

### SQL Server on Azure VM

[SQL Server on Azure VM](https://learn.microsoft.com/en-us/azure/azure-sql/virtual-machines/windows/sql-server-on-azure-vm-iaas-what-is-overview?view=azuresql) falls into the industry category Infrastructure-as-a-Service (IaaS) and allows you to run SQL Server inside a fully managed virtual machine (VM) in Azure.

* SQL Server installed and hosted in the cloud runs on Windows Server or Linux virtual machines running on Azure, also known as an infrastructure as a service (IaaS). SQL virtual machines are a good option for migrating on-premises SQL Server databases and applications without any database change. All recent versions and editions of SQL Server are available for installation in an IaaS virtual machine.
* Best for migrations and applications requiring OS-level access. SQL virtual machines in Azure are lift-and-shift ready for existing applications that require fast migration to the cloud with minimal changes or no changes. SQL virtual machines offer full administrative control over the SQL Server instance and underlying OS for migration to Azure.
* The most significant difference from SQL Database and SQL Managed Instance is that SQL Server on Azure Virtual Machines allows full control over the database engine. You can choose when to start maintenance/patching, change the recovery model to simple or bulk-logged, pause or start the service when needed, and you can fully customize the SQL Server database engine. With this additional control comes the added responsibility to manage the virtual machine.
* Rapid development and test scenarios when you do not want to buy on-premises non-production SQL Server hardware. SQL virtual machines also run on standardized hardware that is owned, hosted, and maintained by Microsoft. When using SQL virtual machines, you can either pay-as-you-go for a SQL Server license already included in a SQL Server image or easily use an existing license. You can also stop or resume the VM as needed.
* Optimized for migrating existing applications to Azure or extending existing on-premises applications to the cloud in hybrid deployments. In addition, you can use SQL Server in a virtual machine to develop and test traditional SQL Server applications. With SQL virtual machines, you have the full administrative rights over a dedicated SQL Server instance and a cloud-based VM. It is a perfect choice when an organization already has IT resources available to maintain the virtual machines. These capabilities allow you to build a highly customized system to address your application's specific performance and availability requirements.

### Comparison table

Additional differences are listed in the following table, but both SQL Database and SQL Managed Instance are optimized to reduce overall management costs to a minimum for provisioning and managing many databases. Ongoing administration costs are reduced since you do not have to manage any virtual machines, operating system, or database software. You do not have to manage upgrades, high availability, or [backups](https://learn.microsoft.com/en-us/azure/azure-sql/database/automated-backups-overview?view=azuresql).

In general, SQL Database and SQL Managed Instance can dramatically increase the number of databases managed by a single IT or development resource. [Elastic pools](https://learn.microsoft.com/en-us/azure/azure-sql/database/elastic-pool-overview?view=azuresql) also support SaaS multi-tenant application architectures with features including tenant isolation and the ability to scale to reduce costs by sharing resources across databases. [SQL Managed Instance](https://learn.microsoft.com/en-us/azure/azure-sql/managed-instance/sql-managed-instance-paas-overview?view=azuresql) provides support for instance-scoped features enabling easy migration of existing applications, as well as sharing resources among databases. Whereas, [SQL Server on Azure VMs](https://learn.microsoft.com/en-us/azure/azure-sql/virtual-machines/windows/sql-server-on-azure-vm-iaas-what-is-overview?view=azuresql) provide DBAs with an experience most similar to the on-premises environment they're familiar with.

| **Azure SQL Database** | **Azure SQL Managed Instance** | **SQL Server on Azure VM** |
| --- | --- | --- |
| Supports most on-premises database-level capabilities. The most commonly used SQL Server features are available. 99.995% availability guaranteed. Built-in backups, patching, recovery. Latest stable Database Engine version. Ability to assign necessary resources (CPU/storage) to individual databases. Built-in advanced intelligence and security. Online change of resources (CPU/storage). | Supports almost all on-premises instance-level and database-level capabilities. High compatibility with SQL Server. 99.99% availability guaranteed. Built-in backups, patching, recovery. Latest stable Database Engine version. Easy migration from SQL Server. Private IP address within Azure Virtual Network. Built-in advanced intelligence and security. Online change of resources (CPU/storage). | You have full control over the SQL Server engine. Supports all on-premises capabilities. Up to 99.99% availability. Full parity with the matching version of on-premises SQL Server. Fixed, well-known Database Engine version. Easy migration from SQL Server. Private IP address within Azure Virtual Network. You have the ability to deploy application or services on the host where SQL Server is placed. |
| Migration from SQL Server might be challenging. Some SQL Server features are not available. Configurable [maintenance windows](https://learn.microsoft.com/en-us/azure/azure-sql/database/maintenance-window?view=azuresql). Compatibility with the SQL Server version can be achieved only using database compatibility levels. Private IP address support with [Azure Private Link](https://learn.microsoft.com/en-us/azure/azure-sql/database/private-endpoint-overview?view=azuresql). | There is still some minimal number of SQL Server features that are not available. Configurable [maintenance windows](https://learn.microsoft.com/en-us/azure/azure-sql/database/maintenance-window?view=azuresql). Compatibility with the SQL Server version can be achieved only using database compatibility levels. | You may use [manual or automated backups](https://learn.microsoft.com/en-us/azure/azure-sql/virtual-machines/windows/backup-restore?view=azuresql). You need to implement your own High-Availability solution. There is a downtime while changing the resources(CPU/storage) |
| Databases of up to 100 TB. | Up to 16 TB. | SQL Server instances with up to 256 TB of storage. The instance can support as many databases as needed. |
| On-premises application can access data in Azure SQL Database. | [Native virtual network implementation](https://learn.microsoft.com/en-us/azure/azure-sql/managed-instance/vnet-existing-add-subnet?view=azuresql) and connectivity to your on-premises environment using Azure Express Route or VPN Gateway. | With SQL virtual machines, you can have applications that run partly in the cloud and partly on-premises. For example, you can extend your on-premises network and Active Directory Domain to the cloud via [Azure Virtual Network](https://learn.microsoft.com/en-us/azure/virtual-network/virtual-networks-overview). For more information on hybrid cloud solutions, see [Extending on-premises data solutions to the cloud](https://learn.microsoft.com/en-us/azure/architecture/data-guide/scenarios/hybrid-on-premises-and-cloud). |

### Administration

For many businesses, the decision to transition to a cloud service is as much about offloading complexity of administration as it is cost. With IaaS and PaaS, Azure administers the underlying infrastructure and automatically replicates all data to provide disaster recovery, configures and upgrades the database software, manages load balancing, and does transparent failover if there is a server failure within a data center.

* With **SQL Database** and **SQL Managed Instance**, you can continue to administer your database, but you no longer need to manage the database engine, the operating system, or the hardware. Examples of items you can continue to administer include databases and logins, index and query tuning, and auditing and security. Additionally, configuring high availability to another data center requires minimal configuration and administration.
* With **SQL on Azure VM**, you have full control over the operating system and SQL Server instance configuration. With a VM, it's up to you to decide when to update/upgrade the operating system and database software and when to install any additional software such as anti-virus. Some automated features are provided to dramatically simplify patching, backup, and high availability. In addition, you can control the size of the VM, the number of disks, and their storage configurations. Azure allows you to change the size of a VM as needed. For information, see [Virtual Machine and Cloud Service Sizes for Azure](https://learn.microsoft.com/en-us/azure/virtual-machines/sizes).

## Create a single database - Azure SQL Database

<https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-create-quickstart?view=azuresql&tabs=azure-portal>

In this quickstart, you create a [single database](https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-overview?view=azuresql) in Azure SQL Database using either the Azure portal. You then query the database using **Query editor** in the Azure portal.

### Create a single database

This quickstart creates a single database in the [serverless compute tier](https://learn.microsoft.com/en-us/azure/azure-sql/database/serverless-tier-overview?view=azuresql).

To create a single database in the Azure portal, this quickstart starts at the Azure SQL page.

1. Browse to the [Select SQL Deployment option](https://portal.azure.com/#create/Microsoft.AzureSQL) (<https://portal.azure.com/#create/Microsoft.AzureSQL>) page.
2. Under **SQL databases**, leave **Resource type** set to **Single database**, and select **Create**.
3. On the **Basics** tab of the **Create SQL Database** form, under **Project details**, select the desired Azure **Subscription**.
4. For **Resource group**, select **Create new**, enter myResourceGroup, and select **OK**.
5. For **Database name**, enter mySampleDatabase.
6. For **Server**, select **Create new**, and fill out the **New server** form with the following values:

* **Server name**: Enter mysqlserver, and add some characters for uniqueness. We can't provide an exact server name to use because server names must be globally unique for all servers in Azure, not just unique within a subscription. So, enter something like mysqlserver12345, and the portal lets you know if it's available or not.
* **Location**: Select a location from the dropdown list.
* **Authentication method**: Select **Use SQL authentication**.
* **Server admin login**: Enter azureuser.
* **Password**: Enter a password that meets requirements, and enter it again in the **Confirm password** field.

Select **OK**.

1. Leave **Want to use SQL elastic pool** set to **No**.
2. Under **Compute + storage**, select **Configure database**.
3. This quickstart uses a serverless database, so leave **Service tier** set to **General purpose (Most budget-friendly, serverless compute)** and set **Compute tier** to **Serverless**. Select **Apply**.
4. Under **Backup storage redundancy**, choose a redundancy option for the storage account where your backups will be saved. To learn more, see [backup storage redundancy](https://learn.microsoft.com/en-us/azure/azure-sql/database/automated-backups-overview?view=azuresql#backup-storage-redundancy).
5. Select **Next: Networking** at the bottom of the page.
6. On the **Networking** tab, for **Connectivity method**, select **Public endpoint**.
7. For **Firewall rules**, set **Add current client IP address** to **Yes**. Leave **Allow Azure services and resources to access this server** set to **No**.

Verify your IP address with **whatsmyip.com**.

1. Under **Connection policy**, choose the **Default** [connection policy](https://learn.microsoft.com/en-us/azure/azure-sql/database/connectivity-architecture?view=azuresql#connection-policy), and leave the **Minimum TLS version** at the default of TLS 1.2.
2. Select **Next: Security** at the bottom of the page.
3. On the **Security** page, you can choose to start a free trial of [Microsoft Defender for SQL](https://learn.microsoft.com/en-us/azure/azure-sql/database/azure-defender-for-sql?view=azuresql), as well as configure [Ledger](https://learn.microsoft.com/en-us/sql/relational-databases/security/ledger/ledger-overview), [Managed identities](https://learn.microsoft.com/en-us/azure/active-directory/managed-identities-azure-resources/overview) and [Transparent data encryption (TDE)](https://learn.microsoft.com/en-us/azure/azure-sql/database/transparent-data-encryption-byok-overview?view=azuresql) if you desire. Select **Next: Additional settings** at the bottom of the page.
4. On the **Additional settings** tab, in the **Data source** section, for **Use existing data**, select **Sample**. This creates an AdventureWorksLT sample database so there's some tables and data to query and experiment with, as opposed to an empty blank database. You can also configure [database collation](https://learn.microsoft.com/en-us/sql/t-sql/statements/collations) and a [maintenance window](https://learn.microsoft.com/en-us/azure/azure-sql/database/maintenance-window?view=azuresql).
5. Select **Review + create** at the bottom of the page.
6. On the **Review + create** page, after reviewing, select **Create**.

### Query the database

Once your database is created, you can use the **Query editor (preview)** in the Azure portal to connect to the database and query data.

1. In the portal, search for and select **SQL databases**, and then select your database from the list.
2. On the page for your database, select **Query editor (preview)** in the left menu.
3. Enter your server admin login information, and select **OK**.
4. Enter the following query in the **Query editor** pane.

SELECT TOP 20 pc.Name as CategoryName, p.name as ProductName

FROM SalesLT.ProductCategory pc

JOIN SalesLT.Product p

ON pc.productcategoryid = p.productcategoryid;

1. Select **Run**, and then review the query results in the **Results** pane.
2. Close the **Query editor** page, and select **OK** when prompted to discard your unsaved edits.

### Clean up resources

Keep the resource group, server, and single database to go on to the next steps, and learn how to connect and query your database with different methods.

When you're finished using these resources, you can delete the resource group you created, which will also delete the server and single database within it.

To delete **myResourceGroup** and all its resources using the Azure portal:

1. In the portal, search for and select **Resource groups**, and then select **myResourceGroup** from the list.
2. On the resource group page, select **Delete resource group**.
3. Under **Type the resource group name**, enter myResourceGroup, and then select **Delete**.

## Create a server-level firewall rule in Azure portal

<https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-create-server-level-portal-quickstart?view=azuresql>

This quickstart describes how to create a [server-level firewall rule](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-configure?view=azuresql) in Azure SQL Database. Firewall rules can give access to [logical SQL servers](https://learn.microsoft.com/en-us/azure/azure-sql/database/logical-servers?view=azuresql), single databases, and elastic pools and their databases. Firewall rules are also needed to connect on-premises and other Azure resources to databases. Server-level firewall rules do not apply to Azure SQL Managed Instance.

### Prerequisites

We will use the resources developed in [Create a single database using the Azure portal](#_Create_a_single) as a starting point for this tutorial.

### Create a server-level IP-based firewall rule

Azure SQL Database creates a firewall at the server level for single and pooled databases. This firewall blocks connections from IP addresses that do not have permission. To connect to an Azure SQL database from an IP address outside of Azure, you need to create a firewall rule. You can use rules to open a firewall for a specific IP address or for a range of IP addresses. For more information about server-level and database-level firewall rules, see [Server-level and database-level IP-based firewall rules](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-configure?view=azuresql).

**Note**: Azure SQL Database communicates over port 1433. When you connect from within a corporate network, outbound traffic over port 1433 may not be permitted by your network firewall. This means your IT department needs to open port 1433 for you to connect to your server.

**Important**: A firewall rule of 0.0.0.0 enables all Azure services to pass through the server-level firewall rule and attempt to connect to a database through the server.

We'll use the following steps to create a server-level IP-based, firewall rule for a specific, client IP address. This enables external connectivity for that IP address through the Azure SQL Database firewall.

1. After the [database](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-create-server-level-portal-quickstart?view=azuresql#prerequisites) deployment completes, select **SQL databases** from the left-hand menu and then select **mySampleDatabase** on the **SQL databases** page. The overview page for your database opens. It displays the fully qualified server name (such as **mydocssampleserver.database.windows.net**) and provides options for further configuration. You can also find the firewall settings by navigating directly to your server, and selecting **Networking** under **Security**.
2. Copy the fully qualified **server name**. You will use it when you connect to your server and its databases in other quickstarts. Select **Set server firewall** on the toolbar.
3. Set Public network access to Selected networks to reveal the virtual networks and firewall rules. When set to **Disabled**, virtual networks and firewall rule settings are hidden.
4. Choose **Add your client IP** to add your current IP address to a new, server-level, firewall rule. This rule can open Port 1433 for a single IP address or for a range of IP addresses. You can also configure firewall settings by choosing **Add a firewall rule**.

**Important**: By default, access through the Azure SQL Database firewall is disabled for all Azure services. Choose **ON** on this page to enable access for all Azure services.

1. Select **Save**. Port 1433 is now open on the server and a server-level IP-based, firewall rule is created for your current IP address.
2. Close the **Networking** page.

Open SQL Server Management Studio or another tool of your choice. Use the server admin account you created earlier to connect to the server and its databases from your IP address.

1. Save the resources from this quickstart to complete additional SQL database tutorials.

### Clean up resources

Use the following steps to delete the resources that you created during this quickstart:

1. From the left-hand menu in Azure portal, select **Resource groups** and then select **myResourceGroup**.
2. On your resource group page, select **Delete**, type **myResourceGroup** in the text box, and then select **Delete**.

## Use the Azure portal query editor to query Azure SQL Database

<https://learn.microsoft.com/en-us/azure/azure-sql/database/connect-query-portal?view=azuresql>

The Azure SQL Database [Query editor](https://learn.microsoft.com/en-us/azure/azure-sql/database/query-editor?view=azuresql) (preview) is a tool to run SQL queries against Azure SQL Database in the Azure portal. In this quickstart, you connect to an Azure SQL database in the Azure portal and use query editor to run Transact-SQL (T-SQL) queries.

### Prerequisites

* The AdventureWorksLT sample Azure SQL database. If you don't have it, you can [create a database in Azure SQL Database](https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-create-quickstart?view=azuresql) that has the AdventureWorks sample data.
* A user account with permissions to connect to the database and query editor. You can either:
  + Have or set up a user that can connect to the database with SQL authentication.
  + Have or set up a user that can connect to the database with Azure Active Directory (Azure AD) authentication.

### Connect to the query editor

1. On your SQL database **Overview** page in the [Azure portal](https://portal.azure.com/), select **Query editor (preview)** from the left menu.
2. On the sign-in screen, provide credentials to connect to the database. You can connect using SQL authentication or Azure AD.

* To connect with SQL authentication, under **SQL server authentication**, enter a **Login** and **Password** for a user that has access to the database, and then select **OK**. You can always use the login and password for the server admin.
  + To connect using Azure AD, if you're the Azure AD server admin, select **Continue as <your user or group ID>**. If sign-in is unsuccessful, try refreshing the page.

### Query the database

On the **Query editor (preview)** page, run the following example queries against your AdventureWorksLT sample database.

#### Run a SELECT query

1. To query for the top 20 products in the database, paste the following [SELECT](https://learn.microsoft.com/en-us/sql/t-sql/queries/select-transact-sql) query into the query editor:

SELECT TOP 20 pc.Name as CategoryName, p.name as ProductName

FROM SalesLT.ProductCategory pc

JOIN SalesLT.Product p

ON pc.productcategoryid = p.productcategoryid;

1. Select **Run**, and then review the output in the **Results** pane.
2. Optionally, you can select **Save query** to save the query as an .sql file, or select **Export data as** to export the results as a .json, .csv, or .xml file.

#### Run an INSERT query

To add a new product to the SalesLT.Product table, run the following [INSERT](https://learn.microsoft.com/en-us/sql/t-sql/statements/insert-transact-sql/) T-SQL statement.

1. In the query editor, replace the previous query with the following query:

INSERT INTO [SalesLT].[Product]

( [Name]

, [ProductNumber]

, [Color]

, [ProductCategoryID]

, [StandardCost]

, [ListPrice]

, [SellStartDate]

)

VALUES

('myNewProduct'

,123456789

,'NewColor'

,1

,100

,100

,GETDATE() );

1. Select **Run** to add the new product. After the query runs, the **Messages** pane displays **Query succeeded: Affected rows: 1**.

#### Run an UPDATE query

Run the following [UPDATE](https://learn.microsoft.com/en-us/sql/t-sql/queries/update-transact-sql/) T-SQL statement to update the price of your new product.

1. In the query editor, replace the previous query with the following query:

UPDATE [SalesLT].[Product]

SET [ListPrice] = 125

WHERE Name = 'myNewProduct';

1. Select **Run** to update the specified row in the Product table. The **Messages** pane displays **Query succeeded: Affected rows: 1**.

#### Run a DELETE query

Run the following [DELETE](https://learn.microsoft.com/en-us/sql/t-sql/statements/delete-transact-sql/) T-SQL statement to remove your new product.

1. In the query editor, replace the previous query with the following query:

DELETE FROM [SalesLT].[Product]

WHERE Name = 'myNewProduct';

1. Select **Run** to delete the specified row in the Product table. The **Messages** pane displays **Query succeeded: Affected rows: 1**.

## Connect to and query Azure SQL Database using .NET and Entity Framework Core

<https://learn.microsoft.com/en-us/azure/azure-sql/database/azure-sql-dotnet-entity-framework-core-quickstart?view=azuresql&tabs=visual-studio%2Cservice-connector>

This quickstart describes how to connect an application to a database in Azure SQL Database and perform queries using .NET and Entity Framework Core. This quickstart follows the recommended passwordless approach to connect to the database. You can learn more about passwordless connections on the [passwordless hub](https://learn.microsoft.com/en-us/azure/developer/intro/passwordless-overview).

### Prerequisites

* An [Azure subscription](https://azure.microsoft.com/free/dotnet/).
* A SQL database configured with Azure Active Directory (Azure AD) authentication. You can create one using the [Create database quickstart](https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-create-quickstart?view=azuresql).
* [.NET 7.0](https://dotnet.microsoft.com/download) or later.
* [Visual Studio](https://visualstudio.microsoft.com/vs/) or later with the **ASP.NET and web development** workload.
* The latest version of the [Azure CLI](https://learn.microsoft.com/en-us/cli/azure/get-started-with-azure-cli).
* The latest version of the Entity Framework Core tools:
  + Visual Studio users should install the [Package Manager Console tools for Entity Framework Core](https://learn.microsoft.com/en-us/ef/core/cli/powershell).
  + .NET CLI users should install the [.NET CLI tools for Entity Framework Core](https://learn.microsoft.com/en-us/ef/core/cli/dotnet).

### Configure the database server

Secure, passwordless connections to Azure SQL Database with .NET require certain database configurations. Verify the following settings on your [logical server in Azure](https://learn.microsoft.com/en-us/azure/azure-sql/database/logical-servers?view=azuresql) to properly connect to Azure SQL Database in both local and hosted environments:

1. For local development connections, make sure your logical server is configured to allow your local machine IP address and other Azure services to connect:

* Navigate to the **Networking** page of your server.
* Toggle the **Selected networks** radio button to show additional configuration options.
* Select **Add your client IPv4 address(xx.xx.xx.xx)** to add a firewall rule that will enable connections from your local machine IPv4 address. Alternatively, you can also select **+ Add a firewall rule** to enter a specific IP address of your choice.
* Make sure the **Allow Azure services and resources to access this server** checkbox is selected.

[](https://learn.microsoft.com/en-us/azure/azure-sql/database/media/passwordless-connections/configure-firewall.png?view=azuresql#lightbox)

**Warning**: Enabling the **Allow Azure services and resources to access this server** setting is not a recommended security practice for production scenarios. Real applications should implement more secure approaches, such as stronger firewall restrictions or virtual network configurations.

You can read more about database security configurations on the following resources:

* [**Configure Azure SQL Database firewall rules**](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-configure).
* [**Configure a virtual network with private endpoints**](https://learn.microsoft.com/en-us/azure/private-link/tutorial-private-endpoint-sql-portal).

1. The server must also have Azure AD authentication enabled with an Azure Active Directory admin account assigned. For local development connections, the Azure Active Directory admin account should be an account you can also log into Visual Studio or the Azure CLI with locally. You can verify whether your server has Azure AD authentication enabled on the **Azure Active Directory** page.

[](https://learn.microsoft.com/en-us/azure/azure-sql/database/media/passwordless-connections/enable-active-directory.png?view=azuresql#lightbox)

1. If you're using a personal Azure account, make sure you have [Azure Active Directory setup and configured for Azure SQL Database](https://learn.microsoft.com/en-us/azure/azure-sql/database/authentication-aad-configure?view=azuresql) in order to assign your account as a server admin. If you're using a corporate account, Azure Active Directory will most likely already be configured for you.

### Create the project

The steps in this section create a .NET Minimal Web API by using either the .NET CLI or Visual Studio 2022.

1. In the Visual Studio menu bar, navigate to **File** > **New** > **Project..**.
2. In the dialog window, enter ASP.NET into the project template search box and select the ASP.NET Core Web API result. Choose **Next** at the bottom of the dialog.
3. For the **Project Name**, enter DotNetSQL. Leave the default values for the rest of the fields and select **Next**.
4. For the **Framework**, select .NET 7.0 and uncheck **Use controllers (uncheck to use minimal APIs)**. This quickstart uses a Minimal API template to streamline endpoint creation and configuration. Uncheck **Use HTTPS**.
5. Choose **Create**. The new project opens inside the Visual Studio environment.

### Add Entity Framework Core to the project

To connect to Azure SQL Database by using .NET and Entity Framework Core you need to add three NuGet packages to your project using one of the following methods:

1. In the **Solution Explorer** window, right-click the project's **Dependencies** node and select **Manage NuGet Packages**.
2. In the resulting window, search for EntityFrameworkCore. Locate and install the following packages:

* **Microsoft.EntityFrameworkCore**: Provides essential Entity Framework Core functionality
* **Microsoft.EntityFrameworkCore.SqlServer**: Provides additional components to connect to the logical server
* **Microsoft.EntityFrameworkCore.Design**: Provides support for running Entity Framework migrations

Alternatively, you can also run the Install-Package cmdlet in the **Package Manager Console** window:

Install-Package Microsoft.EntityFrameworkCore

Install-Package Microsoft.EntityFrameworkCore.SqlServer

Install-Package Microsoft.EntityFrameworkCore.Design

Install-Package Microsoft.EntityFrameworkCore.Tools

### Add the code to connect to Azure SQL Database

The Entity Framework Core libraries rely on the Microsoft.Data.SqlClient and Azure.Identity libraries to implement passwordless connections to Azure SQL Database. The Azure.Identity library provides a class called [DefaultAzureCredential](https://learn.microsoft.com/en-us/dotnet/azure/sdk/authentication#defaultazurecredential) that handles passwordless authentication to Azure.

DefaultAzureCredential supports multiple authentication methods and determines which to use at runtime. This approach enables your app to use different authentication methods in different environments (local vs. production) without implementing environment-specific code. The [Azure Identity library overview](https://learn.microsoft.com/en-us/dotnet/api/overview/azure/Identity-readme#defaultazurecredential) explains the order and locations in which DefaultAzureCredential looks for credentials.

Complete the following steps to connect to Azure SQL Database using Entity Framework Core and the underlying DefaultAzureCredential class:

1. Add a **ConnectionStrings** section to the **appsettings.Development.json** and **appsettings.json** files so that it matches the following code. Remember to update the <your database-server-name> and <your-database-name> placeholders.

The passwordless connection string includes a configuration value of Authentication=Active Directory Default, which enables Entity Framework Core to use DefaultAzureCredential to connect to Azure services. When the app runs locally, it authenticates with the user you're signed into Visual Studio with. Once the app deploys to Azure, the same code discovers and applies the managed identity that is associated with the hosted app, which you'll configure later.

**Note**: Passwordless connection strings are safe to commit to source control, since they do not contain any secrets such as usernames, passwords, or access keys.

**Passwordless AD:**

"ConnectionStrings": {

"AZURE\_SQL\_CONNECTIONSTRING": "Data Source=ajs-sqlserver.database.windows.net; Initial Catalog=ajs-sampledb; Authentication=Active Directory Default; Encrypt=True;"

}

**SQL Auth (Preferred):**

"ConnectionStrings": {

"AZURE\_SQL\_CONNECTIONSTRING": "Server=tcp:ajs-sqlserver.database.windows.net,1433;Initial Catalog=ajs-sampledb;Persist Security Info=False;User ID=asingala;Password=Password@123;MultipleActiveResultSets=False;Encrypt=True;TrustServerCertificate=False;Connection Timeout=30;"

}

{

"Logging": {

"LogLevel": {

"Default": "Information",

"Microsoft.AspNetCore": "Warning"

}

},

"ConnectionStrings": {

"AZURE\_SQL\_CONNECTIONSTRING": "Server=tcp:ajs-sqlserver.database.windows.net,1433;Initial Catalog=ajs-sampledb;Persist Security Info=False;User ID=asingala;Password=Password@123;MultipleActiveResultSets=False;Encrypt=True;TrustServerCertificate=False;Connection Timeout=30;"

}

}

1. Add the following code to the Program.cs file above the line of code that reads **var app = builder.Build();**. This code performs the following configurations:

* Retrieves the passwordless database connection string from the appsettings.Development.json file for local development, or from the environment variables for hosted production scenarios.
* Registers the Entity Framework Core DbContext class with the .NET dependency injection container.

var connection = String.Empty;

if (builder.Environment.IsDevelopment())

{

builder.Configuration.AddEnvironmentVariables().AddJsonFile("appsettings.Development.json");

connection = builder.Configuration.GetConnectionString("AZURE\_SQL\_CONNECTIONSTRING");

}

else

{

// connection = Environment.GetEnvironmentVariable("AZURE\_SQL\_CONNECTIONSTRING");

builder.Configuration.AddEnvironmentVariables().AddJsonFile("appsettings.Development.json");

builder.Configuration.AddEnvironmentVariables().AddJsonFile("appsettings.json");

connection = builder.Configuration.GetConnectionString("AZURE\_SQL\_CONNECTIONSTRING");

}

builder.Services.AddDbContext<PersonDbContext>(options =>

options.UseSqlServer(connection));

1. Add the following endpoints to the bottom of the Program.cs file above app.Run() to retrieve and add entities in the database using the PersonDbContext class.

app.MapGet("/Person", (PersonDbContext context) =>

{

return context.Person.ToList();

})

.WithName("GetPersons")

.WithOpenApi();

app.MapPost("/Person", (Person person, PersonDbContext context) =>

{

context.Add(person);

context.SaveChanges();

})

.WithName("CreatePerson")

.WithOpenApi();

Finally, add the Person and PersonDbContext classes to the bottom of the Program.cs file. The Person class represents a single record in the database's Persons table. The PersonDbContext class represents the Person database and allows you to perform operations on it through code. You can read more about DbContext in the [Getting Started](https://learn.microsoft.com/en-us/ef/core/get-started/overview/first-app) documentation for Entity Framework Core.

public class Person

{

public int Id { get; set; }

public string FirstName { get; set; }

public string LastName { get; set; }

}

public class PersonDbContext : DbContext

{

public PersonDbContext(DbContextOptions<PersonDbContext> options)

: base(options)

{

}

public DbSet<Person> Person { get; set; }

}

### Run the migrations to create the database

To update the database schema to match your data model using Entity Framework Core you must use a migration. Migrations can create and incrementally update a database schema to keep it in sync with your application's data model. You can learn more about this pattern in the [migrations overview](https://learn.microsoft.com/en-us/ef/core/managing-schemas/migrations).

1. Open a terminal window to the root of your project.
2. Run the following command to generate an initial migration that can create the database:

Add-Migration InitialCreate

1. A Migrations folder should appear in your project directory, along with a file called InitialCreate with unique numbers prepended. Run the migration to create the database using the following command:

Update-Database

The Entity Framework Core tooling will create the database schema in Azure defined by the PersonDbContext class.

### Test the app locally

The app is ready to be tested locally. Make sure you're signed in to Visual Studio or the Azure CLI with the same account you set as the admin for your database.

1. Press the run button at the top of Visual Studio to launch the API project.
2. On the Swagger UI page, expand the POST method and select **Try it**.
3. Modify the sample JSON to include values for the first and last name. Select **Execute** to add a new record to the database. The API returns a successful response.
4. Expand the **GET** method on the Swagger UI page and select **Try it**. Select **Execute**, and the person you just created is returned.

### Deploy to Azure App Service

The app is ready to be deployed to Azure. Visual Studio can create an Azure App Service and deploy your application in a single workflow.

1. Make sure the app is stopped and builds successfully.
2. In Visual Studio's **Solution Explorer** window, right-click on the top-level project node and select **Publish**.
3. In the publishing dialog, select **Azure** as the deployment target, and then select **Next**.
4. For the specific target, select **Azure App Service (Windows)**, and then select **Next**.
5. Select the green **+** icon to create a new App Service to deploy to and enter the following values:

* **Name**: Leave the default value.
* **Subscription name**: Select the subscription to deploy to.
* **Resource group**: Select **New** and create a new resource group called msdocs-dotnet-sql.
* **Hosting Plan**: Select **New** to open the hosting plan dialog. Leave the default values and select **OK**.
* Select **Create** to close the original dialog. Visual Studio creates the App Service resource in Azure.

[](https://learn.microsoft.com/en-us/azure/azure-sql/database/media/passwordless-connections/create-app-service.png?view=azuresql#lightbox)

1. Once the resource is created, make sure it's selected in the list of app services, and then select **Next**.
2. On the **API Management** step, select the **Skip this step** checkbox at the bottom and then select **Finish**.
3. Select **Publish** in the upper right of the publishing profile summary to deploy the app to Azure.

When the deployment finishes, Visual Studio launches the browser to display the hosted app. Add **/person** to the url and it should show you the results. To create records, use Postman and submit a **POST** request to the **<app-service-url/person>** url with the person data in JSON format as follows:

{

"id":0,

"firstName":"John",

"lastName":"Smith"

}

Verify the data is created by navigating the browser and refreshing the app service url.

~~When the deployment finishes, Visual Studio launches the browser to display the hosted app, but at this point the app doesn't work correctly on Azure. You still need to configure the secure connection between the App Service and the SQL database to retrieve your data.~~

### ~~Connect the App Service to Azure SQL Database~~

~~The following steps are required to connect the App Service instance to Azure SQL Database:~~

1. ~~Create a managed identity for the App Service. The Microsoft.Data.SqlClient library included in your app will automatically discover the managed identity, just like it discovered your local Visual Studio user.~~
2. ~~Create a SQL database user and associate it with the App Service managed identity.~~
3. ~~Assign SQL roles to the database user that allow for read, write, and potentially other permissions.~~

~~There are multiple tools available to implement these steps:~~

##### ~~Service Connector (Recommended)~~

~~Service Connector is a tool that streamlines authenticated connections between different services in Azure. Service Connector currently supports connecting an App Service to a SQL database via the Azure CLI using the az webapp connection create sql command. This single command completes the three steps mentioned above for you.~~

~~az webapp connection create sql~~

~~-g <your-resource-group>~~

~~-n <your-app-service-name>~~

~~--tg <your-database-server-resource-group>~~

~~--server <your-database-server-name>~~

~~--database <your-database-name>~~

~~--system-identity~~

~~You can verify the changes made by Service Connector on the App Service settings.~~

1. ~~Navigate to the~~**~~Identity~~**~~page for your App Service. Under the~~**~~System assigned~~**~~tab, the~~**~~Status~~**~~should be set to~~**~~On~~**~~. This value means that a system-assigned managed identity was enabled for your app.~~
2. ~~Navigate to the~~**~~Configuration~~**~~page for your App Service. Under the~~**~~Connection strings~~**~~tab, you should see a connection string called~~**~~AZURE\_SQL\_CONNECTIONSTRING~~**~~. Select the~~**~~Click to show value~~**~~text to view the generated passwordless connection string. The name of this connection string aligns with the one you configured in your app, so it will be discovered automatically when running in Azure.~~

##### ~~Azure Portal~~

~~The Azure portal allows you to work with managed identities and run queries against Azure SQL Database. Complete the following steps to create a passwordless connection from your App Service instance to Azure SQL Database:~~

**~~Create the managed identity~~**

1. ~~In the Azure portal, navigate to your App Service and select~~**~~Identity~~**~~on the left navigation.~~
2. ~~On the identity page, make sure the~~**~~Enable system-assigned managed identity~~**~~option is enabled. When this setting is enabled, a system-assigned managed identity is created with the same name as your App Service. System-assigned identities are tied to the service instance and are destroyed with the app when it's deleted.~~

**~~Create the database user and assign roles~~**

1. ~~In the Azure portal, browse to your SQL database and select~~**~~Query editor (preview)~~**~~.~~
2. ~~Select~~**~~Continue as <your-username>~~**~~on the right side of the screen to sign into the database using your account.~~
3. ~~On the query editor view, run the following T-SQL commands:~~

~~CREATE USER <your-app-service-name> FROM EXTERNAL PROVIDER;~~

~~ALTER ROLE db\_datareader ADD MEMBER <your-app-service-name>;~~

~~ALTER ROLE db\_datawriter ADD MEMBER <your-app-service-name>;~~

~~ALTER ROLE db\_ddladmin ADD MEMBER <your-app-service-name>;~~

~~GO~~

~~This SQL script creates a SQL database user that maps back to the managed identity of your App Service instance. It also assigns the necessary SQL roles to the user to allow your app to read, write, and modify the data and schema of your database. After this step is completed, your services are connected.~~

**~~Important:~~** ~~Although this solution provides a simple approach for getting started, it's not a best practice for production-grade environments. In those scenarios, the app shouldn't perform all operations using a single, elevated identity. You should try to implement the principle of least privilege by configuring multiple identities with specific permissions for specific tasks.~~

~~You can read more about configuring database roles and security on the following resources:~~

* [**~~Tutorial: Secure a database in Azure SQL Database~~**](https://learn.microsoft.com/en-us/azure/azure-sql/database/secure-database-tutorial?view=azuresql)
* [**~~Authorize database access to SQL Database~~**](https://learn.microsoft.com/en-us/azure/azure-sql/database/logins-create-manage?view=azuresql)

### Test the deployed application

Browse to the URL of the app to test that the connection to Azure SQL Database is working. You can locate the URL of your app on the App Service overview page. Append the /person path to the end of the URL to browse to the same endpoint you tested locally.

The person you created locally should display in the browser. Congratulations! Your application is now connected to Azure SQL Database in both local and hosted environments.

## Connect to and query Azure SQL Database using .NET and the Microsoft.Data.SqlClient library

<https://learn.microsoft.com/en-us/azure/azure-sql/database/azure-sql-dotnet-quickstart?view=azuresql&tabs=visual-studio%2Cpasswordless%2Cservice-connector>

This quickstart describes how to connect an application to a database in Azure SQL Database and perform queries using .NET and the [Microsoft.Data.SqlClient](https://www.nuget.org/packages/Microsoft.Data.SqlClient) library. This quickstart follows the recommended passwordless approach to connect to the database. You can learn more about passwordless connections on the [passwordless hub](https://learn.microsoft.com/en-us/azure/developer/intro/passwordless-overview).

### Prerequisites

* An [Azure subscription](https://azure.microsoft.com/free/dotnet/).
* An Azure SQL database configured with Azure Active Directory (Azure AD) authentication. You can create one using the [Create database quickstart](https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-create-quickstart?view=azuresql).
* The latest version of the [Azure CLI](https://learn.microsoft.com/en-us/cli/azure/get-started-with-azure-cli).
* [Visual Studio](https://visualstudio.microsoft.com/vs/) or later with the **ASP.NET and web development** workload.
* [.NET 7.0](https://dotnet.microsoft.com/download) or later.

### Configure the database

Secure, passwordless connections to Azure SQL Database with .NET require certain database configurations. Verify the following settings on your [logical server in Azure](https://learn.microsoft.com/en-us/azure/azure-sql/database/logical-servers?view=azuresql) to properly connect to Azure SQL Database in both local and hosted environments:

1. For local development connections, make sure your logical server is configured to allow your local machine IP address and other Azure services to connect:

* Navigate to the **Networking** page of your server.
* Toggle the **Selected networks** radio button to show additional configuration options.
* Select **Add your client IPv4 address(xx.xx.xx.xx)** to add a firewall rule that will enable connections from your local machine IPv4 address. Alternatively, you can also select **+ Add a firewall rule** to enter a specific IP address of your choice.
* Make sure the **Allow Azure services and resources to access this server** checkbox is selected.

[](https://learn.microsoft.com/en-us/azure/azure-sql/database/media/passwordless-connections/configure-firewall.png?view=azuresql#lightbox)

**Warning**: Enabling the **Allow Azure services and resources to access this server** setting is not a recommended security practice for production scenarios. Real applications should implement more secure approaches, such as stronger firewall restrictions or virtual network configurations.

You can read more about database security configurations on the following resources:

* [**Configure Azure SQL Database firewall rules**](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-configure).
* [**Configure a virtual network with private endpoints**](https://learn.microsoft.com/en-us/azure/private-link/tutorial-private-endpoint-sql-portal).

1. The server must also have Azure AD authentication enabled with an Azure Active Directory admin account assigned. For local development connections, the Azure Active Directory admin account should be an account you can also log into Visual Studio or the Azure CLI with locally. You can verify whether your server has Azure AD authentication enabled on the **Azure Active Directory** page.

[](https://learn.microsoft.com/en-us/azure/azure-sql/database/media/passwordless-connections/enable-active-directory.png?view=azuresql#lightbox)

1. If you're using a personal Azure account, make sure you have [Azure Active Directory setup and configured for Azure SQL Database](https://learn.microsoft.com/en-us/azure/azure-sql/database/authentication-aad-configure?view=azuresql) in order to assign your account as a server admin. If you're using a corporate account, Azure Active Directory will most likely already be configured for you.

### Create the project

For the steps ahead, create a .NET Minimal Web API using either the .NET CLI or Visual Studio 2022.

1. In the Visual Studio menu, navigate to **File** > **New** > **Project..**.
2. In the dialog window, enter ASP.NET into the project template search box and select the ASP.NET Core Web API result. Choose **Next** at the bottom of the dialog.
3. For the **Project Name**, enter DotNetSQL. Leave the default values for the rest of the fields and select **Next**.
4. For the **Framework**, select .NET 7.0 and uncheck **Use controllers (uncheck to use minimal APIs)**. This quickstart uses a Minimal API template to streamline endpoint creation and configuration.
5. Choose **Create**. The new project opens inside the Visual Studio environment.

### Add the Microsoft.Data.SqlClient library

To connect to Azure SQL Database by using .NET, install Microsoft.Data.SqlClient. This package acts as a data provider for connecting to databases, executing commands, and retrieving results.

**Note**: Make sure to install Microsoft.Data.SqlClient and not System.Data.SqlClient. Microsoft.Data.SqlClient is a newer version of the SQL client library that provides additional capabilities.

1. In the **Solution Explorer** window, right-click the project's **Dependencies** node and select **Manage NuGet Packages**.
2. In the resulting window, search for SqlClient. Locate the Microsoft.Data.SqlClient result and select **Install**.

### Configure the connection string

#### Passwordless (Recommended)

For local development with passwordless connections to Azure SQL Database, add the following ConnectionStrings section to the appsettings.json file. Replace the <database-server-name> and <database-name> placeholders with your own values.

"ConnectionStrings": {

"AZURE\_SQL\_CONNECTIONSTRING": "Server=tcp:<database-server-name>.database.windows.net,1433;Initial Catalog=<database-name>;Encrypt=True;TrustServerCertificate=False;Connection Timeout=30;Authentication=\"Active Directory Default\";"

}

The passwordless connection string sets a configuration value of Authentication="Active Directory Default", which instructs the Microsoft.Data.SqlClient library to connect to Azure SQL Database using a class called [DefaultAzureCredential](https://learn.microsoft.com/en-us/dotnet/azure/sdk/authentication#defaultazurecredential). DefaultAzureCredential enables passwordless connections to Azure services and is provided by the Azure Identity library on which the SQL client library depends. DefaultAzureCredential supports multiple authentication methods and determines which to use at runtime for different environments.

For example, when the app runs locally, DefaultAzureCredential authenticates via the user you're signed into Visual Studio with, or other local tools like the Azure CLI. Once the app deploys to Azure, the same code discovers and applies the managed identity that is associated with the hosted app, which you'll configure later. The [Azure Identity library overview](https://learn.microsoft.com/en-us/dotnet/api/overview/azure/Identity-readme#defaultazurecredential) explains the order and locations in which DefaultAzureCredential looks for credentials.

**Note**: Passwordless connection strings are safe to commit to source control, since they don't contain secrets such as usernames, passwords, or access keys.

#### SQL Authentication

For local development with SQL Authentication to Azure SQL Database, add the following ConnectionStrings section to the appsettings.json file. Replace the <database-server-name>, <database-name>, <user-id>, and <password> placeholders with your own values.

"ConnectionStrings": {

"AZURE\_SQL\_CONNECTIONSTRING": "Server=tcp:<database-server-name>.database.windows.net,1433;Initial Catalog=<database-name>;Persist Security Info=False;User ID=<user-id>;Password=<password>;MultipleActiveResultSets=False;Encrypt=True;TrustServerCertificate=False;"

}

**Warning**: Use caution when managing connection strings that contain secrets such as usernames, passwords, or access keys. These secrets shouldn't be committed to source control or placed in unsecure locations where they might be accessed by unintended users. During local development, on a real app, you'll generally connect to a local database that doesn't require storing secrets or connecting directly to Azure.

### Add the code to connect to Azure SQL Database

Replace the contents of the Program.cs file with the following code, which performs the following important steps:

* Retrieves the passwordless connection string from appsettings.json
* Creates a Persons table in the database during startup (for testing scenarios only)
* Creates an HTTP GET endpoint to retrieve all records stored in the Persons table
* Creates an HTTP POST endpoint to add new records to the Persons table

using Microsoft.Data.SqlClient;

var builder = WebApplication.CreateBuilder(args);

builder.Services.AddEndpointsApiExplorer();

builder.Services.AddSwaggerGen();

var app = builder.Build();

// For production scenarios, consider keeping Swagger configurations behind the environment check

// if (app.Environment.IsDevelopment())

// {

app.UseSwagger();

app.UseSwaggerUI();

// }

app.UseHttpsRedirection();

string connectionString = app.Configuration.GetConnectionString("AZURE\_SQL\_CONNECTIONSTRING")!;

try

{

// Table would be created ahead of time in production

using var conn = new SqlConnection(connectionString);

conn.Open();

var command = new SqlCommand(

"CREATE TABLE Persons (ID int NOT NULL PRIMARY KEY IDENTITY, FirstName varchar(255), LastName varchar(255));",

conn);

using SqlDataReader reader = command.ExecuteReader();

}

catch (Exception e)

{

// Table may already exist

Console.WriteLine(e.Message);

}

app.MapGet("/Person", () => {

var rows = new List<string>();

using var conn = new SqlConnection(connectionString);

conn.Open();

var command = new SqlCommand("SELECT \* FROM Persons", conn);

using SqlDataReader reader = command.ExecuteReader();

if (reader.HasRows)

{

while (reader.Read())

{

rows.Add($"{reader.GetInt32(0)}, {reader.GetString(1)}, {reader.GetString(2)}");

}

}

return rows;

})

.WithName("GetPersons")

.WithOpenApi();

app.MapPost("/Person", (Person person) => {

using var conn = new SqlConnection(connectionString);

conn.Open();

var command = new SqlCommand(

$"INSERT INTO Persons (firstName, lastName) VALUES ('{person.FirstName}', '{person.LastName}')",

conn);

using SqlDataReader reader = command.ExecuteReader();

})

.WithName("CreatePerson")

.WithOpenApi();

app.Run();

Finally, add the Person class to the bottom of the Program.cs file. This class represents a single record in the database's Persons table.

public class Person

{

public required string FirstName { get; set; }

public required string LastName { get; set; }

}

### Run and test the app locally

The app is ready to be tested locally. Make sure you're signed in to Visual Studio or the Azure CLI with the same account you set as the admin for your database.

1. Press the run button at the top of Visual Studio to launch the API project.
2. On the Swagger UI page, expand the POST method and select **Try it**.
3. Modify the sample JSON to include values for the first and last name. Select **Execute** to add a new record to the database. The API returns a successful response.
4. Expand the **GET** method on the Swagger UI page and select **Try it**. Choose **Execute**, and the person you just created is returned.

### Deploy to Azure App Service

The app is ready to be deployed to Azure. Visual Studio can create an Azure App Service and deploy your application in a single workflow.

1. Make sure the app is stopped and builds successfully.
2. In Visual Studio's **Solution Explorer** window, right-click on the top-level project node and select **Publish**.
3. In the publishing dialog, select **Azure** as the deployment target, and then select **Next**.
4. For the specific target, select **Azure App Service (Windows)**, and then select **Next**.
5. Select the **+** icon to create a new App Service to deploy to and enter the following values:

* **Name**: Leave the default value.
* **Subscription name**: Select the subscription to deploy to.
* **Resource group**: Select **New** and create a new resource group called msdocs-dotnet-sql.
* **Hosting Plan**: Select **New** to open the hosting plan dialog. Leave the default values and select **OK**.
* Select **Create** to close the original dialog. Visual Studio creates the App Service resource in Azure.

[](https://learn.microsoft.com/en-us/azure/azure-sql/database/media/passwordless-connections/create-app-service.png?view=azuresql#lightbox)

1. Once the resource is created, make sure it's selected in the list of app services, and then select **Next**.
2. On the **API Management** step, select the **Skip this step** checkbox at the bottom and then choose **Finish**.
3. On the Finish step, select **Close** if the dialog does not close automatically.
4. Select **Publish** in the upper right of the publishing profile summary to deploy the app to Azure.

When the deployment finishes, Visual Studio launches the browser to display the hosted app, but at this point the app doesn't work correctly on Azure. You still need to configure the secure connection between the App Service and the SQL database to retrieve your data.

### Connect the App Service to Azure SQL Database

#### SQL Authentication

No additional steps are required to connect the App Service to Azure SQL Database using SQL Authentication. The connection string you configured in the appsettings.json file includes the necessary credentials to authenticate.

**Warning**: Use caution when managing connection strings that contain secrets such as usernames, passwords, or access keys. These secrets shouldn't be committed to source control or placed in unsecure locations where they might be accessed by unintended users. For a real application in a production-grade Azure environment, you can store connection strings in a secure location such as App Service configuration settings or Azure Key Vault. During local development, you'll generally connect to a local database that doesn't require storing secrets or connecting directly to Azure.

#### Passwordless (Recommended)

The following steps are required to create a passwordless connection between the App Service instance and Azure SQL Database:

1. Create a managed identity for the App Service. The Microsoft.Data.SqlClient library included in your app will automatically discover the managed identity, just like it discovered your local Visual Studio user.
2. Create a SQL database user and associate it with the App Service managed identity.
3. Assign SQL roles to the database user that allow for read, write, and potentially other permissions.

There are multiple tools available to implement these steps:

##### Service Connector (Recommended)

Service Connector is a tool that streamlines authenticated connections between different services in Azure. Service Connector currently supports connecting an App Service to a SQL database via the Azure CLI using the az webapp connection create sql command. This single command completes the three steps mentioned above for you.

az webapp connection create sql \

-g <app-service-resource-group> \

-n <app-service-name> \

--tg <database-server-resource-group> \

--server <database-server-name> \

--database <database-name> \

--system-identity

You can verify the changes made by Service Connector on the App Service settings.

1. Navigate to the **Identity** page for your App Service. Under the **System assigned** tab, the **Status** should be set to **On**. This value means that a system-assigned managed identity was enabled for your app.
2. Navigate to the **Configuration** page for your App Service. Under the **Connection strings** tab, you should see a connection string called **AZURE\_SQL\_CONNECTIONSTRING**. Select the **Click to show value** text to view the generated passwordless connection string. The name of this connection string matches the one you configured in your app, so it will be discovered automatically when running in Azure.

##### Azure Portal

The Azure portal allows you to work with managed identities and run queries against Azure SQL Database. Complete the following steps to create a passwordless connection from your App Service instance to Azure SQL Database:

**Create the managed identity**

1. In the Azure portal, navigate to your App Service and select **Identity** on the left navigation.
2. On the **Identity** page's **System assigned** tab, make sure the **Status** toggle is set to **On**. When this setting is enabled, a system-assigned managed identity is created with the same name as your App Service. System-assigned identities are tied to the service instance and are destroyed with the app when it's deleted.

**Create the database user and assign roles**

1. In the Azure portal, browse to your SQL database and select **Query editor (preview)**.
2. Select **Continue as <your-username>** on the right side of the screen to sign into the database using your account.
3. On the query editor view, run the following T-SQL commands:

CREATE USER <your-app-service-name> FROM EXTERNAL PROVIDER;

ALTER ROLE db\_datareader ADD MEMBER <your-app-service-name>;

ALTER ROLE db\_datawriter ADD MEMBER <your-app-service-name>;

ALTER ROLE db\_ddladmin ADD MEMBER <your-app-service-name>;

GO

This SQL script creates a SQL database user that maps back to the managed identity of your App Service instance. It also assigns the necessary SQL roles to the user to allow your app to read, write, and modify the data and schema of your database. After this step is completed, your services are connected.

**Important:** Although this solution provides a simple approach for getting started, it's not a best practice for production-grade environments. In those scenarios, the app shouldn't perform all operations using a single, elevated identity. You should try to implement the principle of least privilege by configuring multiple identities with specific permissions for specific tasks.

You can read more about configuring database roles and security on the following resources:

* [**Tutorial: Secure a database in Azure SQL Database**](https://learn.microsoft.com/en-us/azure/azure-sql/database/secure-database-tutorial?view=azuresql)
* [**Authorize database access to SQL Database**](https://learn.microsoft.com/en-us/azure/azure-sql/database/logins-create-manage?view=azuresql)

### Test the deployed application

1. Select the **Browse** button at the top of App Service overview page to launch the root url of your app.
2. Append the /swagger/index.html path to the URL to load the same Swagger test page you used locally.
3. Execute test GET and POST requests to verify that the endpoints work as expected.

**Tip**: If you receive a 500 Internal Server error while testing, it may be due to your database networking configurations. Verify that your logical server is configured with the settings outlined in the [**Configure the database**](https://learn.microsoft.com/en-us/azure/azure-sql/database/azure-sql-dotnet-quickstart#configure-the-database) section.

Congratulations! Your application is now connected to Azure SQL Database in both local and hosted environments.

## Secure a database in Azure SQL Database

<https://learn.microsoft.com/en-us/azure/azure-sql/database/secure-database-tutorial?view=azuresql>

## Design a relational database in Azure SQL Database using SSMS

<https://learn.microsoft.com/en-us/azure/azure-sql/database/design-first-database-tutorial?view=azuresql>

Azure SQL Database is a relational database-as-a-service (DBaaS) in the Microsoft Cloud (Azure). In this tutorial, you learn how to use the Azure portal and [SQL Server Management Studio](https://learn.microsoft.com/en-us/sql/ssms/sql-server-management-studio-ssms) (SSMS) to:

* Create a database using the Azure portal\*
* Set up a server-level IP firewall rule using the Azure portal
* Connect to the database with SSMS
* Create tables with SSMS
* Bulk load data with BCP
* Query data with SSMS

### Prerequisites

To complete this tutorial, make sure you've installed:

* [SQL Server Management Studio](https://learn.microsoft.com/en-us/sql/ssms/sql-server-management-studio-ssms) (latest version)
* [BCP and SQLCMD](https://www.microsoft.com/download/details.aspx?id=36433) (latest version)
  + Dowload from <https://www.microsoft.com/en-us/download/details.aspx?id=36433> and install.

### Create a blank database in Azure SQL Database

A database in Azure SQL Database is created with a defined set of compute and storage resources. The database is created within an [Azure resource group](https://learn.microsoft.com/en-us/azure/active-directory-b2c/overview) and is managed using an [logical SQL server](https://learn.microsoft.com/en-us/azure/azure-sql/database/logical-servers?view=azuresql).

Follow these steps to create a blank database.

1. On the Azure portal menu or from the **Home** page, select **Create a resource**.
2. On the **New** page, select **Databases** in the Azure Marketplace section, and then click **SQL Database** in the **Featured** section.
3. Fill out the **SQL Database** form with the following information, as shown on the preceding image:

| **Setting** | **Suggested value** | **Description** |
| --- | --- | --- |
| **Database name** | yourDatabase | For valid database names, see [Database identifiers](https://learn.microsoft.com/en-us/sql/relational-databases/databases/database-identifiers). |
| **Subscription** | yourSubscription | For details about your subscriptions, see [Subscriptions](https://account.windowsazure.com/Subscriptions). |
| **Resource group** | yourResourceGroup | For valid resource group names, see [Naming rules and restrictions](https://learn.microsoft.com/en-us/azure/architecture/best-practices/resource-naming). |
| **Select source** | Blank database | Specifies that a blank database should be created. |

1. Choose a server from the drop-down to use an existing server or select **Create new** to create and configure a new server. Either select an existing server or click **Create a new server** and fill out the **New server** form with the following information:

| **Setting** | **Suggested value** | **Description** |
| --- | --- | --- |
| **Server name** | Any globally unique name | For valid server names, see [Naming rules and restrictions](https://learn.microsoft.com/en-us/azure/architecture/best-practices/resource-naming). |
| **Server admin login** | Any valid name | For valid login names, see [Database identifiers](https://learn.microsoft.com/en-us/sql/relational-databases/databases/database-identifiers). |
| **Password** | Any valid password | Your password must have at least eight characters and must use characters from three of the following categories: upper case characters, lower case characters, numbers, and non-alphanumeric characters. |
| **Location** | Any valid location | For information about regions, see [Azure Regions](https://azure.microsoft.com/regions/). |

1. Click **Select**.
2. Click **Pricing tier** to specify the service tier, the number of DTUs or vCores, and the amount of storage. You may explore the options for the number of DTUs/vCores and storage that is available to you for each service tier.

After selecting the service tier, the number of DTUs or vCores, and the amount of storage, click **Apply**.

1. Enter a **Collation** for the blank database (for this tutorial, use the default value). For more information about collations, see [Collations](https://learn.microsoft.com/en-us/sql/t-sql/statements/collations)
2. Now that you've completed the **SQL Database** form, click **Create** to provision the database. This step may take a few minutes.
3. On the toolbar, click **Notifications** to monitor the deployment process.

### Create a server-level IP firewall rule

Azure SQL Database creates an IP firewall at the server-level. This firewall prevents external applications and tools from connecting to the server and any databases on the server unless a firewall rule allows their IP through the firewall. To enable external connectivity to your database, you must first add an IP firewall rule for your IP address (or IP address range). Follow these steps to create a [server-level IP firewall rule](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-configure?view=azuresql).

**Important**: Azure SQL Database communicates over port 1433. If you are trying to connect to this service from within a corporate network, outbound traffic over port 1433 may not be allowed by your network's firewall. If so, you cannot connect to your database unless your administrator opens port 1433.

1. After the deployment completes, select **SQL databases** from the Azure portal menu or search for and select SQL databases from any page.
2. Select yourDatabase on the **SQL databases** page. The overview page for your database opens, showing you the fully qualified **Server name** (such as contosodatabaseserver01.database.windows.net) and provides options for further configuration.
3. Copy this fully qualified server name for use to connect to your server and databases from SQL Server Management Studio.
4. Select **Networking** under **Settings**. Choose the **Public Access** tab, and then select **Selected networks** under **Public network access** to display the **Firewall rules** section.
5. Select **Add your client IPv4** on the toolbar to add your current IP address to a new IP firewall rule. An IP firewall rule can open port 1433 for a single IP address or a range of IP addresses.
6. Select **Save**. A server-level IP firewall rule is created for your current IP address opening port 1433 on the server.
7. Select **OK** and then close the **Firewall settings** page.

Your IP address can now pass through the IP firewall. You can now connect to your database using SQL Server Management Studio or another tool of your choice. Be sure to use the server admin account you created previously.

**Important**: By default, access through the SQL Database IP firewall is enabled for all Azure services. Click **OFF** on this page to disable for all Azure services.

### Connect to the database

Use [SQL Server Management Studio](https://learn.microsoft.com/en-us/sql/ssms/sql-server-management-studio-ssms) to establish a connection to your database.

1. Open SQL Server Management Studio.
2. In the **Connect to Server** dialog box, enter the following information:

| **Setting** | **Suggested value** | **Description** |
| --- | --- | --- |
| **Server type** | Database engine | This value is required. |
| **Server name** | The fully qualified server name | For example, yourserver.database.windows.net. |
| **Authentication** | SQL Server Authentication | SQL Authentication is the only authentication type that we've configured in this tutorial. |
| **Login** | The server admin account | The account that you specified when you created the server. |
| **Password** | The password for your server admin account | The password that you specified when you created the server. |

1. Click **Options** in the **Connect to server** dialog box. In the **Connect to database** section, enter yourDatabase to connect to this database.
2. Click **Connect**. The **Object Explorer** window opens in SSMS.
3. In **Object Explorer**, expand **Databases** and then expand yourDatabase to view the objects in the sample database.

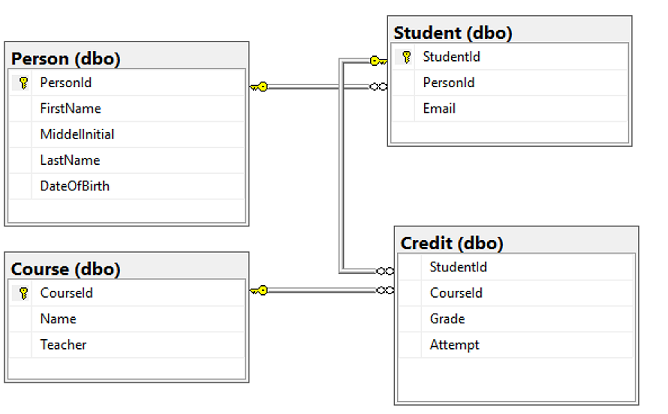
### Create tables in your database

Create a database schema with four tables that model a student management system for universities using [Transact-SQL](https://learn.microsoft.com/en-us/sql/t-sql/language-reference):

* Person
* Course
* Student
* Credit

The following diagram shows how these tables are related to each other. Some of these tables reference columns in other tables. For example, the Student table references the PersonId column of the Person table. Study the diagram to understand how the tables in this tutorial are related to one another. For an in-depth look at how to create effective database tables, see [Create effective database tables](https://learn.microsoft.com/en-us/previous-versions/tn-archive/cc505842(v=technet.10)). For information about choosing data types, see [Data types](https://learn.microsoft.com/en-us/sql/t-sql/data-types/data-types-transact-sql).

**Note**: You can also use the [**table designer in SQL Server Management Studio**](https://learn.microsoft.com/en-us/sql/ssms/visual-db-tools/design-database-diagrams-visual-database-tools) to create and design your tables.



1. In **Object Explorer**, right-click yourDatabase and select **New Query**. A blank query window opens that is connected to your database.
2. In the query window, execute the following query to create four tables in your database:

-- Create Person table

CREATE TABLE Person

(

PersonId INT IDENTITY PRIMARY KEY,

FirstName NVARCHAR(128) NOT NULL,

MiddelInitial NVARCHAR(10),

LastName NVARCHAR(128) NOT NULL,

DateOfBirth DATE NOT NULL

)

-- Create Student table

CREATE TABLE Student

(

StudentId INT IDENTITY PRIMARY KEY,

PersonId INT REFERENCES Person (PersonId),

Email NVARCHAR(256)

)

-- Create Course table

CREATE TABLE Course

(

CourseId INT IDENTITY PRIMARY KEY,

Name NVARCHAR(50) NOT NULL,

Teacher NVARCHAR(256) NOT NULL

)

-- Create Credit table

CREATE TABLE Credit

(

StudentId INT REFERENCES Student (StudentId),

CourseId INT REFERENCES Course (CourseId),

Grade DECIMAL(5,2) CHECK (Grade <= 100.00),

Attempt TINYINT,

CONSTRAINT [UQ\_studentgrades] UNIQUE CLUSTERED

(

StudentId, CourseId, Grade, Attempt

)

)

1. Expand the **Tables** node under yourDatabase in the **Object Explorer** to see the tables you created.

### Load data into the tables

1. Create a folder called sampleData in your Downloads folder to store sample data for your database.
2. Right-click the following links and save them into the sampleData folder.

* [SampleCourseData](https://github.com/microsoft/sql-server-samples/releases/download/sqldbtutorial/SampleCourseData) (<https://github.com/microsoft/sql-server-samples/releases/download/sqldbtutorial/SampleCourseData>)
* [SamplePersonData](https://github.com/microsoft/sql-server-samples/releases/download/sqldbtutorial/SamplePersonData) (<https://github.com/microsoft/sql-server-samples/releases/download/sqldbtutorial/SamplePersonData>)
* [SampleStudentData](https://github.com/microsoft/sql-server-samples/releases/download/sqldbtutorial/SampleStudentData) (<https://github.com/microsoft/sql-server-samples/releases/download/sqldbtutorial/SampleStudentData>)
* [SampleCreditData](https://github.com/microsoft/sql-server-samples/releases/download/sqldbtutorial/SampleCreditData) (<https://github.com/microsoft/sql-server-samples/releases/download/sqldbtutorial/SampleCreditData>)

1. Open a command prompt window and navigate to the sampleData folder.
2. Execute the following commands to insert sample data into the tables replacing the values for server, database, user, and password with the values for your environment.

bcp Course in SampleCourseData -S <server>.database.windows.net -d <database> -U <user> -P <password> -q -c -t ","

bcp Person in SamplePersonData -S <server>.database.windows.net -d <database> -U <user> -P <password> -q -c -t ","

bcp Student in SampleStudentData -S <server>.database.windows.net -d <database> -U <user> -P <password> -q -c -t ","

bcp Credit in SampleCreditData -S <server>.database.windows.net -d <database> -U <user> -P <password> -q -c -t ","

You have now loaded sample data into the tables you created earlier.

### Query data

Execute the following queries to retrieve information from the database tables. See [Write SQL queries](https://learn.microsoft.com/en-us/previous-versions/sql/sql-server-2005/express-administrator/bb264565(v=sql.90)) to learn more about writing SQL queries. The first query joins all four tables to find the students taught by 'Dominick Pope' who have a grade higher than 75%. The second query joins all four tables and finds the courses in which 'Noe Coleman' has ever enrolled.

1. In a SQL Server Management Studio query window, execute the following query:

-- Find the students taught by Dominick Pope who have a grade higher than 75%

SELECT person.FirstName, person.LastName, course.Name, credit.Grade

FROM Person AS person

INNER JOIN Student AS student ON person.PersonId = student.PersonId

INNER JOIN Credit AS credit ON student.StudentId = credit.StudentId

INNER JOIN Course AS course ON credit.CourseId = course.courseId

WHERE course.Teacher = 'Dominick Pope'

AND Grade > 75

1. In a query window, execute the following query:

SQLCopy

-- Find all the courses in which Noe Coleman has ever enrolled

SELECT course.Name, course.Teacher, credit.Grade

FROM Course AS course

INNER JOIN Credit AS credit ON credit.CourseId = course.CourseId

INNER JOIN Student AS student ON student.StudentId = credit.StudentId

INNER JOIN Person AS person ON person.PersonId = student.PersonId

WHERE person.FirstName = 'Noe'

AND person.LastName = 'Coleman'

## Design a relational database in Azure SQL Database using Azure Data Studio (ADS)

<https://learn.microsoft.com/en-us/azure/azure-sql/database/design-first-database-azure-data-studio?view=azuresql>

## What is Azure SQL Managed Instance (MI)?

<https://learn.microsoft.com/en-us/azure/azure-sql/managed-instance/sql-managed-instance-paas-overview?view=azuresql>

## What is SQL Server on Windows Azure Virtual Machines?

<https://learn.microsoft.com/en-us/azure/azure-sql/virtual-machines/windows/sql-server-on-azure-vm-iaas-what-is-overview?view=azuresql>

# Azure Storage

<https://intellipaat.com/blog/tutorial/microsoft-azure-tutorial/azure-storage/>

## Introduction to Azure Storage – Compare Core Storage Services

<https://learn.microsoft.com/en-us/azure/storage/common/storage-introduction?toc=%2Fazure%2Fstorage%2Fblobs%2Ftoc.json&bc=%2Fazure%2Fstorage%2Fblobs%2Fbreadcrumb%2Ftoc.json>

## Azure Storage redundancy

<https://learn.microsoft.com/en-us/azure/storage/common/storage-redundancy>

## Storage Explorer

<https://learn.microsoft.com/en-us/azure/vs-azure-tools-storage-manage-with-storage-explorer?tabs=windows>

Microsoft Azure Storage Explorer is a standalone app that makes it easy to work with Azure Storage data on Windows, macOS, and Linux.

### Prerequisites

#### Windows

The following versions of Windows support the latest versions of Storage Explorer:

* Windows 11
* Windows 10

Additional requirements include:

* Starting with Storage Explorer version 1.30.0, your Windows install must support 64-bit applications.
* Starting with Storage Explorer version 1.30.0, you must have a x64 .NET 6 runtime installed. You can download the latest .NET 6 runtime from [here](https://dotnet.microsoft.com/download/dotnet/6.0).

#### MacOS

The following versions of macOS support Storage Explorer:

* macOS 10.13 High Sierra and later versions

#### Ubuntu

Storage Explorer is available in the [Snap Store](https://snapcraft.io/storage-explorer). The Storage Explorer snap installs all of its dependencies and updates when new versions are published to the Snap Store.

Ubuntu comes preinstalled with snapd, which allows you to run snaps. You can learn more on the [snapd installation page](https://snapcraft.io/docs/installing-snapd).

Storage Explorer requires the use of a password manager. You can connect Storage Explorer to your system's password manager by running the following command:

snap connect storage-explorer:password-manager-service :password-manager-service

Installing the Storage Explorer snap is recommended, but Storage Explorer is also available as a .tar.gz download. If you use the .tar.gz, you must install all of Storage Explorer's dependencies manually.

For more help installing Storage Explorer on Ubuntu, see [Storage Explorer dependencies](https://learn.microsoft.com/en-us/azure/storage/common/storage-explorer-troubleshooting#storage-explorer-dependencies) in the Azure Storage Explorer troubleshooting guide.

### Download and install

To download and install Storage Explorer, see [Azure Storage Explorer](https://www.storageexplorer.com/) (<https://azure.microsoft.com/en-us/products/storage/storage-explorer/>).

### Connect to a storage account or service

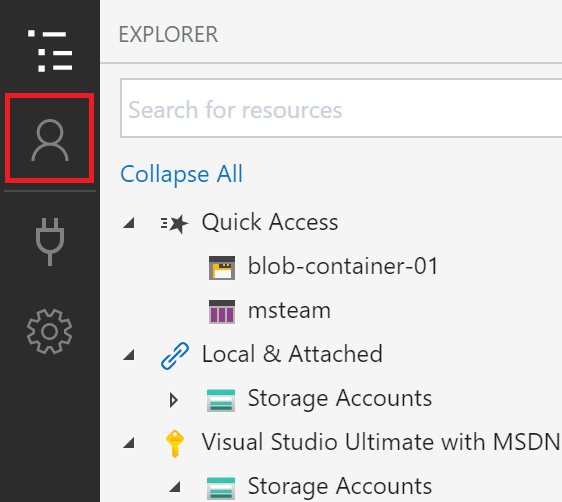
Storage Explorer provides several ways to connect to Azure resources:

* [Sign in to Azure to access your subscriptions and their resources](https://learn.microsoft.com/en-us/azure/vs-azure-tools-storage-manage-with-storage-explorer?tabs=windows#sign-in-to-azure)
* [Attach to an individual Azure Storage resource](https://learn.microsoft.com/en-us/azure/vs-azure-tools-storage-manage-with-storage-explorer?tabs=windows#attach-to-an-individual-resource)

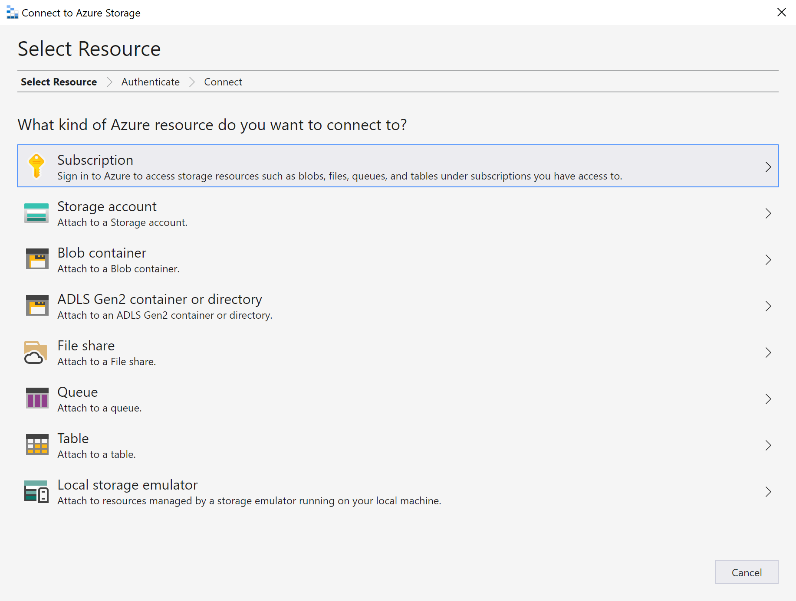
#### Sign in to Azure

**Note**: To fully access resources after you sign in, Storage Explorer requires both management (Azure Resource Manager) and data layer permissions. This means that you need Azure Active Directory (Azure AD) permissions to access your storage account, the containers in the account, and the data in the containers. If you have permissions only at the data layer, consider choosing the **Sign in using Azure Active Directory (Azure AD)** option when attaching to a resource. For more information about the specific permissions Storage Explorer requires, see the [**Azure Storage Explorer troubleshooting guide**](https://learn.microsoft.com/en-us/azure/storage/common/storage-explorer-troubleshooting#azure-rbac-permissions-issues).

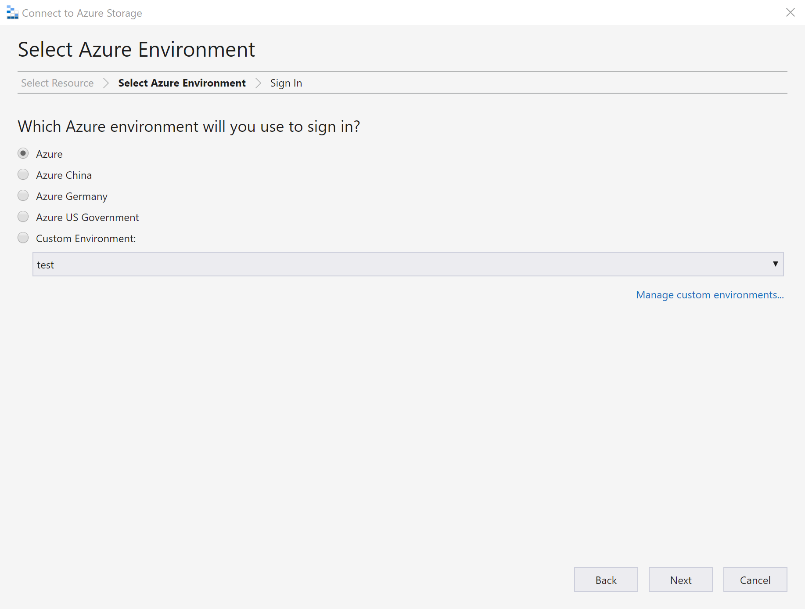
1. In Storage Explorer, select **View** > **Account Management** or select the **Manage Accounts** button.



1. **ACCOUNT MANAGEMENT** now displays all the Azure accounts you're signed in to. To connect to another account, select **Add an account...**.
2. The **Connect to Azure Storage** dialog opens. In the **Select Resource** panel, select **Subscription**.

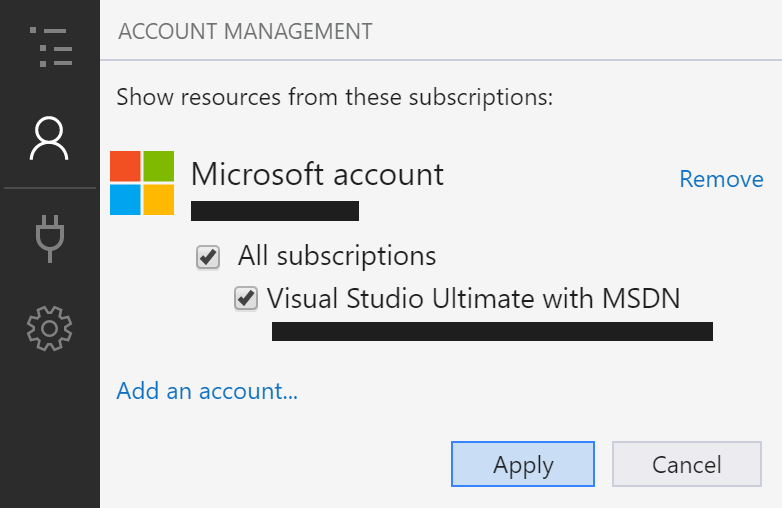


1. In the **Select Azure Environment** panel, select an Azure environment to sign in to. You can sign in to global Azure, a national cloud or an Azure Stack instance. Then select **Next**.

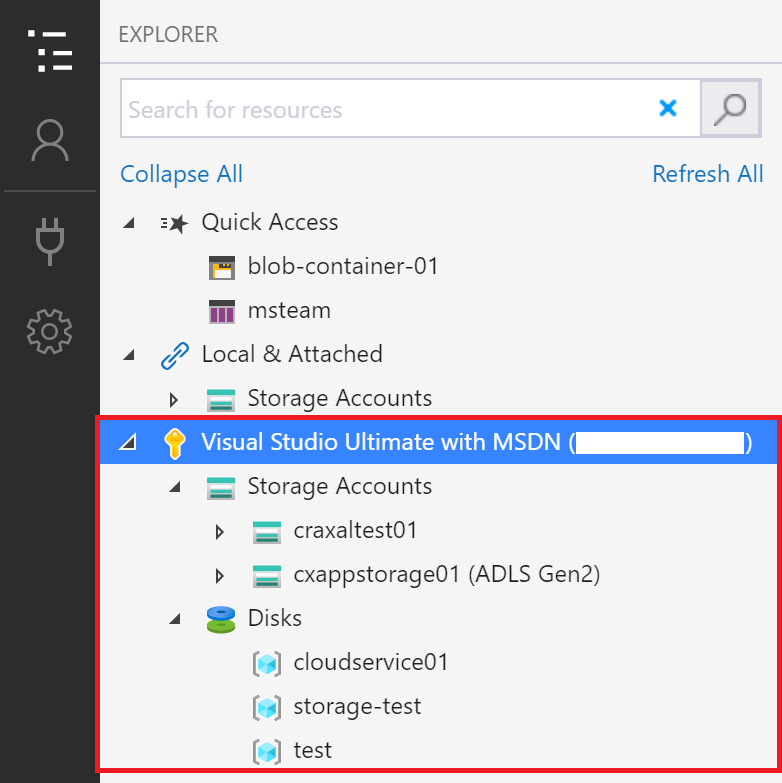


**Tip**: For more information about Azure Stack, see [**Connect Storage Explorer to an Azure Stack subscription or storage account**](https://learn.microsoft.com/en-us/azure-stack/user/azure-stack-storage-connect-se).

1. Storage Explorer will open a webpage for you to sign in.
2. After you successfully sign in with an Azure account, the account and the Azure subscriptions associated with that account appear under **ACCOUNT MANAGEMENT**. Select the Azure subscriptions that you want to work with, and then select **Apply**.



1. **EXPLORER** displays the storage accounts associated with the selected Azure subscriptions.



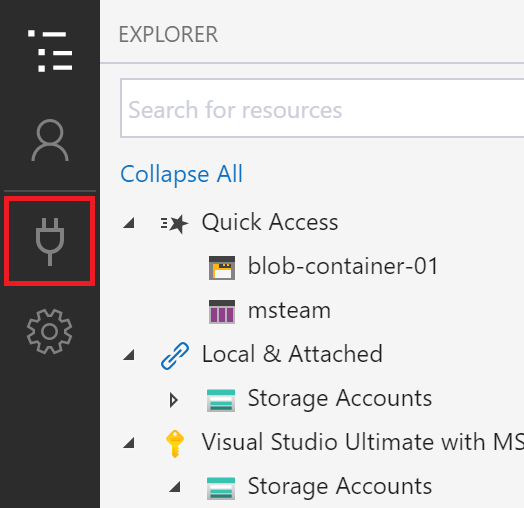
#### Attach to an individual resource

Storage Explorer lets you connect to individual resources, such as an Azure Data Lake Storage Gen2 container, using various authentication methods. Some authentication methods are only supported for certain resource types.

| **Resource type** | **Azure AD** | **Account Name and Key** | **Shared Access Signature (SAS)** | **Public (anonymous)** |
| --- | --- | --- | --- | --- |
| Storage accounts | Yes | Yes | Yes (connection string or URL) | No |
| Blob containers | Yes | No | Yes (URL) | Yes |
| Gen2 containers | Yes | No | Yes (URL) | Yes |
| Gen2 directories | Yes | No | Yes (URL) | Yes |
| File shares | No | No | Yes (URL) | No |
| Queues | Yes | No | Yes (URL) | No |
| Tables | Yes | No | Yes (URL) | No |

Storage Explorer can also connect to a [local storage emulator](https://learn.microsoft.com/en-us/azure/vs-azure-tools-storage-manage-with-storage-explorer?tabs=windows#local-storage-emulator) using the emulator's configured ports.

To connect to an individual resource, select the **Connect** button in the left-hand toolbar. Then follow the instructions for the resource type you want to connect to.



When a connection to a storage account is successfully added, a new tree node will appear under **Local & Attached** > **Storage Accounts**.

For other resource types, a new node is added under **Local & Attached** > **Storage Accounts** > **(Attached Containers)**. The node will appear under a group node matching its type. For example, a new connection to an Azure Data Lake Storage Gen2 container will appear under **Blob Containers**.

If Storage Explorer couldn't add your connection, or if you can't access your data after successfully adding the connection, see the [Azure Storage Explorer troubleshooting guide](https://learn.microsoft.com/en-us/azure/storage/common/storage-explorer-troubleshooting).

The following sections describe the different authentication methods you can use to connect to individual resources.

##### Azure AD

Storage Explorer can use your Azure account to connect to the following resource types:

* Blob containers
* Azure Data Lake Storage Gen2 containers
* Azure Data Lake Storage Gen2 directories
* Queues

Azure AD is the preferred option if you have data layer access to your resource but no management layer access.

1. Sign in to at least one Azure account using the [steps described above](https://learn.microsoft.com/en-us/azure/vs-azure-tools-storage-manage-with-storage-explorer?tabs=windows#sign-in-to-azure).
2. In the **Select Resource** panel of the **Connect to Azure Storage** dialog, select **Blob container**, **ADLS Gen2 container**, or **Queue**.
3. Select **Sign in using Azure Active Directory (Azure AD)** and select **Next**.
4. Select an Azure account and tenant. The account and tenant must have access to the Storage resource you want to attach to. Select **Next**.
5. Enter a display name for your connection and the URL of the resource. Select **Next**.
6. Review your connection information in the **Summary** panel. If the connection information is correct, select **Connect**.

##### Account name and key

Storage Explorer can connect to a storage account using the storage account's name and key.

You can find your account keys in the [Azure portal](https://portal.azure.com/). Open your storage account page and select **Settings** > **Access keys**.

1. In the **Select Resource** panel of the **Connect to Azure Storage** dialog, select **Storage account**.
2. Select **Account name and key** and select **Next**.
3. Enter a display name for your connection, the name of the account, and one of the account keys. Select the appropriate Azure environment. Select **Next**.
4. Review your connection information in the **Summary** panel. If the connection information is correct, select **Connect**.

##### Shared access signature (SAS) connection string

Storage Explorer can connect to a storage account using a connection string with a Shared Access Signature (SAS). A SAS connection string looks like this:

SharedAccessSignature=sv=2020-04-08&ss=btqf&srt=sco&st=2021-03-02T00%3A22%3A19Z&se=2020-03-03T00%3A22%3A19Z&sp=rl&sig=fFFpX%2F5tzqmmFFaL0wRffHlhfFFLn6zJuylT6yhOo%2FY%3F;

BlobEndpoint=https://contoso.blob.core.windows.net/;

FileEndpoint=https://contoso.file.core.windows.net/;

QueueEndpoint=https://contoso.queue.core.windows.net/;

TableEndpoint=https://contoso.table.core.windows.net/;

1. In the **Select Resource** panel of the **Connect to Azure Storage** dialog, select **Storage account**.
2. Select **Shared access signature (SAS)** and select **Next**.
3. Enter a display name for your connection and the SAS connection string for the storage account. Select **Next**.
4. Review your connection information in the **Summary** panel. If the connection information is correct, select **Connect**.

##### Shared access signature (SAS) URL

Storage Explorer can connect to the following resource types using a SAS URI:

* Blob container
* Azure Data Lake Storage Gen2 container or directory
* File share
* Queue
* Table

A SAS URI looks like this:

https://contoso.blob.core.windows.net/container01?sv=2020-04-08&st=2021-03-02T00%3A30%3A33Z&se=2020-03-03T00%3A30%3A33Z&sr=c&sp=rl&sig=z9VFdWffrV6FXU51T8b8HVfipZPOpYOFLXuQw6wfkFY%3F

1. In the **Select Resource** panel of the **Connect to Azure Storage** dialog, select the resource you want to connect to.
2. Select **Shared access signature (SAS)** and select **Next**.
3. Enter a display name for your connection and the SAS URI for the resource. Select **Next**.
4. Review your connection information in the **Summary** panel. If the connection information is correct, select **Connect**.

##### Local storage emulator

Storage Explorer can connect to an Azure Storage emulator. Currently, there are two supported emulators:

* [Azure Storage Emulator](https://learn.microsoft.com/en-us/azure/storage/common/storage-use-emulator) (Windows only)
* [Azurite](https://github.com/azure/azurite) (Windows, macOS, or Linux)

If your emulator is listening on the default ports, you can use the **Local & Attached** > **Storage Accounts** > **Emulator - Default Ports** node to access your emulator.

If you want to use a different name for your connection, or if your emulator isn't running on the default ports:

1. Start your emulator.

**Important**: Storage Explorer doesn't automatically start your emulator. You must start it manually.

1. In the **Select Resource** panel of the **Connect to Azure Storage** dialog, select **Local storage emulator**.
2. Enter a display name for your connection and the port number for each emulated service you want to use. If you don't want to use to a service, leave the corresponding port blank. Select **Next**.
3. Review your connection information in the **Summary** panel. If the connection information is correct, select **Connect**.

## Create a Storage Account

<https://learn.microsoft.com/en-us/azure/storage/common/storage-account-create?toc=%2Fazure%2Fstorage%2Fqueues%2Ftoc.json&tabs=azure-portal>

An Azure storage account contains all of your Azure Storage data objects: blobs, files, queues, and tables. The storage account provides a unique namespace for your Azure Storage data that is accessible from anywhere in the world over HTTP or HTTPS. For more information about Azure storage accounts, see [Storage account overview](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview).

A storage account is an Azure Resource Manager resource. Resource Manager is the deployment and management service for Azure. For more information, see [Azure Resource Manager overview](https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/overview).

Every Resource Manager resource, including an Azure storage account, must belong to an Azure resource group. A resource group is a logical container for grouping your Azure services. When you create a storage account, you have the option to either create a new resource group, or use an existing resource group. This how-to shows how to create a new resource group.

To create an Azure storage account with the Azure portal, follow these steps:

1. From the left portal menu, select **Storage accounts** to display a list of your storage accounts. If the portal menu isn't visible, select the menu button to toggle it on.
2. On the **Storage accounts** page, select **Create**.

Options for your new storage account are organized into tabs in the **Create a storage account** page. The following sections describe each of the tabs and their options.

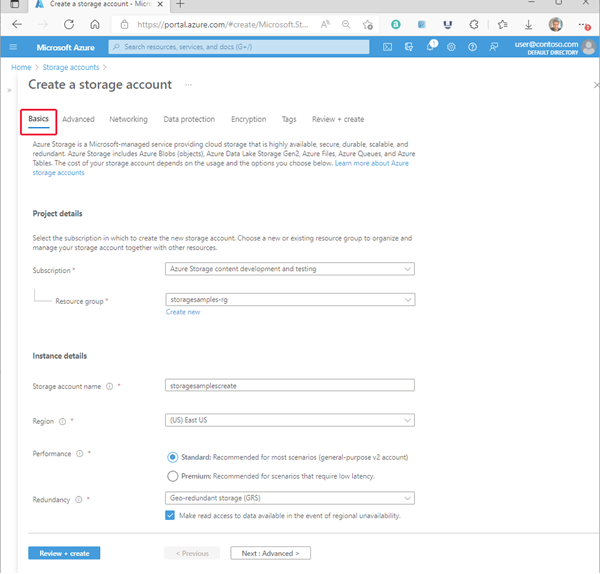
### Basics tab

On the **Basics** tab, provide the essential information for your storage account. After you complete the **Basics** tab, you can choose to further customize your new storage account by setting options on the other tabs, or you can select **Review + create** to accept the default options and proceed to validate and create the account.

The following table describes the fields on the **Basics** tab.

| **Section** | **Field** | **Required or optional** | **Description** |
| --- | --- | --- | --- |
| Project details | Subscription | Required | Select the subscription for the new storage account. |
| Project details | Resource group | Required | Create a new resource group for this storage account, or select an existing one. For more information, see [Resource groups](https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/overview#resource-groups). |
| Instance details | Storage account name | Required | Choose a unique name for your storage account. Storage account names must be between 3 and 24 characters in length and may contain numbers and lowercase letters only. |
| Instance details | Region | Required | Select the appropriate region for your storage account. For more information, see [Regions and Availability Zones in Azure](https://learn.microsoft.com/en-us/azure/availability-zones/az-overview).  Not all regions are supported for all types of storage accounts or redundancy configurations. For more information, see [Azure Storage redundancy](https://learn.microsoft.com/en-us/azure/storage/common/storage-redundancy).  The choice of region can have a billing impact. For more information, see [Storage account billing](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview#storage-account-billing).  If your subscription supports Azure public multi-access edge zones (Azure MEC), you can deploy your storage account to an edge zone. For more information about edge zones, see [What is Azure public MEC?](https://learn.microsoft.com/en-us/azure/public-multi-access-edge-compute-mec/overview). |
| Instance details | Performance | Required | Select **Standard** performance for general-purpose v2 storage accounts (default). This type of account is recommended by Microsoft for most scenarios. For more information, see [Types of storage accounts](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview#types-of-storage-accounts).  Select **Premium** for scenarios requiring low latency. After selecting **Premium**, select the type of premium storage account to create. The following types of premium storage accounts are available:  [Block blobs](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview)  [File shares](https://learn.microsoft.com/en-us/azure/storage/files/storage-files-planning#management-concepts)  [Page blobs](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blob-pageblob-overview) |
| Instance details | Redundancy | Required | Select your desired redundancy configuration. Not all redundancy options are available for all types of storage accounts in all regions. For more information about redundancy configurations, see [Azure Storage redundancy](https://learn.microsoft.com/en-us/azure/storage/common/storage-redundancy).  If you select a geo-redundant configuration (GRS or GZRS), your data is replicated to a data center in a different region. For read access to data in the secondary region, select **Make read access to data available in the event of regional unavailability**. |

The following image shows a standard configuration of the basic properties for a new storage account.

[](https://learn.microsoft.com/en-us/azure/storage/common/media/storage-account-create/create-account-basics-tab-lrg.png#lightbox)

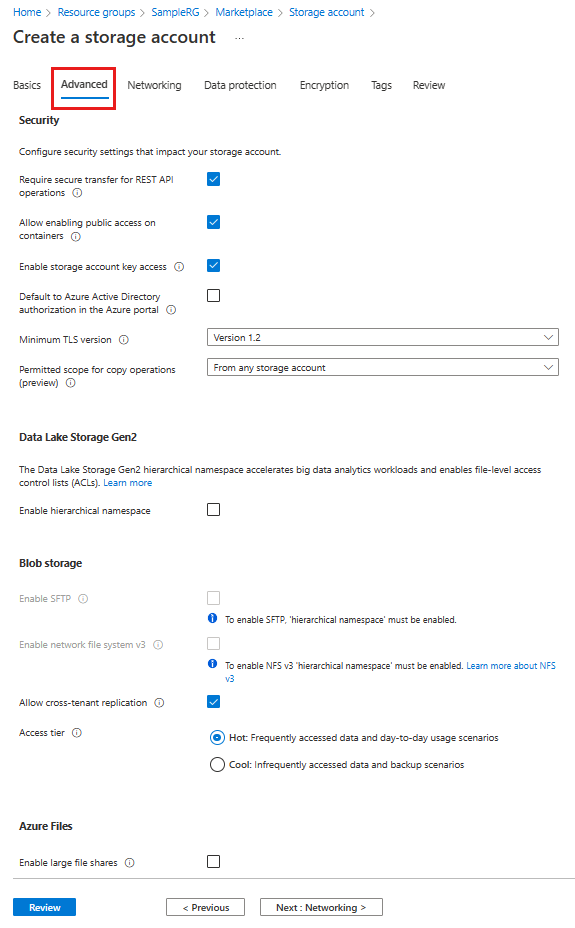
### Advanced tab

On the **Advanced** tab, you can configure additional options and modify default settings for your new storage account. Some of these options can also be configured after the storage account is created, while others must be configured at the time of creation.

The following table describes the fields on the **Advanced** tab.

| **Section** | **Field** | **Required or optional** | **Description** |
| --- | --- | --- | --- |
| Security | Require secure transfer for REST API operations | Optional | Require secure transfer to ensure that incoming requests to this storage account are made only via HTTPS (default). Recommended for optimal security. For more information, see [Require secure transfer to ensure secure connections](https://learn.microsoft.com/en-us/azure/storage/common/storage-require-secure-transfer). |
| Security | Allow enabling public access on containers | Optional | When enabled, this setting allows a user with the appropriate permissions to enable anonymous public access to a container in the storage account (default). Disabling this setting prevents all anonymous public access to the storage account. For more information, see [Prevent anonymous public read access to containers and blobs](https://learn.microsoft.com/en-us/azure/storage/blobs/anonymous-read-access-prevent).  Enabling blob public access does not make blob data available for public access unless the user takes the additional step to explicitly configure the container's public access setting. |
| Security | Enable storage account key access | Optional | When enabled, this setting allows clients to authorize requests to the storage account using either the account access keys or an Azure Active Directory (Azure AD) account (default). Disabling this setting prevents authorization with the account access keys. For more information, see [Prevent Shared Key authorization for an Azure Storage account](https://learn.microsoft.com/en-us/azure/storage/common/shared-key-authorization-prevent). |
| Security | Default to Azure Active Directory authorization in the Azure portal | Optional | When enabled, the Azure portal authorizes data operations with the user's Azure AD credentials by default. If the user does not have the appropriate permissions assigned via Azure role-based access control (Azure RBAC) to perform data operations, then the portal will use the account access keys for data access instead. The user can also choose to switch to using the account access keys. For more information, see [Default to Azure AD authorization in the Azure portal](https://learn.microsoft.com/en-us/azure/storage/blobs/authorize-data-operations-portal#default-to-azure-ad-authorization-in-the-azure-portal). |
| Security | Minimum TLS version | Required | Select the minimum version of Transport Layer Security (TLS) for incoming requests to the storage account. The default value is TLS version 1.2. When set to the default value, incoming requests made using TLS 1.0 or TLS 1.1 are rejected. For more information, see [Enforce a minimum required version of Transport Layer Security (TLS) for requests to a storage account](https://learn.microsoft.com/en-us/azure/storage/common/transport-layer-security-configure-minimum-version). |
| Security | Permitted scope for copy operations (preview) | Required | Select the scope of storage accounts from which data can be copied to the new account. The default value is From any storage account. When set to the default value, users with the appropriate permissions can copy data from any storage account to the new account.  Select From storage accounts in the same Azure AD tenant to only allow copy operations from storage accounts within the same Azure AD tenant. Select From storage accounts that have a private endpoint to the same virtual network to only allow copy operations from storage accounts with private endpoints on the same virtual network.  For more information, see [Restrict the source of copy operations to a storage account](https://learn.microsoft.com/en-us/azure/storage/common/security-restrict-copy-operations). |
| Data Lake Storage Gen2 | Enable hierarchical namespace | Optional | To use this storage account for Azure Data Lake Storage Gen2 workloads, configure a hierarchical namespace. For more information, see [Introduction to Azure Data Lake Storage Gen2](https://learn.microsoft.com/en-us/azure/storage/blobs/data-lake-storage-introduction). |
| Blob storage | Enable SFTP | Optional | Enable the use of Secure File Transfer Protocol (SFTP) to securely transfer of data over the internet. For more information, see [Secure File Transfer (SFTP) protocol support in Azure Blob Storage](https://learn.microsoft.com/en-us/azure/storage/blobs/secure-file-transfer-protocol-support). |
| Blob storage | Enable network file system (NFS) v3 | Optional | NFS v3 provides Linux file system compatibility at object storage scale enables Linux clients to mount a container in Blob storage from an Azure Virtual Machine (VM) or a computer on-premises. For more information, see [Network File System (NFS) 3.0 protocol support in Azure Blob Storage](https://learn.microsoft.com/en-us/azure/storage/blobs/network-file-system-protocol-support). |
| Blob storage | Allow cross-tenant replication | Required | By default, users with appropriate permissions can configure object replication across Azure AD tenants. To prevent replication across tenants, deselect this option. For more information, see [Prevent replication across Azure AD tenants](https://learn.microsoft.com/en-us/azure/storage/blobs/object-replication-overview#prevent-replication-across-azure-ad-tenants). |
| Blob storage | Access tier | Required | Blob access tiers enable you to store blob data in the most cost-effective manner, based on usage. Select the hot tier (default) for frequently accessed data. Select the cool tier for infrequently accessed data. For more information, see [Hot, Cool, and Archive access tiers for blob data](https://learn.microsoft.com/en-us/azure/storage/blobs/access-tiers-overview). |
| Azure Files | Enable large file shares | Optional | Available only for standard file shares with the LRS or ZRS redundancies. |

The following image shows a standard configuration of the advanced properties for a new storage account.

[](https://learn.microsoft.com/en-us/azure/storage/common/media/storage-account-create/create-account-advanced-tab.png#lightbox)

### Networking tab

On the **Networking** tab, you can configure network connectivity and routing preference settings for your new storage account. These options can also be configured after the storage account is created.

The following table describes the fields on the **Networking** tab.

| **Section** | **Field** | **Required or optional** | **Description** |
| --- | --- | --- | --- |
| Network connectivity | Network access | Required | By default, incoming network traffic is routed to the public endpoint for your storage account. You can specify that traffic must be routed to the public endpoint through an Azure virtual network. You can also configure private endpoints for your storage account. For more information, see [Use private endpoints for Azure Storage](https://learn.microsoft.com/en-us/azure/storage/common/storage-private-endpoints). |
| Network connectivity | Endpoint type | Required | Azure Storage supports two types of endpoints: [standard endpoints](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview#standard-endpoints) (the default) and [Azure DNS zone endpoints](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview#azure-dns-zone-endpoints-preview) (preview). Within a given subscription, you can create up to 2501 accounts with standard endpoints per region, and up to 5000 accounts with Azure DNS zone endpoints per region, for a total of 5250 storage accounts. To register for the preview, see [About the preview](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview#about-the-preview). |
| Network routing | Routing preference | Required | The network routing preference specifies how network traffic is routed to the public endpoint of your storage account from clients over the internet. By default, a new storage account uses Microsoft network routing. You can also choose to route network traffic through the POP closest to the storage account, which may lower networking costs. For more information, see [Network routing preference for Azure Storage](https://learn.microsoft.com/en-us/azure/storage/common/network-routing-preference). |

1With a quota increase, you can create up to 500 storage accounts with standard endpoints per region in a given subscription, for a total of 5500 storage accounts per region. For more information, see [Increase Azure Storage account quotas](https://learn.microsoft.com/en-us/azure/quotas/storage-account-quota-requests).

The following image shows a standard configuration of the networking properties for a new storage account.

[](https://learn.microsoft.com/en-us/azure/storage/common/media/storage-account-create/create-account-networking-tab-lrg.png#lightbox)

**Important**: Azure DNS zone endpoints are currently in PREVIEW. See the [**Supplemental Terms of Use for Microsoft Azure Previews**](https://azure.microsoft.com/support/legal/preview-supplemental-terms/) for legal terms that apply to Azure features that are in beta, preview, or otherwise not yet released into general availability.

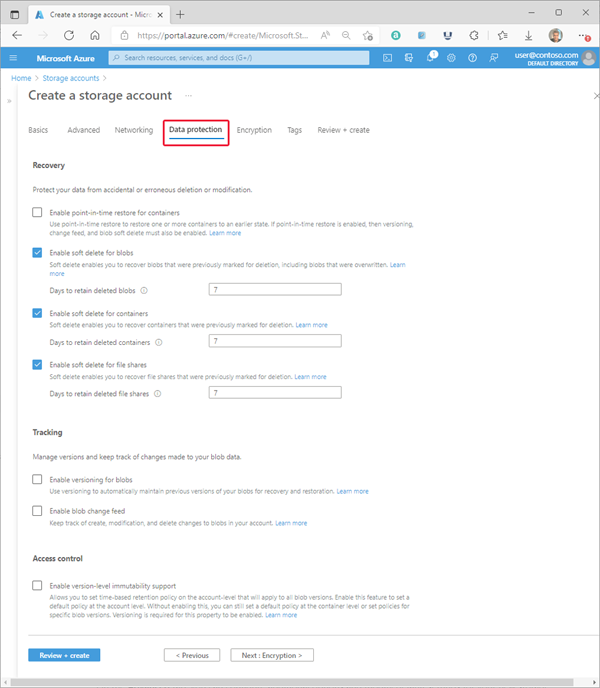
### Data protection tab

On the **Data protection** tab, you can configure data protection options for blob data in your new storage account. These options can also be configured after the storage account is created. For an overview of data protection options in Azure Storage, see [Data protection overview](https://learn.microsoft.com/en-us/azure/storage/blobs/data-protection-overview).

The following table describes the fields on the **Data protection** tab.

| **Section** | **Field** | **Required or optional** | **Description** |
| --- | --- | --- | --- |
| Recovery | Enable point-in-time restore for containers | Optional | Point-in-time restore provides protection against accidental deletion or corruption by enabling you to restore block blob data to an earlier state. For more information, see [Point-in-time restore for block blobs](https://learn.microsoft.com/en-us/azure/storage/blobs/point-in-time-restore-overview).  Enabling point-in-time restore also enables blob versioning, blob soft delete, and blob change feed. These prerequisite features may have a cost impact. For more information, see [Pricing and billing](https://learn.microsoft.com/en-us/azure/storage/blobs/point-in-time-restore-overview#pricing-and-billing) for point-in-time restore. |
| Recovery | Enable soft delete for blobs | Optional | Blob soft delete protects an individual blob, snapshot, or version from accidental deletes or overwrites by maintaining the deleted data in the system for a specified retention period. During the retention period, you can restore a soft-deleted object to its state at the time it was deleted. For more information, see [Soft delete for blobs](https://learn.microsoft.com/en-us/azure/storage/blobs/soft-delete-blob-overview).  Microsoft recommends enabling blob soft delete for your storage accounts and setting a minimum retention period of seven days. |
| Recovery | Enable soft delete for containers | Optional | Container soft delete protects a container and its contents from accidental deletes by maintaining the deleted data in the system for a specified retention period. During the retention period, you can restore a soft-deleted container to its state at the time it was deleted. For more information, see [Soft delete for containers](https://learn.microsoft.com/en-us/azure/storage/blobs/soft-delete-container-overview).  Microsoft recommends enabling container soft delete for your storage accounts and setting a minimum retention period of seven days. |
| Recovery | Enable soft delete for file shares | Optional | Soft delete for file shares protects a file share and its contents from accidental deletes by maintaining the deleted data in the system for a specified retention period. During the retention period, you can restore a soft-deleted file share to its state at the time it was deleted. For more information, see [Prevent accidental deletion of Azure file shares](https://learn.microsoft.com/en-us/azure/storage/files/storage-files-prevent-file-share-deletion).  Microsoft recommends enabling soft delete for file shares for Azure Files workloads and setting a minimum retention period of seven days. |
| Tracking | Enable versioning for blobs | Optional | Blob versioning automatically saves the state of a blob in a previous version when the blob is overwritten. For more information, see [Blob versioning](https://learn.microsoft.com/en-us/azure/storage/blobs/versioning-overview).  Microsoft recommends enabling blob versioning for optimal data protection for the storage account. |
| Tracking | Enable blob change feed | Optional | The blob change feed provides transaction logs of all changes to all blobs in your storage account, as well as to their metadata. For more information, see [Change feed support in Azure Blob Storage](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blob-change-feed). |
| Access control | Enable version-level immutability support | Optional | Enable support for immutability policies that are scoped to the blob version. If this option is selected, then after you create the storage account, you can configure a default time-based retention policy for the account or for the container, which blob versions within the account or container will inherit by default. For more information, see [Enable version-level immutability support on a storage account](https://learn.microsoft.com/en-us/azure/storage/blobs/immutable-policy-configure-version-scope#enable-version-level-immutability-support-on-a-storage-account). |

The following image shows a standard configuration of the data protection properties for a new storage account.

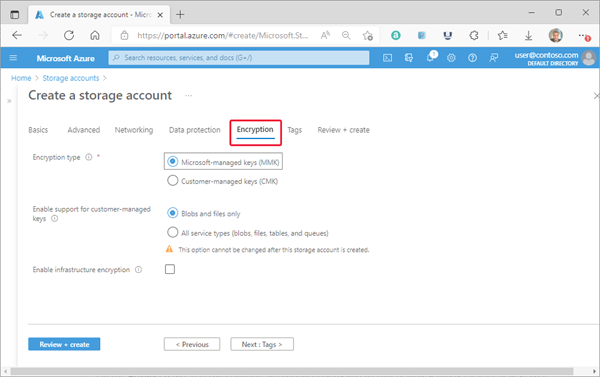
[](https://learn.microsoft.com/en-us/azure/storage/common/media/storage-account-create/create-account-protection-tab-lrg.png#lightbox)

### Encryption tab

On the **Encryption** tab, you can configure options that relate to how your data is encrypted when it is persisted to the cloud. Some of these options can be configured only when you create the storage account.

| **Field** | **Required or optional** | **Description** |
| --- | --- | --- |
| Encryption type | Required | By default, data in the storage account is encrypted by using Microsoft-managed keys. You can rely on Microsoft-managed keys for the encryption of your data, or you can manage encryption with your own keys. For more information, see [Azure Storage encryption for data at rest](https://learn.microsoft.com/en-us/azure/storage/common/storage-service-encryption). |
| Enable support for customer-managed keys | Required | By default, customer managed keys can be used to encrypt only blobs and files. Set this option to **All service types (blobs, files, tables, and queues)** to enable support for customer-managed keys for all services. You are not required to use customer-managed keys if you choose this option. For more information, see [Customer-managed keys for Azure Storage encryption](https://learn.microsoft.com/en-us/azure/storage/common/customer-managed-keys-overview). |
| Encryption key | Required if **Encryption type** field is set to **Customer-managed keys**. | If you choose **Select a key vault and key**, you are presented with the option to navigate to the key vault and key that you wish to use. If you choose **Enter key from URI**, then you are presented with a field to enter the key URI and the subscription. |
| User-assigned identity | Required if **Encryption type** field is set to **Customer-managed keys**. | If you are configuring customer-managed keys at create time for the storage account, you must provide a user-assigned identity to use for authorizing access to the key vault. |
| Enable infrastructure encryption | Optional | By default, infrastructure encryption is not enabled. Enable infrastructure encryption to encrypt your data at both the service level and the infrastructure level. For more information, see [Create a storage account with infrastructure encryption enabled for double encryption of data](https://learn.microsoft.com/en-us/azure/storage/common/infrastructure-encryption-enable). |

The following image shows a standard configuration of the encryption properties for a new storage account.

[](https://learn.microsoft.com/en-us/azure/storage/common/media/storage-account-create/create-account-encryption-tab-lrg.png#lightbox)

### Tags tab

On the **Tags** tab, you can specify Resource Manager tags to help organize your Azure resources. For more information, see [Tag resources, resource groups, and subscriptions for logical organization](https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/tag-resources).

### Review + create tab

When you navigate to the **Review + create** tab, Azure runs validation on the storage account settings that you have chosen. If validation passes, you can proceed to create the storage account.

If validation fails, then the portal indicates which settings need to be modified.

### Delete a storage account

Deleting a storage account deletes the entire account, including all data in the account. Be sure to back up any data you want to save before you delete the account.

Under certain circumstances, a deleted storage account may be recovered, but recovery is not guaranteed. For more information, see [Recover a deleted storage account](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-recover).

If you try to delete a storage account associated with an Azure virtual machine, you may get an error about the storage account still being in use. For help troubleshooting this error, see [Troubleshoot errors when you delete storage accounts](https://learn.microsoft.com/en-us/troubleshoot/azure/virtual-machines/storage-resource-deletion-errors).

1. Navigate to the storage account in the [Azure portal](https://portal.azure.com/).
2. Select **Delete**.

## Azure Blobs Storage

<https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blobs-overview>

<https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blobs-introduction>

Azure Blob Storage is Microsoft's object storage solution for the cloud. Blob Storage is optimized for storing massive amounts of unstructured data. Unstructured data is data that doesn't adhere to a particular data model or definition, such as text or binary data.

### About Blob Storage

Blob Storage is designed for:

* Serving images or documents directly to a browser.
* Storing files for distributed access.
* Streaming video and audio.
* Writing to log files.
* Storing data for backup and restore, disaster recovery, and archiving.
* Storing data for analysis by an on-premises or Azure-hosted service.

Users or client applications can access objects in Blob Storage via HTTP/HTTPS, from anywhere in the world. Objects in Blob Storage are accessible via the [Azure Storage REST API](https://learn.microsoft.com/en-us/rest/api/storageservices/blob-service-rest-api), [Azure PowerShell](https://learn.microsoft.com/en-us/powershell/module/az.storage), [Azure CLI](https://learn.microsoft.com/en-us/cli/azure/storage), or an Azure Storage client library. Client libraries are available for different languages, including:

* [.NET](https://learn.microsoft.com/en-us/dotnet/api/overview/azure/storage)
* [Java](https://learn.microsoft.com/en-us/java/api/overview/azure/storage)
* [Node.js](https://github.com/Azure/azure-sdk-for-js/tree/master/sdk/storage)
* [Python](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-quickstart-blobs-python)
* [Go](https://github.com/Azure/azure-sdk-for-go/tree/main/sdk/storage/azblob)

### Upload, download, and list blobs with the Azure portal

<https://learn.microsoft.com/en-us/azure/storage/blobs/storage-quickstart-blobs-portal>

#### Prerequisites

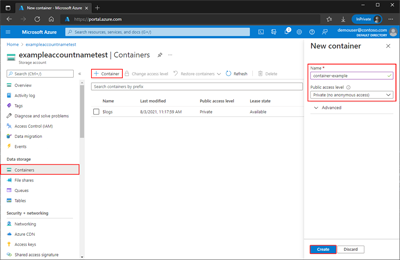
To access Azure Storage, you'll need an Azure subscription. If you don't already have a subscription, create a [free account](https://azure.microsoft.com/free/?WT.mc_id=A261C142F) before you begin.

All access to Azure Storage takes place through a storage account. For this quickstart, create a storage account using the [Azure portal](https://portal.azure.com/), Azure PowerShell, or Azure CLI. For help creating a storage account, see [Create a storage account](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-create).

#### Create a container

To create a container in the Azure portal, follow these steps:

1. Navigate to your new storage account in the Azure portal.
2. In the left menu for the storage account, scroll to the **Data storage** section, then select **Containers**.
3. Select the **+ Container** button.
4. Type a name for your new container. The container name must be lowercase, must start with a letter or number, and can include only letters, numbers, and the dash (-) character. For more information about container and blob names, see [Naming and referencing containers, blobs, and metadata](https://learn.microsoft.com/en-us/rest/api/storageservices/naming-and-referencing-containers--blobs--and-metadata).
5. Set the level of public access to the container. The default level is **Private (no anonymous access)**.
6. Select **Create** to create the container.

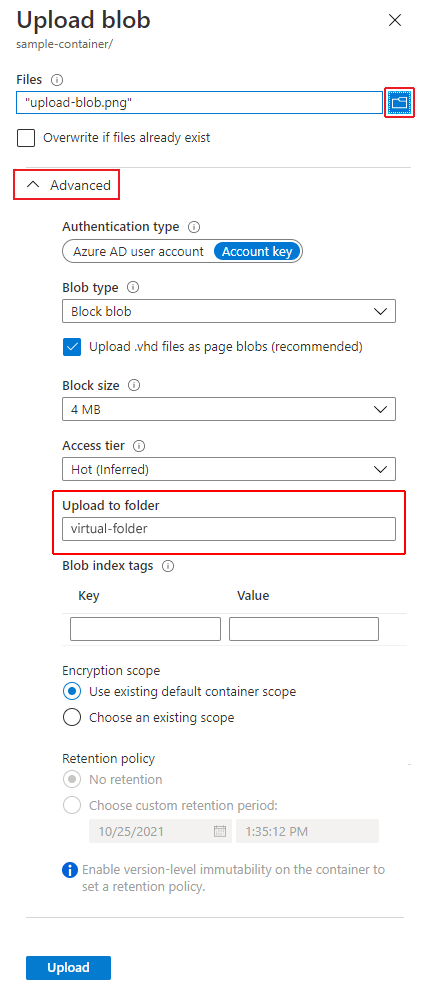
[](https://learn.microsoft.com/en-us/azure/storage/blobs/media/storage-quickstart-blobs-portal/create-container-lrg.png#lightbox)

#### Upload a block blob

Block blobs consist of blocks of data assembled to make a blob. Most scenarios using Blob storage employ block blobs. Block blobs are ideal for storing text and binary data in the cloud, like files, images, and videos. This quickstart shows how to work with block blobs.

To upload a block blob to your new container in the Azure portal, follow these steps:

1. In the Azure portal, navigate to the container you created in the previous section.
2. Select the container to show a list of blobs it contains. This container is new, so it won't yet contain any blobs.
3. Select the **Upload** button to open the upload blade and browse your local file system to find a file to upload as a block blob. You can optionally expand the **Advanced** section to configure other settings for the upload operation. You can, for example, upload a blob into a new or existing virtual folder or by supplying a value in the **Upload to folder** field.

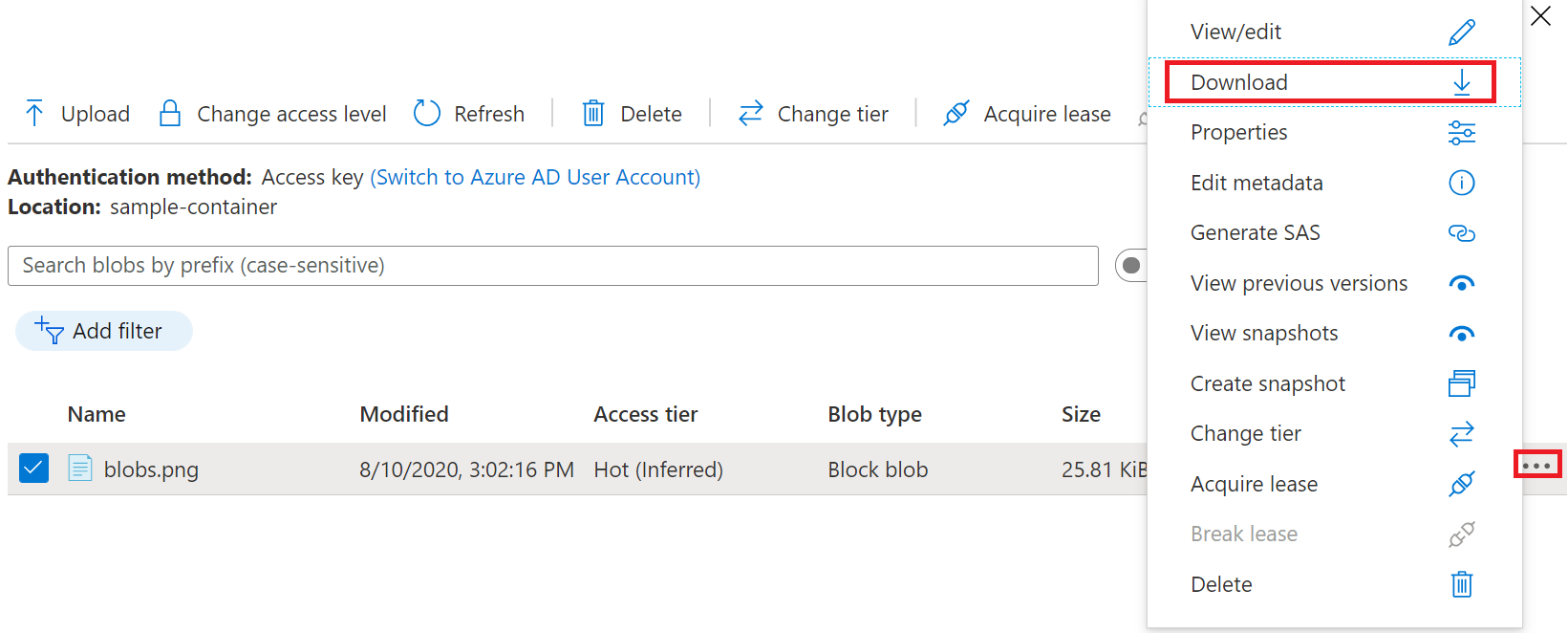


1. Select the **Upload** button to upload the blob.
2. Upload as many blobs as you like in this way. You'll see that the new blobs are now listed within the container.

#### Download a block blob

You can download a block blob to display in the browser or save to your local file system. To download a block blob, follow these steps:

1. Navigate to the list of blobs that you uploaded in the previous section.
2. Right-click the blob you want to download, and select **Download**.



#### Delete a block blob

To delete one or more blobs in the Azure portal, follow these steps:

1. In the Azure portal, navigate to the container.
2. Display the list of blobs in the container.
3. Use the checkbox to select one or more blobs from the list.
4. Select the **Delete** button to delete the selected blobs.
5. In the dialog, confirm the deletion, and indicate whether you also want to delete blob snapshots.

#### Clean up resources

To remove all the resources you created in this quickstart, you can simply delete the container. All blobs in the container will also be deleted.

To delete the container:

1. In the Azure portal, navigate to the list of containers in your storage account.
2. Select the container to delete.
3. Select the **More** button (**...**), and select **Delete**.
4. Confirm that you want to delete the container.

### Use Azure Storage Explorer to create a blob

<https://learn.microsoft.com/en-us/azure/storage/blobs/quickstart-storage-explorer>

### Azure Blob Storage client library for .NET

<https://learn.microsoft.com/en-us/azure/storage/blobs/storage-quickstart-blobs-dotnet?tabs=visual-studio%2Cmanaged-identity%2Croles-azure-portal%2Csign-in-azure-cli%2Cidentity-visual-studio>

#### Prerequisites

* Azure subscription - [create one for free](https://azure.microsoft.com/free/)
* Azure storage account - [create a storage account](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-create)
* Current [.NET SDK](https://dotnet.microsoft.com/download/dotnet) for your operating system. Be sure to get the SDK and not the runtime.

The following sections walk you through preparing a project to work with the Azure Blob Storage client library for .NET.

#### Create the project

For the steps ahead, you'll need to create a .NET console app using either the .NET CLI or Visual Studio 2022.

1. At the top of Visual Studio, navigate to **File** > **New** > **Project..**.
2. In the dialog window, enter console app into the project template search box and select the first result. Choose **Next** at the bottom of the dialog.
3. For the **Project Name**, enter BlobQuickstart. Leave the default values for the rest of the fields and select **Next**.
4. For the **Framework**, ensure .NET 6.0 is selected. Then choose **Create**. The new project will open inside the Visual Studio environment.

#### Install the package

To interact with Azure Blob Storage, install the Azure Blob Storage client library for .NET.

1. In **Solution Explorer**, right-click the **Dependencies** node of your project. Select **Manage NuGet Packages**.
2. In the resulting window, search for Azure.Storage.Blobs. Select the appropriate result, and select **Install**.

#### Set up the app code

Replace the starting code in the Program.cs file so that it matches the following example, which includes the necessary using statements for this exercise.

using Azure.Storage.Blobs;

using Azure.Storage.Blobs.Models;

using System;

using System.IO;

// See https://aka.ms/new-console-template for more information

Console.WriteLine("Hello, World!");

#### Authenticate to Azure and authorize access to blob data

Application requests to Azure Blob Storage must be authorized. Using the DefaultAzureCredential class provided by the Azure Identity client library is the recommended approach for implementing passwordless connections to Azure services in your code, including Blob Storage.

You can also authorize requests to Azure Blob Storage by using the account access key. However, this approach should be used with caution. Developers must be diligent to never expose the access key in an unsecure location. Anyone who has the access key is able to authorize requests against the storage account, and effectively has access to all the data. DefaultAzureCredential offers improved management and security benefits over the account key to allow passwordless authentication. Both options are demonstrated in the following example.

##### Connection String

A connection string includes the storage account access key and uses it to authorize requests. Always be careful to never expose the keys in an unsecure location.

**Note**: To authorize data access with the storage account access key, you'll need permissions for the following Azure RBAC action: [**Microsoft.Storage/storageAccounts/listkeys/action**](https://learn.microsoft.com/en-us/azure/role-based-access-control/resource-provider-operations#microsoftstorage). The least privileged built-in role with permissions for this action is [**Reader and Data Access**](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#reader-and-data-access), but any role which includes this action will work.

1. Sign in to the [Azure portal](https://portal.azure.com/).
2. Locate your storage account.
3. In the storage account menu pane, under **Security + networking**, select **Access keys**. Here, you can view the account access keys and the complete connection string for each key.
4. In the **Access keys** pane, select **Show keys**.
5. In the **key1** section, locate the **Connection string** value. Select the **Copy to clipboard** icon to copy the connection string. You'll add the connection string value to an environment variable in the next section.

##### Configure your storage connection string

After you copy the connection string, write it to a new environment variable on the local machine running the application. To set the environment variable, open a console window, and follow the instructions for your operating system. Replace <yourconnectionstring> with your actual connection string.

**Windows**:

setx AZURE\_STORAGE\_CONNECTION\_STRING "<yourconnectionstring>"

After you add the environment variable in Windows, you must start a new instance of the command window. If you're using Visual Studio on Windows, you may need to relaunch Visual Studio after creating the environment variable for the change to be detected.

**Linux**:

export AZURE\_STORAGE\_CONNECTION\_STRING="<yourconnectionstring>"

##### Configure the connection string

The code below retrieves the connection string for the storage account from the environment variable created in the [Configure your storage connection string](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-quickstart-blobs-dotnet?tabs=visual-studio%2Cconnection-string%2Croles-azure-portal%2Csign-in-azure-cli%2Cidentity-visual-studio#configure-your-storage-connection-string) section, and uses the connection string to construct a service client object.

Add following code to the end of the Program.cs file:

// Retrieve the connection string for use with the application.

string connectionString = Environment.GetEnvironmentVariable("AZURE\_STORAGE\_CONNECTION\_STRING");

// Create a BlobServiceClient object

var blobServiceClient = new BlobServiceClient(connectionString);

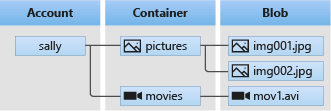
**Important**: The account access key should be used with caution. If your account access key is lost or accidentally placed in an insecure location, your service may become vulnerable. Anyone who has the access key is able to authorize requests against the storage account, and effectively has access to all the data. DefaultAzureCredential provides enhanced security features and benefits and is the recommended approach for managing authorization to Azure services.

#### Object model

Azure Blob Storage is optimized for storing massive amounts of unstructured data. Unstructured data doesn't adhere to a particular data model or definition, such as text or binary data. Blob storage offers three types of resources:

* The storage account
* A container in the storage account
* A blob in the container

The following diagram shows the relationship between these resources.



Use the following .NET classes to interact with these resources:

* [BlobServiceClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobserviceclient): The BlobServiceClient class allows you to manipulate Azure Storage resources and blob containers.
* [BlobContainerClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobcontainerclient): The BlobContainerClient class allows you to manipulate Azure Storage containers and their blobs.
* [BlobClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobclient): The BlobClient class allows you to manipulate Azure Storage blobs.

#### Code examples

The sample code snippets in the following sections demonstrate how to perform basic data operations with the Azure Blob Storage client library for .NET.

**Important**: Make sure you have installed the correct NuGet packages and added the necessary using statements in order for the code samples to work, as described in the [**setting up**](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-quickstart-blobs-dotnet?tabs=visual-studio%2Cconnection-string%2Croles-azure-portal%2Csign-in-azure-cli%2Cidentity-visual-studio#setting-up) section.

* **Azure.Identity** (if you are using the passwordless approach)
* **Azure.Storage.Blobs**

#### Create a container

Decide on a name for the new container. The code below appends a GUID value to the container name to ensure that it is unique.

**Important**: Container names must be lowercase. For more information about naming containers and blobs, see [**Naming and Referencing Containers, Blobs, and Metadata**](https://learn.microsoft.com/en-us/rest/api/storageservices/naming-and-referencing-containers--blobs--and-metadata).

You can call the [CreateBlobContainerAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobserviceclient.createblobcontainerasync) method on the blobServiceClient to create a container in your storage account.

Add this code to the end of the Program.cs class:

// TODO: Replace <storage-account-name> with your actual storage account name

var blobServiceClient = new BlobServiceClient(

new Uri("https://<storage-account-name>.blob.core.windows.net"),

new DefaultAzureCredential());

//Create a unique name for the container

string containerName = "quickstartblobs" + Guid.NewGuid().ToString();

// Create the container and return a container client object

BlobContainerClient containerClient = await blobServiceClient.CreateBlobContainerAsync(containerName);

To learn more about creating a container, and to explore more code samples, see [Create a blob container with .NET](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blob-container-create).

#### Upload a blob to a container

Add the following code to the end of the Program.cs class:

// Create a local file in the ./data/ directory for uploading and downloading

string localPath = "data";

Directory.CreateDirectory(localPath);

string fileName = "quickstart" + Guid.NewGuid().ToString() + ".txt";

string localFilePath = Path.Combine(localPath, fileName);

// Write text to the file

await File.WriteAllTextAsync(localFilePath, "Hello, World!");

// Get a reference to a blob

BlobClient blobClient = containerClient.GetBlobClient(fileName);

Console.WriteLine("Uploading to Blob storage as blob:\n\t {0}\n", blobClient.Uri);

// Upload data from the local file

await blobClient.UploadAsync(localFilePath, true);

The code snippet completes the following steps:

1. Creates a text file in the local data directory.
2. Gets a reference to a [BlobClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobclient) object by calling the [GetBlobClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobcontainerclient.getblobclient) method on the container from the [Create a container](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-quickstart-blobs-dotnet?tabs=visual-studio%2Cconnection-string%2Croles-azure-portal%2Csign-in-azure-cli%2Cidentity-visual-studio#create-a-container) section.
3. Uploads the local text file to the blob by calling the [UploadAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobclient.uploadasync#Azure_Storage_Blobs_BlobClient_UploadAsync_System_String_System_Boolean_System_Threading_CancellationToken_) method. This method creates the blob if it doesn't already exist, and overwrites it if it does.

To learn more about uploading blobs, and to explore more code samples, see [Upload a blob with .NET](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blob-upload).

#### List blobs in a container

List the blobs in the container by calling the [GetBlobsAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobcontainerclient.getblobsasync) method. In this case, only one blob has been added to the container, so the listing operation returns just that one blob.

Add the following code to the end of the Program.cs class:

Console.WriteLine("Listing blobs...");

// List all blobs in the container

await foreach (BlobItem blobItem in containerClient.GetBlobsAsync())

{

Console.WriteLine("\t" + blobItem.Name);

}

To learn more about listing blobs, and to explore more code samples, see [List blobs with .NET](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blobs-list).

#### Download a blob

Download the previously created blob by calling the [DownloadToAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.specialized.blobbaseclient.downloadtoasync) method. The example code adds a suffix of "DOWNLOADED" to the file name so that you can see both files in local file system.

Add the following code to the end of the Program.cs class:

// Download the blob to a local file

// Append the string "DOWNLOADED" before the .txt extension

// so you can compare the files in the data directory

string downloadFilePath = localFilePath.Replace(".txt", "DOWNLOADED.txt");

Console.WriteLine("\nDownloading blob to\n\t{0}\n", downloadFilePath);

// Download the blob's contents and save it to a file

await blobClient.DownloadToAsync(downloadFilePath);

To learn more about downloading blobs, and to explore more code samples, see [Download a blob with .NET](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blob-download).

#### Delete a container

The following code cleans up the resources the app created by deleting the entire container by using [DeleteAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobcontainerclient.deleteasync). It also deletes the local files created by the app.

The app pauses for user input by calling Console.ReadLine before it deletes the blob, container, and local files. This is a good chance to verify that the resources were actually created correctly, before they are deleted.

Add the following code to the end of the Program.cs class:

// Clean up

Console.Write("Press any key to begin clean up");

Console.ReadLine();

Console.WriteLine("Deleting blob container...");

await containerClient.DeleteAsync();

Console.WriteLine("Deleting the local source and downloaded files...");

File.Delete(localFilePath);

File.Delete(downloadFilePath);

Console.WriteLine("Done");

To learn more about deleting a container, and to explore more code samples, see [Delete and restore a blob container with .NET](https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blob-container-delete).

#### The completed code

After completing these steps the code in your Program.cs file should now resemble the following:

using Azure.Storage.Blobs;

using Azure.Storage.Blobs.Models;

// TODO: Replace <storage-account-name> with your actual storage account name

var blobServiceClient = new BlobServiceClient("<storage-account-connection-string>");

//Create a unique name for the container

string containerName = "quickstartblobs" + Guid.NewGuid().ToString();

// Create the container and return a container client object

BlobContainerClient containerClient = await blobServiceClient.CreateBlobContainerAsync(containerName);

// Create a local file in the ./data/ directory for uploading and downloading

string localPath = "data";

Directory.CreateDirectory(localPath);

string fileName = "quickstart" + Guid.NewGuid().ToString() + ".txt";

string localFilePath = Path.Combine(localPath, fileName);

// Write text to the file

await File.WriteAllTextAsync(localFilePath, "Hello, World!");

// Get a reference to a blob

BlobClient blobClient = containerClient.GetBlobClient(fileName);

Console.WriteLine("Uploading to Blob storage as blob:\n\t {0}\n", blobClient.Uri);

// Upload data from the local file

await blobClient.UploadAsync(localFilePath, true);

Console.WriteLine("Listing blobs...");

// List all blobs in the container

await foreach (BlobItem blobItem in containerClient.GetBlobsAsync())

{

Console.WriteLine("\t" + blobItem.Name);

}

// Download the blob to a local file

// Append the string "DOWNLOADED" before the .txt extension

// so you can compare the files in the data directory

string downloadFilePath = localFilePath.Replace(".txt", "DOWNLOADED.txt");

Console.WriteLine("\nDownloading blob to\n\t{0}\n", downloadFilePath);

// Download the blob's contents and save it to a file

await blobClient.DownloadToAsync(downloadFilePath);

// Clean up

Console.Write("Press any key to begin clean up");

Console.ReadLine();

Console.WriteLine("Deleting blob container...");

await containerClient.DeleteAsync();

Console.WriteLine("Deleting the local source and downloaded files...");

File.Delete(localFilePath);

File.Delete(downloadFilePath);

Console.WriteLine("Done");

#### Run the code

This app creates a test file in your local data folder and uploads it to Blob storage. The example then lists the blobs in the container and downloads the file with a new name so that you can compare the old and new files.

If you're using Visual Studio, press F5 to build and run the code and interact with the console app. If you're using the .NET CLI, navigate to your application directory, then build and run the application.

dotnet build

dotnet run

The output of the app is similar to the following example:

**Output**

Azure Blob Storage - .NET quickstart sample

Uploading to Blob storage as blob:

https://mystorageacct.blob.core.windows.net/quickstartblobs60c70d78-8d93-43ae-954d-8322058cfd64/quickstart2fe6c5b4-7918-46cb-96f4-8c4c5cb2fd31.txt

Listing blobs...

quickstart2fe6c5b4-7918-46cb-96f4-8c4c5cb2fd31.txt

Downloading blob to

./data/quickstart2fe6c5b4-7918-46cb-96f4-8c4c5cb2fd31DOWNLOADED.txt

Press any key to begin clean up

Deleting blob container...

Deleting the local source and downloaded files...

Done

Before you begin the clean-up process, check your data folder for the two files. You can open them and observe that they are identical.

After you've verified the files, press the **Enter** key to delete the test files and finish the demo.

### Host a static website on Blob Storage

<https://learn.microsoft.com/en-us/azure/storage/blobs/storage-blob-static-website-host>

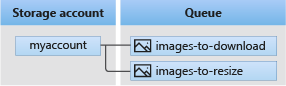
## Azure Queue Storage

<https://learn.microsoft.com/en-us/azure/storage/queues/storage-queues-introduction>

Azure Queue Storage is a service for storing large numbers of messages. You access messages from anywhere in the world via authenticated calls using HTTP or HTTPS. A queue message can be up to 64 KB in size. A queue may contain millions of messages, up to the total capacity limit of a storage account. Queues are commonly used to create a backlog of work to process asynchronously.

### Queue Storage concepts

Queue Storage contains the following components:



* **URL format:** Queues are addressable using the following URL format:

https://<storage account>.queue.core.windows.net/<queue>

The following URL addresses a queue in the diagram:

https://myaccount.queue.core.windows.net/images-to-download

* **Storage account:** All access to Azure Storage is done through a storage account. For information about storage account capacity, see [Scalability and performance targets for standard storage accounts](https://learn.microsoft.com/en-us/azure/storage/common/scalability-targets-standard-account?toc=/azure/storage/queues/toc.json).
* **Queue:** A queue contains a set of messages. The queue name **must** be all lowercase. For information on naming queues, see [Naming queues and metadata](https://learn.microsoft.com/en-us/rest/api/storageservices/naming-queues-and-metadata).
* **Message:** A message, in any format, of up to 64 KB. Before version 2017-07-29, the maximum time-to-live allowed is seven days. For version 2017-07-29 or later, the maximum time-to-live can be any positive number, or -1 indicating that the message doesn't expire. If this parameter is omitted, the default time-to-live is seven days.

### Create a queue and add a message with the Azure portal

<https://learn.microsoft.com/en-us/azure/storage/queues/storage-quickstart-queues-portal>

To create a queue in the Azure portal, follow these steps:

1. Navigate to your new storage account in the Azure portal.
2. In the left menu for the storage account, scroll to the **Queue Storage** section, then select **Queues**.
3. Select the **+ Queue** button.
4. Type a name for your new queue. The queue name must be lowercase, must start with a letter or number, and can include only letters, numbers, and the dash (-) character.
5. Select **OK** to create the queue.

#### Add a message

Next, add a message to the new queue. A message can be up to 64 KB in size.

1. Select the new queue from the list of queues in the storage account.
2. Select the **+ Add message** button to add a message to the queue. Enter a message in the **Message text** field.
3. Specify when the message expires. Valid values that can be entered in the **Expires in** field are between 1 second and 7 days. Select **Message never expires** to indicate a message that will remain in the queue until it is explicitly removed.
4. Indicate whether to encode the message as Base64. Encoding binary data is recommended.
5. Select the **OK** button to add the message.

#### View message properties

After you add a message, the Azure portal displays a list of all of the messages in the queue. You can view the message ID, the contents of the message, the message insertion time, and the message expiration time. You can also see how many times this message has been dequeued.

#### Dequeue a message

You can dequeue a message from the front of the queue from the Azure portal. When you dequeue a message, the message is deleted.

Dequeueing always removes the oldest message in the queue.

### Azure Queue Storage client library for .NET Core

<https://learn.microsoft.com/en-us/azure/storage/queues/storage-quickstart-queues-dotnet?tabs=connection-string%2Croles-azure-portal%2Cenvironment-variable-windows%2Csign-in-azure-cli>

Use the Azure Queue Storage client library for .NET to:

* Create a queue
* Add messages to a queue
* Peek at messages in a queue
* Update a message in a queue
* Get the queue length
* Receive messages from a queue
* Delete messages from a queue
* Delete a queue

#### Create the project

Create a .NET application named QueuesQuickstart.

1. In a console window (such as cmd, PowerShell, or Bash), use the dotnet new command to create a new console app with the name QueuesQuickstart. This command creates a simple "hello world" C# project with a single source file named Program.cs.

dotnet new console -n QueuesQuickstart

1. Switch to the newly created QueuesQuickstart directory.

cd QueuesQuickstart

#### Install the packages

While still in the application directory, install the Azure Queue Storage client library for .NET package by using the dotnet add package command.

dotnet add package Azure.Storage.Queues

The Azure Identity client library package is also needed for passwordless connections to Azure services.

dotnet add package Azure.Identity

#### Set up the app framework

1. Open the project in your editor of choice
2. Open the Program.cs file
3. Update the existing code to match the following:

using Azure;

using Azure.Identity;

using Azure.Storage.Queues;

using Azure.Storage.Queues.Models;

using System;

using System.Threading.Tasks;

Console.WriteLine("Azure Queue Storage client library - .NET quickstart sample");

// Quickstart code goes here

#### Authenticate to Azure

Application requests to most Azure services must be authorized. Using the DefaultAzureCredential class provided by the Azure Identity client library is the recommended approach for implementing passwordless connections to Azure services in your code.

You can also authorize requests to Azure services using passwords, connection strings, or other credentials directly. However, this approach should be used with caution. Developers must be diligent to never expose these secrets in an unsecure location. Anyone who gains access to the password or secret key is able to authenticate. DefaultAzureCredential offers improved management and security benefits over the account key to allow passwordless authentication. Both options are demonstrated in the following example.

##### Connection String

**Copy your credentials from the Azure portal**

When the sample application makes a request to Azure Storage, it must be authorized. To authorize a request, add your storage account credentials to the application as a connection string. To view your storage account credentials, follow these steps:

1. Sign in to the [Azure portal](https://portal.azure.com/).
2. Locate your storage account.
3. In the storage account menu pane, under **Security + networking**, select **Access keys**. Here, you can view the account access keys and the complete connection string for each key.
4. In the **Access keys** pane, select **Show keys**.
5. In the **key1** section, locate the **Connection string** value. Select the **Copy to clipboard** icon to copy the connection string. You'll add the connection string value to an environment variable in the next section.

##### Configure your storage connection string

After you copy the connection string, write it to a new environment variable on the local machine running the application. To set the environment variable, open a console window, and follow the instructions for your operating system. Replace <yourconnectionstring> with your actual connection string.

**Windows**

setx AZURE\_STORAGE\_CONNECTION\_STRING "<yourconnectionstring>"

**Linux & MacOS**

export AZURE\_STORAGE\_CONNECTION\_STRING="<yourconnectionstring>"

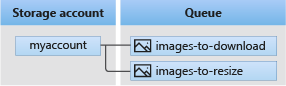
After you add the environment variable in Windows, you must start a new instance of the command window and the IDE.

#### Object model

Azure Queue Storage is a service for storing large numbers of messages. A queue message can be up to 64 KB in size. A queue may contain millions of messages, up to the total capacity limit of a storage account. Queues are commonly used to create a backlog of work to process asynchronously. Queue Storage offers three types of resources:

* **Storage account**: All access to Azure Storage is done through a storage account. For more information about storage accounts, see [Storage account overview](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview)
* **Queue**: A queue contains a set of messages. All messages must be in a queue. Note that the queue name must be all lowercase. For information on naming queues, see [Naming Queues and Metadata](https://learn.microsoft.com/en-us/rest/api/storageservices/Naming-Queues-and-Metadata).
* **Message**: A message, in any format, of up to 64 KB. A message can remain in the queue for a maximum of 7 days. For version 2017-07-29 or later, the maximum time-to-live can be any positive number, or -1 indicating that the message doesn't expire. If this parameter is omitted, the default time-to-live is seven days.

The following diagram shows the relationship between these resources.



Use the following .NET classes to interact with these resources:

* [QueueServiceClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueserviceclient): The QueueServiceClient allows you to manage the all queues in your storage account.
* [QueueClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient): The QueueClient class allows you to manage and manipulate an individual queue and its messages.
* [QueueMessage](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.models.queuemessage): The QueueMessage class represents the individual objects returned when calling [ReceiveMessages](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient.receivemessages) on a queue.

#### Authorize access and create a client object

**Get the connection string and create a client**

The following code retrieves the connection string for the storage account. The connection string is stored in the environment variable created in the [Configure your storage connection string](https://learn.microsoft.com/en-us/azure/storage/queues/storage-quickstart-queues-dotnet?tabs=connection-string%2Croles-azure-portal%2Cenvironment-variable-linux%2Csign-in-azure-cli#configure-your-storage-connection-string) section.

Add this code to the end of the Program.cs file:

// Retrieve the connection string for use with the application. The storage

// connection string is stored in an environment variable called

// AZURE\_STORAGE\_CONNECTION\_STRING on the machine running the application.

// If the environment variable is created after the application is launched

// in a console or with Visual Studio, the shell or application needs to be

// closed and reloaded to take the environment variable into account.

string connectionString = Environment.GetEnvironmentVariable("AZURE\_STORAGE\_CONNECTION\_STRING");

Decide on a name for the queue and create an instance of the [QueueClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient) class, using the connection string for authorization. We use this client object to create and interact with the queue resource in the storage account.

**Important**: Queue names may only contain lowercase letters, numbers, and hyphens, and must begin with a letter or a number. Each hyphen must be preceded and followed by a non-hyphen character. The name must also be between 3 and 63 characters long. For more information, see [**Naming queues and metadata**](https://learn.microsoft.com/en-us/rest/api/storageservices/naming-queues-and-metadata).

Add this code to the end of the Program.cs file:

// Create a unique name for the queue

string queueName = "quickstartqueues-" + Guid.NewGuid().ToString();

// Instantiate a QueueClient to create and interact with the queue

QueueClient queueClient = new QueueClient(connectionString, queueName);

**Note**: Messages sent using the [**QueueClient**](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient) class must be in a format that can be included in an XML request with UTF-8 encoding. You can optionally set the [**MessageEncoding**](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclientoptions.messageencoding) option to [**Base64**](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queuemessageencoding) to handle non-compliant messages.

#### Create a queue

Using the QueueClient object, call the [CreateAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient.createasync) method to create the queue in your storage account.

Add this code to the end of the Program.cs method:

Console.WriteLine($"Creating queue: {queueName}");

// Create the queue

await queueClient.CreateAsync();

#### Add messages to a queue

The following code snippet asynchronously adds messages to queue by calling the [SendMessageAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient.sendmessageasync) method. It also saves a [SendReceipt](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.models.sendreceipt) returned from a SendMessageAsync call. The receipt is used to update the message later in the program.

Add this code to the end of the Program.cs file:

Console.WriteLine("\nAdding messages to the queue...");

// Send several messages to the queue

await queueClient.SendMessageAsync("First message");

await queueClient.SendMessageAsync("Second message");

// Save the receipt so we can update this message later

SendReceipt receipt = await queueClient.SendMessageAsync("Third message");

#### Peek at messages in a queue

Peek at the messages in the queue by calling the [PeekMessagesAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient.peekmessagesasync) method. This method retrieves one or more messages from the front of the queue but doesn't alter the visibility of the message.

Add this code to the end of the Program.cs file:

Console.WriteLine("\nPeek at the messages in the queue...");

// Peek at messages in the queue

PeekedMessage[] peekedMessages = await queueClient.PeekMessagesAsync(maxMessages: 10);

foreach (PeekedMessage peekedMessage in peekedMessages)

{

// Display the message

Console.WriteLine($"Message: {peekedMessage.MessageText}");

}

#### Update a message in a queue

Update the contents of a message by calling the [UpdateMessageAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient.updatemessageasync) method. This method can change a message's visibility timeout and contents. The message content must be a UTF-8 encoded string that is up to 64 KB in size. Along with the new content for the message, pass in the values from the SendReceipt that was saved earlier in the code. The SendReceipt values identify which message to update.

Console.WriteLine("\nUpdating the third message in the queue...");

// Update a message using the saved receipt from sending the message

await queueClient.UpdateMessageAsync(receipt.MessageId, receipt.PopReceipt, "Third message has been updated");

#### Get the queue length

You can get an estimate of the number of messages in a queue. The [GetProperties](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient.getproperties) method returns queue properties including the message count. The [ApproximateMessagesCount](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.models.queueproperties.approximatemessagescount) property contains the approximate number of messages in the queue. This number isn't lower than the actual number of messages in the queue, but could be higher.

Add this code to the end of the Program.cs file:

QueueProperties properties = queueClient.GetProperties();

// Retrieve the cached approximate message count

int cachedMessagesCount = properties.ApproximateMessagesCount;

// Display number of messages

Console.WriteLine($"Number of messages in queue: {cachedMessagesCount}");

#### Receive messages from a queue

Download previously added messages by calling the [ReceiveMessagesAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient.receivemessagesasync) method.

Add this code to the end of the Program.cs file:

Console.WriteLine("\nReceiving messages from the queue...");

// Get messages from the queue

QueueMessage[] messages = await queueClient.ReceiveMessagesAsync(maxMessages: 10);

You can optionally specify a value for maxMessages, which is the number of messages to retrieve from the queue. The default is 1 message and the maximum is 32 messages. You can also specify a value for visibilityTimeout, which hides the messages from other operations for the timeout period. The default is 30 seconds.

#### Delete messages from a queue

Delete messages from the queue after they've been processed. In this case, processing is just displaying the message on the console.

The app pauses for user input by calling Console.ReadLine before it processes and deletes the messages. Verify in your [Azure portal](https://portal.azure.com/) that the resources were created correctly, before they're deleted. Any messages not explicitly deleted eventually become visible in the queue again for another chance to process them.

Add this code to the end of the Program.cs file:

Console.WriteLine("\nPress Enter key to 'process' messages and delete them from the queue...");

Console.ReadLine();

// Process and delete messages from the queue

foreach (QueueMessage message in messages)

{

// "Process" the message

Console.WriteLine($"Message: {message.MessageText}");

// Let the service know we're finished with

// the message and it can be safely deleted.

await queueClient.DeleteMessageAsync(message.MessageId, message.PopReceipt);

}

#### Delete a queue

The following code cleans up the resources the app created by deleting the queue using the [DeleteAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.queues.queueclient.deleteasync) method.

Add this code to the end of the Program.cs file:

Console.WriteLine("\nPress Enter key to delete the queue...");

Console.ReadLine();

// Clean up

Console.WriteLine($"Deleting queue: {queueClient.Name}");

await queueClient.DeleteAsync();

Console.WriteLine("Done");

#### Run the code

This app creates and adds three messages to an Azure queue. The code lists the messages in the queue, then retrieves and deletes them, before finally deleting the queue.

In your console window, navigate to your application directory, then build and run the application.

dotnet build

dotnet run

The output of the app is similar to the following example:

**Output:**

Azure Queue Storage client library - .NET quickstart sample

Creating queue: quickstartqueues-5c72da2c-30cc-4f09-b05c-a95d9da52af2

Adding messages to the queue...

Peek at the messages in the queue...

Message: First message

Message: Second message

Message: Third message

Updating the third message in the queue...

Receiving messages from the queue...

Press Enter key to 'process' messages and delete them from the queue...

Message: First message

Message: Second message

Message: Third message has been updated

Press Enter key to delete the queue...

Deleting queue: quickstartqueues-5c72da2c-30cc-4f09-b05c-a95d9da52af2

Done

When the app pauses before receiving messages, check your storage account in the [Azure portal](https://portal.azure.com/). Verify the messages are in the queue.

Press the Enter key to receive and delete the messages. When prompted, press the Enter key again to delete the queue and finish the demo.

### Get started with Azure Queue Storage using .NET Framework

<https://learn.microsoft.com/en-us/azure/storage/queues/storage-dotnet-how-to-use-queues>

### Work with Azure Queue Storage queues in .NET

<https://learn.microsoft.com/en-us/azure/storage/queues/storage-tutorial-queues?toc=%2Fazure%2Fstorage%2Fqueues%2Ftoc.json&tabs=environment-variable-windows>

## Azure Table Storage

<https://learn.microsoft.com/en-us/azure/storage/tables/table-storage-overview>

**Tip**: The content in this article applies to the original Azure Table storage. However, the same concepts apply to the newer Azure Cosmos DB for Table, which offers higher performance and availability, global distribution, and automatic secondary indexes. It is also available in a consumption-based [**serverless**](https://learn.microsoft.com/en-us/azure/cosmos-db/serverless) mode. There are some [**feature differences**](https://learn.microsoft.com/en-us/azure/cosmos-db/table/introduction) between Table API in Azure Cosmos DB and Azure Table storage. For more information, see [**Azure Cosmos DB for Table**](https://learn.microsoft.com/en-us/azure/cosmos-db/table-introduction). For ease of development, we now provide a unified [**Azure Tables SDK**](https://devblogs.microsoft.com/azure-sdk/announcing-the-new-azure-data-tables-libraries/) that can be used to target both Azure Table storage and Azure Cosmos DB for Table.

Azure Table storage is a service that stores non-relational structured data (also known as structured NoSQL data) in the cloud, providing a key/attribute store with a schemaless design. Because Table storage is schemaless, it's easy to adapt your data as the needs of your application evolve. Access to Table storage data is fast and cost-effective for many types of applications, and is typically lower in cost than traditional SQL for similar volumes of data.

You can use Table storage to store flexible datasets like user data for web applications, address books, device information, or other types of metadata your service requires. You can store any number of entities in a table, and a storage account may contain any number of tables, up to the capacity limit of the storage account.

### What is Table storage

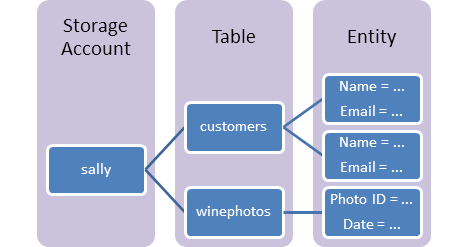
Azure Table storage stores large amounts of structured data. The service is a NoSQL datastore which accepts authenticated calls from inside and outside the Azure cloud. Azure tables are ideal for storing structured, non-relational data. Common uses of Table storage include:

* Storing TBs of structured data capable of serving web scale applications
* Storing datasets that don't require complex joins, foreign keys, or stored procedures and can be denormalized for fast access
* Quickly querying data using a clustered index
* Accessing data using the OData protocol and LINQ queries with WCF Data Service .NET Libraries

You can use Table storage to store and query huge sets of structured, non-relational data, and your tables will scale as demand increases.

### Table storage concepts

Table storage contains the following components:



* **URL format:** Azure Table Storage accounts use this format: http://<storage account>.table.core.windows.net/<table>

Azure Cosmos DB for Table accounts use this format: http://<storage account>.table.cosmosdb.azure.com/<table>

You can address Azure tables directly using this address with the OData protocol. For more information, see [OData.org](https://www.odata.org/).

* **Accounts**: All access to Azure Storage is done through a storage account. For more information about storage accounts, see [Storage account overview](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-overview).

All access to Azure Cosmos DB is done through an Azure Cosmos DB for Table account. For more information, see [Create an Azure Cosmos DB for Table account](https://learn.microsoft.com/en-us/azure/cosmos-db/create-table-dotnet#create-a-database-account).

* **Table**: A table is a collection of entities. Tables don't enforce a schema on entities, which means a single table can contain entities that have different sets of properties.
* **Entity**: An entity is a set of properties, similar to a database row. An entity in Azure Storage can be up to 1MB in size. An entity in Azure Cosmos DB can be up to 2MB in size.
* **Properties**: A property is a name-value pair. Each entity can include up to 252 properties to store data. Each entity also has three system properties that specify a partition key, a row key, and a timestamp. Entities with the same partition key can be queried more quickly, and inserted/updated in atomic operations. An entity's row key is its unique identifier within a partition.

### Understanding the Table service data model

<https://learn.microsoft.com/en-us/rest/api/storageservices/understanding-the-table-service-data-model>

The Table service offers structured storage in the form of tables. The following sections outline the Table service data model.

#### Storage Account

A storage account is a globally unique entity within the storage system. The storage account is the parent namespace for the Table service, and is the basis for authorization. You can create any number of tables within a given storage account, as long as each table is uniquely named.

The storage account must always be specified in the request URI. The base URI for accessing the Table service is as follows:

https://myaccount.table.core.windows.net

#### Tables, Entities, and Properties

Tables store data as collections of entities. Entities are similar to rows. An entity has a primary key and a set of properties. A property is a name, typed-value pair, similar to a column.

The Table service does not enforce any schema for tables, so two entities in the same table may have different sets of properties. Developers may choose to enforce a schema on the client side. A table may contain any number of entities.

#### Table Names

Table names must conform to these rules:

* Table names must be unique within an account.
* Table names may contain only alphanumeric characters.
* Table names cannot begin with a numeric character.
* Table names are case-insensitive.
* Table names must be from 3 to 63 characters long.
* Some table names are reserved, including "tables". Attempting to create a table with a reserved table name returns error code 404 (Bad Request).

These rules are also described by the regular expression "^[A-Za-z][A-Za-z0-9]{2,62}$".

Table names preserve the case with which they were created, but are case-insensitive when used.

#### Property Names

Property names are case-sensitive strings up to 255 characters in size. Property names should follow naming rules for [C# identifiers](https://go.microsoft.com/fwlink/?LinkId=155321).

**Note**: Some C# identifiers are not valid according to the [**XML specification**](https://go.microsoft.com/fwlink/?LinkId=155322). These identifiers may not be used in property names, because property names are sent via an XML payload in a request against the Table service.

**Important**: Property names are passed to the Table service within a URL. Certain characters must be percent-encoded to appear in a URL, using UTF-8 (preferred) or MBCS. This encoding occurs automatically when you use the Azure Storage client libraries. However, there are certain characters that are not valid in URL paths even when encoded. These characters cannot appear in property names. Code points like \uE000, while valid in NTFS filenames, are not valid Unicode characters, so they cannot be used. In addition, some ASCII or Unicode characters, like control characters (0x00 to 0x1F, \u0081, etc.), are also not allowed. For rules governing Unicode strings in HTTP/1.1 see:

* [**RFC 2616, Section 2.2: Basic Rules**](http://www.ietf.org/rfc/rfc2616.txt)
* [**RFC 3987**](http://www.ietf.org/rfc/rfc3987.txt)

**Note**: Beginning with version 2009-04-14, the Table service no longer supports including the dash (-) character in property names.

#### Property Limitations

An entity can have up to 255 properties, including 3 system properties described in the following section. Therefore, the user may include up to 252 custom properties, in addition to the 3 system properties. The combined size of all data in an entity's properties cannot exceed 1 MiB.

#### System Properties

An entity always has the following system properties:

* PartitionKey property
* RowKey property
* Timestamp property

These system properties are automatically included for every entity in a table. The names of these properties are reserved and cannot be changed. The developer is responsible for inserting and updating the values of PartitionKey and RowKey. The server manages the value of Timestamp, which cannot be modified.

##### Characters Disallowed in Key Fields

The following characters are not allowed in values for the PartitionKey and RowKey properties:

* The forward slash (/) character
* The backslash (\) character
* The number sign (#) character
* The question mark (?) character
* Control characters from U+0000 to U+001F, including:
  + The horizontal tab (\t) character
  + The linefeed (\n) character
  + The carriage return (\r) character
* Control characters from U+007F to U+009F

##### PartitionKey Property

Tables are partitioned to support load balancing across storage nodes. A table's entities are organized by partition. A partition is a consecutive range of entities possessing the same partition key value. The partition key is a unique identifier for the partition within a given table, specified by the PartitionKey property. The partition key forms the first part of an entity's primary key. The partition key may be a string value up to 1 KiB in size.

You must include the PartitionKey property in every insert, update, and delete operation.

##### RowKey Property

The second part of the primary key is the row key, specified by the RowKey property. The row key is a unique identifier for an entity within a given partition. Together the PartitionKey and RowKey uniquely identify every entity within a table.

The row key is a string value that may be up to 1 KiB in size.

You must include the RowKey property in every insert, update, and delete operation.

##### Timestamp Property

The Timestamp property is a DateTime value that is maintained on the server side to record the time an entity was last modified. The Table service uses the Timestamp property internally to provide optimistic concurrency. The value of the Timestamp property for an entity advances each time the entity is modified. This property should not be set on insert or update operations (the value will be ignored).

The Timestamp property must be expressed in one of the accepted ISO 8601 UTC formats. For more information about accepted UTC formats, see [Formatting DateTime values](https://learn.microsoft.com/en-us/rest/api/storageservices/formatting-datetime-values).

#### Property Types

The Table service supports a subset of data types defined by the [OData Protocol Specification](https://www.odata.org/). The following table shows the supported property types for the Table service:

| **OData Data Type** | **Common Language Runtime type** | **Details** |
| --- | --- | --- |
| Edm.Binary | byte[] | An array of bytes up to 64 KiB in size. |
| Edm.Boolean | bool | A Boolean value. |
| Edm.DateTime | DateTime | A 64-bit value expressed as Coordinated Universal Time (UTC). The supported DateTime range begins from 12:00 midnight, January 1, 1601 A.D. (C.E.), UTC. The range ends at December 31, 9999. For more information, see [Formatting DateTime values](https://learn.microsoft.com/en-us/rest/api/storageservices/formatting-datetime-values). |
| Edm.Double | double | A 64-bit floating point value. |
| Edm.Guid | Guid | A 128-bit globally unique identifier. |
| Edm.Int32 | Int32 or int | A 32-bit integer. |
| Edm.Int64 | Int64 or long | A 64-bit integer. |
| Edm.String | String | A UTF-16-encoded value. String values may be up to 64 KiB in size. Note that the maximum number of characters supported is about 32 K or less. |

By default a property is created as type String, unless you specify a different type. To explicitly type a property, specify its data type by using the appropriate OData data type for an [Insert Entity](https://learn.microsoft.com/en-us/rest/api/storageservices/insert-entity) or [Update Entity](https://learn.microsoft.com/en-us/rest/api/storageservices/update-entity2) operation. For more information, see [Inserting and Updating Entities](https://learn.microsoft.com/en-us/rest/api/storageservices/inserting-and-updating-entities).

The Table service does not persist null values for properties. When querying entities, the above property types are all non-nullable. When writing entities, the above property types are all nullable, and any property with a null value is handled as if the payload did not contain that property.

For examples that show how to filter on the various property types in a query request URI, see [Querying Tables and Entities](https://learn.microsoft.com/en-us/rest/api/storageservices/querying-tables-and-entities).

### Create a table in the Azure portal

<https://learn.microsoft.com/en-us/azure/storage/tables/table-storage-quickstart-portal>

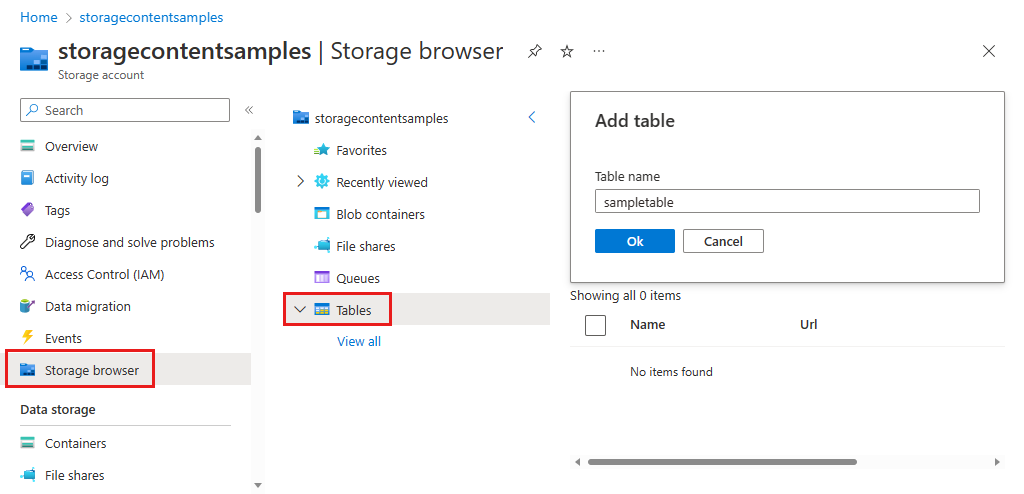
#### Prerequisites

To complete this quickstart, first create an Azure storage account in the [Azure portal](https://portal.azure.com/#create/Microsoft.StorageAccount-ARM). For help creating the account, see [Create a storage account](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-create).

#### Add a table

To create a table in the Azure portal:

1. Navigate to your storage account in the Azure portal.
2. Select **Storage Browser** in the left-hand navigation panel.
3. In the Storage Browser tree, select select **Tables**.
4. Select the **Add table** button to add a new table.
5. In the **Add table** dialog, provide a name for the new table.

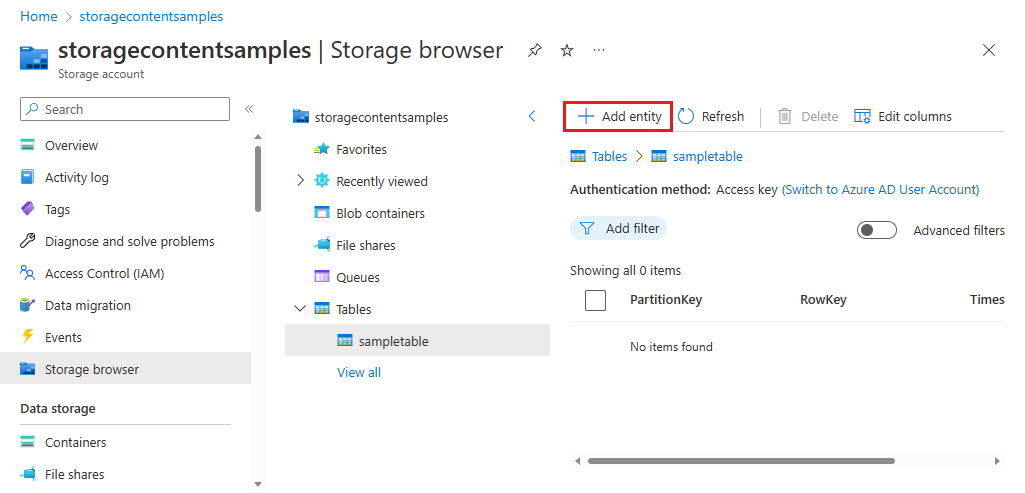


1. Select **Ok** to create the new table.

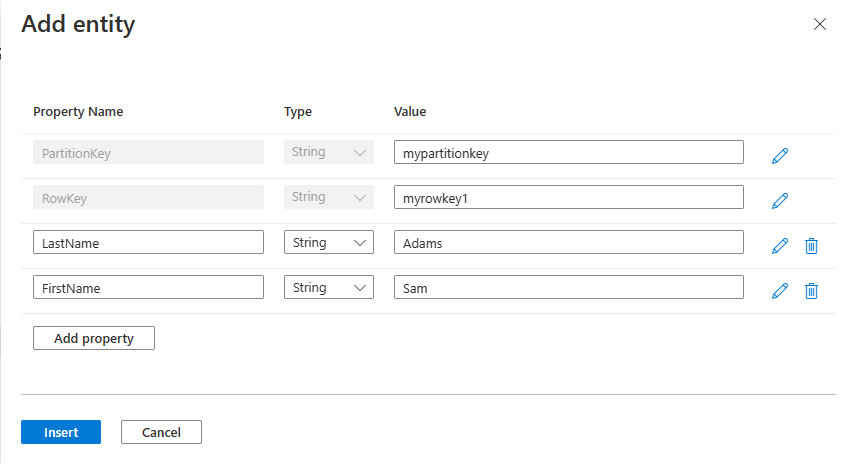
#### Add an entity to the table

To add an entity to your table from the Azure portal:

1. In the Storage Browser in the Azure portal, select the table you created previously.
2. Select the **Add entity** button to add a new entity.



1. In the **Add entity** dialog, provide a partition key and a row key, then add any additional properties for data that you want to write to the entity.



### Azure Cosmos DB for Table for .NET

<https://learn.microsoft.com/en-us/azure/cosmos-db/table/quickstart-dotnet?toc=https%3A%2F%2Flearn.microsoft.com%2Fen-us%2Fazure%2Fstorage%2Ftables%2Ftoc.json&bc=https%3A%2F%2Flearn.microsoft.com%2Fen-us%2Fazure%2Fbread%2Ftoc.json&tabs=azure-cli%2Cwindows>

This quickstart shows how to get started with the Azure Cosmos DB for Table from a .NET application. The Azure Cosmos DB for Table is a schemaless data store allowing applications to store structured NoSQL data in the cloud. You'll learn how to create tables, rows, and perform basic tasks within your Azure Cosmos DB resource using the [Azure.Data.Tables Package (NuGet)](https://www.nuget.org/packages/Azure.Data.Tables/).

**Note**: The [**example code snippets**](https://github.com/Azure-Samples/cosmos-db-table-api-dotnet-samples) are available on GitHub as a .NET project.

#### Prerequisites

* An Azure account with an active subscription. [Create an account for free](https://azure.microsoft.com/free).
* [.NET 6.0](https://dotnet.microsoft.com/download)
* [Azure Command-Line Interface (CLI)](https://learn.microsoft.com/en-us/cli/azure/) or [Azure PowerShell](https://learn.microsoft.com/en-us/powershell/azure/)

#### Prerequisite check

* In a terminal or command window, run dotnet --list-sdks to check that .NET 6.x is one of the available versions.
* Run az --version (Azure CLI) or Get-Module -ListAvailable AzureRM (Azure PowerShell) to check that you have the appropriate Azure command-line tools installed.

#### Setting up

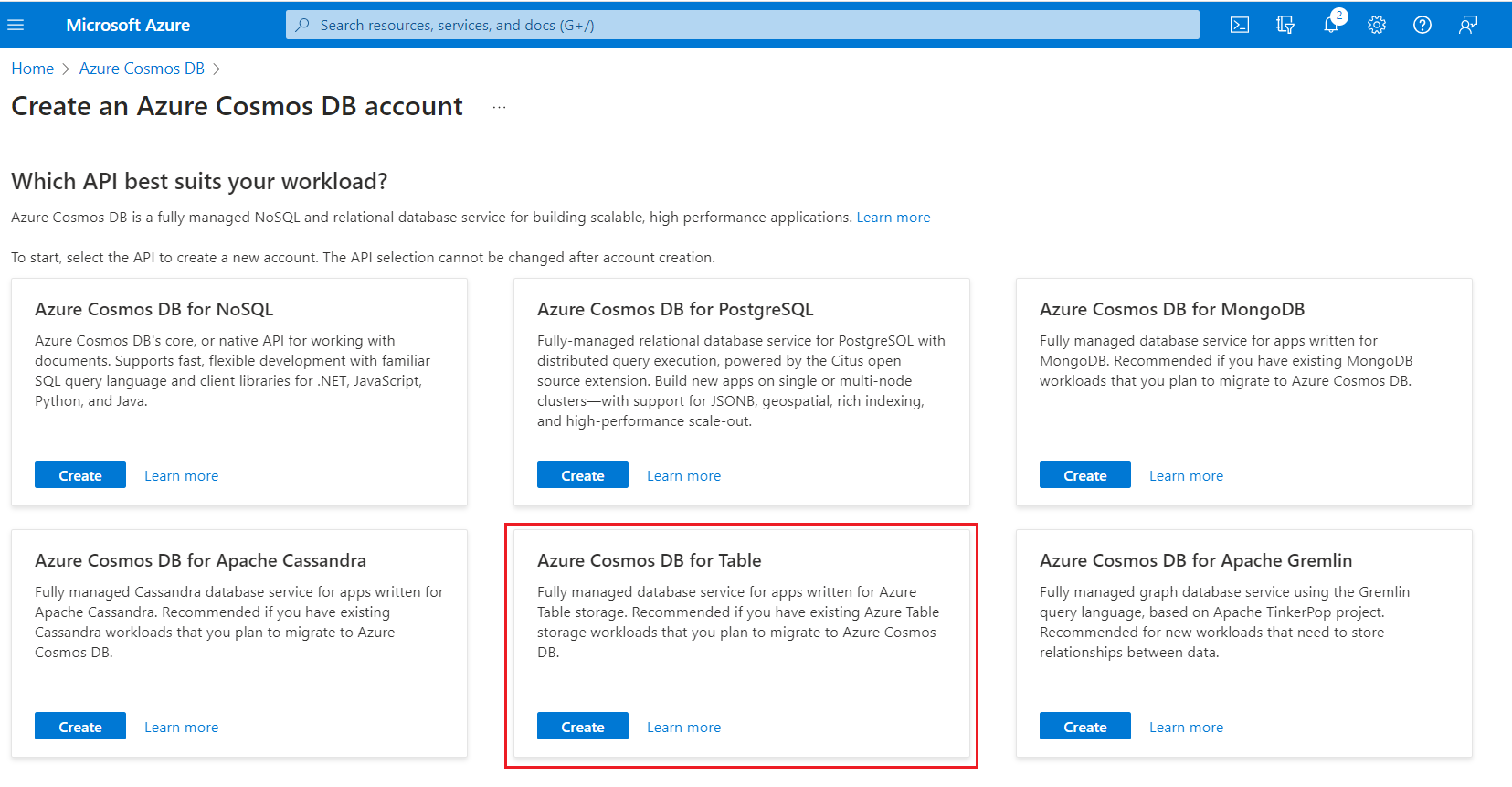
This section walks you through how to create an Azure Cosmos DB account and set up a project that uses the API for Table NuGet packages.

#### Create an Azure Cosmos DB account

This quickstart will create a single Azure Cosmos DB account using the API for Table.

**Tip**: For this quickstart, we recommend using the resource group name msdocs-cosmos-quickstart-rg.

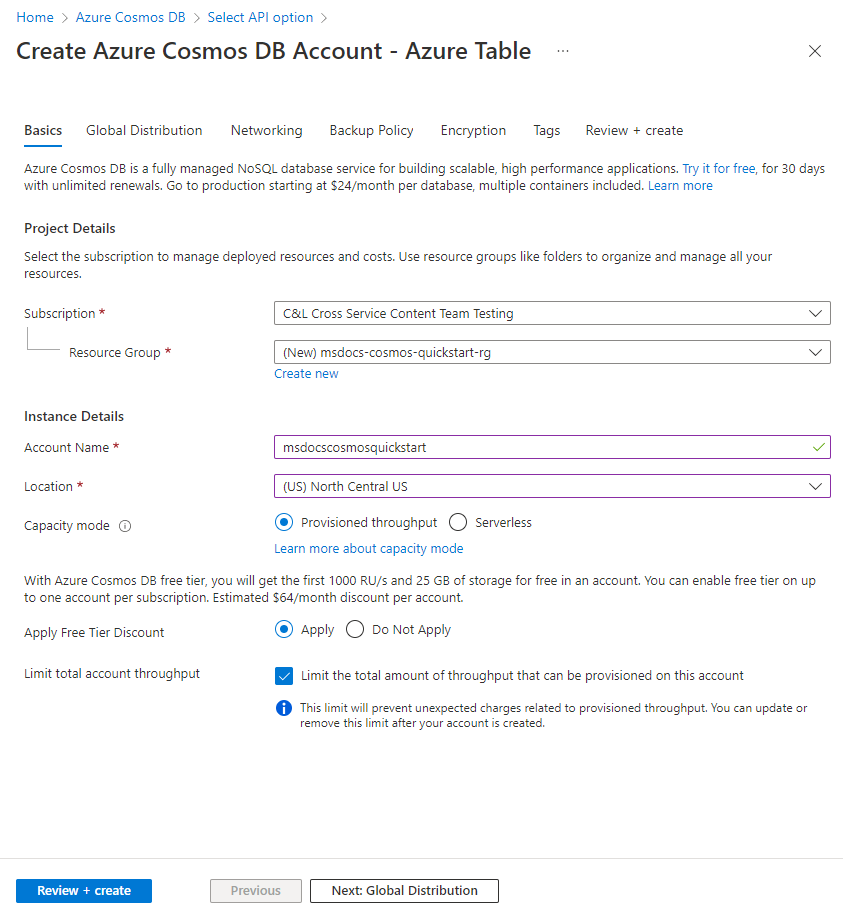
1. Sign in to the [Azure portal](https://portal.azure.com/).
2. From the Azure portal menu or the **Home page**, select **Create a resource**.
3. On the **New** page, search for and select **Azure Cosmos DB**.
4. On the **Select API option** page, select the **Create** option within the **Azure Table** section. Azure Cosmos DB has five APIs: SQL, MongoDB, Gremlin, Table, and Cassandra. [Learn more about the API for Table](https://learn.microsoft.com/en-us/azure/cosmos-db/table/introduction).



1. On the **Create Azure Cosmos DB Account** page, enter the following information:

| **Setting** | **Value** | **Description** |
| --- | --- | --- |
| Subscription | Subscription name | Select the Azure subscription that you wish to use for this Azure Cosmos DB account. |
| Resource Group | Resource group name | Select a resource group, or select **Create new**, then enter a unique name for the new resource group. |
| Account Name | A unique name | Enter a name to identify your Azure Cosmos DB account. The name will be used as part of a fully qualified domain name (FQDN) with a suffix of documents.azure.com, so the name must be globally unique. The name can only contain lowercase letters, numbers, and the hyphen (-) character. The name must also be between 3-44 characters in length. |
| Location | The region closest to your users | Select a geographic location to host your Azure Cosmos DB account. Use the location that is closest to your users to give them the fastest access to the data. |
| Capacity mode | Provisioned throughput or Serverless | Select **Provisioned throughput** to create an account in [provisioned throughput](https://learn.microsoft.com/en-us/azure/cosmos-db/set-throughput) mode. Select **Serverless** to create an account in [serverless](https://learn.microsoft.com/en-us/azure/cosmos-db/serverless) mode. |
| Apply Azure Cosmos DB free tier discount | **Apply** or **Do not apply** | With Azure Cosmos DB free tier, you'll get the first 1000 RU/s and 25 GB of storage for free in an account. Learn more about [free tier](https://azure.microsoft.com/pricing/details/cosmos-db/). |
| Version | MongoDB version | Select the MongoDB server version that matches your application requirements. |

**Note**: You can have up to one free tier Azure Cosmos DB account per Azure subscription and must opt-in when creating the account. If you do not see the option to apply the free tier discount, this means another account in the subscription has already been enabled with free tier.



1. Select **Review + create**.
2. Review the settings you provide, and then select **Create**. It takes a few minutes to create the account. Wait for the portal page to display **Your deployment is complete** before moving on.
3. Select **Go to resource** to go to the Azure Cosmos DB account page.

#### Get API for Table connection string

1. From the Azure Cosmos DB for Table account page, select the **Connection String** navigation menu option.
2. Record the values for the **PRIMARY CONNECTION STRING** field. You'll use this value in a later step.

#### Create a new .NET app

Create a new .NET application in an empty folder using your preferred terminal. Use the [dotnet new console](https://learn.microsoft.com/en-us/dotnet/core/tools/dotnet-new) to create a new console app.

dotnet new console --output <app-name>

#### Install the NuGet package

Add the [Azure.Data.Tables](https://www.nuget.org/packages/Azure.Data.Tables) NuGet package to the new .NET project. Use the [dotnet add package](https://learn.microsoft.com/en-us/dotnet/core/tools/dotnet-add-package) command specifying the name of the NuGet package.

dotnet add package Azure.Data.Tables

#### Configure environment variables

To use the **CONNECTION STRING** values within your code, set this value on the local machine running the application. To set the environment variable, use your preferred terminal to run the following commands:

##### Windows – Powershell

$env:COSMOS\_CONNECTION\_STRING = "<cosmos-connection-string>"

##### Linux / macOS - Bash

export COSMOS\_CONNECTION\_STRING="<cosmos-connection-string>"

##### .env

A .env file is a standard way to store environment variables in a project. Create a .env file in the root of your project. Add the following lines to the .env file:

COSMOS\_CONNECTION\_STRING="<cosmos-connection-string>"

#### Code examples

* [Authenticate the client](https://learn.microsoft.com/en-us/azure/cosmos-db/table/quickstart-dotnet?tabs=azure-portal%2Cdotenv#authenticate-the-client)
* [Create a table](https://learn.microsoft.com/en-us/azure/cosmos-db/table/quickstart-dotnet?tabs=azure-portal%2Cdotenv#create-a-table)
* [Create an item](https://learn.microsoft.com/en-us/azure/cosmos-db/table/quickstart-dotnet?tabs=azure-portal%2Cdotenv#create-an-item)
* [Get an item](https://learn.microsoft.com/en-us/azure/cosmos-db/table/quickstart-dotnet?tabs=azure-portal%2Cdotenv#get-an-item)
* [Query items](https://learn.microsoft.com/en-us/azure/cosmos-db/table/quickstart-dotnet?tabs=azure-portal%2Cdotenv#query-items)

The sample code described in this article creates a table named adventureworks. Each table row contains the details of a product such as name, category, quantity, and a sale indicator. Each product also contains a unique identifier.

You'll use the following API for Table classes to interact with these resources:

* [TableServiceClient](https://learn.microsoft.com/en-us/dotnet/api/azure.data.tables.tableserviceclient) - This class provides methods to perform service level operations with Azure Cosmos DB for Table.
* [TableClient](https://learn.microsoft.com/en-us/dotnet/api/azure.data.tables.tableclient) - This class allows you to interact with tables hosted in the Azure Cosmos DB table API.
* [TableEntity](https://learn.microsoft.com/en-us/dotnet/api/azure.data.tables.tableentity) - This class is a reference to a row in a table that allows you to manage properties and column data.

##### Authenticate the client

From the project directory, open the Program.cs file. In your editor, add a using directive for Azure.Data.Tables.

using Azure.Data.Tables;

Define a new instance of the TableServiceClient class using the constructor, and [Environment.GetEnvironmentVariable](https://learn.microsoft.com/en-us/dotnet/api/system.environment.getenvironmentvariables) to read the connection string you set earlier.

// New instance of the TableClient class

TableServiceClient tableServiceClient = new TableServiceClient(Environment.GetEnvironmentVariable("COSMOS\_CONNECTION\_STRING"));

##### Create a table

Retrieve an instance of the TableClient using the TableServiceClient class. Use the [TableClient.CreateIfNotExistsAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.data.tables.tableclient.createifnotexistsasync) method on the TableClient to create a new table if it doesn't already exist. This method will return a reference to the existing or newly created table.

// New instance of TableClient class referencing the server-side table

TableClient tableClient = tableServiceClient.GetTableClient(

tableName: "adventureworks"

);

await tableClient.CreateIfNotExistsAsync();

##### Create an item

The easiest way to create a new item in a table is to create a class that implements the [ITableEntity](https://learn.microsoft.com/en-us/dotnet/api/azure.data.tables.itableentity) interface. You can then add your own properties to the class to populate columns of data in that table row. Create a new file Product.cs and add the following code:

// C# record type for items in the table

public record Product : ITableEntity

{

public string RowKey { get; set; } = default!;

public string PartitionKey { get; set; } = default!;

public string Name { get; init; } = default!;

public int Quantity { get; init; }

public bool Sale { get; init; }

public ETag ETag { get; set; } = default!;

public DateTimeOffset? Timestamp { get; set; } = default!;

}

Create an item in the collection using the Product class by calling [TableClient.AddEntityAsync<T>](https://learn.microsoft.com/en-us/dotnet/api/azure.data.tables.tableclient.addentityasync).

// Create new item using composite key constructor

var prod1 = new Product()

{

RowKey = "68719518388",

PartitionKey = "gear-surf-surfboards",

Name = "Ocean Surfboard",

Quantity = 8,

Sale = true

};

// Add new item to server-side table

await tableClient.AddEntityAsync<Product>(prod1);

##### Get an item

You can retrieve a specific item from a table using the [TableEntity.GetEntityAsync<T>](https://learn.microsoft.com/en-us/dotnet/api/azure.data.tables.tableclient.getentity) method. Provide the partitionKey and rowKey as parameters to identify the correct row to perform a quick point read of that item.

// Read a single item from container

var product = await tableClient.GetEntityAsync<Product>(

rowKey: "68719518388",

partitionKey: "gear-surf-surfboards"

);

Console.WriteLine("Single product:");

Console.WriteLine(product.Value.Name);

##### Query items

After you insert an item, you can also run a query to get all items that match a specific filter by using the TableClient.Query<T> method. This example filters products by category using [Linq](https://learn.microsoft.com/en-us/dotnet/standard/linq) syntax, which is a benefit of using typed ITableEntity models like the Product class.

**Note**: You can also query items using [**OData**](https://learn.microsoft.com/en-us/rest/api/storageservices/querying-tables-and-entities) syntax. You can see an example of this approach in the [**Query Data**](https://learn.microsoft.com/en-us/azure/cosmos-db/table/tutorial-query) tutorial.

// Read multiple items from container

var prod2 = new Product()

{

RowKey = "68719518390",

PartitionKey = "gear-surf-surfboards",

Name = "Sand Surfboard",

Quantity = 5,

Sale = false

};

await tableClient.AddEntityAsync<Product>(prod2);

var products = tableClient.Query<Product>(x => x.PartitionKey == "gear-surf-surfboards");

Console.WriteLine("Multiple products:");

foreach (var item in products)

{

Console.WriteLine(item.Name);

}

##### Run the code

This app creates an Azure Cosmos DB Table API table. The example then creates an item and then reads the exact same item back. Finally, the example creates a second item and then performs a query that should return multiple items. With each step, the example outputs metadata to the console about the steps it has performed.

To run the app, use a terminal to navigate to the application directory and run the application.

dotnet run

The output of the app should be similar to this example:

**Output**

Single product name:

Yamba Surfboard

Multiple products:

Yamba Surfboard

Sand Surfboard

##### Clean up resources

When you no longer need the Azure Cosmos DB for Table account, you can delete the corresponding resource group.

1. Navigate to the resource group you previously created in the Azure portal.
2. Select **Delete resource group**.
3. On the **Are you sure you want to delete** dialog, enter the name of the resource group, and then select **Delete**.

### Choose Table Storage or Azure CosmosDB for Table

<https://learn.microsoft.com/en-us/azure/cosmos-db/table/support?toc=https%3A%2F%2Flearn.microsoft.com%2Fen-us%2Fazure%2Fstorage%2Ftables%2Ftoc.json&bc=https%3A%2F%2Flearn.microsoft.com%2Fen-us%2Fazure%2Fbread%2Ftoc.json>

## Tables, Blobs, Queues & File Storage in Microsoft Azure

<https://www.edureka.co/blog/azure-storage-tutorial/>

## Azure Files Storage

<https://learn.microsoft.com/en-us/azure/storage/files/storage-files-introduction>

### Create and use an Azure file share

<https://learn.microsoft.com/en-us/azure/storage/files/storage-how-to-use-files-portal?tabs=azure-portal>

### Create an SMB Azure file share and connect it to a Windows VM using the Azure portal

<https://learn.microsoft.com/en-us/azure/storage/files/storage-files-quick-create-use-windows>

### Mount SMB Azure file share on Windows

<https://learn.microsoft.com/en-us/azure/storage/files/storage-how-to-use-files-windows>

# Azure CosmosDB

<https://learn.microsoft.com/en-us/azure/cosmos-db/introduction>

<https://learn.microsoft.com/en-us/azure/cosmos-db/choose-api>

<https://learn.microsoft.com/en-us/azure/cosmos-db/nosql/modeling-data>

## Create an Azure Cosmos DB account, database, container, and items from the Azure portal

<https://learn.microsoft.com/en-us/azure/cosmos-db/nosql/quickstart-portal>

Azure Cosmos DB is Microsoft's globally distributed multi-model database service. You can use Azure Cosmos DB to quickly create and query key/value databases, document databases, and graph databases. This approach benefits from the global distribution and horizontal scale capabilities at the core of Azure Cosmos DB.

This quickstart demonstrates how to use the Azure portal to create an Azure Cosmos DB [API for NoSQL](https://learn.microsoft.com/en-us/azure/cosmos-db/introduction) account. In that account, you create a document database, and container, and add data to the container. Without a credit card or an Azure subscription, you can set up a free [Try Azure Cosmos DB account](https://aka.ms/trycosmosdb).

### Prerequisites

An Azure subscription or free Azure Cosmos DB trial account.

* If you don't have an [Azure subscription](https://learn.microsoft.com/en-us/azure/guides/developer/azure-developer-guide#understanding-accounts-subscriptions-and-billing), create an [Azure free account](https://azure.microsoft.com/free/?ref=microsoft.com&utm_source=microsoft.com&utm_medium=docs&utm_campaign=visualstudio) before you begin.
* You can [try Azure Cosmos DB for free](https://learn.microsoft.com/en-us/azure/cosmos-db/try-free), without an Azure subscription, and with no commitment required. Alternatively, you can create an [Azure Cosmos DB free tier account](https://learn.microsoft.com/en-us/azure/cosmos-db/optimize-dev-test#azure-cosmos-db-free-tier), with the first 1000 RU/s and 25 GB of storage for free. You can also use the [Azure Cosmos DB emulator](https://learn.microsoft.com/en-us/azure/cosmos-db/local-emulator) with a URI of https://localhost:8081. For the key to use with the emulator, see [Authenticating requests](https://learn.microsoft.com/en-us/azure/cosmos-db/local-emulator#authenticate-requests).

### Create an Azure Cosmos DB account

1. From the Azure portal menu or the **Home page**, select **Create a resource**.
2. Search for **Azure Cosmos DB**. Select **Create** > **Azure Cosmos DB**.
3. On the **Create an Azure Cosmos DB account** page, select the **Create** option within the **Azure Cosmos DB for NoSQL** section.

Azure Cosmos DB provides several APIs:

* NoSQL, for document data
* PostgreSQL
* MongoDB, for document data
* Apache Cassandra
* Table
* Apache Gremlin, for graph data

To learn more about the API for NoSQL, see [Welcome to Azure Cosmos DB](https://learn.microsoft.com/en-us/azure/cosmos-db/introduction).

1. In the **Create Azure Cosmos DB Account** page, enter the basic settings for the new Azure Cosmos DB account.

| **Setting** | **Value** | **Description** |
| --- | --- | --- |
| Subscription | Subscription name | Select the Azure subscription that you want to use for this Azure Cosmos DB account. |
| Resource Group | Resource group name | Select a resource group, or select **Create new**, then enter a unique name for the new resource group. |
| Account Name | A unique name | Enter a name to identify your Azure Cosmos DB account. Because documents.azure.com is appended to the name that you provide to create your URI, use a unique name. The name can contain only lowercase letters, numbers, and the hyphen (-) character. It must be 3-44 characters. |
| Location | The region closest to your users | Select a geographic location to host your Azure Cosmos DB account. Use the location that is closest to your users to give them the fastest access to the data. |
| Capacity mode | **Provisioned throughput** or **Serverless** | Select **Provisioned throughput** to create an account in [provisioned throughput](https://learn.microsoft.com/en-us/azure/cosmos-db/set-throughput) mode. Select **Serverless** to create an account in [serverless](https://learn.microsoft.com/en-us/azure/cosmos-db/serverless) mode. |
| Apply Azure Cosmos DB free tier discount | **Apply** or **Do not apply** | With Azure Cosmos DB free tier, you get the first 1000 RU/s and 25 GB of storage for free in an account. Learn more about [free tier](https://azure.microsoft.com/pricing/details/cosmos-db/). |
| Limit total account throughput | Selected or not | Limit the total amount of throughput that can be provisioned on this account. This limit prevents unexpected charges related to provisioned throughput. You can update or remove this limit after your account is created. |

You can have up to one free tier Azure Cosmos DB account per Azure subscription and must opt in when creating the account. If you don't see the option to apply the free tier discount, another account in the subscription has already been enabled with free tier.

**Note**:The following options are not available if you select **Serverless** as the **Capacity mode**:

* Apply Free Tier Discount
* Limit total account throughput

1. In the **Global Distribution** tab, configure the following details. You can leave the default values for this quickstart:

| **Setting** | **Value** | **Description** |
| --- | --- | --- |
| Geo-Redundancy | Disable | Enable or disable global distribution on your account by pairing your region with a pair region. You can add more regions to your account later. |
| Multi-region Writes | Disable | Multi-region writes capability allows you to take advantage of the provisioned throughput for your databases and containers across the globe. |
| Availability Zones | Disable | Availability Zones help you further improve availability and resiliency of your application. |

**Note**: The following options are not available if you select **Serverless** as the **Capacity mode** in the previous **Basics** page:

* Geo-redundancy
* Multi-region Writes

1. Optionally, you can configure more details in the following tabs:

* **Networking**. Configure [access from a virtual network](https://learn.microsoft.com/en-us/azure/cosmos-db/how-to-configure-vnet-service-endpoint).
* **Backup Policy**. Configure either [periodic](https://learn.microsoft.com/en-us/azure/cosmos-db/periodic-backup-restore-introduction) or [continuous](https://learn.microsoft.com/en-us/azure/cosmos-db/provision-account-continuous-backup) backup policy.
* **Encryption**. Use either service-managed key or a [customer-managed key](https://learn.microsoft.com/en-us/azure/cosmos-db/how-to-setup-cmk#create-a-new-azure-cosmos-account).
* **Tags**. Tags are name/value pairs that enable you to categorize resources and view consolidated billing by applying the same tag to multiple resources and resource groups.

1. Select **Review + create**.
2. Review the account settings, and then select **Create**. It takes a few minutes to create the account. Wait for the portal page to display **Your deployment is complete**.
3. Select **Go to resource** to go to the Azure Cosmos DB account page.

### Add a database and a container

You can use the Data Explorer in the Azure portal to create a database and container.

1. Select **Data Explorer** from the left navigation on your Azure Cosmos DB account page, and then select **New Container** > **New Container**.

You may need to scroll right to see the **New Container** window.

1. In the **New Container** pane, enter the settings for the new container.

| **Setting** | **Suggested value** | **Description** |
| --- | --- | --- |
| **Database id** | ToDoList | Enter ToDoList as the name for the new database. Database names must contain 1-255 characters, and they can't contain /, \, #, ?, or a trailing space. Check the **Share throughput across containers** option. It allows you to share the throughput provisioned on the database across all the containers within the database. This option also helps with cost savings. |
| **Database throughput** | **Autoscale** or **Manual** | Manual throughput allows you to scale request units per second (RU/s) yourself whereas autoscale throughput allows the system to scale RU/s based on usage. Select **Manual** for this example. |
| **Database Max RU/s** | 400 RU/s | If you want to reduce latency, you can scale up the throughput later by estimating the required RU/s with the [capacity calculator](https://learn.microsoft.com/en-us/azure/cosmos-db/nosql/estimate-ru-with-capacity-planner). **Note**: This setting isn't available when creating a new container in a serverless account. |
| **Container id** | Items | Enter Items as the name for your new container. Container IDs have the same character requirements as database names. |
| **Partition key** | /category | The sample described in this article uses /category as the partition key. |

1. Don't add **Unique keys** or turn on **Analytical store** for this example.

* Unique keys let you add a layer of data integrity to the database by ensuring the uniqueness of one or more values per partition key. For more information, see [Unique keys in Azure Cosmos DB](https://learn.microsoft.com/en-us/azure/cosmos-db/unique-keys).
* [Analytical store](https://learn.microsoft.com/en-us/azure/cosmos-db/analytical-store-introduction) is used to enable large-scale analytics against operational data without any effect on your transactional workloads.

1. Select **OK**. The Data Explorer displays the new database and the container that you created.

### Add data to your database

Add data to your new database using Data Explorer.

1. In **Data Explorer**, expand the **ToDoList** database, and expand the **Items** container.
2. Next, select **Items**, and then select **New Item**.
3. Add the following structure to the document on the right side of the **Documents** pane:

{

"id": "1",

"category": "personal",

"name": "groceries",

"description": "Pick up apples and strawberries.",

"isComplete": false

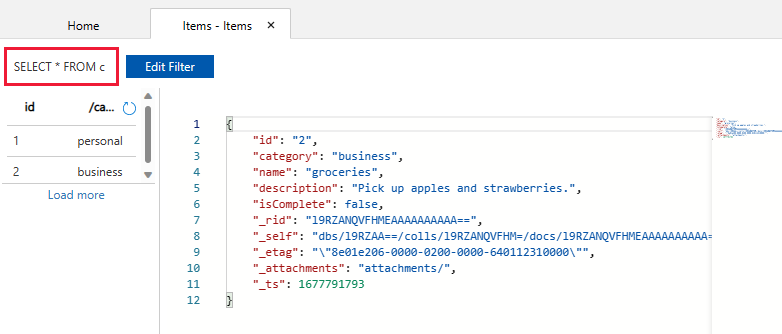
}

1. Select **Save**.
2. Select **New Item** again, and create and save another document with a unique id, and any other properties and values you want. Your documents can have any structure, because Azure Cosmos DB doesn't impose any schema on your data.

### Query your data

You can use queries in Data Explorer to retrieve and filter your data.

1. At the top of the **Items** tab in Data Explorer, review the default query SELECT \* FROM c. This query retrieves and displays all documents from the container ordered by ID.



1. To change the query, select **Edit Filter**, replace the default query with ORDER BY c.\_ts DESC, and then select **Apply Filter**.

The modified query displays the documents in descending order based on their description, so now your second document is listed first.

If you're familiar with SQL syntax, you can enter any supported [SQL queries](https://learn.microsoft.com/en-us/azure/cosmos-db/nosql/query/getting-started) in the query predicate box. You can also use Data Explorer to create stored procedures, user defined functions, and triggers for server-side business logic.

Data Explorer provides easy access in the Azure portal to all of the built-in programmatic data access features available in the APIs. You can also use the Azure portal to scale throughput, get keys and connection strings, and review metrics and SLAs for your Azure Cosmos DB account.

### Clean up resources

When you're done with your app and Azure Cosmos DB account, you can delete the Azure resources you created so you don't incur more charges. To delete the resources:

1. In the Azure portal Search bar, search for and select **Resource groups**.
2. From the list, select the resource group you created for this quickstart.
3. On the resource group **Overview** page, select **Delete resource group**.
4. In the next window, enter the name of the resource group to delete, and then select **Delete**.

If you wish to delete just the database and use the Azure Cosmos DB account in future, you can delete the database with the following steps:

1. Go to your Azure Cosmos DB account.
2. Open **Data Explorer**, select the **More** (**...**) for the database that you want to delete and select **Delete Database**.
3. Enter the database ID or database name to confirm the delete operation.

## Azure Cosmos DB for NoSQL client library for .NET

<https://learn.microsoft.com/en-us/azure/cosmos-db/nosql/quickstart-dotnet?tabs=azure-portal%2Cwindows%2Cpasswordless%2Csign-in-azure-cli>

## Azure Cosmos DB for Table for .NET

<https://learn.microsoft.com/en-us/azure/cosmos-db/table/quickstart-dotnet?tabs=azure-cli%2Cwindows>

## Develop an ASP.NET web application with Azure Cosmos DB for NoSQL

<https://learn.microsoft.com/en-us/azure/cosmos-db/nosql/tutorial-dotnet-web-app>

## Develop a .NET console application with Azure Cosmos DB for NoSQL

<https://learn.microsoft.com/en-us/azure/cosmos-db/nosql/tutorial-dotnet-console-app>

## Getting started with Azure Cosmos DB – end to end example

<https://devblogs.microsoft.com/cosmosdb/getting-started-end-to-end-example-1/>

# Azure Functions

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-overview>

<https://docs.microsoft.com/en-us/learn/modules/create-serverless-logic-with-azure-functions/3-create-an-azure-functions-app-in-the-azure-portal?pivots=javascript>

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-get-started?pivots=programming-language-csharp>

Azure Functions is a serverless solution that allows you to write less code, maintain less infrastructure, and save on costs. Instead of worrying about deploying and maintaining servers, the cloud infrastructure provides all the up-to-date resources needed to keep your applications running.

You focus on the code that matters most to you, in the most productive language for you, and Azure Functions handles the rest.

## Scenarios

Functions provides a comprehensive set of event-driven [triggers and bindings](https://learn.microsoft.com/en-us/azure/azure-functions/functions-triggers-bindings) that connect your functions to other services without having to write extra code.

The following are a common, but by no means exhaustive, set of integrated scenarios that feature Functions.

| **If you want to...** | **then...** |
| --- | --- |
| [Process file uploads](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenarios#process-file-uploads) | Run code when a file is uploaded or changed in blob storage. |
| [Process data in real time](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenarios#real-time-stream-and-event-processing) | Capture and transform data from event and IoT source streams on the way to storage. |
| [Infer on data models](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenarios#machine-learning-and-ai) | Pull text from a queue and present it to various AI services for analysis and classification. |
| [Run scheduled task](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenarios#run-scheduled-tasks) | Execute data clean-up code on pre-defined timed intervals. |
| [Build a scalable web API](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenarios#build-a-scalable-web-api) | Implement a set of REST endpoints for your web applications using HTTP triggers. |
| [Build a serverless workflow](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenarios#build-a-serverless-workflow) | Create an event-driven workflow from a series of functions using Durable Functions. |
| [Respond to database changes](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenarios#respond-to-database-changes) | Run custom logic when a document is created or updated in Azure Cosmos DB. |
| [Create reliable message systems](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenarios#create-reliable-message-systems) | Process message queues using Queue Storage, Service Bus, or Event Hubs. |

These scenarios allow you to build event-driven systems using modern architectural patterns.

## Development lifecycle

With Functions, you write your function code in your preferred language using your favorite development tools and then deploy your code to the Azure cloud. Functions provides native support for developing in [C#, Java, JavaScript, PowerShell, Python](https://learn.microsoft.com/en-us/azure/azure-functions/supported-languages), plus the ability to use [more languages](https://learn.microsoft.com/en-us/azure/azure-functions/functions-custom-handlers), such as Rust and Go.

Functions integrates directly with Visual Studio, Visual Studio Code, Maven, and other popular development tools to enable seemless debugging and [deployments](https://learn.microsoft.com/en-us/azure/azure-functions/functions-deployment-technologies).

Functions also integrates with Azure Monitor and Azure Application Insights to provide comprehensive runtime telemetry and analysis of your [functions in the cloud](https://learn.microsoft.com/en-us/azure/azure-functions/functions-monitoring).

## Differences between in-process and isolated worker process .NET Azure Functions

<https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-in-process-differences>

There are two process models for .NET functions:

| **Execution mode** | **Description** |
| --- | --- |
| **In-process** | Your function code runs in the same process as the Functions host process. Supports only [Long Term Support (LTS) versions of .NET](https://learn.microsoft.com/en-us/azure/azure-functions/functions-dotnet-class-library#supported-versions). To learn more, see [Develop .NET class library functions](https://learn.microsoft.com/en-us/azure/azure-functions/functions-dotnet-class-library). |
| **Isolated worker process** | Your function code runs in a separate .NET worker process. Use with [supported versions of .NET and .NET Framework](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#supported-versions). To learn more, see [Develop .NET isolated worker process functions](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide). |

### Execution mode comparison table

Use the following table to compare feature and functional differences between the two models:

| **Feature/behavior** | **In-process3** | **Isolated worker process** |
| --- | --- | --- |
| [Supported .NET versions](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#supported-versions) | Long Term Support (LTS) versions | [All supported versions](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#supported-versions) + .NET Framework |
| Core packages | [Microsoft.NET.Sdk.Functions](https://www.nuget.org/packages/Microsoft.NET.Sdk.Functions/) | [Microsoft.Azure.Functions.Worker](https://www.nuget.org/packages/Microsoft.Azure.Functions.Worker/) [Microsoft.Azure.Functions.Worker.Sdk](https://www.nuget.org/packages/Microsoft.Azure.Functions.Worker.Sdk) |
| Binding extension packages | [Microsoft.Azure.WebJobs.Extensions.\*](https://www.nuget.org/packages?q=Microsoft.Azure.WebJobs.Extensions) | [Microsoft.Azure.Functions.Worker.Extensions.\*](https://www.nuget.org/packages?q=Microsoft.Azure.Functions.Worker.Extensions) |
| Durable Functions | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-overview) | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-isolated-create-first-csharp?pivots=code-editor-visualstudio) |
| Model types exposed by bindings | Simple types [JSON serializable](https://learn.microsoft.com/en-us/dotnet/api/system.text.json.jsonserializeroptions) types Arrays/enumerations Service SDK types4 | Simple types JSON serializable types Arrays/enumerations [Service SDK types](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#sdk-types)4 |
| HTTP trigger model types | [HttpRequest](https://learn.microsoft.com/en-us/dotnet/api/microsoft.aspnetcore.http.httprequest) / [IActionResult](https://learn.microsoft.com/en-us/dotnet/api/microsoft.aspnetcore.mvc.iactionresult) | [HttpRequestData](https://learn.microsoft.com/en-us/dotnet/api/microsoft.azure.functions.worker.http.httprequestdata?view=azure-dotnet&preserve-view=true) / [HttpResponseData](https://learn.microsoft.com/en-us/dotnet/api/microsoft.azure.functions.worker.http.httpresponsedata?view=azure-dotnet&preserve-view=true) [HttpRequest](https://learn.microsoft.com/en-us/dotnet/api/microsoft.aspnetcore.http.httprequest) / [IActionResult](https://learn.microsoft.com/en-us/dotnet/api/microsoft.aspnetcore.mvc.iactionresult) (as a [public preview extension](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#aspnet-core-integration-preview)) |
| Output binding interactions | Return values (single output only) out parameters IAsyncCollector | Return values (expanded model with single or [multiple outputs](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#multiple-output-bindings)) |
| Imperative bindings1 | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/functions-dotnet-class-library#binding-at-runtime) | Not supported |
| Dependency injection | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/functions-dotnet-dependency-injection) | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#dependency-injection) |
| Middleware | Not supported | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#middleware) |
| Logging | [ILogger](https://learn.microsoft.com/en-us/dotnet/api/microsoft.extensions.logging.ilogger) passed to the function [ILogger<T>](https://learn.microsoft.com/en-us/dotnet/api/microsoft.extensions.logging.logger-1) via [dependency injection](https://learn.microsoft.com/en-us/azure/azure-functions/functions-dotnet-dependency-injection) | [ILogger<T>](https://learn.microsoft.com/en-us/dotnet/api/microsoft.extensions.logging.logger-1)/[ILogger](https://learn.microsoft.com/en-us/dotnet/api/microsoft.extensions.logging.ilogger) obtained from [FunctionContext](https://learn.microsoft.com/en-us/dotnet/api/microsoft.azure.functions.worker.functioncontext) or via [dependency injection](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#dependency-injection) |
| Application Insights dependencies | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/functions-monitoring#dependencies) | [Supported (public preview)](https://www.nuget.org/packages/Microsoft.Azure.Functions.Worker.ApplicationInsights) |
| Cancellation tokens | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/functions-dotnet-class-library#cancellation-tokens) | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#cancellation-tokens) |
| Cold start times2 | (Baseline) | Additionally includes process launch |
| ReadyToRun | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/functions-dotnet-class-library#readytorun) | [Supported](https://learn.microsoft.com/en-us/azure/azure-functions/dotnet-isolated-process-guide#readytorun) |

1 When you need to interact with a service using parameters determined at runtime, using the corresponding service SDKs directly is recommended over using imperative bindings. The SDKs are less verbose, cover more scenarios, and have advantages for error handling and debugging purposes. This recommendation applies to both models.

2 Cold start times may be additionally impacted on Windows when using some preview versions of .NET due to just-in-time loading of preview frameworks. This impact applies to both the in-process and out-of-process models but may be noticeable when comparing across different versions. This delay for preview versions isn't present on Linux plans.

3 C# Script functions also run in-process and use the same libraries as in-process class library functions. For more information, see the [Azure Functions C# script (.csx) developer reference](https://learn.microsoft.com/en-us/azure/azure-functions/functions-reference-csharp).

4 Service SDK types include types from the [Azure SDK for .NET](https://learn.microsoft.com/en-us/dotnet/azure/sdk/azure-sdk-for-dotnet) such as [BlobClient](https://learn.microsoft.com/en-us/dotnet/api/azure.storage.blobs.blobclient). For the isolated process model, support from some extensions is currently in preview.

## Create Azure Function using Visual Studio

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-create-your-first-function-visual-studio?tabs=in-process>

### Create a function app project

**Solution**: <https://github.com/AjaySingala/dotNetFullStackDemos/tree/main/Azure/FunctionApp>

**Project**: FunctionApp.csproj

**File**: HttpExample.cs

**Region**: HttpExample Simple (without Queue Trigger).

The Azure Functions project template in Visual Studio creates a C# class library project that you can publish to a function app in Azure. You can use a function app to group functions as a logical unit for easier management, deployment, scaling, and sharing of resources.

1. From the Visual Studio menu, select **File** > **New** > **Project**.
2. In **Create a new project**, enter functions in the search box, choose the **Azure Functions** template, and then select **Next**.
3. In **Configure your new project**, enter a **Project name** for your project, and then select **Next**. The function app name must be valid as a C# namespace, so don't use underscores, hyphens, or any other nonalphanumeric characters.
4. For the remaining **Additional information** settings,

| **Setting** | **Value** | **Description** |
| --- | --- | --- |
| **Functions worker** | **.NET 6.0 Isolated (Long Term Support)** | Your functions run on .NET 6 in an isolated worker process. |
| **Function** | **HTTP trigger** | This value creates a function triggered by an HTTP request. |
| **Use Azurite for runtime storage account (AzureWebJobsStorage)** | Enable | Because a function app in Azure requires a storage account, one is assigned or created when you publish your project to Azure. An HTTP trigger doesn't use an Azure Storage account connection string; all other trigger types require a valid Azure Storage account connection string. When you select this option, the [Azurite emulator](https://learn.microsoft.com/en-us/azure/storage/common/storage-use-azurite?tabs=visual-studio) is used. |
| **Authorization level** | **Anonymous** | The created function can be triggered by any client without providing a key. This authorization setting makes it easy to test your new function. For more information about keys and authorization, see [Authorization keys](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-http-webhook-trigger#authorization-keys) and [HTTP and webhook bindings](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-http-webhook). |

Make sure you set the **Authorization level** to **Anonymous**. If you choose the default level of **Function**, you're required to present the [function key](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-http-webhook-trigger#authorization-keys) in requests to access your function endpoint in Azure.

1. Select **Create** to create the function project and HTTP trigger function.

Visual Studio creates a project and class that contains boilerplate code for the HTTP trigger function type. The boilerplate code sends an HTTP response that includes a value from the request body or query string. The HttpTrigger attribute specifies that the function is triggered by an HTTP request.

### Rename the function

The FunctionName method attribute sets the name of the function, which by default is generated as Function1. Since the tooling doesn't let you override the default function name when you create your project, take a minute to create a better name for the function class, file, and metadata.

1. In **File Explorer**, right-click the Function1.cs file and rename it to HttpExample.cs.
2. In the code, rename the Function1 class to HttpExample.
3. In the HttpTrigger method named Run, rename the FunctionName method attribute to HttpExample.

The code should look like this:

public class HttpExample

{

private readonly ILogger \_logger;

public HttpExample(ILoggerFactory loggerFactory)

{

\_logger = loggerFactory.CreateLogger<HttpExample>();

}

#region HttpExample Simple (without Queue Trigger).

[Function("HttpExample")]

public HttpResponseData Run(

[HttpTrigger(AuthorizationLevel.Anonymous, "get", "post")] HttpRequestData req,

FunctionContext executionContext)

{

\_logger.LogInformation("C# HTTP trigger function processed a request.");

var query = System.Web.HttpUtility.ParseQueryString(req.Url.Query);

string name = query["Name"];

var response = req.CreateResponse(HttpStatusCode.OK);

response.Headers.Add("Content-Type", "text/plain; charset=utf-8");

string message = $"Welcome to Azure Functions!" +

$" Hello, {name}. This HTTP triggered function executed successfully.";

response.WriteString(message);

return response;

}

#endregion

}

Now that you've renamed the function, you can test it on your local computer.

### Run the function locally

Visual Studio integrates with Azure Functions Core Tools so that you can test your functions locally using the full Azure Functions runtime.

1. To run your function, press F5 in Visual Studio. You might need to enable a firewall exception so that the tools can handle HTTP requests. Authorization levels are never enforced when you run a function locally.
2. Copy the URL of your function from the Azure Functions runtime output.
3. Paste the URL for the HTTP request into your browser's address bar. Append the query string ?name=<YOUR\_NAME> to this URL and run the request
4. To stop debugging, press Shift+F5 in Visual Studio.

After you've verified that the function runs correctly on your local computer, it's time to publish the project to Azure.

### Publish the project to Azure

Visual Studio can publish your local project to Azure. Before you can publish your project, you must have a function app in your Azure subscription. If you don't already have a function app in Azure, Visual Studio publishing creates one for you the first time you publish your project. In this article, you create a function app and related Azure resources.

1. In **Solution Explorer**, right-click the project and select **Publish**. In **Target**, select **Azure** then **Next**.
2. Select **Azure Function App (Windows)** for the **Specific target**, which creates a function app that runs on Windows, and then select **Next**.
3. In the **Function Instance**, choose **Create a new Azure Function...**
4. Create a new instance using the values specified in the following table:

| **Setting** | **Value** | **Description** |
| --- | --- | --- |
| **Name** | Globally unique name | Name that uniquely identifies your new function app. Accept this name or enter a new name. Valid characters are: a-z, 0-9, and -. |
| **Subscription** | Your subscription | The Azure subscription to use. Accept this subscription or select a new one from the drop-down list. |
| [**Resource group**](https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/overview) | Name of your resource group | The resource group in which you want to create your function app. Select an existing resource group from the drop-down list or select **New** to create a new resource group. |
| [**Plan Type**](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scale) | Consumption | When you publish your project to a function app that runs in a [Consumption plan](https://learn.microsoft.com/en-us/azure/azure-functions/consumption-plan), you pay only for executions of your functions app. Other hosting plans incur higher costs. |
| **Location** | Location of the app service | Choose a **Location** in a [region](https://azure.microsoft.com/regions/) near you or other services your functions access. |
| [**Azure Storage**](https://learn.microsoft.com/en-us/azure/azure-functions/storage-considerations) | General-purpose storage account | An Azure storage account is required by the Functions runtime. Select **New** to configure a general-purpose storage account. You can also choose an existing account that meets the [storage account requirements](https://learn.microsoft.com/en-us/azure/azure-functions/storage-considerations#storage-account-requirements). |

1. Select **Create** to create a function app and its related resources in Azure. The status of resource creation is shown in the lower-left of the window.
2. In the **Functions instance**, make sure that the **Run from package file** is checked. Your function app is deployed using [Zip Deploy](https://learn.microsoft.com/en-us/azure/azure-functions/functions-deployment-technologies#zip-deploy) with [Run-From-Package](https://learn.microsoft.com/en-us/azure/azure-functions/run-functions-from-deployment-package) mode enabled. Zip Deploy is the recommended deployment method for your functions project resulting in better performance.
3. Select **Finish**, and on the Publish page, select **Publish** to deploy the package containing your project files to your new function app in Azure.

After the deployment completes, the root URL of the function app in Azure is shown in the **Publish** tab.

1. In the Publish tab, in the Hosting section, choose **Open in Azure portal**. This opens the new function app Azure resource in the Azure portal.

### Verify your function in Azure

1. In Cloud Explorer, your new function app should be selected. If not, expand your subscription > **App Services**, and select your new function app.
2. Right-click the function app and choose **Open in Browser**. This opens the root of your function app in your default web browser and displays the page that indicates your function app is running.
3. In the address bar in the browser, append the string /api/HttpExample?name=Functions to the base URL and run the request.

The URL that calls your HTTP trigger function is in the following format:

http://<APP\_NAME>.azurewebsites.net/api/HttpExample?name=Functions

1. Go to this URL and you see a response in the browser to the remote GET request returned by the function.

### Clean up resources

Resources in Azure refer to function apps, functions, storage accounts, and so forth. They're grouped into resource groups, and you can delete everything in a group by deleting the group.

You created Azure resources to complete this quickstart. You may be billed for these resources, depending on your [account status](https://azure.microsoft.com/account/) and [service pricing](https://azure.microsoft.com/pricing/). Other quickstarts in this collection build upon this quickstart. If you plan to work with subsequent quickstarts, tutorials, or with any of the services you've created in this quickstart, don't clean up the resources.

Use the following steps to delete the function app and its related resources to avoid incurring any further costs.

1. In the Visual Studio Publish dialogue, in the Hosting section, select **Open in Azure portal**.
2. In the function app page, select the **Overview** tab and then select the link under **Resource group**.
3. In the **Resource group** page, review the list of included resources, and verify that they're the ones you want to delete.
4. Select **Delete resource group** and follow the instructions.

Deletion may take a couple of minutes. When it's done, a notification appears for a few seconds. You can also select the bell icon at the top of the page to view the notification.

## Create Azure Function using Visual Studio Code

<https://learn.microsoft.com/en-us/azure/azure-functions/create-first-function-vs-code-csharp?tabs=in-process>

## Connect F­­unctions to Azure Storage using Visual Studio

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-add-output-binding-storage-queue-vs?tabs=in-process>

Azure Functions lets you connect Azure services and other resources to functions without having to write your own integration code. These bindings, which represent both input and output, are declared within the function definition. Data from bindings is provided to the function as parameters. A trigger is a special type of input binding. Although a function has only one trigger, it can have multiple input and output bindings. To learn more, see [Azure Functions triggers and bindings concepts](https://learn.microsoft.com/en-us/azure/azure-functions/functions-triggers-bindings).

This article shows you how to use Visual Studio to connect the function you created in the [previous quickstart article](https://learn.microsoft.com/en-us/azure/azure-functions/functions-create-your-first-function-visual-studio) to Azure Storage. The output binding that you add to this function writes data from the HTTP request to a message in an Azure Queue storage queue.

Most bindings require a stored connection string that Functions uses to access the bound service. To make it easier, you use the Storage account that you created with your function app. The connection to this account is already stored in an app setting named AzureWebJobsStorage.

**Solution**: <https://github.com/AjaySingala/dotNetFullStackDemos/tree/main/Azure/FunctionApp>

**Project**: FunctionApp.csproj

**File**: HttpExample.cs

**Region**: HttpExample Simple (with Queue Trigger).

### Prerequisites

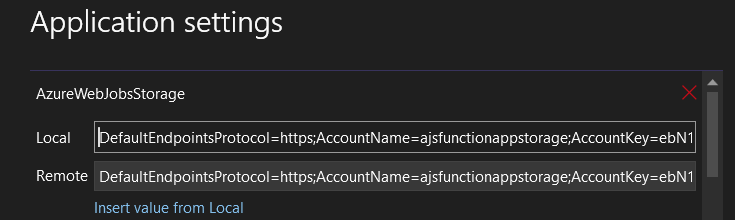
Before you start this article, you must:

* Complete [part 1 of the Visual Studio quickstart](https://learn.microsoft.com/en-us/azure/azure-functions/functions-create-your-first-function-visual-studio).
* Install [Azure Storage Explorer](https://storageexplorer.com/). Storage Explorer is a tool that you'll use to examine queue messages generated by your output binding. Storage Explorer is supported on macOS, Windows, and Linux-based operating systems.
* Sign-in to your Azure subscription from Visual Studio.

### Download the Function App Settings

In the [previous quickstart article](#_Create_Azure_Function), you created a function app in Azure along with the required Storage account. The connection string for this account is stored securely in app settings in Azure. In this article, you write messages to a Storage queue in the same account. To connect to your Storage account when running the function locally, you must download app settings to the local.settings.json file.

1. In **Solution Explorer**, right-click the project and select **Publish**.
2. In the **Publish** tab under **Hosting**, expand the three dots (**...**) and select **Manage Azure App Service settings**.
3. Under **AzureWebJobsStorage**, copy the **Remote** string value to **Local**, and then select **OK**.



The storage binding, which uses the AzureWebJobsStorage setting for the connection, can now connect to your Queue storage when running locally.

### Register Binding Extensions

Because you're using a Queue storage output binding, you need the Storage bindings extension installed before you run the project. Except for HTTP and timer triggers, bindings are implemented as extension packages.

1. From the **Tools** menu, select **NuGet Package Manager** > **Package Manager Console**.
2. In the console, run the following [Install-Package](https://learn.microsoft.com/en-us/nuget/tools/ps-ref-install-package) command to install the Storage extensions:

**For Isolated Process**:

install-package Microsoft.Azure.Functions.Worker.Extensions.Storage.Queues

**For In-Process**:

Install-Package Microsoft.Azure.WebJobs.Extensions.Storage

Now, you can add the storage output binding to your project.

### Add An Output Binding

In a C# project, the bindings are defined as binding attributes on the function method. Specific definitions depend on whether your app runs in-process (C# class library) or in an isolated worker process.

**For Isolated Process**:

Open the *HttpExample.cs* project file and add the following MultiResponse class:

public class MultiResponse

{

[QueueOutput("outqueue",Connection = "AzureWebJobsStorage")]

public string[] Messages { get; set; }

public HttpResponseData HttpResponse { get; set; }

}

The MultiResponse class allows you to write to a storage queue named outqueue and an HTTP success message. Multiple messages could be sent to the queue because the QueueOutput attribute is applied to a string array.

The Connection property sets the connection string for the storage account. In this case, you could omit Connection because you're already using the default storage account.

**For In-Process**:

Open the *HttpExample.cs* project file and add the following parameter to the Run method definition:

[Queue("outqueue"),StorageAccount("AzureWebJobsStorage")] ICollector<string> msg,

The msg parameter is an ICollector<T> type, representing a collection of messages written to an output binding when the function completes. In this case, the output is a storage queue named outqueue. The StorageAccountAttribute sets the connection string for the storage account. This attribute indicates the setting that contains the storage account connection string and can be applied at the class, method, or parameter level. In this case, you could omit StorageAccountAttribute because you're already using the default storage account.

The Run method definition must now look like the following code:

[FunctionName("HttpExample")]

public static async Task<IActionResult> Run(

[HttpTrigger(AuthorizationLevel.Anonymous, "get", "post", Route = null)] HttpRequest req,

[Queue("outqueue"),StorageAccount("AzureWebJobsStorage")] ICollector<string> msg,

ILogger log)

### Add Code that Uses the Output Binding

After the binding is defined, you can use the name of the binding to access it as an attribute in the function signature. By using an output binding, you don't have to use the Azure Storage SDK code for authentication, getting a queue reference, or writing data. The Functions runtime and queue output binding do those tasks for you.

**For Isolated Process**:

Replace the existing HttpExample class with the following code:

[Function("HttpExample")]

public static MultiResponse Run([HttpTrigger(AuthorizationLevel.Function, "get", "post")] HttpRequestData req,

FunctionContext executionContext)

{

var logger = executionContext.GetLogger("HttpExample");

logger.LogInformation("C# HTTP trigger function processed a request.");

var message = "Welcome to Azure Functions!";

var response = req.CreateResponse(HttpStatusCode.OK);

response.Headers.Add("Content-Type", "text/plain; charset=utf-8");

response.WriteString(message);

// Return a response to both HTTP trigger and storage output binding.

return new MultiResponse()

{

// Write a single message.

Messages = new string[] { message },

HttpResponse = response

};

}

}

**For In-Process**:

Add code that uses the msg output binding object to create a queue message. Add this code before the method returns.

if (!string.IsNullOrEmpty(name))

{

// Add a message to the output collection.

msg.Add(name);

}

At this point, your function must look as follows:

[FunctionName("HttpExample")]

public static async Task<IActionResult> Run(

[HttpTrigger(AuthorizationLevel.Anonymous, "get", "post", Route = null)] HttpRequest req,

[Queue("outqueue"),StorageAccount("AzureWebJobsStorage")] ICollector<string> msg,

ILogger log)

{

log.LogInformation("C# HTTP trigger function processed a request.");

string name = req.Query["name"];

string requestBody = await new StreamReader(req.Body).ReadToEndAsync();

dynamic data = JsonConvert.DeserializeObject(requestBody);

name = name ?? data?.name;

if (!string.IsNullOrEmpty(name))

{

// Add a message to the output collection.

msg.Add(name);

}

return name != null

? (ActionResult)new OkObjectResult($"Hello, {name}")

: new BadRequestObjectResult("Please pass a name on the query string or in the request body");

}

### Run the Function Locally

1. To run your function, press F5 in Visual Studio. You might need to enable a firewall exception so that the tools can handle HTTP requests. Authorization levels are never enforced when you run a function locally.
2. Copy the URL of your function from the Azure Functions runtime output.
3. Paste the URL for the HTTP request into your browser's address bar. Append the query string ?name=<YOUR\_NAME> to this URL and run the request. Should the result in the browser.
4. To stop debugging, press Shift+F5 in Visual Studio.

A new queue named outqueue is created in your storage account by the Functions runtime when the output binding is first used. You'll use Storage Explorer to verify that the queue was created along with the new message.

### Connect Storage Explorer to Your Account

Skip this section if you've already installed Azure Storage Explorer and connected it to your Azure account.

1. Run the [Azure Storage Explorer](https://storageexplorer.com/) tool, select the connect icon on the left, and select **Add an account**.
2. In the **Connect** dialog, choose **Add an Azure account**, choose your **Azure environment**, and then select **Sign in...**.
3. After you successfully sign in to your account, you see all of the Azure subscriptions associated with your account. Choose your subscription and select **Open Explorer**.

### Examine the Output Queue

1. In Storage Explorer, expand the **Queues** node, and then select the queue named **outqueue**.

The queue contains the message that the queue output binding created when you ran the HTTP-triggered function. If you invoked the function with the default name value of Azure, the queue message is Name passed to the function: Azure.

1. Run the function again, send another request, and you see a new message in the queue.

Now, it's time to republish the updated function app to Azure.

### Redeploy and Verify the Updated App

1. In **Solution Explorer**, right-click the project and select **Publish**, then choose **Publish** to republish the project to Azure.
2. After deployment completes, you can again use the browser to test the redeployed function. As before, append the query string &name=<yourname> to the URL.
3. Again, view the message in the storage queue to verify that the output binding again generates a new message in the queue.

## Create Azure Function with Queue Trigger using Visual Studio

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-develop-vs?tabs=isolated-process>

**Solution**: <https://github.com/AjaySingala/dotNetFullStackDemos/tree/main/Azure/FunctionApp>

**Project**: FunctionApp.csproj

**File**: FunctionQueueTrigger.cs

In the same project created earlier in the section [Connect Functions to Azure Storage using Visual Studio](#_Connect_functions_to), create a new Function as follows:

1. Right-click on the project and select **Add** -> **New Azure Function**.
2. Enter the name of the function as **FunctionQueueTrigger** and click on **Add**.
3. In the **New Azure Function** window, select **Queue Trigger** in the left pane.
4. In the right pane, enter a **Connection string setting name** like **ajsQueueStorage** and the **Queue name** as **ajs-queue-items**.
5. Select the checkbox for **Configure Queue trigger connection**.
6. Then, click on **Add**.
7. In the **Connect to dependency** window, select **Storage Azurite emulator (Local)** so that we can test this locally. Click **Next**.
8. In the **Connect to Storage Azurite emulator (Local)** window, enter a Connection string name as **ajsTest**, **Connection string value** as **UseDevelopmentServer=true** and select **Do not save value anywhere**. Click **Next**.
9. Click **Finish**.
10. Replace the Run function created with the following code:

[Function("FunctionQueueTrigger")]

[QueueOutput("outqueue")]

public static string Run(

[QueueTrigger("ajs-queue-items", Connection = "ajsQueueStorage")] string myQueueItem,

FunctionContext executionContext)

{

var logger = executionContext.GetLogger("FunctionQueueTrigger");

logger.LogInformation($"FunctionQueueTrigger function processed: {myQueueItem}");

string message = $"{myQueueItem}";

return message;

}

1. Make sure Azurite is running. You can find it here: **C:\Program Files\Microsoft Visual Studio\2022\Enterprise\Common7\IDE\Extensions\Microsoft\Azure Storage Emulator**.
   1. If Azurite is not running, run **Azurite.exe** from this folder.
2. Connect to Azurite local storage from Azure Storage Explorer:
   1. Click on the **Plug** icon (*Open Connect Dialog*).
   2. Select **Local storage emulator**.
   3. Give it a name as **Azurite**. Leave all other options as-is and click on **Next**.
   4. On the Summary page, click **Connect**.
3. Expand **Azurite**.
4. Right-click on **Queues** and select **Create Queue**.
5. Give the Queue the name you selected earlier, **ajs-queue-items**.
6. Run your program from Visual Studio.
7. In the storage explorer, select the queue **ajs-queue-items**.
8. Click on **Add Message**, enter some text and click on **Ok**.
9. Switch to the Azure queue named **outqueue** (from the previous demo) and refresh.
10. You should see the message in this queue.
11. Also, the message from **ajs-queue-items** is dequeued after a while.

**To test from Azure queue**:

1. Change the **[QueueTrigger]** line to read as follows:

[QueueTrigger("ajs-queue-items", Connection = "AzureWebJobsStorage")] string myQueueItem,

1. Create a queue named **ajs-queue-items** on Azure.
2. Run your app from Visual Studio.
3. Create a new message in the **ajs-queue-items** queue on Azure.
4. The message should appear in the **outqueue** in Azure as well as your storage explorer.

The following code will also work:

[Function("FunctionQueueTrigger")]

public static MultiResponse Run(

[QueueTrigger("ajs-queue-items", Connection = "ajsQueueStorage")] string myQueueItem,

FunctionContext executionContext)

{

var logger = executionContext.GetLogger("FunctionQueueTrigger");

logger.LogInformation($"FunctionQueueTrigger function processed: {myQueueItem}");

string message = $"{myQueueItem}";

// Put the message recd. in the output queue.

return new MultiResponse()

{

// Write a single message.

Messages = new string[] { message }

};

}

## Connect Azure Functions to Azure SQL Database using Visual Studio

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-scenario-database-table-cleanup>

This article shows you how to use Azure Functions to create a scheduled job that connects to an Azure SQL Database or Azure SQL Managed Instance. The function code cleans up rows in a table in the database. The new C# function is created based on a pre-defined timer trigger template in Visual Studio 2019. To support this scenario, you must also set a database connection string as an app setting in the function app. For Azure SQL Managed Instance you need to [enable public endpoint](https://learn.microsoft.com/en-us/azure/azure-sql/managed-instance/public-endpoint-configure) to be able to connect from Azure Functions. This scenario uses a bulk operation against the database.

### Prerequisites

* Complete the steps in the article [Create your first function using Visual Studio](https://learn.microsoft.com/en-us/azure/azure-functions/functions-create-your-first-function-visual-studio) to create a local function app that targets version 2.x or a later version of the runtime. You must also have published your project to a function app in Azure.
* This article demonstrates a Transact-SQL command that executes a bulk cleanup operation in the **SalesOrderHeader** table in the AdventureWorksLT sample database. To create the AdventureWorksLT sample database, complete the steps in the article [Create a database in Azure SQL Database using the Azure portal](https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-create-quickstart).
* You must add a [server-level firewall rule](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-create-server-level-portal-quickstart) (*see below*) for the public IP address of the computer you use for this quickstart. This rule is required to be able access the SQL Database instance from your local computer.

### Create a Server-Level Firewall Rule in Azure Portal

<https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-create-server-level-portal-quickstart?view=azuresql>

This quickstart describes how to create a [server-level firewall rule](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-configure?view=azuresql) in Azure SQL Database. Firewall rules can give access to [logical SQL servers](https://learn.microsoft.com/en-us/azure/azure-sql/database/logical-servers?view=azuresql), single databases, and elastic pools and their databases. Firewall rules are also needed to connect on-premises and other Azure resources to databases. Server-level firewall rules do not apply to Azure SQL Managed Instance.

#### Prerequisites

We will use the resources developed in [Create a single database using the Azure portal](https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-create-quickstart?view=azuresql) as a starting point for this tutorial.

#### Create a server-level IP-based firewall rule

Azure SQL Database creates a firewall at the server level for single and pooled databases. This firewall blocks connections from IP addresses that do not have permission. To connect to an Azure SQL database from an IP address outside of Azure, you need to create a firewall rule. You can use rules to open a firewall for a specific IP address or for a range of IP addresses. For more information about server-level and database-level firewall rules, see [Server-level and database-level IP-based firewall rules](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-configure?view=azuresql).

**Note**: Azure SQL Database communicates over port 1433. When you connect from within a corporate network, outbound traffic over port 1433 may not be permitted by your network firewall. This means your IT department needs to open port 1433 for you to connect to your server.

**Important**: A firewall rule of 0.0.0.0 enables all Azure services to pass through the server-level firewall rule and attempt to connect to a database through the server.

We'll use the following steps to create a server-level IP-based, firewall rule for a specific, client IP address. This enables external connectivity for that IP address through the Azure SQL Database firewall.

First, sign into Azure portal.

1. After the [database](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-create-server-level-portal-quickstart?view=azuresql#prerequisites) deployment completes, select **SQL databases** from the left-hand menu and then select **mySampleDatabase** on the **SQL databases** page. The overview page for your database opens. It displays the fully qualified server name (such as **mydocssampleserver.database.windows.net**) and provides options for further configuration. You can also find the firewall settings by navigating directly to your server, and selecting **Networking** under **Security**.
2. Copy the fully qualified server name. You will use it when you connect to your server and its databases in other quickstarts. Select **Set server firewall** on the toolbar.
3. Set **Public network access** to **Selected networks** to reveal the virtual networks and firewall rules. When set to **Disabled**, virtual networks and firewall rule settings are hidden.
4. Choose **Add your client IP** to add your current IP address to a new, server-level, firewall rule. This rule can open Port 1433 for a single IP address or for a range of IP addresses. You can also configure firewall settings by choosing **Add a firewall rule**.

**Important**: By default, access through the Azure SQL Database firewall is disabled for all Azure services. Choose **ON** on this page to enable access for all Azure services.

1. Select **Save**. Port 1433 is now open on the server and a server-level IP-based, firewall rule is created for your current IP address.
2. Close the **Networking** page.

Open SQL Server Management Studio or another tool of your choice. Use the server admin account you created earlier to connect to the server and its databases from your IP address.

1. Save the resources from this quickstart to complete additional SQL database tutorials.

### Get Connection Information

You need to get the connection string for the database you created when you completed [Create a database in Azure SQL Database using the Azure portal](https://learn.microsoft.com/en-us/azure/azure-sql/database/single-database-create-quickstart).

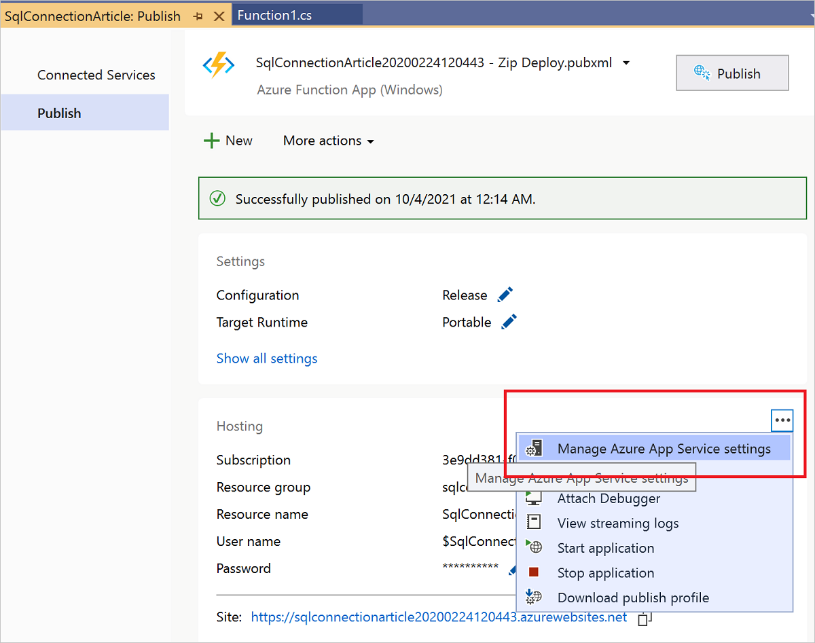
1. Sign in to the [Azure portal](https://portal.azure.com/).
2. Select **SQL Databases** from the left-hand menu, and select your database on the **SQL databases** page.
3. Select **Connection strings** under **Settings** and copy the complete **ADO.NET** connection string. For Azure SQL Managed Instance copy connection string for public endpoint.

### Set the Connection String

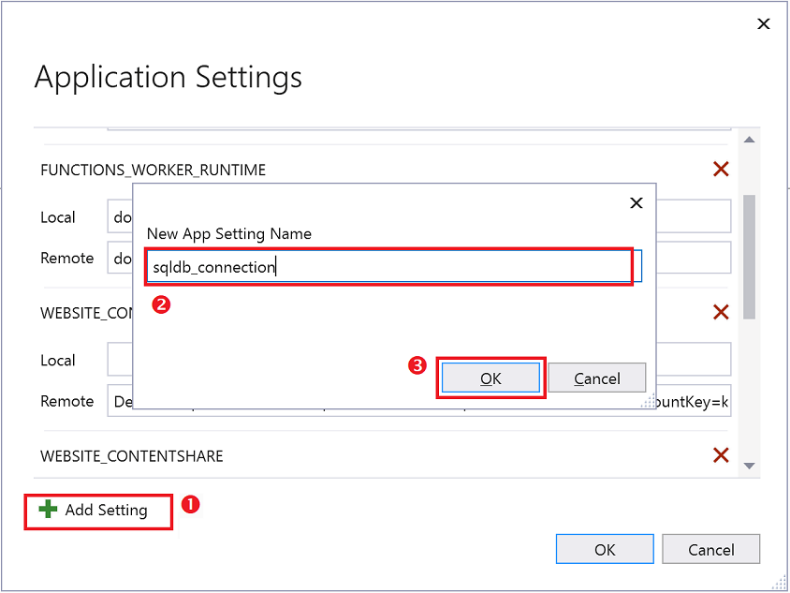
A function app hosts the execution of your functions in Azure. As a best security practice, store connection strings and other secrets in your function app settings. Using application settings prevents accidental disclosure of the connection string with your code. You can access app settings for your function app right from Visual Studio.

You must have previously published your app to Azure. If you haven't already done so, [Publish your function app to Azure](https://learn.microsoft.com/en-us/azure/azure-functions/functions-develop-vs#publish-to-azure).

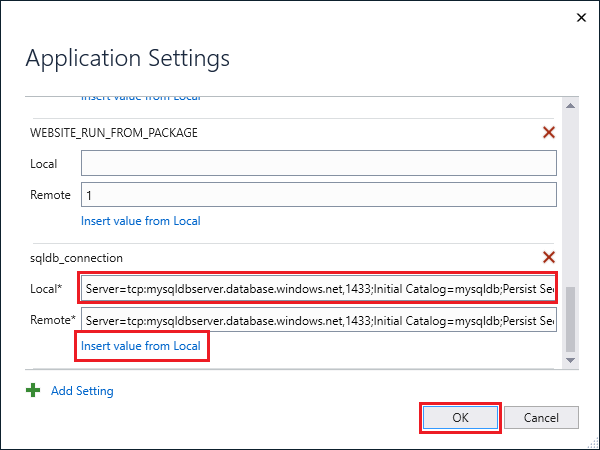
1. In Solution Explorer, right-click the function app project and choose **Publish**.
2. On the **Publish** page, select the ellipses (...) in the **Hosting** area, and choose **Manage Azure App Service settings**.



1. In **Application Settings** select **Add setting**, in **New app setting name** type sqldb\_connection, and select **OK**.



1. In the new **sqldb\_connection** setting, paste the connection string you copied in the previous section into the **Local** field and replace {your\_username} and {your\_password} placeholders with real values. Select **Insert value from local** to copy the updated value into the **Remote** field, and then select **OK**.



1. The connection strings are stored encrypted in Azure (**Remote**). To prevent leaking secrets, the local.settings.json project file (**Local**) should be excluded from source control, such as by using a .gitignore file.

### Add the SqlClient package to the project

You need to add the NuGet package that contains the SqlClient library. This data access library is needed to connect to SQL Database.

1. Open your local function app project in Visual Studio 2022.
2. In Solution Explorer, right-click the function app project and choose **Manage NuGet Packages**.
3. On the **Browse** tab, search for Microsoft.Data.SqlClient and, when found, select it.
4. In the **Microsoft.Data.SqlClient** page, select version 5.1.0 and then click **Install**.
5. When the install completes, review the changes and then click **OK** to close the **Preview** window.
6. If a **License Acceptance** window appears, click **I Accept**.

Now, you can add the C# function code that connects to your SQL Database.

### Add a timer triggered function

1. In Solution Explorer, right-click the function app project and choose **Add** > **New Azure function**.
2. With the **Azure Functions** template selected, name the new item something like DatabaseCleanup.cs and select **Add**.
3. In the **New Azure function** dialog box, choose **Timer trigger** and then **Add**. This dialog creates a code file for the timer triggered function.
4. Open the new code file and add the following using statements at the top of the file:

using Microsoft.Data.SqlClient;

using System.Threading.Tasks;

1. Replace the existing Run function with the following code:

[FunctionName("DatabaseCleanup")]

public static async Task Run([TimerTrigger("\*/15 \* \* \* \* \*")]TimerInfo myTimer, ILogger log)

{

// Get the connection string from app settings and use it to create a connection.

var str = Environment.GetEnvironmentVariable("sqldb\_connection");

using (SqlConnection conn = new SqlConnection(str))

{

conn.Open();

var text = "UPDATE SalesLT.SalesOrderHeader " +

"SET [Status] = 5 WHERE ShipDate < GetDate();";

using (SqlCommand cmd = new SqlCommand(text, conn))

{

// Execute the command and log the # rows affected.

var rows = await cmd.ExecuteNonQueryAsync();

log.LogInformation($"{rows} rows were updated");

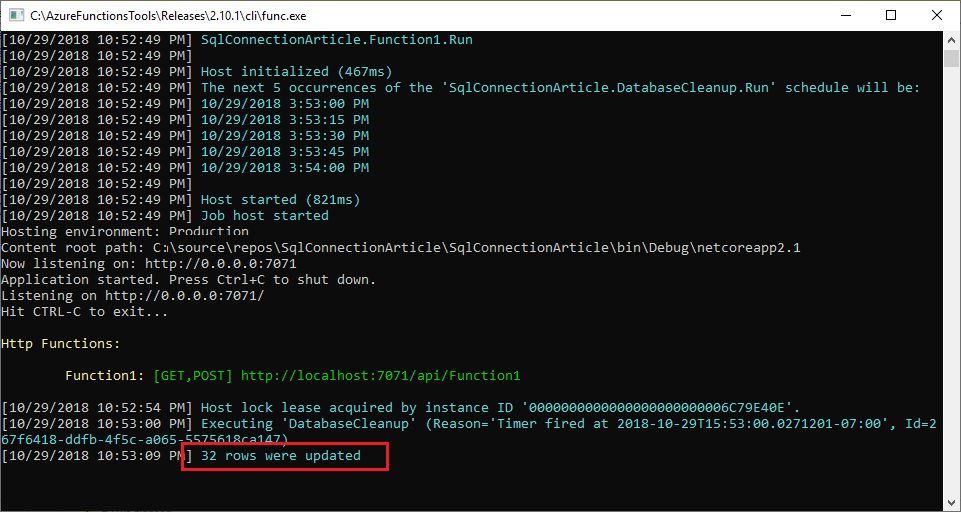
}

}

}

This function runs every 15 seconds to update the Status column based on the ship date. To learn more about the Timer trigger, see [Timer trigger for Azure Functions](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-timer).

1. Press **F5** to start the function app. The [Azure Functions Core Tools](https://learn.microsoft.com/en-us/azure/azure-functions/functions-develop-local) execution window opens behind Visual Studio.
2. At 15 seconds after startup, the function runs. Watch the output and note the number of rows updated in the **SalesOrderHeader** table.



On the first execution, you should update 32 rows of data. Following runs update no data rows, unless you make changes to the SalesOrderHeader table data so that more rows are selected by the UPDATE statement.

If you plan to [publish this function](https://learn.microsoft.com/en-us/azure/azure-functions/functions-develop-vs#publish-to-azure), remember to change the TimerTrigger attribute to a more reasonable [cron schedule](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-timer#ncrontab-expressions) than every 15 seconds. You also need to make sure that your function app can access the Azure SQL Database or Azure SQL Managed Instance. For more information, see one of the following links based on your type of Azure SQL:

* [Azure SQL Database](https://learn.microsoft.com/en-us/azure/azure-sql/database/firewall-configure#connections-from-inside-azure.)
* [Azure SQL Managed Instance](https://learn.microsoft.com/en-us/azure/azure-sql/managed-instance/connect-application-instance#connect-azure-app-service)

## Connect Azure Functions to Azure SQL Database using Visual Studio Code

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-add-output-binding-azure-sql-vs-code?pivots=programming-language-csharp&tabs=in-process%2Cv1>

## Http Trigger with Blob Input

<https://github.com/Azure/azure-functions-dotnet-worker/blob/main/samples/FunctionApp/HttpTriggerWithBlobInput/HttpTriggerWithBlobInput.cs>

// HttpTriggerWithBlobInput.cs

using System.Net;

using System.Text.Json;

using Microsoft.Azure.Functions.Worker;

using Microsoft.Azure.Functions.Worker.Http;

namespace FunctionApp

{

public static class HttpTriggerWithBlobInput

{

[Function(nameof(HttpTriggerWithBlobInput))]

public static MyOutputType Run(

[HttpTrigger(AuthorizationLevel.Anonymous, "get", "post", Route = null)] HttpRequestData req,

[BlobInput("test-samples/sample1.txt", Connection = "AzureWebJobsStorage")] string myBlob, FunctionContext context)

{

var bookVal = (Book)JsonSerializer.Deserialize(myBlob, typeof(Book));

var response = req.CreateResponse(HttpStatusCode.OK);

response.Headers.Add("Date", "Mon, 18 Jul 2016 16:06:00 GMT");

response.Headers.Add("Content-Type", "text/html; charset=utf-8");

response.WriteString("Book Sent to Queue!");

return new MyOutputType()

{

Book = bookVal,

HttpResponse = response

};

}

public class MyOutputType

{

[QueueOutput("functionstesting2", Connection = "AzureWebJobsStorage")]

public Book Book { get; set; }

public HttpResponseData HttpResponse { get; set; }

}

public class Book

{

public string name { get; set; }

public string id { get; set; }

}

}

}

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-storage-queue-output?tabs=python-v2%2Cisolated-process%2Cextensionv5&pivots=programming-language-csharp>

# Durable Functions

<https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-overview?tabs=csharp-inproc>

<https://github.com/Azure-Samples/durablefunctions-apiscraping-dotnet>

Durable Functions is an extension of [Azure Functions](https://learn.microsoft.com/en-us/azure/azure-functions/functions-overview) that lets you write stateful functions in a serverless compute environment. The extension lets you define stateful workflows by writing [orchestrator functions](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-orchestrations) and stateful entities by writing [entity functions](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-entities) using the Azure Functions programming model. Behind the scenes, the extension manages state, checkpoints, and restarts for you, allowing you to focus on your business logic.

## Supported languages

Durable Functions is designed to work with all Azure Functions programming languages but may have different minimum requirements for each language. The following table shows the minimum supported app configurations:

| **Language stack** | **Azure Functions Runtime versions** | **Language worker version** | **Minimum bundles version** |
| --- | --- | --- | --- |
| .NET / C# / F# | Functions 1.0+ | In-process Out-of-process | n/a |
| JavaScript/TypeScript (V3 prog. model) | Functions 2.0+ | Node 8+ | 2.x bundles |
| JavaScript/TypeScript (V4 prog. model) | Functions 4.16.5+ | Node 18+ | 3.15+ bundles |
| Python | Functions 2.0+ | Python 3.7+ | 2.x bundles |
| Python (V2 prog. model) | Functions 4.0+ | Python 3.7+ | 3.15+ bundles |
| PowerShell | Functions 3.0+ | PowerShell 7+ | 2.x bundles |
| Java | Functions 4.0+ | Java 8+ | 4.x bundles |

**Note**: The new programming models for authoring Functions in Python (V2) and Node.js (V4) are currently in preview. Compared to the current models, the new experiences are designed to be more flexible and intuitive for Python and JavaScript/TypeScript developers. Learn more about the differences between the models in the [**Python developer guide**](https://learn.microsoft.com/en-us/azure/azure-functions/functions-reference-python?pivots=python-mode-decorators) and [**Node.js upgrade guide**](https://learn.microsoft.com/en-us/azure/azure-functions/functions-node-upgrade-v4).

In the following code snippets, Python (PM2) denotes programming model V2, and JavaScript (PM4) denotes programming model V4, the new experiences.

Like Azure Functions, there are templates to help you develop Durable Functions using [Visual Studio](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-create-first-csharp), [Visual Studio Code](https://learn.microsoft.com/en-us/azure/azure-functions/durable/quickstart-js-vscode), and the [Azure portal](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-create-portal).

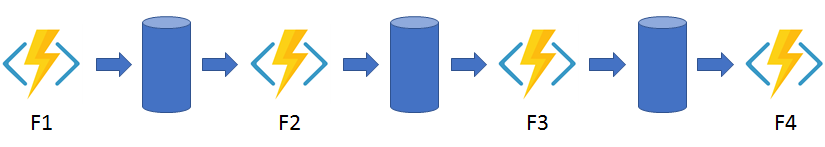
## Application patterns

The primary use case for Durable Functions is simplifying complex, stateful coordination requirements in serverless applications. The following sections describe typical application patterns that can benefit from Durable Functions:

* [Function chaining](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-overview?tabs=csharp-inproc#chaining)
* [Fan-out/fan-in](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-overview?tabs=csharp-inproc#fan-in-out)
* [Async HTTP APIs](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-overview?tabs=csharp-inproc#async-http)
* [Monitoring](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-overview?tabs=csharp-inproc#monitoring)
* [Human interaction](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-overview?tabs=csharp-inproc#human)
* [Aggregator (stateful entities)](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-overview?tabs=csharp-inproc#aggregator)

### Pattern #1: Function chaining

In the function chaining pattern, a sequence of functions executes in a specific order. In this pattern, the output of one function is applied to the input of another function. The use of queues between each function ensures that the system stays durable and scalable, even though there is a flow of control from one function to the next.



You can use Durable Functions to implement the function chaining pattern concisely as shown in the following example.

In this example, the values F1, F2, F3, and F4 are the names of other functions in the same function app. You can implement control flow by using normal imperative coding constructs. Code executes from the top down. The code can involve existing language control flow semantics, like conditionals and loops. You can include error handling logic in try/catch/finally blocks.

[FunctionName("Chaining")]

public static async Task<object> Run(

[OrchestrationTrigger] IDurableOrchestrationContext context)

{

try

{

var x = await context.CallActivityAsync<object>("F1", null);

var y = await context.CallActivityAsync<object>("F2", x);

var z = await context.CallActivityAsync<object>("F3", y);

return await context.CallActivityAsync<object>("F4", z);

}

catch (Exception)

{

// Error handling or compensation goes here.

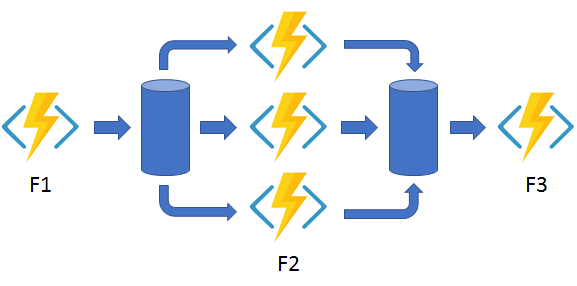
}

}

You can use the context parameter to invoke other functions by name, pass parameters, and return function output. Each time the code calls await, the Durable Functions framework checkpoints the progress of the current function instance. If the process or virtual machine recycles midway through the execution, the function instance resumes from the preceding await call. For more information, see the next section, Pattern #2: Fan out/fan in.

### Pattern #2: Fan out/fan in

In the fan out/fan in pattern, you execute multiple functions in parallel and then wait for all functions to finish. Often, some aggregation work is done on the results that are returned from the functions.



With normal functions, you can fan out by having the function send multiple messages to a queue. Fanning back in is much more challenging. To fan in, in a normal function, you write code to track when the queue-triggered functions end, and then store function outputs.

The Durable Functions extension handles this pattern with relatively simple code:

**C# Isolated**:

[Function("FanOutFanIn")]

public static async Task Run(

[OrchestrationTrigger] TaskOrchestrationContext context)

{

var parallelTasks = new List<Task<int>>();

// Get a list of N work items to process in parallel.

object[] workBatch = await context.CallActivityAsync<object[]>("F1", null);

for (int i = 0; i < workBatch.Length; i++)

{

Task<int> task = context.CallActivityAsync<int>("F2", workBatch[i]);

parallelTasks.Add(task);

}

await Task.WhenAll(parallelTasks);

// Aggregate all N outputs and send the result to F3.

int sum = parallelTasks.Sum(t => t.Result);

await context.CallActivityAsync("F3", sum);

}

**C# InProcess**:

[FunctionName("FanOutFanIn")]

public static async Task Run(

[OrchestrationTrigger] IDurableOrchestrationContext context)

{

var parallelTasks = new List<Task<int>();

// Get a list of N work items to process in parallel.

object[] workBatch = await context.CallActivityAsync<object[]>("F1", null);

for (int i = 0; i < workBatch.Length; i++)

{

Task<int> task = context.CallActivityAsync<int>("F2", workBatch[i]);

parallelTasks.Add(task);

}

await Task.WhenAll(parallelTasks);

// Aggregate all N outputs and send the result to F3.

int sum = parallelTasks.Sum(t => t.Result);

await context.CallActivityAsync("F3", sum);

}

The fan-out work is distributed to multiple instances of the F2 function. The work is tracked by using a dynamic list of tasks. Task.WhenAll is called to wait for all the called functions to finish. Then, the F2 function outputs are aggregated from the dynamic task list and passed to the F3 function.

The automatic checkpointing that happens at the await call on Task.WhenAll ensures that a potential midway crash or reboot doesn't require restarting an already completed task.

**Note**: In rare circumstances, it's possible that a crash could happen in the window after an activity function completes but before its completion is saved into the orchestration history. If this happens, the activity function would re-run from the beginning after the process recovers.

### Pattern #3: Async HTTP APIs

The async HTTP API pattern addresses the problem of coordinating the state of long-running operations with external clients. A common way to implement this pattern is by having an HTTP endpoint trigger the long-running action. Then, redirect the client to a status endpoint that the client polls to learn when the operation is finished.

A picture containing text, electric blue, diagram, screenshot

Description automatically generated

Durable Functions provides **built-in support** for this pattern, simplifying or even removing the code you need to write to interact with long-running function executions. For example, the Durable Functions quickstart samples ([C#](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-create-first-csharp), [JavaScript](https://learn.microsoft.com/en-us/azure/azure-functions/durable/quickstart-js-vscode), [TypeScript](https://learn.microsoft.com/en-us/azure/azure-functions/durable/quickstart-ts-vscode), [Python](https://learn.microsoft.com/en-us/azure/azure-functions/durable/quickstart-python-vscode), [PowerShell](https://learn.microsoft.com/en-us/azure/azure-functions/durable/quickstart-powershell-vscode), and [Java](https://learn.microsoft.com/en-us/azure/azure-functions/durable/quickstart-java)) show a simple REST command that you can use to start new orchestrator function instances. After an instance starts, the extension exposes webhook HTTP APIs that query the orchestrator function status.

The following example shows REST commands that start an orchestrator and query its status. For clarity, some protocol details are omitted from the example.

> curl -X POST https://myfunc.azurewebsites.net/api/orchestrators/DoWork -H "Content-Length: 0" -i

HTTP/1.1 202 Accepted

Content-Type: application/json

Location: https://myfunc.azurewebsites.net/runtime/webhooks/durabletask/instances/b79baf67f717453ca9e86c5da21e03ec

{"id":"b79baf67f717453ca9e86c5da21e03ec", ...}

> curl https://myfunc.azurewebsites.net/runtime/webhooks/durabletask/instances/b79baf67f717453ca9e86c5da21e03ec -i

HTTP/1.1 202 Accepted

Content-Type: application/json

Location: https://myfunc.azurewebsites.net/runtime/webhooks/durabletask/instances/b79baf67f717453ca9e86c5da21e03ec

{"runtimeStatus":"Running","lastUpdatedTime":"2019-03-16T21:20:47Z", ...}

> curl https://myfunc.azurewebsites.net/runtime/webhooks/durabletask/instances/b79baf67f717453ca9e86c5da21e03ec -i

HTTP/1.1 200 OK

Content-Length: 175

Content-Type: application/json

{"runtimeStatus":"Completed","lastUpdatedTime":"2019-03-16T21:20:57Z", ...}

Because the Durable Functions runtime manages state for you, you don't need to implement your own status-tracking mechanism.

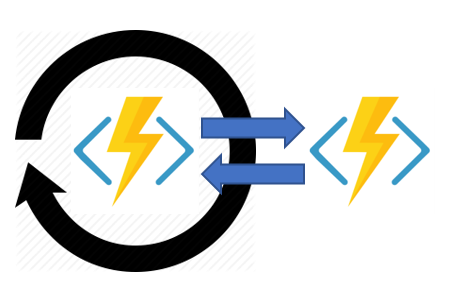
The Durable Functions extension exposes built-in HTTP APIs that manage long-running orchestrations. You can alternatively implement this pattern yourself by using your own function triggers (such as HTTP, a queue, or Azure Event Hubs) and the [durable client binding](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-bindings#orchestration-client). For example, you might use a queue message to trigger termination. Or, you might use an HTTP trigger that's protected by an Azure Active Directory authentication policy instead of the built-in HTTP APIs that use a generated key for authentication.

For more information, see the [HTTP features](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-http-features) article, which explains how you can expose asynchronous, long-running processes over HTTP using the Durable Functions extension.

### Pattern #4: Monitor

The monitor pattern refers to a flexible, recurring process in a workflow. An example is polling until specific conditions are met. You can use a regular [timer trigger](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-timer) to address a basic scenario, such as a periodic cleanup job, but its interval is static and managing instance lifetimes becomes complex. You can use Durable Functions to create flexible recurrence intervals, manage task lifetimes, and create multiple monitor processes from a single orchestration.

An example of the monitor pattern is to reverse the earlier async HTTP API scenario. Instead of exposing an endpoint for an external client to monitor a long-running operation, the long-running monitor consumes an external endpoint, and then waits for a state change.



In a few lines of code, you can use Durable Functions to create multiple monitors that observe arbitrary endpoints. The monitors can end execution when a condition is met, or another function can use the durable orchestration client to terminate the monitors. You can change a monitor's wait interval based on a specific condition (for example, exponential backoff.)

The following code implements a basic monitor:

**C# Isolated**:

[Function("MonitorJobStatus")]

public static async Task Run(

[OrchestrationTrigger] TaskOrchestrationContext context, int jobId)

{

int pollingInterval = GetPollingInterval();

DateTime expiryTime = GetExpiryTime();

while (context.CurrentUtcDateTime < expiryTime)

{

var jobStatus = await context.CallActivityAsync<string>("GetJobStatus", jobId);

if (jobStatus == "Completed")

{

// Perform an action when a condition is met.

await context.CallActivityAsync("SendAlert", jobId);

break;

}

// Orchestration sleeps until this time.

var nextCheck = context.CurrentUtcDateTime.AddSeconds(pollingInterval);

await context.CreateTimer(nextCheck, CancellationToken.None);

}

// Perform more work here, or let the orchestration end.

}

**C# InProcess**:

[FunctionName("MonitorJobStatus")]

public static async Task Run(

[OrchestrationTrigger] IDurableOrchestrationContext context)

{

int jobId = context.GetInput<int>();

int pollingInterval = GetPollingInterval();

DateTime expiryTime = GetExpiryTime();

while (context.CurrentUtcDateTime < expiryTime)

{

var jobStatus = await context.CallActivityAsync<string>("GetJobStatus", jobId);

if (jobStatus == "Completed")

{

// Perform an action when a condition is met.

await context.CallActivityAsync("SendAlert", jobId);

break;

}

// Orchestration sleeps until this time.

var nextCheck = context.CurrentUtcDateTime.AddSeconds(pollingInterval);

await context.CreateTimer(nextCheck, CancellationToken.None);

}

// Perform more work here, or let the orchestration end.

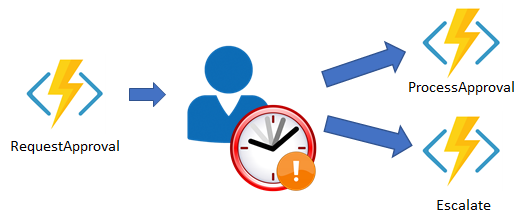
}

When a request is received, a new orchestration instance is created for that job ID. The instance polls a status until either a condition is met or until a timeout expires. A durable timer controls the polling interval. Then, more work can be performed, or the orchestration can end.

### Pattern #5: Human interaction

Many automated processes involve some kind of human interaction. Involving humans in an automated process is tricky because people aren't as highly available and as responsive as cloud services. An automated process might allow for this interaction by using timeouts and compensation logic.

An approval process is an example of a business process that involves human interaction. Approval from a manager might be required for an expense report that exceeds a certain dollar amount. If the manager doesn't approve the expense report within 72 hours (maybe the manager went on vacation), an escalation process kicks in to get the approval from someone else (perhaps the manager's manager).



You can implement the pattern in this example by using an orchestrator function. The orchestrator uses a [durable timer](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-timers) to request approval. The orchestrator escalates if timeout occurs. The orchestrator waits for an [external event](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-external-events), such as a notification that's generated by a human interaction.

These examples create an approval process to demonstrate the human interaction pattern:

**C# Isolated**:

[Function("ApprovalWorkflow")]

public static async Task Run(

[OrchestrationTrigger] TaskOrchestrationContext context)

{

await context.CallActivityAsync("RequestApproval", null);

using (var timeoutCts = new CancellationTokenSource())

{

DateTime dueTime = context.CurrentUtcDateTime.AddHours(72);

Task durableTimeout = context.CreateTimer(dueTime, timeoutCts.Token);

Task<bool> approvalEvent = context.WaitForExternalEvent<bool>("ApprovalEvent");

if (approvalEvent == await Task.WhenAny(approvalEvent, durableTimeout))

{

timeoutCts.Cancel();

await context.CallActivityAsync("ProcessApproval", approvalEvent.Result);

}

else

{

await context.CallActivityAsync("Escalate", null);

}

}

}

**C# InProcess**:

[FunctionName("ApprovalWorkflow")]

public static async Task Run(

[OrchestrationTrigger] IDurableOrchestrationContext context)

{

await context.CallActivityAsync("RequestApproval", null);

using (var timeoutCts = new CancellationTokenSource())

{

DateTime dueTime = context.CurrentUtcDateTime.AddHours(72);

Task durableTimeout = context.CreateTimer(dueTime, timeoutCts.Token);

Task<bool> approvalEvent = context.WaitForExternalEvent<bool>("ApprovalEvent");

if (approvalEvent == await Task.WhenAny(approvalEvent, durableTimeout))

{

timeoutCts.Cancel();

await context.CallActivityAsync("ProcessApproval", approvalEvent.Result);

}

else

{

await context.CallActivityAsync("Escalate", null);

}

}

}

To create the durable timer, call context.CreateTimer. The notification is received by context.WaitForExternalEvent. Then, Task.WhenAny is called to decide whether to escalate (timeout happens first) or process the approval (the approval is received before timeout).

**Note**: There is no charge for time spent waiting for external events when running in the Consumption plan.

An external client can deliver the event notification to a waiting orchestrator function by using the [built-in HTTP APIs](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-http-api#raise-event):

curl -d "true" http://localhost:7071/runtime/webhooks/durabletask/instances/{instanceId}/raiseEvent/ApprovalEvent -H "Content-Type: application/json"

An event can also be raised using the durable orchestration client from another function in the same function app:

**C# Isolated**:

[Function("RaiseEventToOrchestration")]

public static async Task Run(

[HttpTrigger] string instanceId,

[DurableClient] DurableTaskClient client)

{

bool isApproved = true;

await client.RaiseEventAsync(instanceId, "ApprovalEvent", isApproved);

}

**C# InProcess**:

[FunctionName("RaiseEventToOrchestration")]

public static async Task Run(

[HttpTrigger] string instanceId,

[DurableClient] IDurableOrchestrationClient client)

{

bool isApproved = true;

await client.RaiseEventAsync(instanceId, "ApprovalEvent", isApproved);

}

### Pattern #6: Aggregator (stateful entities)

The sixth pattern is about aggregating event data over a period of time into a single, addressable entity. In this pattern, the data being aggregated may come from multiple sources, may be delivered in batches, or may be scattered over long-periods of time. The aggregator might need to take action on event data as it arrives, and external clients may need to query the aggregated data.



The tricky thing about trying to implement this pattern with normal, stateless functions is that concurrency control becomes a huge challenge. Not only do you need to worry about multiple threads modifying the same data at the same time, you also need to worry about ensuring that the aggregator only runs on a single VM at a time.

You can use [Durable entities](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-entities) to easily implement this pattern as a single function.

**C# Isolated**:

Durable entities are currently not supported in the .NET-isolated worker.

**C# InProcess**:

[FunctionName("Counter")]

public static void Counter([EntityTrigger] IDurableEntityContext ctx)

{

int currentValue = ctx.GetState<int>();

switch (ctx.OperationName.ToLowerInvariant())

{

case "add":

int amount = ctx.GetInput<int>();

ctx.SetState(currentValue + amount);

break;

case "reset":

ctx.SetState(0);

break;

case "get":

ctx.Return(currentValue);

break;

}

}

Durable entities can also be modeled as classes in .NET. This model can be useful if the list of operations is fixed and becomes large. The following example is an equivalent implementation of the Counter entity using .NET classes and methods.

public class Counter

{

[JsonProperty("value")]

public int CurrentValue { get; set; }

public void Add(int amount) => this.CurrentValue += amount;

public void Reset() => this.CurrentValue = 0;

public int Get() => this.CurrentValue;

[FunctionName(nameof(Counter))]

public static Task Run([EntityTrigger] IDurableEntityContext ctx)

=> ctx.DispatchAsync<Counter>();

}

Clients can enqueue operations for (also known as "signaling") an entity function using the [entity client binding](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-bindings#entity-client).

**C# Isolated**:

Durable entities are currently not supported in the .NET-isolated worker.

**C# InProcess**:

[FunctionName("EventHubTriggerCSharp")]

public static async Task Run(

[EventHubTrigger("device-sensor-events")] EventData eventData,

[DurableClient] IDurableEntityClient entityClient)

{

var metricType = (string)eventData.Properties["metric"];

var delta = BitConverter.ToInt32(eventData.Body, eventData.Body.Offset);

// The "Counter/{metricType}" entity is created on-demand.

var entityId = new EntityId("Counter", metricType);

await entityClient.SignalEntityAsync(entityId, "add", delta);

}

**Note**: Dynamically generated proxies are also available in .NET for signaling entities in a type-safe way. And in addition to signaling, clients can also query for the state of an entity function using [**type-safe methods**](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-dotnet-entities#accessing-entities-through-interfaces) on the orchestration client binding.

## Create a Durable Function in C# Using Visual Studio

<https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-create-first-csharp?pivots=code-editor-visualstudio>

Durable Functions is an extension of [Azure Functions](https://learn.microsoft.com/en-us/azure/azure-functions/functions-overview) that lets you write stateful functions in a serverless environment. The extension manages state, checkpoints, and restarts for you.

In this article, you learn how to use Visual Studio 2022 to locally create and test a "hello world" durable function. This function orchestrates and chains-together calls to other functions. You then publish the function code to Azure. These tools are available as part of the Azure development workload in Visual Studio 2022.

### Prerequisites

To complete this tutorial:

* Install [Visual Studio 2022](https://visualstudio.microsoft.com/vs/). Make sure that the **Azure development** workload is also installed. Visual Studio 2019 also supports Durable Functions development, but the UI and steps differ.
* Verify that you have the [Azurite Emulator](https://learn.microsoft.com/en-us/azure/storage/common/storage-use-azurite) installed and running.

If you don't have an [Azure subscription](https://learn.microsoft.com/en-us/azure/guides/developer/azure-developer-guide#understanding-accounts-subscriptions-and-billing), create an [Azure free account](https://azure.microsoft.com/free/?ref=microsoft.com&utm_source=microsoft.com&utm_medium=docs&utm_campaign=visualstudio) before you begin.

### Create a function app project

The Azure Functions template creates a project that can be published to a function app in Azure. A function app lets you group functions as a logical unit for easier management, deployment, scaling, and sharing of resources.

1. In Visual Studio, select **New** > **Project** from the **File** menu.
2. In the **Create a new project** dialog, search for functions, choose the **Azure Functions** template, and then select **Next**.
3. Enter a **Project name** for your project, and select **OK**. The project name must be valid as a C# namespace, so don't use underscores, hyphens, or nonalphanumeric characters.
4. Under **Additional information**, use the settings specified in the table that follows the image.

| **Setting** | **Suggested value** | **Description** |
| --- | --- | --- |
| **Functions worker** | .NET 6 | Creates a function project that supports .NET 6 and the Azure Functions Runtime 4.0. For more information, see [How to target Azure Functions runtime version](https://learn.microsoft.com/en-us/azure/azure-functions/functions-versions). |
| **Function** | Empty | Creates an empty function app. |
| **Storage account** | Storage Emulator | A storage account is required for durable function state management. |

1. Select **Create** to create an empty function project. This project has the basic configuration files needed to run your functions.

### Add functions to the app

The following steps use a template to create the durable function code in your project.

1. Right-click the project in Visual Studio and select **Add** > **New Azure Function**.
2. Verify **Azure Function** is selected from the add menu, enter a name for your C# file, and then select **Add**.
3. Select the **Durable Functions Orchestration** template and then select **Add**.



A new durable function is added to the app. Open the new .cs file to view the contents. This durable function is a simple function chaining example with the following methods:

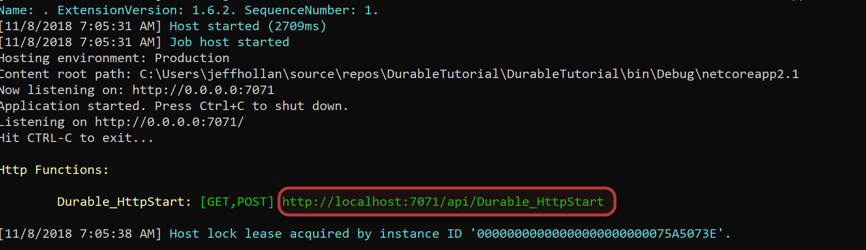
| **Method** | **FunctionName** | **Description** |
| --- | --- | --- |
| **RunOrchestrator** | <file-name> | Manages the durable orchestration. In this case, the orchestration starts, creates a list, and adds the result of three functions calls to the list. When the three function calls are complete, it returns the list. |
| **SayHello** | <file-name>\_Hello | The function returns a hello. It's the function that contains the business logic that is being orchestrated. |
| **HttpStart** | <file-name>\_HttpStart | An [HTTP-triggered function](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-http-webhook) that starts an instance of the orchestration and returns a check status response. |

You can test it on your local computer now that you've created your function project and a durable function.

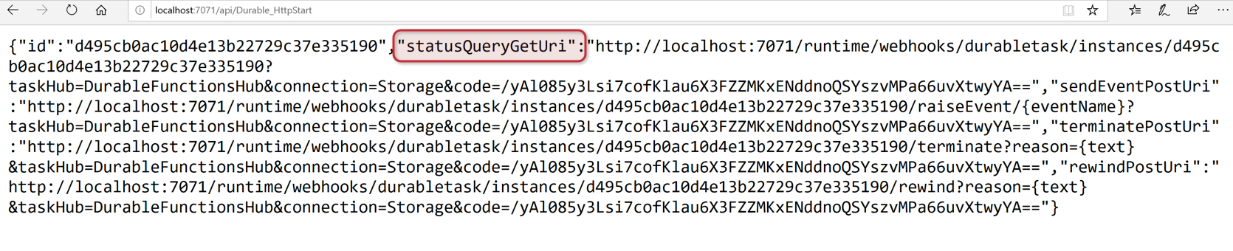
### Test the function locally

Azure Functions Core Tools lets you run an Azure Functions project on your local development computer. You're prompted to install these tools the first time you start a function from Visual Studio.

1. To test your function, press F5. If prompted, accept the request from Visual Studio to download and install Azure Functions Core (CLI) tools. You may also need to enable a firewall exception so that the tools can handle HTTP requests.
2. Copy the URL of your function from the Azure Functions runtime output.



1. Paste the URL for the HTTP request into your browser's address bar and execute the request. The following shows the response in the browser to the local GET request returned by the function:



The response is the HTTP function's initial result, letting us know that the durable orchestration has started successfully. It isn't yet the end result of the orchestration. The response includes a few useful URLs. For now, let's query the status of the orchestration.

1. Copy the URL value for statusQueryGetUri, paste it into the browser's address bar, and execute the request.

The request will query the orchestration instance for the status. You must get an eventual response that looks like the following. This output shows us the instance has completed and includes the outputs or results of the durable function.

{

"name": "Durable",

"instanceId": "d495cb0ac10d4e13b22729c37e335190",

"runtimeStatus": "Completed",

"input": null,

"customStatus": null,

"output": [

"Hello Tokyo!",

"Hello Seattle!",

"Hello London!"

],

"createdTime": "2019-11-02T07:07:40Z",

"lastUpdatedTime": "2019-11-02T07:07:52Z"

}

1. To stop debugging, press Shift + F5.

After you've verified that the function runs correctly on your local computer, it's time to publish the project to Azure.

### Publish the project to Azure

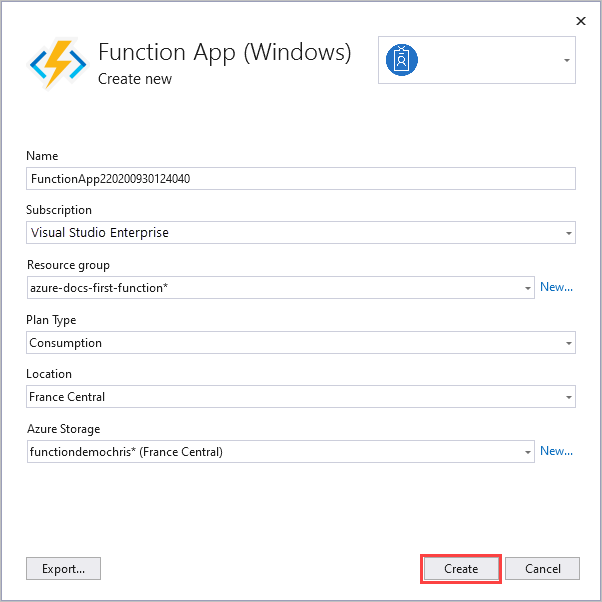
You must have a function app in your Azure subscription before publishing your project. You can create a function app right from Visual Studio.

1. In **Solution Explorer**, right-click the project and select **Publish**. In **Target**, select **Azure** then **Next**.
2. Select **Azure Function App (Windows)** for the **Specific target**, which creates a function app that runs on Windows, and then select **Next**.
3. In the **Function Instance**, choose **Create a new Azure Function...**

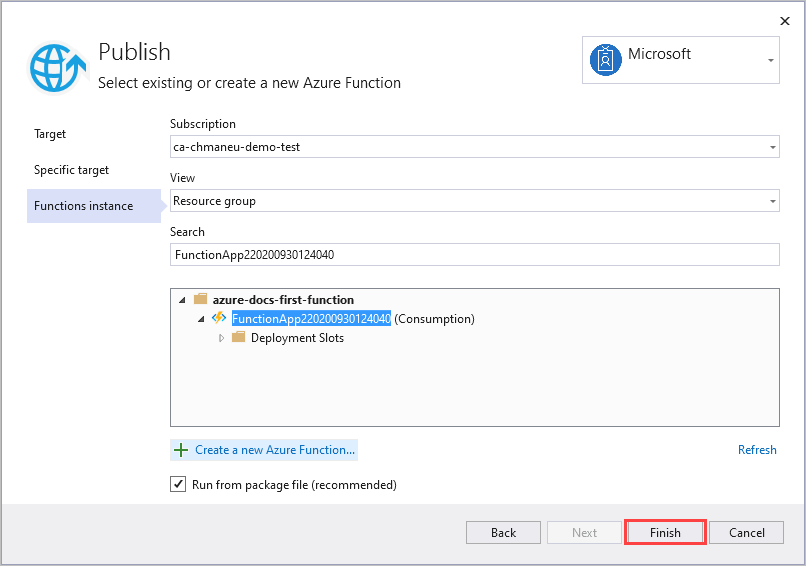


1. Create a new instance using the values specified in the following table:

| **Setting** | **Value** | **Description** |
| --- | --- | --- |
| **Name** | Globally unique name | Name that uniquely identifies your new function app. Accept this name or enter a new name. Valid characters are: a-z, 0-9, and -. |
| **Subscription** | Your subscription | The Azure subscription to use. Accept this subscription or select a new one from the drop-down list. |
| [**Resource group**](https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/overview) | Name of your resource group | The resource group in which you want to create your function app. Select an existing resource group from the drop-down list or select **New** to create a new resource group. |
| [**Plan Type**](https://learn.microsoft.com/en-us/azure/azure-functions/functions-scale) | Consumption | When you publish your project to a function app that runs in a [Consumption plan](https://learn.microsoft.com/en-us/azure/azure-functions/consumption-plan), you pay only for executions of your functions app. Other hosting plans incur higher costs. |
| **Location** | Location of the app service | Choose a **Location** in a [region](https://azure.microsoft.com/regions/) near you or other services your functions access. |
| [**Azure Storage**](https://learn.microsoft.com/en-us/azure/azure-functions/storage-considerations) | General-purpose storage account | An Azure storage account is required by the Functions runtime. Select **New** to configure a general-purpose storage account. You can also choose an existing account that meets the [storage account requirements](https://learn.microsoft.com/en-us/azure/azure-functions/storage-considerations#storage-account-requirements). |



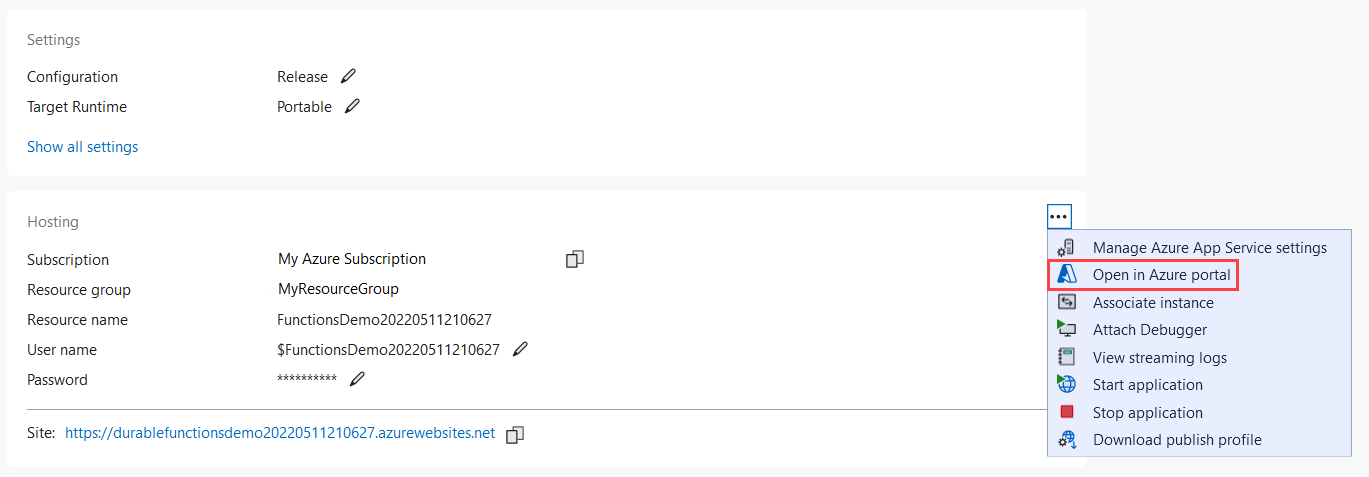
1. Select **Create** to create a function app and its related resources in Azure. The status of resource creation is shown in the lower-left of the window.
2. In the **Functions instance**, make sure that the **Run from package file** is checked. Your function app is deployed using [Zip Deploy](https://learn.microsoft.com/en-us/azure/azure-functions/functions-deployment-technologies#zip-deploy) with [Run-From-Package](https://learn.microsoft.com/en-us/azure/azure-functions/run-functions-from-deployment-package) mode enabled. Zip Deploy is the recommended deployment method for your functions project resulting in better performance.



1. Select **Finish**, and on the Publish page, select **Publish** to deploy the package containing your project files to your new function app in Azure.

After the deployment completes, the root URL of the function app in Azure is shown in the **Publish** tab.

1. In the Publish tab, in the Hosting section, choose **Open in Azure portal**. This opens the new function app Azure resource in the Azure portal.



### Test your function in Azure

1. Copy the base URL of the function app from the Publish profile page. Replace the localhost:port portion of the URL you used when testing the function locally with the new base URL.

The URL that calls your durable function HTTP trigger must be in the following format:

https://<APP\_NAME>.azurewebsites.net/api/<FUNCTION\_NAME>\_HttpStart

For e.g.;

<https://durablefunctionappjul2023.azurewebsites.net/api/DurableFunctionDemo_HttpStart>

1. Paste this new URL for the HTTP request into your browser's address bar. You must get the same status response as before when using the published app.

## Create a Durable Function in C# Using Visual Studio Code

<https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-create-first-csharp?pivots=code-editor-vscode>

Durable Functions is an extension of [Azure Functions](https://learn.microsoft.com/en-us/azure/azure-functions/functions-overview) that lets you write stateful functions in a serverless environment. The extension manages state, checkpoints, and restarts for you.

In this article, you learn how to use Visual Studio Code to locally create and test a "hello world" durable function. This function orchestrates and chains together calls to other functions. You can then publish the function code to Azure. These tools are available as part of the Visual Studio Code [Azure Functions extension](https://marketplace.visualstudio.com/items?itemName=ms-azuretools.vscode-azurefunctions).

### Prerequisites

To complete this tutorial:

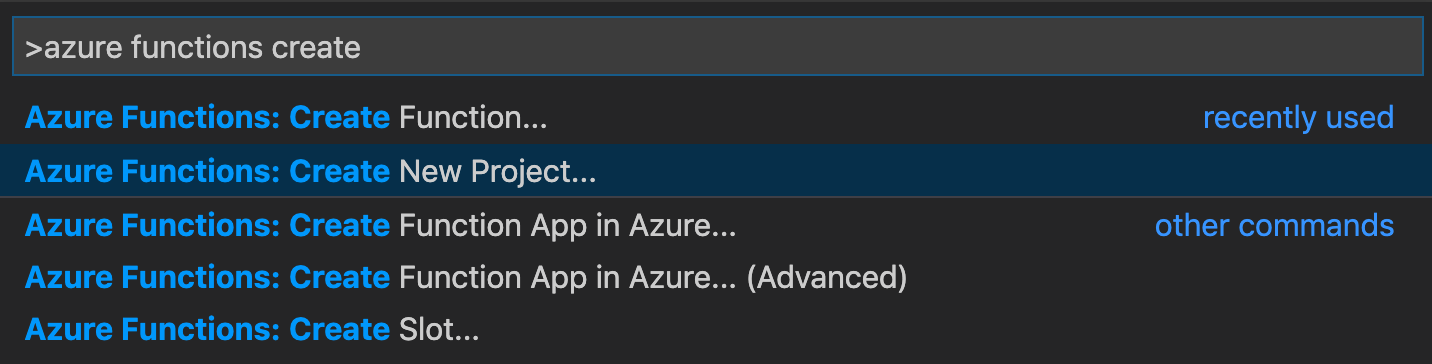
* Install [Visual Studio Code](https://code.visualstudio.com/download).
* Install the following Visual Studio Code extensions:
  + [Azure Functions](https://marketplace.visualstudio.com/items?itemName=ms-azuretools.vscode-azurefunctions)
  + [C#](https://marketplace.visualstudio.com/items?itemName=ms-dotnettools.csharp)
* Make sure that you have the latest version of the [Azure Functions Core Tools](https://learn.microsoft.com/en-us/azure/azure-functions/functions-run-local).
* Durable Functions require an Azure storage account. You need an Azure subscription.
* Make sure that you have version 3.1 or a later version of the [.NET Core SDK](https://dotnet.microsoft.com/download) installed.

If you don't have an [Azure subscription](https://learn.microsoft.com/en-us/azure/guides/developer/azure-developer-guide#understanding-accounts-subscriptions-and-billing), create an [Azure free account](https://azure.microsoft.com/free/?ref=microsoft.com&utm_source=microsoft.com&utm_medium=docs&utm_campaign=visualstudio) before you begin.

### Create your local project

In this section, you use Visual Studio Code to create a local Azure Functions project.

1. In Visual Studio Code, press F1 (or Ctrl/Cmd+Shift+P) to open the command palette. In the command palette, search for and select Azure Functions: Create New Project....



1. Choose an empty folder location for your project and choose **Select**.
2. Follow the prompts and provide the following information:

| **Prompt** | **Value** | **Description** |
| --- | --- | --- |
| Select a language for your function app project | C# | Create a local C# Functions project. |
| Select a version | Azure Functions v4 | You only see this option when the Core Tools aren't already installed. In this case, Core Tools are installed the first time you run the app. |
| Select a template for your project's first function | Skip for now |  |
| Select how you would like to open your project | Open in current window | Reopens Visual Studio Code in the folder you selected. |

Visual Studio Code installs the Azure Functions Core Tools if needed. It also creates a function app project in a folder. This project contains the [host.json](https://learn.microsoft.com/en-us/azure/azure-functions/functions-host-json) and [local.settings.json](https://learn.microsoft.com/en-us/azure/azure-functions/functions-develop-local#local-settings-file) configuration files.

### Add functions to the app

The following steps use a template to create the durable function code in your project.

1. In the command palette, search for and select Azure Functions: Create Function....
2. Follow the prompts and provide the following information:

| **Prompt** | **Value** | **Description** |
| --- | --- | --- |
| Select a template for your function | DurableFunctionsOrchestration | Create a Durable Functions orchestration |
| Provide a function name | HelloOrchestration | Name of the class in which functions are created |
| Provide a namespace | Company.Function | Namespace for the generated class |

1. When Visual Studio Code prompts you to select a storage account, choose **Select storage account**. Follow the prompts and provide the following information to create a new storage account in Azure:

| **Prompt** | **Value** | **Description** |
| --- | --- | --- |
| Select subscription | name of your subscription | Select your Azure subscription |
| Select a storage account | Create a new storage account |  |
| Enter the name of the new storage account | unique name | Name of the storage account to create |
| Select a resource group | unique name | Name of the resource group to create |
| Select a location | region | Select a region close to you |

A class containing the new functions is added to the project. Visual Studio Code also adds the storage account connection string to local.settings.json and a reference to the [Microsoft.Azure.WebJobs.Extensions.DurableTask](https://www.nuget.org/packages/Microsoft.Azure.WebJobs.Extensions.DurableTask) NuGet package to the .csproj project file.

Open the new HelloOrchestration.cs file to view the contents. This durable function is a simple function chaining example with the following methods:

| **Method** | **FunctionName** | **Description** |
| --- | --- | --- |
| **RunOrchestrator** | HelloOrchestration | Manages the durable orchestration. In this case, the orchestration starts, creates a list, and adds the result of three functions calls to the list. When the three function calls are complete, it returns the list. |
| **SayHello** | HelloOrchestration\_Hello | The function returns a hello. It's the function that contains the business logic that is being orchestrated. |
| **HttpStart** | HelloOrchestration\_HttpStart | An [HTTP-triggered function](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-http-webhook) that starts an instance of the orchestration and returns a check status response. |

Now that you've created your function project and a durable function, you can test it on your local computer.

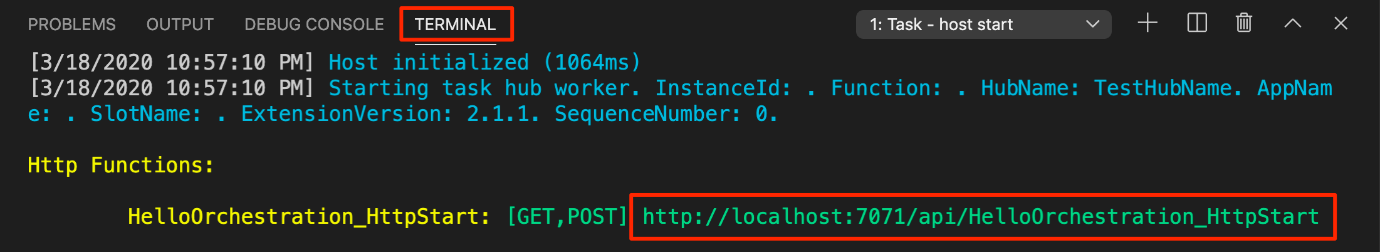
### Test the function locally

Azure Functions Core Tools lets you run an Azure Functions project on your local development computer. You're prompted to install these tools the first time you start a function from Visual Studio Code.

1. To test your function, set a breakpoint in the SayHello activity function code and press F5 to start the function app project. Output from Core Tools is displayed in the **Terminal** panel.

Note: For more information on debugging, see [Durable Functions Diagnostics](https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-diagnostics#debugging).

1. In the **Terminal** panel, copy the URL endpoint of your HTTP-triggered function.



1. Use a tool like [Postman](https://www.getpostman.com/) or [cURL](https://curl.haxx.se/), and then send an HTTP POST request to the URL endpoint.

The response is the HTTP function's initial result, letting us know that the durable orchestration has started successfully. It isn't yet the end result of the orchestration. The response includes a few useful URLs. For now, let's query the status of the orchestration.

1. Copy the URL value for statusQueryGetUri, paste it into the browser's address bar, and execute the request. Alternatively, you can also continue to use Postman to issue the GET request.

The request will query the orchestration instance for the status. You must get an eventual response, which shows us that the instance has completed and includes the outputs or results of the durable function. It looks like:

{

"name": "HelloOrchestration",

"instanceId": "9a528a9e926f4b46b7d3deaa134b7e8a",

"runtimeStatus": "Completed",

"input": null,

"customStatus": null,

"output": [

"Hello Tokyo!",

"Hello Seattle!",

"Hello London!"

],

"createdTime": "2020-03-18T21:54:49Z",

"lastUpdatedTime": "2020-03-18T21:54:54Z"

}

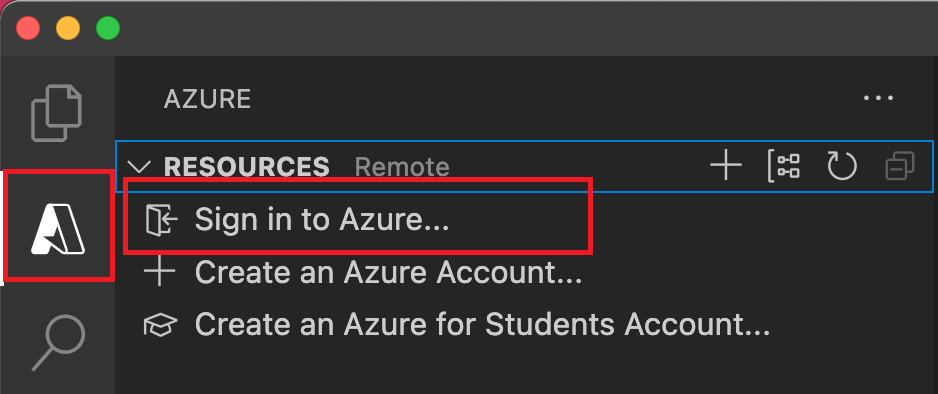
1. To stop debugging, press Shift + F5 in Visual Studio Code.

After you've verified that the function runs correctly on your local computer, it's time to publish the project to Azure.

### Sign in to Azure

Before you can publish your app, you must sign in to Azure.

1. If you aren't already signed in, choose the Azure icon in the Activity bar. Then in the **Resources** area, choose **Sign in to Azure...**.



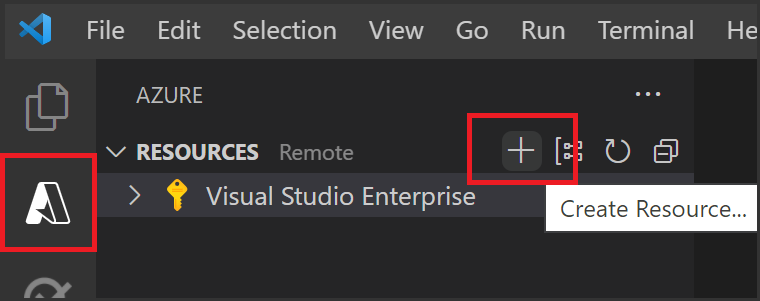
If you're already signed in and can see your existing subscriptions, go to the next section. If you don't yet have an Azure account, choose **Create an Azure Account...**. Students can choose **Create an Azure for Students Account...**.

1. When prompted in the browser, choose your Azure account and sign in using your Azure account credentials. If you create a new account, you can sign in after your account is created.
2. After you've successfully signed in, you can close the new browser window. The subscriptions that belong to your Azure account are displayed in the sidebar.

### Create the function app in Azure

In this section, you create a function app and related resources in your Azure subscription.

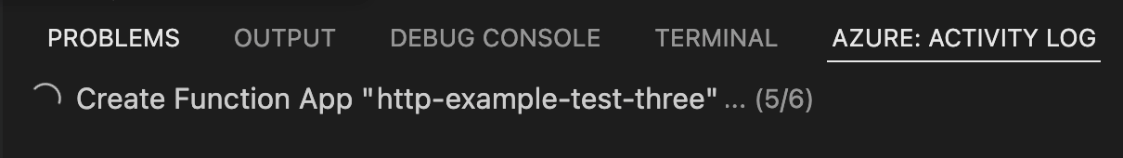
1. Choose the Azure icon in the Activity bar. Then in the **Resources** area, select the **+** icon and choose the **Create Function App in Azure** option.



1. Provide the following information at the prompts:

| **Prompt** | **Selection** |
| --- | --- |
| **Select subscription** | Choose the subscription to use. You won't see this prompt when you have only one subscription visible under **Resources**. |
| **Enter a globally unique name for the function app** | Type a name that is valid in a URL path. The name you type is validated to make sure that it's unique in Azure Functions. |
| **Select a runtime stack** | Choose the language version on which you've been running locally. |
| **Select a location for new resources** | For better performance, choose a [region](https://azure.microsoft.com/regions/) near you. |

The extension shows the status of individual resources as they're being created in Azure in the **Azure: Activity Log** panel.



1. When the creation is complete, the following Azure resources are created in your subscription. The resources are named based on your function app name:

* A [resource group](https://learn.microsoft.com/en-us/azure/azure-resource-manager/management/overview), which is a logical container for related resources.
* A standard [Azure Storage account](https://learn.microsoft.com/en-us/azure/storage/common/storage-account-create), which maintains state and other information about your projects.
* A function app, which provides the environment for executing your function code. A function app lets you group functions as a logical unit for easier management, deployment, and sharing of resources within the same hosting plan.
* An App Service plan, which defines the underlying host for your function app.
* An Application Insights instance connected to the function app, which tracks usage of your functions in the app.

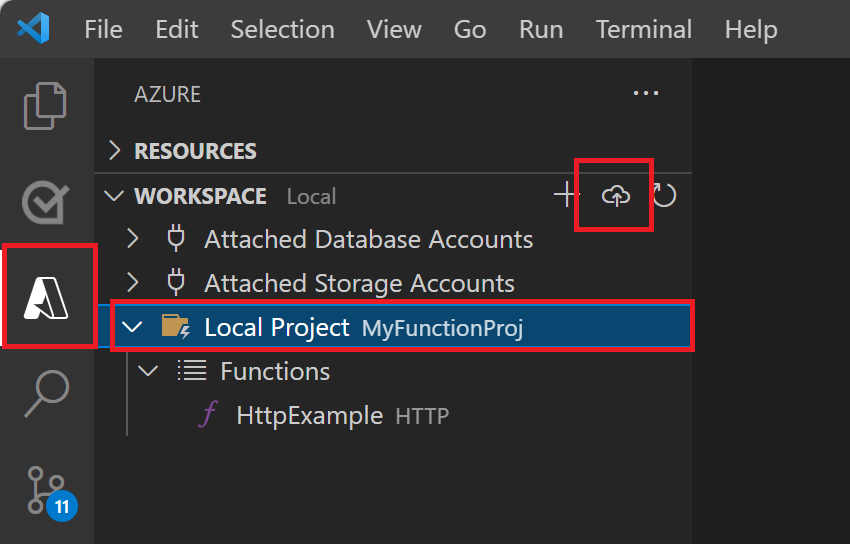
A notification is displayed after your function app is created and the deployment package is applied.

**Tip**: By default, the Azure resources required by your function app are created based on the function app name you provide. By default, they're also created in the same new resource group with the function app. If you want to either customize the names of these resources or reuse existing resources, you need to [**publish the project with advanced create options**](https://learn.microsoft.com/en-us/azure/azure-functions/functions-develop-vs-code#enable-publishing-with-advanced-create-options) instead.

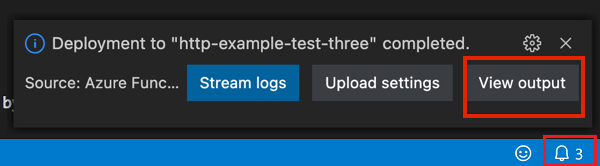
### Deploy the project to Azure

**Important**: Deploying to an existing function app always overwrites the contents of that app in Azure.

1. Choose the Azure icon in the Activity bar, then in the **Workspace** area, select your project folder and select the **Deploy...** button.



1. Select **Deploy to Function App...**, choose the function app you just created, and select **Deploy**.
2. After deployment completes, select **View Output** to view the creation and deployment results, including the Azure resources that you created. If you miss the notification, select the bell icon in the lower right corner to see it again.



### Test your function in Azure

1. Copy the URL of the HTTP trigger from the **Output** panel. The URL that calls your HTTP-triggered function must be in the following format:

https://<functionappname>.azurewebsites.net/api/HelloOrchestration\_HttpStart

1. Paste this new URL for the HTTP request into your browser's address bar. You must get the same status response as before when using the published app.

## Function chaining in Durable Functions - Hello sequence sample

<https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-sequence?tabs=csharp>

## Fan-out/fan-in scenario in Durable Functions - Cloud backup example

<https://learn.microsoft.com/en-us/azure/azure-functions/durable/durable-functions-cloud-backup?tabs=csharp>

# Azure Logic Apps

<https://learn.microsoft.com/en-us/azure/logic-apps/logic-apps-overview>

## Create an example Consumption workflow in multi-tenant Azure Logic Apps with the Azure portal

<https://learn.microsoft.com/en-us/azure/logic-apps/quickstart-create-example-consumption-workflow>

## Create automated integration workflows with multi-tenant Azure Logic Apps and Visual Studio

<https://learn.microsoft.com/en-us/azure/logic-apps/quickstart-create-logic-apps-with-visual-studio>

## Create an example Standard workflow in single-tenant Azure Logic Apps with the Azure portal

<https://learn.microsoft.com/en-us/azure/logic-apps/create-single-tenant-workflows-azure-portal?tabs=standard>

## Create a Standard logic app workflow for single-tenant Azure Logic Apps using Visual Studio Code

<https://learn.microsoft.com/en-us/azure/logic-apps/create-single-tenant-workflows-visual-studio-code>

# Azure Event Grid

<https://learn.microsoft.com/en-us/azure/event-grid/overview>

Azure Event Grid is a highly scalable, fully managed Pub Sub message distribution service that offers flexible message consumption patterns using the MQTT and HTTP protocols. With Azure Event Grid, you can build data pipelines with device data, integrate applications, and build event-driven serverless architectures. Event Grid enables clients to publish and subscribe to messages over the MQTT v3.1.1 and v5.0 protocols to support Internet of Things (IoT) solutions. Through HTTP, Event Grid enables you to build event-driven solutions where a publisher service announces its system state changes (events) to subscriber applications. Event Grid can be configured to send events to subscribers (push delivery) or subscribers can connect to Event Grid to read events (pull delivery). Event Grid supports [CloudEvents 1.0](https://github.com/cloudevents/spec) specification to provide interoperability across systems.

[A diagram of a function

Description automatically generated](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/general-event-grid-high-res.png#lightbox)

Azure Event Grid is a generally available service deployed across availability zones in all regions that support them. For a list of regions supported by Event Grid, see [Products available by region](https://azure.microsoft.com/global-infrastructure/services/?products=event-grid&regions=all).

**Note**: The following features have been released with our 2023-06-01-preview API:

* MQTT v3.1.1 and v5.0 support (preview)
* Pull-style event consumption using HTTP (preview)

The initial regions where these features are available are: East US, Central US, South Central US, West US 2, East Asia, Southeast Asia, North Europe, West Europe, UAE North

**Important**: The MQTT Messaging and Pull Delivery features along with the following resources are currently in **PREVIEW**.

* Namespaces
* Namespace topics
* Event subscriptions to namespace topics
* Topic spaces
* Clients
* Client Groups
* Certificates
* Permission Bindings

## Overview

Azure Event Grid is used at different stages of data pipelines to achieve a diverse set of integration goals.

**MQTT messaging (preview)**. IoT devices and applications can communicate with each other over MQTT. Event Grid can also be used to route MQTT messages to Azure services or custom endpoints for further data analysis, visualization, or storage. This integration with Azure services enables you to build data pipelines that start with data ingestion from your IoT devices.

**Data distribution using push and pull delivery (preview) modes**. At any point in a data pipeline, HTTP applications can consume messages using push or pull APIs. The source of the data may include MQTT clients’ data, but also includes the following data sources that send their events over HTTP:

* Azure services
* Your custom applications
* External partner (SaaS) systems

When configuring Event Grid for push delivery, Event Grid can send data to [destinations](https://learn.microsoft.com/en-us/azure/event-grid/event-handlers) that include your own application webhooks and Azure services.

## Capabilities

Event Grid offers a rich mixture of features. These features include:

### MQTT messaging (preview)

* [**MQTT v3.1.1 and MQTT v5.0**](https://learn.microsoft.com/en-us/azure/event-grid/mqtt-publish-and-subscribe-portal) support – use any open source MQTT client library to communicate with the service.
* **Custom topics with wildcards support** - leverage your own topic structure.
* **Publish-subscribe messaging model** - communicate efficiently using one-to-many, many-to-one, and one-to-one messaging patterns.
* [**Built-in cloud integration**](https://learn.microsoft.com/en-us/azure/event-grid/mqtt-routing) - route your MQTT messages to Azure services or custom webhooks for further processing.
* **Flexible and fine-grained**[**access control model**](https://learn.microsoft.com/en-us/azure/event-grid/mqtt-access-control) - group clients and topic to simplify access control management, and use the variable support in topic templates for a fine-grained access control.
* **X.509 certificate**[**authentication**](https://learn.microsoft.com/en-us/azure/event-grid/mqtt-client-authentication) - authenticate your devices the standard mechanism for device authentication in the IoT industry.
* **TLS 1.2 and TLS 1.3 support** - secure your client communication using robust encryption protocols.
* **Multi-session support** - connect your applications with multiple active sessions to ensure reliability and scalability.
* **MQTT over WebSockets** - enable connectivity for clients in firewall-restricted environments.

### Event messaging (HTTP)

* **Flexible event consumption model** – when using HTTP, consume events using pull (preview) or push delivery mode.
* **System events** – Get up and running quickly with built-in Azure service events.
* **Your own application events** - Use Event Grid to route, filter, and reliably deliver custom events from your app.
* **Partner events** – Subscribe to your partner SaaS provider events and process them on Azure.
* **Advanced filtering** – Filter on event type or other event attributes to make sure your event handlers or consumer apps receive only relevant events.
* **Reliability** – Push delivery features a 24-hour retry mechanism with exponential backoff to make sure events are delivered. Using pull delivery, your application has full control over event consumption.
* **High throughput** - Build high-volume integrated solutions with Event Grid.

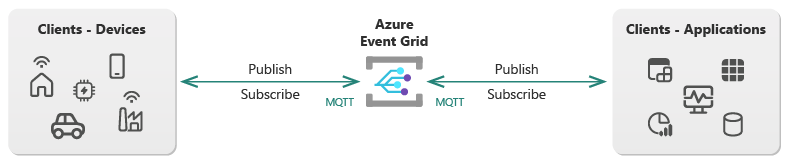
## Use cases:

Event Grid supports the following use cases:

### MQTT messaging

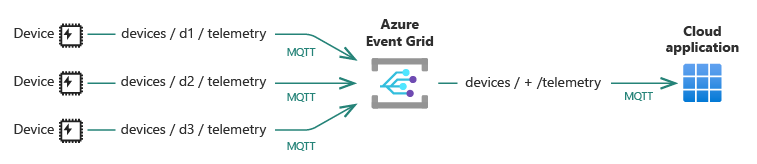
Event Grid enables your clients to communicate on [custom MQTT topic names](https://docs.oasis-open.org/mqtt/mqtt/v5.0/os/mqtt-v5.0-os.html#_Toc3901107) using a publish-subscribe messaging model. Event Grid supports clients that publish and subscribe to messages over MQTT v3.1.1, MQTT v3.1.1 over WebSockets, MQTT v5, and MQTT v5 over WebSockets. Event Grid allows you to send MQTT messages to the cloud for data analysis, storage, and visualizations, among other use cases.

The MQTT support in Event Grid is ideal for the implementation of automotive and mobility scenarios, among others. See [the reference architecture](https://learn.microsoft.com/en-us/azure/event-grid/mqtt-automotive-connectivity-and-data-solution) to learn how to build secure and scalable solutions for connecting millions of vehicles to the cloud, using Azure’s messaging and data analytics services.

[](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/mqtt-messaging-high-res.png#lightbox)

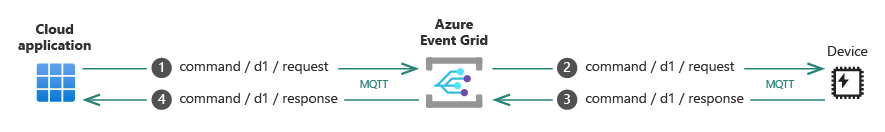
Event Grid’s MQTT support enables you to accomplish the following scenarios.

#### Ingest IoT telemetry

[](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/ingest-telemetry-high-res.png#lightbox)

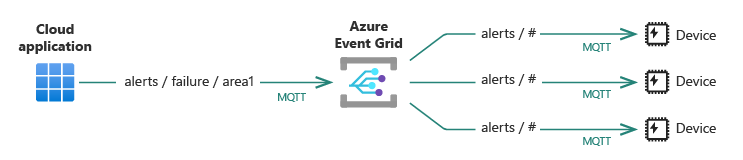
Ingest telemetry using a **many-to-one messaging** pattern. For example, use Event Grid to send telemetry from multiple IoT devices to a cloud application. This pattern enables the application to offload the burden of managing the high number of connections with devices to Event Grid.

#### Command and control

[](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/command-control-high-res.png#lightbox)

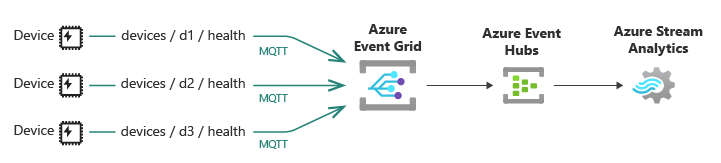
Control your MQTT clients using the **request-response** (one-to-one) message pattern. For example, use Event Grid to send a command from a cloud application to an IoT device.

#### Broadcast alerts

[](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/broadcast-alerts-high-res.png#lightbox)

Broadcast alerts to a fleet of clients using the **one-to-many** messaging pattern. For example, use Event Grid to send an alert from a cloud application to multiple IoT devices. This pattern enables the application to publish only one message that the service replicates for every interested client.

#### Integrate MQTT data

[](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/integrate-data-high-res.png#lightbox)

Integrate data from your MQTT clients by routing MQTT messages to Azure services and Webhooks through the [HTTP Push delivery](https://learn.microsoft.com/en-us/azure/event-grid/push-delivery-overview#push-delivery-1) functionality. For example, use Event Grid to route telemetry from your IoT devices to Event Hubs and then to Azure Stream Analytics to gain insights from your device telemetry.

### Push delivery of discrete events

Event Grid can be configured to send events to a diverse set of Azure services or webhooks using push event delivery. Event sources include your custom applications, Azure services, and partner (SaaS) services that publish events announcing system state changes (also known as "discrete" events). In turn, Event Grid delivers those events to configured subscribers’ destinations.

Event Grid’s push delivery allows you to realize the following use cases.

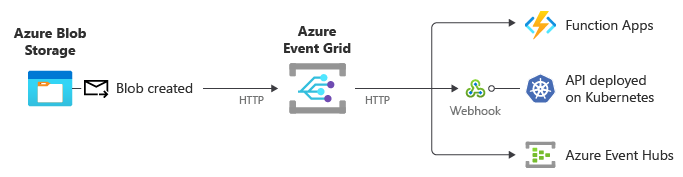
#### Build event-driven serverless solutions

[A diagram of a computer

Description automatically generated](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/build-event-serverless-high-res.png#lightbox)

Use Event Grid to build serverless solutions with Azure Functions Apps, Logic Apps, and API Management. Using serverless services with Event Grid affords you a level of productivity, effort economy, and integration superior to that of classical computing models where you have to procure, manage, secure, and maintain all infrastructure deployed.

#### Receive events from Azure services

[](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/receive-events-azure-high-res.png#lightbox)

Event Grid can receive events from 20+ Azure services so that you can automate your operations. For example, you can configure Event Grid to receive an event when a new blob has been created on an Azure Storage Account so that your downstream application can read and process its content. For a list of all supported Azure services and events, see [System topics](https://learn.microsoft.com/en-us/azure/event-grid/system-topics).

#### Receive events from your applications

[A diagram of a event grid

Description automatically generated](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/receive-events-apps-high-res.png#lightbox)

Your own service or application publishes events to Event Grid that subscriber applications process. Event Grid features [Custom Topics](https://learn.microsoft.com/en-us/azure/event-grid/custom-topics) to address basic integration scenarios and [Domains](https://learn.microsoft.com/en-us/azure/event-grid/event-domains) to offer a simple management and routing model when you need to distribute events to hundreds or thousands of different groups.

#### Receive events from partner (SaaS providers)

[A diagram of a event grid

Description automatically generated](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/receive-saas-providers-high-res.png#lightbox)

A multi-tenant SaaS provider or platform can publish their events to Event Grid through a feature called [Partner Events](https://learn.microsoft.com/en-us/azure/event-grid/partner-events-overview). You can [subscribe to those events](https://learn.microsoft.com/en-us/azure/event-grid/subscribe-to-partner-events) and automate tasks, for example. Events from the following partners are currently available:

* [Auth0](https://learn.microsoft.com/en-us/azure/event-grid/auth0-overview)
* [Microsoft Graph API](https://learn.microsoft.com/en-us/azure/event-grid/subscribe-to-graph-api-events). Through Microsoft Graph API you can get events from [Azure AD](https://learn.microsoft.com/en-us/azure/event-grid/azure-active-directory-events), [Microsoft Outlook](https://learn.microsoft.com/en-us/azure/event-grid/outlook-events), [Teams](https://learn.microsoft.com/en-us/azure/event-grid/teams-events), Conversations, security alerts, and Universal Print.
* [Tribal Group](https://learn.microsoft.com/en-us/azure/event-grid/subscribe-to-tribal-group-events)
* [SAP](https://learn.microsoft.com/en-us/azure/event-grid/subscribe-to-sap-events)

#### Event Handlers

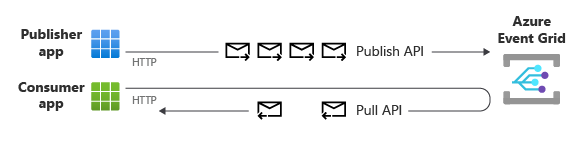
An event subscription is a generic configuration resource that allows you to define the event handler or destination to which events are sent using push delivery. The following [event handlers](https://learn.microsoft.com/en-us/azure/event-grid/event-handlers) are supported:

* [Webhooks](https://learn.microsoft.com/en-us/azure/event-grid/handler-webhooks). Azure Automation runbooks and Logic Apps are supported via webhooks.
* [Azure functions](https://learn.microsoft.com/en-us/azure/event-grid/handler-functions)
* [Event Hubs](https://learn.microsoft.com/en-us/azure/event-grid/handler-event-hubs)
* [Service Bus queues and topics](https://learn.microsoft.com/en-us/azure/event-grid/handler-service-bus)
* [Relay hybrid connections](https://learn.microsoft.com/en-us/azure/event-grid/handler-relay-hybrid-connections)
* [Storage queues](https://learn.microsoft.com/en-us/azure/event-grid/handler-storage-queues)

### Pull delivery of discrete events

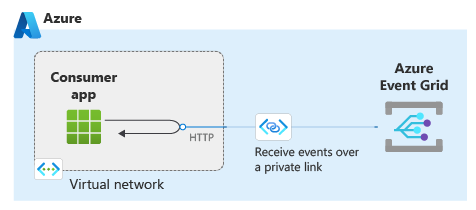
Azure Event Grid features [pull CloudEvents delivery](https://learn.microsoft.com/en-us/azure/event-grid/pull-delivery-overview#push-and-pull-delivery). Using this delivery mode, clients connect to Event Grid to read events. The following use cases can be realized using pull delivery.

#### Receive events at your own pace

[](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/pull-events-at-your-own-pace-high-res.png#lightbox)

One or more clients can connect to Azure Event Grid to read messages at their own pace. Event Grid affords clients full control on events consumption. Your application can receive events at certain times of the day, for example. Your solution can also increase the rate of consumption by adding more clients that read from Event Grid.

#### Consume events over a private link

[](https://learn.microsoft.com/en-us/azure/event-grid/media/overview/consume-private-link-pull-api-high-res.png#lightbox)

You can configure **private links** to connect to Azure Event Grid to **publish and read** CloudEvents through a [private endpoint](https://learn.microsoft.com/en-us/azure/private-link/private-endpoint-overview) in your virtual network. Traffic between your virtual network and Event Grid travels the Microsoft backbone network.

**Important**: Private links are available with pull delivery, not with push delivery. This is not a gap. Private links “…[**enables you to access Azure PaaS Services**](https://learn.microsoft.com/en-us/azure/private-link/private-link-overview)…” That is, private links were designed to be used when you connect to Event Grid for publishing events or receiving events, not when Event Grid is connecting (sending events) to your webhook or Azure Service.

## How much does Event Grid cost?

Azure Event Grid uses a pay-per-event pricing model. You only pay for what you use. For the push-style delivery that is generally available, the first 100,000 operations per month are free. Examples of operations include event publication, event delivery, delivery attempts, event filter evaluations that refer to event data properties (sometimes referred to as Advanced Filters), and events sent to a dead letter location. For details, see the [pricing page](https://azure.microsoft.com/pricing/details/event-grid/).

Event Grid operations involving Namespaces and its resources, including MQTT and pull HTTP delivery operations, are in public preview and are available at no charge today.

## Subscribe to Storage Events

### Use Azure Event Grid to Route Blob Storage Events to Web Endpoint (Azure portal)

<https://learn.microsoft.com/en-us/azure/event-grid/blob-event-quickstart-portal>

**Sample web app used**: <https://github.com/Azure-Samples/azure-event-grid-viewer>

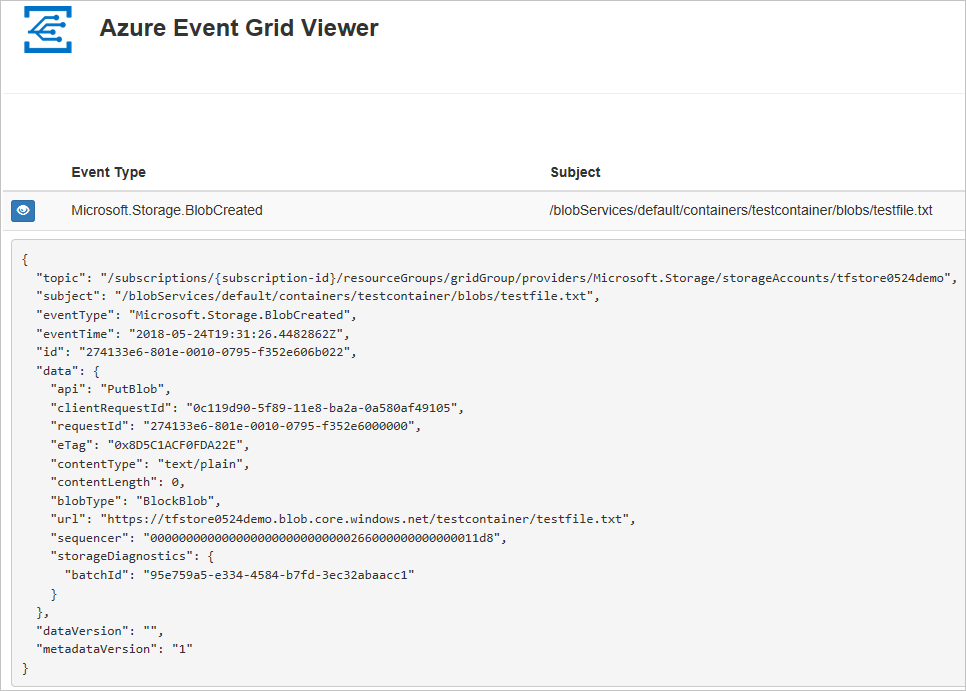
Event Grid is a fully managed service that enables you to easily manage events across many different Azure services and applications. It simplifies building event-driven and serverless applications. For an overview of the service, see [Event Grid overview](https://learn.microsoft.com/en-us/azure/event-grid/overview).

In this article, you use the Azure portal to do the following tasks:

1. Create a Blob storage account.
2. Subscribe to events for that blob storage.
3. Trigger an event by uploading a file to the blob storage.
4. View the result in a handler web app. Typically, you send events to an endpoint that processes the event data and takes actions. To keep it simple, you send events to a web app that collects and displays the messages.

If you don't have an [Azure subscription](https://learn.microsoft.com/en-us/azure/guides/developer/azure-developer-guide#understanding-accounts-subscriptions-and-billing), create an [Azure free account](https://azure.microsoft.com/free/?ref=microsoft.com&utm_source=microsoft.com&utm_medium=docs&utm_campaign=visualstudio) before you begin.

When you're finished, you see that the event data has been sent to the web app.



### Create a storage account

1. Sign in to [Azure portal](https://portal.azure.com/).
2. To create a Blob storage, select **Create a resource**.
3. In the **Search**, enter **Storage account**, and select **Storage account** from the result list.
4. On the **Storage account** page, select **Create** to start creating the storage account. To subscribe to events, create either a general-purpose v2 storage account or a Blob storage account.
5. On the **Create storage account** page, do the following steps:

* Select your Azure subscription.
* For **Resource group**, create a new resource group or select an existing one.
* Enter the name for your storage account.
* Select the **Region** in which you want the storage account to be created.
* For **Redundancy**, select **Locally-redundant storage (LRS)** from the drop-down list.
* Select **Review** at the bottom of the page.
* On the **Review** page, review the settings, and select **Create**.

**Note**: Only storage accounts of kind **StorageV2 (general purpose v2)** and **BlobStorage** support event integration. **Storage (general purpose v1)** does *not* support integration with Event Grid.

1. The deployment may take a few minutes to complete. On the **Deployment** page, select **Go to resource**.
2. On the **Storage account** page, select **Events** on the left menu.
3. Keep this page in the web browser open.

### Create a message endpoint

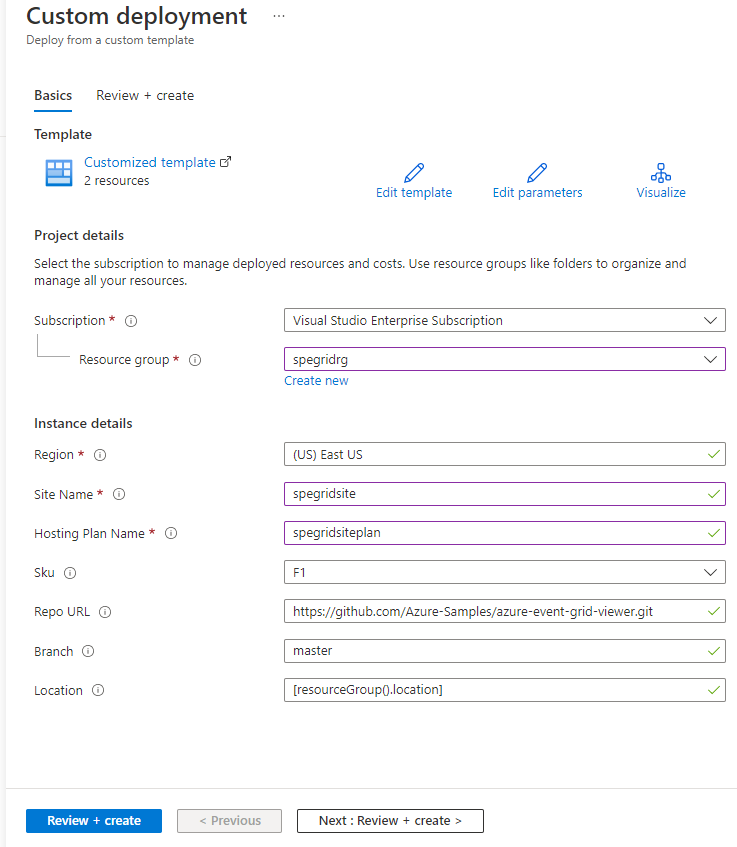
Before subscribing to the events for the Blob storage, let's create the endpoint for the event message. Typically, the endpoint takes actions based on the event data. To simplify this quickstart, you deploy a [pre-built web app](https://github.com/Azure-Samples/azure-event-grid-viewer) that displays the event messages. The deployed solution includes an App Service plan, an App Service web app, and source code from GitHub.

1. Select **Deploy to Azure** to deploy the solution to your subscription.

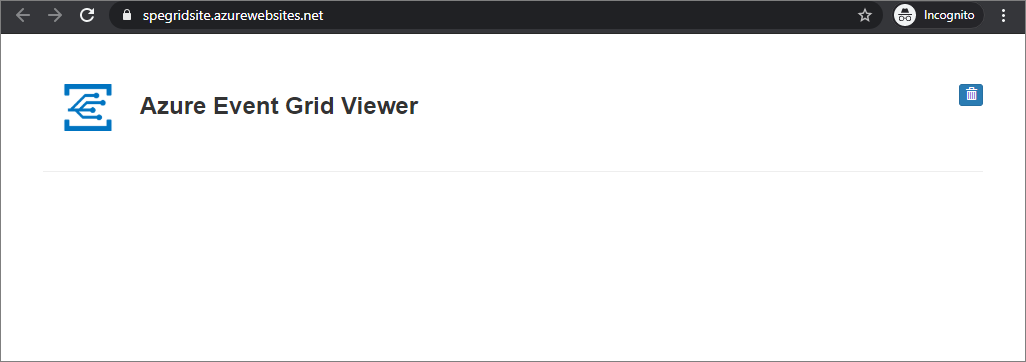
A blue rectangle with white text

Description automatically generated

1. On the **Custom deployment** page, do the following steps:
2. For **Resource group**, select the resource group that you created when creating the storage account. It will be easier for you to clean up after you're done with the tutorial by deleting the resource group.
3. For **Site Name**, enter a name for the web app.
4. For **Hosting plan name**, enter a name for the App Service plan to use for hosting the web app.
5. Select **Review + create**.



1. On the **Review + create** page, select **Create**.
2. The deployment may take a few minutes to complete. On the **Deployment** page, select **Go to resource group**.
3. On the **Resource group** page, in the list of resources, select the web app that you created. You also see the App Service plan and the storage account in this list.
4. On the **App Service** page for your web app, select the URL to navigate to the web site. The URL should be in this format: https://<your-site-name>.azurewebsites.net.
5. Confirm that you see the site but no events have been posted to it yet.



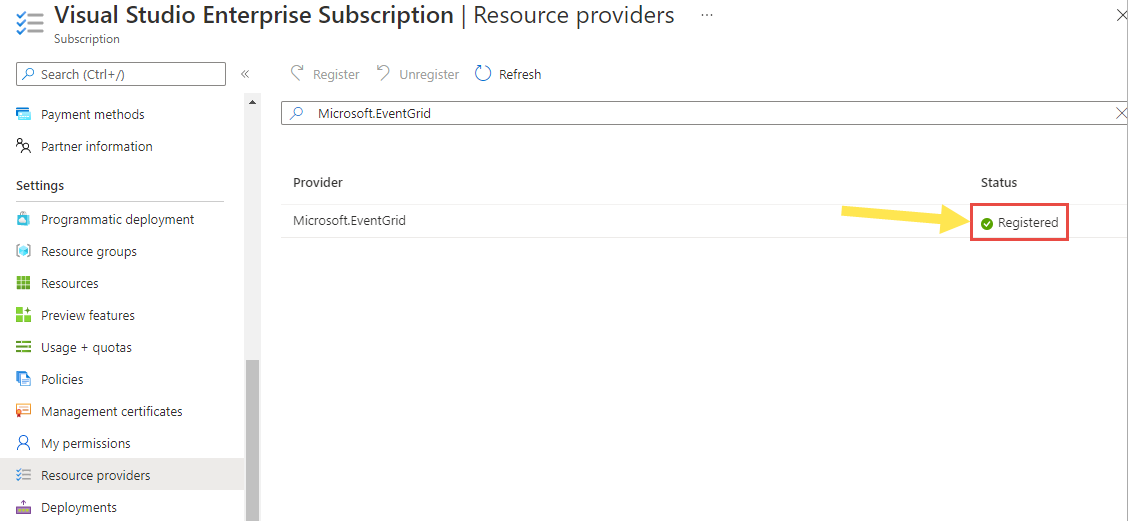
**Important**: Keep the Azure Event Grid Viewer window open so that you can see events as they are posted.

### Register the Event Grid resource provider

Unless you've used Event Grid before, you'll need to register the Event Grid resource provider. If you’ve used Event Grid before, skip to the next section.

In the Azure portal, do the following steps:

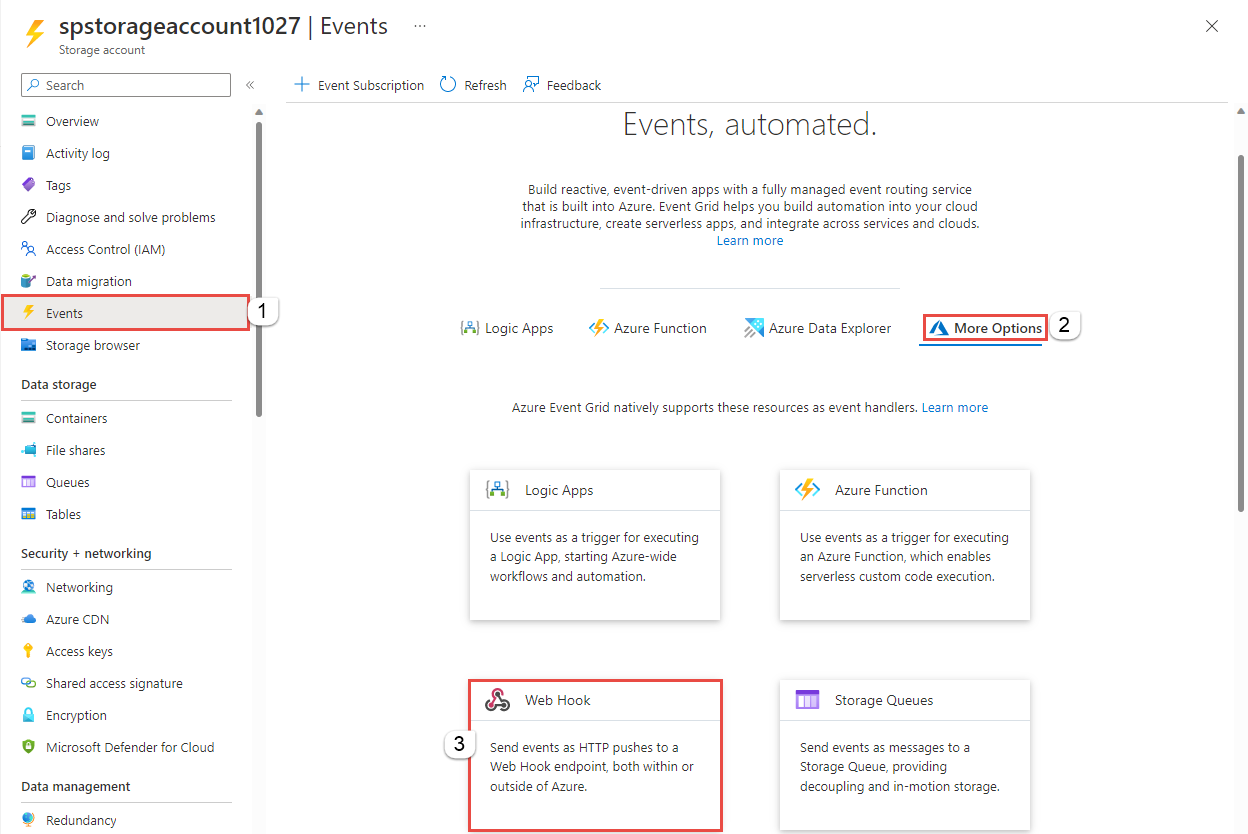
1. On the left menu, select **Subscriptions**.
2. Select the **subscription** you want to use for Event Grid from the subscription list.
3. On the **Subscription** page, select **Resource providers** under **Settings** on the left menu.
4. Search for **Microsoft.EventGrid**, and select it in the provider list.
5. Select **Register** on the command bar.
6. Refresh to make sure the status of **Microsoft.EventGrid** is changed to **Registered**.



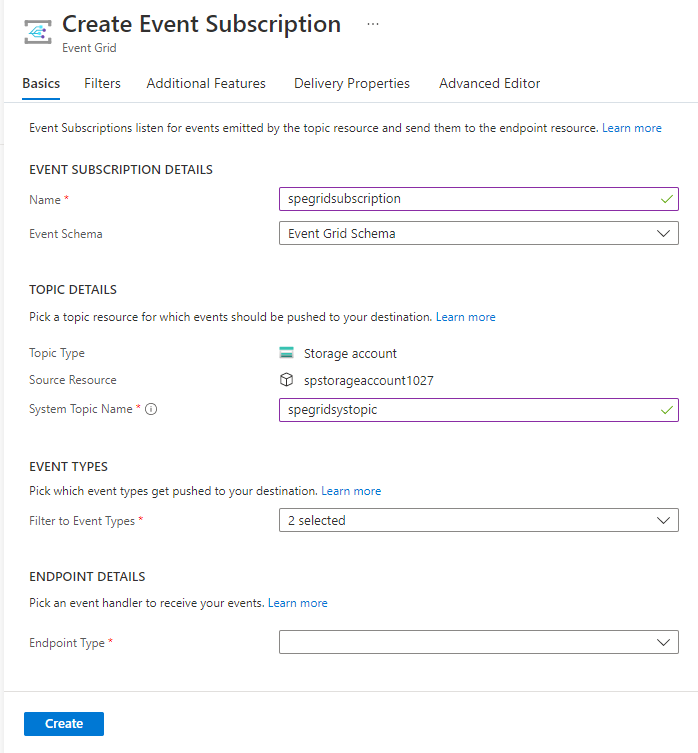
### Subscribe to the Blob storage

You subscribe to a topic to tell Event Grid which events you want to track, and where to send the events.

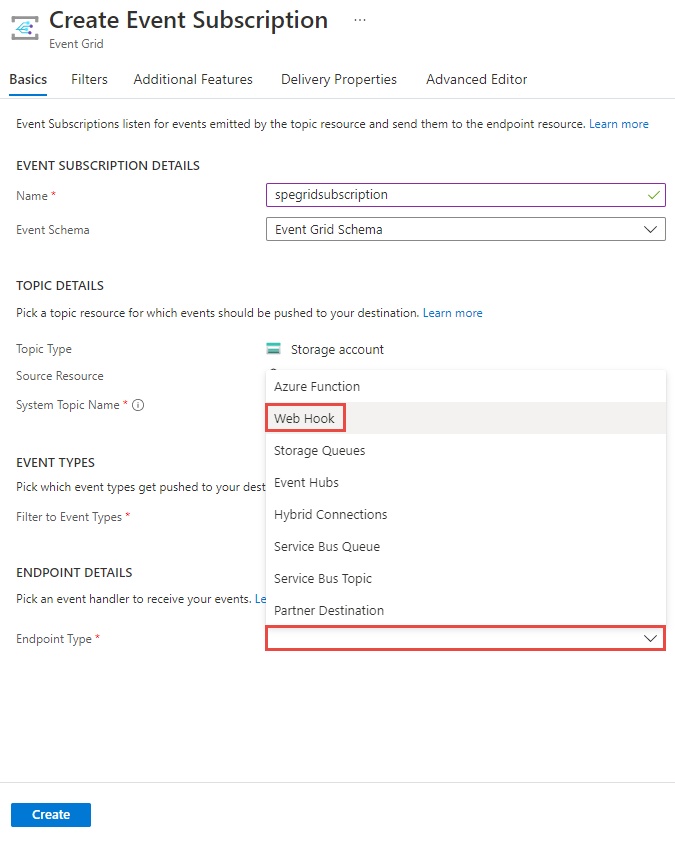
1. If you closed the **Storage account** page, navigate to your Azure Storage account that you created earlier. On the left menu, select **All resources** and select your storage account.
2. On the **Storage account** page, select **Events** on the left menu.
3. Select **More Options**, and **Web Hook**. You're sending events to your viewer app using a web hook for the endpoint.



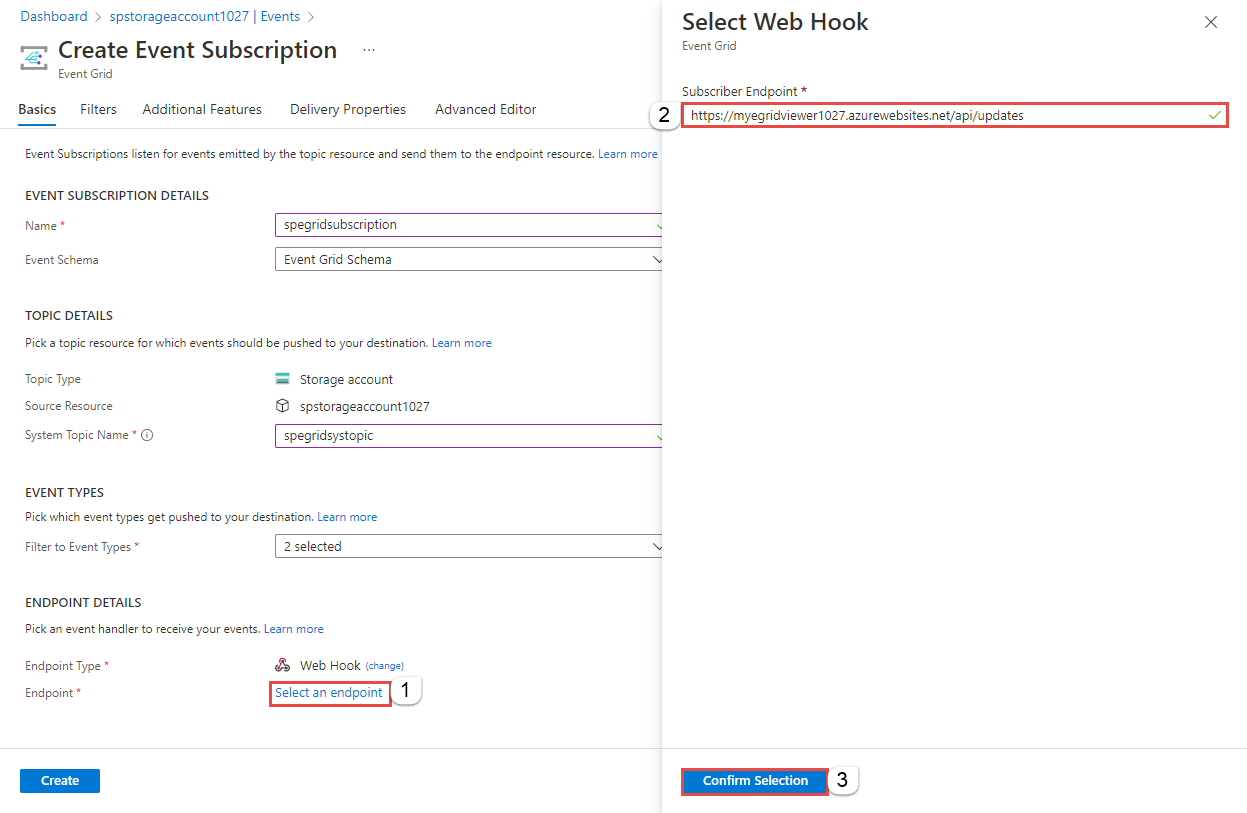
1. On the **Create Event Subscription** page, do the following steps:
2. Enter a **name** for the event subscription.
3. Enter a **name** for the **system topic**. To learn about system topics, see [Overview of system topics](https://learn.microsoft.com/en-us/azure/event-grid/system-topics).



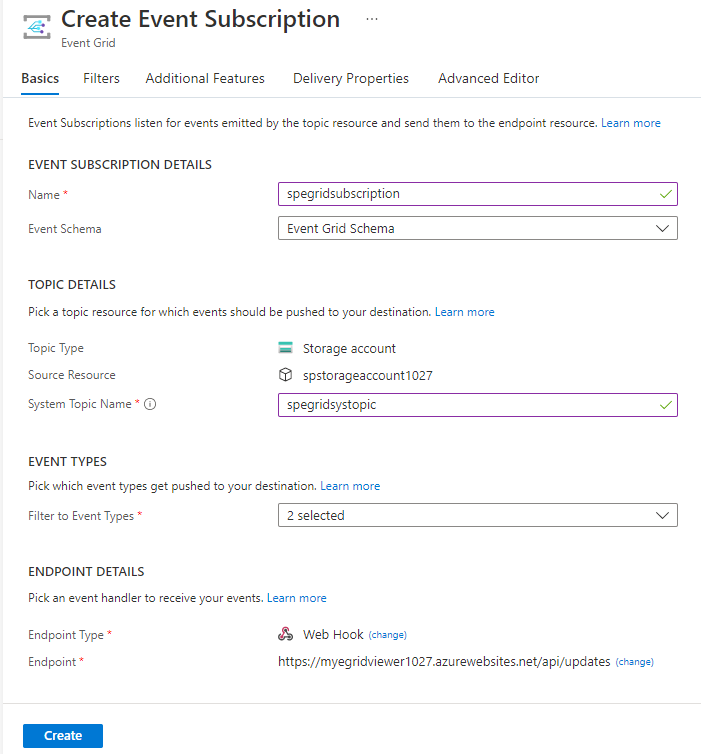
1. Select **Web Hook** for **Endpoint type**.



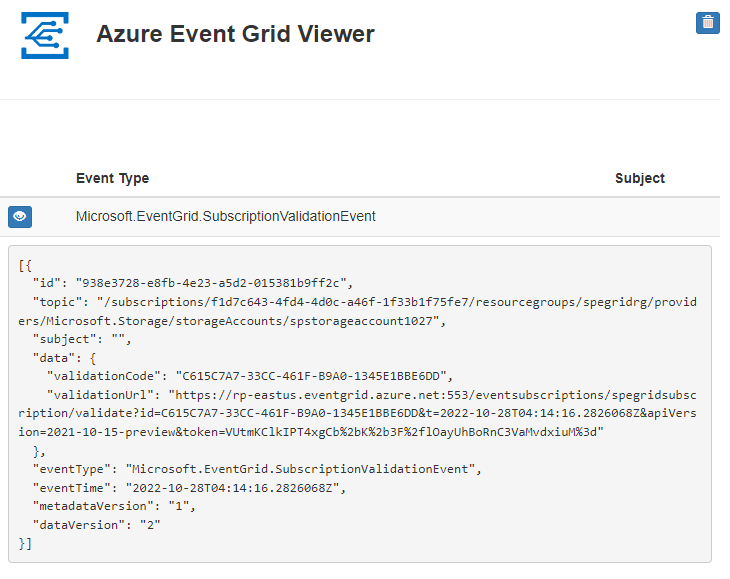
1. For **Endpoint**, click **Select an endpoint**, and enter the URL of your web app and add api/updates to the home page URL (for example: https://spegridsite.azurewebsites.net/api/updates), and then select **Confirm Selection**.

[](https://learn.microsoft.com/en-us/azure/event-grid/media/blob-event-quickstart-portal/confirm-endpoint-selection.png#lightbox)

1. Now, on the **Create Event Subscription** page, select **Create** to create the event subscription.



1. View your web app again, and notice that a subscription validation event has been sent to it. Select the eye icon to expand the event data. Event Grid sends the validation event so the endpoint can verify that it wants to receive event data. The web app includes code to validate the subscription.

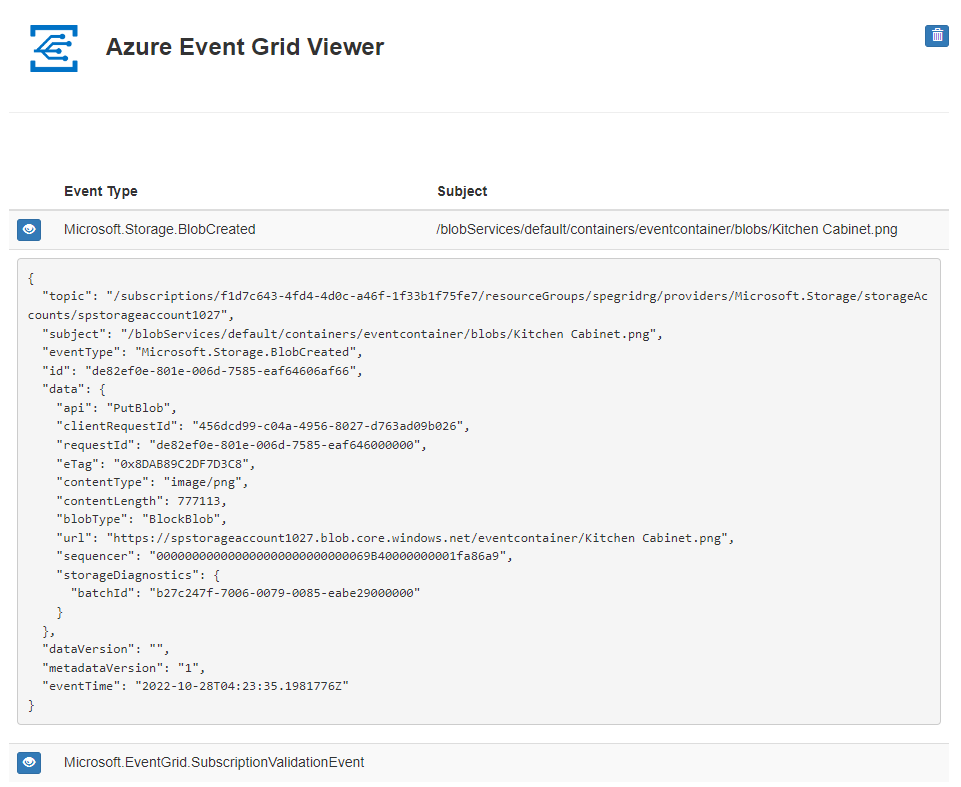


Now, let's trigger an event to see how Event Grid distributes the message to your endpoint.

### Send an event to your endpoint

You trigger an event for the Blob storage by uploading a file. The file doesn't need any specific content. The articles assumes you have a file named testfile.txt, but you can use any file.

1. In the Azure portal, navigate to your Blob storage account, and select **Containers** on the let menu.
2. Select **+ Container**. Give your container a name, and use any access level, and select **Create**.
3. Select your new container.
4. To upload a file, select **Upload**. On the **Upload blob** page, browse and select a file that you want to upload for testing, and then select **Upload** on that page.
5. Browse to your test file and upload it.
6. You've triggered the event, and Event Grid sent the message to the endpoint you configured when subscribing. The message is in the JSON format and it contains an array with one or more events. In the following example, the JSON message contains an array with one event. View your web app and notice that a **blob created** event was received.



### Clean up resources

If you plan to continue working with this event, don't clean up the resources created in this article. Otherwise, delete the resources you created in this article.

* Select the resource group, and select **Delete resource group**.

## Route custom events to web endpoint with the Azure portal and Azure Event Grid

<https://learn.microsoft.com/en-us/azure/event-grid/custom-event-quickstart-portal>

## Route Custom Events to an Azure Function with Event Grid

<https://learn.microsoft.com/en-us/azure/event-grid/custom-event-to-function>

[Azure Event Grid](https://learn.microsoft.com/en-us/azure/event-grid/overview) is an eventing service for the cloud. Azure Functions is one of the [supported event handlers](https://learn.microsoft.com/en-us/azure/event-grid/event-handlers). In this article, you use the Azure portal to create a custom topic, subscribe to the custom topic, and trigger the event to view the result. You send the events to an Azure Function.

If you don't have an [Azure subscription](https://learn.microsoft.com/en-us/azure/guides/developer/azure-developer-guide#understanding-accounts-subscriptions-and-billing), create an [Azure free account](https://azure.microsoft.com/free/?ref=microsoft.com&utm_source=microsoft.com&utm_medium=docs&utm_campaign=visualstudio) before you begin.

### Create Azure function app

1. Sign in to the [Azure portal](https://portal.azure.com/).
2. On the left navigational menu, select **All services**.
3. Select **Compute** in the list of **Categories**.
4. Hover (not select) the mouse over **Function App**, and select **Create**.
5. On the **Basics** page of the **Create Function App** wizard, follow these steps:
6. Select your **Azure subscription** in which you want to create the function app.
7. Create a new **resource group** or select an existing resource group.
8. Specify a **name** for the function app.
9. Select **.NET** for **Runtime stack**.
10. Select the **region** closest to you.
11. Select **Next: Hosting** at the bottom of the page.
12. On the **Hosting** page, create a new storage account or select an existing storage account to be associated with the function app, and then select **Review + create** at the bottom of the page.
13. On the **Review + create** page, review settings, and select **Create** at the bottom of the page to create the function app.
14. Once the deployment is successful, select **Go to resource** to navigate to the home page for the function app.

### Create a function

Before subscribing to the custom topic, create a function to handle the events.

1. On the **Function App** page, select **Functions** on the left menu.
2. Select **+ Create** on the toolbar to create a function.
3. On the **Create Function** page, follow these steps:
4. This step is optional. For **Development environment**, select the development environment that you want to use to work with the function code.
5. In the **Select a template** section, in the filter or search box, type **Azure Event Grid trigger**.
6. Select **Azure Event Grid Trigger** template in the template list.
7. In the **Template details** section in the bottom pane, enter a name for the function. In this example, it's **HandleEventsFunc**.
8. Select **Create**.
9. On the **Function** page for the **HandleEventsFunc**, select **Code + Test** on the left navigational menu.
10. Replace the code with the following code.

#r "Azure.Messaging.EventGrid"

#r "System.Memory.Data"

using Azure.Messaging.EventGrid;

using System;

public static void Run(EventGridEvent eventGridEvent, ILogger log)

{

log.LogInformation(eventGridEvent.Data.ToString());

}

1. Select **Monitor** on the left menu, and then select **Logs**.
2. Keep this window or tab of the browser open so that you can see the received event information.

### Create a custom topic

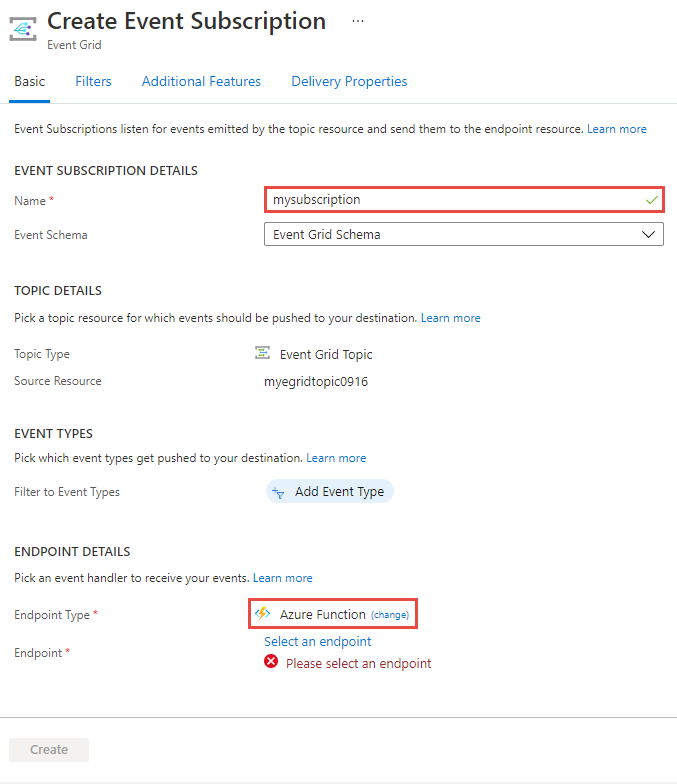
An Event Grid topic provides a user-defined endpoint that you post your events to.

1. On a new tab of the web browser window, sign in to [Azure portal](https://portal.azure.com/).
2. In the search bar at the topic, search for **Event Grid Topics**, and select **Event Grid Topics**.
3. On the **Event Grid Topics** page, select **+ Create** on the command bar.
4. On the **Create Topic** page, follow these steps:
5. Select your **Azure subscription**.
6. Select the same **resource group** from the previous steps.
7. Provide a unique **name** for the custom topic. The topic name must be unique because it's represented by a DNS entry. Don't use the name shown in the image. Instead, create your own name - it must be between 3-50 characters and contain only values a-z, A-Z, 0-9, and "-".
8. Select a **location** for the Event Grid topic.
9. Select **Review + create**.
10. On the **Review + create** page, review settings and select **Create**.
11. After the custom topic has been created, select **Go to resource** link to see the following Event Grid topic page for the topic you created.

### Subscribe to custom topic

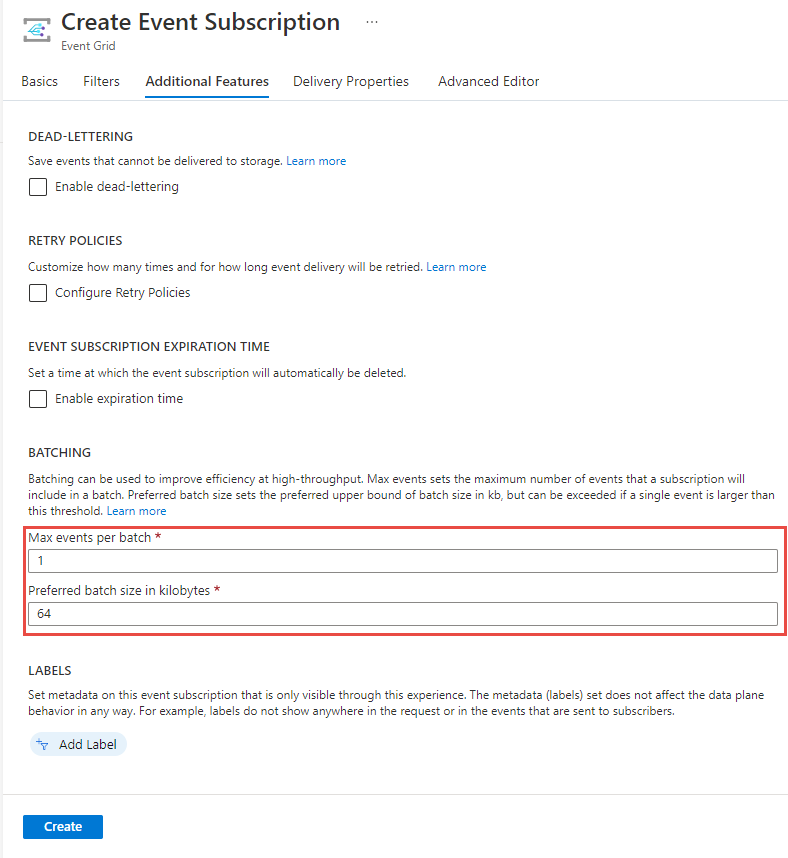
You subscribe to an Event Grid topic to tell Event Grid which events you want to track, and where to send the events.

1. Now, on the **Event Grid Topic** page for your custom topic, select **+ Event Subscription** on the toolbar.
2. On the **Create Event Subscription** page, follow these steps:
3. Enter a **name** for the event subscription.
4. Select **Azure Function** for the **Endpoint type**.
5. Choose **Select an endpoint**.



1. For the function endpoint, select the Azure Subscription and Resource Group your Function App is in and then select the Function App and function you created earlier. Select **Confirm Selection**.
2. This step is optional, but recommended for production scenarios. On the **Create Event Subscription** page, switch to the **Advanced Features** tab, and set values for **Max events per batch** and **Preferred batch size in kilobytes**.

Batching can give you high-throughput. For **Max events per batch**, set maximum number of events that a subscription will include in a batch. Preferred batch size sets the preferred upper bound of batch size in kilo bytes, but can be exceeded if a single event is larger than this threshold.



1. On the **Create Event Subscription** page, select **Create**.

### Send an event to your topic

Now, let's trigger an event to see how Event Grid distributes the message to your endpoint. Use either Azure CLI or PowerShell to send a test event to your custom topic. Typically, an application or Azure service would send the event data.

The first example uses Azure CLI. It gets the URL and key for the custom topic, and sample event data. Use your custom topic name for <topic name>. It creates sample event data. The data element of the JSON is the payload of your event. Any well-formed JSON can go in this field. You can also use the subject field for advanced routing and filtering. CURL is a utility that sends HTTP requests.

#### Azure CLI

1. In the Azure portal, select **Cloud Shell**. Select **Bash** in the top-left corner of the Cloud Shell window.
2. Set the topicname and resourcegroupname variables that will be used in the commands.

Replace TOPICNAME with the name of your Event Grid topic.

topicname="TOPICNAME"

Replace RESOURCEGROUPNAME with the name of the Azure resource group that contains the Event Grid topic.

resourcegroupname="RESOURCEGROUPNAME"

1. Run the following command to get the **endpoint** for the topic: After you copy and paste the command, update the **topic name** and **resource group name** before you run the command.

endpoint=$(az eventgrid topic show --name $topicname -g $resourcegroupname --query "endpoint" --output tsv)

1. Run the following command to get the **key** for the custom topic: After you copy and paste the command, update the **topic name** and **resource group** name before you run the command.

key=$(az eventgrid topic key list --name $topicname -g $resourcegroupname --query "key1" --output tsv)

1. Copy the following statement with the event definition, and press **ENTER**.

event='[ {"id": "'"$RANDOM"'", "eventType": "recordInserted", "subject": "myapp/vehicles/motorcycles", "eventTime": "'`date +%Y-%m-%dT%H:%M:%S%z`'", "data":{ "make": "Ducati", "model": "Monster"},"dataVersion": "1.0"} ]'

1. Run the following **Curl** command to post the event:

curl -X POST -H "aeg-sas-key: $key" -d "$event" $endpoint

#### Azure PowerShell

The second example uses PowerShell to perform similar steps.

1. In the Azure portal, select **Cloud Shell** (alternatively go to https://shell.azure.com/). Select **PowerShell** in the top-left corner of the Cloud Shell window. See the sample **Cloud Shell** window image in the Azure CLI section.
2. Set the following variables. After you copy and paste each command, update the **topic name** and **resource group name** before you run the command:

$resourceGroupName = "RESOURCEGROUPNAME"

PowerShellCopy

$topicName = "TOPICNAME"

1. Run the following commands to get the **endpoint** and the **keys** for the topic:

$endpoint = (Get-AzEventGridTopic -ResourceGroupName $resourceGroupName -Name $topicName).Endpoint

$keys = Get-AzEventGridTopicKey -ResourceGroupName $resourceGroupName -Name $topicName

1. Prepare the event. Copy and run the statements in the Cloud Shell window.

$eventID = Get-Random 99999

#Date format should be SortableDateTimePattern (ISO 8601)

$eventDate = Get-Date -Format s

#Construct body using Hashtable

$htbody = @{

id= $eventID

eventType="recordInserted"

subject="myapp/vehicles/motorcycles"

eventTime= $eventDate

data= @{

make="Ducati"

model="Monster"

}

dataVersion="1.0"

}

#Use ConvertTo-Json to convert event body from Hashtable to JSON Object

#Append square brackets to the converted JSON payload since they are expected in the event's JSON payload syntax

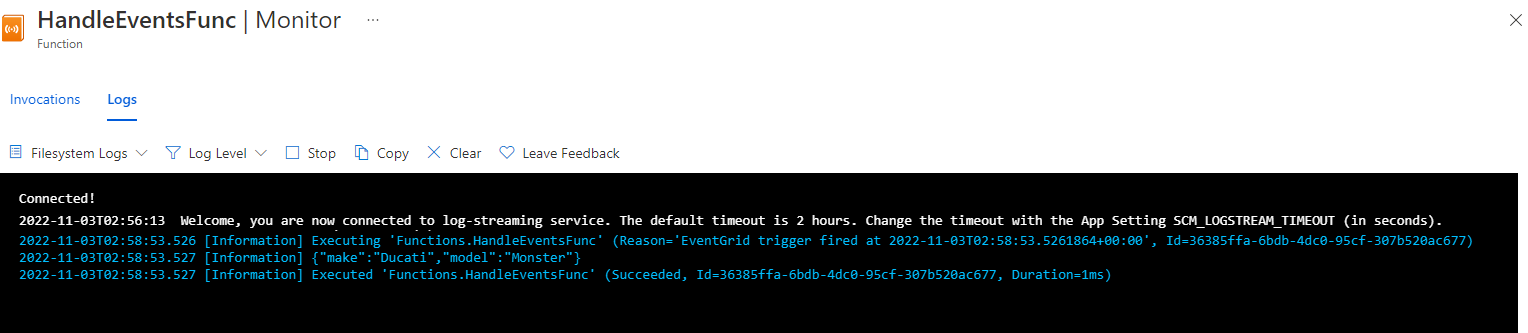
$body = "["+(ConvertTo-Json $htbody)+"]"

1. Use the **Invoke-WebRequest** cmdlet to send the event.

Invoke-WebRequest -Uri $endpoint -Method POST -Body $body -Headers @{"aeg-sas-key" = $keys.Key1}

#### Verify that function received the event

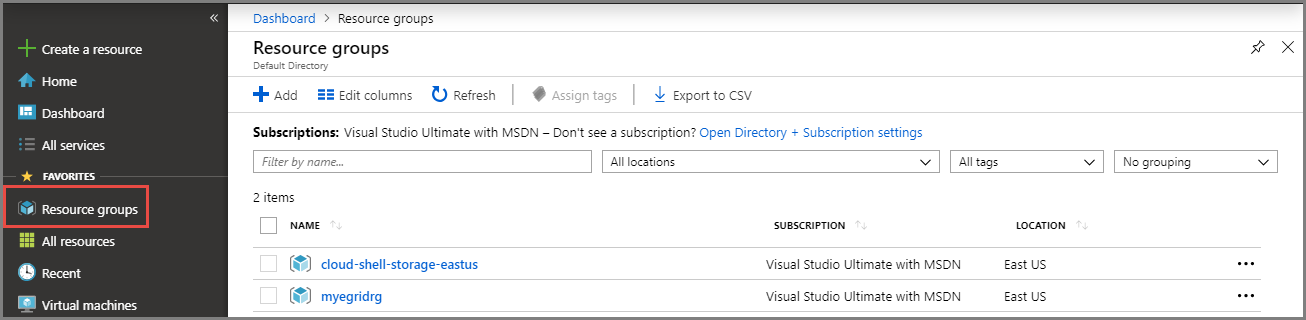
You've triggered the event, and Event Grid sent the message to the endpoint you configured when subscribing. Navigate to your Event Grid triggered function and open the logs. You should see a copy of the data payload of the event in the logs. If you don't make sure you open the logs window first, or hit reconnect, and then try sending a test event again.

[](https://learn.microsoft.com/en-us/azure/event-grid/media/custom-event-to-function/successful-function.png#lightbox)

### Clean up resources

If you plan to continue working with this event, don't clean up the resources created in this article. Otherwise, delete the resources you created in this article.

1. Select **Resource Groups** on the left menu. If you don't see it on the left menu, select **All Services** on the left menu, and select **Resource Groups**.
2. Select the resource group to launch the **Resource Group** page.
3. Select **Delete resource group** on the toolbar.
4. Confirm deletion by entering the name of the resource group, and select **Delete**.



The other resource group you see in the image was created and used by the Cloud Shell window. Delete it if you don't plan to use the Cloud Shell window later.

## Route Custom Events to Azure Queue storage via Event Grid using Azure CLI

<https://learn.microsoft.com/en-us/azure/event-grid/custom-event-to-queue-storage>

## Route Custom Events to Azure Event Hubs with Azure CLI and Event Grid

<https://learn.microsoft.com/en-us/azure/event-grid/custom-event-to-eventhub>

## Email when VM Changes

<https://learn.microsoft.com/en-us/azure/event-grid/monitor-virtual-machine-changes-logic-app>

## Resize Uploaded Images

### Step 1: Upload image data in the cloud with Azure Storage

<https://learn.microsoft.com/en-us/azure/event-grid/storage-upload-process-images?tabs=dotnet%2Cazure-powershell>

Sample web app: <https://github.com/Azure-Samples/storage-blob-upload-from-webapp>

### Step 2: Automate resizing uploaded images using Event Grid

<https://learn.microsoft.com/en-us/azure/event-grid/resize-images-on-storage-blob-upload-event?tabs=dotnet%2Cazure-powershell>

# Azure API Management

<https://learn.microsoft.com/en-us/azure/api-management/api-management-key-concepts>

## Create a new Azure API Management service instance by using the Azure portal

<https://learn.microsoft.com/en-us/azure/api-management/get-started-create-service-instance>

## Import and Publish your First API

<https://learn.microsoft.com/en-us/azure/api-management/import-and-publish>

API used: <https://conferenceapi.azurewebsites.net/?format=json>

## Create and Publish a Product

<https://learn.microsoft.com/en-us/azure/api-management/api-management-howto-add-products?tabs=azure-portal>

## Mock API Responses

<https://learn.microsoft.com/en-us/azure/api-management/mock-api-responses?tabs=azure-portal>

## Transform and Protect your API

<https://learn.microsoft.com/en-us/azure/api-management/transform-api>

## Monitor Published APIs

<https://learn.microsoft.com/en-us/azure/api-management/api-management-howto-use-azure-monitor>

## Debug your APIs using Request Tracing

<https://learn.microsoft.com/en-us/azure/api-management/api-management-howto-api-inspector>

## Add Revisions – Use Revisions to make Non-Breaking API changes safely

<https://learn.microsoft.com/en-us/azure/api-management/api-management-get-started-revise-api?tabs=azure-portal>

## Add Multiple Versions – Publish Multiple Versions of your API

<https://learn.microsoft.com/en-us/azure/api-management/api-management-get-started-publish-versions>

## Access and Customize the Developer Portal

<https://learn.microsoft.com/en-us/azure/api-management/api-management-howto-developer-portal-customize>

## Manage APIs in VS Code – Use the API Management Extension for Visual Studio Code to import and manage APIs

<https://learn.microsoft.com/en-us/azure/api-management/visual-studio-code-tutorial>

## Create a new Azure API Management service instance using Visual Studio Code

<https://learn.microsoft.com/en-us/azure/api-management/vscode-create-service-instance>

## Introduction to Azure API Management - Training

<https://learn.microsoft.com/en-us/training/modules/introduction-to-azure-api-management/>

# Azure Service Bus

<https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-messaging-overview>

Azure Service Bus is a fully managed enterprise message broker with message queues and publish-subscribe topics (in a namespace). Service Bus is used to decouple applications and services from each other, providing the following benefits:

* Load-balancing work across competing workers
* Safely routing and transferring data and control across service and application boundaries
* Coordinating transactional work that requires a high degree of reliability

## Overview

Data is transferred between different applications and services using **messages**. A message is a container decorated with metadata and contains data. The data can be any kind of information, including structured data encoded with the common formats such as the following ones: JSON, XML, Apache Avro, Plain Text.

Some common messaging scenarios are:

* **Messaging**. Transfer business data, such as sales or purchase orders, journals, or inventory movements.
* **Decouple applications**. Improve reliability and scalability of applications and services. Producer and consumer don't have to be online or readily available at the same time. The [load is leveled](https://learn.microsoft.com/en-us/azure/architecture/patterns/queue-based-load-leveling) such that traffic spikes don't overtax a service.
* **Load balancing**. Allow for multiple [competing consumers](https://learn.microsoft.com/en-us/azure/architecture/patterns/competing-consumers) to read from a queue at the same time, each safely obtaining exclusive ownership to specific messages.
* **Topics and subscriptions**. Enable 1:n relationships between [publishers and subscribers](https://learn.microsoft.com/en-us/azure/architecture/patterns/publisher-subscriber), allowing subscribers to select particular messages from a published message stream.
* **Transactions**. Allows you to do several operations, all in the scope of an atomic transaction. For example, the following operations can be done in the scope of a transaction.

1. Obtain a message from one queue.
2. Post results of processing to one or more different queues.
3. Move the input message from the original queue.

The results become visible to downstream consumers only upon success, including the successful settlement of input message, allowing for once-only processing semantics. This transaction model is a robust foundation for the [compensating transactions](https://learn.microsoft.com/en-us/azure/architecture/patterns/compensating-transaction) pattern in the greater solution context.

* **Message sessions**. Implement high-scale coordination of workflows and multiplexed transfers that require strict message ordering or message deferral.

If you're familiar with other message brokers like Apache ActiveMQ, Service Bus concepts are similar to what you know. As Service Bus is a platform-as-a-service (PaaS) offering, a key difference is that you don't need to worry about the following actions. Azure takes care of those chores for you.

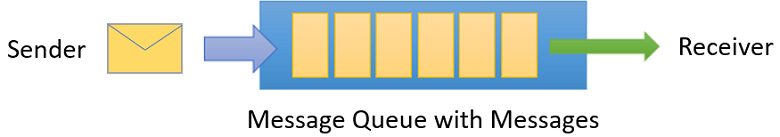
* Worrying about hardware failures
* Keeping the operating systems or the products patched
* Placing logs and managing disk space
* Handling backups
* Failing over to a reserve machine

## Concepts

This section discusses basic concepts of Service Bus.

### Queues

Messages are sent to and received from **queues**. Queues store messages until the receiving application is available to receive and process them.



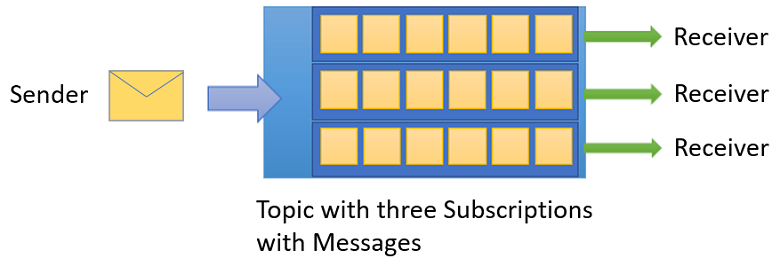
Messages in queues are ordered and timestamped on arrival. Once the broker accepts the message, the message is always held durably in triple-redundant storage, spread across availability zones if the namespace is zone-enabled. Service Bus keeps messages in memory or volatile storage until they've been reported by the client as accepted.

Messages are delivered in **pull** mode, only delivering messages when requested. Unlike the busy-polling model of some other cloud queues, the pull operation can be long-lived and only complete once a message is available.

**Note**: For a comparison of Service Bus queues with Storage queues, see [**Storage queues and Service Bus queues - compared and contrasted**](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-azure-and-service-bus-queues-compared-contrasted).

### Topics

You can also use **topics** to send and receive messages. While a queue is often used for point-to-point communication, topics are useful in publish/subscribe scenarios.



Topics can have multiple, independent subscriptions, which attach to the topic and otherwise work exactly like queues from the receiver side. A subscriber to a topic can receive a copy of each message sent to that topic. Subscriptions are named entities. Subscriptions are durable by default, but can be configured to expire and then be automatically deleted. Via the Java Message Service (JMS) API, Service Bus Premium also allows you to create volatile subscriptions that exist for the duration of the connection.

You can define rules on a subscription. A subscription rule has a **filter** to define a condition for the message to be copied into the subscription and an optional **action** that can modify message metadata. For more information, see [Topic filters and actions](https://learn.microsoft.com/en-us/azure/service-bus-messaging/topic-filters). This feature is useful in the following scenarios:

* You don't want a subscription to receive all messages sent to a topic.
* You want to mark up messages with extra metadata when they pass through a subscription.

### Namespaces

A namespace is a container for all messaging components (queues and topics). Multiple queues and topics can be in a single namespace, and namespaces often serve as application containers.

A namespace can be compared to a server in the terminology of other brokers, but the concepts aren't directly equivalent. A Service Bus namespace is your own capacity slice of a large cluster made up of dozens of all-active virtual machines. It may optionally span three [Azure availability zones](https://learn.microsoft.com/en-us/azure/availability-zones/az-overview). So, you get all the availability and robustness benefits of running the message broker at enormous scale. And, you don't need to worry about underlying complexities. Service Bus is serverless messaging.

## Advanced features

Service Bus also has advanced features that enable you to solve more complex messaging problems. The following sections describe these key features:

### Message sessions

To realize a first-in, first-out (**FIFO**) guarantee in processing messages in Service Bus queue or subscriptions, use sessions. Sessions can also be used in implementing request-response patterns. The **request-response pattern** enables the sender application to send a request and provides a way for the receiver to correctly send a response back to the sender application. For more information, see [Message sessions](https://learn.microsoft.com/en-us/azure/service-bus-messaging/message-sessions)

### Auto-forwarding

The **Auto-forwarding** feature enables you to chain a queue or subscription to another queue or topic that is part of the same namespace. When auto-forwarding is enabled, Service Bus automatically removes messages that are placed in the first queue or subscription (source) and puts them in the second queue or topic (destination). For more information, see [Chaining Service Bus entities with auto-forwarding](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-auto-forwarding)

### Dead-lettering

Service Bus queues and topic subscriptions provide a secondary subqueue, called a dead-letter queue (DLQ). The dead letter queue holds messages that can't be delivered to any receiver, or messages that can't be processed. You can then remove messages from the DLQ and inspect them. An application might, with help of an operator, correct issues and resubmit the message, log the fact that there was an error, and take a corrective action. For more information, see [Overview of Service Bus dead-letter queues](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-dead-letter-queues).

### Scheduled delivery

You can submit messages to a queue or topic for delayed processing. For example, to schedule a job to become available for processing by a system at a certain time. For more information, see [Scheduled messages](https://learn.microsoft.com/en-us/azure/service-bus-messaging/message-sequencing#scheduled-messages).

### Message deferral

When a queue or subscription client receives a message that it's willing to process, but for which processing isn't currently possible because of special circumstances within the application, the entity can defer retrieval of the message to a later point. The message remains in the queue or subscription, but it's set aside. For more information, see [Message deferral](https://learn.microsoft.com/en-us/azure/service-bus-messaging/message-deferral).

### Transactions

A transaction groups two or more operations together into an execution scope. Service Bus supports grouping operations against a single messaging entity (queue, topic, subscription) within the scope of a transaction. For more information, see [Overview of Service Bus transaction processing](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-transactions).

### Filters and actions

Subscribers can define which messages they want to receive from a topic. These messages are specified in the form of one or more named subscription rules. Each rule consists of a **filter condition** that selects particular messages, and **optionally** contains an **action** that annotates the selected message. For each matching rule condition, the subscription produces a copy of the message, which may be differently annotated for each matching rule. For more information, see [Topic filters and actions](https://learn.microsoft.com/en-us/azure/service-bus-messaging/topic-filters).

### Auto-delete on idle

[Auto-delete on idle](https://learn.microsoft.com/en-us/dotnet/api/microsoft.servicebus.messaging.queuedescription.autodeleteonidle) enables you to specify an idle interval after which the queue is automatically deleted. The interval is reset when there's traffic on the queue. The minimum duration is 5 minutes.

### Duplicate detection

If an error occurs that causes the client to have any doubt about the outcome of a send operation, duplicate detection takes the doubt out of these situations by enabling the sender to resend the same message, and the queue or topic discards any duplicate copies. For more information, see [Duplicate detection](https://learn.microsoft.com/en-us/azure/service-bus-messaging/duplicate-detection).

### Security

Service Bus supports security protocols such as [Shared Access Signatures](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-sas) (SAS), [Role Based Access Control (RBAC)](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-role-based-access-control) (RBAC) and [Managed identities for Azure resources](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-managed-service-identity).

Service Bus supports standard [Advanced Message Queuing Protocol (AMQP) 1.0](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-amqp-overview) and [HTTP/REST](https://learn.microsoft.com/en-us/rest/api/servicebus/) protocols.

### Geo-disaster recovery

When Azure regions or datacenters experience downtime, [Geo-disaster recovery](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-geo-dr) enables data processing to continue operating in a different region or datacenter.

## Integration

Service Bus fully integrates with many Microsoft and Azure services, for instance:

* [Event Grid](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-to-event-grid-integration-example)
* [Logic Apps](https://learn.microsoft.com/en-us/azure/connectors/connectors-create-api-servicebus)
* [Azure Functions](https://learn.microsoft.com/en-us/azure/azure-functions/functions-bindings-service-bus)
* [Power Platform](https://learn.microsoft.com/en-us/azure/connectors/connectors-create-api-servicebus)
* [Dynamics 365](https://learn.microsoft.com/en-us/dynamics365/fin-ops-core/dev-itpro/business-events/how-to/how-to-servicebus)
* [Azure Stream Analytics](https://learn.microsoft.com/en-us/azure/stream-analytics/stream-analytics-define-outputs)

## Azure Service Bus Queues

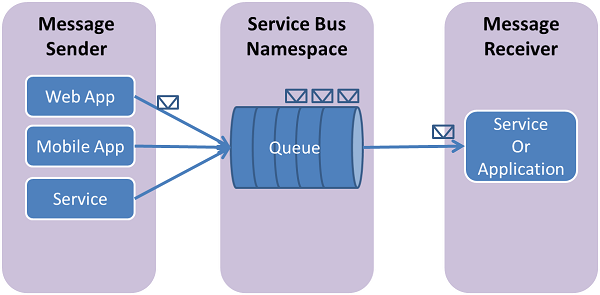
### Create a Service Bus Queue Namespace and Queue using the Azure Portal

<https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-quickstart-portal>

This quickstart shows you how to create a Service Bus namespace and a queue using the [Azure portal](https://portal.azure.com/). It also shows you how to get authorization credentials that a client application can use to send/receive messages to/from the queue.

#### What are Service Bus queues?

Service Bus queues support a **brokered messaging** communication model. When using queues, components of a distributed application do not communicate directly with each other; instead, they exchange messages via a queue, which acts as an intermediary (broker). A message producer (sender) hands off a message to the queue and then continues its processing. Asynchronously, a message consumer (receiver) pulls the message from the queue and processes it. The producer does not have to wait for a reply from the consumer in order to continue to process and send further messages. Queues offer **First In, First Out (FIFO)** message delivery to one or more competing consumers. That is, messages are typically received and processed by the receivers in the order in which they were added to the queue, and each message is received and processed by only one message consumer.



Service Bus queues are a general-purpose technology that can be used for a wide variety of scenarios:

* Communication between web and worker roles in a multi-tier Azure application.
* Communication between on-premises apps and Azure-hosted apps in a hybrid solution.
* Communication between components of a distributed application running on-premises in different organizations or departments of an organization.

Using queues enables you to scale your applications more easily, and enable more resiliency to your architecture.

#### Prerequisites

To complete this quickstart, make sure you have an Azure subscription. If you don't have an Azure subscription, you can create a [free account](https://azure.microsoft.com/free/?ref=microsoft.com&utm_source=microsoft.com&utm_medium=docs&utm_campaign=visualstudio) before you begin.

#### Create a namespace in the Azure portal

To begin using Service Bus messaging entities in Azure, you must first create a namespace with a name that is unique across Azure. A namespace provides a scoping container for Service Bus resources within your application.

To create a namespace:

1. Sign in to the [Azure portal](https://portal.azure.com/)
2. In the left navigation pane of the portal, select **All services**, select **Integration** from the list of categories, hover the mouse over **Service Bus**, and then select **Create** on the Service Bus tile.
3. In the **Basics** tag of the **Create namespace** page, follow these steps:
   1. For **Subscription**, choose an Azure subscription in which to create the namespace.
   2. For **Resource group**, choose an existing resource group in which the namespace will live, or create a new one.
   3. Enter a **name for the namespace**. The namespace name should adhere to the following naming conventions:
   * The name must be unique across Azure. The system immediately checks to see if the name is available.
   * The name length is at least 6 and at most 50 characters.
   * The name can contain only letters, numbers, hyphens “-“.
   * The name must start with a letter and end with a letter or number.
   * The name doesn't end with “-sb“ or “-mgmt“.
4. For **Location**, choose the region in which your namespace should be hosted.
5. For **Pricing tier**, select the pricing tier (Basic, Standard, or Premium) for the namespace. For this quickstart, select **Standard**.

**Important**: If you want to use [**topics and subscriptions**](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-queues-topics-subscriptions#topics-and-subscriptions), choose either Standard or Premium. Topics/subscriptions aren't supported in the Basic pricing tier.

If you selected the **Premium** pricing tier, specify the number of **messaging units**. The premium tier provides resource isolation at the CPU and memory level so that each workload runs in isolation. This resource container is called a messaging unit. A premium namespace has at least one messaging unit. You can select 1, 2, 4, 8 or 16 messaging units for each Service Bus Premium namespace. For more information, see [Service Bus Premium Messaging](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-premium-messaging).

1. Select **Review + create** at the bottom of the page.
2. On the **Review + create** page, review settings, and select **Create**.
3. Once the deployment of the resource is successful, select **Go to resource** on the deployment page.
4. You see the home page for your service bus namespace.

#### Create a queue in the Azure portal

1. On the **Service Bus Namespace** page, select **Queues** in the left navigational menu.
2. On the **Queues** page, select **+ Queue** on the toolbar.
3. Enter a **name** for the queue, and leave the other values with their defaults.
4. Now, select **Create**.

### QuickStart: Send and Receive Messages from an Azure Service Bus Queue (.NET)

<https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-dotnet-get-started-with-queues?tabs=passwordless>

<https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-dotnet-get-started-with-queues?tabs=connection-string>

<https://github.com/Azure/azure-sdk-for-net/blob/main/sdk/servicebus/Azure.Messaging.ServiceBus/samples/Sample01_SendReceive.md>

<https://github.com/Azure/azure-service-bus/tree/master/samples/DotNet/Azure.Messaging.ServiceBus>

In this quickstart, you'll do the following steps:

1. Create a Service Bus namespace, using the Azure portal.
2. Create a Service Bus queue, using the Azure portal.
3. Write a .NET console application to send a set of messages to the queue.
4. Write a .NET console application to receive those messages from the queue.

**Note**: This quick start provides step-by-step instructions to implement a simple scenario of sending a batch of messages to a Service Bus queue and then receiving them. For an overview of the .NET client library, see [**Azure Service Bus client library for .NET**](https://github.com/Azure/azure-sdk-for-net/blob/main/sdk/servicebus/Azure.Messaging.ServiceBus/README.md). For more samples, see [**Service Bus .NET samples on GitHub**](https://github.com/Azure/azure-sdk-for-net/tree/master/sdk/servicebus/Azure.Messaging.ServiceBus/samples).

#### Prerequisites

If you're new to the service, see [Service Bus overview](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-messaging-overview) before you do this quickstart.

* **Azure subscription**. To use Azure services, including Azure Service Bus, you need a subscription. If you don't have an existing Azure account, you can sign up for a [free trial](https://azure.microsoft.com/free/dotnet).
* **Visual Studio 2022**. The sample application makes use of new features that were introduced in C# 10. You can still use the Service Bus client library with previous C# language versions, but the syntax may vary. To use the latest syntax, we recommend that you install .NET 6.0 or higher and set the language version to latest. If you're using Visual Studio, versions before Visual Studio 2022 aren't compatible with the tools needed to build C# 10 projects.

#### Create a namespace in the Azure portal

To begin using Service Bus messaging entities in Azure, you must first create a namespace with a name that is unique across Azure. A namespace provides a scoping container for Service Bus resources within your application.

To create a namespace:

1. Sign in to the [Azure portal](https://portal.azure.com/)
2. In the left navigation pane of the portal, select **All services**, select **Integration** from the list of categories, hover the mouse over **Service Bus**, and then select **Create** on the Service Bus tile.
3. In the **Basics** tag of the **Create namespace** page, follow these steps:
   1. For **Subscription**, choose an Azure subscription in which to create the namespace.
   2. For **Resource group**, choose an existing resource group in which the namespace will live, or create a new one.
   3. Enter a **name for the namespace**. The namespace name should adhere to the following naming conventions:

* The name must be unique across Azure. The system immediately checks to see if the name is available.
* The name length is at least 6 and at most 50 characters.
* The name can contain only letters, numbers, hyphens “-“.
* The name must start with a letter and end with a letter or number.
* The name doesn't end with “-sb“ or “-mgmt“.
  1. For **Location**, choose the region in which your namespace should be hosted.
  2. For **Pricing tier**, select the pricing tier (Basic, Standard, or Premium) for the namespace. For this quickstart, select **Standard**.

**Important:** If you want to use [**topics and subscriptions**](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-queues-topics-subscriptions#topics-and-subscriptions), choose either Standard or Premium. Topics/subscriptions aren't supported in the Basic pricing tier.

If you selected the **Premium** pricing tier, specify the number of **messaging units**. The premium tier provides resource isolation at the CPU and memory level so that each workload runs in isolation. This resource container is called a messaging unit. A premium namespace has at least one messaging unit. You can select 1, 2, 4, 8 or 16 messaging units for each Service Bus Premium namespace. For more information, see [Service Bus Premium Messaging](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-premium-messaging).

* 1. Select **Review + create** at the bottom of the page.
  2. On the **Review + create** page, review settings, and select **Create**.

1. Once the deployment of the resource is successful, select **Go to resource** on the deployment page.
2. You see the home page for your service bus namespace.

#### Create a queue in the Azure portal

1. On the **Service Bus Namespace** page, select **Queues** in the left navigational menu.
2. On the **Queues** page, select **+ Queue** on the toolbar.
3. Enter a **name** for the queue and leave the other values with their defaults.
4. Now, select **Create**.

#### Authenticate the app to Azure

This quick start shows you two ways of connecting to Azure Service Bus: **passwordless** and **connection string**.

The first option shows you how to use your security principal in Azure Active Directory and role-based access control (RBAC) to connect to a Service Bus namespace. You don't need to worry about having hard-coded connection string in your code or in a configuration file or in a secure storage like Azure Key Vault.

The second option shows you how to use a connection string to connect to a Service Bus namespace. If you are new to Azure, you may find the connection string option easier to follow. We recommend using the passwordless option in real-world applications and production environments. For more information, see [Authentication and authorization](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-authentication-and-authorization). You can also read more about passwordless authentication on the [overview page](https://learn.microsoft.com/en-us/dotnet/azure/sdk/authentication?tabs=command-line).

##### Passwordless (Recommended)

###### Assign roles to your Azure AD user

When developing locally, make sure that the user account that connects to Azure Service Bus has the correct permissions. You'll need the [Azure Service Bus Data Owner](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#azure-service-bus-data-owner) role in order to send and receive messages. To assign yourself this role, you'll need the User Access Administrator role, or another role that includes the Microsoft.Authorization/roleAssignments/write action. You can assign Azure RBAC roles to a user using the Azure portal, Azure CLI, or Azure PowerShell. Learn more about the available scopes for role assignments on the [scope overview](https://learn.microsoft.com/en-us/azure/role-based-access-control/scope-overview) page.

The following example assigns the Azure Service Bus Data Owner role to your user account, which provides full access to Azure Service Bus resources. In a real scenario, follow the [Principle of Least Privilege](https://learn.microsoft.com/en-us/azure/active-directory/develop/secure-least-privileged-access) to give users only the minimum permissions needed for a more secure production environment.

###### Azure built-in roles for Azure Service Bus

For Azure Service Bus, the management of namespaces and all related resources through the Azure portal and the Azure resource management API is already protected using the Azure RBAC model. Azure provides the below Azure built-in roles for authorizing access to a Service Bus namespace:

* [Azure Service Bus Data Owner](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#azure-service-bus-data-owner): Enables data access to Service Bus namespace and its entities (queues, topics, subscriptions, and filters). A member of this role can send and receive messages from queues or topics/subscriptions.
* [Azure Service Bus Data Sender](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#azure-service-bus-data-sender): Use this role to give the send access to Service Bus namespace and its entities.
* [Azure Service Bus Data Receiver](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#azure-service-bus-data-receiver): Use this role to give the receive access to Service Bus namespace and its entities.

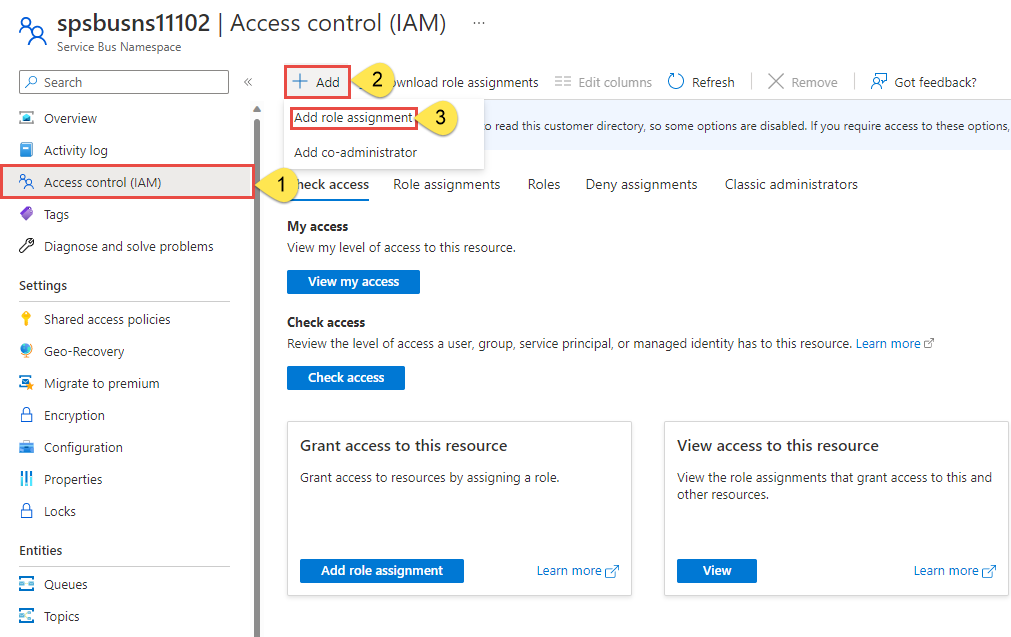
If you want to create a custom role, see [Rights required for Service Bus operations](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-sas#rights-required-for-service-bus-operations).

Add Azure AD user to Azure Service Bus Owner role

Add your Azure AD user name to the **Azure Service Bus Data Owner** role at the Service Bus namespace level. It will allow an app running in the context of your user account to send messages to a queue or a topic, and receive messages from a queue or a topic's subscription.

**Important**: In most cases, it will take a minute or two for the role assignment to propagate in Azure. In rare cases, it may take up to **eight minutes**. If you receive authentication errors when you first run your code, wait a few moments and try again.

1. If you don't have the Service Bus Namespace page open in the Azure portal, locate your Service Bus namespace using the main search bar or left navigation.
2. On the overview page, select **Access control (IAM)** from the left-hand menu.
3. On the **Access control (IAM)** page, select the **Role assignments** tab.
4. Select **+ Add** from the top menu and then **Add role assignment** from the resulting drop-down menu.



1. Use the search box to filter the results to the desired role. For this example, search for Azure Service Bus Data Owner and select the matching result. Then choose **Next**.
2. Under **Assign access to**, select **User, group, or service principal**, and then choose **+ Select members**.
3. In the dialog, search for your Azure AD username (usually your user@domain email address) and then choose **Select** at the bottom of the dialog.
4. Select **Review + assign** to go to the final page, and then **Review + assign** again to complete the process.

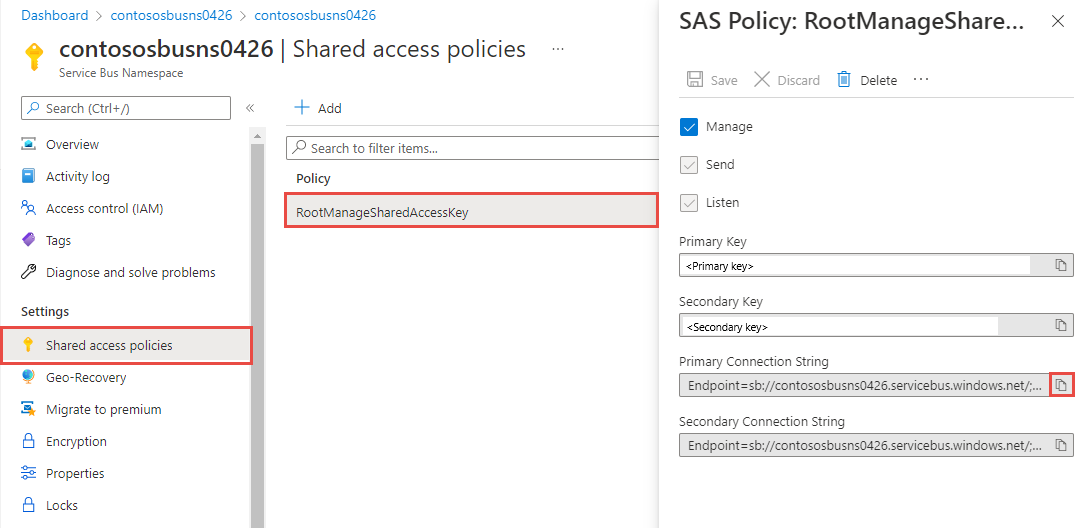
##### Connection String

###### Get the connection string

Creating a new namespace automatically generates an initial Shared Access Signature (SAS) policy with primary and secondary keys, and primary and secondary connection strings that each grant full control over all aspects of the namespace. See [Service Bus authentication and authorization](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-authentication-and-authorization) for information about how to create rules with more constrained rights for regular senders and receivers.

A client can use the connection string to connect to the Service Bus namespace. To copy the primary connection string for your namespace, follow these steps:

1. On the **Service Bus Namespace** page, select **Shared access policies** on the left menu.
2. On the **Shared access policies** page, select **RootManageSharedAccessKey**.
3. In the **Policy: RootManageSharedAccessKey** window, select the copy button next to **Primary Connection String**, to copy the connection string to your clipboard for later use. Paste this value into Notepad or some other temporary location.

[](https://learn.microsoft.com/en-us/azure/includes/passwordless/service-bus/media/service-bus-create-namespace-portal/connection-string.png#lightbox)

You can use this page to copy primary key, secondary key, primary connection string, and secondary connection string.

#### Launch Visual Studio and sign-in to Azure

You can authorize access to the service bus namespace using the following steps:

1. Launch Visual Studio. If you see the **Get started** window, select the **Continue without code** link in the right pane.
2. Select the **Sign in** button in the top right of Visual Studio.
3. Sign-in using the Azure AD account you assigned a role to previously.

#### Send Messages to the Queue

This section shows you how to create a .NET console application to send messages to a Service Bus queue.

**Note**: This quick start provides step-by-step instructions to implement a simple scenario of sending a batch of messages to a Service Bus queue and then receiving them. For more samples on other and advanced scenarios, see [**Service Bus .NET samples on GitHub**](https://github.com/Azure/azure-sdk-for-net/tree/master/sdk/servicebus/Azure.Messaging.ServiceBus/samples).

**Solution**: <https://github.com/AjaySingala/dotNetFullStackDemos/tree/main/Azure/ServiceBusConsoleApp/ServiceBusConsoleApp.sln>

**Project**: QueueSender

##### Create a console application

1. In Visual Studio, select **File** -> **New** -> **Project** menu.
2. On the **Create a new project** dialog box, do the following steps: If you don't see this dialog box, select **File** on the menu, select **New**, and then select **Project**.
   1. Select **C#** for the programming language.
   2. Select **Console** for the type of the application.
   3. Select **Console App** from the results list.
   4. Then, select **Next**.
3. Enter **QueueSender** for the project name, **ServiceBusQueueQuickStart** for the solution name, and then select **Next**.
4. On the **Additional information** page, select **Create** to create the solution and the project.

##### Without Top-Level Statements

If you create the project without top-level statements, use this code for the Main method:

public static void Main(string[] args)

{

MainAsync().GetAwaiter().GetResult();

}

static async Task MainAsync()

{

const int numberOfMessages = 5;

Console.WriteLine("================================================");

Console.WriteLine("Press any key to exit after sending the message.");

Console.WriteLine("================================================");

// Your methods called from here.

//SendMessages(3);

//ReceiveMessages();

SendMessageBatch();

Console.ReadKey();

}

##### Add the NuGet packages to the project

###### Passwordless

1. Select Tools > NuGet Package Manager > Package Manager Console from the menu.
2. Run the following command to install the Azure.Messaging.ServiceBus NuGet package.

Install-Package Azure.Messaging.ServiceBus

1. Run the following command to install the **Azure.Identity** NuGet package.

Install-Package Azure.Identity

###### Connection String

1. Select Tools > NuGet Package Manager > Package Manager Console from the menu.
2. Run the following command to install the Azure.Messaging.ServiceBus NuGet package:

Install-Package Azure.Messaging.ServiceBus

##### Add code to send messages to the queue

1. Replace the contents of Program.cs with the following code. The important steps are outlined below, with additional information in the code comments.

###### Passwordless

* Creates a [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object using the DefaultAzureCredential object. DefaultAzureCredential will automatically discover and use the credentials of your Visual Studio login to authenticate to Azure Service Bus.
* Invokes the [CreateSender](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient.createsender) method on the [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object to create a [ServiceBusSender](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender) object for the specific Service Bus queue.
* Creates a [ServiceBusMessageBatch](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusmessagebatch) object by using the [ServiceBusSender.CreateMessageBatchAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender.createmessagebatchasync) method.
* Add messages to the batch using the [ServiceBusMessageBatch.TryAddMessage](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusmessagebatch.tryaddmessage).
* Sends the batch of messages to the Service Bus queue using the [ServiceBusSender.SendMessagesAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender.sendmessagesasync) method.

**Important**: Update placeholder values (<NAMESPACE-CONNECTION-STRING> and <QUEUE-NAME>) in the code snippet with names of your Service Bus namespace and queue.

using Azure.Messaging.ServiceBus;

using Azure.Identity;

// name of your Service Bus queue

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the sender used to publish messages to the queue

ServiceBusSender sender;

// number of messages to be sent to the queue

const int numOfMessages = 3;

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Set the transport type to AmqpWebSockets so that the ServiceBusClient uses the port 443.

// If you use the default AmqpTcp, ensure that ports 5671 and 5672 are open.

var clientOptions = new ServiceBusClientOptions

{

TransportType = ServiceBusTransportType.AmqpWebSockets

};

//TODO: Replace the "<NAMESPACE-NAME>" and "<QUEUE-NAME>" placeholders.

client = new ServiceBusClient(

"<NAMESPACE-NAME>.servicebus.windows.net",

new DefaultAzureCredential(),

clientOptions);

sender = client.CreateSender("<QUEUE-NAME>");

// create a batch

using ServiceBusMessageBatch messageBatch = await sender.CreateMessageBatchAsync();

for (int i = 1; i <= numOfMessages; i++)

{

// try adding a message to the batch

if (!messageBatch.TryAddMessage(new ServiceBusMessage($"Message {i}")))

{

// if it is too large for the batch

throw new Exception($"The message {i} is too large to fit in the batch.");

}

}

try

{

// Use the producer client to send the batch of messages to the Service Bus queue

await sender.SendMessagesAsync(messageBatch);

Console.WriteLine($"A batch of {numOfMessages} messages has been published to the queue.");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await sender.DisposeAsync();

await client.DisposeAsync();

}

Console.WriteLine("Press any key to end the application");

Console.ReadKey();

###### Connection String

* Creates a [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object using the connection string.
* Invokes the [CreateSender](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient.createsender) method on the [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object to create a [ServiceBusSender](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender) object for the specific Service Bus queue.
* Creates a [ServiceBusMessageBatch](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusmessagebatch) object by using the [ServiceBusSender.CreateMessageBatchAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender.createmessagebatchasync) method.
* Add messages to the batch using the [ServiceBusMessageBatch.TryAddMessage](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusmessagebatch.tryaddmessage).
* Sends the batch of messages to the Service Bus queue using the [ServiceBusSender.SendMessagesAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender.sendmessagesasync) method.

**Important**: Update placeholder values (<NAMESPACE-CONNECTION-STRING> and <QUEUE-NAME>) in the code snippet with names of your Service Bus namespace and queue.

using Azure.Messaging.ServiceBus;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the sender used to publish messages to the queue

ServiceBusSender sender;

// number of messages to be sent to the queue

const int numOfMessages = 3;

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// set the transport type to AmqpWebSockets so that the ServiceBusClient uses the port 443.

// If you use the default AmqpTcp, you will need to make sure that the ports 5671 and 5672 are open

// TODO: Replace the <NAMESPACE-CONNECTION-STRING> and <QUEUE-NAME> placeholders

var clientOptions = new ServiceBusClientOptions()

{

TransportType = ServiceBusTransportType.AmqpWebSockets

};

client = new ServiceBusClient("<NAMESPACE-CONNECTION-STRING>", clientOptions);

sender = client.CreateSender("<QUEUE-NAME>");

// create a batch

using ServiceBusMessageBatch messageBatch = await sender.CreateMessageBatchAsync();

for (int i = 1; i <= numOfMessages; i++)

{

// try adding a message to the batch

if (!messageBatch.TryAddMessage(new ServiceBusMessage($"Message {i}")))

{

// if it is too large for the batch

throw new Exception($"The message {i} is too large to fit in the batch.");

}

}

try

{

// Use the producer client to send the batch of messages to the Service Bus queue

await sender.SendMessagesAsync(messageBatch);

Console.WriteLine($"A batch of {numOfMessages} messages has been published to the queue.");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await sender.DisposeAsync();

await client.DisposeAsync();

}

Console.WriteLine("Press any key to end the application");

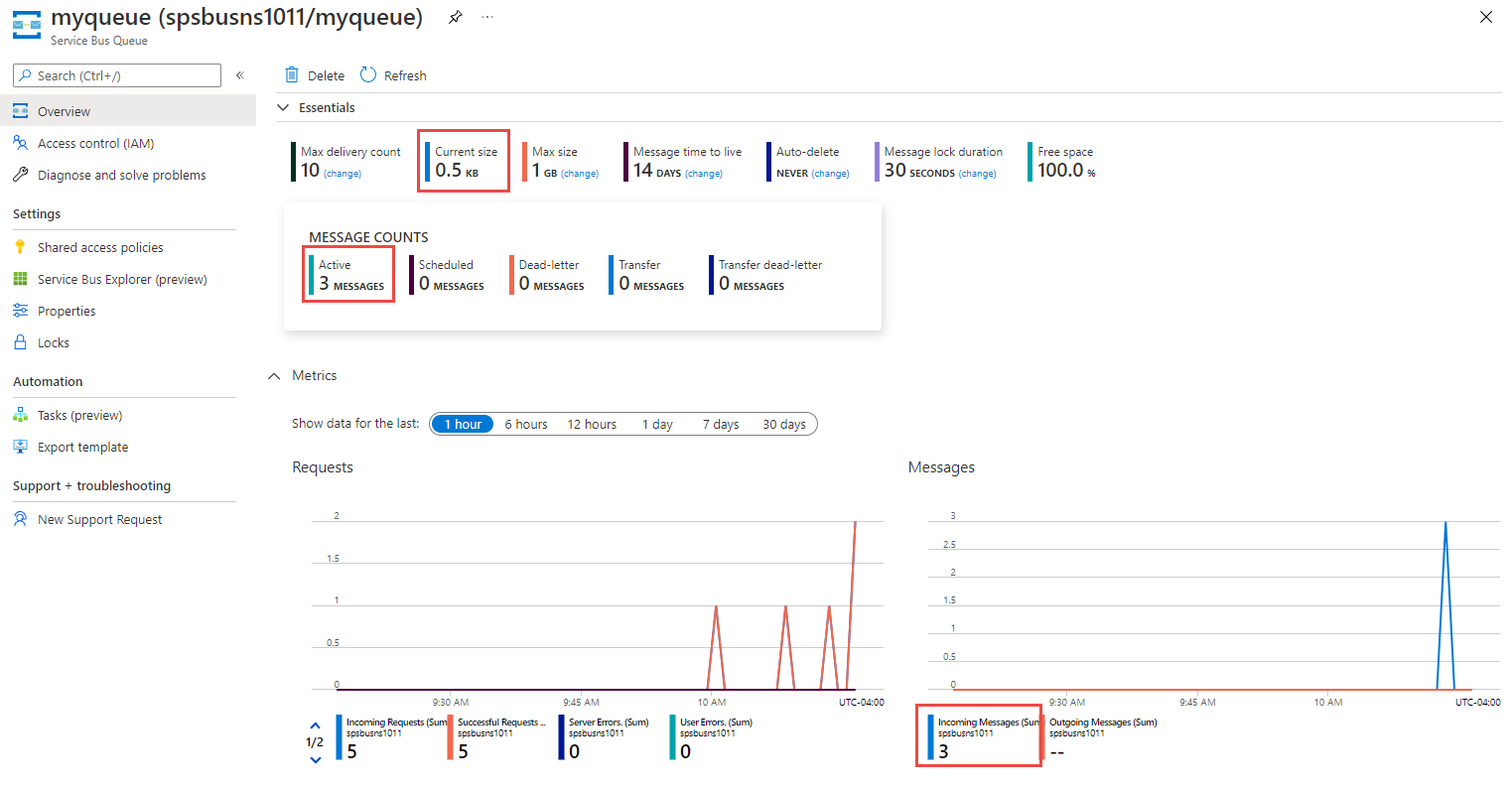
Console.ReadKey();

1. Build the project, and ensure that there are no errors.
2. Run the program and wait for the confirmation message.

A batch of 3 messages has been published to the queue

**Important**: In most cases, it will take a minute or two for the role assignment to propagate in Azure. In rare cases, it may take up to **eight minutes**. If you receive authentication errors when you first run your code, wait a few moments and try again.

1. In the Azure portal, follow these steps:
   1. Navigate to your Service Bus namespace.
   2. On the **Overview** page, select the queue in the bottom-middle pane.
   3. Notice the values in the **Essentials** section.



1. Notice the following values:
   * The **Active** message count value for the queue is now **3**. Each time you run this sender app without retrieving the messages, this value increases by 3.
   * The **current size** of the queue increments each time the app adds messages to the queue.
   * In the **Messages** chart in the bottom **Metrics** section, you can see that there are three incoming messages for the queue.

#### Receive Messages from the Queue

In this section, you'll create a .NET console application that receives messages from the queue.

**Note**: This quickstart provides step-by-step instructions to implement a scenario of sending a batch of messages to a Service Bus queue and then receiving them. For more samples on other and advanced scenarios, see [**Service Bus .NET samples on GitHub**](https://github.com/Azure/azure-sdk-for-net/tree/master/sdk/servicebus/Azure.Messaging.ServiceBus/samples).

**Solution**: <https://github.com/AjaySingala/dotNetFullStackDemos/tree/main/Azure/ServiceBusConsoleApp/ServiceBusConsoleApp.sln>

**Project**: QueueReceiver

##### Create a project for the receiver

1. In the Solution Explorer window, right-click the **ServiceBusQueueQuickStart** solution, point to **Add**, and select **New Project**.
2. Select **Console application**, and select **Next**.
3. Enter **QueueReceiver** for the **Project name**, and select **Create**.
4. In the **Solution Explorer** window, right-click **QueueReceiver**, and select **Set as a Startup Project**.

##### Add the NuGet packages to the project

###### Passwordless

1. Select **Tools** > **NuGet Package Manager** > **Package Manager Console** from the menu.
2. Select **QueueReceiver** for **Default project**.
3. Run the following command to install the **Azure.Messaging.ServiceBus** NuGet package.

Install-Package Azure.Messaging.ServiceBus

1. Run the following command to install the **Azure.Identity** NuGet package.

Install-Package Azure.Identity

###### Connection String

1. Select Tools > NuGet Package Manager > Package Manager Console from the menu.
2. Run the following command to install the Azure.Messaging.ServiceBus NuGet package:

Install-Package Azure.Messaging.ServiceBus

##### Add the Code to Receive Messages from the Queue

In this section, you'll add code to retrieve messages from the queue.

1. Within the Program class, add the following code:

###### Passwordless

using System.Threading.Tasks;

using Azure.Identity;

using Azure.Messaging.ServiceBus;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the processor that reads and processes messages from the queue

ServiceBusProcessor processor;

###### Connection String

using System.Threading.Tasks;

using Azure.Messaging.ServiceBus;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the processor that reads and processes messages from the queue

ServiceBusProcessor processor;

1. Append the following methods to the end of the Program class.

// handle received messages

async Task MessageHandler(ProcessMessageEventArgs args)

{

string body = args.Message.Body.ToString();

Console.WriteLine($"Received: {body}");

// complete the message. message is deleted from the queue.

await args.CompleteMessageAsync(args.Message);

}

// handle any errors when receiving messages

Task ErrorHandler(ProcessErrorEventArgs args)

{

Console.WriteLine(args.Exception.ToString());

return Task.CompletedTask;

}

1. Append the following code to the end of the Program class. The important steps are outlined below, with additional information in the code comments.

###### Password less

* Creates a [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object using the DefaultAzureCredential object. DefaultAzureCredential will automatically discover and use the credentials of your Visual Studio login to authenticate to Azure Service Bus.
* Invokes the [CreateProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient.createprocessor) method on the ServiceBusClient object to create a [ServiceBusProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor) object for the specified Service Bus queue.
* Specifies handlers for the [ProcessMessageAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.processmessageasync) and [ProcessErrorAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.processerrorasync) events of the [ServiceBusProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor) object.
* Starts processing messages by invoking the [StartProcessingAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.startprocessingasync) on the ServiceBusProcessor object.
* When user presses a key to end the processing, invokes the [StopProcessingAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.stopprocessingasync) on the ServiceBusProcessor object.

**Important**: Update placeholder values (<NAMESPACE-NAME> and <QUEUE-NAME>) in the code snippet with names of your Service Bus namespace and queue.

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Set the transport type to AmqpWebSockets so that the ServiceBusClient uses port 443.

// If you use the default AmqpTcp, make sure that ports 5671 and 5672 are open.

// TODO: Replace the <NAMESPACE-NAME> placeholder

var clientOptions = new ServiceBusClientOptions()

{

TransportType = ServiceBusTransportType.AmqpWebSockets

};

client = new ServiceBusClient(

"<NAMESPACE-NAME>.servicebus.windows.net",

new DefaultAzureCredential(),

clientOptions);

// create a processor that we can use to process the messages

// TODO: Replace the <QUEUE-NAME> placeholder

processor = client.CreateProcessor("<QUEUE-NAME>", new ServiceBusProcessorOptions());

try

{

// add handler to process messages

processor.ProcessMessageAsync += MessageHandler;

// add handler to process any errors

processor.ProcessErrorAsync += ErrorHandler;

// start processing

await processor.StartProcessingAsync();

Console.WriteLine("Wait for a minute and then press any key to end the processing");

Console.ReadKey();

// stop processing

Console.WriteLine("\nStopping the receiver...");

await processor.StopProcessingAsync();

Console.WriteLine("Stopped receiving messages");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await processor.DisposeAsync();

await client.DisposeAsync();

###### Connection String

* Creates a [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object using the connection string.
* Invokes the [CreateProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient.createprocessor) method on the [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object to create a [ServiceBusProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor) object for the specified Service Bus queue.
* Specifies handlers for the [ProcessMessageAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.processmessageasync) and [ProcessErrorAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.processerrorasync) events of the [ServiceBusProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor) object.
* Starts processing messages by invoking the [StartProcessingAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.startprocessingasync) on the [ServiceBusProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor) object.
* When user presses a key to end the processing, invokes the [StopProcessingAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.stopprocessingasync) on the [ServiceBusProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor) object.

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Set the transport type to AmqpWebSockets so that the ServiceBusClient uses port 443.

// If you use the default AmqpTcp, make sure that ports 5671 and 5672 are open.

// TODO: Replace the <NAMESPACE-CONNECTION-STRING> and <QUEUE-NAME> placeholders

var clientOptions = new ServiceBusClientOptions()

{

TransportType = ServiceBusTransportType.AmqpWebSockets

};

client = new ServiceBusClient("<NAMESPACE-CONNECTION-STRING>", clientOptions);

// create a processor that we can use to process the messages

// TODO: Replace the <QUEUE-NAME> placeholder

processor = client.CreateProcessor("<QUEUE-NAME>", new ServiceBusProcessorOptions());

try

{

// add handler to process messages

processor.ProcessMessageAsync += MessageHandler;

// add handler to process any errors

processor.ProcessErrorAsync += ErrorHandler;

// start processing

await processor.StartProcessingAsync();

Console.WriteLine("Wait for a minute and then press any key to end the processing");

Console.ReadKey();

// stop processing

Console.WriteLine("\nStopping the receiver...");

await processor.StopProcessingAsync();

Console.WriteLine("Stopped receiving messages");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await processor.DisposeAsync();

await client.DisposeAsync();

}

1. The completed Program class should match the following code:

###### Password less

using System.Threading.Tasks;

using Azure.Messaging.ServiceBus;

using Azure.Identity;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the processor that reads and processes messages from the queue

ServiceBusProcessor processor;

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Set the transport type to AmqpWebSockets so that the ServiceBusClient uses port 443.

// If you use the default AmqpTcp, make sure that ports 5671 and 5672 are open.

// TODO: Replace the <NAMESPACE-NAME> and <QUEUE-NAME> placeholders

var clientOptions = new ServiceBusClientOptions()

{

TransportType = ServiceBusTransportType.AmqpWebSockets

};

client = new ServiceBusClient("<NAMESPACE-NAME>.servicebus.windows.net",

new DefaultAzureCredential(), clientOptions);

// create a processor that we can use to process the messages

// TODO: Replace the <QUEUE-NAME> placeholder

processor = client.CreateProcessor("<QUEUE-NAME>", new ServiceBusProcessorOptions());

try

{

// add handler to process messages

processor.ProcessMessageAsync += MessageHandler;

// add handler to process any errors

processor.ProcessErrorAsync += ErrorHandler;

// start processing

await processor.StartProcessingAsync();

Console.WriteLine("Wait for a minute and then press any key to end the processing");

Console.ReadKey();

// stop processing

Console.WriteLine("\nStopping the receiver...");

await processor.StopProcessingAsync();

Console.WriteLine("Stopped receiving messages");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await processor.DisposeAsync();

await client.DisposeAsync();

}

// handle received messages

async Task MessageHandler(ProcessMessageEventArgs args)

{

string body = args.Message.Body.ToString();

Console.WriteLine($"Received: {body}");

// complete the message. message is deleted from the queue.

await args.CompleteMessageAsync(args.Message);

}

// handle any errors when receiving messages

Task ErrorHandler(ProcessErrorEventArgs args)

{

Console.WriteLine(args.Exception.ToString());

return Task.CompletedTask;

}

###### Connection String

using Azure.Messaging.ServiceBus;

using System;

using System.Threading.Tasks;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the processor that reads and processes messages from the queue

ServiceBusProcessor processor;

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Set the transport type to AmqpWebSockets so that the ServiceBusClient uses port 443.

// If you use the default AmqpTcp, make sure that ports 5671 and 5672 are open.

// TODO: Replace the <NAMESPACE-CONNECTION-STRING> and <QUEUE-NAME> placeholders

var clientOptions = new ServiceBusClientOptions()

{

TransportType = ServiceBusTransportType.AmqpWebSockets

};

client = new ServiceBusClient("<NAMESPACE-CONNECTION-STRING>", clientOptions);

// create a processor that we can use to process the messages

// TODO: Replace the <QUEUE-NAME> placeholder

processor = client.CreateProcessor("<QUEUE-NAME>", new ServiceBusProcessorOptions());

try

{

// add handler to process messages

processor.ProcessMessageAsync += MessageHandler;

// add handler to process any errors

processor.ProcessErrorAsync += ErrorHandler;

// start processing

await processor.StartProcessingAsync();

Console.WriteLine("Wait for a minute and then press any key to end the processing");

Console.ReadKey();

// stop processing

Console.WriteLine("\nStopping the receiver...");

await processor.StopProcessingAsync();

Console.WriteLine("Stopped receiving messages");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await processor.DisposeAsync();

await client.DisposeAsync();

}

// handle received messages

async Task MessageHandler(ProcessMessageEventArgs args)

{

string body = args.Message.Body.ToString();

Console.WriteLine($"Received: {body}");

// complete the message. message is deleted from the queue.

await args.CompleteMessageAsync(args.Message);

}

// handle any errors when receiving messages

Task ErrorHandler(ProcessErrorEventArgs args)

{

Console.WriteLine(args.Exception.ToString());

return Task.CompletedTask;

}

1. Build the project, and ensure that there are no errors.
2. Run the receiver application. You should see the received messages. Press any key to stop the receiver and the application.

Wait for a minute and then press any key to end the processing

Received: Message 1

Received: Message 2

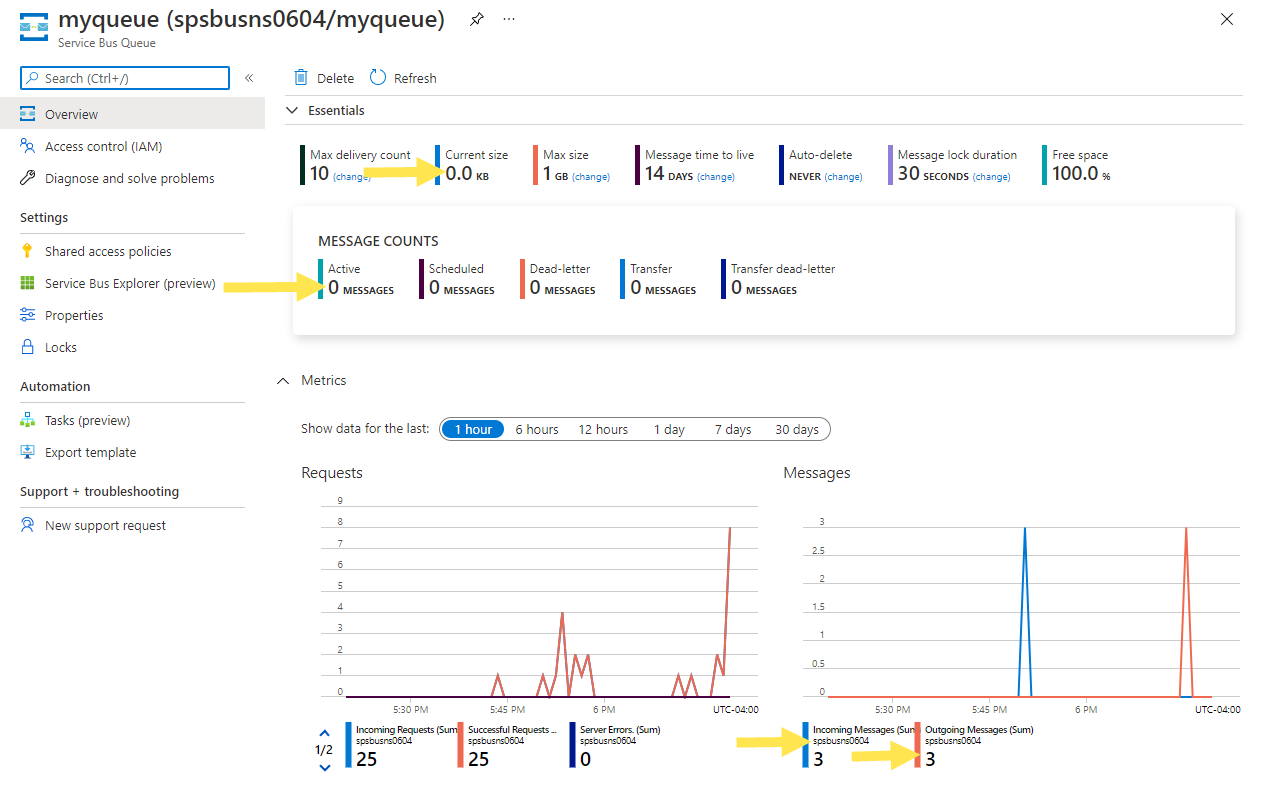
Received: Message 3

Stopping the receiver...

Stopped receiving messages

1. Check the portal again. Wait for a few minutes and refresh the page if you don't see 0 for **Active** messages.

* The **Active** message count and **Current size** values are now **0**.
* In the **Messages** chart in the bottom **Metrics** section, you can see that there are three incoming messages and three outgoing messages for the queue.

[](https://learn.microsoft.com/en-us/azure/service-bus-messaging/media/service-bus-dotnet-get-started-with-queues/queue-messages-size-final.png#lightbox)

#### Clean up resources

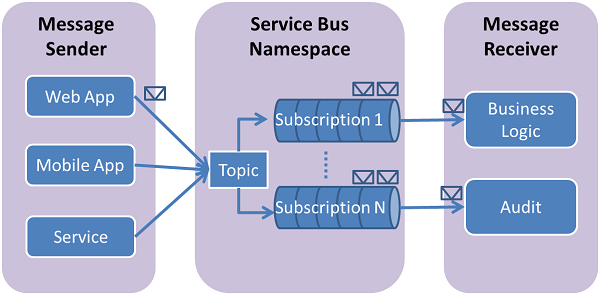
Navigate to your Service Bus namespace in the Azure portal, and select **Delete** on the Azure portal to delete the namespace and the queue in it.

## Azure Service Bus Topics and Subscriptions

## Create Service Bus Topics and Subscriptions using the Azure Portal

<https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-quickstart-topics-subscriptions-portal>

Service Bus topics and subscriptions support a publish/subscribe messaging communication model. When using topics and subscriptions, components of a distributed application do not communicate directly with each other; instead they exchange messages via a topic, which acts as an intermediary.



In contrast with Service Bus queues, in which each message is processed by a single consumer, topics and subscriptions provide a one-to-many form of communication, using a publish/subscribe pattern. It is possible to register multiple subscriptions to a topic. When a message is sent to a topic, it is then made available to each subscription to handle/process independently. A subscription to a topic resembles a virtual queue that receives copies of the messages that were sent to the topic. You can optionally register filter rules for a topic on a per-subscription basis, which allows you to filter or restrict which messages to a topic are received by which topic subscriptions.

Service Bus topics and subscriptions enable you to scale to process a large number of messages across a large number of users and applications.

### Create a Namespace in the Azure Portal

To begin using Service Bus messaging entities in Azure, you must first create a namespace with a name that is unique across Azure. A namespace provides a scoping container for Service Bus resources within your application.

To create a namespace:

1. Sign in to the [Azure portal](https://portal.azure.com/)
2. In the left navigation pane of the portal, select **All services**, select **Integration** from the list of categories, hover the mouse over **Service Bus**, and then select **Create** on the Service Bus tile.
3. In the **Basics** tag of the **Create namespace** page, follow these steps:
   1. For **Subscription**, choose an Azure subscription in which to create the namespace.
   2. For **Resource group**, choose an existing resource group in which the namespace will live, or create a new one.
   3. Enter a **name for the namespace**. The namespace name should adhere to the following naming conventions:

* The name must be unique across Azure. The system immediately checks to see if the name is available.
* The name length is at least 6 and at most 50 characters.
* The name can contain only letters, numbers, hyphens “-“.
* The name must start with a letter and end with a letter or number.
* The name doesn't end with “-sb“ or “-mgmt“.
  1. For **Location**, choose the region in which your namespace should be hosted.
  2. For **Pricing tier**, select the pricing tier (Basic, Standard, or Premium) for the namespace. For this quickstart, select **Standard**.

**Important**: If you want to use [**topics and subscriptions**](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-queues-topics-subscriptions#topics-and-subscriptions), choose either Standard or Premium. Topics/subscriptions aren't supported in the Basic pricing tier.

If you selected the **Premium** pricing tier, specify the number of **messaging units**. The premium tier provides resource isolation at the CPU and memory level so that each workload runs in isolation. This resource container is called a messaging unit. A premium namespace has at least one messaging unit. You can select 1, 2, 4, 8 or 16 messaging units for each Service Bus Premium namespace. For more information, see [Service Bus Premium Messaging](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-premium-messaging).

* 1. Select **Review + create** at the bottom of the page.
  2. On the **Review + create** page, review settings, and select **Create**.

1. Once the deployment of the resource is successful, select **Go to resource** on the deployment page.
2. You see the home page for your service bus namespace.

### Create a Topic using the Azure Portal

1. On the **Service Bus Namespace** page, select **Topics** on the left menu.
2. Select **+ Topic** on the toolbar.
3. Enter a **name** for the topic. Leave the other options with their default values.
4. Select **Create**.

### Create Subscriptions to the Topic

1. Select the **topic** that you created in the previous section.
2. On the **Service Bus Topic** page, select **Subscriptions** from the left menu, and then select **+ Subscription** on the toolbar.
3. On the **Create subscription** page, follow these steps:
   1. Enter **S1** for **name** of the subscription.
   2. Enter **3** for **Max delivery count**. Leave the remaining values as default.
   3. Then, select **Create** to create the subscription.
4. Repeat the previous step twice to create subscriptions named **S2** and **S3**.

**Note**: You can manage Service Bus resources with [**Service Bus Explorer**](https://github.com/paolosalvatori/ServiceBusExplorer/). The Service Bus Explorer allows users to connect to a Service Bus namespace and administer messaging entities in an easy manner. The tool provides advanced features like import/export functionality or the ability to test topic, queues, subscriptions, relay services, notification hubs and events hubs.

## Publish and Subscribe for Messages (.NET)

<https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-dotnet-how-to-use-topics-subscriptions?tabs=passwordless>

This quickstart shows how to send messages to a Service Bus topic and receive messages from a subscription to that topic by using the [Azure.Messaging.ServiceBus](https://www.nuget.org/packages/Azure.Messaging.ServiceBus/) .NET library.

In this quickstart, you'll do the following steps:

1. Create a Service Bus namespace, using the Azure portal.
2. Create a Service Bus topic, using the Azure portal.
3. Create a Service Bus subscription to that topic, using the Azure portal.
4. Write a .NET console application to send a set of messages to the topic.
5. Write a .NET console application to receive those messages from the subscription.

**Note**: This quick start provides step-by-step instructions to implement a simple scenario of sending a batch of messages to a Service Bus topic and receiving those messages from a subscription of the topic. For more samples on other and advanced scenarios, see [**Service Bus .NET samples on GitHub**](https://github.com/Azure/azure-sdk-for-net/tree/master/sdk/servicebus/Azure.Messaging.ServiceBus/samples).

* This quick start shows you two ways of connecting to Azure Service Bus: **connection string** and **passwordless**. The first option shows you how to use a connection string to connect to a Service Bus namespace. The second option shows you how to use your security principal in Azure Active Directory and the role-based access control (RBAC) to connect to a Service Bus namespace. You don't need to worry about having hard-coded connection string in your code or in a configuration file or in secure storage like Azure Key Vault. If you are new to Azure, you may find the connection string option easier to follow. We recommend using the passwordless option in real-world applications and production environments. For more information, see [**Authentication and authorization**](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-authentication-and-authorization).

### Prerequisites

If you're new to the service, see [Service Bus overview](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-messaging-overview) before you do this quickstart.

* **Azure subscription**. To use Azure services, including Azure Service Bus, you need a subscription. If you don't have an existing Azure account, you can sign up for a [free trial](https://azure.microsoft.com/free/dotnet/).
* **Visual Studio 2022**. The sample application makes use of new features that were introduced in C# 10. You can still use the Service Bus client library with previous C# language versions, but the syntax may vary. To use the latest syntax, we recommend that you install .NET 6.0 or higher and set the language version to latest. If you're using Visual Studio, versions before Visual Studio 2022 aren't compatible with the tools needed to build C# 10 projects.

### Create a Namespace in the Azure Portal

Refer to the [Create a Namespace in the Azure Portal](#_Create_a_Namespace) section above for the steps.

### Create a topic using the Azure portal

Refer to the [Create a Topic using the Azure Portal](#_Create_a_Topic) section above for the steps.

### Create a Subscription to the Topic

Refer to the [Create a Subscription to the Topic](#_Create_Subscriptions_to) section above for the steps.

### Authenticate the app to Azure

This quick start shows you two ways of connecting to Azure Service Bus: **passwordless** and **connection string**.

The first option shows you how to use your security principal in Azure Active Directory and role-based access control (RBAC) to connect to a Service Bus namespace. You don't need to worry about having hard-coded connection string in your code or in a configuration file or in a secure storage like Azure Key Vault.

The second option shows you how to use a connection string to connect to a Service Bus namespace. If you are new to Azure, you may find the connection string option easier to follow. We recommend using the passwordless option in real-world applications and production environments. For more information, see [Authentication and authorization](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-authentication-and-authorization). You can also read more about passwordless authentication on the [overview page](https://learn.microsoft.com/en-us/dotnet/azure/sdk/authentication?tabs=command-line).

#### Passwordless (Recommended)

##### Assign roles to your Azure AD user

When developing locally, make sure that the user account that connects to Azure Service Bus has the correct permissions. You'll need the [Azure Service Bus Data Owner](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#azure-service-bus-data-owner) role in order to send and receive messages. To assign yourself this role, you'll need the User Access Administrator role, or another role that includes the Microsoft.Authorization/roleAssignments/write action. You can assign Azure RBAC roles to a user using the Azure portal, Azure CLI, or Azure PowerShell. Learn more about the available scopes for role assignments on the [scope overview](https://learn.microsoft.com/en-us/azure/role-based-access-control/scope-overview) page.

The following example assigns the Azure Service Bus Data Owner role to your user account, which provides full access to Azure Service Bus resources. In a real scenario, follow the [Principle of Least Privilege](https://learn.microsoft.com/en-us/azure/active-directory/develop/secure-least-privileged-access) to give users only the minimum permissions needed for a more secure production environment.

##### Azure built-in roles for Azure Service Bus

For Azure Service Bus, the management of namespaces and all related resources through the Azure portal and the Azure resource management API is already protected using the Azure RBAC model. Azure provides the below Azure built-in roles for authorizing access to a Service Bus namespace:

* [Azure Service Bus Data Owner](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#azure-service-bus-data-owner): Enables data access to Service Bus namespace and its entities (queues, topics, subscriptions, and filters). A member of this role can send and receive messages from queues or topics/subscriptions.
* [Azure Service Bus Data Sender](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#azure-service-bus-data-sender): Use this role to give the send access to Service Bus namespace and its entities.
* [Azure Service Bus Data Receiver](https://learn.microsoft.com/en-us/azure/role-based-access-control/built-in-roles#azure-service-bus-data-receiver): Use this role to give the receive access to Service Bus namespace and its entities.

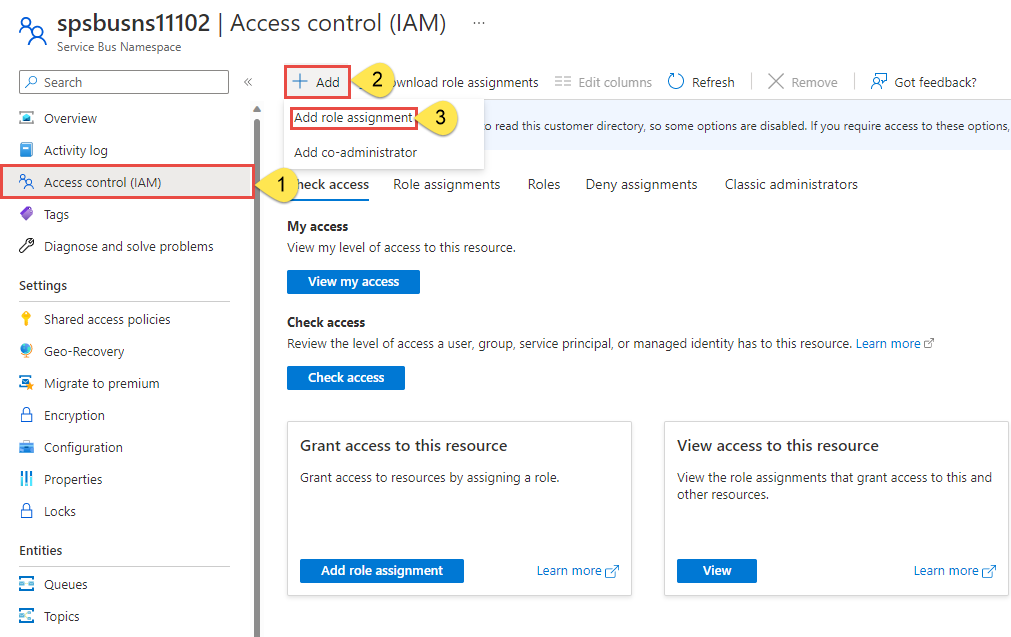
If you want to create a custom role, see [Rights required for Service Bus operations](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-sas#rights-required-for-service-bus-operations).

##### Add Azure AD user to Azure Service Bus Owner role

Add your Azure AD user name to the **Azure Service Bus Data Owner** role at the Service Bus namespace level. It will allow an app running in the context of your user account to send messages to a queue or a topic, and receive messages from a queue or a topic's subscription.

**Important**: In most cases, it will take a minute or two for the role assignment to propagate in Azure. In rare cases, it may take up to **eight minutes**. If you receive authentication errors when you first run your code, wait a few moments and try again.

1. If you don't have the Service Bus Namespace page open in the Azure portal, locate your Service Bus namespace using the main search bar or left navigation.
2. On the overview page, select **Access control (IAM)** from the left-hand menu.
3. On the **Access control (IAM)** page, select the **Role assignments** tab.
4. Select **+ Add** from the top menu and then **Add role assignment** from the resulting drop-down menu.



1. Use the search box to filter the results to the desired role. For this example, search for Azure Service Bus Data Owner and select the matching result. Then choose **Next**.
2. Under **Assign access to**, select **User, group, or service principal**, and then choose **+ Select members**.
3. In the dialog, search for your Azure AD username (usually your user@domain email address) and then choose **Select** at the bottom of the dialog.
4. Select **Review + assign** to go to the final page, and then **Review + assign** again to complete the process.

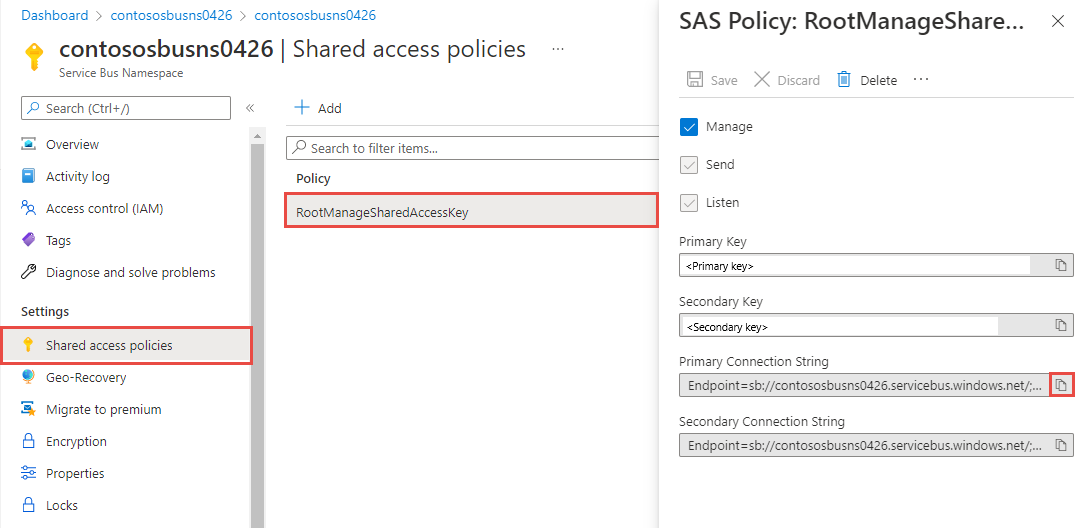
#### Connection String

##### Get the connection string

Creating a new namespace automatically generates an initial Shared Access Signature (SAS) policy with primary and secondary keys, and primary and secondary connection strings that each grant full control over all aspects of the namespace. See [Service Bus authentication and authorization](https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-authentication-and-authorization) for information about how to create rules with more constrained rights for regular senders and receivers.

A client can use the connection string to connect to the Service Bus namespace. To copy the primary connection string for your namespace, follow these steps:

1. On the **Service Bus Namespace** page, select **Shared access policies** on the left menu.
2. On the **Shared access policies** page, select **RootManageSharedAccessKey**.
3. In the **Policy: RootManageSharedAccessKey** window, select the copy button next to **Primary Connection String**, to copy the connection string to your clipboard for later use. Paste this value into Notepad or some other temporary location.

[](https://learn.microsoft.com/en-us/azure/includes/passwordless/service-bus/media/service-bus-create-namespace-portal/connection-string.png#lightbox)

You can use this page to copy primary key, secondary key, primary connection string, and secondary connection string.

### Launch Visual Studio and sign-in to Azure

You can authorize access to the service bus namespace using the following steps:

1. Launch Visual Studio. If you see the **Get started** window, select the **Continue without code** link in the right pane.
2. Select the **Sign in** button in the top right of Visual Studio.
3. Sign-in using the Azure AD account you assigned a role to previously.

### Send messages to the topic

This section shows you how to create a .NET console application to send messages to a Service Bus topic.

**Note**: This quick start provides step-by-step instructions to implement a simple scenario of sending a batch of messages to a Service Bus topic and receiving those messages from a subscription of the topic. For more samples on other and advanced scenarios, see [**Service Bus .NET samples on GitHub**](https://github.com/Azure/azure-sdk-for-net/tree/master/sdk/servicebus/Azure.Messaging.ServiceBus/samples).

#### Create a Console Application

1. In Visual Studio, select **File** -> **New** -> **Project** menu.
2. On the **Create a new project** dialog box, do the following steps: If you don't see this dialog box, select **File** on the menu, select **New**, and then select **Project**.
   1. Select **C#** for the programming language.
   2. Select **Console** for the type of the application.
   3. Select **Console App** from the results list.
   4. Then, select **Next**.
3. Enter **TopicSender** for the project name, **ServiceBusTopicQuickStart** for the solution name, and then select **Next**.
4. On the **Additional information** page, select **Create** to create the solution and the project.

#### Add the NuGet packages to the project

##### Passwordless (Recommended)

1. Select Tools > NuGet Package Manager > Package Manager Console from the menu.
2. Run the following command to install the Azure.Messaging.ServiceBus NuGet package.

Install-Package Azure.Messaging.ServiceBus

1. Run the following command to install the **Azure.Identity** NuGet package.

Install-Package Azure.Identity

##### Connection String

1. Select Tools > NuGet Package Manager > Package Manager Console from the menu.
2. Run the following command to install the Azure.Messaging.ServiceBus NuGet package:

Install-Package Azure.Messaging.ServiceBus

#### Add code to send messages to the topic

1. Replace the contents of Program.cs with the following code. The important steps are outlined below, with additional information in the code comments.

##### Passwordless (Recommended)

1. Creates a [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object using the DefaultAzureCredential object. DefaultAzureCredential will automatically discover and use the credentials of your Visual Studio login to authenticate to Azure Service Bus.
2. Invokes the [CreateSender](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient.createsender) method on the ServiceBusClient object to create a [ServiceBusSender](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender) object for the specific Service Bus topic.
3. Creates a [ServiceBusMessageBatch](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusmessagebatch) object by using the [ServiceBusSender.CreateMessageBatchAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender.createmessagebatchasync).
4. Add messages to the batch using the [ServiceBusMessageBatch.TryAddMessage](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusmessagebatch.tryaddmessage).
5. Sends the batch of messages to the Service Bus topic using the [ServiceBusSender.SendMessagesAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender.sendmessagesasync) method.

**Important**: Update placeholder values (<NAMESPACE-NAME> and <TOPIC-NAME>) in the code snippet with names of your Service Bus namespace and topic.

using System.Threading.Tasks;

using Azure.Messaging.ServiceBus;

using Azure.Identity;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the sender used to publish messages to the topic

ServiceBusSender sender;

// number of messages to be sent to the topic

const int numOfMessages = 3;

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//TODO: Replace the "<NAMESPACE-NAME>" and "<TOPIC-NAME>" placeholders.

client = new ServiceBusClient(

"<NAMESPACE-NAME>.servicebus.windows.net",

new DefaultAzureCredential());

sender = client.CreateSender("<TOPIC-NAME>");

// create a batch

using ServiceBusMessageBatch messageBatch = await sender.CreateMessageBatchAsync();

for (int i = 1; i <= numOfMessages; i++)

{

// try adding a message to the batch

if (!messageBatch.TryAddMessage(new ServiceBusMessage($"Message {i}")))

{

// if it is too large for the batch

throw new Exception($"The message {i} is too large to fit in the batch.");

}

}

try

{

// Use the producer client to send the batch of messages to the Service Bus topic

await sender.SendMessagesAsync(messageBatch);

Console.WriteLine($"A batch of {numOfMessages} messages has been published to the topic.");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await sender.DisposeAsync();

await client.DisposeAsync();

}

Console.WriteLine("Press any key to end the application");

Console.ReadKey();

##### Connection String

**Important**: Update placeholder values (<NAMESPACE-CONNECTION-STRING> and <TOPIC-NAME>) in the code snippet with actual values you noted down earlier.

1. Creates a [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object using the connection string to the namespace.
2. Invokes the [CreateSender](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient.createsender) method on the ServiceBusClient object to create a [ServiceBusSender](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender) object for the specific Service Bus topic.
3. Creates a [ServiceBusMessageBatch](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusmessagebatch) object by using the [ServiceBusSender.CreateMessageBatchAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender.createmessagebatchasync).
4. Add messages to the batch using the [ServiceBusMessageBatch.TryAddMessage](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusmessagebatch.tryaddmessage).
5. Sends the batch of messages to the Service Bus topic using the [ServiceBusSender.SendMessagesAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebussender.sendmessagesasync) method.

using System.Threading.Tasks;

using Azure.Messaging.ServiceBus;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the sender used to publish messages to the topic

ServiceBusSender sender;

// number of messages to be sent to the topic

const int numOfMessages = 3;

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//TODO: Replace the "<NAMESPACE-CONNECTION-STRING>" and "<TOPIC-NAME>" placeholders.

client = new ServiceBusClient("<NAMESPACE-CONNECTION-STRING>");

sender = client.CreateSender("<TOPIC-NAME>");

// create a batch

using ServiceBusMessageBatch messageBatch = await sender.CreateMessageBatchAsync();

for (int i = 1; i <= numOfMessages; i++)

{

// try adding a message to the batch

if (!messageBatch.TryAddMessage(new ServiceBusMessage($"Message {i}")))

{

// if it is too large for the batch

throw new Exception($"The message {i} is too large to fit in the batch.");

}

}

try

{

// Use the producer client to send the batch of messages to the Service Bus topic

await sender.SendMessagesAsync(messageBatch);

Console.WriteLine($"A batch of {numOfMessages} messages has been published to the topic.");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await sender.DisposeAsync();

await client.DisposeAsync();

}

Console.WriteLine("Press any key to end the application");

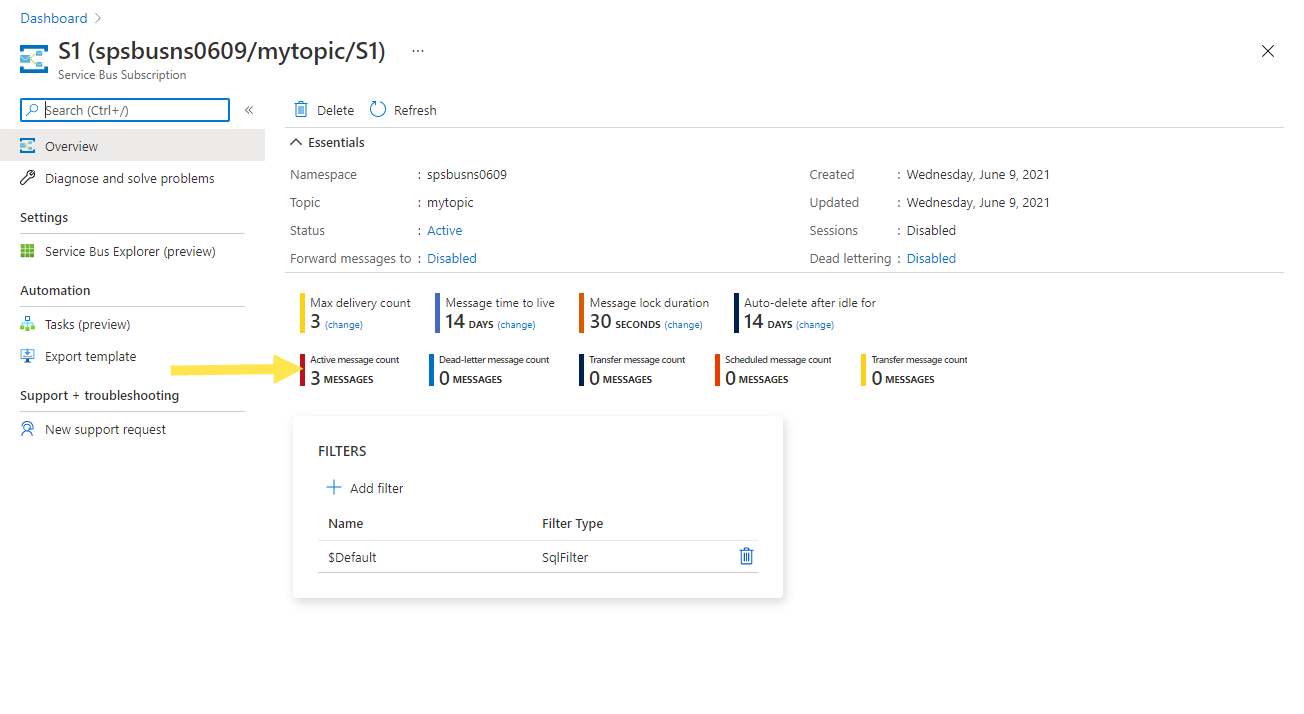
Console.ReadKey();

1. Build the project, and ensure that there are no errors.
2. Run the program and wait for the confirmation message.

A batch of 3 messages has been published to the topic

**Important**: In most cases, it will take a minute or two for the role assignment to propagate in Azure. In rare cases, it may take up to **eight minutes**. If you receive authentication errors when you first run your code, wait a few moments and try again.

1. In the Azure portal, follow these steps:
   1. Navigate to your Service Bus namespace.
   2. On the **Overview** page, in the bottom-middle pane, switch to the **Topics** tab, and select the Service Bus topic. In the following example, it's mytopic.
   3. On the **Service Bus Topic** page, In the **Messages** chart in the bottom **Metrics** section, you can see that there are three incoming messages for the topic. If you don't see the value, wait for a few minutes, and refresh the page to see the updated chart.
   4. Select the subscription in the bottom pane. In the following example, it's **S1**. On the **Service Bus Subscription** page, you see the **Active message count** as **3**. The subscription has received the three messages that you sent to the topic, but no receiver has picked them yet.



### Receive messages from a subscription

In this section, you'll create a .NET console application that receives messages from the subscription to the Service Bus topic.

**Note**: This quick start provides step-by-step instructions to implement a simple scenario of sending a batch of messages to a Service Bus topic and receiving those messages from a subscription of the topic. For more samples on other and advanced scenarios, see [**Service Bus .NET samples on GitHub**](https://github.com/Azure/azure-sdk-for-net/tree/master/sdk/servicebus/Azure.Messaging.ServiceBus/samples).

#### Create a project for the receiver

1. In the Solution Explorer window, right-click the **ServiceBusTopicQuickStart** solution, point to **Add**, and select **New Project**.
2. Select **Console application**, and select **Next**.
3. Enter **SubscriptionReceiver** for the **Project name**, and select **Next**.
4. On the **Additional information** page, select **Create**.
5. In the **Solution Explorer** window, right-click **SubscriptionReceiver**, and select **Set as a Startup Project**.

#### Add the NuGet packages to the project

##### Passwordless (Recommended)

1. Select Tools > NuGet Package Manager > Package Manager Console from the menu.
2. Select SubscriptionReceiver for Default project drop-down list.
3. Run the following command to install the Azure.Messaging.ServiceBus NuGet package.

Install-Package Azure.Messaging.ServiceBus

1. Run the following command to install the **Azure.Identity** NuGet package.

Install-Package Azure.Identity

##### Connection String

1. Select Tools > NuGet Package Manager > Package Manager Console from the menu.
2. Run the following command to install the Azure.Messaging.ServiceBus NuGet package:

Install-Package Azure.Messaging.ServiceBus

#### Add code to receive messages from the subscription

In this section, you'll add code to retrieve messages from the subscription.

1. Replace the existing contents of Program.cs with the following properties and methods:

##### Passwordless (Recommended)

using System.Threading.Tasks;

using Azure.Messaging.ServiceBus;

using Azure.Identity;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the processor that reads and processes messages from the subscription

ServiceBusProcessor processor;

// handle received messages

async Task MessageHandler(ProcessMessageEventArgs args)

{

string body = args.Message.Body.ToString();

Console.WriteLine($"Received: {body} from subscription.");

// complete the message. messages is deleted from the subscription.

await args.CompleteMessageAsync(args.Message);

}

// handle any errors when receiving messages

Task ErrorHandler(ProcessErrorEventArgs args)

{

Console.WriteLine(args.Exception.ToString());

return Task.CompletedTask;

}

##### Connection String

using System.Threading.Tasks;

using Azure.Messaging.ServiceBus;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the processor that reads and processes messages from the subscription

ServiceBusProcessor processor;

// handle received messages

async Task MessageHandler(ProcessMessageEventArgs args)

{

// TODO: Replace the <TOPIC-SUBSCRIPTION-NAME> placeholder

string body = args.Message.Body.ToString();

Console.WriteLine($"Received: {body} from subscription: <TOPIC-SUBSCRIPTION-NAME>");

// complete the message. messages is deleted from the subscription.

await args.CompleteMessageAsync(args.Message);

}

// handle any errors when receiving messages

Task ErrorHandler(ProcessErrorEventArgs args)

{

Console.WriteLine(args.Exception.ToString());

return Task.CompletedTask;

}

1. Append the following code to the end of Program.cs.

##### Passwordless (Recommended)

* Creates a [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object using the DefaultAzureCredential object. DefaultAzureCredential will automatically discover and use the credentials of your Visual Studio login to authenticate to Azure Service Bus.
* Invokes the [CreateProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient.createprocessor) method on the ServiceBusClient object to create a [ServiceBusProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor) object for the specified Service Bus topic.
* Specifies handlers for the [ProcessMessageAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.processmessageasync) and [ProcessErrorAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.processerrorasync) events of the ServiceBusProcessor object.
* Starts processing messages by invoking the [StartProcessingAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.startprocessingasync) on the ServiceBusProcessor object.
* When user presses a key to end the processing, invokes the [StopProcessingAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.stopprocessingasync) on the ServiceBusProcessor object.

**Important**: Update placeholder values (<NAMESPACE-NAME>, <TOPIC-NAME>, <SUBSCRIPTION-NAME>) in the code snippet with names of your Service Bus namespace, topic, and subscription.

For more information, see code comments.

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Create the clients that we'll use for sending and processing messages.

// TODO: Replace the <NAMESPACE-NAME> placeholder

client = new ServiceBusClient(

"<NAMESPACE-NAME>.servicebus.windows.net",

new DefaultAzureCredential());

// create a processor that we can use to process the messages

// TODO: Replace the <TOPIC-NAME> and <SUBSCRIPTION-NAME> placeholders

processor = client.CreateProcessor("<TOPIC-NAME>", "<SUBSCRIPTION-NAME>", new ServiceBusProcessorOptions());

try

{

// add handler to process messages

processor.ProcessMessageAsync += MessageHandler;

// add handler to process any errors

processor.ProcessErrorAsync += ErrorHandler;

// start processing

await processor.StartProcessingAsync();

Console.WriteLine("Wait for a minute and then press any key to end the processing");

Console.ReadKey();

// stop processing

Console.WriteLine("\nStopping the receiver...");

await processor.StopProcessingAsync();

Console.WriteLine("Stopped receiving messages");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await processor.DisposeAsync();

await client.DisposeAsync();

}

##### Connection String

**Important**

Update placeholder values (<NAMESPACE-CONNECTION-STRING>, <TOPIC-NAME>, <SUBSCRIPTION-NAME>) in the code snippet with actual values you noted down earlier.

* Creates a [ServiceBusClient](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient) object using the connection string to the namespace.
* Invokes the [CreateProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusclient.createprocessor) method on the ServiceBusClient object to create a [ServiceBusProcessor](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor) object for the specified Service Bus topic.
* Specifies handlers for the [ProcessMessageAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.processmessageasync) and [ProcessErrorAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.processerrorasync) events of the ServiceBusProcessor object.
* Starts processing messages by invoking the [StartProcessingAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.startprocessingasync) on the ServiceBusProcessor object.
* When user presses a key to end the processing, invokes the [StopProcessingAsync](https://learn.microsoft.com/en-us/dotnet/api/azure.messaging.servicebus.servicebusprocessor.stopprocessingasync) on the ServiceBusProcessor object.

For more information, see code comments.

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Create the clients that we'll use for sending and processing messages.

// TODO: Replace the <NAMESPACE-CONNECTION-STRING> placeholder

client = new ServiceBusClient("<NAMESPACE-CONNECTION-STRING>");

// create a processor that we can use to process the messages

// TODO: Replace the <TOPIC-NAME> and <SUBSCRIPTION-NAME> placeholders

processor = client.CreateProcessor("<TOPIC-NAME>", "<SUBSCRIPTION-NAME>", new ServiceBusProcessorOptions());

try

{

// add handler to process messages

processor.ProcessMessageAsync += MessageHandler;

// add handler to process any errors

processor.ProcessErrorAsync += ErrorHandler;

// start processing

await processor.StartProcessingAsync();

Console.WriteLine("Wait for a minute and then press any key to end the processing");

Console.ReadKey();

// stop processing

Console.WriteLine("\nStopping the receiver...");

await processor.StopProcessingAsync();

Console.WriteLine("Stopped receiving messages");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await processor.DisposeAsync();

await client.DisposeAsync();

}

1. Here's what your Program.cs should look like:

##### Passwordless (Recommended)

using System;

using System.Threading.Tasks;

using Azure.Messaging.ServiceBus;

using Azure.Identity;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the processor that reads and processes messages from the subscription

ServiceBusProcessor processor;

// handle received messages

async Task MessageHandler(ProcessMessageEventArgs args)

{

string body = args.Message.Body.ToString();

Console.WriteLine($"Received: {body} from subscription.");

// complete the message. messages is deleted from the subscription.

await args.CompleteMessageAsync(args.Message);

}

// handle any errors when receiving messages

Task ErrorHandler(ProcessErrorEventArgs args)

{

Console.WriteLine(args.Exception.ToString());

return Task.CompletedTask;

}

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Create the clients that we'll use for sending and processing messages.

// TODO: Replace the <NAMESPACE-NAME> placeholder

client = new ServiceBusClient(

"<NAMESPACE-NAME>.servicebus.windows.net",

new DefaultAzureCredential());

// create a processor that we can use to process the messages

// TODO: Replace the <TOPIC-NAME> and <SUBSCRIPTION-NAME> placeholders

processor = client.CreateProcessor("<TOPIC-NAME>", "<SUBSCRIPTION-NAME>", new ServiceBusProcessorOptions());

try

{

// add handler to process messages

processor.ProcessMessageAsync += MessageHandler;

// add handler to process any errors

processor.ProcessErrorAsync += ErrorHandler;

// start processing

await processor.StartProcessingAsync();

Console.WriteLine("Wait for a minute and then press any key to end the processing");

Console.ReadKey();

// stop processing

Console.WriteLine("\nStopping the receiver...");

await processor.StopProcessingAsync();

Console.WriteLine("Stopped receiving messages");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await processor.DisposeAsync();

await client.DisposeAsync();

}

##### Connection String

using System;

using System.Threading.Tasks;

using Azure.Messaging.ServiceBus;

// the client that owns the connection and can be used to create senders and receivers

ServiceBusClient client;

// the processor that reads and processes messages from the subscription

ServiceBusProcessor processor;

// handle received messages

async Task MessageHandler(ProcessMessageEventArgs args)

{

string body = args.Message.Body.ToString();

Console.WriteLine($"Received: {body} from subscription.");

// complete the message. messages is deleted from the subscription.

await args.CompleteMessageAsync(args.Message);

}

// handle any errors when receiving messages

Task ErrorHandler(ProcessErrorEventArgs args)

{

Console.WriteLine(args.Exception.ToString());

return Task.CompletedTask;

}

// The Service Bus client types are safe to cache and use as a singleton for the lifetime

// of the application, which is best practice when messages are being published or read

// regularly.

//

// Create the clients that we'll use for sending and processing messages.

// TODO: Replace the <NAMESPACE-CONNECTION-STRING> placeholder

client = new ServiceBusClient("<NAMESPACE-CONNECTION-STRING>");

// create a processor that we can use to process the messages

// TODO: Replace the <TOPIC-NAME> and <SUBSCRIPTION-NAME> placeholders

processor = client.CreateProcessor("<TOPIC-NAME>", "<SUBSCRIPTION-NAME>", new ServiceBusProcessorOptions());

try

{

// add handler to process messages

processor.ProcessMessageAsync += MessageHandler;

// add handler to process any errors

processor.ProcessErrorAsync += ErrorHandler;

// start processing

await processor.StartProcessingAsync();

Console.WriteLine("Wait for a minute and then press any key to end the processing");

Console.ReadKey();

// stop processing

Console.WriteLine("\nStopping the receiver...");

await processor.StopProcessingAsync();

Console.WriteLine("Stopped receiving messages");

}

finally

{

// Calling DisposeAsync on client types is required to ensure that network

// resources and other unmanaged objects are properly cleaned up.

await processor.DisposeAsync();

await client.DisposeAsync();

}

1. Build the project, and ensure that there are no errors.
2. Run the receiver application. You should see the received messages. Press any key to stop the receiver and the application.

Wait for a minute and then press any key to end the processing

Received: Message 1 from subscription: S1

Received: Message 2 from subscription: S1

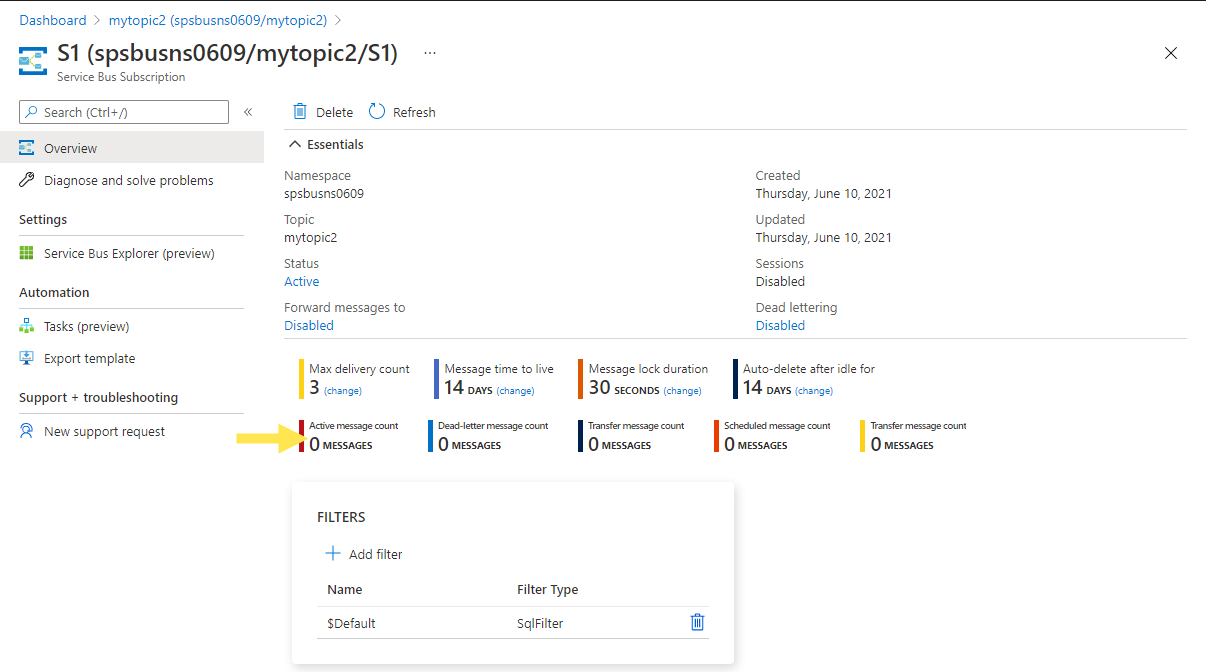
Received: Message 3 from subscription: S1

Stopping the receiver...

Stopped receiving messages

1. Check the portal again.

* On the **Service Bus Topic** page, in the **Messages** chart, you see three incoming messages and three outgoing messages. If you don't see these numbers, wait for a few minutes, and refresh the page to see the updated chart.
* On the **Service Bus Subscription** page, you see the **Active message count** as zero. It's because a receiver has received messages from this subscription and completed the messages.



## Respond to Azure Service Bus events received via Azure Event Grid by using Azure Logic Apps

<https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-to-event-grid-integration-example>

## Respond to Azure Service Bus events received via Azure Event Grid by using Azure Functions

<https://learn.microsoft.com/en-us/azure/service-bus-messaging/service-bus-to-event-grid-integration-function>

# Azure Monitor

<https://learn.microsoft.com/en-us/azure/azure-monitor/overview>

## Getting Started with Azure Monitor

<https://learn.microsoft.com/en-us/azure/azure-monitor/getting-started>

## Monitor Azure Resources with Azure Monitor

<https://learn.microsoft.com/en-us/azure/azure-monitor/essentials/monitor-azure-resource>

## Analyze Metrics for an Azure resource

<https://learn.microsoft.com/en-us/azure/azure-monitor/essentials/tutorial-metrics>

## Collect and Analyze Resource Logs from an Azure Resource

<https://learn.microsoft.com/en-us/azure/azure-monitor/essentials/tutorial-resource-logs>

## Create a Metric Alert for an Azure Resource

<https://learn.microsoft.com/en-US/Azure/azure-monitor/alerts/tutorial-metric-alert>

# Azure Application Insights

## Application Insights Overview

<https://learn.microsoft.com/en-us/azure/azure-monitor/app/app-insights-overview?tabs=net>

## Application Insights for ASP.NET Core applications

<https://learn.microsoft.com/en-us/azure/azure-monitor/app/asp-net-core?tabs=netcorenew%2Cnetcore6>

## ILogger: Application Insights Logging with .NET

<https://learn.microsoft.com/en-us/azure/azure-monitor/app/ilogger?tabs=dotnet6>

## Enable Application Insights for ASP.NET Core applications

<https://learn.microsoft.com/en-us/azure/azure-monitor/app/tutorial-asp-net-core>

# Azure DevOps

## Creating a Service Connection

<https://learn.microsoft.com/en-us/azure/devops/pipelines/library/connect-to-azure?view=azure-devops>

This is required to select Azure App Services during deployment.

## Classic

<https://learn.microsoft.com/en-us/azure/app-service/deploy-azure-pipelines?view=azure-devops&tabs=classic>

<https://adamtheautomator.com/azure-pipelines/>

**Solution**: <https://github.com/AjaySingala/SampleAPI/SampleAPI.sln>

**Note**: Remember to rename azure-pipeline.yml to something else before demos.

* Create a Build Pipeline.
* In “Variables” tab of the Build Pipeline, add a variable.
* Add a Command Line task in the build pipeline.
* Display the value of the variable with echo $(var\_name).
* Run Build pipeline.
* Show output.
* Show case Unit Tests.
* Run Build pipeline.
* Show unit test results.
* Create a Release Pipeline.
  + Select the source artifact.
  + Show App Service.
  + Show Service Connection.
* Run it and navigate to the App Service.
* In Build Pipeline, under “Triggers” tab, enable Continuous Integration.
* Select the “feature1” branch.
* Save.
* Change and commit some code to the “feature1” branch.
* Should start Build Pipeline automatically.
* For Continuous Deployment on Release Pipeline, click on the lightning bolt on the Artifact section.
* Enable Continuous Deployment Trigger.
* Trigger a build. It should start the deployment as well.

### Variable Scope in Release Pipeline

* Add stages for each environment.
* Same variable name can be used for different scopes with environment specific values.
* Create variables for each Scope (*environment*) in the Release Pipeline.
* Select the relevant Stage from the Scope dropdown for the variable.
* Use the variable in the pipeline with $(variable\_name).

## YAML

<https://learn.microsoft.com/en-us/azure/app-service/deploy-azure-pipelines?view=azure-devops&tabs=yaml>

**Solution**: <https://github.com/AjaySingala/SampleAPI/SampleAPI.sln>

Use [Azure Pipelines](https://learn.microsoft.com/en-us/azure/devops/pipelines/) to automatically deploy your web app to [Azure App Service](https://learn.microsoft.com/en-us/azure/app-service/overview) on every successful build. Azure Pipelines lets you build, test, and deploy with continuous integration (CI) and continuous delivery (CD) using [Azure DevOps](https://learn.microsoft.com/en-us/azure/devops/).

YAML pipelines are defined using a YAML file in your repository. A step is the smallest building block of a pipeline and can be a script or task (pre-packaged script).

You'll use the [Azure Web App task](https://learn.microsoft.com/en-us/azure/devops/pipelines/tasks/deploy/azure-rm-web-app) to deploy to Azure App Service in your pipeline.

### Prerequisites

* An Azure account with an active subscription. [Create an account for free](https://azure.microsoft.com/free/?WT.mc_id=A261C142F).
* An Azure DevOps organization. [Create one for free](https://learn.microsoft.com/en-us/azure/devops/pipelines/get-started/pipelines-sign-up).
* An ability to run pipelines on Microsoft-hosted agents. You can either purchase a [parallel job](https://learn.microsoft.com/en-us/azure/devops/pipelines/licensing/concurrent-jobs) or you can request a free tier.
  + A working Azure App Service app with code hosted on [GitHub](https://docs.github.com/en/get-started/quickstart/create-a-repo) or [Azure Repos](https://docs.github.com/en/get-started/quickstart/create-a-repo).
  + .NET: [Create an ASP.NET Core web app in Azure](https://learn.microsoft.com/en-us/azure/app-service/quickstart-dotnetcore)
  + ASP.NET: [Create an ASP.NET Framework web app in Azure](https://learn.microsoft.com/en-us/azure/app-service/quickstart-dotnetcore?tabs=netframework48)
  + JavaScript: [Create a Node.js web app in Azure App Service](https://learn.microsoft.com/en-us/azure/app-service/quickstart-nodejs)
  + Java: [Create a Java app on Azure App Service](https://learn.microsoft.com/en-us/azure/app-service/quickstart-java)
  + Python: [Create a Python app in Azure App Service](https://learn.microsoft.com/en-us/azure/app-service/quickstart-python)

### Create Your Pipeline

The code examples in this section assume you are deploying an ASP.NET web app. You can adapt the instructions for other frameworks.

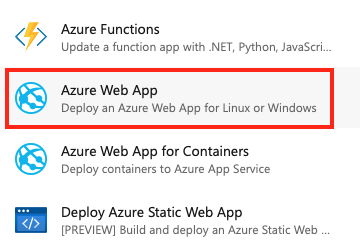
1. Sign in to your Azure DevOps organization and navigate to your project.
2. Go to **Pipelines**, and then select **New Pipeline**.
3. When prompted, select the location of your source code: either **Azure Repos Git** or **GitHub**.

You might be redirected to GitHub to sign in. If so, enter your GitHub credentials.

1. When the list of repositories appears, select your repository.
2. You might be redirected to GitHub to install the Azure Pipelines app. If so, select **Approve & install**.
3. When the **Configure** tab appears, select **ASP.NET Core**.
4. When your new pipeline appears, take a look at the YAML to see what it does. When you're ready, select **Save and run**.

#### Add the Azure Web App Task

1. Use the Task assistant to add the [Azure Web App](https://learn.microsoft.com/en-us/azure/devops/pipelines/tasks/deploy/azure-rm-web-app) task.



1. Select **Azure Resource Manager** for the **Connection type** and choose your **Azure subscription**. Make sure to **Authorize** your connection.
2. Select **Web App on Linux** and enter your azureSubscription, appName, and package. Your complete YAML should look like this.

variables:

buildConfiguration: 'Release'

steps:

- script: dotnet build --configuration $(buildConfiguration)

displayName: 'dotnet build $(buildConfiguration)'

- task: DotNetCoreCLI@2

inputs:

command: 'publish'

publishWebProjects: true

- task: AzureWebApp@1

inputs:

azureSubscription: '<Azure service connection>'

appType: 'webAppLinux'

appName: '<Name of web app>'

package: '$(System.DefaultWorkingDirectory)/\*\*/\*.zip'

* **azureSubscription**: your Azure subscription.
* **appName**: the name of your existing app service.
* **package**: the file path to the package or a folder containing your app service contents. Wildcards are supported.

Now you're ready to read through the rest of this topic to learn some of the more common changes that people make to customize an Azure Web App deployment.

#### Use the Azure Web App Task

The Azure Web App Deploy task is the simplest way to deploy to an Azure Web App. By default, your deployment happens to the root application in the Azure Web App.

The [Azure App Service Deploy task](https://learn.microsoft.com/en-us/azure/devops/pipelines/tasks/deploy/azure-rm-web-app-deployment) allows you to modify configuration settings inside web packages and XML parameters files.

##### Deploy a Web Deploy Package

To deploy a .zip Web Deploy package (for example, from an ASP.NET web app) to an Azure Web App, add the following snippet to your azure-pipelines.yml file:

- task: AzureWebApp@1

inputs:

azureSubscription: '<Azure service connection>'

appName: '<Name of web app>'

package: $(System.DefaultWorkingDirectory)/\*\*/\*.zip

* **azureSubscription**: your Azure subscription.
* **appName**: the name of your existing app service.
* **package**: the file path to the package or a folder containing your app service contents. Wildcards are supported.

The snippet assumes that the build steps in your YAML file produce the zip archive in the $(System.DefaultWorkingDirectory) folder on your agent.

##### Deploy a .NET App

If you're building a [.NET Core app](https://learn.microsoft.com/en-us/azure/devops/pipelines/ecosystems/dotnet-core), use the following snippet to deploy the build to an app.

variables:

buildConfiguration: 'Release'

steps:

- script: dotnet build --configuration $(buildConfiguration)

displayName: 'dotnet build $(buildConfiguration)'

- task: DotNetCoreCLI@2

inputs:

command: 'publish'

publishWebProjects: true

- task: AzureWebApp@1

inputs:

azureSubscription: '<Azure service connection>'

appType: 'webAppLinux'

appName: '<Name of web app>'

package: '$(System.DefaultWorkingDirectory)/\*\*/\*.zip'

* **azureSubscription**: your Azure subscription.
* **appType**: your Web App type.
* **appName**: the name of your existing app service.
* **package**: the file path to the package or a folder containing your app service contents. Wildcards are supported.

#### Run the Pipeline

Save and run the pipeline to trigger the build & deployment.

It may ask permissions to access the Service Connection. Grant permission to proceed.

#### Use a Service Connection

To deploy to Azure App Service, you'll need to use an Azure Resource Manager [service connection](https://learn.microsoft.com/en-us/azure/devops/pipelines/library/service-endpoints). The Azure service connection stores the credentials to connect from Azure Pipelines or Azure DevOps Server to Azure.

You'll need an Azure service connection for the AzureWebApp task. The Azure service connection stores the credentials to connect from Azure Pipelines to Azure. See [Create an Azure service connection](https://learn.microsoft.com/en-us/azure/devops/pipelines/library/connect-to-azure).

#### Deploy to a Virtual Application

By default, your deployment happens to the root application in the Azure Web App. You can deploy to a specific virtual application by using the VirtualApplication property of the AzureRmWebAppDeployment task:

- task: AzureRmWebAppDeployment@4

inputs:

VirtualApplication: '<name of virtual application>'

* **VirtualApplication**: the name of the Virtual Application that has been configured in the Azure portal. See [Configure an App Service app in the Azure portal](https://learn.microsoft.com/en-us/azure/app-service/configure-common)for more details.

#### Deploy to a Slot

You can configure the Azure Web App to have multiple slots. Slots allow you to safely deploy your app and test it before making it available to your customers.

The following example shows how to deploy to a staging slot, and then swap to a production slot:

- task: AzureWebApp@1

inputs:

azureSubscription: '<Azure service connection>'

appType: webAppLinux

appName: '<name of web app>'

deployToSlotOrASE: true

resourceGroupName: '<name of resource group>'

slotName: staging

package: '$(Build.ArtifactStagingDirectory)/\*\*/\*.zip'

- task: AzureAppServiceManage@0

inputs:

azureSubscription: '<Azure service connection>'

appType: webAppLinux

WebAppName: '<name of web app>'

ResourceGroupName: '<name of resource group>'

SourceSlot: staging

SwapWithProduction: true

* + **azureSubscription**: your Azure subscription.
  + **appType**: (optional) Use webAppLinux to deploy to a Web App on Linux.
  + **appName**: the name of your existing app service.
  + **deployToSlotOrASE**: Boolean. Deploy to an existing deployment slot or Azure App Service Environment.
  + **resourceGroupName**: Name of the resource group. Required if deployToSlotOrASE is true.
  + **slotName**: Name of the slot, defaults to production. Required if deployToSlotOrASE is true.
  + **package**: the file path to the package or a folder containing your app service contents. Wildcards are supported.
  + **SourceSlot**: Slot sent to production when SwapWithProduction is true.
  + **SwapWithProduction**: Boolean. Swap the traffic of source slot with production.

#### Deploy to Multiple Web Apps

You can use [jobs](https://learn.microsoft.com/en-us/azure/devops/pipelines/process/phases) in your YAML file to set up a pipeline of deployments. By using jobs, you can control the order of deployment to multiple web apps.

jobs:

- job: buildandtest

pool:

vmImage: ubuntu-latest

steps:

# publish an artifact called drop

- task: PublishPipelineArtifact@1

inputs:

targetPath: '$(Build.ArtifactStagingDirectory)'

artifactName: drop

# deploy to Azure Web App staging

- task: AzureWebApp@1

inputs:

azureSubscription: '<Azure service connection>'

appType: <app type>

appName: '<name of test stage web app>'

deployToSlotOrASE: true

resourceGroupName: <resource group name>

slotName: 'staging'

package: '$(Build.ArtifactStagingDirectory)/\*\*/\*.zip'

- job: deploy

dependsOn: buildandtest

condition: succeeded()

pool:

vmImage: ubuntu-latest

steps:

# download the artifact drop from the previous job

- task: DownloadPipelineArtifact@2

inputs:

source: 'current'

artifact: 'drop'

path: '$(Pipeline.Workspace)'

- task: AzureWebApp@1

inputs:

azureSubscription: '<Azure service connection>'

appType: <app type>

appName: '<name of test stage web app>'

resourceGroupName: <resource group name>

package: '$(Pipeline.Workspace)/\*\*/\*.zip'

### Make configuration changes

For most language stacks, [app settings](https://learn.microsoft.com/en-us/azure/app-service/configure-common?toc=/azure/app-service/containers/toc.json#configure-app-settings) and [connection strings](https://learn.microsoft.com/en-us/azure/app-service/configure-common?toc=/azure/app-service/containers/toc.json#configure-connection-strings) can be set as environment variables at runtime.

App settings can also be resolved from Key Vault using [Key Vault references](https://learn.microsoft.com/en-us/azure/app-service/app-service-key-vault-references).

For ASP.NET and ASP.NET Core developers, setting app settings in App Service are like setting them in <appSettings> in Web.config. You might want to apply a specific configuration for your web app target before deploying to it. This is useful when you deploy the same build to multiple web apps in a pipeline. For example, if your Web.config file contains a connection string named connectionString, you can change its value before deploying to each web app. You can do this either by applying a Web.config transformation or by substituting variables in your Web.config file.

**Azure App Service Deploy task** allows users to modify configuration settings in configuration files (\*.config files) inside web packages and XML parameters files (parameters.xml), based on the stage name specified.

**Note**: File transforms and variable substitution are also supported by the separate [**File Transform task**](https://learn.microsoft.com/en-us/azure/devops/pipelines/tasks/utility/file-transform) for use in Azure Pipelines. You can use the File Transform task to apply file transformations and variable substitutions on any configuration and parameters files.

#### Variable substitution

The following snippet shows an example of variable substitution:

jobs:

- job: test

variables:

connectionString: <test-stage connection string>

steps:

- task: AzureRmWebAppDeployment@4

inputs:

azureSubscription: '<Test stage Azure service connection>'

WebAppName: '<name of test stage web app>'

enableXmlVariableSubstitution: true

- job: prod

dependsOn: test

variables:

connectionString: <prod-stage connection string>

steps:

- task: AzureRmWebAppDeployment@4

inputs:

azureSubscription: '<Prod stage Azure service connection>'

WebAppName: '<name of prod stage web app>'

enableXmlVariableSubstitution: true

### Deploying conditionally

To do this in YAML, you can use one of these techniques:

* Isolate the deployment steps into a separate job, and add a condition to that job.
* Add a condition to the step.

The following example shows how to use step conditions to deploy only builds that originate from the main branch:

- task: AzureWebApp@1

condition: and(succeeded(), eq(variables['Build.SourceBranch'], 'refs/heads/main'))

inputs:

azureSubscription: '<Azure service connection>'

appName: '<name of web app>'

To learn more about conditions, see [Specify conditions](https://learn.microsoft.com/en-us/azure/devops/pipelines/process/conditions).

### Add Unit Test and Code Coverage to the YAML Pipeline

<https://build5nines.com/azure-pipeline-publish-unit-test-and-code-coverage-results-with-net-solution-using-vstest-cobertura-and-coverlet/>

### Run Basic Unit Tests

- task: DotNetCoreCLI@2

displayName: 'Run Unit Tests - $(buildConfiguration)'

inputs:

command: 'test'

arguments: '--no-build --configuration $(buildConfiguration)'

publishTestResults: false

### Run Unit Tests with VSTest and Output Unit Test and Code Coverage Results Files

There are a couple different ways to run the Unit Tests for the .NET solution within the Azure Pipeline. The method chosen in this article using the DotNetCoreCLI@2 task to run the dotnet test command with some arguments passed in. Let’s take a look at modifying this task to also output the Unit Test results and Code Coverage results!

The following is the basic task using DotNetCoreCLI@2 to run the dotnet test command for executing the Unit Tests within the solution:

- task: DotNetCoreCLI@2

displayName: 'Run Unit Tests - $(buildConfiguration)'

inputs:

command: 'test'

arguments: '--no-build --configuration $(buildConfiguration)'

publishTestResults: false

This task is passing in the following 2 arguments to the dotnet test command:

* --no-build – This tells it to skip building the solution. We’ll do this since it’s already been done previously in the pipeline.
* --configuration – This is used to pass in the Build Configuration for the Visual Studio solution. In this example, the $(buildConfiguration) variable within the pipeline is being used to configure the Build Configuration to use; which is configured to debug.

Yes, the DotNetCLI@2 task has the publishTestResults input that can be configured. However, when this is done, the task will not allow both Unit Test results and Code Coverage results to be published. So for now, we’ll set the publishTestResults input to false, so we can override this with our own configuration of arguments to output the results as needed.

To configure the dotnet test command to output both Unit Test and Code Coverage results, a couple more arguments are needed for each.

### Configure dotnet test to Output Unit Test Results

The DotNetCoreCLI@2 task for running the Unit Tests (via dotnet test command) requires additional arguments to configure it to output the Unit Test Results. The argument to use is the --logger argument and will be used to configure the unit test results format to output. In this case, for VSTest format, the trx value will be configured.

The following is the --logger argument that’s required for this:

--logger trx

Next, the --results-directory argument is required to tell the task to output the unit test results files to the desired directory. In this article, we’ll build the pipeline to use the $(Build.SourceDirectory)/TestResults/Coverage/ directory for this.

The following is the --results-directory argument that is required for this:

--results-directory "$(Build.SourcesDirectory)/TestResults/Coverage/"

The following is the task to run the Unit Tests with these required arguments for it to output the VSTest .trx results files in the desired directory:

- task: DotNetCoreCLI@2

displayName: 'Run Unit Tests - $(buildConfiguration)'

inputs:

command: 'test'

arguments: '--no-build --configuration $(buildConfiguration) --logger trx --results-directory "$(Build.SourcesDirectory)/TestResults/Coverage/"'

publishTestResults: false

### Configure dotnet test to Output Code Coverage Results

he DotNetCoreCLI@2 task for running the Unit Tests (via dotnet test command) requires additional arguments to configure it to output the Code Coverage Results. The argument to use is the --collect argument and will be used to configure the code coverage data collector to use. In this case, to use Coverlet, the value of XPlat Code Coverage will be configured.

The following is the --collect argument that’s required for this:

--collect "XPlat Code Coverage"

Next, the --results-directory argument is required to tell the task to output the unit test results files to the desired directory. In this article, we’ll build the pipeline to use the $(Build.SourceDirectory)/TestResults/Coverage/ directory for this.

The following is the --results-directory argument that is required for this:

--results-directory "$(Build.SourcesDirectory)/TestResults/Coverage/"

The following is the task to run the Unit Tests with these required arguments for it to output the Coverlet Code Coverage Results files in the desired directory:

- task: DotNetCoreCLI@2

displayName: 'Run Unit Tests - $(buildConfiguration)'

inputs:

command: 'test'

arguments: '--no-build --configuration $(buildConfiguration) --results-directory "$(Build.SourcesDirectory)/TestResults/Coverage/" --collect "XPlat Code Coverage"'

publishTestResults: false

### Full DotNetCoreCLI@2 Task to Output Unit Test and Code Coverage Results

Now, let’s put the two examples of configuring the DotNetCoreCLI@2 task running the dotnet test command together so we have a single YAML task that will output both the VSTest Unit Test Results and Coverlet Code Coverage Results.

The following is the full DotNetCoreCLI@2 task is configured to output both the unit test and code coverage results:

- task: DotNetCoreCLI@2

displayName: 'Run Unit Tests - $(buildConfiguration)'

inputs:

command: 'test'

arguments: '--no-build --configuration $(buildConfiguration) --logger trx --results-directory "$(Build.SourcesDirectory)/TestResults/Coverage/" --collect "XPlat Code Coverage"'

publishTestResults: false

To use this in the Azure Pipeline YAML example shown previously, simply replace the Unit Test task within the previous Azure Pipeline YAML with this code. This will configure the pipeline to output the unit test and code coverage results. The next steps are to add tasks to the YAML that will publish these results to the Azure Pipeline.

### Publish VSTest Unit Test Result to Azure Pipeline

Using the previous DotNetCoreCLI@2 task that runs dotnet test and outputs the VSTest .trx format Unit Test Results, the next step is to publish the unit test results to the Azure Pipeline.

Since the task that ran the Unit Tests using dotnet test previously was configured to output the test results in .trx format, then the PublishTestResults@2 task can be configured as follows:

- task: PublishTestResults@2

displayName: 'Publish Test Results'

inputs:

testResultsFormat: VSTest

testResultsFiles: '\*\*/\*.trx'

searchFolder: '$(Build.SourcesDirectory)/TestResults/Coverage/'

The following inputs on the task are configured as follows:

* testResultsFormat – Configured to VSTest since VSTest was used by dotnet test to run the unit tests and the results are in .trx format.
* testResultsFiles – Configured to the filter of \*\*/\*.trx so it look for .trx files to publish the unit test results from.
* searchFolder – This is configured to the directory that the unit test results were output to. For the examples in this article it’s $(Build.SourcesDirectory)/TestResults/Coverage/.

To use this task, it must be places after the Run Unit Tests task in the Azure Pipeline YAML.

### Publish Coverlet and Cobertura Code Coverage Results to Azure Pipeline

Using the previous DotNetCoreCLI@2 task that runs dotnet test and outputs the VSTest .trx format Unit Test Results, the next step is to publish the Code Coverage Results. The task is configured to output the code coverage results using Coverlet. Before these results can be published to the Azure Pipeline, the process chosen in this article requires a Code Coverage Report to be generated. To generate this report, we can use reportgenerator.

The tasks required for this process to generate the code coverage report and publish it to the Azure Pipeline are as follows:

1. DotNetCoreCLI@2 – The dotnet tool install command will be used to install the reportgenerator tool.
2. PowerShell@2 – The reportgenerator tool will be called to generate the Code Coverage Report, using Cobertura, based on the Coverlet format Code Coverage Results that were previously output from the running the Unit Tests.
3. PublishCodeCoverageResults@1 – Publish the Code Coverage Report that was generated using reportgenerator to the Azure Pipeline.

The following YAML are these 3 tasks configured as appropriate:

- task: DotNetCoreCLI@2

displayName: 'dotnet Tool Install "reportgenerator"'

inputs:

command: custom

custom: tool

arguments: 'install -g dotnet-reportgenerator-globaltool'

- task: PowerShell@2

displayName: 'Create Code Coverage Report'

inputs:

targetType: 'inline'

script: reportgenerator -reports:$(Build.SourcesDirectory)/\*\*/coverage.cobertura.xml -targetdir:$(Build.SourcesDirectory)/CodeCoverage -reporttypes:HtmlInline\_AzurePipelines

- task: PublishCodeCoverageResults@1

displayName: 'Publish Code Coverage Report'

inputs:

codeCoverageTool: 'cobertura'

summaryFileLocation: '$(Build.SourcesDirectory)/\*\*/coverage.cobertura.xml'

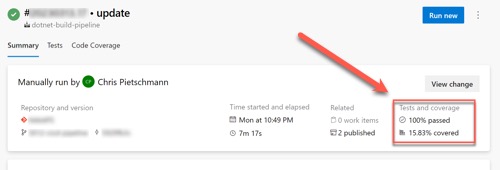
Keep in mind, this YAML code is also configured for the reportgenerator to look in the $(Build.SourcesDirectory)/CodeCoverage directory using the targetdir argument for the Code Coverage Results that were output from the dotnet test command that ran the Unit Tests previously.

To use this task, it must be places after the Run Unit Tests task in the Azure Pipeline YAML.

### Azure Pipeline Display of Unit Test and Code Coverage Results

Once the Unit Test results and the Code Coverage results publishing has been integrated into the YAML pipeline, when the pipeline is executed there will be 2 new tabs added to the build results for the pipeline status. The overall Unit Test results pass/fail percentages and Code Coverage percentages will also be displayed on the main Summary view for the pipeline build results.

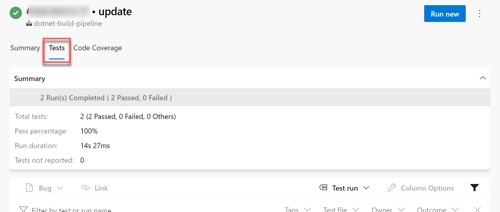
The following is a screenshot of the pipeline Summary view with these results shown:



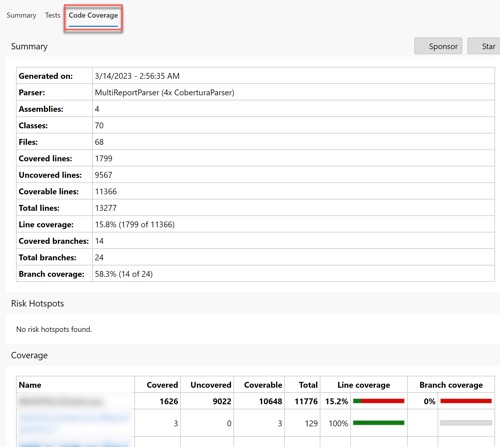
The following tabs will be added:

* **Tests** – This tab will display the Unit Test results for the solution as published by the YAML pipeline.
* **Code Coverage** – This will display the Code Coverage Report that was generated and published by the YAML pipeline.

The following is a screenshot of the **Tests** tab for the Azure Pipeline showing the full Unit Test results that also allows you to drill into view the full unit test pass/fail results:



The following is a screenshot of the **Code Coverage** tab for the Azure Pipeline showing the full Code Coverage Report and results that also allows you to drill into view the full code coverage details:



### Full YAML

# ASP.NET Core

# Build and test ASP.NET Core projects targeting .NET Core.

# Add steps that run tests, create a NuGet package, deploy, and more:

# https://docs.microsoft.com/azure/devops/pipelines/languages/dotnet-core

trigger:

- main

pool:

  vmImage: ubuntu-latest

variables:

  buildConfiguration: 'Release'

steps:

- script: dotnet build --configuration $(buildConfiguration)

  displayName: 'dotnet build $(buildConfiguration)'

- task: DotNetCoreCLI@2

  displayName: Publish

  inputs:

    command: 'publish'

    publishWebProjects: true

# run unit tests and generate both:

# 1. Test results in .trx file format / VSTest format

# 2. Code coverage results in Cobertura file format

- task: DotNetCoreCLI@2

  displayName: 'Run Unit Tests - $(buildConfiguration)'

  inputs:

    command: 'test'

    arguments: '--no-build --configuration $(buildConfiguration) --logger trx --results-directory "$(Build.SourcesDirectory)/TestResults/Coverage/"  --collect "XPlat Code Coverage"'

    publishTestResults: false

- task: PublishTestResults@2

  displayName: 'Publish Test Results'

  inputs:

    testResultsFormat: VSTest

    testResultsFiles: '\*\*/\*.trx'

    searchFolder: '$(Build.SourcesDirectory)/TestResults/Coverage/'

- task: DotNetCoreCLI@2

  displayName: 'dotnet Tool Install "reportgenerator"'

  inputs:

    command: custom

    custom: tool

    arguments: 'install -g dotnet-reportgenerator-globaltool'

- task: PowerShell@2

  displayName: 'Create Code Coverage Report'

  inputs:

    targetType: 'inline'

    script: reportgenerator -reports:$(Build.SourcesDirectory)/\*\*/coverage.cobertura.xml -targetdir:$(Build.SourcesDirectory)/CodeCoverage -reporttypes:HtmlInline\_AzurePipelines

- task: PublishCodeCoverageResults@1

  displayName: 'Publish Code Coverage Report'

  inputs:

    codeCoverageTool: 'cobertura'

    summaryFileLocation: '$(Build.SourcesDirectory)/\*\*/coverage.cobertura.xml'

- task: AzureWebApp@1

  displayName: Deploy

  inputs:

    azureSubscription: 'AJS-DevOps-Svc-Connection'

    appType: 'webAppLinux'

    appName: 'ajsSampleAPI'

    package: '$(System.DefaultWorkingDirectory)/\*\*/\*.zip'

## Deploy an Azure Function App using Azure DevOps

### YAML

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-how-to-azure-devops?view=azure-devops&tabs=csharp%2Cyaml&pivots=v1>

### Classic

<https://learn.microsoft.com/en-us/azure/azure-functions/functions-how-to-azure-devops?view=azure-devops&tabs=csharp%2Cclassic&pivots=v1>

**Solution**: <https://github.com/AjaySingala/FunctionApp/FunctionApp.sln>

There are two Function Apps in this project:

* HttpExample
* FunctionQueueTrigger

They use the following Azure resources:

* Resource Group: ajsFunctionApp-rg
* Storage account: ajsfunctionappstorage
* Queues:
  + ajs-queue-items
  + outqueue
* App Service: ajsFunctionAppJun2023
* In the project code config, for Azure they use the connection config named “AzureWebJobsStorage”.

# Terraform on Azure

<https://learn.microsoft.com/en-us/azure/developer/terraform/>

<https://learn.microsoft.com/en-us/azure/developer/terraform/overview>

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started>

## What is Infrastructure as Code with Terraform?

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started/infrastructure-as-code>

Infrastructure as code (IaC) tools allow you to manage infrastructure with configuration files rather than through a graphical user interface. IaC allows you to build, change, and manage your infrastructure in a safe, consistent, and repeatable way by defining resource configurations that you can version, reuse, and share.

Terraform is HashiCorp's infrastructure as code tool. It lets you define resources and infrastructure in human-readable, declarative configuration files, and manages your infrastructure's lifecycle. Using Terraform has several advantages over manually managing your infrastructure:

* Terraform can manage infrastructure on multiple cloud platforms.
* The human-readable configuration language helps you write infrastructure code quickly.
* Terraform's state allows you to track resource changes throughout your deployments.
* You can commit your configurations to version control to safely collaborate on infrastructure.

[Hashicorp Terraform](https://www.terraform.io/) is an open-source IaC (Infrastructure-as-Code) tool for provisioning and managing cloud infrastructure. It codifies infrastructure in configuration files that describe the desired state for your topology. Terraform enables the management of any infrastructure - such as public clouds, private clouds, and SaaS services - by using [Terraform providers](https://www.terraform.io/language/providers).

## Terraform providers for Azure infrastructure

There are several Terraform providers that enable the management of Azure infrastructure:

* [AzureRM](https://registry.terraform.io/providers/hashicorp/azurerm/latest/docs): Manage stable Azure resources and functionality such as virtual machines, storage accounts, and networking interfaces.
* [AzureAD](https://registry.terraform.io/providers/hashicorp/azuread/latest/docs): Manage Azure Active directory resources such as groups, users, service principals, and applications.
* [AzureDevops](https://registry.terraform.io/providers/microsoft/azuredevops/latest/docs): Manage Azure DevOps resources such as agents, repositories, projects, pipelines, and queries.
* [AzAPI](https://registry.terraform.io/providers/Azure/azapi/latest/docs): Manage Azure resources and functionality using the Azure Resource Manager APIs directly. This provider compliments the AzureRM provider by enabling the management of Azure resources that aren't released. For more information about the AzAPI provider, see [Terraform AzAPI provider](https://learn.microsoft.com/en-us/azure/developer/terraform/overview-azapi-provider).
* [Azure Stack](https://registry.terraform.io/providers/hashicorp/azurestack/latest/docs): Manage Azure Stack resources such as virtual machines, DNS, VNet, and storage.

## Benefits of Terraform with Azure

This section describes the benefits of using Terraform to manage Azure infrastructure.

### Common IaC tool

Terraform Azure providers enable you to manage all of your Azure infrastructure using the same declarative syntax and tooling. Using these providers you can:

* Provision core platform capabilities such as management groups, policies, users, groups, and policies. For more information, see [Terraform implementation of Cloud Adoption Framework Enterprise-scale](https://github.com/Azure/terraform-azurerm-caf-enterprise-scale#readme).
* Provision Azure DevOps Projects and pipelines to automate regular infrastructure and application deployments.
* Provision Azure resources required by your applications.

### Automate infrastructure management

The Terraform template-based configuration file syntax enables you to configure Azure resources in a repeatable and predictable manner. Automating infrastructure includes the following benefits:

* Lowers the potential for human errors while deploying and managing infrastructure.
* Deploys the same template multiple times to create identical development, test, and production environments.
* Reduces the cost of development and test environments by creating them on-demand.

### Understand infrastructure changes before being applied

As a resource topology becomes complex, understanding the meaning and impact of infrastructure changes can be difficult.

The Terraform CLI enables users to validate and preview infrastructure changes before application of the plan. Previewing infrastructure changes in a safe manner has several benefits:

* Team members can collaborate more effectively by understanding proposed changes and their impact.
* Unintended changes can be caught early in the development process.

## Terraform Benefits – In General

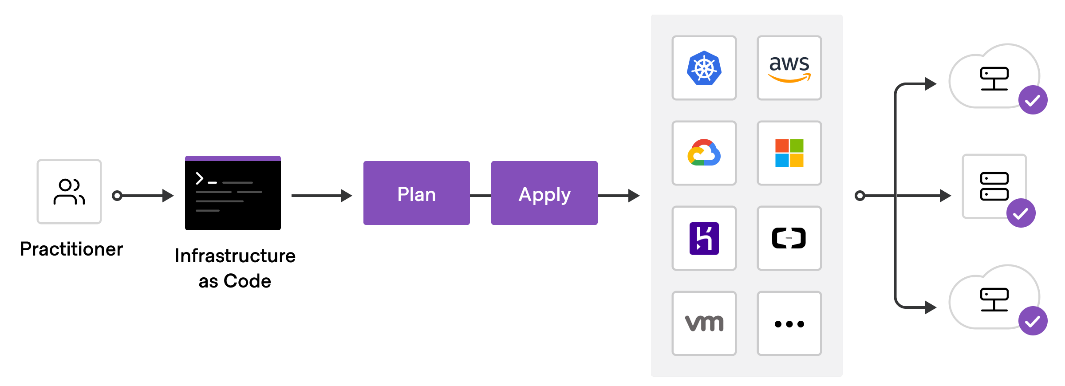
### Manage any infrastructure

Terraform plugins called providers let Terraform interact with cloud platforms and other services via their application programming interfaces (APIs). HashiCorp and the Terraform community have written over 1,000 providers to manage resources on Amazon Web Services (AWS), Azure, Google Cloud Platform (GCP), Kubernetes, Helm, GitHub, Splunk, and DataDog, just to name a few. Find providers for many of the platforms and services you already use in the [Terraform Registry](https://registry.terraform.io/browse/providers). If you don't find the provider you're looking for, you can write your own.

### Standardize your deployment workflow

Providers define individual units of infrastructure, for example compute instances or private networks, as resources. You can compose resources from different providers into reusable Terraform configurations called modules, and manage them with a consistent language and workflow.

Terraform's configuration language is declarative, meaning that it describes the desired end-state for your infrastructure, in contrast to procedural programming languages that require step-by-step instructions to perform tasks. Terraform providers automatically calculate dependencies between resources to create or destroy them in the correct order.



To deploy infrastructure with Terraform:

* **Scope** - Identify the infrastructure for your project.
* **Author** - Write the configuration for your infrastructure.
* **Initialize** - Install the plugins Terraform needs to manage the infrastructure.
* **Plan** - Preview the changes Terraform will make to match your configuration.
* **Apply** - Make the planned changes.

### Track your infrastructure

Terraform keeps track of your real infrastructure in a state file, which acts as a source of truth for your environment. Terraform uses the state file to determine the changes to make to your infrastructure so that it will match your configuration.

### Collaborate

Terraform allows you to collaborate on your infrastructure with its remote state backends. When you use Terraform Cloud (free for up to five users), you can securely share your state with your teammates, provide a stable environment for Terraform to run in, and prevent race conditions when multiple people make configuration changes at once.

You can also connect Terraform Cloud to version control systems (VCSs) like GitHub, GitLab, and others, allowing it to automatically propose infrastructure changes when you commit configuration changes to VCS. This lets you manage changes to your infrastructure through version control, as you would with application code.

## Install Terraform

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started/install-cli>

To use Terraform you will need to install it. HashiCorp distributes Terraform as a [binary package](https://developer.hashicorp.com/terraform/downloads). You can also install Terraform using popular package managers.

### Manual Installation

Retrieve the terraform binary by downloading a pre-compiled binary or compiling it from source.

To install Terraform, find the [appropriate package](https://developer.hashicorp.com/terraform/downloads) for your system and download it as a zip archive.

After downloading Terraform, unzip the package. Terraform runs as a single binary named terraform. Any other files in the package can be safely removed and Terraform will still function.

Finally, make sure that the terraform binary is available on your PATH. This process will differ depending on your operating system.

#### Windows

Set the PATH environment variable.

#### Mac or Linux

Print a colon-separated list of locations in your PATH.

$ echo $PATH

Move the Terraform binary to one of the listed locations. This command assumes that the binary is currently in your downloads folder and that your PATH includes /usr/local/bin, but you can customize it if your locations are different.

$ mv ~/Downloads/terraform /usr/local/bin/

export PATH=$PATH:/usr/local/bin/terraform

You could add the export command to the .bashrc file and then run source ~/.bashrc command.

### Homebrew on OS X

[Homebrew](https://brew.sh/) is a free and open-source package management system for Mac OS X. Install the official [Terraform formula](https://github.com/hashicorp/homebrew-tap) from the terminal.

First, install the HashiCorp tap, a repository of all our Homebrew packages.

$ brew tap hashicorp/tap

Now, install Terraform with hashicorp/tap/terraform.

$ brew install hashicorp/tap/terraform

**Note**:This installs a signed binary and is automatically updated with every new official release.

To update to the latest version of Terraform, first update Homebrew.

$ brew update

Then, run the upgrade command to download and use the latest Terraform version.

$ brew upgrade hashicorp/tap/terraform

==> Upgrading 1 outdated package:

hashicorp/tap/terraform 0.15.3 -> 1.0.0

==> Upgrading hashicorp/tap/terraform 0.15.3 -> 1.0.0

### Chocolatey on Windows

[Chocolatey](https://chocolatey.org/) is a free and open-source package management system for Windows. Install the [Terraform package](https://chocolatey.org/packages/terraform) from the command-line.

$ choco install terraform

**Note**: Chocolatey and the Terraform package are **NOT** directly maintained by HashiCorp. The latest version of Terraform is always available by manual installation.

### Linux

Ensure that your system is up to date and you have installed the gnupg, software-properties-common, and curl packages installed. You will use these packages to verify HashiCorp's GPG signature and install HashiCorp's Debian package repository.

$ sudo apt-get update && sudo apt-get install -y gnupg software-properties-common

Install the HashiCorp [GPG key](https://apt.releases.hashicorp.com/gpg).

$ wget -O- https://apt.releases.hashicorp.com/gpg | \

gpg --dearmor | \

sudo tee /usr/share/keyrings/hashicorp-archive-keyring.gpg

Verify the key's fingerprint.

$ gpg --no-default-keyring \

--keyring /usr/share/keyrings/hashicorp-archive-keyring.gpg \

--fingerprint

The gpg command will report the key fingerprint:

/usr/share/keyrings/hashicorp-archive-keyring.gpg

-------------------------------------------------

pub rsa4096 XXXX-XX-XX [SC]

AAAA AAAA AAAA AAAA

uid [ unknown] HashiCorp Security (HashiCorp Package Signing) <security+packaging@hashicorp.com>

sub rsa4096 XXXX-XX-XX [E]

**Tip**: Refer to the [Official Packaging Guide](https://www.hashicorp.com/official-packaging-guide) for the latest public signing key. You can also verify the key on [Security at HashiCorp](https://www.hashicorp.com/security) under **Linux Package Checksum Verification**.

Add the official HashiCorp repository to your system. The lsb\_release -cs command finds the distribution release codename for your current system, such as buster, groovy, or sid.

$ echo "deb [signed-by=/usr/share/keyrings/hashicorp-archive-keyring.gpg] \

https://apt.releases.hashicorp.com $(lsb\_release -cs) main" | \

sudo tee /etc/apt/sources.list.d/hashicorp.list

Download the package information from HashiCorp.

$ sudo apt update

Install Terraform from the new repository.

$ sudo apt-get install terraform

**Tip**: Now that you have added the HashiCorp repository, you can install [Vault](https://developer.hashicorp.com/vault/tutorials/getting-started/getting-started-install), [Consul](https://developer.hashicorp.com/consul/tutorials/get-started-vms/virtual-machine-gs-deploy), [Nomad](https://developer.hashicorp.com/nomad/tutorials/get-started/get-started-install) and [Packer](https://developer.hashicorp.com/packer/tutorials/docker-get-started/get-started-install-cli) with the same command.

### Verify the installation

Verify that the installation worked by opening a new terminal session and listing Terraform's available subcommands.

$ terraform -help

Add any subcommand to terraform -help to learn more about what it does and available options.

$ terraform -help plan

### Troubleshoot

If you get an error that terraform could not be found, your PATH environment variable was not set up properly. Please go back and ensure that your PATH variable contains the directory where Terraform was installed.

### Enable tab completion

If you use either Bash or Zsh, you can enable tab completion for Terraform commands. To enable autocomplete, first ensure that a config file exists for your chosen shell.

#### Bash

$ touch ~/.bashrc

#### Zsh

$ touch ~/.zshrc

Then install the autocomplete package.

$ terraform -install-autocomplete

Once the autocomplete support is installed, you will need to restart your shell.

### Quick start tutorial

Now that you've installed Terraform, you can provision an NGINX server in less than a minute using [Docker](https://www.docker.com/products/docker-desktop) on Mac, Windows, or Linux. You can also follow the rest of this tutorial in your web browser.

#### Docker Desktop for Windows

To run Docker on your Windows 10 machine, you must use the Windows Subsystem for Linux (WSL2). [Download and install WSL2](https://docs.microsoft.com/en-us/windows/wsl/install-win10) before moving on.

Download [Docker Desktop for Windows](https://docs.docker.com/docker-for-windows/install).

After you install Terraform and Docker on your local machine, start Docker Desktop by searching for Docker from your Start Menu and select Docker Desktop in the search results. When the whale icon in the status bar stays steady, Docker Desktop is up-and-running, and is accessible from any terminal window.

#### Docker Engine for Linux

<https://docs.docker.com/desktop/install/linux-install/>

For Ubuntu: <https://docs.docker.com/desktop/install/ubuntu/>

#### Post-Installation of Docker

Create a directory named learn-terraform-docker-container.

$ mkdir learn-terraform-docker-container

This working directory houses the configuration files that you write to describe the infrastructure you want Terraform to create and manage. When you initialize and apply the configuration here, Terraform uses this directory to store required plugins, modules (pre-written configurations), and information about the real infrastructure it created.

Navigate into the working directory.

$ cd learn-terraform-docker-container

In the working directory, create a file called main.tf and paste the following Terraform configuration into it.

##### Windows

terraform {

required\_providers {

docker = {

source = "kreuzwerker/docker"

version = "~> 3.0.1"

}

}

}

provider "docker" {

host = "npipe:////.//pipe//docker\_engine"

}

resource "docker\_image" "nginx" {

name = "nginx"

keep\_locally = false

}

resource "docker\_container" "nginx" {

image = docker\_image.nginx.image\_id

name = "tutorial"

ports {

internal = 80

external = 8000

}

}

##### Mac or Linux

terraform {

required\_providers {

docker = {

source = "kreuzwerker/docker"

version = "~> 3.0.1"

}

}

}

provider "docker" {}

resource "docker\_image" "nginx" {

name = "nginx"

keep\_locally = false

}

resource "docker\_container" "nginx" {

image = docker\_image.nginx.image\_id

name = "tutorial"

ports {

internal = 80

external = 8000

}

}

Initialize the project, which downloads a plugin called a provider that lets Terraform interact with Docker.

$ terraform init

Provision the NGINX server container with apply. When Terraform asks you to confirm type yes and press ENTER.

$ terraform apply

Verify the existence of the NGINX container by visiting [localhost:8000](http://localhost:8000/) in your web browser or running docker ps to see the container.



$ docker ps

CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS NAMES

425d5ee58619 e791337790a6 "nginx -g 'daemon of…" 20 seconds ago Up 19 seconds 0.0.0.0:8000->80/tcp tutorial

To stop the container, run terraform destroy.

$ terraform destroy

You've now provisioned and destroyed a NGINX webserver with Terraform.

## Build Infrastructure - Terraform Azure Example

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started/azure-build>

In this tutorial, you will create a Terraform configuration to deploy an Azure resource group. This resource group is the foundation for the infrastructure you will build in the subsequent tutorials.

### Prerequisites

An Azure subscription. If you do not have an Azure account, [create one now](https://azure.microsoft.com/en-us/free/). This tutorial can be completed using only the services included in an Azure [free account](https://azure.microsoft.com/en-us/free/free-account-faq/).

If you are using a paid subscription, you may be charged for the resources needed to complete the tutorial.

* Terraform 0.14.9 or later
* The Azure CLI Tool installed

### Install the Azure CLI tool

You will use the Azure CLI tool to authenticate with Azure.

Open your PowerShell prompt as an administrator and run the following command:

$ Invoke-WebRequest -Uri https://aka.ms/installazurecliwindows -OutFile .\AzureCLI.msi; Start-Process msiexec.exe -Wait -ArgumentList '/I AzureCLI.msi /quiet'; rm .\AzureCLI.msi

### Authenticate using the Azure CLI

Terraform must authenticate to Azure to create infrastructure.

In your terminal, use the Azure CLI tool to setup your account permissions locally.

$ az login

Your browser will open and prompt you to enter your Azure login credentials. After successful authentication, your terminal will display your subscription information.

You have logged in. Now let us find all the subscriptions to which you have access...

[

{

"cloudName": "AzureCloud",

"homeTenantId": "0envbwi39-home-Tenant-Id",

"id": "35akss-subscription-id",

"isDefault": true,

"managedByTenants": [],

"name": "Subscription-Name",

"state": "Enabled",

"tenantId": "0envbwi39-TenantId",

"user": {

"name": "your-username@domain.com",

"type": "user"

}

}

]

Find the id column for the subscription account you want to use.

Once you have chosen the account subscription ID, set the account with the Azure CLI.

$ az account set --subscription "35akss-subscription-id"

### Create a Service Principal

Next, create a Service Principal. A Service Principal is an application within Azure Active Directory with the authentication tokens Terraform needs to perform actions on your behalf. Update the <SUBSCRIPTION\_ID> with the subscription ID you specified in the previous step.

$ az ad sp create-for-rbac --role="Contributor" --scopes="/subscriptions/<SUBSCRIPTION\_ID>"

Creating 'Contributor' role assignment under scope '/subscriptions/35akss-subscription-id'

The output includes credentials that you must protect. Be sure that you do not include these credentials in your code or check the credentials into your source control. For more information, see https://aka.ms/azadsp-cli

{

"appId": "xxxxxx-xxx-xxxx-xxxx-xxxxxxxxxx",

"displayName": "azure-cli-2022-xxxx",

"password": "xxxxxx~xxxxxx~xxxxx",

"tenant": "xxxxx-xxxx-xxxxx-xxxx-xxxxx"

}

### Set your environment variables

HashiCorp recommends setting these values as environment variables rather than saving them in your Terraform configuration.

**Windows Powershell**

In your Powershell terminal, set the following environment variables. Be sure to update the variable values with the values Azure returned in the previous command.

$ $Env:ARM\_CLIENT\_ID = "<APPID\_VALUE>"

$ $Env:ARM\_CLIENT\_SECRET = "<PASSWORD\_VALUE>"

$ $Env:ARM\_SUBSCRIPTION\_ID = "<SUBSCRIPTION\_ID>"

$ $Env:ARM\_TENANT\_ID = "<TENANT\_VALUE>"

**macOS / Linux**

In your terminal, set the following environment variables. Be sure to update the variable values with the values Azure returned in the previous command.

$ export ARM\_CLIENT\_ID="<APPID\_VALUE>"

$ export ARM\_CLIENT\_SECRET="<PASSWORD\_VALUE>"

$ export ARM\_SUBSCRIPTION\_ID="<SUBSCRIPTION\_ID>"

$ export ARM\_TENANT\_ID="<TENANT\_VALUE>"

### Write Configuration

**Windows Powershell**

Create a folder called learn-terraform-azure.

$ New-Item -Path "c:\" -Name "learn-terraform-azure" -ItemType "directory"

**macOS / Linux**

Create a directory called learn-terraform-azure.

$ mkdir learn-terraform-azure

Change into the new directory.

$ cd learn-terraform-azure

Create a new file called main.tf and paste the configuration below.

# main.tf

# Configure the Azure provider

terraform {

required\_providers {

azurerm = {

source = "hashicorp/azurerm"

version = "~> 3.0.2"

}

}

required\_version = ">= 1.1.0"

}

provider "azurerm" {

features {}

}

resource "azurerm\_resource\_group" "rg" {

name = "myTFResourceGroup"

location = "westus2"

}

**Note**: The location of your resource group is hardcoded in this example. If you do not have access to the resource group location westus2, update the main.tf file with your [Azure region](https://docs.microsoft.com/en-us/azure/virtual-machines/regions).

This is a complete configuration that Terraform can apply. In the following sections you will review each block of the configuration in more detail.

#### Terraform Block

The terraform {} block contains Terraform settings, including the required providers Terraform will use to provision your infrastructure. For each provider, the source attribute defines an optional hostname, a namespace, and the provider type. Terraform installs providers from the [Terraform Registry](https://registry.terraform.io/) by default. In this example configuration, the azurerm provider's source is defined as hashicorp/azurerm, which is shorthand for registry.terraform.io/hashicorp/azurerm.

You can also define a version constraint for each provider in the required\_providers block. The version attribute is optional, but we recommend using it to enforce the provider version. Without it, Terraform will always use the latest version of the provider, which may introduce breaking changes.

To learn more, reference the [provider source documentation](https://developer.hashicorp.com/terraform/language/providers/requirements).

#### Providers

The provider block configures the specified provider, in this case azurerm. A provider is a plugin that Terraform uses to create and manage your resources. You can define multiple provider blocks in a Terraform configuration to manage resources from different providers.

#### Resource

Use resource blocks to define components of your infrastructure. A resource might be a physical component such as a server, or it can be a logical resource such as a Heroku application.

Resource blocks have two strings before the block: the resource type and the resource name. In this example, the resource type is azurerm\_resource\_group and the name is rg. The prefix of the type maps to the name of the provider. In the example configuration, Terraform manages the azurerm\_resource\_group resource with the azurerm provider. Together, the resource type and resource name form a unique ID for the resource. For example, the ID for your network is azurerm\_resource\_group.rg.

Resource blocks contain arguments which you use to configure the resource. The [Azure provider documentation](https://registry.terraform.io/providers/hashicorp/azurerm/latest/docs) documents supported resources and their configuration options, including [azurerm\_resource\_group](https://registry.terraform.io/providers/hashicorp/azurerm/latest/docs/resources/resource_group) and its supported arguments.

### Initialize your Terraform configuration

Initialize your learn-terraform-azure directory in your terminal. The terraform commands will work with any operating system. Your output should look similar to the one below.

$ terraform init

Initializing the backend...

Initializing provider plugins...

- Finding hashicorp/azurerm versions matching "~> 3.0.2"...

- Installing hashicorp/azurerm v3.0.2...

- Installed hashicorp/azurerm v3.0.2 (signed by HashiCorp)

Terraform has been successfully initialized!

You may now begin working with Terraform. Try running "terraform plan" to see

any changes that are required for your infrastructure. All Terraform commands

should now work.

If you ever set or change modules or backend configuration for Terraform,

rerun this command to reinitialize your working directory. If you forget, other

commands will detect it and remind you to do so if necessary.

### Format and validate the configuration

We recommend using consistent formatting in all of your configuration files. The terraform fmt command automatically updates configurations in the current directory for readability and consistency.

Format your configuration. Terraform will print out the names of the files it modified, if any. In this case, your configuration file was already formatted correctly, so Terraform won't return any file names.

$ terraform fmt

You can also make sure your configuration is syntactically valid and internally consistent by using the terraform validate command.

Validate your configuration. The example configuration provided above is valid, so Terraform will return a success message.

$ terraform validate

Success! The configuration is valid.

### Apply your Terraform Configuration

Run the terraform apply command to apply your configuration.

This output shows the execution plan and will prompt you for approval before proceeding. If anything in the plan seems incorrect or dangerous, it is safe to abort here with no changes made to your infrastructure. Type yes at the confirmation prompt to proceed.

$ terraform apply

An execution plan has been generated and is shown below.

Resource actions are indicated with the following symbols:

+ create

Terraform will perform the following actions:

# azurerm\_resource\_group.rg will be created

+ resource "azurerm\_resource\_group" "rg" {

+ id = (known after apply)

+ location = "westus2"

+ name = "myTFResourceGroup"

}

Plan: 1 to add, 0 to change, 0 to destroy.

Do you want to perform these actions?

Terraform will perform the actions described above.

Only 'yes' will be accepted to approve.

Enter a value: yes

azurerm\_resource\_group.rg: Creating...

azurerm\_resource\_group.rg: Creation complete after 1s [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

Apply complete! Resources: 1 added, 0 changed, 0 destroyed.

Navigate to the [Azure portal](https://portal.azure.com/#blade/HubsExtension/BrowseResourceGroups) in your web browser to validate the resource group.

### Inspect your state

When you apply your configuration, Terraform writes data into a file called terraform.tfstate. This file contains the IDs and properties of the resources Terraform created so that it can manage or destroy those resources going forward. Your state file contains all of the data in your configuration and could also contain sensitive values in plaintext, so do not share it or check it in to source control.

For teams or larger projects, consider [storing your state remotely](https://developer.hashicorp.com/terraform/tutorials/cloud/cloud-migrate). Remote stage storage enables collaboration using Terraform but is beyond the scope of this tutorial.

Inspect the current state using terraform show.

$ terraform show

# azurerm\_resource\_group.rg:

resource "azurerm\_resource\_group" "rg" {

id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup"

location = "westus2"

name = "myTFResourceGroup"

}

When Terraform created this resource group, it also gathered the resource's properties and meta-data. These values can be referenced to configure other resources or outputs, which you will encounter in later tutorials.

To review the information in your state file, use the state command. If you have a long state file, you can see a list of the resources you created with Terraform by using the list subcommand.

$ terraform state list

azurerm\_resource\_group.rg

If you run terraform state, you will see a full list of available commands to view and manipulate the configuration's state.

$ terraform state

Usage: terraform state <subcommand> [options] [args]

This command has subcommands for advanced state management.

These subcommands can be used to slice and dice the Terraform state.

This is sometimes necessary in advanced cases. For your safety, all

state management commands that modify the state create a timestamped

backup of the state prior to making modifications.

The structure and output of the commands is specifically tailored to work

well with the common Unix utilities such as grep, awk, etc. We recommend

using those tools to perform more advanced state tasks.

Subcommands:

list List resources in the state

mv Move an item in the state

pull Pull current state and output to stdout

push Update remote state from a local state file

replace-provider Replace provider in the state

rm Remove instances from the state

show Show a resource in the state

## Change Infrastructure

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started/azure-change>

In the previous tutorial, you created your first infrastructure with Terraform: a resource group. Now you will modify your configuration by defining an additional resource that references your resource group and adding tags to your resource group.

### Create a new resource

In your main.tf file, add the resource block below to create a virtual network (VNet).

# main.tf

# Create a virtual network

resource "azurerm\_virtual\_network" "vnet" {

name = "myTFVnet"

address\_space = ["10.0.0.0/16"]

location = "westus2"

resource\_group\_name = azurerm\_resource\_group.rg.name

}

To create a new Azure VNet, you have to specify the name of the resource group to contain the VNet. By referencing the resource group, you establish a dependency between the resources. Terraform ensures that resources are created in proper order by constructing a dependency graph for your configuration.

### Apply your changes

After changing the configuration, run terraform apply again to see how Terraform will apply this change to your infrastructure. Respond yes to the prompt to confirm the changes.

$ terraform apply

azurerm\_resource\_group.rg: Refreshing state... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

Terraform used the selected providers to generate the following execution plan. Resource actions are indicated with the following symbols:

+ create

Terraform will perform the following actions:

# azurerm\_virtual\_network.vnet will be created

+ resource "azurerm\_virtual\_network" "vnet" {

+ address\_space = [

+ "10.0.0.0/16",

]

+ guid = (known after apply)

+ id = (known after apply)

+ location = "westus2"

+ name = "myTFVnet"

+ resource\_group\_name = "myTFResourceGroup"

+ subnet = (known after apply)

+ vm\_protection\_enabled = false

}

Plan: 1 to add, 0 to change, 0 to destroy.

Do you want to perform these actions?

Terraform will perform the actions described above.

Only 'yes' will be accepted to approve.

Enter a value: yes

azurerm\_virtual\_network.vnet: Creating...

azurerm\_virtual\_network.vnet: Creation complete after 6s [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup/providers/Microsoft.Network/virtualNetworks/myTFVnet]

Apply complete! Resources: 1 added, 0 changed, 0 destroyed.

Terraform builds an execution plan by comparing your desired state as described in the configuration to the current state, which is saved in either the local terraform.tfstate file or in a remote state backend depending on your configuration.

### Modify an existing resource

In addition to creating new resources, Terraform can modify existing resources.

Open your main.tf file. Update the azurerm\_resource\_group resource in your configuration by adding the tags block as shown below:

**Tip**: The below snippet is formatted as a diff to give you context about what in your configuration should change. Add the content in green (exclude the leading + sign).

# main.tf

resource "azurerm\_resource\_group" "rg" {

name = "myTFResourceGroup"

location = "westus2"

tags = {

Environment = "Terraform Getting Started"

Team = "DevOps"

}

}

### Apply your changes

Run terraform apply to modify your infrastructure. Respond yes to the prompt to confirm the operation.

$ terraform apply

azurerm\_resource\_group.rg: Refreshing state... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

azurerm\_virtual\_network.vnet: Refreshing state... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

Terraform used the selected providers to generate the following execution plan. Resource actions are indicated with the following symbols:

~ update in-place

Terraform will perform the following actions:

# azurerm\_resource\_group.rg will be updated in-place

~ resource "azurerm\_resource\_group" "rg" {

id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup"

name = "myTFResourceGroup"

~ tags = {

+ "Environment" = "Terraform Getting Started"

+ "Team" = "DevOps"

}

# (1 unchanged attribute hidden)

}

Plan: 0 to add, 1 to change, 0 to destroy.

Do you want to perform these actions?

Terraform will perform the actions described above.

Only 'yes' will be accepted to approve.

Enter a value: yes

azurerm\_resource\_group.rg: Modifying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

azurerm\_resource\_group.rg: Modifications complete after 1s [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

Apply complete! Resources: 0 added, 1 changed, 0 destroyed.

The prefix ~ means that Terraform will update the resource in-place.

### Review updates to state

Use terraform show again to see the new values associated with this resource group.

$ terraform show

# azurerm\_resource\_group.rg:

resource "azurerm\_resource\_group" "rg" {

id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup"

location = "westus2"

name = "myTFResourceGroup"

tags = {

"Environment" = "Terraform Getting Started"

i "Team" = "DevOps"

}

}

##...

Run terraform state list to get the updated list of resources managed in your workspace.

$ terraform state list

azurerm\_resource\_group.rg

azurerm\_virtual\_network.vnet

### Destroy Infrastructure

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started/azure-destroy>

You have now used Terraform to create and update Azure resources. In this tutorial, you will use Terraform to destroy your infrastructure.

Once you no longer need infrastructure, you may want to destroy it to reduce your security exposure and costs. For example, you may remove a production environment from service or manage short-lived environments like build or testing systems. In addition to building and modifying infrastructure, Terraform can destroy or recreate the infrastructure it manages.

#### Destroy

The terraform destroy command terminates resources managed by your Terraform project. This command is the inverse of terraform apply in that it terminates all the resources specified in your Terraform state. It does not destroy resources running elsewhere that are not managed by the current Terraform project.

Destroy the resources you created. When Terraform prompts you, type yes to execute this plan and destroy the infrastructure.

$ terraform destroy

azurerm\_resource\_group.rg: Refreshing state... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

azurerm\_virtual\_network.vnet: Refreshing state... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup/providers/Microsoft.Network/virtualNetworks/myTFVnet]

Terraform used the selected providers to generate the following execution plan. Resource actions are indicated with the following symbols:

- destroy

Terraform will perform the following actions:

# azurerm\_resource\_group.rg will be destroyed

- resource "azurerm\_resource\_group" "rg" {

- id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup" -> null

- location = "westus2" -> null

- name = "myTFResourceGroup" -> null

- tags = {

- "Environment" = "Terraform Getting Started"

- "Team" = "DevOps"

} -> null

}

# azurerm\_virtual\_network.vnet will be destroyed

- resource "azurerm\_virtual\_network" "vnet" {

- address\_space = [

- "10.0.0.0/16",

] -> null

- dns\_servers = [] -> null

- guid = "1a4efd63-61e5-48bb-ad9d-9ceadd403ecb" -> null

- id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup/providers/Microsoft.Network/virtualNetworks/myTFVnet" -> null

- location = "westus2" -> null

- name = "myTFVnet" -> null

- resource\_group\_name = "myTFResourceGroup" -> null

- subnet = [] -> null

- tags = {} -> null

- vm\_protection\_enabled = false -> null

}

Plan: 0 to add, 0 to change, 2 to destroy.

Do you really want to destroy all resources?

Terraform will destroy all your managed infrastructure, as shown above.

There is no undo. Only 'yes' will be accepted to confirm.

Enter a value: yes

azurerm\_virtual\_network.vnet: Destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup/providers/Microsoft.Network/virtualNetworks/myTFVnet]

azurerm\_virtual\_network.vnet: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...osoft.Network/virtualNetworks/myTFVnet, 10s elapsed]

azurerm\_virtual\_network.vnet: Destruction complete after 11s

azurerm\_resource\_group.rg: Destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

azurerm\_resource\_group.rg: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...29/resourceGroups/myTFResourceGroup, 10s elapsed]

azurerm\_resource\_group.rg: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...29/resourceGroups/myTFResourceGroup, 20s elapsed]

azurerm\_resource\_group.rg: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...29/resourceGroups/myTFResourceGroup, 30s elapsed]

azurerm\_resource\_group.rg: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...29/resourceGroups/myTFResourceGroup, 40s elapsed]

azurerm\_resource\_group.rg: Destruction complete after 47s

Destroy complete! Resources: 2 destroyed.

The - prefix in the output indicates that the instance will be destroyed. As with apply, Terraform shows its execution plan and waits for approval before making any changes.

Just like with apply, Terraform determines the order in which things must be destroyed. In more complicated cases with multiple resources, Terraform will destroy them in a suitable order to respect dependencies.

### Define Input Variables

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started/azure-variables>

You now have enough Terraform knowledge to create useful configurations, but the examples so far have used hard-coded values. Terraform configurations can include variables to make your configuration more dynamic and flexible.

#### Define your variables

In your learn-terraform-azure directory, create a new file called variables.tf. Copy and paste the variable declaration below.

**variables.tf**

variable "resource\_group\_name" {

default = "myTFResourceGroup"

}

This declaration includes a default value for the variable, so the resource\_group\_name variable will not be a required input.

#### Update your Terraform configuration with your variables

Update your azurerm\_resource\_group configuration to use the input variable for the resource group name. Modify the virtual machine block as follows:

**main.tf**

resource "azurerm\_resource\_group" "rg" {

name = var.resource\_group\_name

location = "westus2"

tags = {

Environment = "Terraform Getting Started"

Team = "DevOps"

}

}

#### Apply your configuration

Re-run terraform apply to recreate your infrastructure using input variables. Respond yes to the prompt to confirm the operation.

$ terraform apply

Terraform used the selected providers to generate the following execution plan. Resource actions are indicated with the following symbols:

+ create

Terraform will perform the following actions:

##...

Plan: 2 to add, 0 to change, 0 to destroy.

Do you want to perform these actions?

Terraform will perform the actions described above.

Only 'yes' will be accepted to approve.

Enter a value: yes

azurerm\_resource\_group.rg: Creating...

azurerm\_resource\_group.rg: Creation complete after 1s [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

azurerm\_virtual\_network.vnet: Creating...

azurerm\_virtual\_network.vnet: Creation complete after 7s [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup/providers/Microsoft.Network/virtualNetworks/myTFVnet]

Apply complete! Resources: 2 added, 0 changed, 0 destroyed.

Now apply the configuration again, this time overriding the default resource group name by passing in a variable using the -var flag. Updating the resource group name is a destructive update that forces Terraform to recreate the resource, and in turn the virtual network that depends on it. Respond to the confirmation prompt with yes to rename the resource group and create the new resources.

$ terraform apply -var "resource\_group\_name=myNewResourceGroupName"

azurerm\_resource\_group.rg: Refreshing state... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

azurerm\_virtual\_network.vnet: Refreshing state... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup/providers/Microsoft.Network/virtualNetworks/myTFVnet]

An execution plan has been generated and is shown below.

Resource actions are indicated with the following symbols:

-/+ destroy and then create replacement

Terraform will perform the following actions:

# azurerm\_resource\_group.rg must be replaced

-/+ resource "azurerm\_resource\_group" "rg" {

~ id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup" -> (known after apply)

~ name = "myTFResourceGroup" -> "myNewResourceGroupName" # forces replacement

tags = {

"Environment" = "Terraform Getting Started"

"Team" = "DevOps"

}

# (1 unchanged attribute hidden)

}

# azurerm\_virtual\_network.vnet must be replaced

-/+ resource "azurerm\_virtual\_network" "vnet" {

- dns\_servers = [] -> null

~ guid = "260a1a64-08ed-4693-84d8-eda800326faa" -> (known after apply)

~ id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup/providers/Microsoft.Network/virtualNetworks/myTFVnet" -> (known after apply)

name = "myTFVnet"

~ resource\_group\_name = "myTFResourceGroup" -> "myNewResourceGroupName" # forces replacement

~ subnet = [] -> (known after apply)

- tags = {} -> null

# (3 unchanged attributes hidden)

}

Plan: 2 to add, 0 to change, 2 to destroy.

Do you want to perform these actions?

Terraform will perform the actions described above.

Only 'yes' will be accepted to approve.

Enter a value: yes

azurerm\_virtual\_network.vnet: Destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup/providers/Microsoft.Network/virtualNetworks/myTFVnet]

azurerm\_virtual\_network.vnet: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...osoft.Network/virtualNetworks/myTFVnet, 10s elapsed]

azurerm\_virtual\_network.vnet: Destruction complete after 11s

azurerm\_resource\_group.rg: Destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup]

azurerm\_resource\_group.rg: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...dfb29/resourceGroups/myTFResourceGroup, 10s elapsed]

azurerm\_resource\_group.rg: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...dfb29/resourceGroups/myTFResourceGroup, 20s elapsed]

azurerm\_resource\_group.rg: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...dfb29/resourceGroups/myTFResourceGroup, 30s elapsed]

azurerm\_resource\_group.rg: Still destroying... [id=/subscriptions/c9ed8610-47a3-4107-a2b2-...dfb29/resourceGroups/myTFResourceGroup, 40s elapsed]

azurerm\_resource\_group.rg: Destruction complete after 48s

azurerm\_resource\_group.rg: Creating...

azurerm\_resource\_group.rg: Creation complete after 1s [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myNewResourceGroupName]

azurerm\_virtual\_network.vnet: Creating...

azurerm\_virtual\_network.vnet: Creation complete after 6s [id=/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myNewResourceGroupName/providers/Microsoft.Network/virtualNetworks/myTFVnet]

Apply complete! Resources: 2 added, 0 changed, 2 destroyed.

Setting variables via the command-line will not save their values. Terraform supports many ways to use and set variables so you can avoid having to enter them repeatedly as you execute commands. To learn more, follow our in-depth tutorial, [Customize Terraform Configuration with Variables](https://developer.hashicorp.com/terraform/tutorials/configuration-language/variables).

### Query Data with Output Variables

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started/azure-outputs>

In the previous tutorial, you used input variables to parameterize your Terraform configuration. In this tutorial, you will use output values to organize data to be easily queried and displayed to the Terraform user.

When building complex infrastructure, Terraform stores hundreds or thousands of attribute values for all your resources. As a user of Terraform, you may only be interested in a few values of importance. Outputs designate which data to display. This data is outputted when apply is called and can be queried using the terraform output command.

#### Define an output

Create a file called outputs.tf in your learn-terraform-azure directory. Add the following output definition to outputs.tf.

**outputs.tf**

output "resource\_group\_id" {

value = azurerm\_resource\_group.rg.id

}

This defines an output variable named resource\_group\_id. The name of the variable must conform to Terraform variable naming conventions if it is to be used as an input to other modules. The value field specifies the value, the id attribute of your resource group.

You can define multiple output blocks to specify multiple output variables.

#### Observe your resource outputs

When you add an output to a previously applied configuration, you must re-run terraform apply to observe the new output.

Apply your configuration. Remember to confirm the apply with a yes.

$ terraform apply

## ...

Changes to Outputs:

+ resource\_group\_id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup"

You can apply this plan to save these new output values to the Terraform state, without changing any real infrastructure.

Do you want to perform these actions?

Terraform will perform the actions described above.

Only 'yes' will be accepted to approve.

Enter a value: yes

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

resource\_group\_id = "/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup"

Notice that the apply run returns the outputs. Query the output using the output command with the output ID.

$ terraform output resource\_group\_id

"/subscriptions/c9ed8610-47a3-4107-a2b2-a322114dfb29/resourceGroups/myTFResourceGroup"

### Store Remote State

<https://developer.hashicorp.com/terraform/tutorials/azure-get-started/azure-remote>

Now you have built, changed, and destroyed infrastructure from your local machine. This is great for testing and development, but in production environments you should keep your state secure and encrypted, where your teammates can access it to collaborate on infrastructure. The best way to do this is by running Terraform in a remote environment with shared access to state.

[Terraform Cloud](https://cloud.hashicorp.com/products/terraform) allows teams to easily version, audit, and collaborate on infrastructure changes. It can also store access credentials off of developer machines, and provides a safe, stable environment for long-running Terraform processes.

In this tutorial, you will migrate your state to Terraform Cloud.

#### Prerequisites

This tutorials assumes you have completed the previous tutorials. If not, create a directory named learn-terraform-azure-instance and paste this code into a file named main.tf.

**main.tf**

terraform {

required\_version = ">= 1.1.0"

required\_providers {

azurerm = {

source = "hashicorp/azurerm"

version = "~> 3.0.2"

}

}

}

provider "azurerm" {

features {}

}

resource "azurerm\_resource\_group" "rg" {

name = "myTFResourceGroup"

location = "westus2"

}

**Note**: Because the cloud block is not supported by older versions of Terraform, you must use 1.1.0 or higher in order to follow this tutorial. Previous versions can use the [remote backend block](https://developer.hashicorp.com/terraform/language/settings/backends/remote) to configure the CLI workflow and migrate state.

#### Set up Terraform Cloud

If you have a HashiCorp Cloud Platform or Terraform Cloud account, log in using your existing credentials. For more detailed instructions on how to sign up for a new account and create an organization, review the [Sign up for Terraform Cloud](https://developer.hashicorp.com/terraform/tutorials/cloud-get-started/cloud-sign-up) tutorial.

Next, configure the cloud block in your configuration with the organization name, and a new workspace name of your choice:

**main.tf**

terraform {

required\_version = ">= 1.1.0"

required\_providers {

azurerm = {

source = "hashicorp/azurerm"

version = "~> 3.0.2"

}

}

cloud {

organization = "<ORG\_NAME>"

workspaces {

name = "learn-terraform-azure"

}

}

}

provider "azurerm" {

features {}

}

#### Authenticate with Terraform Cloud

Now that you have defined your Terraform Cloud configuration, you must authenticate with Terraform Cloud in order to proceed with initialization. In order to authenticate with Terraform Cloud, run the terraform login subcommand, and follow the prompts to log in.

Note

If you are using a version of Terraform prior to 0.12.21, the terraform login command is not available. Instead, set up a [CLI configuration file](https://developer.hashicorp.com/terraform/cli/config/config-file#credentials) to authenticate.

$ terraform login

Terraform will request an API token for app.terraform.io using your browser.

If login is successful, Terraform will store the token in plain text in

the following file for use by subsequent commands:

/Users/username/.terraform.d/credentials.tfrc.json

Do you want to proceed? (y/n)

For more detailed instructions on logging in, see the [login tutorial](https://developer.hashicorp.com/terraform/tutorials/cloud-get-started/cloud-login).

#### Migrate the state file

Now you are ready to migrate your local state file to Terraform Cloud. Reinitialize your configuration to begin the migration. This causes Terraform to recognize your cloud block configuration.

$ terraform init

Initializing Terraform Cloud...

Do you wish to proceed?

As part of migrating to Terraform Cloud, Terraform can optionally copy your

current workspace state to the configured Terraform Cloud workspace.

Answer "yes" to copy the latest state snapshot to the configured

Terraform Cloud workspace.

Answer "no" to ignore the existing state and just activate the configured

Terraform Cloud workspace with its existing state, if any.

Should Terraform migrate your existing state?

Enter a value:

During reinitialization, Terraform presents a prompt saying that it will copy the state file to your Terraform Cloud workspace. Enter yes so Terraform will migrate the state from your local machine to Terraform Cloud.

Enter a value: yes

Initializing provider plugins...

- Using previously-installed hashicorp/azurerm v3.0.2

Terraform Cloud has been successfully initialized!

You may now begin working with Terraform Cloud. Try running "terraform plan" to

see any changes that are required for your infrastructure.

If you ever set or change modules or Terraform Settings, run "terraform init"

again to reinitialize your working directory.

When using Terraform Cloud with the CLI-driven workflow, you can choose to have Terraform run remotely, or on your local machine. The default option is remote execution — Terraform Cloud will perform Terraform operations remotely. When using local execution, Terraform Cloud will execute Terraform on your local machine and remotely store your state file in Terraform Cloud. For this tutorial, you will use the default remote execution option for the workspace.

Now that Terraform has migrated the state file to Terraform Cloud, delete the local state file.

$ rm terraform.tfstate

#### Configure a Service Principal

If you are not already logged in to Azure, use the Azure CLI to log in to your account.

$ az login

Your browser window will open and you will be prompted to enter your Azure login credentials. After successful authentication, your terminal will display your subscription information. You do not need to save this output as it is saved in your system for Terraform to use.

A Service Principal is an application within Azure Active Directory whose authentication tokens can be used as environment variables in Terraform Cloud. For more information, visit the [Azure documentation](https://docs.microsoft.com/en-us/azure/active-directory/develop/app-objects-and-service-principals).

First, list the Subscriptions associated with your Azure account.

$ az account list

[

{

"cloudName": "AzureCloud",

"id": "00000000-0000-0000-0000-000000000000",

"isDefault": true,

"name": "PAYG Subscription",

"state": "Enabled",

"tenantId": "00000000-0000-0000-0000-000000000000",

"user": {

"name": "user@example.com",

"type": "user"

}

}

]

Select a subscription and copy its id field value. This is the Subscription ID related to your account. Paste this value into the command below with your own Subscription ID and save the value. You will use it later to give Terraform Cloud access to your Azure account.

$ az account set --subscription="SUBSCRIPTION\_ID"

Create the Service Principal with the same Subscription ID.

$ az ad sp create-for-rbac --role="Contributor" --scopes="/subscriptions/SUBSCRIPTION\_ID"

Creating a role assignment under the scope of "/subscriptions/SUBSCRIPTION\_ID"

{

"appId": "00000000-0000-0000-0000-000000000000",

"displayName": "azure-cli-2017-06-05-10-41-15",

"name": "http://azure-cli-2017-06-05-10-41-15",

"password": "0000-0000-0000-0000-000000000000",

"tenant": "00000000-0000-0000-0000-000000000000"

}

Copy this output somewhere safe.

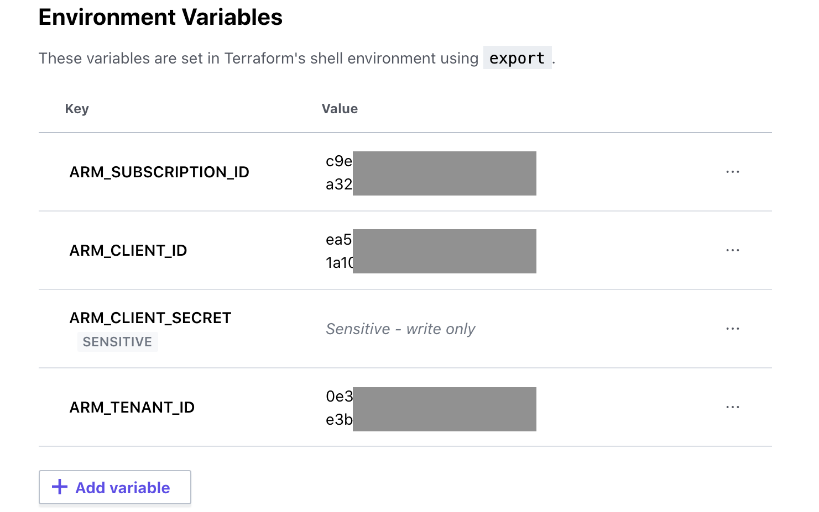
#### Update the Terraform Cloud environment variables

Now that you have the authentication information for your account, navigate to the learn-terraform-azure workspace in the Terraform Cloud UI.

Find the Variables tab and create the below environment variables using the values you put into and got back from the last command. Set the ARM\_CLIENT\_SECRET as a sensitive value.

| **Environment Variable** | **AZ CLI** |
| --- | --- |
| ARM\_SUBSCRIPTION\_ID | SUBSCRIPTION\_ID from the last command's input. |
| ARM\_CLIENT\_ID | appID from the last command's output. |
| ARM\_CLIENT\_SECRET | password from the last command's output. (Sensitive) |
| ARM\_TENANT\_ID | tenant from the last command's output. |

Update and save these four environment variables. Set the ARM\_CLIENT\_SECRET as a sensitive value. Review your environment variables to ensure they match the example below.



#### Apply the configuration

Now, apply your configuration including the required variables. Terraform will tell you that there are no changes.

$ terraform apply

## ...

No changes. Infrastructure is up-to-date.

This means that Terraform did not detect any differences between your

configuration and real physical resources that exist. As a result, Terraform

doesn't need to do anything.

Terraform is now storing your state remotely in Terraform Cloud. Remote state storage makes collaboration easier and keeps state and secret information off your local disk. Remote state is loaded only in memory when it is used.

#### Destroy the infrastructure

Destroy your infrastructure, and remember to confirm with a yes.

$ terraform destroy