Build and deploy a multi-container application in Azure Container Service

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Overview

To run a multi-container application on Azure, you have several deployment choices. This guide and the accompanying GitHub scripts demonstrate how to create a multi-container application using ASP.NET Core and Docker, then deploy it on an Azure Container Service Kubernetes cluster on Linux.

The multi-container application adopts a microservices architecture that consists of a collection of small, autonomous services. Each service is self-contained and implements a single business capability. Microservices have the following characteristics:

- In a microservices architecture, services are small, independent, and loosely coupled.
- Each microservice is a defined by a separate code base, configuration data, and data package that can be managed by a small development team.
- Each microservice can be built using different programming languages, technology stacks, libraries, and frameworks.
- Microservices communicate with each other using well-defined application programming interfaces (APIs). Internal implementation details of each service are hidden from other services.
- Microservices can be versioned and deployed independently. A team can update an existing service without rebuilding and redeploying an entire application.
- Services are responsible for persisting their own data or external state. This approach differs from the traditional model, where a separate data layer handles data persistence.

For detailed guidance about building a microservices architecture on Azure, see Designing, building, and operating microservices on Azure.

In this guide

This guide is intended for software developers with some familiarity with multi-container applications and includes a sample multi-container application created with ASP.NET Core. This guide shows you how to deploy it on Azure in two ways:

- To Azure Container Service–Kubernetes (ACS–Kubernetes) cluster.
- To Azure Container Service with Managed Kubernetes (AKS) cluster.

In each of these scenarios, the cluster can pull images from either Docker Hub or Azure Container Registry. These alternatives are described and sample configuration files are provided on GitHub.

The guide also shows how to:

- Use environment variables in a Dockerfile, Docker Compose file, or Kubernetes templates to specify application settings.
- Set up the deployment for monitoring using Azure Application Insights.
- Delegate a public domain to Azure DNS.

- Use the Azure Cloud Shell to create an app on Kubernetes.

The sample application, scripts, and command files are included in a GitHub repository so you can experiment.

Prerequisites for the development computer

- Install Microsoft Visual Studio 2017 with .NET Core workload. For more information, see Visual Studio Tools for Docker.
- Install Docker for Windows and configure it to use Linux containers.
- Clone or download this container solution into a directory on your local machine.
- Replace the values of the scripts' placeholder parameters as described throughout this guide.

Contents of this project

The GitHub repository contains the projects, code, templates, and scripts used to build and deploy the Todolist multi-container application to ACS–Kubernetes and AKS. Additional projects and scripts in the repository are intended to be used to deploy the multi-container application to Azure Service Fabric.

The Visual Studio solution available in the GitHub repository is composed of the following contents that can be used to build and deploy the sample multi-container application to a an ACS–Kubernetes or AKS cluster:

- **TodoWeb**: This project is an ASP.NET Core Web application that represents the front end of the solution. The user interface is composed of a set of Razor pages that can be used to browse, create, delete, update, and see the details about a collection of to-do items stored in an Azure Cosmos DB collection. The front-end service is configured to send logs, events, traces, requests, dependencies, and exceptions to Application Insights.
- **TodoApi**: This project contains an ASP.NET Core Web API service that is invoked by the **TodoWeb** front-end service to access the data stored in an Azure Cosmos DB SQL API database. Each time a CRUD operation is performed by any of the methods exposed by the **TodoController**, the back-end service sends a notification message to a Service Bus queue. You can use Service Bus Explorer to read messages from the queue. The back-end service is configured to send logs, events, traces, requests, dependencies and exceptions to Application Insights. The back-end service adopts Swagger to expose a machine-readable representation of its RESTful API.

\Scripts

- **ACS-Kubernetes-Cluster** folder contains the create-kubernetes-acs-cluster.cmd command file used to create an Azure Container Service Kubernetes cluster.
- **AKS-Kubernetes-Cluster** folder contains the create-kubernetes-aks-cluster.cmd command file used to create an Azure Container Service Kubernetes managed cluster. For more information, see Azure Container Service (AKS).
- **Azure-Container-Registry** folder contains the create-azure-container-registry.cmd command file used to create an Azure Container Registry repository. Azure Container Registry can be used to store images for container deployments in Azure Container Service, Azure App Service, Azure Batch, Azure Service

Fabric, and other Azure services. For more information, see Introduction to private Docker container registries in Azure.

- **Azure-DNS** folder contains the **create-azure-dns-for-kubernetes-todoapi-service.cmd** command file used to create an Azure DNS service. It is used to resolve a website or service name to its IP address. For more information, see Azure DNS overview.
- **Push-Docker-Images-Scripts** contains the **push-images-to-azure-container-registry.cmd** command file used to push Docker images to an Azure Container Registry. It also contains the push-images-to-docker-hub.cmd script is used to push Docker images to a Docker Hub repository. For more information, see Deploy and use Azure Container Registry.

\Scripts\Kubernetes

These scripts are used to compose and deploy the multi-container application.

- **create-application-in-kubernetes-from-azure-container-service.cmd**: This command file creates the services and deployments that compose the multi-container application. It pulls the Docker images from an Azure Container Registry using the definitions contained in the todolist-deployments-and-services-from-azure-container-registry.yml file. For more information, see Run applications in Kubernetes.
- **create-application-in-kubernetes-from-docker-hub.cmd**: This command file creates the services and deployments that compose the multi-container application. It pulls the Docker images from Docker Hub using the definitions contained in the todolist-deployments-and-services-from-docker-hub.yml file. For more information, see Run applications in Kubernetes.
- **create-todolist-configmap.cmd**: this command file can be used to create the **todolist-configmap** object in the Kubernetes cluster using the **todolist-configmap.yml** that contains non-sensitive configuration data used by the multi-container application.
- **create-todolist-secret.cmd**: This command file can be used to create the **todolist-secret** object in the Kubernetes cluster using the todolist-secret.yml that contains sensitive configuration data used by the multi-container application.
- **delete-kubernetes-pods-and-services-and-deployments.cmd**: This command file deletes pods, services, and deployments from the Kubernetes cluster using the kubectl command line interface (CLI).
- **install-helm.sh**: This bash script is used to install and initialize Helm, a tool for managing Kubernetes charts.
- **install-nginx-ingress-controller.sh**: This bash script is used to install the NGINX ingress controller in your Kubernetes cluster.
- **scale-nginx-ingress-controller-replicas.sh**: This bash script is used to scale out the number of replicas used by the NGINX ingress controller.
- **install-open-ssl.sh**: This bash script is used to install the OpenSSL utility.
- **create-certificate.sh**: This bash script is used to create a test certificate for Kubernetes.
- **create-tls-secret.sh**: This bash script is used to create a secret in your Kubernetes cluster using the self-signed certificate.

ⓘ **NOTE:** Both the front-end (**TodoWeb**) and back-end (**TodoApi**) containerized services use the microsoft/aspnetcore:2.0 image as the base Docker image. For more information, see Official .NET Docker images.

Architecture

The GitHub repository includes scripts for deploying the TodoList multi-container application using an ACS–Kubernetes or AKS cluster as shown in Figure 1.

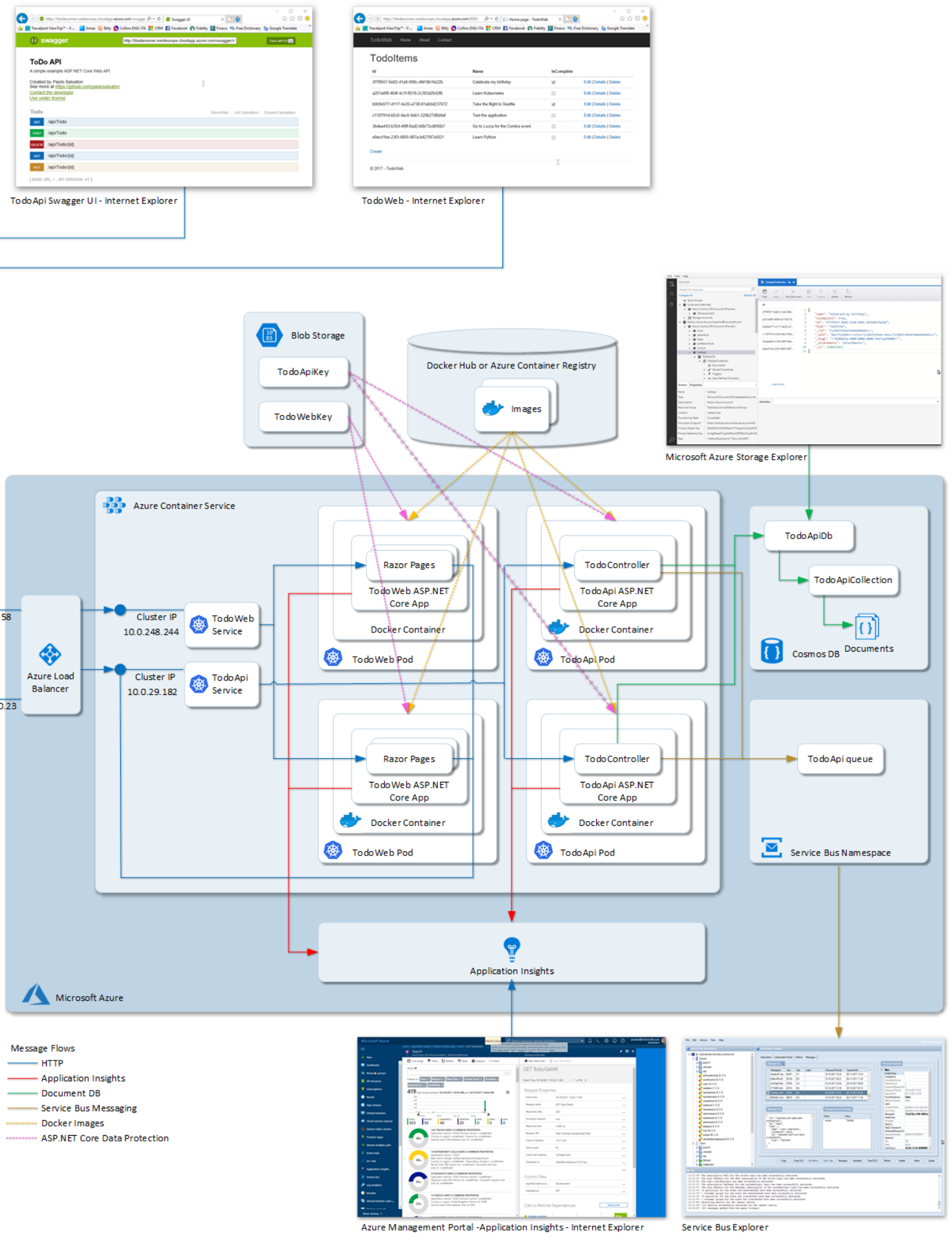


Figure 1. Simplified architecture for deploying the multi-container application to ACS or AKS.

For more information about Kubernetes, see Kubernetes Services in the Kubernetes documentation.

Configuration

In ASP.NET Core, the configuration API provides a way of configuring an app based on a list of name-value pairs. Configuration is read at runtime from multiple sources. The name-value pairs can be grouped hierarchically. ASP.NET Core includes configuration providers for:

- File formats (INI, JSON, and XML)
- Command-line arguments
- Environment variables
- In-memory .NET objects
- An encrypted user store
- Azure Key Vault
- Custom providers that you install or create

ⓘ **NOTE:** To manage sensitive configuration data, the application uses Kubernetes secrets objects.

TodoApi service configuration

The configuration of the **TodoApi** service is defined in the **appsettings.json** file using the following elements.

- The **RepositoryService** element contains the **CosmosDb** element containing the **EndpointUri**, **PrimaryKey**, **DatabaseName,** and **CollectionName** of the Azure Cosmos DB database holding the data.
- The **NotificationService** element contains the **ServiceBus** element, which in turn contains the **ConnectionString** of the Service Bus namespace used by the notification service, and the **QueueName** setting, which holds the name of the queue where the back-end service sends a message any time a CRUD operation is performed on a document.
- The **DataProtection** element contains the **BlobStorage** element, which in turn contains the **ConnectionString** of the storage account used by the data protection and the **ContainerName** setting, which holds the name of the container where the data protection system stores the key. For more information, see Data Protection in ASP.NET Core.
- The **Application Insights** element contains the **instrumentation key** of the **Application Insights** resource used by the service for diagnostics, logging, performance monitoring, analytics, and alerting.
- The **Logging** element contains the log level for the various logging providers.

ⓘ **NOTE:** Ignore the **AzureKeyVault** section. It is available for use only when storing secret values in Key Vault but is not used in this deployment.

The \ToDoApi\appsettings.json code is shown below.

```
{
    "AzureKeyVault": {
      "Certificate": {
```

```
      "CertificateEnvironmentVariable": "",
      "KeyEnvironmentVariable": ""
    },
    "ClientId": "",
    "Name": ""
  },
  "RepositoryService": {
    "CosmosDb": {
      "EndpointUri": "",
      "PrimaryKey": "",
      "DatabaseName": "",
      "CollectionName": ""
    }
  },
  "NotificationService": {
    "ServiceBus": {
      "ConnectionString": "",
      "QueueName": ""
    }
  },
  "DataProtection": {
    "BlobStorage": {
      "ConnectionString": "",
      "ContainerName": ""
    }
  },
  "ApplicationInsights": {
    "InstrumentationKey": ""
  },
  "Logging": {
    "IncludeScopes": false,
    "Debug": {
      "LogLevel": {
        "Default": "Information"
      }
    },
    "Console": {
      "LogLevel": {
        "Default": "Information"
      }
    },
    "EventSource": {
      "LogLevel": {
        "Default": "Warning"
      }
    },
    "ApplicationInsights": {
      "LogLevel": {
        "Default": "Information"
      }
    }
    }
  }
```

TodoWeb service configuration

The configuration of the **TodoWeb** service is defined in the **\ToDoApi\appsettings.json** file using the following elements.

- The **TodoApiService** element contains the **EndpointUri** of the **TodoApi**. This setting is used to contain the name of the **TodoApi** service.
- The **DataProtection** element contains the **BlobStorage** element, which in turn contains the **ConnectionString** of the storage account used by the data protection and the **ContainerName** setting, which holds the name of the container where the data protection system stores the key.
- The **Application Insights** element contains the **instrumentation key** of the Application Insights resource used by the service for diagnostics, logging, performance monitoring, analytics, and alerting.
- The **Logging** element contains the log level for the various logging providers.

ⓘ **NOTE:** Ignore the **AzureKeyVault** section. It is available for use when storing secret values in Key Vault but is not used in this deployment.

The appsettings.json code for the TodoWeb service is shown below.

```
{
  "AzureKeyVault": {
    "Certificate": {
      "CertificateEnvironmentVariable": "",
      "KeyEnvironmentVariable": ""
    },
    "ClientId": "",
    "Name": ""
  },
  "TodoApiService": {
    "EndpointUri": ""
  },
  "DataProtection": {
    "BlobStorage": {
      "ConnectionString": "",
      "ContainerName": ""
    }
  },
  "Logging": {
    "IncludeScopes": false,
    "LogLevel": {
      "Default": "Warning"
    },
    "ApplicationInsights": {
      "LogLevel": {
        "Default": "Information"
      }
    }
  },
  "ApplicationInsights": {
    "InstrumentationKey": ""
  }
}
```

How configuration works in ASP.NET Core

The CreateDefaultBuilder extension method in an ASP.NET Core 2.*x* app adds configuration providers for reading JSON files and system configuration sources:

- appsettings.json
- appsettings.<EnvironmentName>.json
- environment variables

Configuration consists of a hierarchical list of name-value pairs in which the nodes are separated by a colon. To retrieve a value, access the Configuration indexer with the corresponding item's key. For example, if you want to retrieve the value of the **QueueName** setting from the configuration of the **TodoApi** service, you have to use the following format.

```
 var queueName = Configuration["NotificationService:ServiceBus:QueueName"];
```

If you want to create an environment variable to provide a value for a setting defined in the appsettings.json file, you can replace : (colon) with __ (double underscore).

```
NotificationService__ServiceBus__QueueName=todoapi
```

The CreateDefaultBuilder helper method specifies environment variables last, so that the local environment can override anything set in deployed configuration files. This allows you to define settings in the appsettings.json file, but leave their value empty, and specify their value using environment variables.

For more information on configuration, see the following resources:

- Configuration in ASP.NET Core
- Managing ASP.NET Core App Settings on Kubernetes
- ASP.NET Core and Docker Environment Variables

Define the Docker images and containers

For this solution, we used Visual Studio Tools for Docker to build an image based on the microsoft/aspnetcore:2.0 standard image. The tool creates the Dockerfiles that automate the steps to create an image for both the front-end and back-end service. For example, the Dockerfile instructions set up the environment inside your container, load the application you want to run, and map the ports. You can customize the Dockerfile as needed. Then you use it as the input to the *docker build* command, which creates the image.

For example, here is the Dockerfile of the **TodoApi** service:

```
FROM microsoft/aspnetcore:2.0
ARG source
```

```
WORKDIR /app
EXPOSE 80
COPY ${source:-obj/Docker/publish} .
ENTRYPOINT ["dotnet", "TodoApi.dll"]
```

The Dockerfile of the **TodoWeb** service shows the different entry point:

```
FROM microsoft/aspnetcore:2.0
ARG source
WORKDIR /app
EXPOSE 80
COPY ${source:-obj/Docker/publish} .
ENTRYPOINT ["dotnet", "TodoWeb.dll"]
```

Visual Studio Tools for Docker also creates the docker-compose.yml and docker-compose-override.yml files that you can use to test the application locally.

Here is docker-compose.yml:

```
version: '3'

services:
  todoapi:
    image: todoapi
    build:
      context: ./TodoApi
      dockerfile: Dockerfile

  todoweb:
    image: todoweb
    build:
      context: ./TodoWeb
      dockerfile: Dockerfile
  dockerfile: Dockerfile
```

Here is docker-compose-override.yml:

```
version: '3'

services:
  todoapi:
    environment:
      - ASPNETCORE_ENVIRONMENT=Development
      - RepositoryService__CosmosDb__EndpointUri=COSMOS_DB_ENDPOINT_URI
      - RepositoryService__CosmosDb__PrimaryKey=DOCUMENT_DB_PRIMARY_KEY
      - RepositoryService__CosmosDb__DatabaseName=TodoApiDb
      - RepositoryService__CosmosDb__CollectionName=TodoApiCollection
      - NotificationService__ServiceBus__ConnectionString=SERVICE_BUS_CONNECTIONSTRING
      - NotificationService__ServiceBus__QueueName=todoapi
      - DataProtection__BlobStorage__ConnectionString=STORAGE_ACCOUNT_CONNECTION_STRING
      - DataProtection__BlobStorage__ContainerName=todoapi
      - ApplicationInsights__InstrumentationKey=APPLICATION_INSIGHTS_INSTRUMENTATION_KEY

    ports:
      - "80"

  todoweb:
    environment:
      - ASPNETCORE_ENVIRONMENT=Development
      - TodoApiService__EndpointUri=todoapi
      - DataProtection__BlobStorage__ConnectionString=STORAGE_ACCOUNT_CONNECTION_STRING
      - DataProtection__BlobStorage__ContainerName=todoweb
      - ApplicationInsights__InstrumentationKey=APPLICATION_INSIGHTS_INSTRUMENTATION_KEY
    ports:
      - "80"
```

Before debugging the application in Visual Studio, make the following changes to the docker-compose-override.yml file:

- Replace COSMOS_DB_ENDPOINT_URI with your Azure Cosmos DB endpoint URI.
- Replace COSMOS_DB_PRIMARY_KEY with your Azure Cosmos DB primary key.
- Replace SERVICE_BUS_CONNECTION_STRING with the connection string of your Service Bus Messaging namespace.
- Replace STORAGE_ACCOUNT_CONNECTION_STRING with the connection string of the Storage Account used by ASP.NET Core Data Protection.
- Replace APPLICATION_INSIGHTS_INSTRUMENTATION_KEY with the instrumentation key of the Application Insights resource used to monitor the multi-container application.

Push the Docker images to Docker Hub or Azure Container Registry

You can register and deploy your Docker images using repositories from either Docker Hub or Azure Container Registry. This solution includes the scripts for both services.

Push Docker images to Docker Hub

To push to Docker Hub, execute the push-images-to-docker-hub.cmd command shown below. Make sure to replace the DOCKER_HUB_REPOSITORY and DOCKER_HUB_PASSWORD placeholders with your Docker Hub username and password.

```
REM login to docker hub
docker login -u DOCKER_HUB_REPOSITORY -p DOCKER_HUB_PASSWORD

REM tag the local todoapi:v1 image with the name of the DOCKER_HUB_REPOSITORY
docker tag todoapi:latest DOCKER_HUB_REPOSITORY/todoapi:v1

REM push the image DOCKER_HUB_REPOSITORY/todoapi:v1 to the DOCKER_HUB_REPOSITORY
docker push DOCKER_HUB_REPOSITORY/todoapi:v1
```

```
REM tag the local todoweb:v1 image with the name of the DOCKER_HUB_REPOSITORY
docker tag todoweb:latest DOCKER_HUB_REPOSITORY/todoweb:v1

REM push the image DOCKER_HUB_REPOSITORY/todoweb:v1 to the DOCKER_HUB_REPOSITORY
docker push DOCKER_HUB_REPOSITORY/todoweb:v1

REM browse to https://hub.docker.com/r/DOCKER_HUB_REPOSITORY/
start chrome https://hub.docker.com/r/DOCKER_HUB_REPOSITORY/
```

Create and push to an Azure Container Registry

Azure Container Registry is a managed Docker registry service based on the open-source Docker Registry 2.0. This repository can store images for container deployments in Azure Container Service, Azure App Service, Azure Batch, Service Fabric, and others. For more information, see Introduction to private Docker container registries in Azure.

To create an Azure Container Registry, run the create-azure-container-registry.cmd script.

```
REM Create a resource group for the Azure Container Registry
az group create --name ContainerRegistryResourceGroup --location westus2 --output jsonc

REM Create an Azure Container Registry. The name of the Container Registry must be unique
az acr create --resource-group ContainerRegistryResourceGroup --name
AZURE_CONTAINER_REGISTRY --sku Basic --admin-enabled true

REM Login to the newly created Azure Container Registry
az acr login --name AZURE_CONTAINER_REGISTRY
```

To tag and register the images in your repository on Docker Hub, execute the push-images-to-azure-container-registry.cmd command file. Make sure to replace the AZURE_CONTAINER_REGISTRY placeholder with the name of your Azure Container Registry.

```
REM Login to the newly created Azure Container Registry
call az acr login --name AZURE_CONTAINER_REGISTRY

REM Each container image needs to be tagged with the loginServer name of the registry.
REM This tag is used for routing when pushing container images to an image registry.
REM Save the loginServer name to the AKS_CONTAINER_REGISTRY environment variable.
for /f "delims=" %%a in ('call az acr list --resource-group ContainerRegistryResourceGroup -
-query "[].{acrLoginServer:loginServer}" --output tsv') do @set AKS_CONTAINER_REGISTRY=%%a

REM tag the local todoapi:v1 image with the loginServer of the container registry
docker tag todoapi:v1 %AKS_CONTAINER_REGISTRY%/todoapi:v1

REM publish <container registry>/todoapi:v1 to the container registry on Azure
docker push %AKS_CONTAINER_REGISTRY%/todoapi:v1

REM tag the local todoweb:v1 image with the loginServer of the container registry
docker tag todoweb:v1 %AKS_CONTAINER_REGISTRY%/todoweb:v1

REM publish <container registry>/todoweb:v1 to the container registry on Azure
docker push %AKS_CONTAINER_REGISTRY%/todoweb:v1
```

```
REM List images in the container registry on Azure
call az acr repository list --name AZURE_CONTAINER_REGISTRY --output table
```

Deploy the application on a Kubernetes cluster

To deploy the multi-container application, you first need to create the cluster on Azure using Azure CLI. You can either set up ACS–Kubernetes or use the new AKS service, which offers an improved developer interface and other benefits.

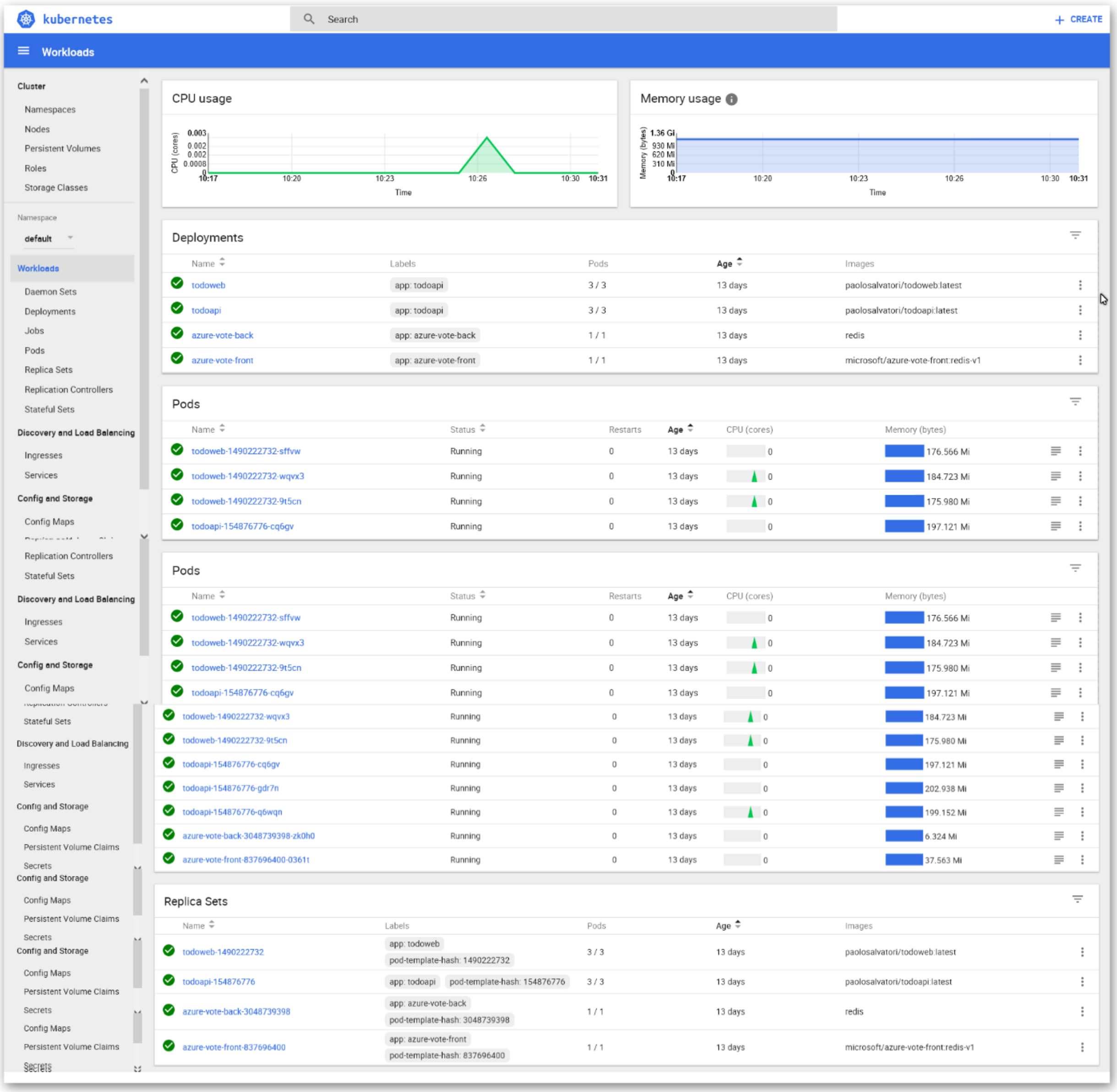
Either way, to run commands on the cluster, use the kubectl command line interface. You can download Azure CLI 2.0 from GitHub.

Create an ACS–Kubernetes cluster

The create-kubernetes-acs-cluster.cmd command file shows how you can create an ACS–Kubernetes cluster.

```
REM Create a resource group for Kubernetes
az group create --name AcsKubernetesResourceGroup --location WestEurope --tags
orchestrator=kubernetes

REM Create a Kubernetes cluster using ACS
az acs create --orchestrator-type kubernetes --name AcsKubernetes --resource-group
AcsKubernetesResourceGroup --generate-ssh-keys --output jsonc

REM Install kubectl on the local machine
az acs kubernetes install-cli

REM Get credentials to connect to Kubernetes cluster using kubectl
az acs kubernetes get-credentials --name AcsKubernetes --resource-group
AcsKubernetesResourceGroup

REM Show the dashboard for a Kubernetes cluster in a web browser
az acs kubernetes browse --name AcsKubernetes --resource-group AcsKubernetesResourceGroup
```

To manage Kubernetes entities such as services, pods, and deployments, you use the Kubernetes web interface shown in the following figure. The last command in the script is used to launch a proxy and browse the Kubernetes web UI.



Deployments

	Name	Labels	Pods	Age	Images
✓	todoweb	app: todoapi	3 / 3	13 days	paolosalvatori/todoweb:latest
✓	todoapi	app: todoapi	3 / 3	13 days	paolosalvatori/todoapi:latest
✓	azure-vote-back	app: azure-vote-back	1 / 1	13 days	redis
✓	azure-vote-front	app: azure-vote-front	1 / 1	13 days	microsoft/azure-vote-front:redis-v1

Pods

	Name	Status	Restarts	Age	CPU (cores)	Memory (bytes)
✓	todoweb-1490222732-sffvw	Running	0	13 days	0	176.566 Mi
✓	todoweb-1490222732-wqvx3	Running	0	13 days	0	184.723 Mi
✓	todoweb-1490222732-9t5cn	Running	0	13 days	0	175.980 Mi
✓	todoapi-154876776-cq6gv	Running	0	13 days	0	197.121 Mi

Pods

	Name	Status	Restarts	Age	CPU (cores)	Memory (bytes)
✓	todoweb-1490222732-sffvw	Running	0	13 days	0	176.566 Mi
✓	todoweb-1490222732-wqvx3	Running	0	13 days	0	184.723 Mi
✓	todoweb-1490222732-9t5cn	Running	0	13 days	0	175.980 Mi
✓	todoapi-154876776-cq6gv	Running	0	13 days	0	197.121 Mi
✓	todoweb-1490222732-wqvx3	Running	0	13 days	0	184.723 Mi
✓	todoweb-1490222732-9t5cn	Running	0	13 days	0	175.980 Mi
✓	todoapi-154876776-cq6gv	Running	0	13 days	0	197.121 Mi
✓	todoapi-154876776-gdr7n	Running	0	13 days	0	202.938 Mi
✓	todoapi-154876776-q6wqn	Running	0	13 days	0	199.152 Mi
✓	azure-vote-back-3048739398-zk0h0	Running	0	13 days	0	6.324 Mi
✓	azure-vote-front-837696400-0361t	Running	0	13 days	0	37.563 Mi

Replica Sets

	Name	Labels	Pods	Age	Images
✓	todoweb-1490222732	app: todoweb pod-template-hash: 1490222732	3 / 3	13 days	paolosalvatori/todoweb:latest
✓	todoapi-154876776	app: todoapi pod-template-hash: 154876776	3 / 3	13 days	paolosalvatori/todoapi:latest
✓	azure-vote-back-3048739398	app: azure-vote-back pod-template-hash: 3048739398	1 / 1	13 days	redis
✓	azure-vote-front-837696400	app: azure-vote-front pod-template-hash: 837696400	1 / 1	13 days	microsoft/azure-vote-front:redis-v1

Figure 2. Web interface for managing Kubernetes entities.

For more information, see [Deploy a Kubernetes cluster in Azure Container Service]()

.

Create an AKS cluster

The create-kubernetes-aks-cluster.cmd command file below shows how you can create an AKS cluster.

```
REM Create a resource group for Kubernetes
az group create --name AksKubernetesResourceGroup --location westus2 --output jsonc

REM Create a Kubernetes cluster using ACS
az aks create --resource-group AksKubernetesResourceGroup --name AksKubernetes --agent-count
3 --generate-ssh-keys --output jsonc

REM Install kubectl on the local machine
az aks install-cli

REM Get credentials to connect to Kubernetes cluster using kubectl
az aks get-credentials --name AksKubernetes --resource-group AksKubernetesResourceGroup

REM Show the dashboard for a Kubernetes cluster in a web browser
az aks browse --name AksKubernetes --resource-group AksKubernetesResourceGroup
```

You can also create the cluster from the Azure Cloud Shell. In this case, you can skip the *az aks install-cli* command, because the kubectl command line interface is already installed in your shell.

For more information, see Azure Container Service (AKS).

Use a ConfigMap in Kubernetes to define non-sensitive configuration data

ConfigMaps are entities that can be used in Kubernetes to decouple non-sensitive configuration data from images and templates used to deploy an application. You can create a ConfigMap object to specify application paremeters, and then map the environment variables in the pod specification to the keys defined the ConfigMap. For more information, see Configure a Pod to Use a ConfigMap.

The first step is to create a YAML file to define a ConfigMap. The multi-container sample uses a ConfigMap to define a value for the following parameter/environment variable pairs:

- aspNetCoreEnvironment/ASPNETCORE_ENVIRONMENT
- todoApiServiceBusQueueName/NotificationService__ServiceBus__QueueName
- todoApiServiceEndpointUri/TodoApiService__EndpointUri
- todoWebDataProtectionBlobStorageContainerName/DataProtection__BlobStorage__ContainerName
- todoApiDataProtectionBlobStorageContainerName/DataProtection__BlobStorage__ContainerName

The following YAML file can be used to create a ConfigMap object named **todolist-configmap** that contains a value for the above parameters.

todolist-configmap.yml

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: todolist-configmap
  namespace: default
data:
  aspNetCoreEnvironment: Development
  todoApiServiceBusQueueName: todoapi
  todoApiServiceEndpointUri: todoapi
  todoWebDataProtectionBlobStorageContainerName: todoweb
  todoApiDataProtectionBlobStorageContainerName: todoapi
```

The create-todolist-configmap.cmd command can be used to create the **todolist-configmap** object in the Kubernetes cluster.

```
kubectl create --filename todolist-configmap.yml --record
```

You can use one of the following commands to read the value of the keys from the **todolist-configmap**:

```
# Get todolist-configmap
kubectl get configmaps todolist-configmap -o yaml

# Describe todolist-configmap
kubectl describe configmap todolist-configmap
```

Use a secret in Kubernetes to define sensitive configuration data

In Kubernetes, a *secret* is an object that contains a small amount of sensitive data such as passwords, connection strings, OAuth tokens, and SSH keys. Sensitive information can be added to a pod specification or stored in an image, but storing it in a ecret object provides several advantages:

- You get more control over how sensitive data is defined.
- Unique values can be used for different deployments of the same application—particularly useful in a multitenant environment where the same Kubernetes cluster hosts multiple instances of the same application, each with different configuration settings.
- Reduces the risk of accidental exposure.

For more information, see Secrets in the Kubernetes documentation.

The first step is to create a YAML file to define a secret. Each item in the file must be base64-encoded. The multi-container sample uses a secret to define a value for the following parameter/environment variable pairs:

- cosmosDbEndpointUri/RepositoryService__CosmosDb__EndpointUri
- cosmosDBPrimaryKey/RepositoryService__CosmosDb__PrimaryKey
- cosmosDbDatabaseName/RepositoryService__CosmosDb__DatabaseName
- cosmosDbCollectionName/RepositoryService__CosmosDb__CollectionName
- serviceBusConnectionString/NotificationService__ServiceBus__ConnectionString
- dataProtectionBlobStorageConnectionString/DataProtection__BlobStorage__ConnectionString
- applicationInsightsInstrumentationKey/ApplicationInsights__InstrumentationKey

The following YAML file can be used to create a secret object named **todolist-secret** that contains a value for the above parameters.

todolist-secret.yml

```
apiVersion: v1
kind: Secret
metadata:
  name: todolist-secret
type: Opaque
data:
  cosmosDbEndpointUri: BASE64-ENCODED-COSMOS-DB-ENDPOINT-URI
  cosmosDBPrimaryKey: BASE64-ENCODED-COSMOS-DB-PRIMARY-KEY
  cosmosDbDatabaseName: BASE64-ENCODED-COSMOS-DB-DATABASE-NAME
  cosmosDbCollectionName: BASE64-ENCODED-COSMOS-DB-COLLECTION-NAME
  serviceBusConnectionString: BASE64-ENCODED-SERVICE-BUS-CONNECTION-STRING
  dataProtectionBlobStorageConnectionString: BASE64-ENCODED-BLOB-STORAGE-CONNECTION-STRING
  applicationInsightsInstrumentationKey: BASE64-ENCODED-APP-INSIGHTS-INSTRUMENTATION-KEY
```

On Windows, you can use the following command to translate a value into a base64 format.

```
powershell "[convert]::ToBase64String([Text.Encoding]::UTF8.GetBytes(\"value\"))"
```

In a Linux bash shell, you can use the base64 command line utility to encode a value to a base64 format.

```
echo -n "value" | base64
```

The create-todolist-secret.cmd command can be used to create the **todolist-secret** object in the Kubernetes cluster:

```
kubectl create --filename todolist-secret.yml --record
```

You can use kubectl to read the value of a setting defined from a secret object. For example, you can use the following bash command to read the value of cosmosDbCollectionName parameter.

```
# Get secret
 kubectl get secret todolist-secret -o jsonpath="{.data.cosmosDbCollectionName}" | base64 --
decode; echo
```

Option: Use Open Service Broker for Azure

The previous section showed how to:

- Define the endpoint URI, primary key, database name, and collection name of an existing Azure Cosmos DB used by the application in a secret object in Kubernetes.
- Map secret data to environment variables in the pod specification.

To create an instance of Azure Cosmos DB and pass its coordinates and credentials to the application via environment variables, you can use Open Service Broker for Azure (OSBA), an implementation of the Open Service Broker API for Azure services. OSBA provides an effective and flexible mechanism to connect a Kubernetes application to a suite of the most popular Azure services, including Azure Cosmos DB. For a complete list of Azure Services currently supported by OSBA, see Open Service Broker for Azure. Open Service Broker for Azure can be deployed to any OSB-compatible platform running in any environment, including Azure Container Service.

For more information about how to deploy OSBA in your Kubernetes cluster and how to provision and bind services, please see the following resources:

- Integrate with Azure-managed services using Open Service Broker for Azure (OSBA)
- Connect your applications to Azure with Open Service Broker for Azure
- Open Service Broker for Azure
- Service Broker on Kubernetes up and running video

Deploy to ACS–Kubernetes from a local machine

On Kubernetes, the multi-container application is composed of the front-end service (**TodoApi**), the back-end service (**TodoWeb**), and five pods for each service. Each pod holds just a container of one of the ASP.NET Core apps (**TodoApi** or **TodoWeb**).

The Docker images can be pulled from an Azure Container Registry or from Docker Hub. The GitHub solution contains scripts and YAML files to accomplish both tasks in the **Scripts/Kubernetes-Scripts** folder.

For example, when Docker Hub is the repository, the todolist-deployments-and-services-from-docker-hub.yml file (shown below) contains the definition for the necessary services and deployments.

Before deploying the application to your ACS-Kubernetes cluster, open the YAML file and replace the DOCKER_HUB_REPOSITORY placeholder with the name of your Docker Hub repository.

todolist-deployments-and-services-from-docker-hub.yml

```yaml
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: todoapi
  labels:
    app: todoapi
spec:
  replicas: 3
  selector:
    matchLabels:
      app: todoapi
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 1
  minReadySeconds: 5
  template:
    metadata:
      labels:
        app: todoapi
    spec:
      containers:
      - name: todoapi
        image: paolosalvatori/todoapi:v2
        ports:
        - containerPort: 80
        env:
        - name: ASPNETCORE_ENVIRONMENT
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: aspNetCoreEnvironment
        - name: RepositoryService__CosmosDb__EndpointUri
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbEndpointUri
        - name: RepositoryService__CosmosDb__PrimaryKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDBPrimaryKey
        - name: RepositoryService__CosmosDb__DatabaseName
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbDatabaseName
        - name: RepositoryService__CosmosDb__CollectionName
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbCollectionName
        - name: NotificationService__ServiceBus__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: serviceBusConnectionString
        - name: NotificationService__ServiceBus__QueueName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiServiceBusQueueName
        - name: DataProtection__BlobStorage__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: dataProtectionBlobStorageConnectionString
        - name: DataProtection__BlobStorage__ContainerName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiDataProtectionBlobStorageContainerName
        - name: ApplicationInsights__InstrumentationKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: applicationInsightsInstrumentationKey
```

```
---
apiVersion: v1
kind: Service
metadata:
  name: todoapi
  labels:
    app: todoapi
spec:
  type: LoadBalancer
  ports:
  - protocol: TCP
    port: 80
  selector:
    app: todoapi
---
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: todoweb
  labels:
    app: todoweb
spec:
  replicas: 3
  selector:
    matchLabels:
      app: todoweb
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 1
  minReadySeconds: 5
  template:
    metadata:
      labels:
        app: todoweb
    spec:
      containers:
      - name: todoweb
        image: paolosalvatori/todoweb:v2
        ports:
        - containerPort: 80
        env:
        - name: ASPNETCORE_ENVIRONMENT
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: aspNetCoreEnvironment
        - name: TodoApiService__EndpointUri
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiServiceEndpointUri
        - name: DataProtection__BlobStorage__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: dataProtectionBlobStorageConnectionString
        - name: DataProtection__BlobStorage__ContainerName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoWebDataProtectionBlobStorageContainerName
        - name: ApplicationInsights__InstrumentationKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: applicationInsightsInstrumentationKey
---
apiVersion: v1
kind: Service
metadata:
  name: todoweb
  labels:
    app: todoweb
spec:
  type: LoadBalancer
  ports:
  - protocol: TCP
    port: 80
  selector:
    app: todoweb
```

ⓘ **NOTE:** To map a secret to an environment variable in a pod specification, create a secret object in Kubernetes, modify the pod definition for the appropriate containers, and then make sure the code looks for values in the right environment variables. For details, see Using secrets as environment variables in the Kubernetes documentation.

Configure Kubernetes with the services and deployments

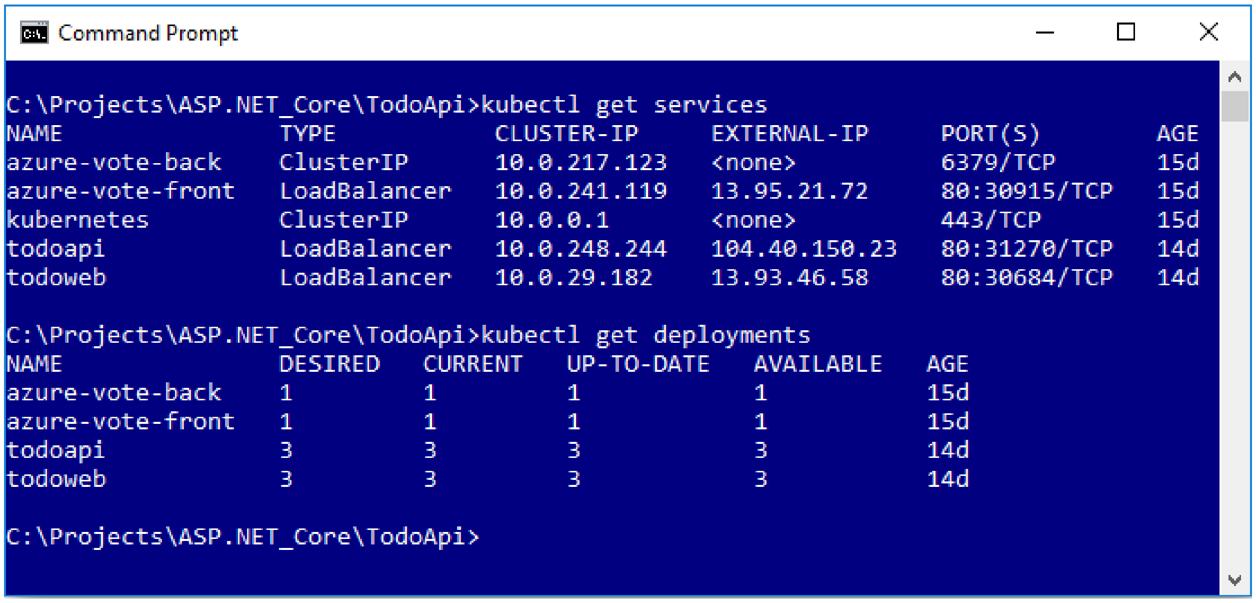
To set up the services and deployments on Kubernetes, you can use the kubectrl command line interface to execute your YAML configuration file. For example, to use the create-application-to-kubernetes-from-docker-hub.cmd script:

```
kubectl create --filename todolist-deployments-and-services-from-docker-hub.yml --record
```

To list the newly created services and deployments, use the **kubectl** command line interface to run the following commands:

```
REM Get services
kubectl get services

REM Get deployments
kubectl get deployments
```

As the following figure shows, you can see the **TodoApi** and **TodoWeb** services and the **TodoApi** and **TodoWeb** deployments.



```
C:\Projects\ASP.NET_Core\TodoApi>kubectl get services
NAME               TYPE           CLUSTER-IP     EXTERNAL-IP     PORT(S)        AGE
azure-vote-back    ClusterIP      10.0.217.123   <none>          6379/TCP       15d
azure-vote-front   LoadBalancer   10.0.241.119   13.95.21.72     80:30915/TCP   15d
kubernetes         ClusterIP      10.0.0.1       <none>          443/TCP        15d
todoapi            LoadBalancer   10.0.248.244   104.40.150.23   80:31270/TCP   14d
todoweb            LoadBalancer   10.0.29.182    13.93.46.58     80:30684/TCP   14d

C:\Projects\ASP.NET_Core\TodoApi>kubectl get deployments
NAME               DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
azure-vote-back    1         1         1            1           15d
azure-vote-front   1         1         1            1           15d
todoapi            3         3         3            3           14d
todoweb            3         3         3            3           14d

C:\Projects\ASP.NET_Core\TodoApi>
```

Figure 3. Kubectl output showing services and deployments.

Load balancer service type for the Kubernetes cluster

Both the **TodoApi** and **TodoWeb** services define *LoadBalancer* as the service type. When you run the deployment script, ACS–Kubernetes cluster creates two load balancing rules using the public IP of both services.

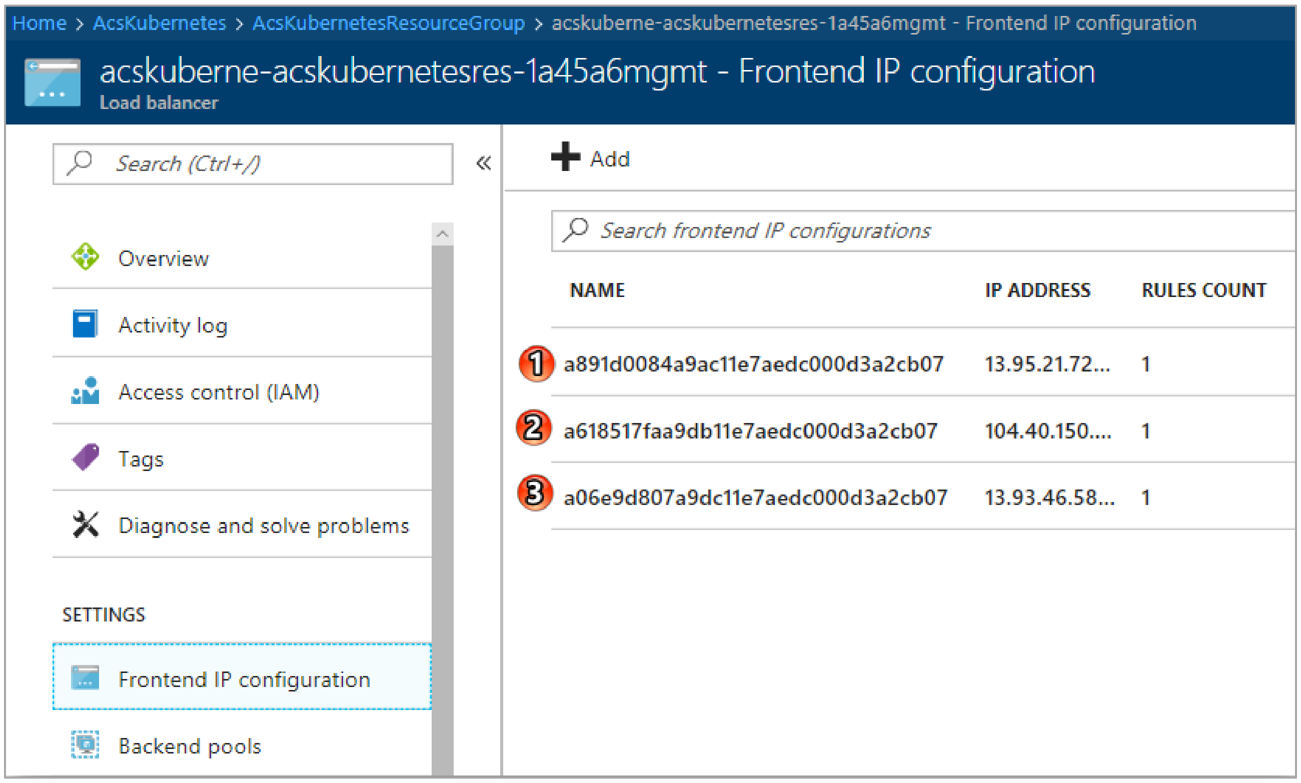
Kubernetes service types allow you to specify the kind of service you want. The default is ClusterIP. A service of type *LoadBalancer* also has a cluster IP, the virtual, internal IP used by the kube-proxy running on each node of the cluster. It's worth noting that if you define the service type as *ClusterIP*, no public IP is exposed over the Internet, and consequently, no load balancing rule is created.

The following service types are available:

- **ClusterIP:** Default. Exposes the service on a cluster-internal IP. The service can be reached from within the cluster only.
- **NodePort:** Exposes the service on each node's IP at a static port (the NodePort). A ClusterIP service, to which the NodePort service will route, is automatically created. You can contact the NodePort service from outside the cluster by sending a request.
- **LoadBalancer:** Exposes the service externally using a cloud provider's load balancer. NodePort and ClusterIP services, to which the external load balancer will route, are automatically created.
- **ExternalName:** Maps the service to the contents of the **externalName** field (for example, *foo.bar.example.com*) by returning a CNAME record with its value. No proxying of any kind is set up. This type requires kube-dns version 1.7 or later.

In our example, if you want to provide the ability to call the REST services exposed by the **TodoApi** service to external applications running outside of the Kubernetes cluster, and not only to the **TodoWeb** service running on the same cluster, you have to specify *LoadBalancer* as a service type.

As the following figure shows, you can use Azure portal to see the front-end IP configuration for the Azure Load Balancer used by Azure Container Service in front of the Kubernetes cluster nodes.


Home > AcsKubernetes > AcsKubernetesResourceGroup > acskuberne-acskubernetesres-1a45a6mgmt - Frontend IP configuration
acskuberne-acskubernetesres-1a45a6mgmt - Frontend IP configuration
Load balancer
Search (Ctrl+/)
Overview
Activity log
Access control (IAM)
Tags
Diagnose and solve problems
SETTINGS
Frontend IP configuration
Backend pools
Add
Search frontend IP configurations

	NAME	IP ADDRESS	RULES COUNT
1	a891d0084a9ac11e7aedc000d3a2cb07	13.95.21.72...	1
2	a618517faa9db11e7aedc000d3a2cb07	104.40.150....	1
3	a06e9d807a9dc11e7aedc000d3a2cb07	13.93.46.58...	1

Figure 4. Configuration of the front-end load balancers for the Kubernetes cluster.

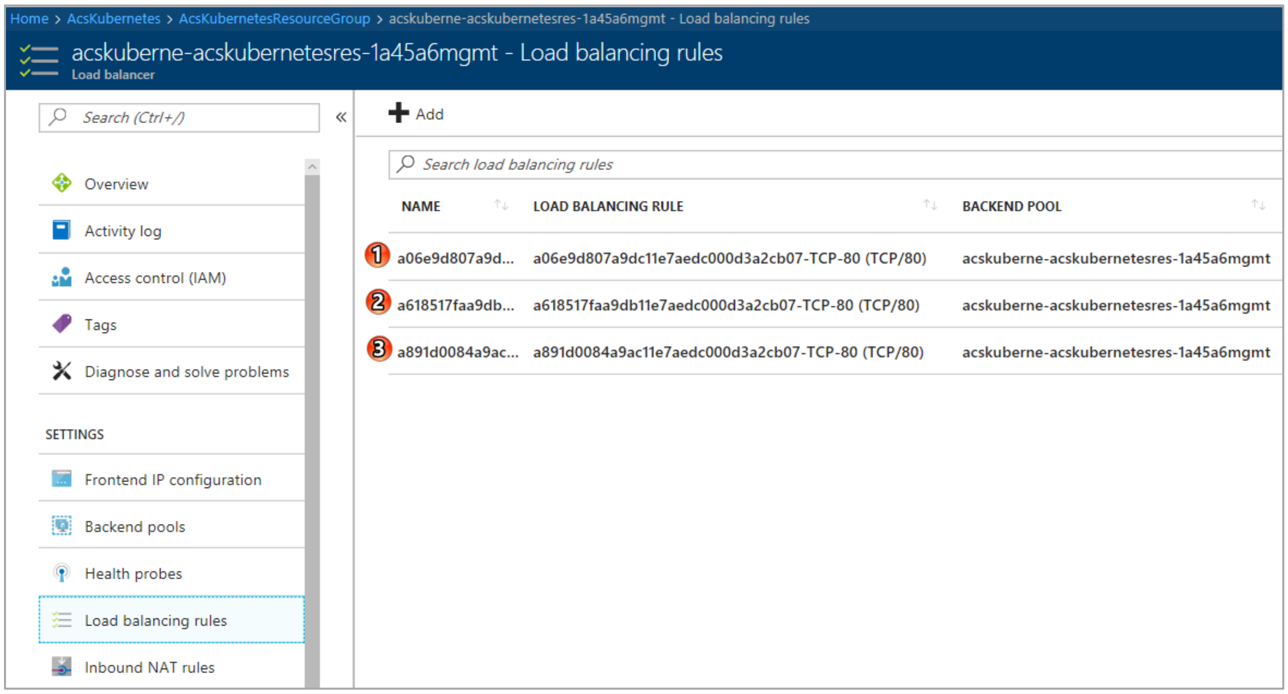
Key:

❶ The first row contains an IP address corresponding to the public IP of the **azure-vote-front** service, a Quickstart sample deployed on the same Kubernetes cluster.

❷ The second row contains an IP address corresponding to the Public IP of the **TodoApi** service.

❸ The third row contains an IP address corresponding to the Public IP of the **TodoWeb** service.

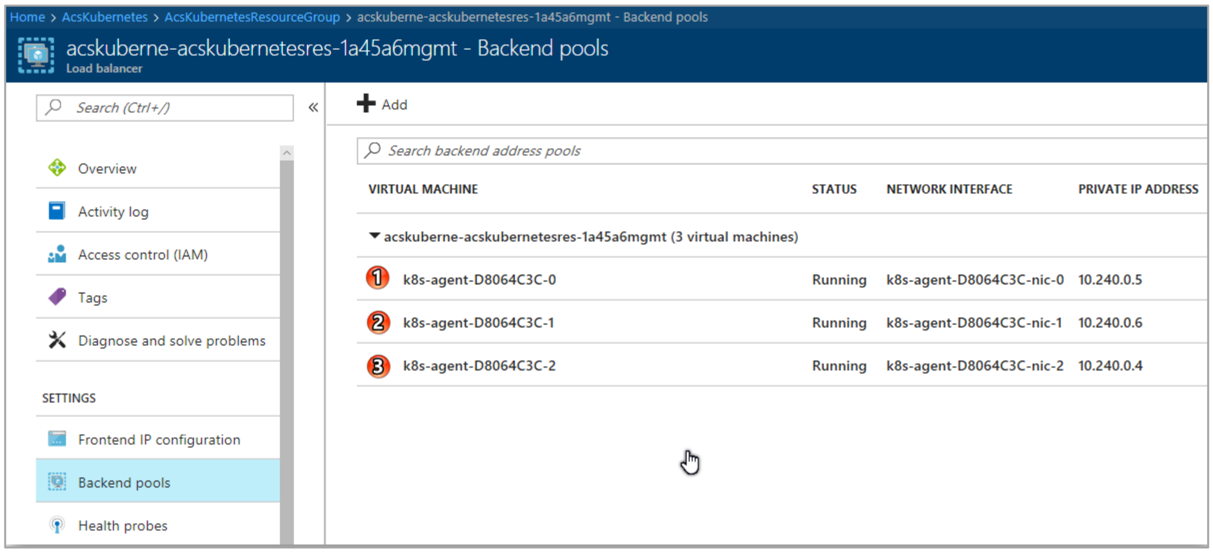
You can also use Azure portal to see the load balancing rules defined for the load balancer used in front of the cluster nodes. Note that there is a rule for each public IP on the port 80, all sharing the same backend pool.


Home > AcsKubernetes > AcsKubernetesResourceGroup > acskuberne-acskubernetesres-1a45a6mgmt - Load balancing rules
acskuberne-acskubernetesres-1a45a6mgmt - Load balancing rules
Load balancer
Search (Ctrl+/)
Overview
Activity log
Access control (IAM)
Tags
Diagnose and solve problems
SETTINGS
Frontend IP configuration
Backend pools
Health probes
Load balancing rules
Inbound NAT rules
Add
Search load balancing rules

	NAME	LOAD BALANCING RULE	BACKEND POOL
1	a06e9d807a9d...	a06e9d807a9dc11e7aedc000d3a2cb07-TCP-80 (TCP/80)	acskuberne-acskubernetesres-1a45a6mgmt
2	a618517faa9db...	a618517faa9db11e7aedc000d3a2cb07-TCP-80 (TCP/80)	acskuberne-acskubernetesres-1a45a6mgmt
3	a891d0084a9ac...	a891d0084a9ac11e7aedc000d3a2cb07-TCP-80 (TCP/80)	acskuberne-acskubernetesres-1a45a6mgmt

Figure 5. Load balancing rules for the Kubernetes cluster.

Azure portal also displays information about the back-end pools. As Figure 9 shows, in this topology, the Azure Container Service–Kubernetes cluster uses a single back-end pool composed of just three nodes.

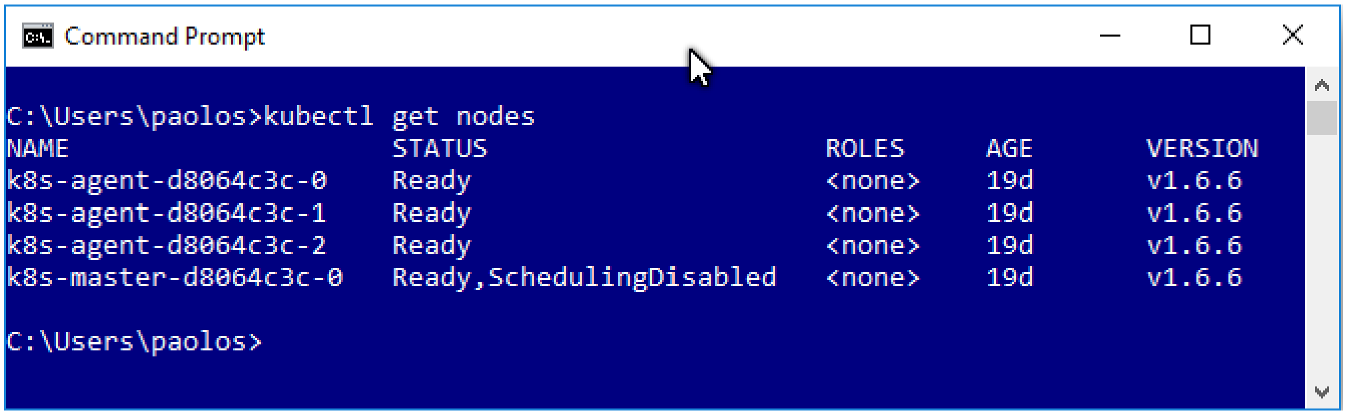

Home > AcsKubernetes > AcsKubernetesResourceGroup > acskuberne-acskubernetesres-1a45a6mgmt - Backend pools
acskuberne-acskubernetesres-1a45a6mgmt - Backend pools
Load balancer
Search (Ctrl+/)
Overview
Activity log
Access control (IAM)
Tags
Diagnose and solve problems
SETTINGS
Frontend IP configuration
Backend pools
Health probes
Add
Search backend address pools

	VIRTUAL MACHINE	STATUS	NETWORK INTERFACE	PRIVATE IP ADDRESS
	acskuberne-acskubernetesres-1a45a6mgmt (3 virtual machines)			
1	k8s-agent-D8064C3C-0	Running	k8s-agent-D8064C3C-nic-0	10.240.0.5
2	k8s-agent-D8064C3C-1	Running	k8s-agent-D8064C3C-nic-1	10.240.0.6
3	k8s-agent-D8064C3C-2	Running	k8s-agent-D8064C3C-nic-2	10.240.0.4

Figure 6. Nodes in the Azure Container Service–Kubernetes cluster.

As Figure 10 shows, you can retrieve information about cluster nodes by running the following command:

```
REM Get nodes
kubectl get nodes
```



```
C:\Users\paolos>kubectl get nodes
NAME                     STATUS                       ROLES     AGE       VERSION
k8s-agent-d8064c3c-0     Ready                        <none>    19d       v1.6.6
k8s-agent-d8064c3c-1     Ready                        <none>    19d       v1.6.6
k8s-agent-d8064c3c-2     Ready                        <none>    19d       v1.6.6
k8s-master-d8064c3c-0    Ready,SchedulingDisabled     <none>    19d       v1.6.6

C:\Users\paolos>
```

Figure 7. Command line information about the nodes in the cluster.

Alternatively, if you want to use the **TodoApi** service only as a back-end service from the **TodoWeb** service, and you don't want to expose it publicly, you can specify *ClusterIP* as its service type. This value makes the service accessible only from within the cluster.

For more information, see:

- Kubernetes Services
- Kubernetes on Azure
- Microsoft Azure Container Service Engine - Kubernetes

Assign a custom DNS to the public IP of the front-end service

One way to access the web UI for the sample application is to use the public IP exposed by the front-end service (13.93.46.58) as shown earlier. However, you can also register a public domain using a domain registrar like GoDaddy, then use the Azure DNS service to associate the domain with the address exposed by the Kubernetes service. With Azure DNS, you can even host a DNS zone and manage the DNS records for a domain in Azure.

For a custom domain's DNS queries to reach Azure DNS, the domain must be delegated to Azure DNS from the parent domain. Keep in mind Azure DNS is *not* the domain registrar.

For example, to deploy babosbird.com, a sample domain created by the author, the steps are as follows:

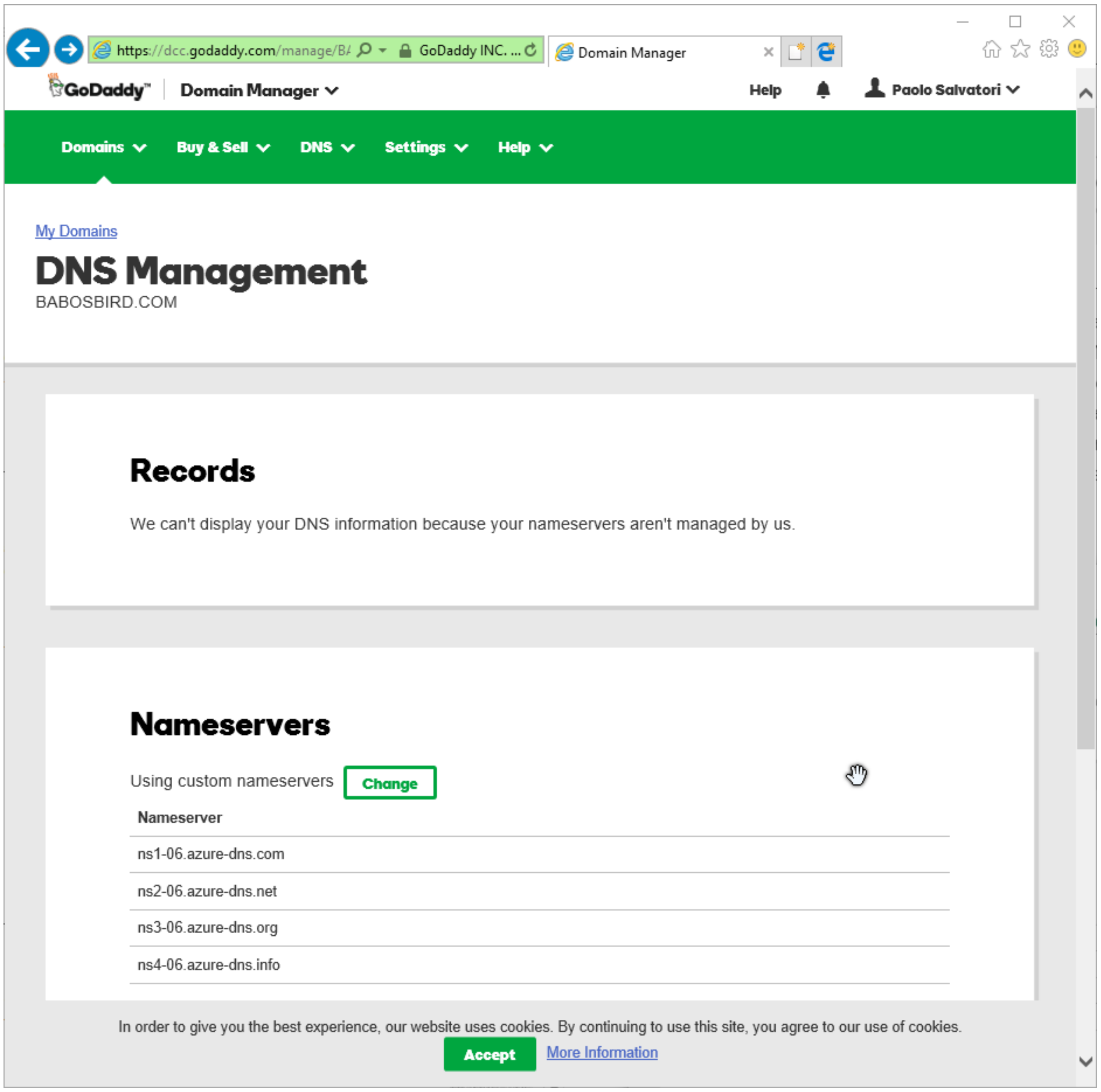
1. Create a public domain using a domain registrar such as GoDaddy. For this example, babosbird.com was created.

2. To create the Azure DNS and related record, run the create-azure-dns-for-kubernetes-todoapi-service.cmd script:

```
REM Create a resource group for the DNS Zone and records
az group create --name DnsResourceGroup --location westeurope

REM Create a DNS zone called babosbird.com in the resource group DnsResourceGroup
az network dns zone create --name babosbird.com --resource-group DnsResourceGroup --tags
environment=K8s type=DNS

REM Create an A record for the public ip exposed by the public load balancer created for the
TodoApi service in Kubernetes
az network dns record-set a add-record --resource-group DnsResourceGroup --zone-name
babosbird.com --record-set-name www --ipv4-address 13.93.46.58
az network dns record-set a add-record --resource-group DnsResourceGroup --zone-name
babosbird.com --record-set-name * --ipv4-address 13.93.46.58

REM View records
az network dns record-set list --resource-group DnsResourceGroup --zone-name babosbird.com

REM View records records at the top of the zone
az network dns record-set list --resource-group DnsResourceGroup --zone-name babosbird.com -
-query "[?name=='@' && ends_with(type, 'NS')]|[0]"

REM Retrieve the name servers for your zone. These name servers should be configured with
REM the domain name registrar where you purchased the domain name
az network dns zone list --resource-group DnsResourceGroup --query
"[?name=='babosbird.com']|[0].nameServers" --output json
```

   The last command in particular can be used to retrieve the name servers. Azure DNS automatically creates authoritative NS records in your zone containing the assigned name servers. You need these name servers to delegate the custom domain to Azure DNS.

3. When the DNS zone is created and you have the name servers, update the parent domain with the Azure DNS name servers. Each registrar has its own DNS management tools to change the name server records for a domain. In the registrar's DNS management page, edit the NS records and replace the NS records with the ones Azure DNS created. Figure 8 shows how this is done in GoDaddy.



DNS Management

BABOSBIRD.COM

Records

We can't display your DNS information because your nameservers aren't managed by us.

Nameservers

Using custom nameservers

Nameserver
ns1-06.azure-dns.com
ns2-06.azure-dns.net
ns3-06.azure-dns.org
ns4-06.azure-dns.info

In order to give you the best experience, our website uses cookies. By continuing to use this site, you agree to our use of cookies.

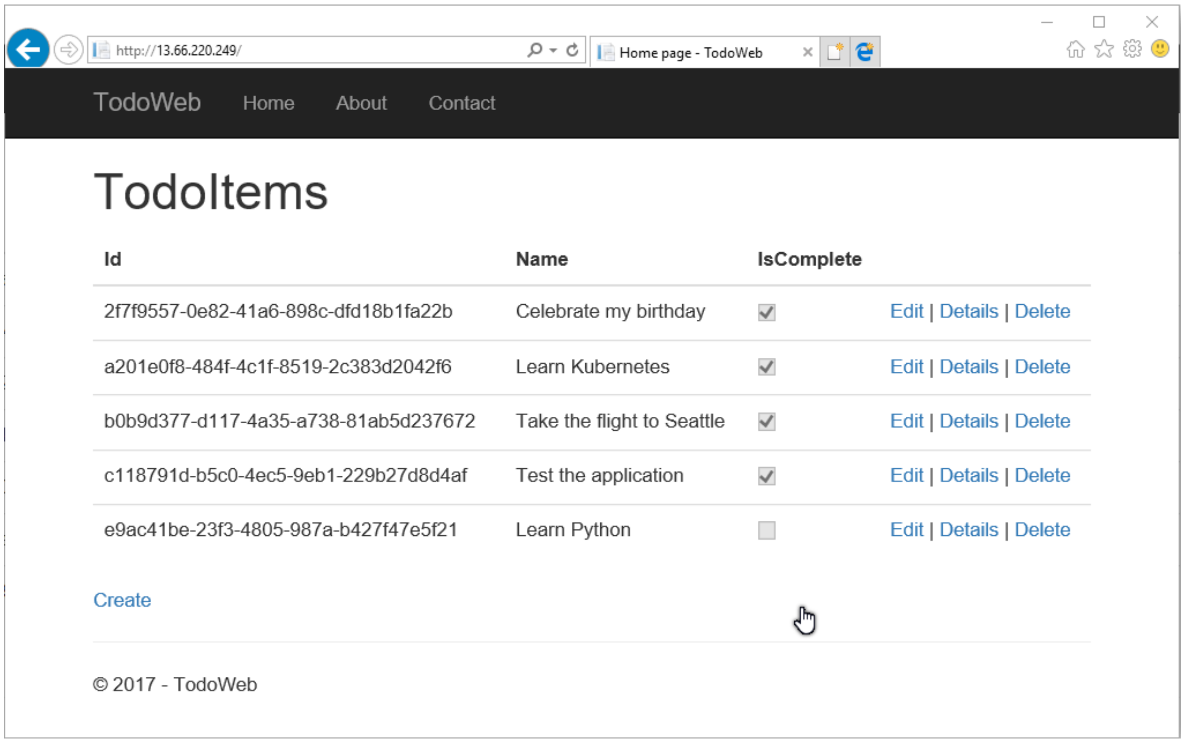
Figure 8. Using GoDaddy to replace the NS records with the Azure DNS names servers.

4. To verify, execute the following command:

```
nslookup -type=A www.babosbird.com
```

This command verifies the front-end service IP that is responding to the public domain you delegated to your Azure DNS.

5. Browse to the front-end web site using the custom domain I registered as Figure 9 shows.



http://13.66.220.249/

Home page - TodoWeb

TodoWeb Home About Contact

TodoItems

Id	Name	IsComplete	
2f7f9557-0e82-41a6-898c-dfd18b1fa22b	Celebrate my birthday	✓	Edit | Details | Delete
a201e0f8-484f-4c1f-8519-2c383d2042f6	Learn Kubernetes	✓	Edit | Details | Delete
b0b9d377-d117-4a35-a738-81ab5d237672	Take the flight to Seattle	✓	Edit | Details | Delete
c118791d-b5c0-4ec5-9eb1-229b27d8d4af	Test the application	✓	Edit | Details | Delete
e9ac41be-23f3-4805-987a-b427f47e5f21	Learn Python	☐	Edit | Details | Delete

Create

© 2017 - TodoWeb

Figure 9. Web interface for TodoWeb service.

For more information about how to create an Azure DNS service and use the Azure CLI to manage zones and records, please see the following resources:

- How to manage DNS Zones in Azure DNS using the Azure CLI 2.0
- Manage DNS records and recordsets in Azure DNS using the Azure CLI 2.0

For more information to delegate a public domain to Azure DNS, see the following articles:

- Delegation of DNS zones with Azure DNS
- Delegate a domain to Azure DNS

Deploy the application to AKS from Cloud Shell

You can deploy the multi-container application from Cloud Shell, an interactive, browser-accessible shell for managing Azure resources. Cloud Shell uses Azure file storage to persist files across sessions.

You use a YAML file to define the services and deployments of the multi-container application and run it from Cloud Shell. The first step is to run a command file from your local computer using the Azure CLI. The command file sets up the Azure environment as follows:

- Creates a resource group.
- Creates a storage account in the new resource group.

- Creates a file share in the storage account.
- Copies a YAML file containing the definition of the services and deployments of the multi-container application to the file share.

Command file

```
REM Create a resource group for the storage account
az group create --name RESOURCE_GROUP --location LOCATION --output jsonc

REM Create a storage account for clouddrive
az storage account create --name STORAGE_ACCOUNT_NAME --resource-group RESOURCE_GROUP --sku
Standard_RAGRS --location LOCATION

REM Create a file share in the storage account
az storage share create --name SHARE_NAME --account-name STORAGE_ACCOUNT_NAME --account-key
STORAGE_ACCOUNT_PRIMARY_KEY --resource-group RESOURCE_GROUP

REM upload the YAML containing the definition of services and deployments to the clouddrive
from a command-prompt on the local machine
az storage file upload --account-name STORAGE_ACCOUNT_NAME --account-key
STORAGE_ACCOUNT_PRIMARY_KEY --share-name SHARE_NAME --source PATH_TO_YAML_FILE
```

Before runnng the command file, change the placeholders as follows:

- Replace RESOURCE_GROUP with the name of the new resource group.
- Replace LOCATION with the location of the resource group and storage account.
- Replace STORAGE_ACCOUNT_NAME with the name of the new storage account.
- Replace STORAGE_ACCOUNT_PRIMARY_KEY with the primary key of the new storage account.
- Replace SHARE_NAME with the name of the new file share in the storage account.
- Replace PATH_TO_YAML_FILE with the path to the YAML containing the definition of the services and deployments of the multi-container application.

For more information about how to mount a file share from an Azure Cloud Shell, see Persist files in Azure Cloud Shell.

Create a ConfigMap using a YAML file

The next step is to create a YAML file to define a ConfigMap. The multi-container sample uses a ConfigMap to define a value for the following parameter/environment variable pairs:

- aspNetCoreEnvironment/ASPNETCORE_ENVIRONMENT
- todoApiServiceBusQueueName/NotificationService__ServiceBus__QueueName
- todoApiServiceEndpointUri/TodoApiService__EndpointUri
- todoWebDataProtectionBlobStorageContainerName/DataProtection__BlobStorage__ContainerName
- todoApiDataProtectionBlobStorageContainerName/DataProtection__BlobStorage__ContainerName

The following YAML file can be used to create a ConfigMap object named **todolist-configmap** that contains a value for the above parameters.

todolist-configmap.yml

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: todolist-configmap
  namespace: default
data:
  aspNetCoreEnvironment: Development
  todoApiServiceBusQueueName: todoapi
  todoApiServiceEndpointUri: todoapi
  todoWebDataProtectionBlobStorageContainerName: todoweb
  todoApiDataProtectionBlobStorageContainerName: todoapi
```

The create-todolist-configmap.cmd command can be used to create the **todolist-configmap** object in the Kubernetes cluster.

```
kubectl create --filename todolist-configmap.yml --record
```

You can use one of the following commands to read the value of the keys from **todolist-configmap**:

```
# Get todolist-configmap
kubectl get configmaps todolist-configmap -o yaml

# Describe todolist-configmap
kubectl describe configmap todolist-configmap
```

Create a secret using a YAML file

The next step is to create a YAML file to define a secret object. Each item in the file must be base64-encoded. The multi-container sample uses a secret to define a value for the following parameter\environment variable pairs:

- cosmosDbEndpointUri\RepositoryService__CosmosDb__EndpointUri
- cosmosDBPrimaryKey\RepositoryService__CosmosDb__PrimaryKey
- cosmosDbDatabaseName\RepositoryService__CosmosDb__DatabaseName
- cosmosDbCollectionName\RepositoryService__CosmosDb__CollectionName
- serviceBusConnectionString\NotificationService__ServiceBus__ConnectionString
- dataProtectionBlobStorageConnectionString\DataProtection__BlobStorage__ConnectionString
- applicationInsightsInstrumentationKey\ApplicationInsights__InstrumentationKey

The following YAML file can be used to create a secret object named **todolist-secret** that contains the values for these parameters. Before running the script, make sure to replace the placeholders in the todolist-secret.yml file with the corresponding base64-encoded value for each configuration setting.

todolist-secret.yml

```
apiVersion: v1
kind: Secret
metadata:
  name: todolist-secret
type: Opaque
data:
  cosmosDbEndpointUri: BASE64-ENCODED-COSMOS-DB-ENDPOINT-URI
  cosmosDBPrimaryKey: BASE64-ENCODED-COSMOS-DB-PRIMARY-KEY
  cosmosDbDatabaseName: BASE64-ENCODED-COSMOS-DB-DATABASE-NAME
  cosmosDbCollectionName: BASE64-ENCODED-COSMOS-DB-COLLECTION-NAME
  serviceBusConnectionString: BASE64-ENCODED-SERVICE-BUS-CONNECTION-STRING
  dataProtectionBlobStorageConnectionString: BASE64-ENCODED-BLOB-STORAGE-CONNECTION-STRING
  applicationInsightsInstrumentationKey: BASE64-ENCODED-APP-INSIGHTS-INSTRUMENTATION-KEY
```

On Windows, you can use the following command to translate a value into a base64 format:

```
powershell "[convert]::ToBase64String([Text.Encoding]::UTF8.GetBytes(\"value\"))"
```

In a Linux bash shell, you can use the base64 command line utility to encode a value to a base64 format:

```
echo -n "value" | base64
```

The create-secret-in-kubernetes.cmd script can be used to create the **todolist-secret** object in the Kubernetes cluster.

create-secret-in-kubernetes.cmd

```
kubectl create --filename todolist-secret.yml --record
```

Deploy the application

After setting up the Azure environment and creating the secret object, you can now deploy the application. The project includes the todolist-deployments-and-services-from-azure-container-registry.yml file, which is configured to pull Docker images from an Azure Container Service repository. Using this configuration file, you can deploy the multi-container application to AKS.

To deploy the multi-container application:

1. Open the todolist-deployments-and-services-from-azure-container-registry.yml file.

```
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: todoapi
  labels:
    app: todoapi
spec:
  replicas: 3
  selector:
    matchLabels:
      app: todoapi
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 1
  minReadySeconds: 5
  template:
    metadata:
      labels:
        app: todoapi
    spec:
      containers:
      - name: todoapi
        image: AZURE_CONTAINER_REGISTRY_NAME.azurecr.io/todoapi:v1
        ports:
        - containerPort: 80
        env:
        - name: ASPNETCORE_ENVIRONMENT
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: aspNetCoreEnvironment
        - name: RepositoryService__CosmosDb__EndpointUri
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbEndpointUri
        - name: RepositoryService__CosmosDb__PrimaryKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDBPrimaryKey
        - name: RepositoryService__CosmosDb__DatabaseName
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbDatabaseName
        - name: RepositoryService__CosmosDb__CollectionName
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbCollectionName
        - name: NotificationService__ServiceBus__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: serviceBusConnectionString
        - name: NotificationService__ServiceBus__QueueName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiServiceBusQueueName
        - name: DataProtection__BlobStorage__ConnectionString
```

```
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: dataProtectionBlobStorageConnectionString
        - name: DataProtection__BlobStorage__ContainerName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiDataProtectionBlobStorageContainerName
        - name: ApplicationInsights__InstrumentationKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: applicationInsightsInstrumentationKey
---
apiVersion: v1
kind: Service
metadata:
  name: todoapi
  labels:
    app: todoapi
spec:
  type: LoadBalancer
  ports:
  - protocol: TCP
    port: 80
  selector:
    app: todoapi
---
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: todoweb
  labels:
    app: todoweb
spec:
  replicas: 3
  selector:
    matchLabels:
      app: todoweb
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 1
  minReadySeconds: 5
  template:
    metadata:
      labels:
        app: todoweb
    spec:
      containers:
```

```
      - name: todoweb
        image: AZURE_CONTAINER_REGISTRY_NAME.azurecr.io/todoweb:v1
        ports:
        - containerPort: 80
        env:
        - name: ASPNETCORE_ENVIRONMENT
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: aspNetCoreEnvironment
        - name: TodoApiService__EndpointUri
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiServiceEndpointUri
        - name: DataProtection__BlobStorage__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: dataProtectionBlobStorageConnectionString
        - name: DataProtection__BlobStorage__ContainerName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoWebDataProtectionBlobStorageContainerName
        - name: ApplicationInsights__InstrumentationKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: applicationInsightsInstrumentationKey
---
apiVersion: v1
kind: Service
metadata:
  name: todoweb
  labels:
    app: todoweb
spec:
  type: LoadBalancer
  ports:
  - protocol: TCP
    port: 80
  selector:
    app: todoweb
```

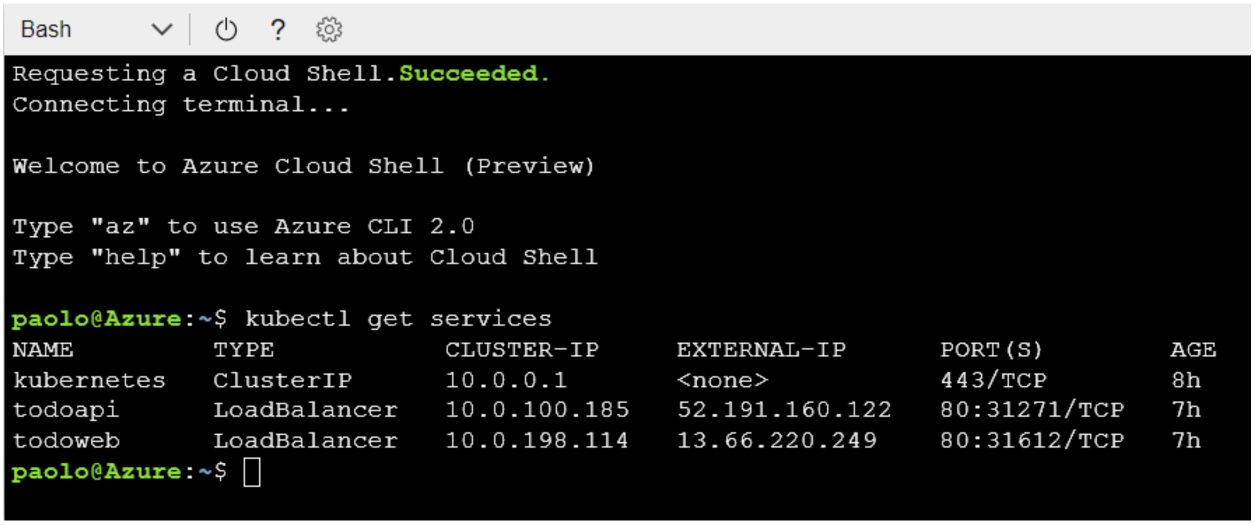
2. Replace AZURE_CONTAINER_REGISTRY_NAME with the name of your Azure container registry.
3. Run the following command from the Azure Cloud Shell to deploy the multi-container application to your Kubernetes cluster:

```
kubectl create --filename todolist-deployments-and-services-from-azure-container-registry.yml --rec
ord
```

4. To display EXTERNAL-IP of the **TodoWeb** front-end service, run the following command:

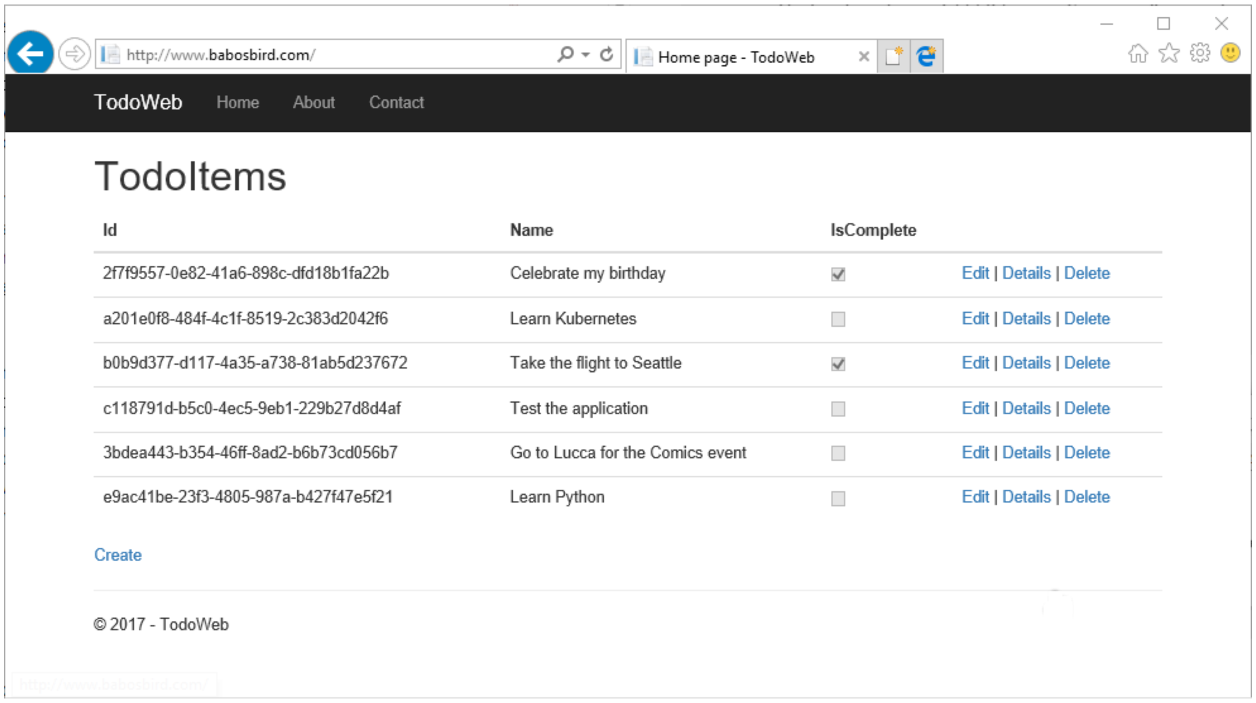
```
kubectl get services
```

The output looks like this:



```
Requesting a Cloud Shell.Succeeded.
Connecting terminal...

Welcome to Azure Cloud Shell (Preview)

Type "az" to use Azure CLI 2.0
Type "help" to learn about Cloud Shell

paolo@Azure:~$ kubectl get services
NAME         TYPE           CLUSTER-IP     EXTERNAL-IP     PORT(S)        AGE
kubernetes   ClusterIP      10.0.0.1       <none>          443/TCP        8h
todoapi      LoadBalancer   10.0.100.185   52.191.160.122  80:31271/TCP   7h
todoweb      LoadBalancer   10.0.198.114   13.66.220.249   80:31612/TCP   7h
paolo@Azure:~$
```

5. To verify that the application works as expected, browse to the public IP of the **TodoWeb** front-end service. It should look like this:



TodoItems

Id	Name	IsComplete	
2f7f9557-0e82-41a6-898c-dfd18b1fa22b	Celebrate my birthday	✓	Edit | Details | Delete
a201e0f8-484f-4c1f-8519-2c383d2042f6	Learn Kubernetes	☐	Edit | Details | Delete
b0b9d377-d117-4a35-a738-81ab5d237672	Take the flight to Seattle	✓	Edit | Details | Delete
c118791d-b5c0-4ec5-9eb1-229b27d8d4af	Test the application	☐	Edit | Details | Delete
3bdea443-b354-46ff-8ad2-b6b73cd056b7	Go to Lucca for the Comics event	☐	Edit | Details | Delete
e9ac41be-23f3-4805-987a-b427f47e5f21	Learn Python	☐	Edit | Details | Delete

Create

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Configure NGINX ingress controller for TLS termination on Kubernetes

So far, we have seen how to configure both the **TodoWeb** front-end service and **TodoApi** back-end service and expose a public HTTP endpoint for each. But what if you want to expose only the **TodoWeb** front-end service? And configure it to use an HTTPS endpoint instead of an HTTP endpoint? You can implement TLS termination in the Kubernetes cluster using an ingress object and the NGINX ingress controller.

The NGINX ingress controller is a daemon deployed as a Kubernetes pod that watches the API server's /ingresses endpoint for updates to the ingress resource. Using this controller, you can implement several patterns such as path-based fanout, SSL passthrough, TLS termination, and basic or digest HTTP authentication.

You can deploy the NGINX ingress controller to your Kubernetes cluster in Azure using either the kubectl CLI or Helm, a tool for managing Kubernetes configurations.

The following steps install Helm, install NGINX, and create a secret containing the certificate and private key used for TLS termination:

1. Use the \Scripts\Helm\install-helm.sh bash script below to install and initialize Helm.

```
#!/bin/bash
# Install helm on the local machine

# Download Helm
curl https://raw.githubusercontent.com/kubernetes/helm/master/scripts/get > get_helm.sh

# Make get_helm executable
$ chmod 700 get_helm.sh

# Execute get_helm.sh
$ ./get_helm.sh

# Initialize helm
helm init
```

ⓘ **NOTE:** The **helm init** command is used to install Helm components in a Kubernetes cluster and make client-side configurations. For more information, see Use Helm with Azure Container Service (AKS) and the Helm documentation.

2. Install the NGINX ingress controller in your Kubernetes cluster using the following bash script:

```
# Installs nginx-ingress using helm
helm install stable/nginx-ingress -n nginx-ingress
```

3. Scale out the number of replicas used by the NGINX ingress controller to from 1 to 3 using the following bash script:

```
# Scale the number of replicas of the nginx-ingress-controller to 3
kubectl scale deployment nginx-ingress-controller --replicas=3

# Scale the number of replicas of the nginx-ingress-default-backend to 3
kubectl scale deployment nginx-ingress-default-backend --replicas=3
```

4. Install the OpenSSL utility using the following bash script:

```
# Install openssl utility
sudo apt update && sudo apt install openssl
```

5. Create a self-signed certificate suitable for testing using the following bash script:

```
# Create a self-signed certificate. Note: private and public keys are saved locally
openssl req -x509 -nodes -days 3650 -newkey rsa:2048 -keyout tls.key -out tls.crt -subj
"/CN=nginxsvc/O=nginxsvc"
```

6. Create a secret in your Kubernetes cluster using the self-signed certificate and its private key. Run the following bash script:

```
# Use the private and public key to create a secret used for SSL termination
kubectl create secret tls tls-secret --key tls.key --cert tls.crt
```

ⓘ **IMPORTANT:** The data keys must be named **tls.crt** and **tls.key**. In a production environment, you should replace the self-signed certificate with a valid certificate issued by a trusted certificate authority.

As an alternative to step 6, you can also use the following YAML file to define the **tls-secret**:

```
apiVersion: v1
kind: Secret
type: kubernetes.io/tls
metadata:
  name: tls-secret
data:
  tls.crt: [BASE64_ENCODED_CERT]
  tls.key: [BASE64_ENCODED_KEY]
```

Then, to create the **tls-secret** in your Kubernetes cluster based on this YAML file, run the following bash command:

```
# Create tls-secret using YAML file
kubectl create -f /mnt/c/[PATH-TO-YAML-FILE]/tls-secret.yml
```

For more information about Helm, see The Kubernetes Package Manager on GitHub. For more information about NGINX ingress controller, see the Readme file for its deployment.

Option: Generate certificates with kube-lego

This guide shows how to manually create and deploy a certificate for TLS termination to a Kubernetes cluster. However, you can use kube-lego for automatic certificate generation. The open source kube-lego app acquires certificates for Kubernetes Ingress resources from Let's Encrypt, which issues certificates for free.

For more information about kube-lego, see Configure Https / TLS / SSL on Kubernetes with Kube-Lego hosted on Azure Container Service.

Install the multi-container application to Kubernetes

Now you are ready to install the multi-container application to Kubernetes. In this section, you will see how to use the kubectl CLI to create services and deployments based on the definitions in a YAML file. In the next section, you will see how to create a Helm chart and use it to deploy the application to Kubernetes.

The todolist-deployments-and-services-from-docker-hub-ssl.yml file is used in deploying the application to your managed Kubernetes service. Before deployment, make sure to replace DOCKER_HUB_REPOSITORY with the name of your Docker Hub repository.

todolist-deployments-and-services-from-docker-hub-ssl.yml

```
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: {{.Values.backend}}
  labels:
    app: {{.Values.backend}}
spec:
  replicas: 3
  selector:
    matchLabels:
      app: {{.Values.backend}}
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 1
  minReadySeconds: 5
  template:
    metadata:
      labels:
        app: {{.Values.backend}}
    spec:
      containers:
      - name: {{.Values.backend}}
        image: {{.Values.imageRegistry}}/{{.Values.backendImage}}:{{.Values.backendTag}}
        ports:
        - containerPort: 80
        env:
        - name: ASPNETCORE_ENVIRONMENT
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: aspNetCoreEnvironment
        - name: RepositoryService__CosmosDb__EndpointUri
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbEndpointUri
        - name: RepositoryService__CosmosDb__PrimaryKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDBPrimaryKey
        - name: RepositoryService__CosmosDb__DatabaseName
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbDatabaseName
        - name: RepositoryService__CosmosDb__CollectionName
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbCollectionName
        - name: NotificationService__ServiceBus__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: serviceBusConnectionString
        - name: NotificationService__ServiceBus__QueueName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiServiceBusQueueName
        - name: DataProtection__BlobStorage__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: dataProtectionBlobStorageConnectionString
        - name: DataProtection__BlobStorage__ContainerName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiDataProtectionBlobStorageContainerName
        - name: ApplicationInsights__InstrumentationKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: applicationInsightsInstrumentationKey
---
apiVersion: v1
kind: Service
metadata:
  name: {{.Values.backend}}
spec:
  type: {{.Values.backendServiceType}}
  ports:
  - protocol: TCP
    port: 80
  selector:
    app: {{.Values.backend}}
---
```

```
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: {{.Values.frontend}}
  labels:
    app: {{.Values.frontend}}
spec:
  replicas: 3
  selector:
    matchLabels:
      app: {{.Values.frontend}}
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 1
  minReadySeconds: 5
  template:
    metadata:
      labels:
        app: {{.Values.frontend}}
    spec:
      containers:
      - name: {{.Values.frontend}}
        image: {{.Values.imageRegistry}}/{{.Values.frontendImage}}:{{.Values.frontendTag}}
        ports:
        - containerPort: 80
        env:
        - name: ASPNETCORE_ENVIRONMENT
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: aspNetCoreEnvironment
        - name: TodoApiService__EndpointUri
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiServiceEndpointUri
        - name: DataProtection__BlobStorage__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: dataProtectionBlobStorageConnectionString
        - name: DataProtection__BlobStorage__ContainerName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoWebDataProtectionBlobStorageContainerName
        - name: ApplicationInsights__InstrumentationKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: applicationInsightsInstrumentationKey
---
apiVersion: v1
kind: Service
metadata:
  name: {{.Values.frontend}}
spec:
  type: {{.Values.frontendServiceType}}
  ports:
  - protocol: TCP
    port: 80
  selector:
    app: {{.Values.frontend}}
```

In the todolist-deployments-and-services-from-docker-hub-ssl.yml file, note that the name of deployments and services includes is now prefixed with *ssl-*. In addition, the type of both **ssl-todoapi** and **ssl-todoweb** services is now **ClusterIP** instead of **LoadBalancer**. As discussed earlier, if you adopt the **ClusterIP** service type, a service is exposed only on a cluster-internal IP and can be reached only from within the cluster. This is the default service type. If you adopt the **LoadBalancer** service type instead, a service is exposed externally using a cloud provider's load balancer. For AKS, the Azure Load Balancer is used in front of the cluster nodes. For more information, see Services in the Kubernetes documentation.

Deploy services to the cluster

You can now run the following bash script to deploy the **ssl-todoapi** and **ssl-todoweb** services to your Kubernetes cluster:

```
# Deploy the TodoList application using kubectl or helm
kubectl create -f /mnt/c/[PATH-TO-YAML-FILE]/todolist-deployments-and-services-from-docker-
hubtodolist-deployments-and-services-from-docker-hub-ssl.yml --record
```

To expose the **ssl-todoweb** front-end service with a HTTPS public endpoint, you have to create an ingress object in the same namespace as the **tls-secret** object.

nginx-ingress.yml

```
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: nginx-ingress
spec:
  tls:
  - secretName: tls-secret
  backend:
    serviceName: ssl-todoweb
```

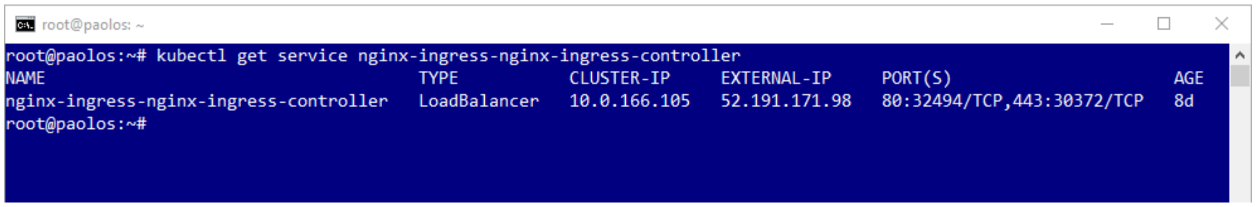
Then, to create the nginx-ingress object in your Kubernetes cluster based on this YAML file, run the following bash command:

create-nginx-ingress.sh

```
# Create nginx-ingress using a YAML file
kubectl create -f /mnt/c/[PATH-TO-YAML-FILE]/nginx-ingress.yml
```

Now the NGINX ingress controller is configured to implement SSL termination and route traffic to the **ssl-todoweb** service via HTTPS. To display the external IP address exposed by the NGINX ingress controller service, run the following bash command as Figure 10 shows:

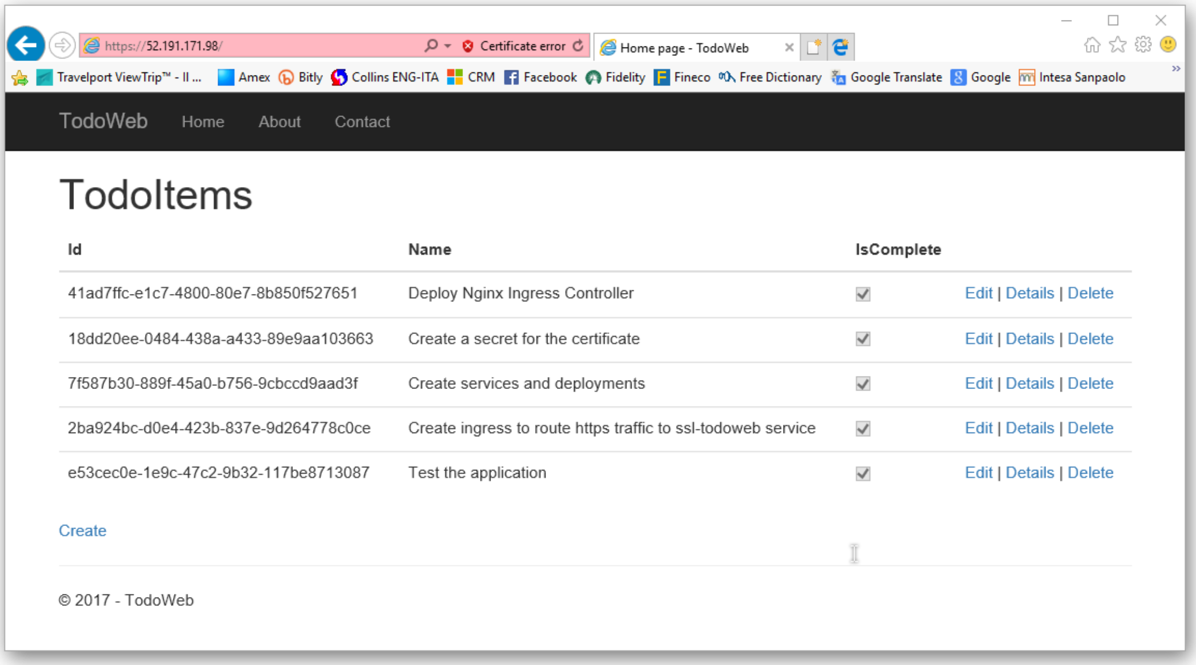
```
kubectl get service nginx-ingress-nginx-ingress-controller
```



```
root@paolos:~# kubectl get service nginx-ingress-nginx-ingress-controller
NAME                                     TYPE           CLUSTER-IP     EXTERNAL-IP     PORT(S)                      AGE
nginx-ingress-nginx-ingress-controller   LoadBalancer   10.0.166.105   52.191.171.98   80:32494/TCP,443:30372/TCP   8d
root@paolos:~#
```

Figure 10. External IP address exposed by the NGINX ingress controller.

With this information, you can now verify that the application works as expected. Browse to the external IP address of the NGINX ingress controller front-end service. You should see the application as Figure 11 shows.



TodoItems

Id	Name	IsComplete	
41ad7ffc-e1c7-4800-80e7-8b850f527651	Deploy Nginx Ingress Controller	✓	Edit | Details | Delete
18dd20ee-0484-438a-a433-89e9aa103663	Create a secret for the certificate	✓	Edit | Details | Delete
7f587b30-889f-45a0-b756-9cbccd9aad3f	Create services and deployments	✓	Edit | Details | Delete
2ba924bc-d0e4-423b-837e-9d264778c0ce	Create ingress to route https traffic to ssl-todoweb service	✓	Edit | Details | Delete
e53cec0e-1e9c-47c2-9b32-117be8713087	Test the application	✓	Edit | Details | Delete

Create

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Figure 11. TodoWeb front end in a browser.

Package and deploy the application using Helm

You can use Helm to package and deploy the application to Kubernetes. Helm is a packaging format used to manage Kubernetes charts. A chart is a collection of files that describe a related set of Kubernetes resources and organized in a directory tree. Then they can be packaged into versioned archives to be deployed.

Charts help simplify a several tasks:

- Share your applications as Kubernetes charts.
- Create reproducible builds of your Kubernetes applications.
- Intelligently manage your Kubernetes manifest files.
- Manage releases of Helm packages.

As Figure 10 shows, a single chart can be used to create the services and deployments that compose the Todolist multi-container application.

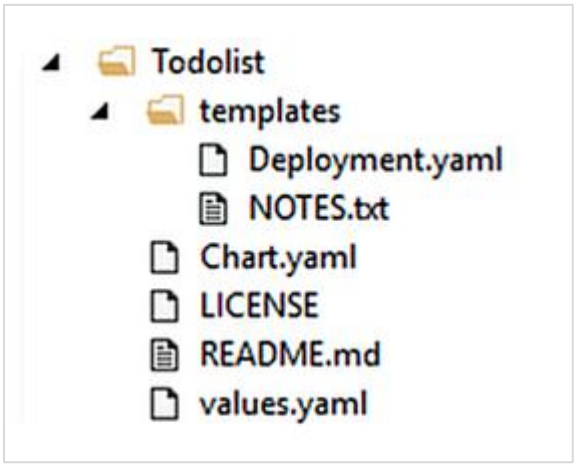
```
◢ Todolist
    ◢ templates
        Deployment.yaml
        NOTES.txt
      Chart.yaml
      LICENSE
      README.md
      values.yaml
```

Figure 12. Todolist directory in a Helm chart.

The directory name is the name of the chart—in this case, Todolist. The Todolist chart is organized as a collection of the following files in this directory:

- **Chart.yaml:** A YAML file containing the chart name, version, keywords, description, and other information.
- **LICENSE:** An optional plain text file containing the license for the chart.
- **README.md:** A markdown file with notes and instructions.
- **requirements.yaml:** An optional YAML file listing any dependencies on other charts. This file is not used in this deployment. The Todolist application has no chart dependencies.
- **values.yaml:** A mandatory file containing the default configuration values for this chart.
- **charts/:** An optional directory containing any charts upon which this chart depends. This directory is not used in this deployment. Todolist has no chart dependencies.
- **templates/:** An optional directory of templates that, when combined with **values**, will generate valid Kubernetes manifest files.
- **templates/Deployment.yaml:** A YAML file containing the definition of the **TodoApi** and **TodoWeb** services and deployments.
- **templates/NOTES.txt:** An optional plain text file containing short usage notes.

For more information about charts, see Charts in the Helm documentation.

Helm deployment files in this project

The \Scripts\Helm folder in the project contains the files used by the Helm chart. The main files are Chart.yaml, values.yaml, Deployment.yaml. As you can see from the code below, Helm chart templates are written in the Go template language, which uses *actions* to describe data evaluations or control structures. Actions are delimited within pairs of curly brackets ({{ and }}). Text outside of the actions is copied to the output unchanged.

```
metadata:
  name: {{.Values.backend}}
```

This project uses actions as placeholders for values defined in the values.yaml file. This technique is extremely powerful, because you can parametrize an entire template, including the service type, container image location, and service and deployment name.

Chart.yaml

```
name: TodoList
version: 1.0.0
description: todolist multi-container app
keywords:
  - todoapi
home: https://github.com/paolosalvatori/service-fabric-acs-kubernetes-multi-container-app
sources:
  - https://github.com/paolosalvatori/service-fabric-acs-kubernetes-multi-container-app
maintainers: # (optional)
  - name: Paolo
    url: https://github.com/paolosalvatori
engine: gotpl
appVersion: 1.0.0
```

values.yaml

```
imageRegistry: "paolosalvatori"
frontendImage: "todoweb"
backendImage: "todoapi"
frontendTag: "v2"
backendTag: "v2"
frontend: "todoweb"
backend: "todoapi"
frontendServiceType: "LoadBalancer"
backendServiceType: "LoadBalancer"
```

templates/Deployment.yaml

```
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: {{.Values.backend}}
  labels:
    app: {{.Values.backend}}
spec:
  replicas: 3
  selector:
    matchLabels:
      app: {{.Values.backend}}
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 1
  minReadySeconds: 5
  template:
    metadata:
      labels:
        app: {{.Values.backend}}
    spec:
      containers:
      - name: {{.Values.backend}}
        image: {{.Values.imageRegistry}}/{{.Values.backendImage}}:{{.Values.backendTag}}
        ports:
        - containerPort: 80
        env:
        - name: ASPNETCORE_ENVIRONMENT
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: aspNetCoreEnvironment
        - name: RepositoryService__CosmosDb__EndpointUri
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbEndpointUri
        - name: RepositoryService__CosmosDb__PrimaryKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDBPrimaryKey
        - name: RepositoryService__CosmosDb__DatabaseName
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbDatabaseName
        - name: RepositoryService__CosmosDb__CollectionName
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: cosmosDbCollectionName
        - name: NotificationService__ServiceBus__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: serviceBusConnectionString
        - name: NotificationService__ServiceBus__QueueName
```

```
          value: {{.Values.queueName}}
        - name: DataProtection__BlobStorage__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: dataProtectionBlobStorageConnectionString
        - name: DataProtection__BlobStorage__ContainerName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiDataProtectionBlobStorageContainerName
        - name: ApplicationInsights__InstrumentationKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: applicationInsightsInstrumentationKey
---
apiVersion: v1
kind: Service
metadata:
  name: {{.Values.backend}}
spec:
  type: {{.Values.backendServiceType}}
  ports:
  - protocol: TCP
    port: 80
  selector:
    app: {{.Values.backend}}
---
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: {{.Values.frontend}}
  labels:
    app: {{.Values.frontend}}
spec:
  replicas: 3
  selector:
    matchLabels:
      app: {{.Values.frontend}}
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 1
  minReadySeconds: 5
  template:
    metadata:
      labels:
        app: {{.Values.frontend}}
    spec:
      containers:
```

```
      - name: {{.Values.frontend}}
        image: {{.Values.imageRegistry}}/{{.Values.frontendImage}}:{{.Values.frontendTag}}
        ports:
        - containerPort: 80
        env:
        - name: ASPNETCORE_ENVIRONMENT
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: aspNetCoreEnvironment
        - name: TodoApiService__EndpointUri
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoApiServiceEndpointUri
        - name: DataProtection__BlobStorage__ConnectionString
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: dataProtectionBlobStorageConnectionString
        - name: DataProtection__BlobStorage__ContainerName
          valueFrom:
            configMapKeyRef:
              name: todolist-configmap
              key: todoWebDataProtectionBlobStorageContainerName
        - name: ApplicationInsights__InstrumentationKey
          valueFrom:
            secretKeyRef:
                name: todolist-secret
                key: applicationInsightsInstrumentationKey
---
apiVersion: v1
kind: Service
metadata:
  name: {{.Values.frontend}}
spec:
  type: {{.Values.frontendServiceType}}
  ports:
  - protocol: TCP
    port: 80
  selector:
    app: {{.Values.frontend}}
```

Package the chart

You can run the following bash script to package the chart. This operation creates a compressed TAR (Tape ARchive) file with the format ChartName-ChartVersion.tgz in the current folder—in this case, TodoList-1.0.0.tgz.

```
# Build package
helm package /mnt/c/[PATH-TO-CHART]/TodoList
```

Make sure you have created the **todolist-config** and **todolist-secret** in your Kubernetes cluster as explained earlier. Then, if you want to install the todolist application, run the following bash command:

```
# Install package
helm install --name todolist TodoList-1.0.0.tgz
```

Customize a deployment

Another advantage of Helm is that you can use its CLI to customize a deployment. You can override all or part of the values provided in the values.yaml file in the chart by specifing an alternate values.yaml file.

For example, say you want to deploy a version of the application that uses HTTPS instead of HTTP. To do this, create an alternative values.yaml file and change the service type for both the **TodoApi** and **TodoWeb** services from **LoadBalancer** to **ClusterIP**. A good practice is to add the *ssl-* prefix to the name of the corresponding services and deployments. To do this:

1. Create the following ssl-todolist-values.yaml file:

```
frontend: "ssl-todoweb"
backend: "ssl-todoapi"
frontendServiceType: "ClusterIP"
backendServiceType: "ClusterIP"
```

2. Run this bash command:

```
# Install package for ssl-todolist
helm install --name ssl-todolist --values /mnt/c/[PATH-TO-CHART]/ssl-todolist-values.yaml
TodoList-1.0.0.tgz
```

Azure services used by this project

Kubernetes is a powerful system for managing containerized applications in a clustered environment. Kubernetes is an open-source platform designed to automate deploying, scaling, and operating application containers. It aims to provide better ways of managing related, distributed components across varied infrastructure.

Azure Container Service for Kubernetes (ACS–Kubernetes) makes it simple to create, configure, and manage a cluster of virtual machines that are preconfigured to run containerized applications. You can draw upon a large and growing body of community expertise to deploy and manage container-based applications on Azure.

Azure Container Service with Managed Kubernetes Service (AKS) manages your hosted Kubernetes environment, making it quick and easy to deploy and manage containerized applications without container orchestration expertise. It also eases ongoing operations and maintenance by provisioning, upgrading, and scaling resources on demand, without taking your applications offline.

Application Insights is an extensible Application Performance Management (APM) service for monitoring live web applications. It detects performance anomalies and includes powerful analytics tools to help you diagnose issues and to understand what users do with your apps. It works for apps on a wide variety of platforms including .NET, Node.js, and J2EE, hosted on-premises or in the cloud.

Service Bus Messaging is a reliable message delivery service for brokered or third-party communications that connect applications through the cloud. Service Bus messaging with queues, topics, and subscriptions can be thought of as asynchronous, or temporally decoupled. Producers (senders) and consumers (receivers) do not have to be online at the same time. The messaging infrastructure reliably stores messages in a "broker" (for example, a queue) until the consuming party is ready to receive them.

Azure Cosmos DB is a globally distributed, multi-model database that can elastically and independently scale throughput and storage across any number of Azure's geographic regions. Azure Cosmos DB supports multiple data models and popular APIs for accessing and querying data. The sample in this solution uses the Azure Cosmos DB SQL API, which provides a schema-less JSON database engine with SQL querying capabilities.

Azure Container Registry is a managed Docker registry service based on the open-source Docker Registry 2.0. You can create and maintain Azure container registries to store and manage your private Docker container images. Container registries in Azure work with your existing container development and deployment pipelines and draw on the body of Docker community expertise.

Azure Domain Name System (DNS) is responsible for translating (or resolving) a website or service name to its IP address. Azure DNS is a hosting service for DNS domains, providing name resolution using the Azure infrastructure. By hosting your domains in Azure, you can manage your DNS records using the same credentials, APIs, tools, and billing as your other Azure services.

Learn more

The Azure Container Service with Kubernetes Documentation provides details on the container features and scenarios. The following useful links contain more in depth information:

- Deploy Kubernetes cluster for Linux containers
- Using the Kubernetes web UI with Azure Container Service
- Tutorial: how to create and deploy a a multi-container application on ACS and Kubernetes

For more information about Docker, see the following resources:

- Introduction to Containers and Docker
- What is Docker?
- Building Docker Images for .NET Core Applications
- Docker File Reference
- Docker Compose
- Securing .NET Microservices and Web Applications

For more information about ASP.NET, see the following resources:

- Configuration in ASP.NET Core
- Introduction to Logging in ASP.NET Core
- Introduction to Error Handling in ASP.NET Core
- Introduction to Razor Pages in ASP.NET Core
- Securing .NET Microservices and Web Applications