Tutorial: Develop IoT Edge modules using Visual Studio Code

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Applies to: IoT Edge 1.4

> **Important**
>
> IoT Edge 1.4 is the **supported release**. If you are on an earlier release, see **Update IoT Edge**.

> **Note**
>
> This article was partially created with the help of artificial intelligence. Before publishing, an author reviewed and revised the content as needed. See **Our principles for using AI-generated content in Microsoft Learn** .

This tutorial walks through developing and deploying your own code to an IoT Edge device. You can use Azure IoT Edge modules to deploy code that implements your business logic directly to your IoT Edge devices. In the Deploy code to a Linux device quickstart, you created an IoT Edge device and deployed a module from the Azure Marketplace.

This article includes steps for two IoT Edge development tools.

- *Azure IoT Edge Dev Tool* command-line tool (CLI). This tool is preferred for development.
- *Azure IoT Edge tools for Visual Studio Code* extension. The extension is in maintenance mode .

Use the tool selector button at the beginning of this article to select the tool version.

In this tutorial, you learn how to:

- ✓ Set up your development machine.
- ✓ Use the IoT Edge tools to create a new project.
- ✓ Build your project as a Docker container and store it in an Azure container registry.
- ✓ Deploy your code to an IoT Edge device.

The IoT Edge module that you create in this tutorial filters the temperature data that your device generates. It only sends messages upstream if the temperature is above a specified threshold. This type of analysis at the edge is useful for reducing the amount of data that's communicated to and stored in the cloud.

Prerequisites

A development machine:

- Use your own computer or a virtual machine.
- Your development machine must support nested virtualization for running a container engine.
- Most operating systems that can run a container engine can be used to develop IoT Edge modules for Linux devices. This tutorial uses a Windows computer, but points out known differences on macOS or Linux.
- Install Visual Studio Code
- Install the Azure CLI.

An Azure IoT Edge device:

- You should run IoT Edge on a separate device. This distinction between development machine and IoT Edge device simulates a true deployment scenario and helps keep the different concepts separate. Use the quickstart article Deploy code to a Linux Device to create an IoT Edge device in Azure or the Azure Resource Template to deploy an IoT Edge enabled VM .

Cloud resources:

- A free or standard-tier IoT hub in Azure.

If you don't have an Azure subscription, create an Azure free account before you begin.

> **Tip**
>
> For guidance on interactive debugging in Visual Studio Code or Visual Studio 2022:
>
> - **Debug Azure IoT Edge modules using Visual Studio Code**
> - **Use Visual Studio 2022 to develop and debug modules for Azure IoT Edge**
>
> This tutorial teaches the development steps for Visual Studio Code.

Key concepts

This tutorial walks through the development of an IoT Edge module. An *IoT Edge module* is a container with executable code. You can deploy one or more modules to an IoT Edge device. Modules perform specific tasks like ingesting data from sensors, cleaning and analyzing data, or sending messages to an IoT hub. For more information, see Understand Azure IoT Edge modules.

When developing IoT Edge modules, it's important to understand the difference between the development machine and the target IoT Edge device where the module deploys. The container that you build to hold your module code must match the operating system (OS) of the *target device*. For example, the most common scenario is someone developing a module on a Windows computer intending to target a Linux device running IoT Edge. In that case, the container operating system would be Linux. As you go through this tutorial, keep in mind the difference between the *development machine OS* and the *container OS*.

> **Tip**
>
> If you're using **IoT Edge for Linux on Windows**, then the *target device* in your scenario is the Linux virtual machine, not the Windows host.

This tutorial targets devices running IoT Edge with Linux containers. You can use your preferred operating system as long as your development machine runs Linux containers. We recommend using Visual Studio Code to develop with Linux containers, so that's what this tutorial uses. You can use Visual Studio as well, although there are differences in support between the two tools.

The following table lists the supported development scenarios for **Linux containers** in Visual Studio Code and Visual Studio.

	Visual Studio Code	**Visual Studio 2019/2022**
Linux device architecture	Linux AMD64 Linux ARM32v7 Linux ARM64	Linux AMD64 Linux ARM32 Linux ARM64
Azure services	Azure Functions Azure Stream Analytics Azure Machine Learning	

	Visual Studio Code	Visual Studio 2019/2022
Languages	C C# Java Node.js Python	C C#
More information	Azure IoT Edge for Visual Studio Code	Azure IoT Edge Tools for Visual Studio 2019 Azure IoT Edge Tools for Visual Studio 2022

Install container engine

IoT Edge modules are packaged as containers, so you need a Docker compatible container management system on your development machine to build and manage them. We recommend Docker Desktop for development because of its feature support and popularity. Docker Desktop on Windows lets you switch between Linux containers and Windows containers so that you can develop modules for different types of IoT Edge devices.

Use the Docker documentation to install on your development machine:

- Install Docker Desktop for Windows
  - When you install Docker Desktop for Windows, you're asked whether you want to use Linux or Windows containers. You can change this decision at any time. For this tutorial, we use Linux containers because our modules are targeting Linux devices. For more information, see Switch between Windows and Linux containers .
- Install Docker Desktop for Mac
- Read About Docker CE for installation information on several Linux platforms.
  - For the Windows Subsystem for Linux (WSL), install Docker Desktop for Windows.

Set up tools

Install the Python-based Azure IoT Edge Dev Tool to create your IoT Edge solution. There are two options:

- Use the prebuilt IoT Edge Dev Container

- Install the tool using the iotedgedev development setup

Install language specific tools

Install tools specific to the language you're developing in:

C#

- .NET Core SDK
- C# Visual Studio Code extension

Create a container registry

In this tutorial, you use the Azure IoT Edge and Azure IoT Hub extensions to build a module and create a **container image** from the files. Then you push this image to a **registry** that stores and manages your images. Finally, you deploy your image from your registry to run on your IoT Edge device.

You can use any Docker-compatible registry to hold your container images. Two popular Docker registry services are Azure Container Registry and Docker Hub. This tutorial uses Azure Container Registry.

If you don't already have a container registry, follow these steps to create a new one in Azure:

1. In the Azure portal, select **Create a resource** > **Containers** > **Container Registry**.

2. Provide the following required values to create your container registry:

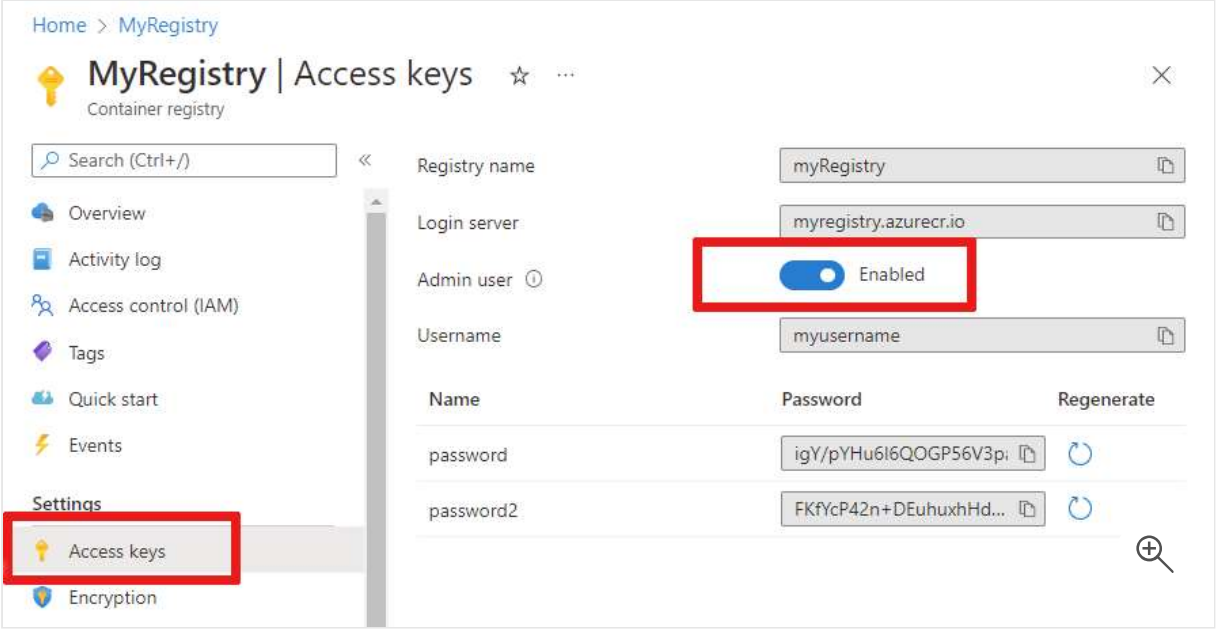
Field	**Value**
Subscription	Select a subscription from the drop-down list.
Resource group	Use the same resource group for all of the test resources that you create during the IoT Edge quickstarts and tutorials. For example, **IoTEdgeResources**.
Registry name	Provide a unique name.
Location	Choose a location close to you.

Field	Value
SKU	Select **Basic**.

3. Select **Review + create**, then **Create**.

4. Select your new container registry from the **Resources** section of your Azure portal home page to open it.

5. In the left pane of your container registry, select **Access keys** from the menu located under **Settings**.



6. Enable **Admin user** with the toggle button and view the **Username** and **Password** for your container registry.

7. Copy the values for **Login server**, **Username**, and **password** and save them somewhere convenient. You use these values throughout this tutorial to provide access to the container registry.

Create a new module project

The Azure IoT Edge extension offers project templates for all supported IoT Edge module languages in Visual Studio Code. These templates have all the files and code that you need to deploy a working module to test IoT Edge, or give you a starting point to customize the template with your own business logic.

Create a project template

The IoT Edge Dev Tool simplifies Azure IoT Edge development to commands driven by environment variables. It gets you started with IoT Edge development with the IoT Edge Dev Container and IoT Edge solution scaffolding that has a default module and all the required configuration files.

1. Create a directory for your solution with the path of your choice. Change into your `iotedgesolution` directory.

   Bash

   ```
   mkdir c:\dev\iotedgesolution
   ```

2. Use the **iotedgedev solution init** command to create a solution and set up your Azure IoT Hub in the development language of your choice.

   C#

   Bash

   ```
   iotedgedev solution init --template csharp
   ```

The *iotedgedev solution init* script prompts you to complete several steps including:

- Authenticate to Azure
- Choose an Azure subscription
- Choose or create a resource group
- Choose or create an Azure IoT Hub
- Choose or create an Azure IoT Edge device

After solution creation, these main files are in the solution:

- A **.vscode** folder contains configuration file *launch.json*.
- A **modules** folder that has subfolders for each module. Within the subfolder for each module, the module.json file controls how modules are built and deployed.
- An **.env** file lists your environment variables. The environment variable for the container registry is *localhost:5000* by default.

- Two module deployment files named **deployment.template.json** and **deployment.debug.template.json** list the modules to deploy to your device. By default, the list includes the IoT Edge system modules (edgeAgent and edgeHub) and sample modules such as:
  - **filtermodule** is a sample module that implements a simple filter function.
  - **SimulatedTemperatureSensor** module that simulates data you can use for testing. For more information about how deployment manifests work, see Learn how to use deployment manifests to deploy modules and establish routes. For more information on how the simulated temperature module works, see the SimulatedTemperatureSensor.csproj source code .

> **Note**
>
> The exact modules installed may depend on your language of choice.

Set IoT Edge runtime version

The latest stable IoT Edge system module version is 1.4. Set your system modules to version 1.4.

1. In Visual Studio Code, open **deployment.template.json** deployment manifest file. The deployment manifest is a JSON document that describes the modules to be configured on the targeted IoT Edge device.

2. Change the runtime version for the system runtime module images **edgeAgent** and **edgeHub**. For example, if you want to use the IoT Edge runtime version 1.4, change the following lines in the deployment manifest file:

```JSON
"systemModules": {
    "edgeAgent": {

        "image": "mcr.microsoft.com/azureiotedge-agent:1.4",

    "edgeHub": {

        "image": "mcr.microsoft.com/azureiotedge-hub:1.4",
```

Provide your registry credentials to the IoT Edge agent

The environment file stores the credentials for your container registry and shares them with the IoT Edge runtime. The runtime needs these credentials to pull your container images onto the IoT Edge device.

The IoT Edge extension tries to pull your container registry credentials from Azure and populate them in the environment file.

> **Note**
>
> The environment file is only created if you provide an image repository for the module. If you accepted the localhost defaults to test and debug locally, then you don't need to declare environment variables.

Check to see if your credentials exist. If not, add them now:

1. If Azure Container Registry is your registry, set an Azure Container Registry username and password. Get these values from your container registry's **Settings** > **Access keys** menu in the Azure portal.

2. Open the **.env** file in your module solution.

3. Add the **username** and **password** values that you copied from your Azure container registry. For example:

   env

   ```
   CONTAINER_REGISTRY_SERVER="myacr.azurecr.io"
   CONTAINER_REGISTRY_USERNAME="myacr"
   CONTAINER_REGISTRY_PASSWORD="<registry_password>"
   ```

4. Save your changes to the *.env* file.

> **Note**
>
> This tutorial uses administrator login credentials for Azure Container Registry that are convenient for development and test scenarios. When you're ready for production scenarios, we recommend a least-privilege authentication option like service principals

or repository-scoped tokens. For more information, see **Manage access to your container registry**.

Target architecture

You need to select the architecture you're targeting with each solution, because that affects how the container is built and runs. The default is Linux AMD64. For this tutorial, we're using an Ubuntu virtual machine as the IoT Edge device and keep the default **amd64**.

If you need to change the target architecture for your solution, use the following steps.

1. Open or create **settings.json** in the **.vscode** directory of your solution.
2. Change the *platform* value to `amd64`, `arm32v7`, `arm64v8`, or `windows-amd64`. For example:

JSON

```
{
    "azure-iot-edge.defaultPlatform": {
        "platform": "amd64",
        "alias": null
    }
}
```

Update module with custom code

Each template includes sample code that takes simulated sensor data from the **SimulatedTemperatureSensor** module and routes it to the IoT hub. The sample module receives messages and then passes them on. The pipeline functionality demonstrates an important concept in IoT Edge, which is how modules communicate with each other.

Each module can have multiple *input* and *output* queues declared in their code. The IoT Edge hub running on the device routes messages from the output of one module into the input of one or more modules. The specific code for declaring inputs and outputs varies between languages, but the concept is the same across all modules. For more information about routing between modules, see Declare routes.

C#

The sample C# code that comes with the project template uses the ModuleClient Class from the IoT Hub SDK for .NET.

1. In the Visual Studio Code explorer, open **modules** > **filtermodule** > **ModuleBackgroundService.cs**.

2. Before the **filtermodule** namespace, add three **using** statements for types that are used later:

```C#
using System.Collections.Generic;      // For KeyValuePair<>
using Microsoft.Azure.Devices.Shared; // For TwinCollection
using Newtonsoft.Json;                // For JsonConvert
```

3. Add the **temperatureThreshold** variable to the **ModuleBackgroundService** class. This variable sets the value that the measured temperature must exceed for the data to be sent to the IoT hub.

```C#
static int temperatureThreshold { get; set; } = 25;
```

4. Add the **MessageBody**, **Machine**, and **Ambient** classes. These classes define the expected schema for the body of incoming messages.

```C#
class MessageBody
{
    public Machine machine {get;set;}
    public Ambient ambient {get; set;}
    public string timeCreated {get; set;}
}
class Machine
{
    public double temperature {get; set;}
    public double pressure {get; set;}
}
class Ambient
{
    public double temperature {get; set;}
```

```
    public int humidity {get; set;}
}
```

5. Find the **ExecuteAsync** function. This function creates and configures a **ModuleClient** object that allows the module to connect to the local Azure IoT Edge runtime to send and receive messages. After creating the **ModuleClient**, the code reads the **temperatureThreshold** value from the module twin's desired properties. The code registers a callback to receive messages from an IoT Edge hub via an endpoint called **input1**.

   Replace the call to the **ProcessMessageAsync** method with a new one that updates the name of the endpoint and the method that's called when input arrives. Also, add a **SetDesiredPropertyUpdateCallbackAsync** method for updates to the desired properties. To make this change, **replace the last line** of the **ExecuteAsync** method with the following code:

   C#

   ```
   // Register a callback for messages that are received by the module.
   // await _moduleClient.SetInputMessageHandlerAsync("input1",
   PipeMessage, cancellationToken);

   // Read the TemperatureThreshold value from the module twin's desired
   properties
   var moduleTwin = await _moduleClient.GetTwinAsync();
   await OnDesiredPropertiesUpdate(moduleTwin.Properties.Desired,
   _moduleClient);

   // Attach a callback for updates to the module twin's desired proper-
   ties.
   await
   _moduleClient.SetDesiredPropertyUpdateCallbackAsync(OnDesiredProperti
   esUpdate, null);

   // Register a callback for messages that are received by the module.
   Messages received on the inputFromSensor endpoint are sent to the
   FilterMessages method.
   await _moduleClient.SetInputMessageHandlerAsync("inputFromSensor",
   FilterMessages, _moduleClient);
   ```

6. Add the **onDesiredPropertiesUpdate** method to the **ModuleBackgroundService** class. This method receives updates on the desired properties from the module twin, and updates the **temperatureThreshold** variable to match. All modules

have their own module twin, which lets you configure the code that's running inside a module directly from the cloud.

C#

```
static Task OnDesiredPropertiesUpdate(TwinCollection desiredProper-
ties, object userContext)
{
    try
    {
        Console.WriteLine("Desired property change:");

Console.WriteLine(JsonConvert.SerializeObject(desiredProperties));

        if (desiredProperties["TemperatureThreshold"]!=null)
            temperatureThreshold =
desiredProperties["TemperatureThreshold"];

    }
    catch (AggregateException ex)
    {
        foreach (Exception exception in ex.InnerExceptions)
        {
            Console.WriteLine();
            Console.WriteLine("Error when receiving desired property:
{0}", exception);
        }
    }
    catch (Exception ex)
    {
        Console.WriteLine();
        Console.WriteLine("Error when receiving desired property:
{0}", ex.Message);
    }
    return Task.CompletedTask;
}
```

7. Add the **FilterMessages** method. This method is called whenever the module receives a message from the IoT Edge hub. It filters out messages that report temperatures below the temperature threshold set via the module twin. It also adds the **MessageType** property to the message with the value set to **Alert**.

C#

```
async Task<MessageResponse> FilterMessages(Message message, object
userContext)
{
```

```
    var counterValue = Interlocked.Increment(ref _counter);
    try
    {
        ModuleClient moduleClient = (ModuleClient)userContext;
        var messageBytes = message.GetBytes();
        var messageString = Encoding.UTF8.GetString(messageBytes);
        Console.WriteLine($"Received message {counterValue}: [{mes-
sageString}]");

        // Get the message body.
        var messageBody = JsonConvert.DeserializeObject<MessageBody>
(messageString);

        if (messageBody != null && messageBody.machine.temperature >
temperatureThreshold)
        {
            Console.WriteLine($"Machine temperature
{messageBody.machine.temperature} " +
                $"exceeds threshold {temperatureThreshold}");
            using (var filteredMessage = new Message(messageBytes))
            {
                foreach (KeyValuePair<string, string> prop in
message.Properties)
                {
                    filteredMessage.Properties.Add(prop.Key,
prop.Value);
                }

                filteredMessage.Properties.Add("MessageType",
"Alert");
                await moduleClient.SendEventAsync("output1", fil-
teredMessage);
            }
        }

        // Indicate that the message treatment is completed.
        return MessageResponse.Completed;
    }
    catch (AggregateException ex)
    {
        foreach (Exception exception in ex.InnerExceptions)
        {
            Console.WriteLine();
            Console.WriteLine("Error in sample: {0}", exception);
        }
        // Indicate that the message treatment is not completed.
        var moduleClient = (ModuleClient)userContext;
        return MessageResponse.Abandoned;
    }
    catch (Exception ex)
    {
```

```
            Console.WriteLine();
            Console.WriteLine("Error in sample: {0}", ex.Message);
            // Indicate that the message treatment is not completed.
            ModuleClient moduleClient = (ModuleClient)userContext;
            return MessageResponse.Abandoned;
        }
    }
```

8. Save the **ModuleBackgroundService.cs** file.

9. In the Visual Studio Code explorer, open the **deployment.template.json** file in your IoT Edge solution workspace.

10. Since we changed the name of the endpoint that the module listens on, we also need to update the routes in the deployment manifest so that the *edgeHub* sends messages to the new endpoint.

    Find the **routes** section in the **$edgeHub** module twin. Update the **sensorTofiltermodule** route to replace `input1` with `inputFromSensor`:

    JSON

    ```
    "sensorTofiltermodule": "FROM
    /messages/modules/tempSensor/outputs/temperatureOutput INTO
    BrokeredEndpoint(\"/modules/filtermodule/inputs/inputFromSensor\")"
    ```

11. Add the **filtermodule** module twin to the deployment manifest. Insert the following JSON content at the bottom of the **modulesContent** section, after the **$edgeHub** module twin:

    JSON

    ```
        "filtermodule": {
            "properties.desired":{
                "TemperatureThreshold":25
            }
        }
    ```

12. Save the **deployment.template.json** file.

Build and push your solution

You've updated the module code and the deployment template to help understand some key deployment concepts. Now, you're ready to build your module container image and push it to your container registry.

Sign in to Docker

Provide your container registry credentials to Docker so that it can push your container image to storage in the registry.

1. Open the Visual Studio Code integrated terminal by selecting **Terminal** > **New Terminal**.

2. Sign in to Docker with the Azure Container Registry (ACR) credentials that you saved after creating the registry.

   Bash

   ```
   docker login -u <ACR username> -p <ACR password> <ACR login server>
   ```

   You may receive a security warning recommending the use of `--password-stdin`. While that's a recommended best practice for production scenarios, it's outside the scope of this tutorial. For more information, see the docker login reference.

3. Sign in to the Azure Container Registry. You may need to Install Azure CLI to use the `az` command. This command asks for your user name and password found in your container registry in **Settings** > **Access keys**.

   Azure CLI

   ```
   az acr login -n <ACR registry name>
   ```

> **Tip**
>
> If you get logged out at any point in this tutorial, repeat the Docker and Azure Container Registry sign in steps to continue.

Build and push

Visual Studio Code now has access to your container registry, so it's time to turn the solution code into a container image.

In Visual Studio Code, open the **deployment.template.json** deployment manifest file. The deployment manifest describes the modules to be configured on the targeted IoT Edge device. Before deployment, you need to update your Azure Container Registry credentials and your module images with the proper `createOptions` values. For more information about createOption values, see How to configure container create options for IoT Edge modules.

If you're using an Azure Container Registry to store your module image, add your credentials to the **modulesContent** > **edgeAgent** > **settings** > **registryCredentials** section in **deployment.template.json**. Replace **myacr** with your own registry name and provide your password and **Login server** address. For example:

JSON

```
"registryCredentials": {
    "myacr": {
        "username": "myacr",
        "password": "<your_acr_password>",
        "address": "myacr.azurecr.io"
    }
}
```

Add or replace the following stringified content to the *createOptions* value for each system (edgeHub and edgeAgent) and custom module (filtermodule and tempSensor) listed. Change the values if necessary.

JSON

```
"createOptions": "{\"HostConfig\":{\"PortBindings\":{\"5671/tcp\":
[{\"HostPort\":\"5671\"}],\"8883/tcp\":[{\"HostPort\":\"8883\"}],\"443/tcp\":
[{\"HostPort\":\"443\"}]}}}"
```

For example, the *filtermodule* configuration should be similar to:

JSON

```
"filtermodule": {
"version": "1.0",
"type": "docker",
"status": "running",
```

```
"restartPolicy": "always",
"settings": {
   "image": "myacr.azurecr.io/filtermodule:0.0.1-amd64",
   "createOptions": "{\"HostConfig\":{\"PortBindings\":{\"5671/tcp\":
[{\"HostPort\":\"5671\"}],\"8883/tcp\":[{\"HostPort\":\"8883\"}],\"443/tcp\":
[{\"HostPort\":\"443\"}]}}}"
}
```

Build module Docker image

Use the module's Dockerfile to build the module Docker image.

Bash

```
docker build --rm -f "<DockerFilePath>" -t <ImageNameAndTag> "<ContextPath>"
```

For example, to build the image for the local registry or an Azure container registry, use the following commands:

Bash

```
# Build the image for the local registry

docker build --rm -f "./modules/filtermodule/Dockerfile.amd64.debug" -t
localhost:5000/filtermodule:0.0.1-amd64 "./modules/filtermodule"

# Or build the image for an Azure Container Registry

docker build --rm -f "./modules/filtermodule/Dockerfile.amd64.debug" -t
myacr.azurecr.io/filtermodule:0.0.1-amd64 "./modules/filtermodule"
```

Push module Docker image

Push your module image to the local registry or a container registry.

Bash

```
docker push <ImageName>
```

For example:

Bash

```
# Push the Docker image to the local registry

docker push localhost:5000/filtermodule:0.0.1-amd64

# Or push the Docker image to an Azure Container Registry
az acr login --name myacr
docker push myacr.azurecr.io/filtermodule:0.0.1-amd64
```

Update the deployment template

Update the deployment template *deployment.template.json* with the container registry image location. For example, if you're using an Azure Container Registry *myacr.azurecr.io* and your image is *filtermodule:0.0.1-amd64*, update the *filtermodule* configuration to:

JSON

```
"filtermodule": {
    "version": "1.0",
    "type": "docker",
    "status": "running",
    "restartPolicy": "always",
    "settings": {
        "image": "myacr.azurecr.io/filtermodule:0.0.1-amd64",
        "createOptions": "{\"HostConfig\":{\"PortBindings\":{\"5671/tcp\":
[{\"HostPort\":\"5671\"}],\"8883/tcp\":[{\"HostPort\":\"8883\"}],\"443/tcp\":
[{\"HostPort\":\"443\"}]}}}"
    }
}
```

Update the build and image

If you make changes to your module code, you need to rebuild and push the module image to your container registry. Use the steps in this section to update the build and image. You can skip this section if you didn't make any changes to your module code.

1. Open the **module.json** file in the *filtermodule* folder.

2. Change the version number for the module image. For example, increment the patch version number to `"version": "0.0.2"` as if you made a small fix in the module code.

   > **Tip**

> Module versions enable version control, and allow you to test changes on a small set of devices before deploying updates to production. If you don't increment the module version before building and pushing, then you overwrite the repository in your container registry.

3. Save your changes to the **module.json** file.

Build and push the updated image with a *0.0.2* version tag.

For example, to build and push the image for the local registry or an Azure container registry, use the following commands:

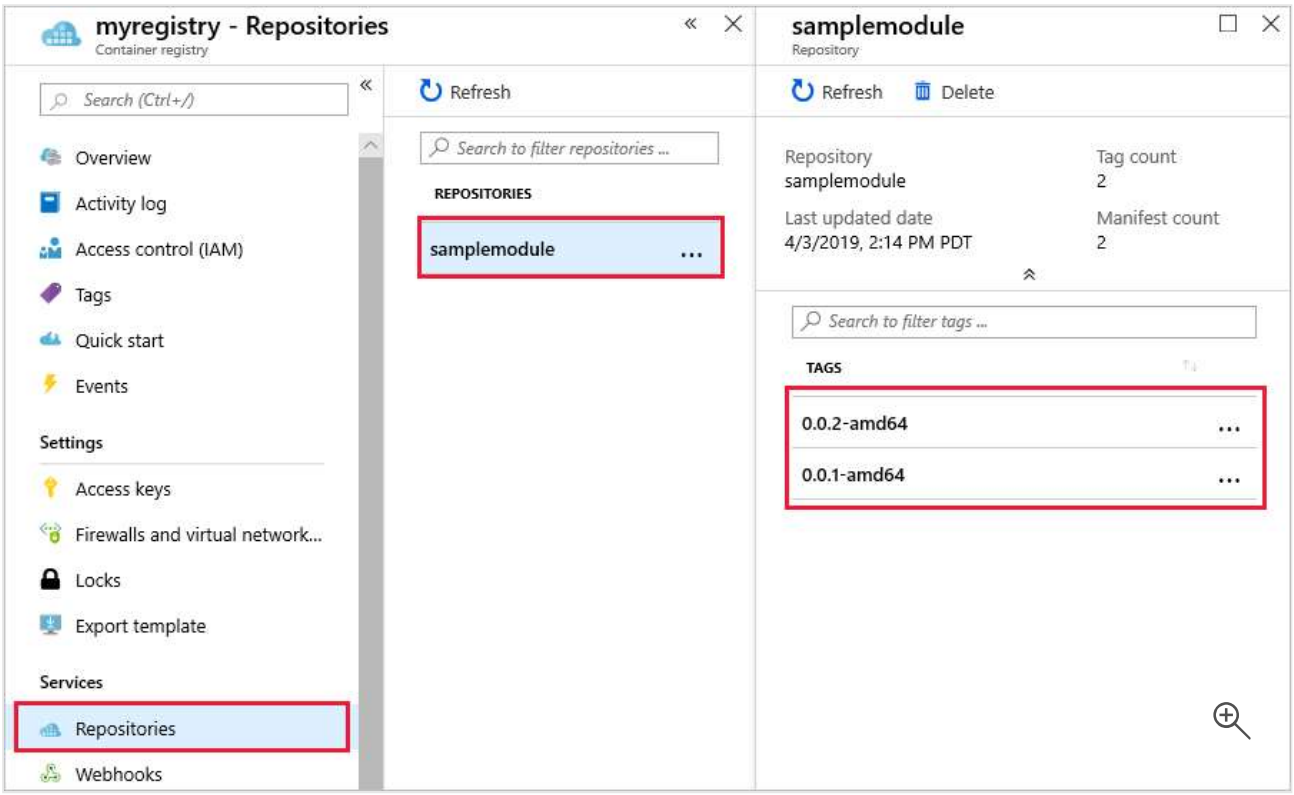
Bash

```
# Build and push the 0.0.2 image for the local registry

docker build --rm -f "./modules/filtermodule/Dockerfile.amd64.debug" -t
localhost:5000/filtermodule:0.0.2-amd64 "./modules/filtermodule"

docker push localhost:5000/filtermodule:0.0.2-amd64

# Or build and push the 0.0.2 image for an Azure Container Registry

docker build --rm -f "./modules/filtermodule/Dockerfile.amd64.debug" -t
myacr.azurecr.io/filtermodule:0.0.2-amd64 "./modules/filtermodule"

docker push myacr.azurecr.io/filtermodule:0.0.2-amd64
```

Open the **deployment.amd64.json** file again. Notice the build system doesn't create a new file when you run the build and push command again. Rather, the same file updates to reflect the changes. The *filtermodule* image now points to the 0.0.2 version of the container.

To further verify what the build and push command did, go to the Azure portal and navigate to your container registry.

In your container registry, select **Repositories** then **filtermodule**. Verify that both versions of the image push to the registry.



Troubleshoot

If you encounter errors when building and pushing your module image, it often has to do with Docker configuration on your development machine. Use the following checks to review your configuration:

- Did you run the `docker login` command using the credentials that you copied from your container registry? These credentials are different than the ones that you use to sign in to Azure.
- Is your container repository correct? Does it have your correct container registry name and your correct module name? Open the **module.json** file in the *filtermodule* folder to check. The repository value should look like **<registry name>.azurecr.io/filtermodule**.
- If you used a different name than **filtermodule** for your module, is that name consistent throughout the solution?
- Is your machine running the same type of containers that you're building? This tutorial is for Linux IoT Edge devices, so Visual Studio Code should say **amd64** or **arm32v7** in the side bar, and Docker Desktop should be running Linux containers.

Deploy modules to device

You verified that there are built container images stored in your container registry, so it's time to deploy them to a device. Make sure that your IoT Edge device is up and running.

Use the IoT Edge Azure CLI set-modules command to deploy the modules to the Azure IoT Hub. For example, to deploy the modules defined in the *deployment.template.json* file to IoT Hub *my-iot-hub* for the IoT Edge device *my-device*, use the following command. Replace the values for **hub-name**, **device-id**, and **login** IoT Hub connection string with your own.

Azure CLI

```
az iot edge set-modules --hub-name my-iot-hub --device-id my-device --content
./deployment.template.json --login "HostName=my-iot-hub.azure-
devices.net;SharedAccessKeyName=iothubowner;SharedAccessKey=<SharedAccessKey>"
```

Tip

You can find your IoT Hub connection string including the shared access key in the Azure portal. Go to your IoT Hub > **Security settings** > **Shared access policies** > **iothubowner**.

View changes on device

If you want to see what's happening on your device itself, use the commands in this section to inspect the IoT Edge runtime and modules running on your device.

The commands in this section are for your IoT Edge device, not your development machine. If you're using a virtual machine for your IoT Edge device, connect to it now. In Azure, go to the virtual machine's overview page and select **Connect** to access the secure shell connection.

- View all modules deployed to your device, and check their status:

  Bash

  ```
  iotedge list
  ```

  You should see four modules: the two IoT Edge runtime modules, *tempSensor*, and *filtermodule*. You should see all four listed as running.

- Inspect the logs for a specific module:

  ```
  Bash

  iotedge logs <module name>
  ```

  IoT Edge modules are case-sensitive.

  The *tempSensor* and *filtermodule* logs should show the messages they're processing. The edgeAgent module is responsible for starting the other modules, so its logs have information about implementing the deployment manifest. If you find a module is unlisted or not running, the edgeAgent logs likely have the errors. The edgeHub module is responsible for communications between the modules and IoT Hub. If the modules are up and running, but the messages aren't arriving at your IoT hub, the edgeHub logs likely have the errors.

Clean up resources

If you plan to continue to the next recommended article, you can keep the resources and configurations that you created and reuse them. You can also keep using the same IoT Edge device as a test device.

Otherwise, you can delete the local configurations and the Azure resources that you used in this article to avoid charges.

Delete Azure resources

Deleting Azure resources and resource groups is irreversible. Make sure that you don't accidentally delete the wrong resource group or resources. If you created the IoT hub inside an existing resource group that has resources that you want to keep, delete only the IoT hub resource itself, not the resource group.

To delete the resources:

1. Sign in to the Azure portal , and then select **Resource groups**.

2. Select the name of the resource group that contains your IoT Edge test resources.

3. Review the list of resources that are contained in your resource group. If you want to delete all of them, you can select **Delete resource group**. If you want to delete only

some of them, you can click into each resource to delete them individually.

Next steps

In this tutorial, you set up Visual Studio Code on your development machine and deployed your first IoT Edge module that contains code to filter raw data generated by your IoT Edge device.

You can continue on to the next tutorials to learn how Azure IoT Edge can help you deploy Azure cloud services to process and analyze data at the edge.

Debug Azure IoT Edge modules | Functions | Stream Analytics | Custom Vision Service