Tutorial: Machine Learning and IoT Edge – configure IoT Edge device

1 Configure IoT Edge device

1.1 Role

This step is typically performed by a cloud developer.

1.2 Introduction

In this section we will configure an Azure Virtual Machine running Linux as an Azure IoT Edge device. We will set up the edge device to act as a transparent gateway. The transparent gateway configuration allows devices to connect to that Azure IoT Hub through the gateway without being aware that the gateway exists. At the same time, a user interacting with the devices in IoT Hub is unaware of the intermediate gateway device. Ultimately, we will use the transparent gateway to add edge analytics to our system by adding edge modules to the gateway.

1.3 Generate certificates

For a device to function as a gateway it needs to be able to securely connect to downstream devices. Azure IoT Edge allows you to use a public key infrastructure (PKI) to set up secure connections between devices. In this case, we're allowing a downstream device to connect to an IoT Edge device acting as a transparent gateway. To maintain reasonable security, the downstream device should confirm the identity of the Edge device. A detailed explanation of certificate use in IoT Edge can be found in this document.

In this section, we create the self-signed certificates using a Docker image that we will build and run. We chose to use a Docker image to complete this step as it significantly reduced the number of steps needed to create the certificates on the Windows development machine. See Generate certificates with Window for the details on how to produce the certificates without using a container. Generate certificates with Linux has the set of instructions that we automated with the Docker image.

1. Login to your development machine
2. Create a directory on the VM. Open a command line and run the command

```
mkdir c:\edgecertificates
```

3. Start "Docker for Windows" from the Windows Start menu
4. Open Visual Studio Code
5. **File->Open Folder…** and choose "C:\source\IoTEdgeAndMlSample\CreateCertificates"
6. Right-click on the dockerfile and choose "Build Image"
7. In the dialog accept the default value for the image name and tag, "createcertificates:latest"
8. Wait for the build to complete

Note: You may see a warning for about a missing public key, it is safe to ignore this warning. Likewise, you will see a "SECURITY WARNING" that recommends you check/reset permissions on you image, which is safe to ignore for this image.

9. In the Visual Studio Code terminal window run the command:

```
docker run --name createcertificates --rm -v
c:\edgeCertificates:/edgeCertificates createcertificates
/edgeCertificates
```

10. Docker will prompt for access to the C:\ drive, click "Share it"

11. Provide your credentials when prompted
12. Once the container finishes running check for the files in c:\edgecertificates:

```
C:\edgeCertificates\certs\azure-iot-test-only.root.ca.cert.pem
C:\edgeCertificates\certs\new-edge-device-full-chain.cert.pem
C:\edgeCertificates\certs\new-edge-device.cert.pem
C:\edgeCertificates\certs\new-edge-device.cert.pfx
C:\edgeCertificates\private\new-edge-device.key.pem
```

1.4 Upload certificates to Azure Key Vault

To store our certificates securely and to make them accessible from multiple devices we will upload the certificates into Azure Key Vault. As you can see from the list above, we have 2 types of certificate files. We will treat the PFX[1] as Key Vault Certificates to be uploaded to Key Vault. The PEM[2] files are plain text and we will treat them as Key Vault Secrets. We will use the Key Vault associated with the Azure Machine Learning service workspace we created by running the Azure Notebooks.

1. Navigate to the Azure Portal (http://portal.azure.com) and find your Machine Learning service workspace
2. From the overview page of the Machine Learning service workspace copy the name of the Key Vault

3. On your development machine, open PowerShell run the command

```
C:\source\IoTEdgeAndMlSample\CreateCertificates\upload-keyvaultcerts.ps1
-SubscriptionId <subscriptionId> -KeyVaultName <keyvaultname>
```

4. Login to azure if you are prompted.

[1] Not necessary for completing the walk-through, but more information about PFX files can be found at: https://en.wikipedia.org/wiki/PKCS_12

[2] More information on PEM can be found in: https://en.wikipedia.org/wiki/Privacy-Enhanced_Mail

5. The script will run for few minutes with output like

```
Uploading azure-iot-test-only.root.ca.cert.pem...
Uploading new-edge-device-full-chain.cert.pem...
Uploading new-edge-device.cert.pem...
Uploading new-edge-device.cert.pfx...
Uploading new-edge-device.key.pem...
Results:

Certificate                         KeyVaultName                    KeyVaultId
-----------                         ------------                    ----------
azure-iot-test-only.root.ca.cert.pem azure-iot-test-only-root-ca-cert-pem https://turbofankeyvaultcohjpfkx.vault.azure.net:443/secrets/azure-iot-test-only-root-ca-cert-pem/30cf4704ed824153b5aa5e5e4421b3a7
new-edge-device-full-chain.cert.pem new-edge-device-full-chain-cert-pem https://turbofankeyvaultcohjpfkx.vault.azure.net:443/secrets/new-edge-device-full-chain-cert-pem/24ae146d3c6e4c86b205d7609eeed475
new-edge-device.cert.pem            new-edge-device-cert-pem            https://turbofankeyvaultcohjpfkx.vault.azure.net:443/secrets/new-edge-device-cert-pem/5aeef731b8be495d8413cbbab9905dec
new-edge-device.cert.pfx            new-edge-device-cert-pfx            https://turbofankeyvaultcohjpfkx.vault.azure.net:443/certificates/new-edge-device-cert-pfx/52cb05478055480287aa0e9a8bf82273
new-edge-device.key.pem             new-edge-device-key-pem             https://turbofankeyvaultcohjpfkx.vault.azure.net:443/secrets/new-edge-device-key-pem/ad2fefb703544103bb3e1fa688f78e61
```

1.5 Create Azure IoT Hub Edge device

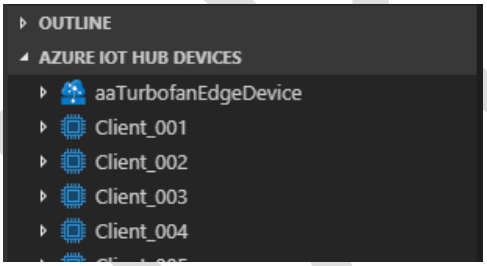
To connect an Azure IoT Edge device to an IoT Hub, we first create a representation of the edge device in the hub. We take the connection string from the hub device representation and use it to configure the runtime on our edge device. Once the edge device has been configured and connects to the hub, we are able to deploy modules and send messages. We can also change the configuration of the edge device by changing the configuration of the corresponding device representation in IoT hub.

You can create an Azure IoT Edge device in the hub in multiple ways including creating using the Azure Portal, using Azure CLI, or, as we do here using Visual Studio Code.

1. On your development machine open Visual Studio Code
2. Open the "AZURE IOT HUB DEVICES" panel from the Visual Studio Code explorer view
3. Click on the ellipsis and choose "Create IoT Edge Device"

4. Give the device a name. For convenience, we use "aaTurbofanEdgeDevice" so it sorts ahead of all of the Client_nnn dervices we created earlier through the device harness to send the test data.

5. The new device will appear in the devices view



1.6 Deploy Azure VM

We use the Azure IoT Edge on Ubuntu image from the Azure Marketplace to create our edge device for this walk-through. The *Azure IoT Edge on Ubuntu* image installs the latest Azure IoT Edge runtime and its dependencies on startup[3]. We will deploy the VM using a PowerShell script, Create-EdgeVM.ps1; an ARM template, IoTEdgeVMTemplate.json; and a shell script, install packages.sh.

1.6.1 Enable programmatic deployment

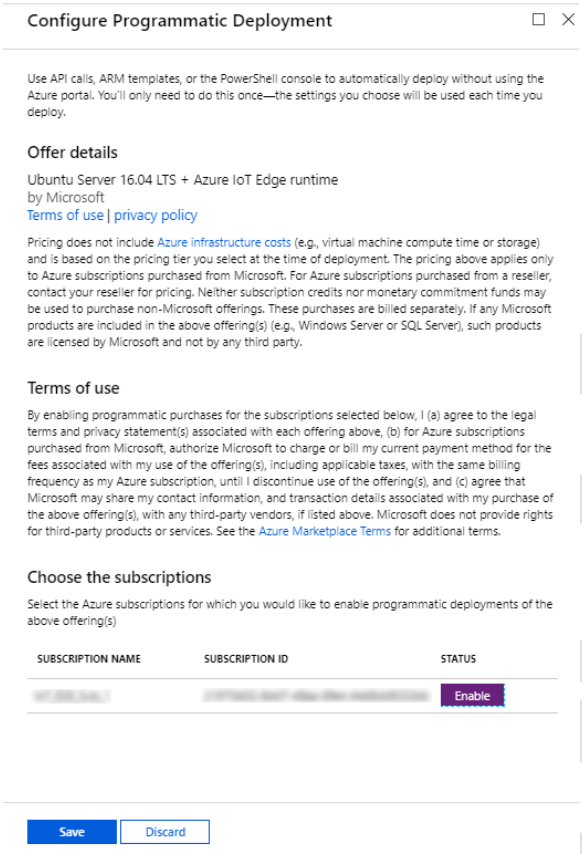
To use the image from the marketplace in a scripted deployment we need to enable programmatic deployment for the image. To do that:

1. Login to http://portal.azure.com
2. From the left navigator click on "All services"
3. Type "marketplace" into the filter and then click on "Marketplace"

[3] See Install the Azure IoT Edge runtime on Linux (x64) for detailed installation steps

4. Type “Azure IoT Edge” into the “Search Everything” box and hit enter
5. Click on “Ubuntu Server 16.04 LTS + Azure IoT Edge runtime”

6. Click the hyperlink “Want to deploy programmatically? Get started ->” below the “Create” button
7. Click on the “Enable” button in the “Configure Programmatic Deployment” page then click “Save”



8. You will see a success notification.

1.6.2 Create virtual machine

Next run the script to create the edge device virtual machine.

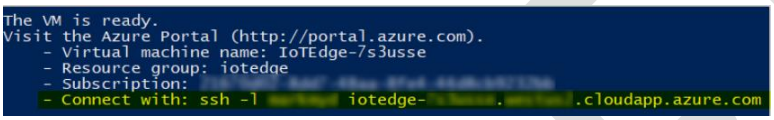
1. Open a PowerShell window and navigate to C:\source\IoTEdgeAndMlSample\EdgeVM”
2. Type the command:

```
.\Create-EdgeVm.ps1
```

3. When prompted provide values for each parameter. For subscription, resource group and location we recommend you use the same as you have for all resources throughout the walk-through
    a. Azure Subscription ID: found in the Azure Portal
    b. Resource Group Name: memorable name for grouping the resources for your walk-through
    c. Location: Azure location where the virtual machine will be created (e.g. West US 2, North Europe, see full list)

d. AdminUsername: the name for the admin account you want to create and use on the virtual machine
e. AdminPassword: the password to set for the AdminUsername on the VM

4. For the script to be able to set up the VM, you need to login to Azure with the credentials associated with the Azure Subscription you are using
5. The script confirms the information for the creation of your VM. Press 'y' or 'Enter' to continue
6. The script will run for several minutes as it executes the steps:
   - Create the Resource Group if it does not exist
   - Deploy the virtual machine
   - Add NSG exceptions for the VM for ports 22 (SSH), 5671 (AMQP), 5672 (AMPQ), and 443 (SSL)
   - Install the Azure CLI (details)
7. Note the script outputs the SSH connection string for connecting to the VM, copy this for the next step



1.7 Connect to the VM using SSH

The next several steps will be configuring the Azure VM we just created. The first step is to get connected to the virtual machine.

1. Open a command shell and paste the SSH connection string you copied from the script output

```
ssh -l <username> iotedge-<suffix>.<region>.cloudapp.azure.com
```

2. You will be prompted to validate the authenticity of the host, type "yes" and hit enter.

3. When prompted provide your password
4. Ubuntu will display a welcome message and then you should see a prompt like <username>@<machinename>:~$

1.8 Download Key Vault certificates

We uploaded the certificates to Key Vault to make them available for our edge device and our leaf device, which is a downstream device that uses the edge device as a gateway to communicate with IoT Hub. We will deal with the leaf device later in the walkthrough. In this step, we will download the certificates to the edge device.

1. From the SSH session on the Linux VM type:

```
az login
```

2. You will be prompted to open a browser to https://microsoft.com/devicelogin and provide a unique code

3. Open a browser on your local machine and navigate to the given location and type in the code CM

4. Hit continue and proceed through the login process for Azure
5. When you complete the login, the remote VM will login and list your Azure subscriptions
6. At the SSH prompt type

```
az account set --subscription <subscription id>
```

7. Create a directory on the VM for the certificates

```
sudo mkdir /edgeMlCertificates
```

8. Download new-edge-device-full-chain.cert.pem, new-edge-device.key.pem and azure-iot-test-only.root.ca.cert.pem

```
key_vault_name="<key vault name>"

sudo az keyvault secret download --vault-name $key_vault_name  --name
new-edge-device-full-chain-cert-pem -f /edgeMlCertificates/new-edge-
device-full-chain.cert.pem
sudo az keyvault secret download --vault-name $key_vault_name  --name
new-edge-device-key-pem -f /edgeMlCertificates/new-edge-device.key.pem
sudo az keyvault secret download --vault-name $key_vault_name  --name
azure-iot-test-only-root-ca-cert-pem -f /edgeMlCertificates/azure-iot-
test-only.root.ca.cert.pem
```

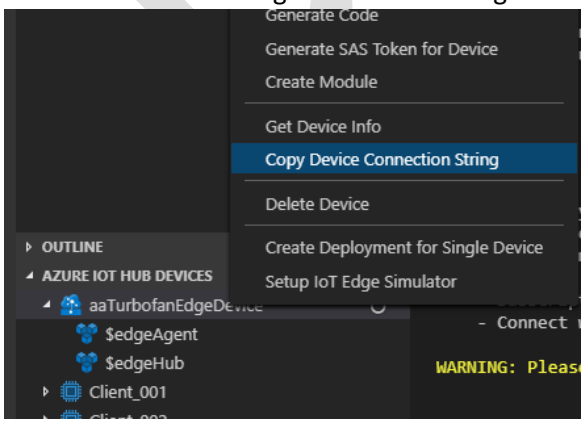
1.9 Update the edge device configuration

The Edge runtime uses the file /etc/iotedge/config.yaml to persist its configuration. We need to update 3 pieces of information in this file:

1. **Device connection string**: the device connection string for this device needs to be set to the value of the connection string for the device we created in the hub
2. **Certificates:** the edge runtime needs to be told which certificates it should use for connections made with downstream devices
3. **Hostname:** the hostname needs to exactly match the fully qualified domain name (FQDN) of the VM edge device.

The *Ubuntu Server 16.04 LTS + Azure IoT Edge runtime* image that we used to create the Edge VM comes with a shell script that updates the config.yaml with the connection string.

1. In Visual Studio Code right-click on the edge device then click “Copy Device Connection String”



2. In your SSH session run the command

```
sudo /etc/iotedge/configedge.sh
"<your_iothub_edge_device_connection_string>"
```

Next we will update the certificates and hostname by directly editing the config.yaml.

1. Open config.yaml with the command

```
sudo nano /etc/iotedge/config.yaml
```

2. Update the certificates section of the config.yaml by removing the leading # and setting the path so this (right-click in the Linux terminal to paste copied text):

```
# certificates:
#   device_ca_cert: "<ADD PATH TO DEVICE CA CERTIFICATE HERE>"
#   device_ca_pk: "<ADD PATH TO DEVICE CA PRIVATE KEY HERE>"
#   trusted_ca_certs: "<ADD PATH TO TRUSTED CA CERTIFICATES HERE>"
```

Becomes:

```
certificates:
  device_ca_cert: "/edgeMlCertificates/new-edge-device-full-
chain.cert.pem"
  device_ca_pk: "/edgeMlCertificates/new-edge-device.key.pem"
  trusted_ca_certs: "/edgeMlCertificates/azure-iot-test-
only.root.ca.cert.pem"
```

Note: it is important to make sure the “certificates:” has no preceding whitespace and that each of the certificates is preceded by 2 spaces.

Note: right clicking in nano will paste the contents of your clipboard to the current cursor position. So replace the string use your keyboard arrows to navigate to the string you want to replace, delete the string, then right-click to paste from the buffer.

3. Find your Edge virtual machine in the Azure Portal on the 'Overview' page copy the DNS name (FQDN of the machine)
4. Paste the FQDN into the hostname section of the config.yml. Make sure that the name is all lowercase:

```
hostname: '<machinename>.<region>.cloudapp.azure.com'
```

5. Save and close the file (Ctrl+X, Y, Enter)
6. Restart the iotedge daemon:

```
sudo systemctl restart iotedge
```

7. Check the status of the IoT Edge Daemon (after the command, type “:q” to exit)

```
systemctl status iotedge
```

8. If you see errors (colored text prefixed with “[ERROR]”) in the status Examine daemon logs for detailed error information

```
journalctl -u iotedge --no-pager --no-full
```

1.10 Disable process identification

While in preview, Azure Machine Learning does not support the process identification security feature enabled by default with IoT Edge. Below are the steps to disable it. This is, however, not suitable for use in production.

1. On your edge device vm get the ipaddress for the docker0 interface and note the inet ipaddress

```
ifconfig docker0
```

2. Open config.yaml for editing:

```
sudo nano /etc/iotedge/config.yaml
```

3. Update the connect section, for example if you docker0 ip is 172.17.0.1:

```
connect:
  management_uri: "http://172.17.0.1:15580"
  workload_uri: "http://172.17.0.1:15581"
```

4. Enter the same addresses in the listen section of the configuration. For example:

```
listen:
  management_uri: "http://172.17.0.1:15580"
  workload_uri: "http://172.17.0.1:15581
```

5. Save and exit the config.yaml file (CTRL+X,Y,ENTER)
6. Create an environment variable IOTEDGE_HOST with the management_uri address

```
export IOTEDGE_HOST="http://172.17.0.1:15580"
```

7. To make it persistent open /etc/environment:

```
sudo nano /etc/environment
```

8. Add to the end of the file:

```
IOTEDGE_HOST="http://172.17.0.1:15580"
```

9. Save and exit the environment file (CTRL+X,Y,ENTER)
10. Restart the iotedge daemon:

```
sudo systemctl restart iotedge
```

11. Check the status of the IoT Edge Daemon

```
systemctl status iotedge
```

1.11 Summary

We just completed configuring an Azure VM as Azure IoT Edge Transparent Gateway. We started by generating test certificates, which we uploaded to Azure Key Vault. Next, we used a script and ARM template to deploy the VM with the "Ubuntu Server 16.04 LTS + Azure IoT Edge runtime" image from the Azure marketplace. The script took the extra step of installing the Azure CLI (Install Azure CLI with apt). With the VM up and running we connected via SSH, logged into azure, downloaded certificates from Key Vault, and made several updates to the configuration of the IoT Edge Runtime by updating the config.yaml file. For more information about using IoT Edge as a gateway see How an IoT Edge device can be used as a gateway. For more details on how to configure an IoT Edge device as a transparent gateway see Configure an IoT Edge device to act as a transparent gateway.