Temperature Alert applying Spike-Dip Anomaly Detection Algorithm using Spark (Python-Scala) and C#

-Azure Function, Azure Databricks, IoT Hub

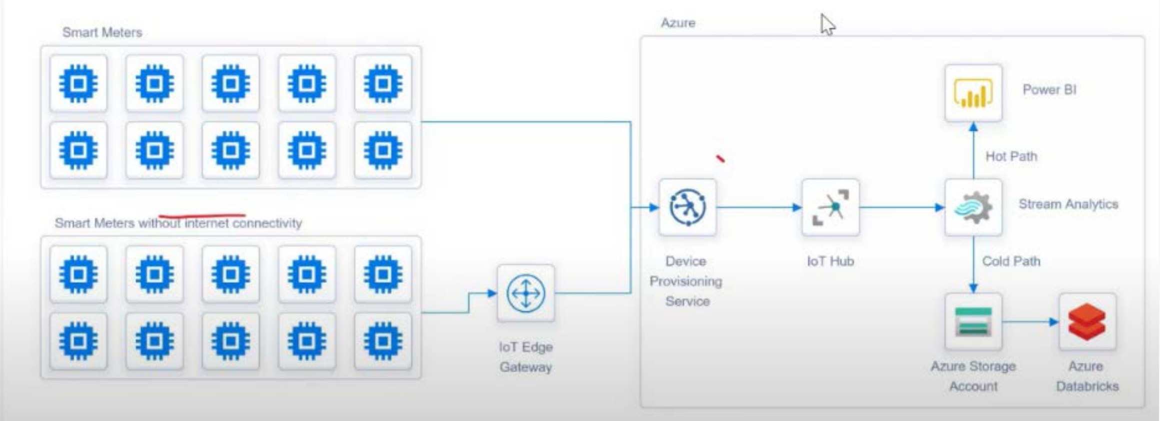
➢ Problem Statement -

I like visiting new places, which landed me to a food factory where cooking and preserving of food is done, having words with chef and co-workers, I realized they have to check temperature manually which is ineffective task. So, I thought to solve this problem, hence came up with idea of temperature alert, which sends mail whenever temperature is more or less than what is required.

➢ Technologies/Services used –

1. Spark (Scala-Python), C#
2. Power BI
3. IoT Edge Gateway
4. IoT Hub
5. Stream Analytics
6. Azure Databricks
7. Azure Function
8. Device Provisioning Service

➢ Solution Architecture -



IoT device provisioning flow is as follows:

1. Device manufacturer adds device registration information to enrollment list in Azure portal.

2. Device passes, identifying information to DPS to prove its identity.

3. DPS validates identity of device by validating registration ID and key against enrollment list entry.

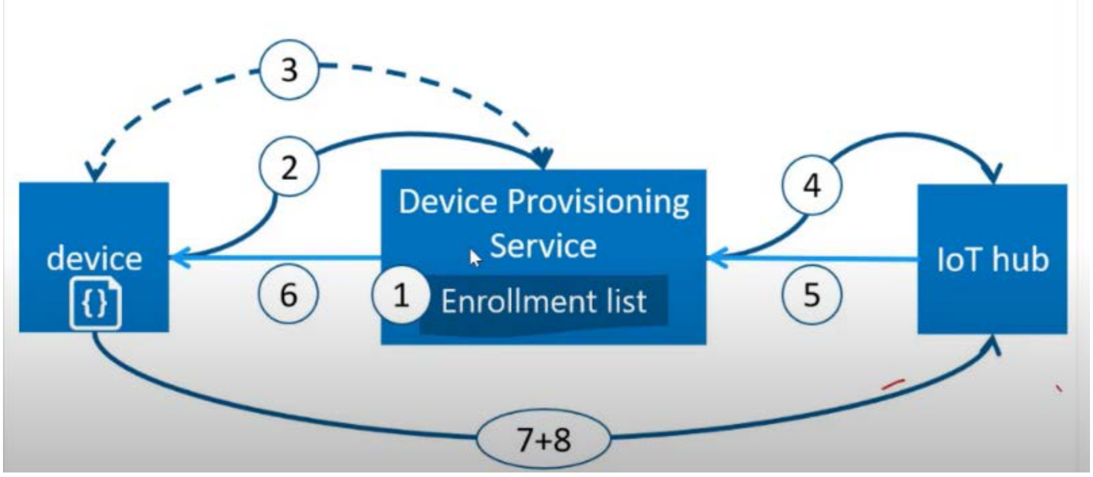
4. DPS registers device with IoT hub and populates device's desired twin state.

5. loT hub returns device ID information to DPS.

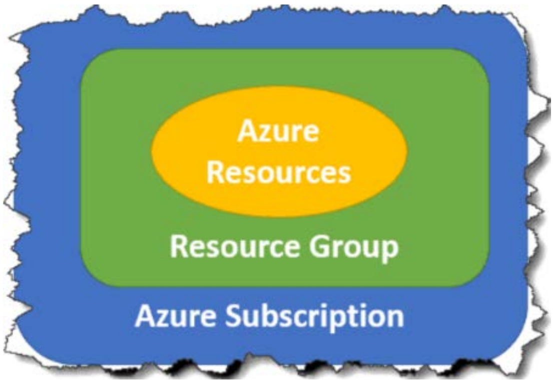
6. DPS returns loT hub connection information to device and start sending data directly to loT hub.

7. Device gets desired state from its device twin in IoT hub

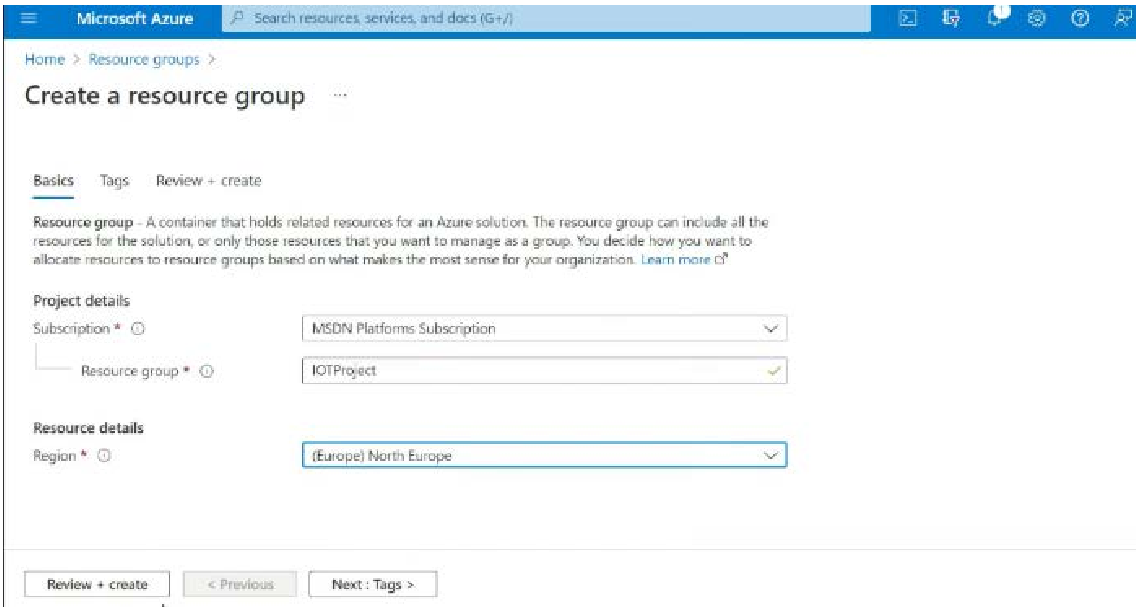
8. Device is connected.



A Resource Group is logical container where you are creating your **Azure resources**. It is created in specific region and contain resources created in other regions.



- ❖ Creation of resource group:



Create a resource group

Resource group - A container that holds related resources for an Azure solution. The resource group can include all the resources for the solution, or only those resources that you want to manage as a group. You decide how you want to allocate resources to resource groups based on what makes the most sense for your organization. Learn more

Project details

Subscription * : MSDN Platforms Subscription

Resource group * : IOTProject

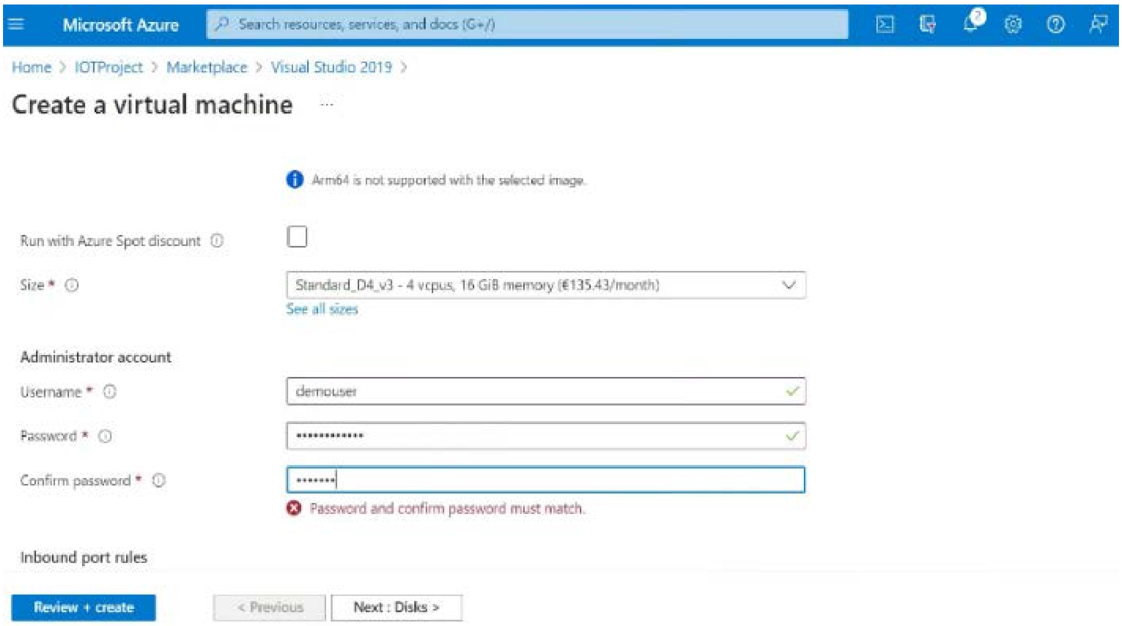
Resource details

Region * : (Europe) North Europe

In resource group create **VM instance**.

You might be wondering what is **VM instance**? So, let’s have a brief look upon it.

A virtual machine (VM) is a digital version of physical computer. It executes all tasks a physical computer can, including running operating systems and applications and are scalable, on-demand computing resources.



Microsoft Azure

Home > IOTProject > Marketplace > Visual Studio 2019 >

Create a virtual machine

ⓘ Arm64 is not supported with the selected image.

Run with Azure Spot discount ⓘ □

Size * ⓘ Standard_D4_v3 - 4 vcpus, 16 GiB memory (€135.43/month)

See all sizes

Administrator account

Username * ⓘ demouser

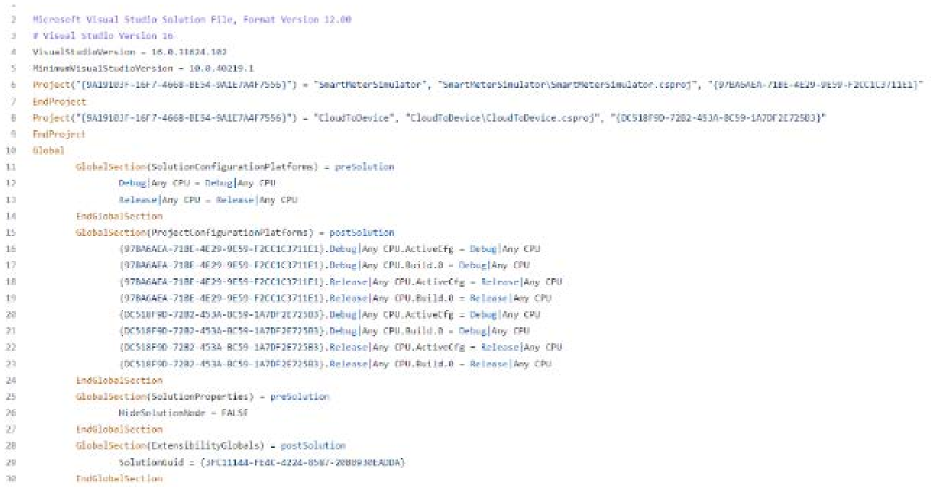
Password * ⓘ •••••••••••••

Confirm password * ⓘ •••••••

Password and confirm password must match.

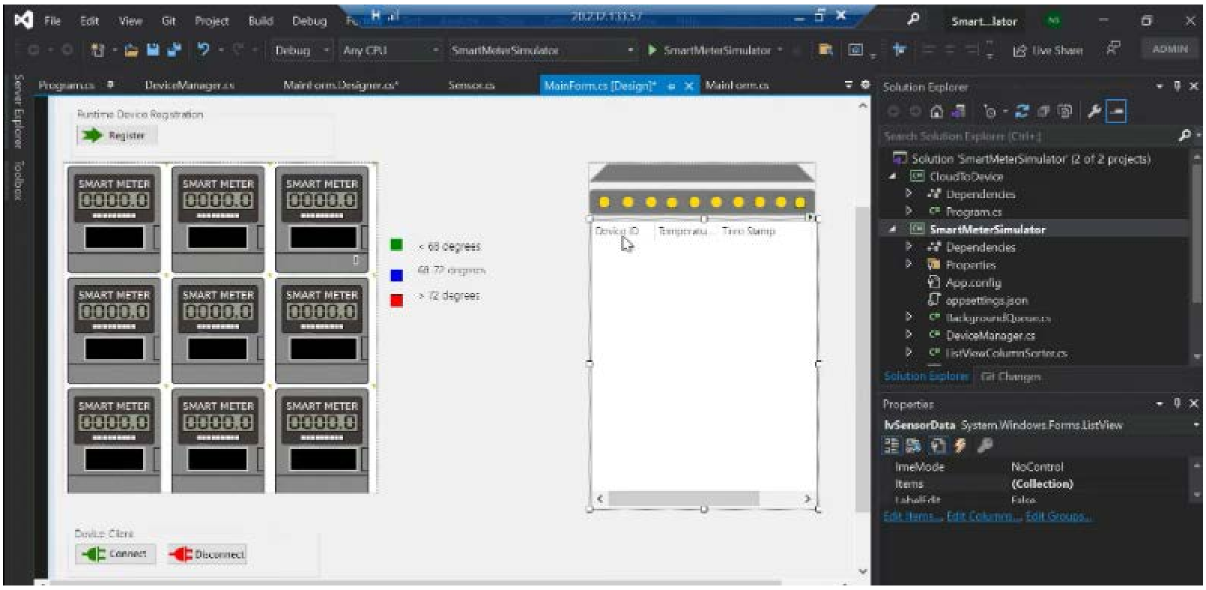
Inbound port rules

After VM is created, start -> run this:



```
Microsoft Visual Studio Solution File, Format Version 12.00
# Visual Studio Version 16
VisualStudioVersion = 16.0.31624.102
MinimumVisualStudioVersion = 10.0.40219.1
Project("{9A19103F-16F7-4668-BE54-9A1E7A4F7556}") = "SmartMeterSimulator", "SmartMeterSimulator\SmartMeterSimulator.csproj", "{97BA6AEA-718E-4E29-9E59-F2CC1C3711E1}"
EndProject
Project("{9A19103F-16F7-4668-BE54-9A1E7A4F7556}") = "CloudToDevice", "CloudToDevice\CloudToDevice.csproj", "{DC518F9D-7282-453A-8C59-1A7DF2E72583}"
EndProject
Global
	GlobalSection(SolutionConfigurationPlatforms) = preSolution
		Debug|Any CPU = Debug|Any CPU
		Release|Any CPU = Release|Any CPU
	EndGlobalSection
	GlobalSection(ProjectConfigurationPlatforms) = postSolution
		{97BA6AEA-718E-4E29-9E59-F2CC1C3711E1}.Debug|Any CPU.ActiveCfg = Debug|Any CPU
		{97BA6AEA-718E-4E29-9E59-F2CC1C3711E1}.Debug|Any CPU.Build.0 = Debug|Any CPU
		{97BA6AEA-718E-4E29-9E59-F2CC1C3711E1}.Release|Any CPU.ActiveCfg = Release|Any CPU
		{97BA6AEA-718E-4E29-9E59-F2CC1C3711E1}.Release|Any CPU.Build.0 = Release|Any CPU
		{DC518F9D-7282-453A-8C59-1A7DF2E72583}.Debug|Any CPU.ActiveCfg = Debug|Any CPU
		{DC518F9D-7282-453A-8C59-1A7DF2E72583}.Debug|Any CPU.Build.0 = Debug|Any CPU
		{DC518F9D-7282-453A-8C59-1A7DF2E72583}.Release|Any CPU.ActiveCfg = Release|Any CPU
		{DC518F9D-7282-453A-8C59-1A7DF2E72583}.Release|Any CPU.Build.0 = Release|Any CPU
	EndGlobalSection
	GlobalSection(SolutionProperties) = preSolution
		HideSolutionNode = FALSE
	EndGlobalSection
	GlobalSection(ExtensibilityGlobals) = postSolution
		SolutionGuid = {3FC11144-FEDC-4224-8587-2088930EAUDA}
	EndGlobalSection
```

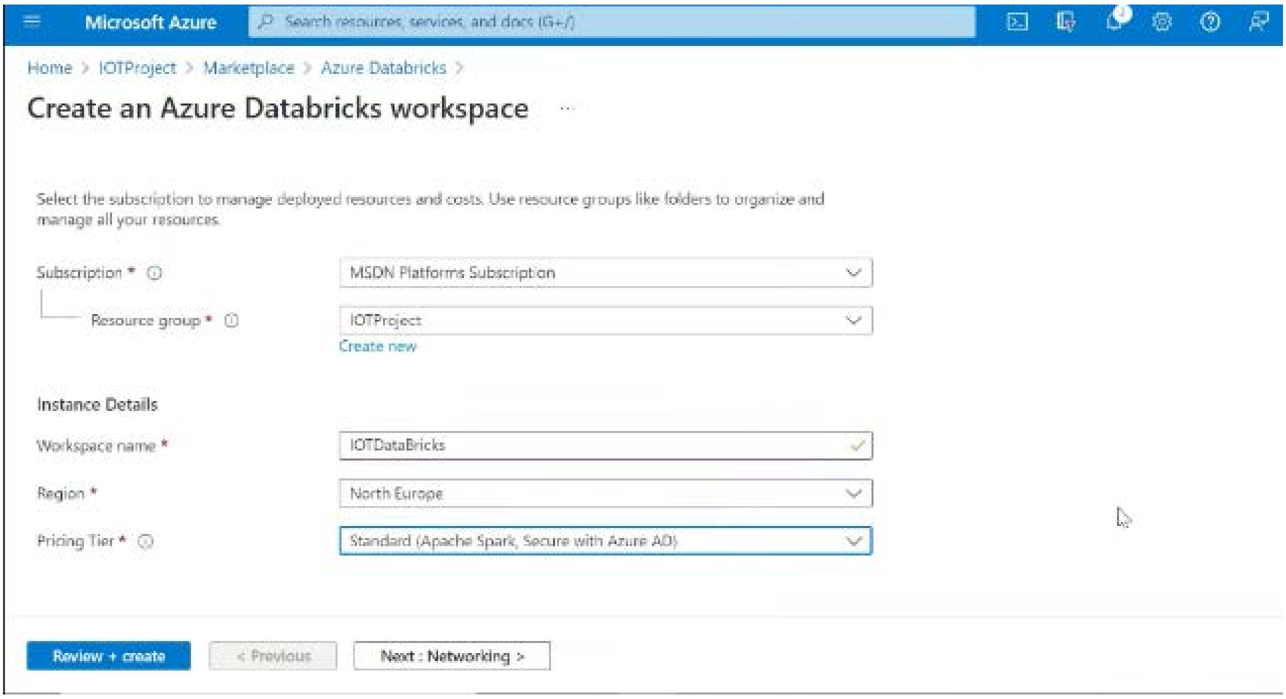
Display will look like:



❖ It’s time to learn **Azure Databricks**.

Azure Databricks is data analytics platform optimized for Azure cloud services platform. It offers three environments:

- Databricks SQL
- Databricks data science and engineering
- Databricks ML


Microsoft Azure
Search resources, services, and docs (G+/)
Home > IOTProject > Marketplace > Azure Databricks >

Create an Azure Databricks workspace

Select the subscription to manage deployed resources and costs. Use resource groups like folders to organize and manage all your resources.

Subscription * MSDN Platforms Subscription

Resource group * IOTProject

Create new

Instance Details

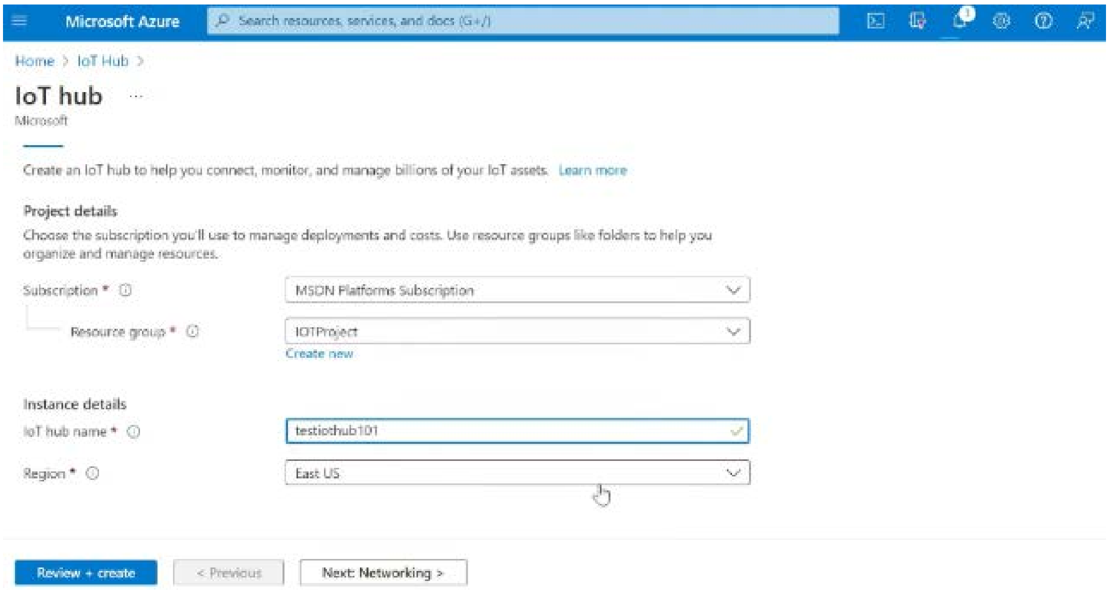
Workspace name * IOTDataBricks

Region * North Europe

Pricing Tier * Standard (Apache Spark, Secure with Azure AD)

- ❖ Creation of IOT hub. Before this let’s have a theoretical knowledge of this:

Azure IoT hub allows full-featured, scalable IoT solutions. Virtually, any device can be connected to Azure IoT Hub and scale up to millions of devices. Events can be tracked, monitored, such as creation, failure, and connection of devices.



IoT hub

Microsoft

Create an IoT hub to help you connect, monitor, and manage billions of your IoT assets. Learn more

Project details

Choose the subscription you'll use to manage deployments and costs. Use resource groups like folders to help you organize and manage resources.

Subscription * MSDN Platforms Subscription

Resource group * IOTProject

Create new

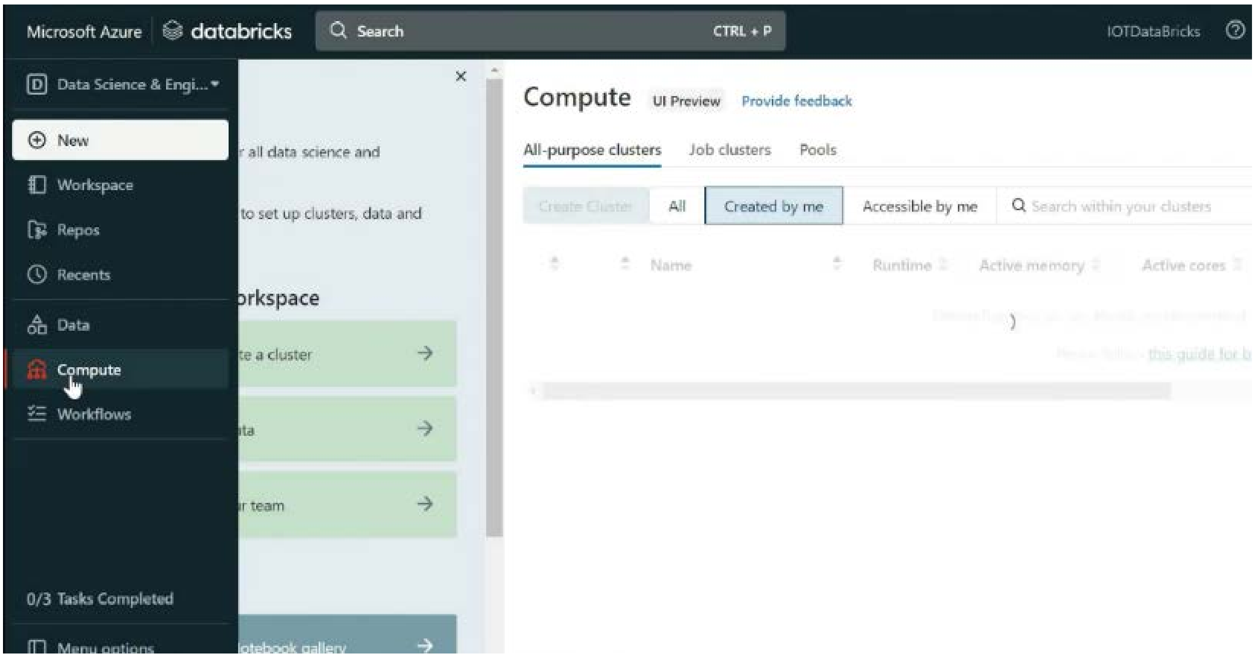
Instance details

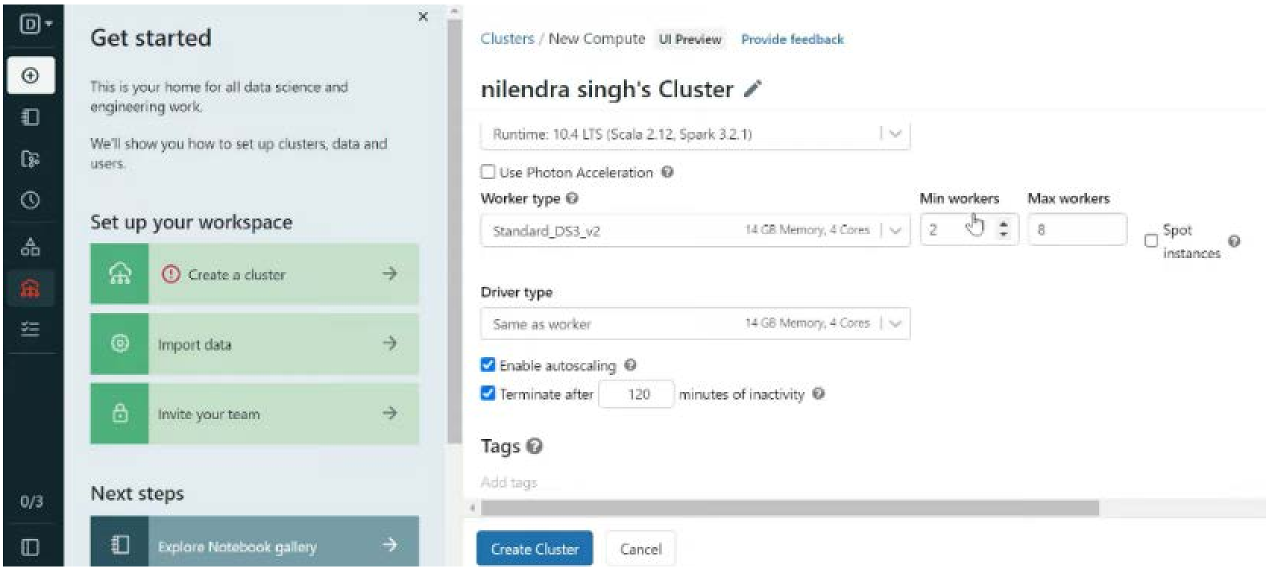
IoT hub name * testiothub101

Region * East US

- ❖ Let’s create a **cluster in databricks**.

The Azure Databricks job scheduler creates job cluster when you run a job on new job cluster and terminates cluster when job is complete.
Databricks -> compute





nilendra singh's Cluster

Runtime: 10.4 LTS (Scala 2.12, Spark 3.2.1)

□ Use Photon Acceleration

Worker type: Standard_DS3_v2 — 14 GB Memory, 4 Cores

Min workers: 2

Max workers: 8

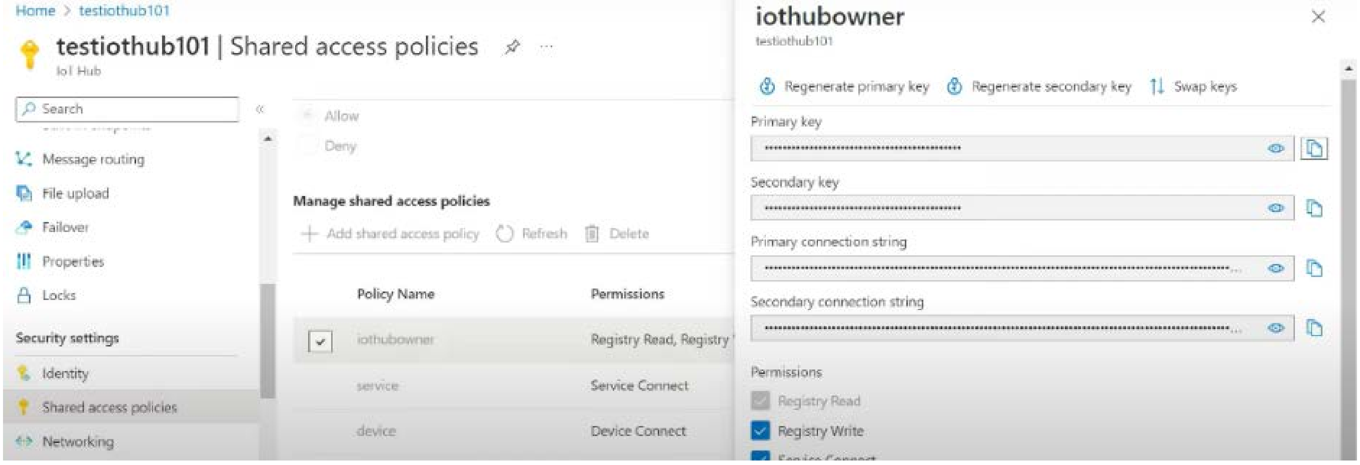
□ Spot instances

Driver type: Same as worker — 14 GB Memory, 4 Cores

☑ Enable autoscaling

☑ Terminate after 120 minutes of inactivity

❖ Click **IOT hub** -> shared access policies.



Policy Name	Permissions
iothubowner	Registry Read, Registry
service	Service Connect
device	Device Connect

Permissions

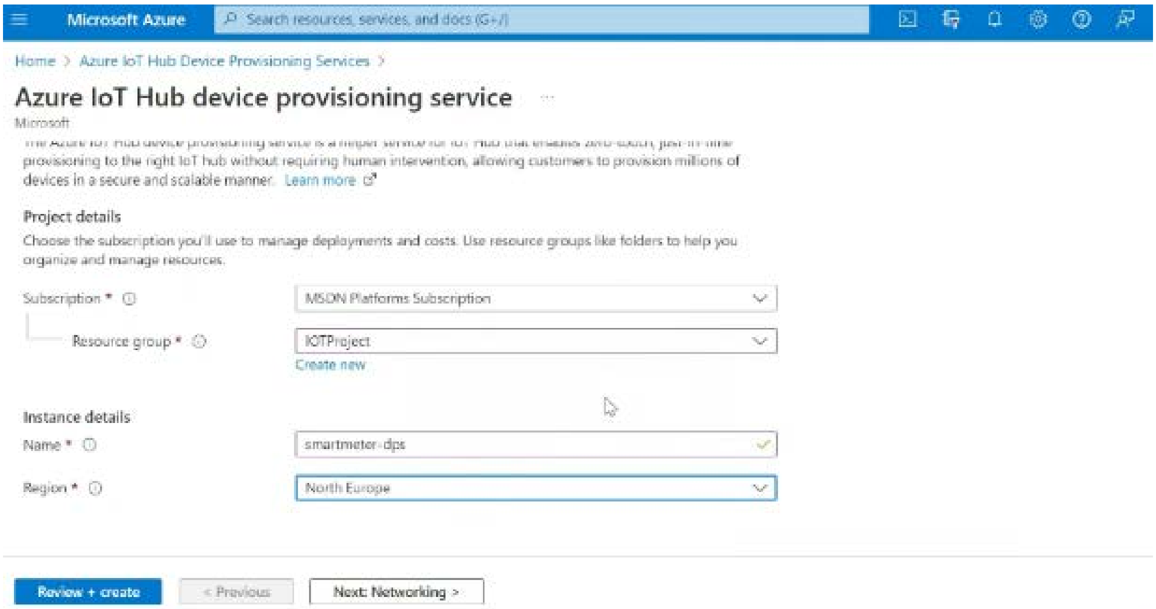
☑ Registry Read

☑ Registry Write

☑ Service Connect

copy primary key. (Keep key safely)

- Go to "**azure IOT hub device provisioning service**" **(DPS). DPS** is helper service for IoT Hub that enables zero-touch, just-in-time provisioning to right IoT hub without requiring human intervention, allowing customers to provision millions of devices in secure and scalable manner.



Home > Azure IoT Hub Device Provisioning Services >

Azure IoT Hub device provisioning service ...

Microsoft

The Azure IoT Hub device provisioning service is a helper service for IoT Hub that enables zero-touch, just-in-time provisioning to the right IoT hub without requiring human intervention, allowing customers to provision millions of devices in a secure and scalable manner. Learn more

Project details

Choose the subscription you'll use to manage deployments and costs. Use resource groups like folders to help you organize and manage resources.

Subscription * : MSDN Platforms Subscription

Resource group * : IOTProject

Create new

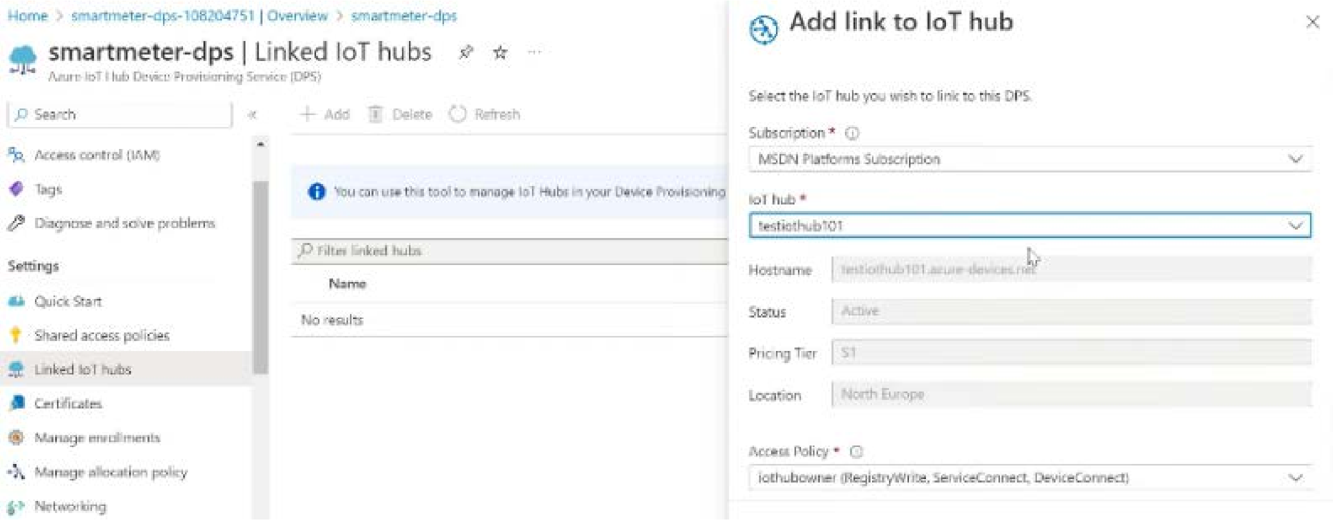
Instance details

Name * : smartmeter-dps

Region * : North Europe

copy ID scope (used further).

- To register IOT hub with DPS service follow these steps:
  IOT hub device service -> Linked IOT hubs -> Add.



Home > smartmeter-dps-108204751 | Overview > smartmeter-dps

smartmeter-dps | Linked IoT hubs

Azure IoT Hub Device Provisioning Service (DPS)

You can use this tool to manage IoT Hubs in your Device Provisioning

Name
No results

Add link to IoT hub

Select the IoT hub you wish to link to this DPS.

Subscription * : MSDN Platforms Subscription

IoT hub * : testiothub101

Hostname : testiothub101.azure-devices.net

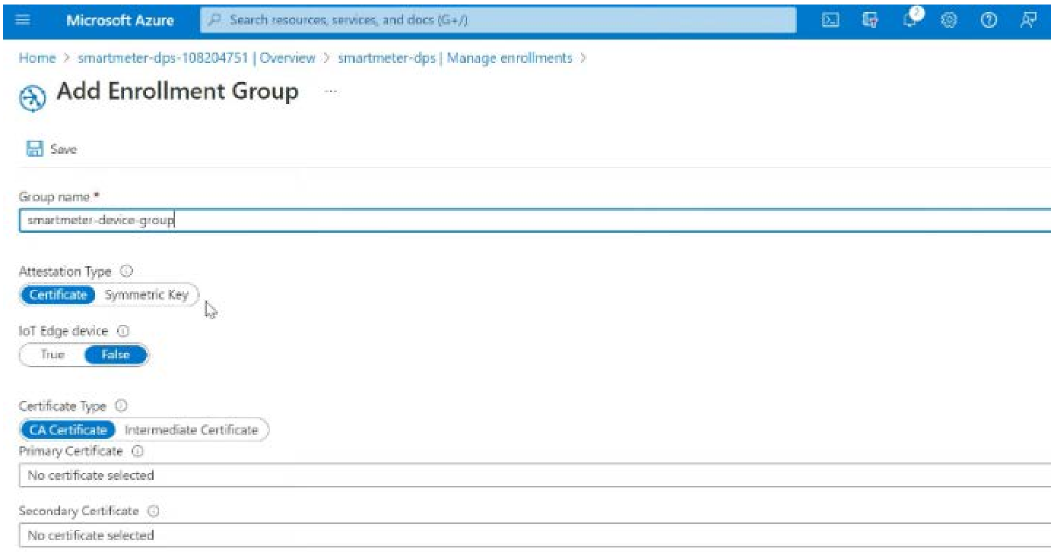
Status : Active

Pricing Tier : S1

Location : North Europe

Access Policy * : iothubowner (RegistryWrite, ServiceConnect, DeviceConnect)

- We need to create enrollment group:



Home > smartmeter-dps-108204751 | Overview > smartmeter-dps | Manage enrollments >

Add Enrollment Group

Save

Group name *: smartmeter-device-group

Attestation Type: [✓ Certificate] Symmetric Key

IoT Edge device: True [✓ False]

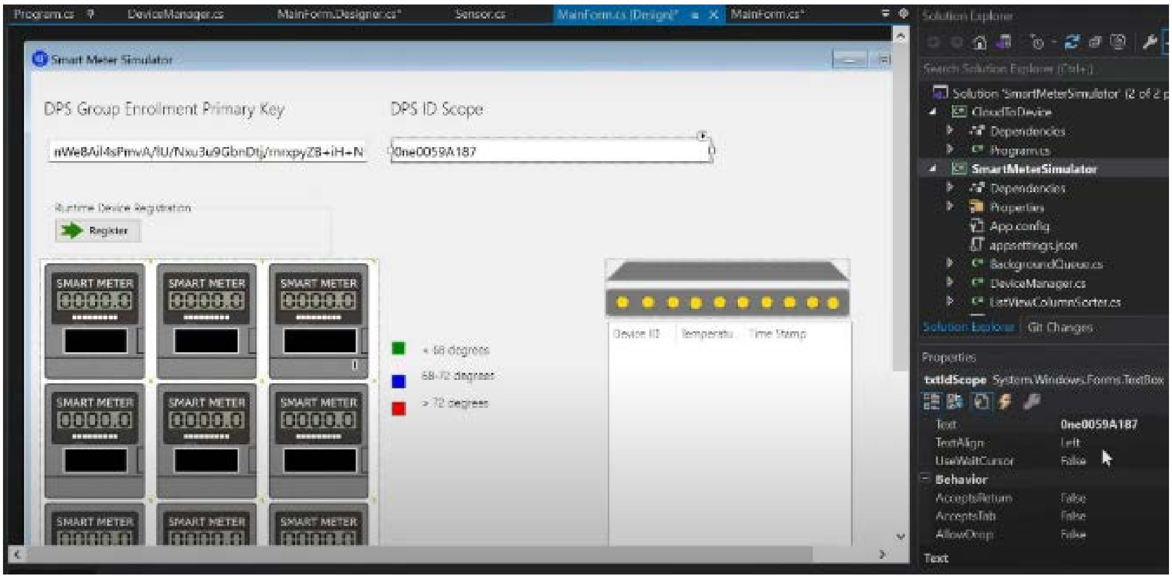
Certificate Type: [✓ CA Certificate] Intermediate Certificate

Primary Certificate: No certificate selected

Secondary Certificate: No certificate selected

copy the primary key (used further).

- ❖ Configure DSP ID scope and DSP Group Enrollment Primary Key (already copied).



Smart Meter Simulator

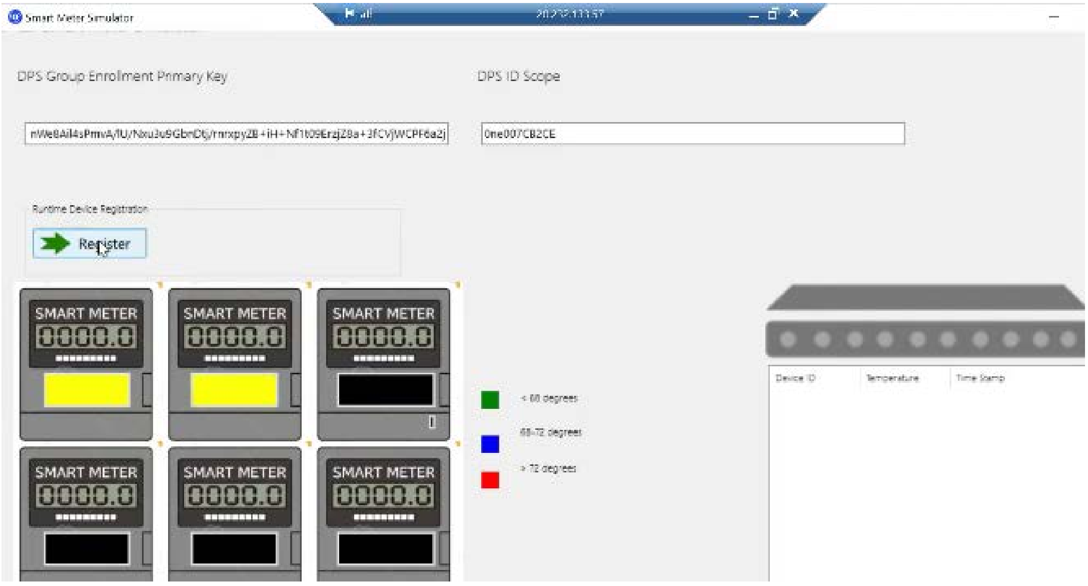
DPS Group Enrollment Primary Key: nWeBAil4sPmvA/lU/Nxu3u9GbnDtj/rnrxpyZ8+iH+N

DPS ID Scope: 0ne0059A187

Properties: txtIdScope System.Windows.Forms.TextBox

Text: 0ne0059A187
TextAlign: Left
UseWaitCursor: False
Behavior
AcceptsReturn: False
AcceptsTab: False
AllowDrop: False

- ❖ Register device by clicking on it.

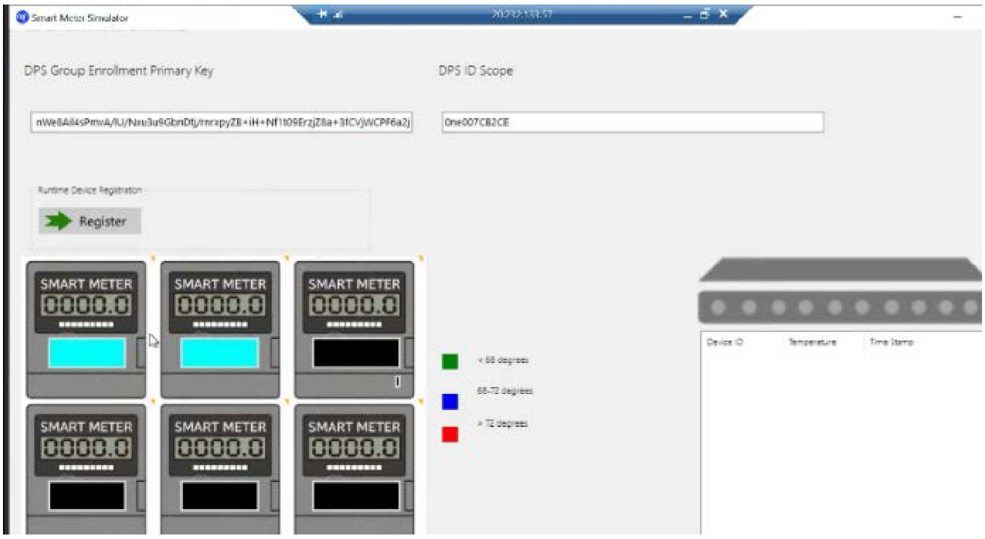


Smart Meter Simulator

DPS Group Enrollment Primary Key: nWeBAil4sPmvA/lU/Nxu3u9GbnDtj/rnrxpyZ8+iH+Nf1t09ErzjZ8a+3fCVjWCPF6a2j

DPS ID Scope: 0ne007CB2CE

colour will turn to blue:

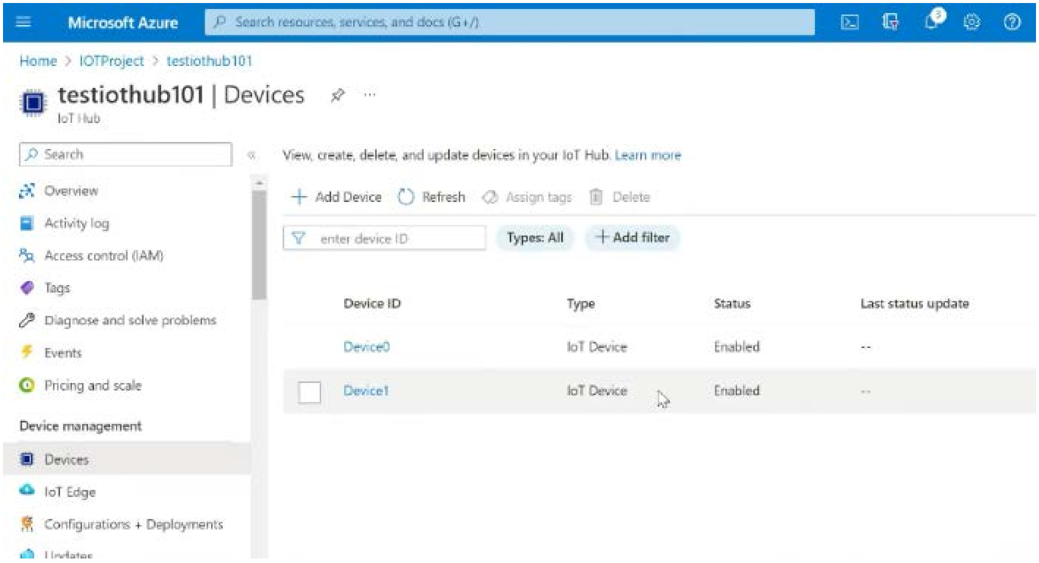


DPS Group Enrollment Primary Key: nWe8Ail4sPmvA/IU/Nxu3u9GbnDtj/rnrxpyZ8+iH+Nf1t09ErzjZ8a+3fCVjWCPf6a2j

DPS ID Scope: 0ne007CB2CE

Runtime Device Registration

- ❖ Verify this by going to Azure IoT hub -> devices.



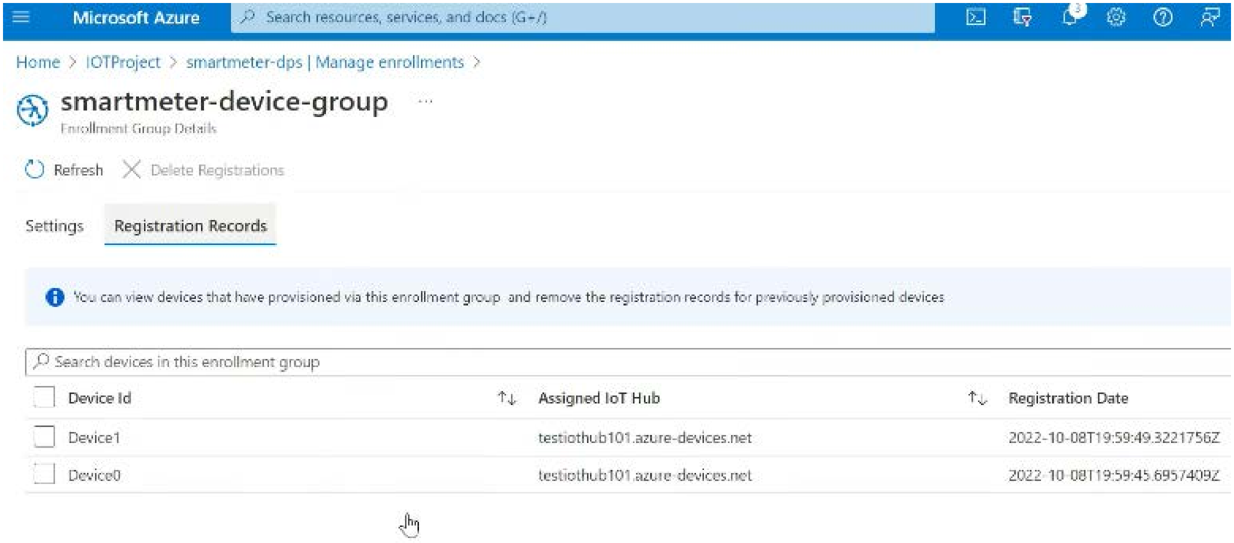
testiothub101 | Devices

IoT Hub

View, create, delete, and update devices in your IoT Hub. Learn more

Device ID	Type	Status	Last status update
Device0	IoT Device	Enabled	--
Device1	IoT Device	Enabled	--

- ❖ Go to enrollment group -> registration records



Microsoft Azure
Search resources, services, and docs (G+/)
Home > IOTProject > smartmeter-dps | Manage enrollments >
Refresh
Delete Registrations
Settings
Registration Records
Search devices in this enrollment group

smartmeter-device-group

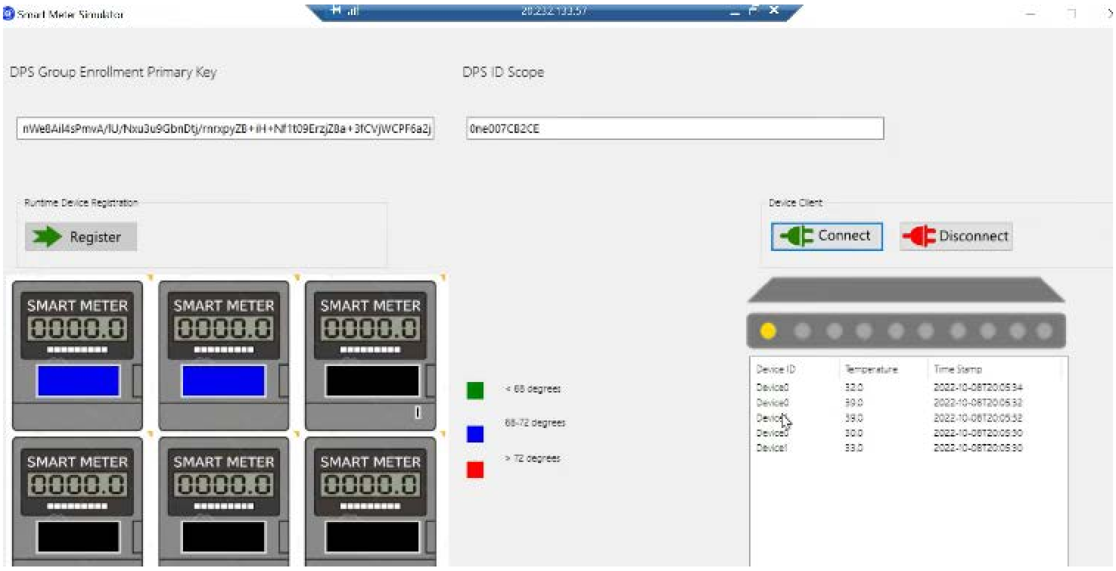
Enrollment Group Details

You can view devices that have provisioned via this enrollment group and remove the registration records for previously provisioned devices

Device Id	Assigned IoT Hub	Registration Date
Device1	testiothub101.azure-devices.net	2022-10-08T19:59:49.3221756Z
Device0	testiothub101.azure-devices.net	2022-10-08T19:59:45.6957409Z

Verify, registration of device has been successfully done.

To send data to IoT hub:



DPS Group Enrollment Primary Key: nWe8Ail4sPmvA/lU/Nxu3u9GbnDtj/rnrxpyZB+iH+Nf1t09ErzjZ8a+3fCVjWCPF6a2j

DPS ID Scope: 0ne007CB2CE

Runtime Device Registration

Device Client

🟩 < 68 degrees

🟦 68-72 degrees

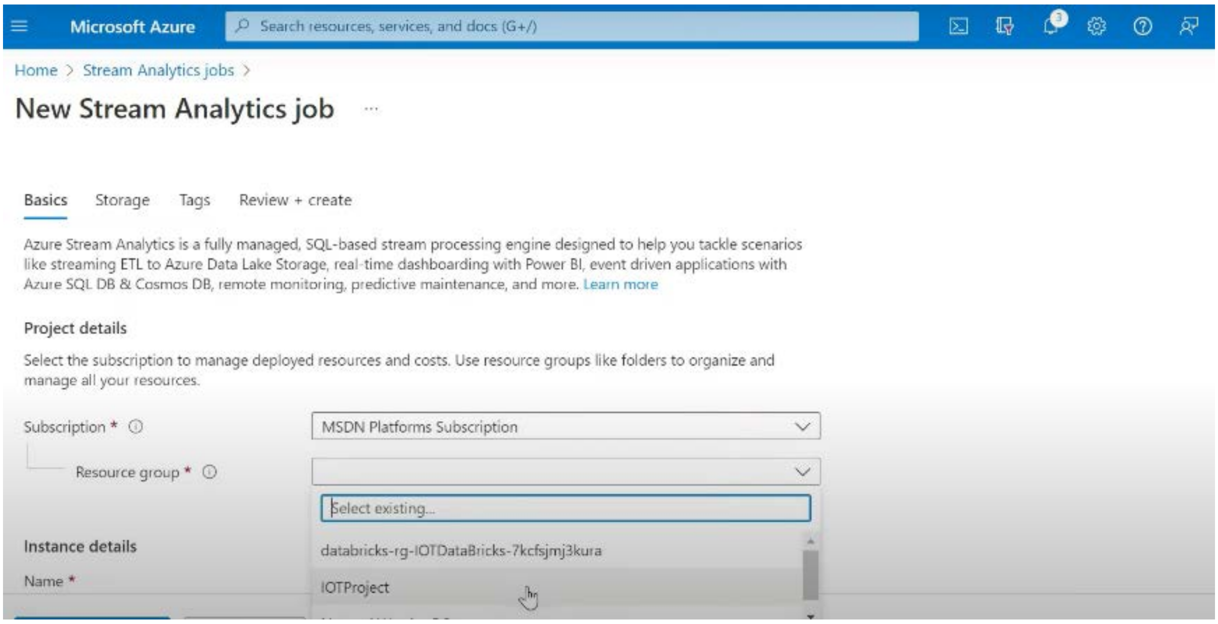
🟥 > 72 degrees

Device ID	Temperature	Time Stamp
Device0	32.0	2022-10-08T20:05:34
Device0	39.0	2022-10-08T20:05:32
Devic	39.0	2022-10-08T20:05:32
Device0	30.0	2022-10-08T20:05:30
Device1	33.0	2022-10-08T20:05:30

Click connect, on terminal output will be displayed.

To process data, we create “**stream Analytics Jobs**”.

Azure Stream Analytics is fully managed stream processing engine that is designed to analyse, process large volumes of streaming data with sub-millisecond latencies. Patterns-relationships can be identified in data that originates from variety of input sources including applications, devices, sensors.



Home > Stream Analytics jobs >

New Stream Analytics job ...

Azure Stream Analytics is a fully managed, SQL-based stream processing engine designed to help you tackle scenarios like streaming ETL to Azure Data Lake Storage, real-time dashboarding with Power BI, event driven applications with Azure SQL DB & Cosmos DB, remote monitoring, predictive maintenance, and more. Learn more

Project details

Select the subscription to manage deployed resources and costs. Use resource groups like folders to organize and manage all your resources.

Subscription * : MSDN Platforms Subscription

Resource group * :

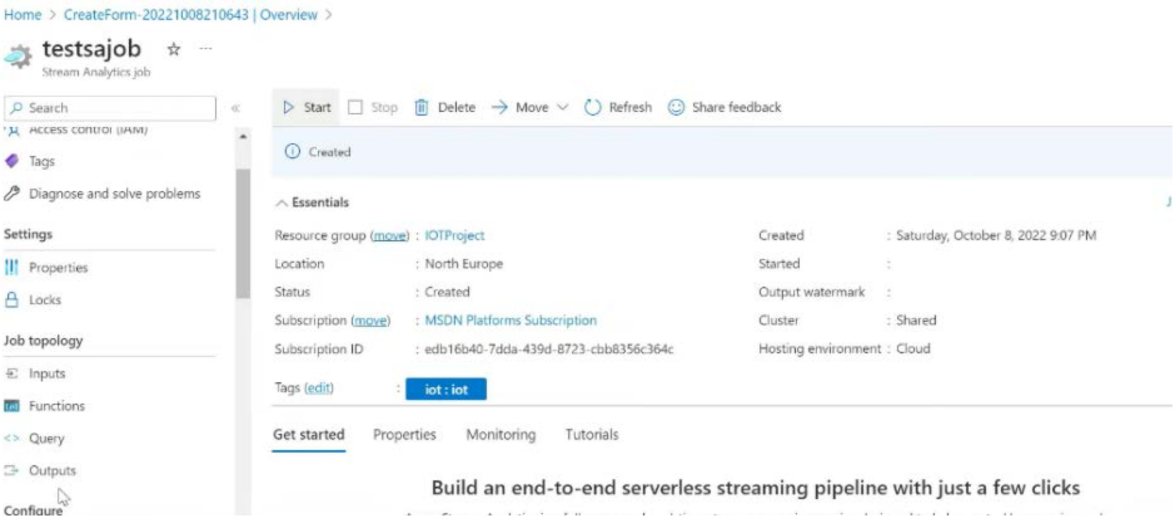
Select existing...

databricks-rg-IOTDataBricks-7kcfsjmj3kura

IOTProject

Instance details

Name *



Home > CreateForm-20221008210643 | Overview >

testsajob

Stream Analytics job

Created

Essentials

Resource group (move) : IOTProject

Location : North Europe

Status : Created

Subscription (move) : MSDN Platforms Subscription

Subscription ID : edb16b40-7dda-439d-8723-cbb8356c364c

Tags (edit) : iot : iot

Created : Saturday, October 8, 2022 9:07 PM

Started :

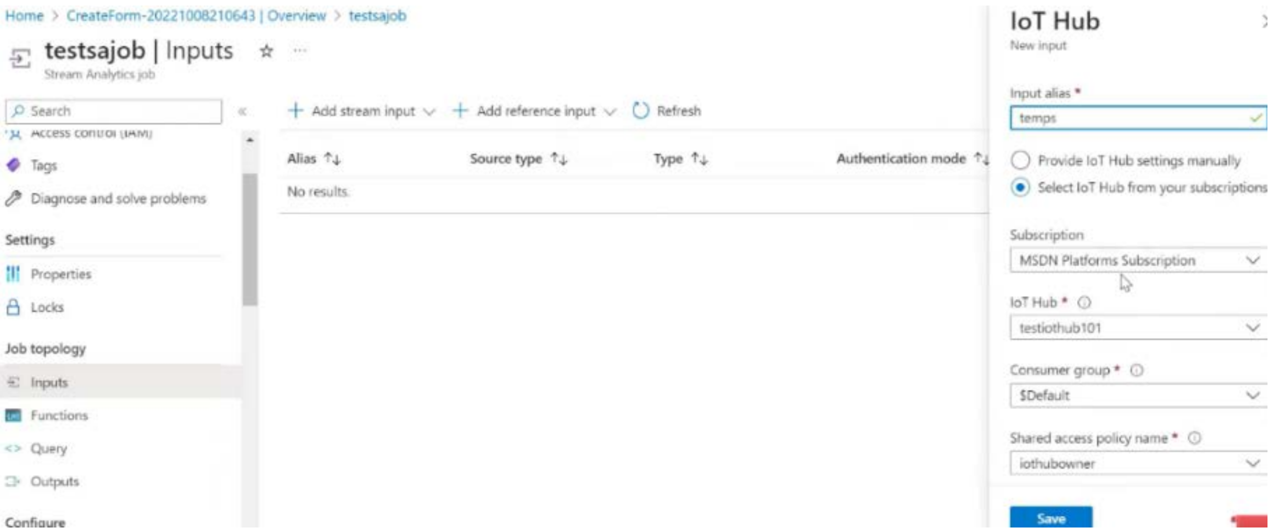
Output watermark :

Cluster : Shared

Hosting environment : Cloud

Build an end-to-end serverless streaming pipeline with just a few clicks

- Go to **stream analytics job -> Inputs -> IoT Hub**.



Home > CreateForm-20221008210643 | Overview > testsajob

testsajob | Inputs

Stream Analytics job

Alias ↑↓	Source type ↑↓	Type ↑↓	Authentication mode ↑↓
No results.			

IoT Hub

New input

Input alias * temps

○ Provide IoT Hub settings manually

● Select IoT Hub from your subscriptions

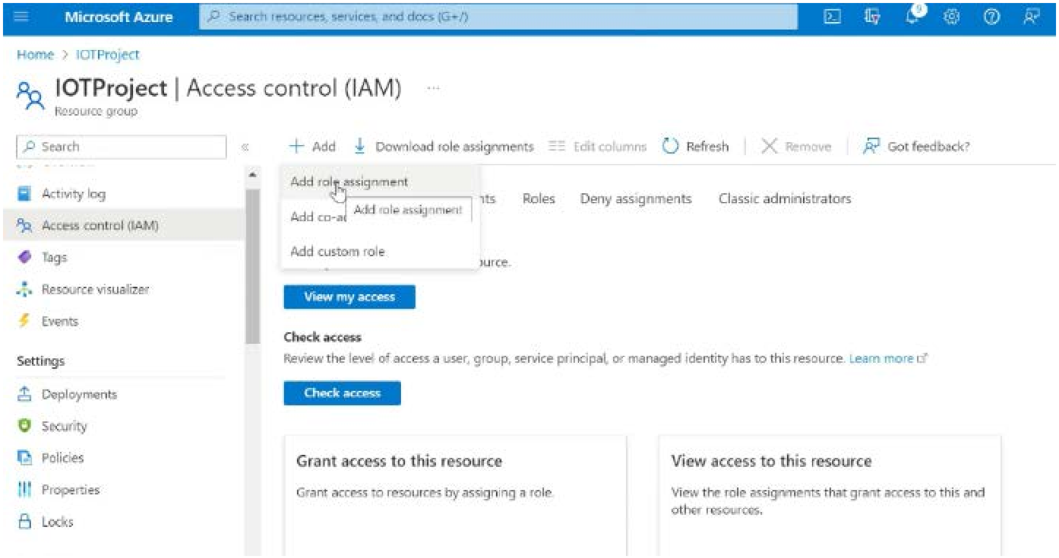
Subscription: MSDN Platforms Subscription

IoT Hub *: testiothub101

Consumer group *: $Default

Shared access policy name *: iothubowner

- Go to Job topologies -> output ->power BI. we are taking output through Power BI app. Log in into Power BI.
  For this we need to give “**access control**”.(IAM)



Home > IOTProject

IOTProject | Access control (IAM)

Resource group

Check access

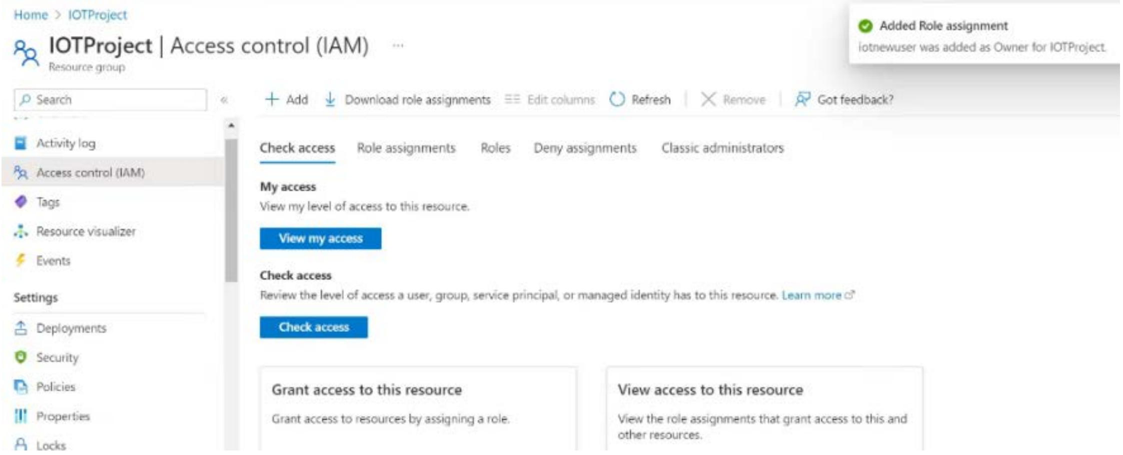
Review the level of access a user, group, service principal, or managed identity has to this resource. Learn more

Grant access to this resource

Grant access to resources by assigning a role.

View access to this resource

View the role assignments that grant access to this and other resources.



Home > IOTProject

IOTProject | Access control (IAM)

Resource group

Added Role assignment

iotnewuser was added as Owner for IOTProject

My access

View my level of access to this resource.

Check access

Review the level of access a user, group, service principal, or managed identity has to this resource. Learn more

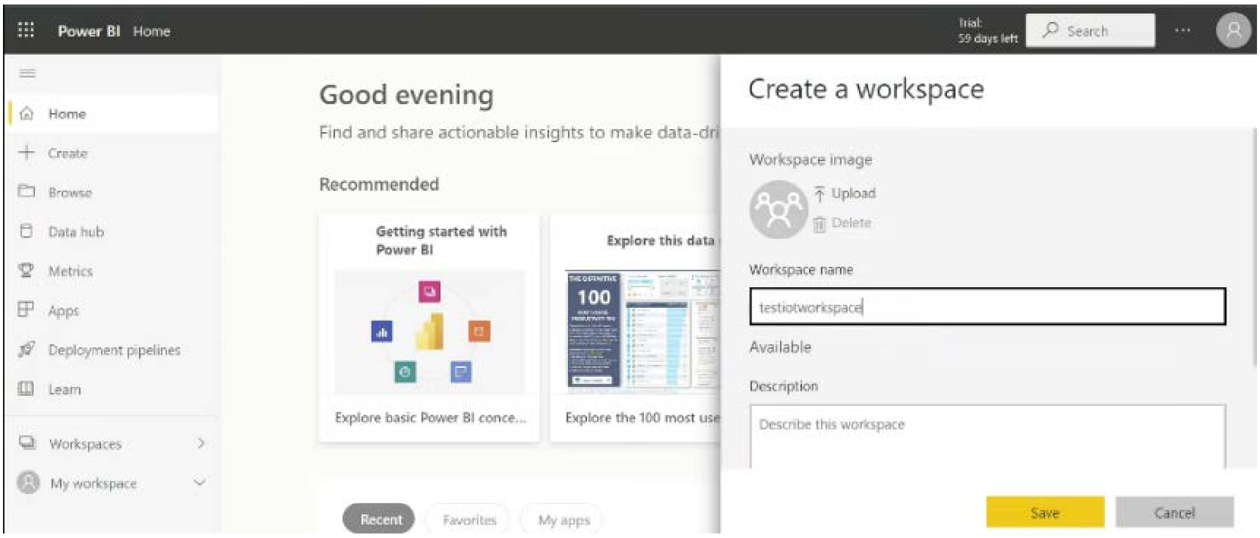
Grant access to this resource

Grant access to resources by assigning a role.

View access to this resource

View the role assignments that grant access to this and other resources.

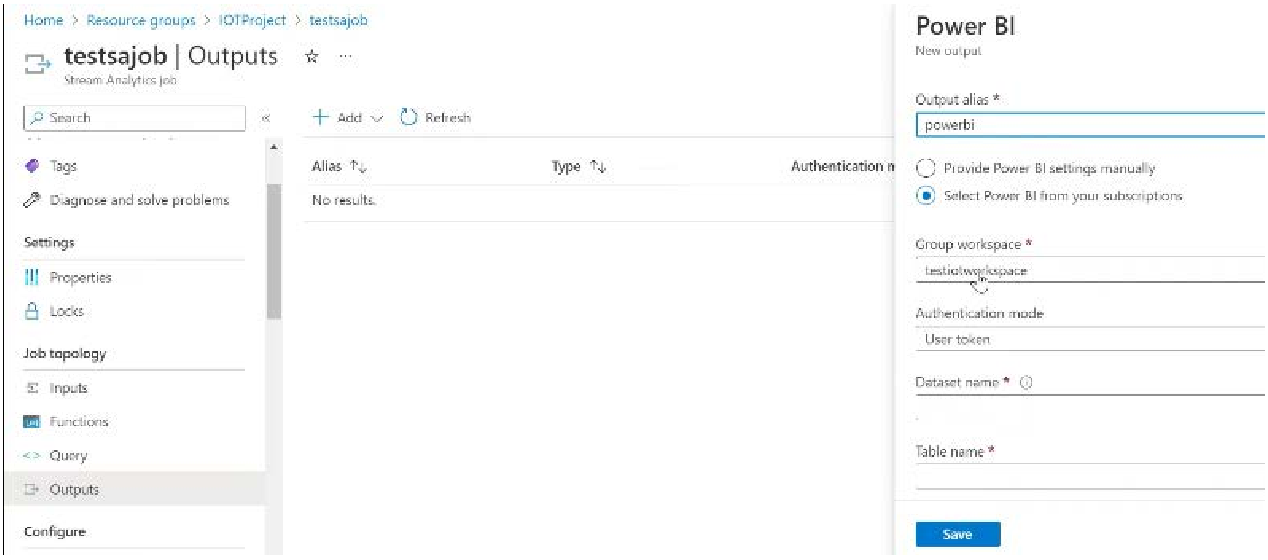
- Create workspace in power BI.



Workspace name: testiotworkspace

Available

Description: Describe this workspace



Output alias *: powerbi

○ Provide Power BI settings manually

● Select Power BI from your subscriptions

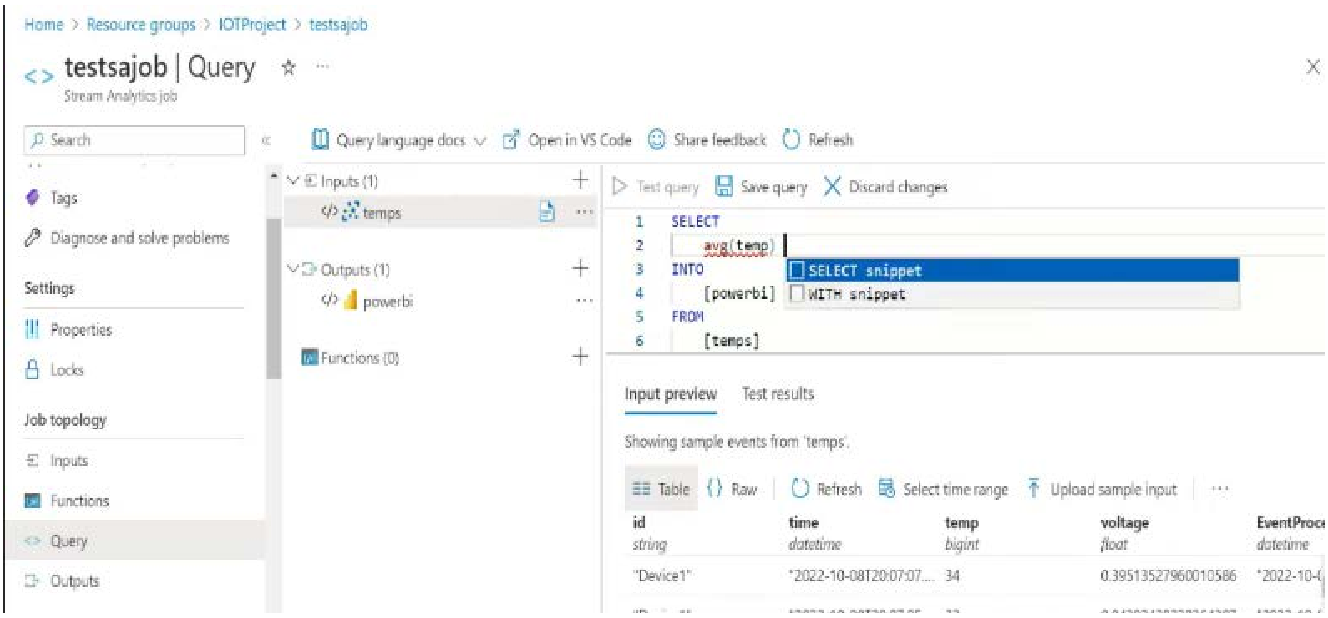
Group workspace *: testiotworkspace

Authentication mode: User token

Dataset name *

Table name *

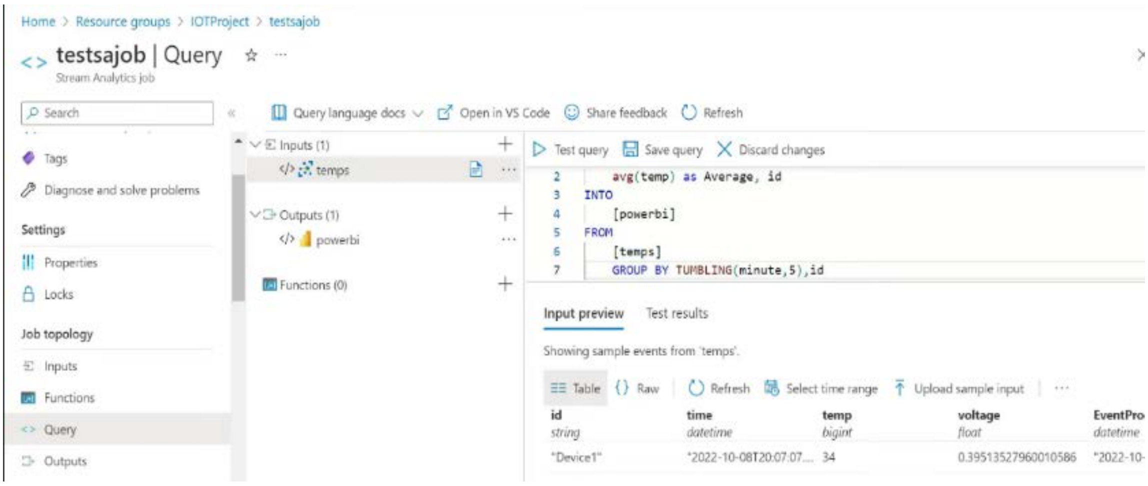
❖ Write query in stream analytics.



```
SELECT
    avg(temp)
INTO
    [powerbi]
FROM
    [temps]
```

Showing sample events from 'temps'.

id string	time datetime	temp bigint	voltage float	EventProce datetime
"Device1"	"2022-10-08T20:07:07....	34	0.39513527960010586	"2022-10-(



```
    avg(temp) as Average, id
INTO
    [powerbi]
FROM
    [temps]
    GROUP BY TUMBLING(minute,5),id
```

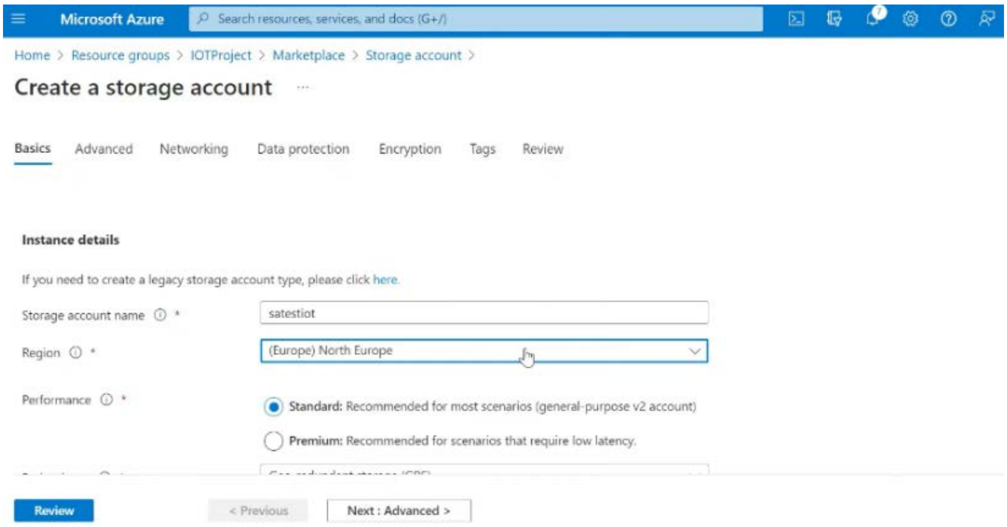
Showing sample events from 'temps'.

id string	time datetime	temp bigint	voltage float	EventPro datetime
"Device1"	"2022-10-08T20:07:07....	34	0.39513527960010586	"2022-10-

Save -> run job, you will see output.

- ❖ Create storage account.
  Let’s have brief understanding about it:

  Azure storage account contains all of your Azure Storage data objects, including blobs, file shares, queues, tables, and disks. It provides unique namespace for your data that's accessible from anywhere in world over HTTP/S.



Instance details

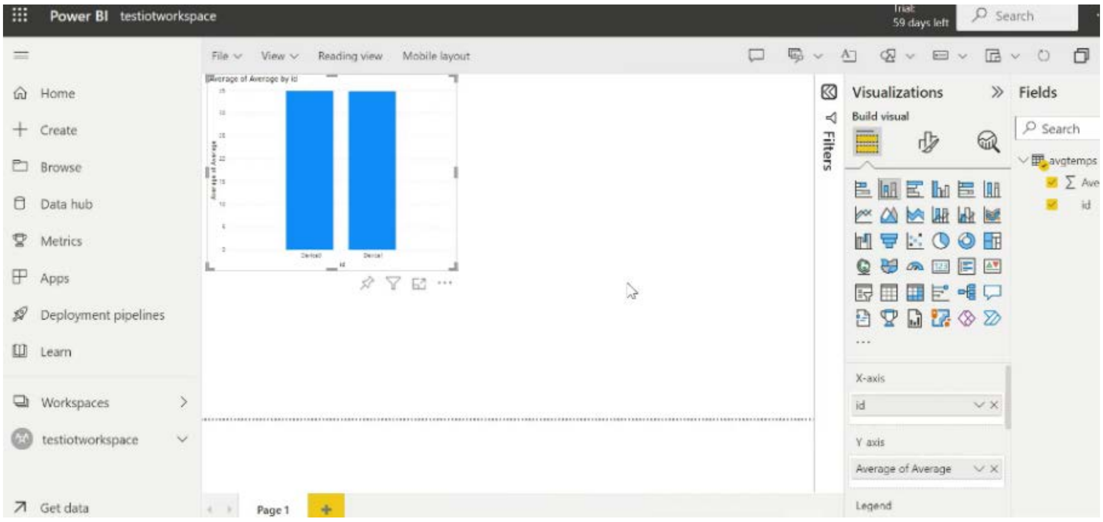
If you need to create a legacy storage account type, please click here.

Storage account name * : satestiot

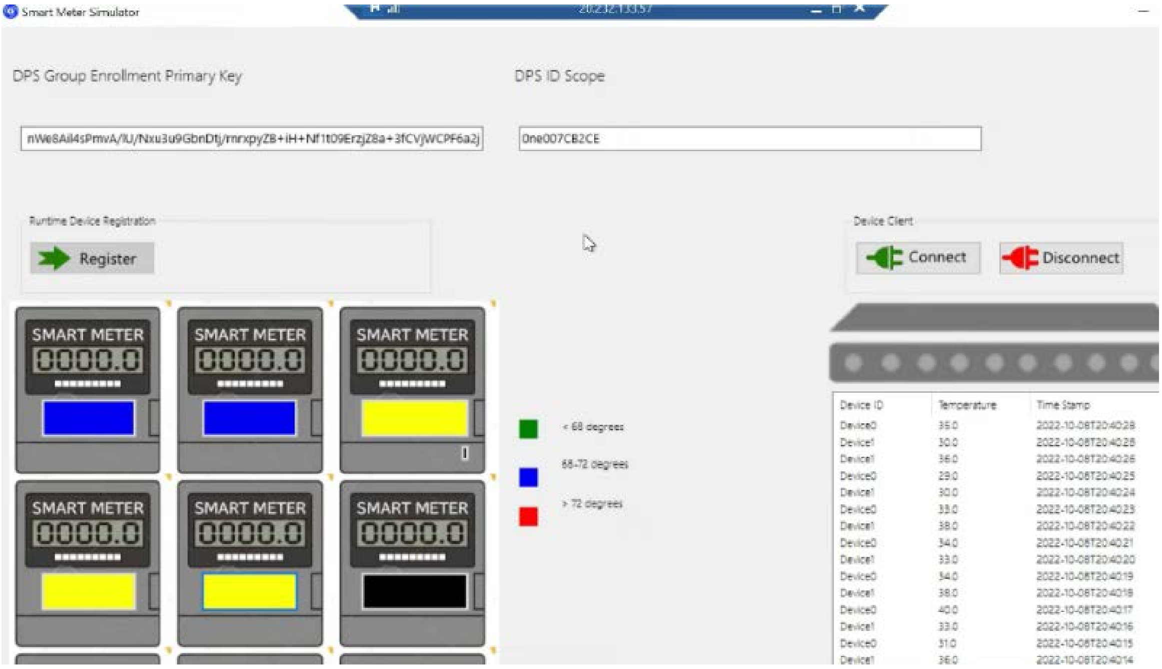
Region * : (Europe) North Europe

Performance * : ● Standard: Recommended for most scenarios (general-purpose v2 account) ○ Premium: Recommended for scenarios that require low latency.

- ❖ Create **power BI dashboard**



Register 3 more devices.



DPS Group Enrollment Primary Key

nWe8Ail4sPmvA/IU/Nxu3u9GbnDtj/mrxpyZ8+iH+Nf1t09ErzjZ8a+3fCVjWCPF6a2j

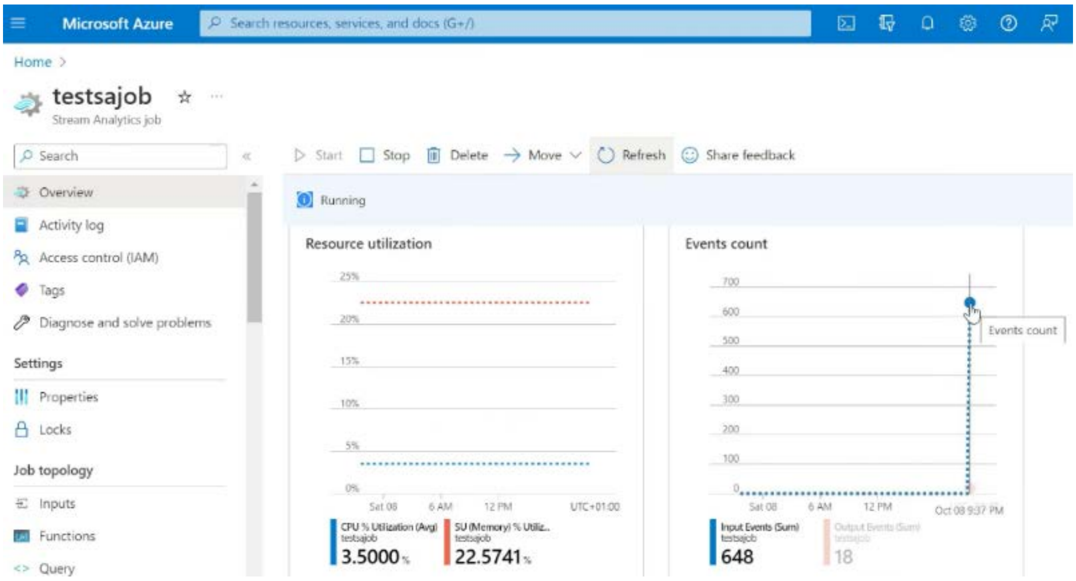
DPS ID Scope

0ne007CB2CE

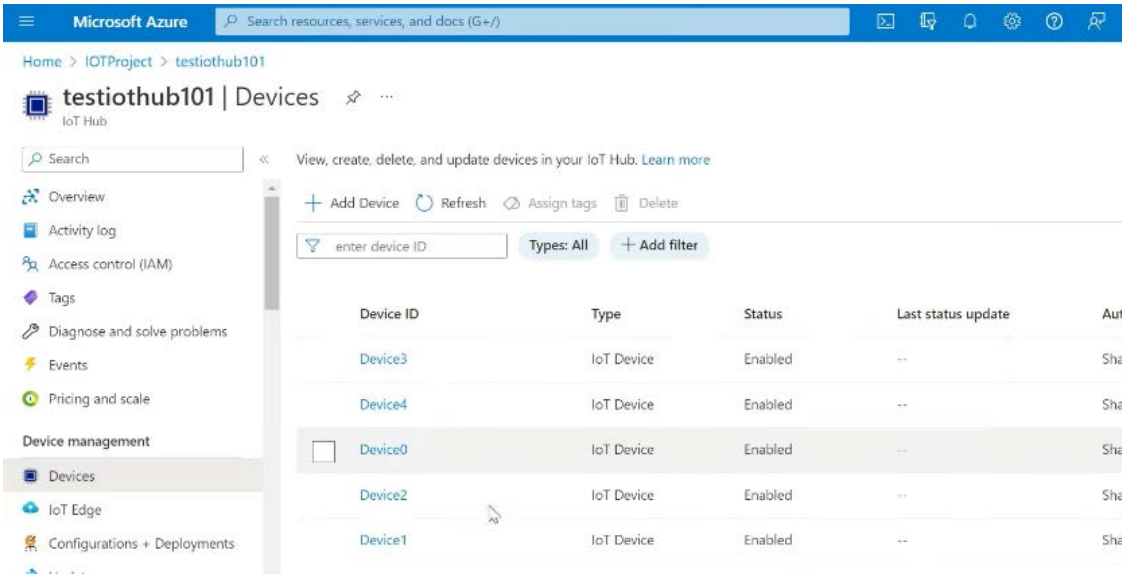
🟩	< 68 degrees
🟦	68-72 degrees
🟥	> 72 degrees

Device ID	Temperature	Time Stamp
Device0	35.0	2022-10-08T20:40:28
Device1	30.0	2022-10-08T20:40:28
Device1	36.0	2022-10-08T20:40:26
Device0	29.0	2022-10-08T20:40:25
Device1	30.0	2022-10-08T20:40:24
Device0	33.0	2022-10-08T20:40:23
Device1	38.0	2022-10-08T20:40:22
Device0	34.0	2022-10-08T20:40:21
Device1	33.0	2022-10-08T20:40:20
Device0	34.0	2022-10-08T20:40:19
Device1	38.0	2022-10-08T20:40:18
Device0	40.0	2022-10-08T20:40:17
Device1	33.0	2022-10-08T20:40:16
Device0	31.0	2022-10-08T20:40:15
Device1	36.0	2022-10-08T20:40:14

Refresh stream analytics page:



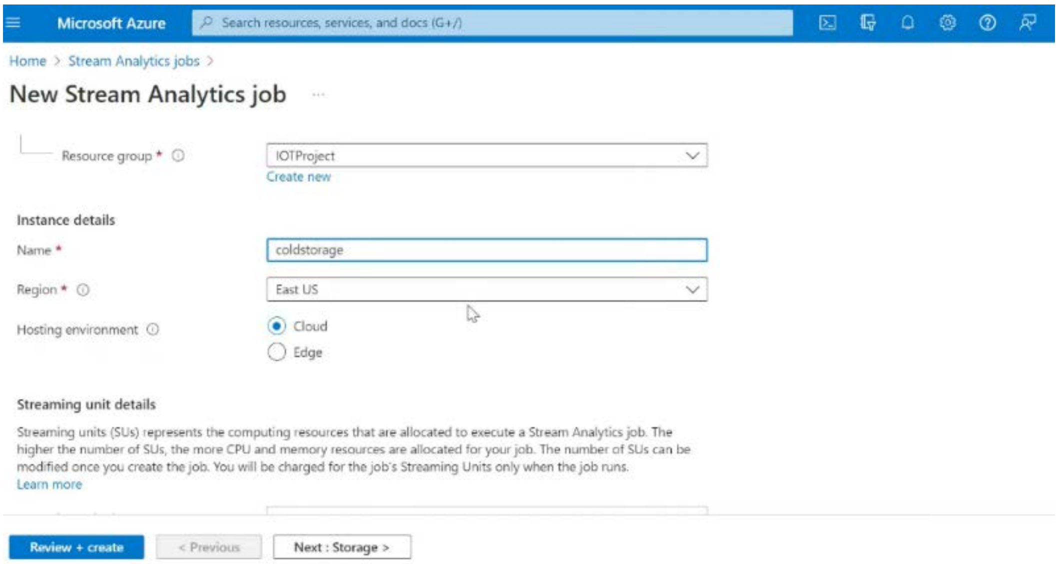
❖ In IoT hub verify devices.



View, create, delete, and update devices in your IoT Hub. Learn more

Device ID	Type	Status	Last status update	Aut
Device3	IoT Device	Enabled	--	Sha
Device4	IoT Device	Enabled	--	Sha
□ Device0	IoT Device	Enabled	--	Sha
Device2	IoT Device	Enabled	--	Sha
Device1	IoT Device	Enabled	--	Sha

Creating one more stream analytics.



Microsoft Azure
Search resources, services, and docs (G+/)
Home > Stream Analytics jobs >

New Stream Analytics job

Resource group * : IOTProject
Create new

Instance details

Name * : coldstorage

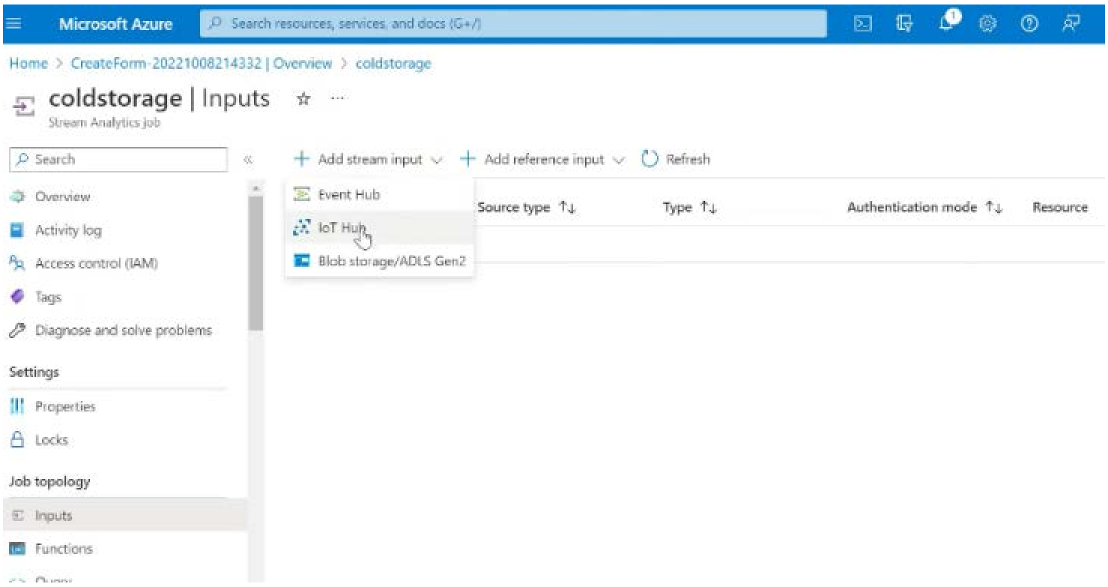
Region * : East US

Hosting environment : ● Cloud ○ Edge

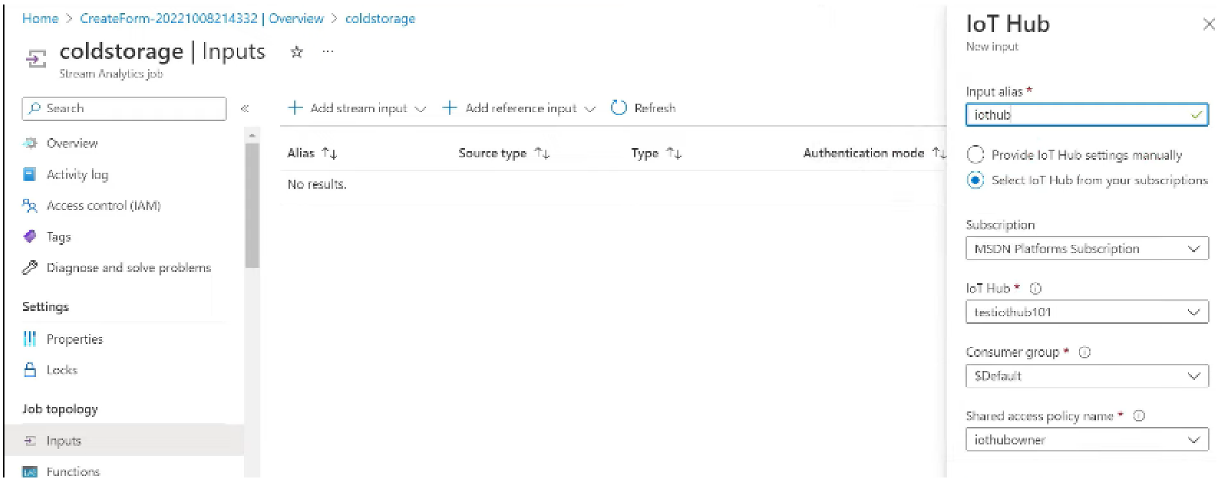
Streaming unit details

Streaming units (SUs) represents the computing resources that are allocated to execute a Stream Analytics job. The higher the number of SUs, the more CPU and memory resources are allocated for your job. The number of SUs can be modified once you create the job. You will be charged for the job's Streaming Units only when the job runs.
Learn more

Click Input -> IoT Hub



❖ Create input name “iothub”.



No results.

IoT Hub
New input

Input alias * : iothub

○ Provide IoT Hub settings manually
● Select IoT Hub from your subscriptions

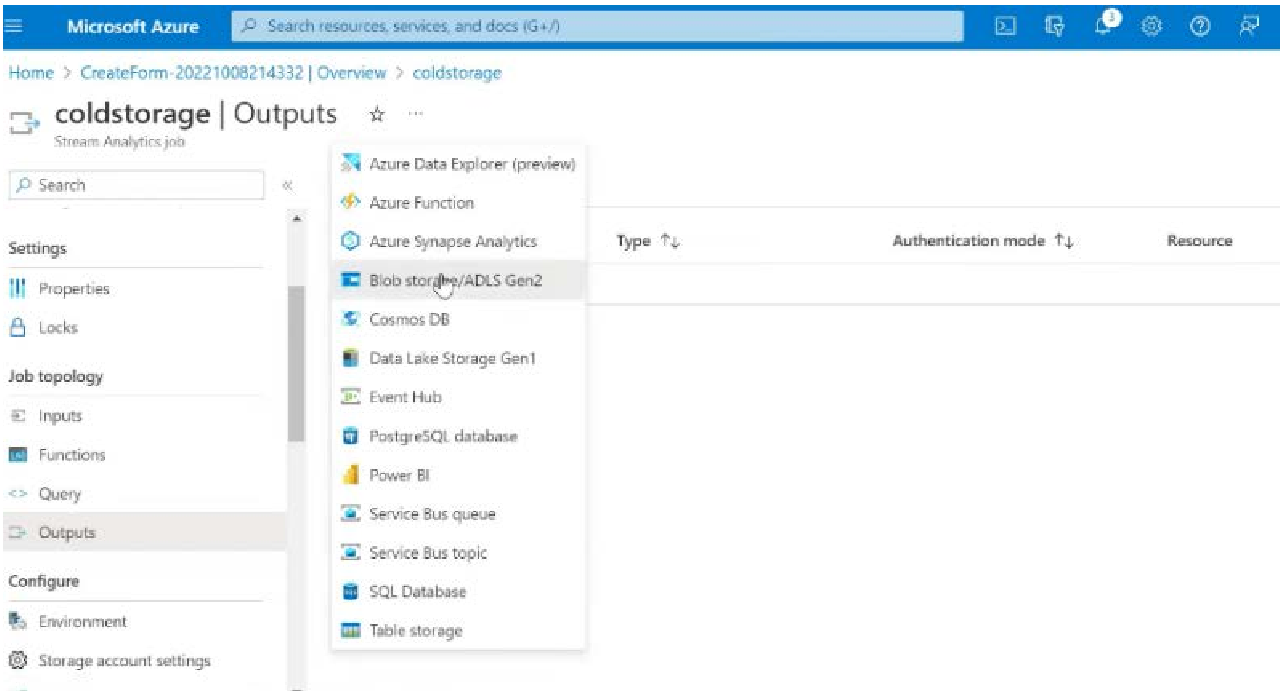
Subscription : MSDN Platforms Subscription

IoT Hub * : testiothub101

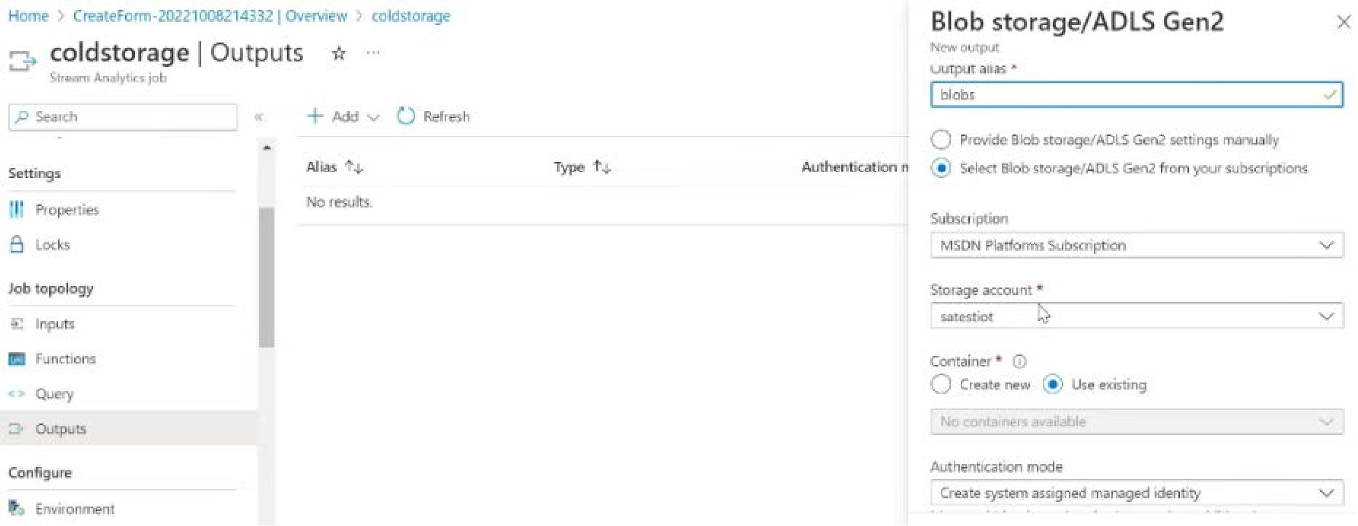
Consumer group * : $Default

Shared access policy name * : iothubowner

Click output -> blob storage:



Create new output:



Blob storage/ADLS Gen2

New output

Output alias *: blobs

○ Provide Blob storage/ADLS Gen2 settings manually

● Select Blob storage/ADLS Gen2 from your subscriptions

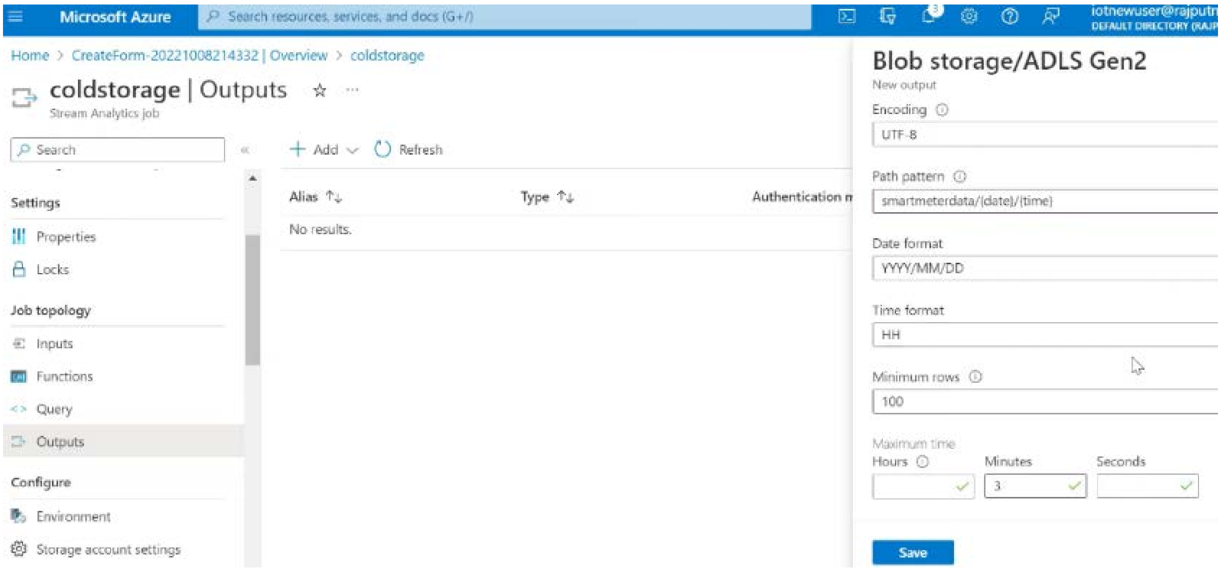
Subscription: MSDN Platforms Subscription

Storage account *: satestiot

Container *: ○ Create new ● Use existing

No containers available

Authentication mode: Create system assigned managed identity



Blob storage/ADLS Gen2

New output

Encoding: UTF-8

Path pattern: smartmeterdata/{date}/{time}

Date format: YYYY/MM/DD

Time format: HH

Minimum rows: 100

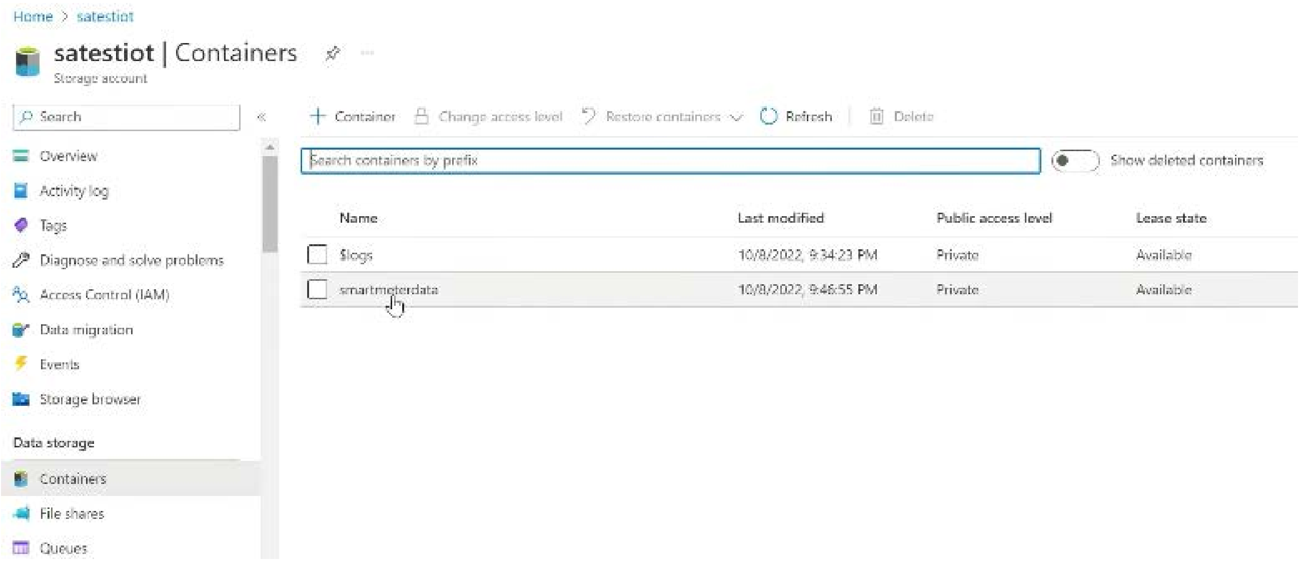
Maximum time

Hours:

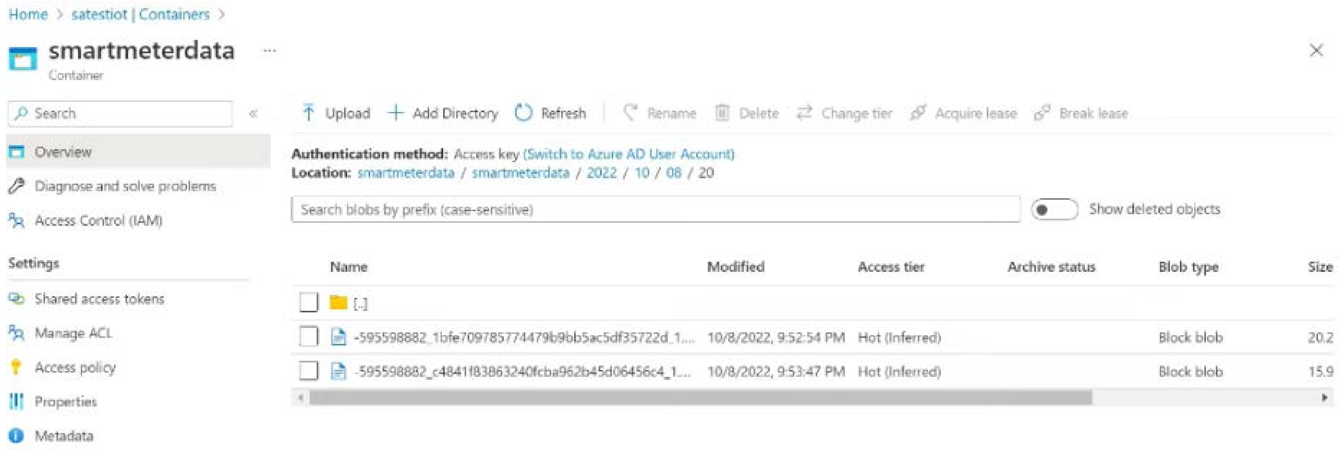
Minutes: 3

Seconds:

❖ Data is stored in storage account:



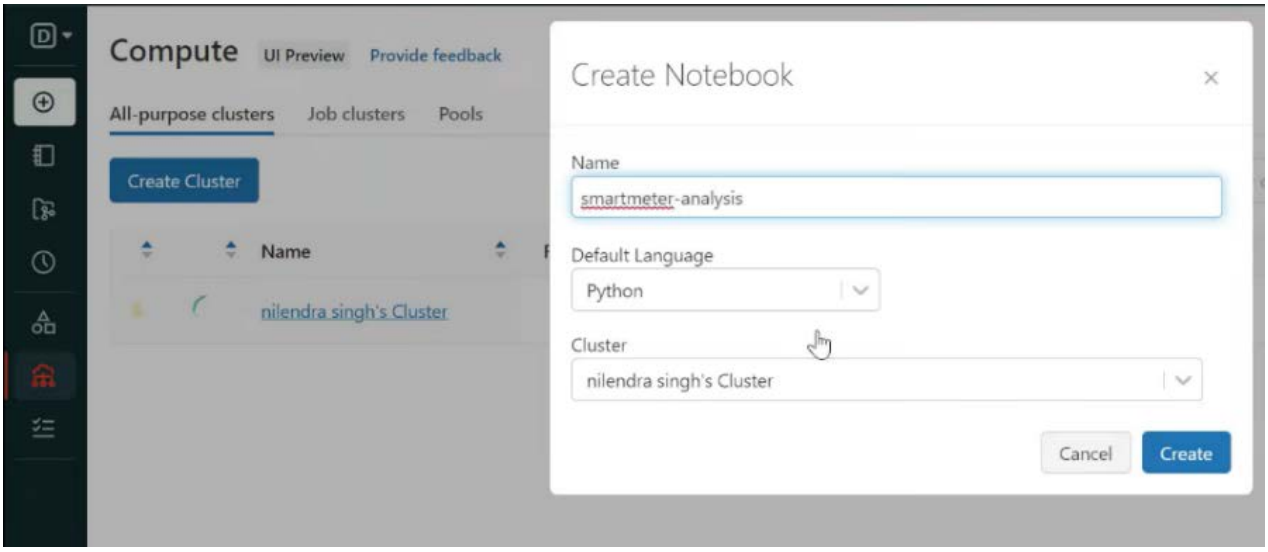
Name	Last modified	Public access level	Lease state
$logs	10/8/2022, 9:34:23 PM	Private	Available
smartmeterdata	10/8/2022, 9:46:55 PM	Private	Available



Authentication method: Access key (Switch to Azure AD User Account)
Location: smartmeterdata / smartmeterdata / 2022 / 10 / 08 / 20

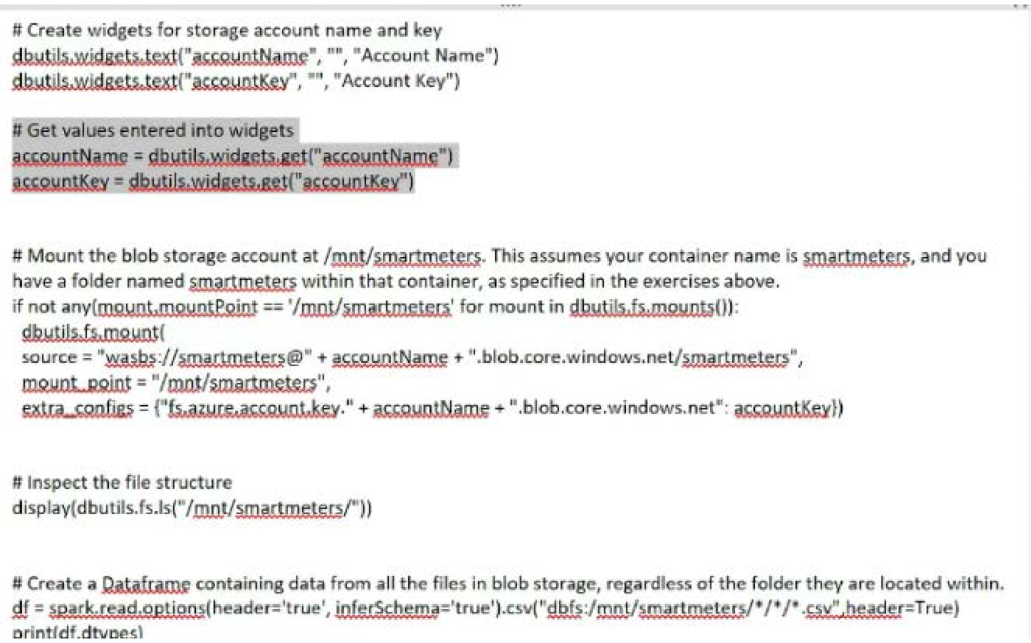
Name	Modified	Access tier	Archive status	Blob type	Size
[..]					
-595598882_1bfe709785774479b9bb5ac5df35722d_1....	10/8/2022, 9:52:54 PM	Hot (Inferred)		Block blob	20.2
-595598882_c4841f83863240fcba962b45d06456c4_1....	10/8/2022, 9:53:47 PM	Hot (Inferred)		Block blob	15.9

❖ Go to databricks, review cluster created back then, create notebook:



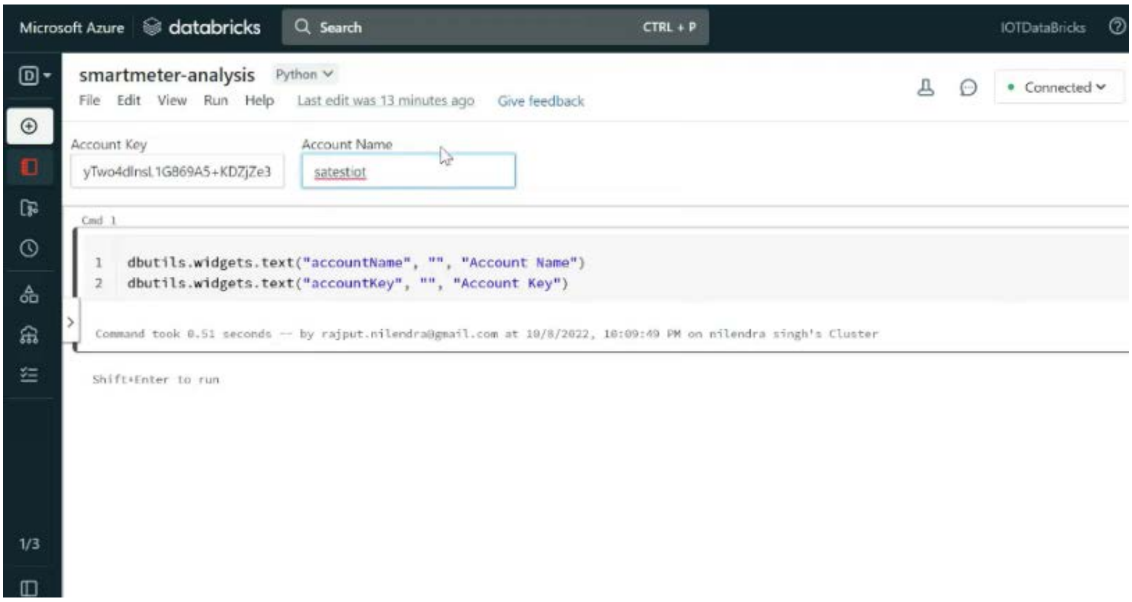
Name: smartmeter-analysis
Default Language: Python
Cluster: nilendra singh's Cluster

Run commands in notebook:



```
# Create widgets for storage account name and key
dbutils.widgets.text("accountName", "", "Account Name")
dbutils.widgets.text("accountKey", "", "Account Key")

# Get values entered into widgets
accountName = dbutils.widgets.get("accountName")
accountKey = dbutils.widgets.get("accountKey")


# Mount the blob storage account at /mnt/smartmeters. This assumes your container name is smartmeters, and you have a folder named smartmeters within that container, as specified in the exercises above.
if not any(mount.mountPoint == '/mnt/smartmeters' for mount in dbutils.fs.mounts()):
  dbutils.fs.mount(
  source = "wasbs://smartmeters@" + accountName + ".blob.core.windows.net/smartmeters",
  mount_point = "/mnt/smartmeters",
  extra_configs = {"fs.azure.account.key." + accountName + ".blob.core.windows.net": accountKey})


# Inspect the file structure
display(dbutils.fs.ls("/mnt/smartmeters/"))


# Create a Dataframe containing data from all the files in blob storage, regardless of the folder they are located within.
df = spark.read.options(header='true', inferSchema='true').csv("dbfs:/mnt/smartmeters/*/*/*.csv",header=True)
print(df.dtypes)
```

Account key is one which we copied before:



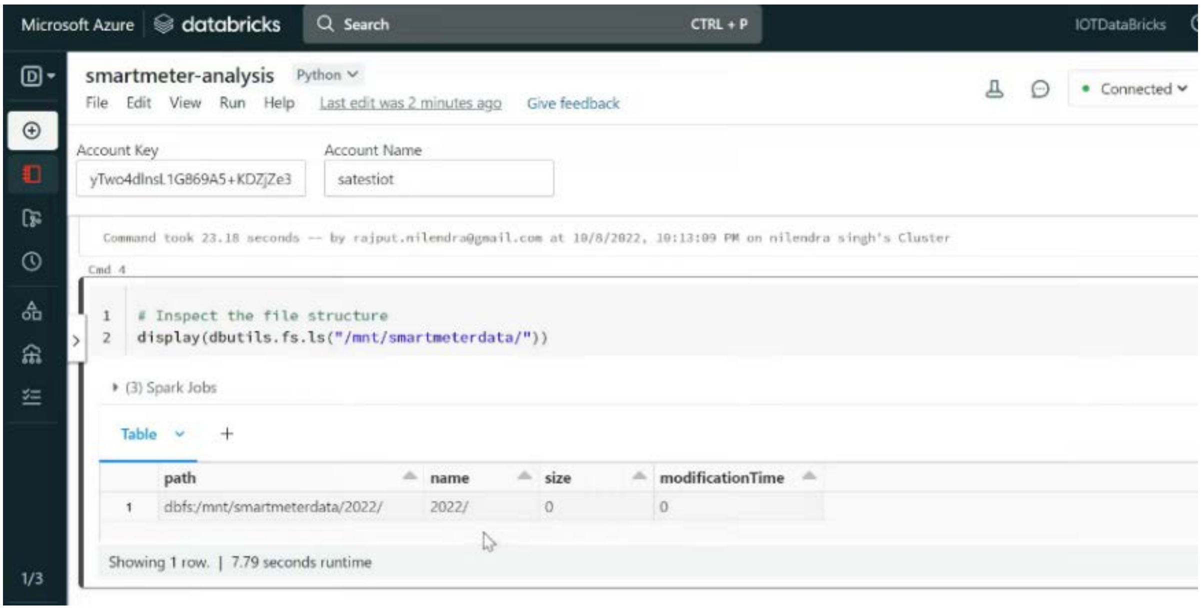
Account Key: yTwo4dlnsL1G869A5+KDZjZe3

Account Name: satestiot

```
dbutils.widgets.text("accountName", "", "Account Name")
dbutils.widgets.text("accountKey", "", "Account Key")
```

```
Command took 0.51 seconds -- by rajput.nilendra@gmail.com at 10/8/2022, 10:09:49 PM on nilendra singh's Cluster
```

Containers have been mounted; hence we have got output:



Account Key: yTwo4dlnsL1G869A5+KDZjZe3

Account Name: satestiot

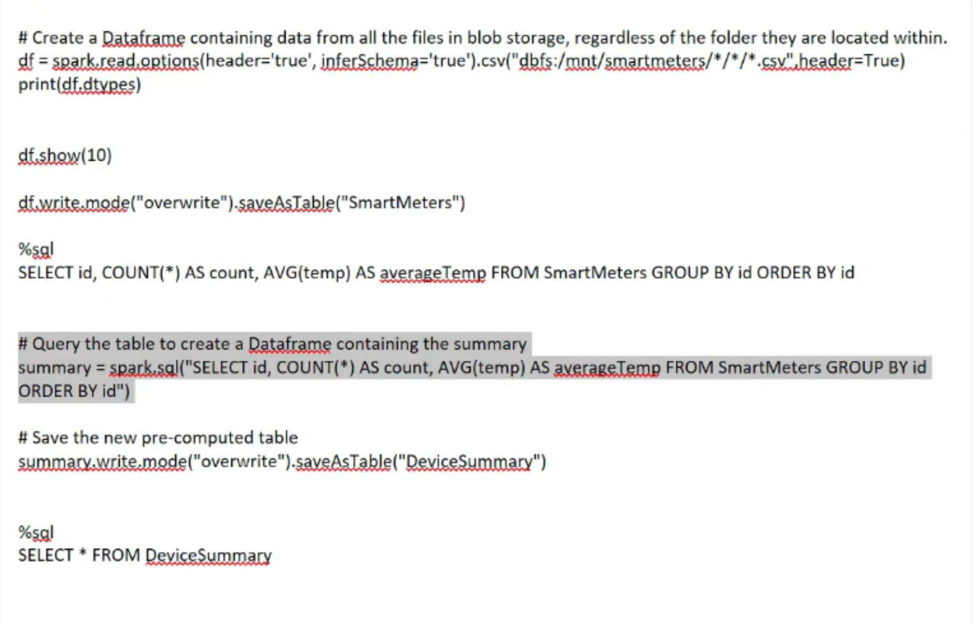
```
Command took 23.18 seconds -- by rajput.nilendra@gmail.com at 10/8/2022, 10:13:09 PM on nilendra singh's Cluster
```

```
# Inspect the file structure
display(dbutils.fs.ls("/mnt/smartmeterdata/"))
```

	path	name	size	modificationTime
1	dbfs:/mnt/smartmeterdata/2022/	2022/	0	0

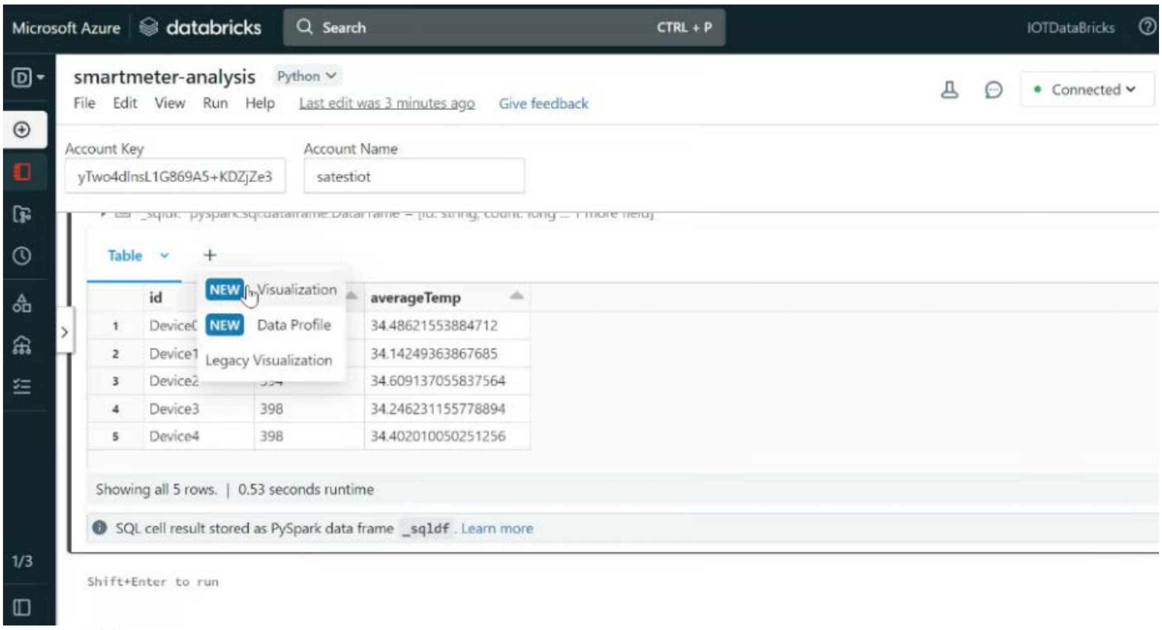
Showing 1 row. | 7.79 seconds runtime

Run commands:



```
# Create a Dataframe containing data from all the files in blob storage, regardless of the folder they are located within.
df = spark.read.options(header='true', inferSchema='true').csv("dbfs:/mnt/smartmeters/*/*/*.csv",header=True)
print(df.dtypes)


df.show(10)

df.write.mode("overwrite").saveAsTable("SmartMeters")

%sql
SELECT id, COUNT(*) AS count, AVG(temp) AS averageTemp FROM SmartMeters GROUP BY id ORDER BY id


# Query the table to create a Dataframe containing the summary
summary = spark.sql("SELECT id, COUNT(*) AS count, AVG(temp) AS averageTemp FROM SmartMeters GROUP BY id
ORDER BY id")

# Save the new pre-computed table
summary.write.mode("overwrite").saveAsTable("DeviceSummary")


%sql
SELECT * FROM DeviceSummary
```

Run second last command, click visualization:



Account Key: yTwo4dlnsL1G869A5+KDZjZe3

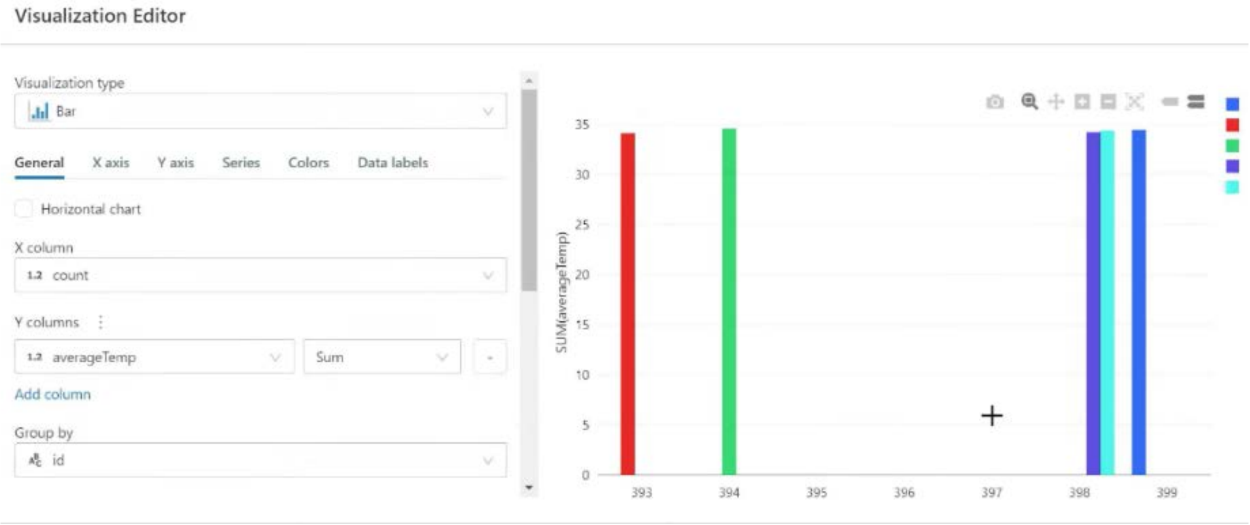
Account Name: satestiot

	id		averageTemp
1	DeviceC		34.48621553884712
2	Device1		34.14249363867685
3	Device2	394	34.609137055837564
4	Device3	398	34.246231155778894
5	Device4	398	34.402010050251256

Showing all 5 rows. | 0.53 seconds runtime

SQL cell result stored as PySpark data frame `_sqldf` . Learn more

Shift+Enter to run



Visualization Editor

Visualization type: Bar

General | X axis | Y axis | Series | Colors | Data labels

☐ Horizontal chart

X column: 1.2 count

Y columns: 1.2 averageTemp | Sum

Add column

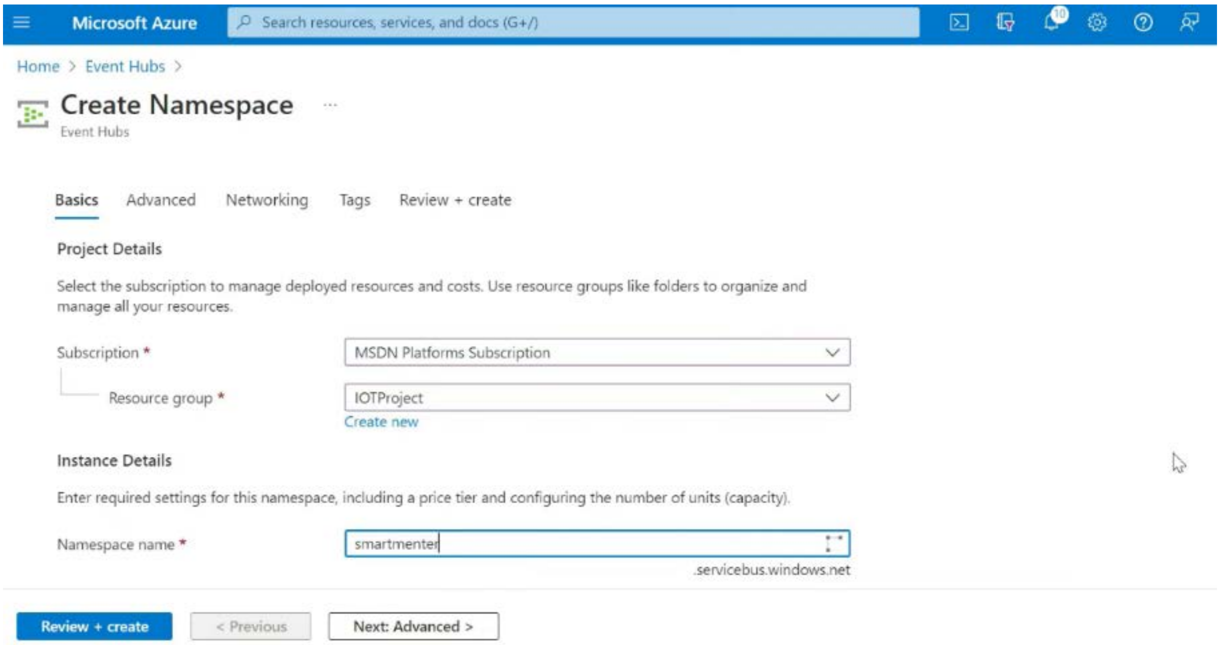
Group by: id

❖ Create alerts; use anomaly detection in stream analytics; create logic app which will be called through azure function.

Major connectivity:

Stream Analytics -> Event Hub -> Azure Function -> Logic App -> Gmail sending

Event Hub:



Create Namespace

Event Hubs

Project Details

Select the subscription to manage deployed resources and costs. Use resource groups like folders to organize and manage all your resources.

Subscription * MSDN Platforms Subscription

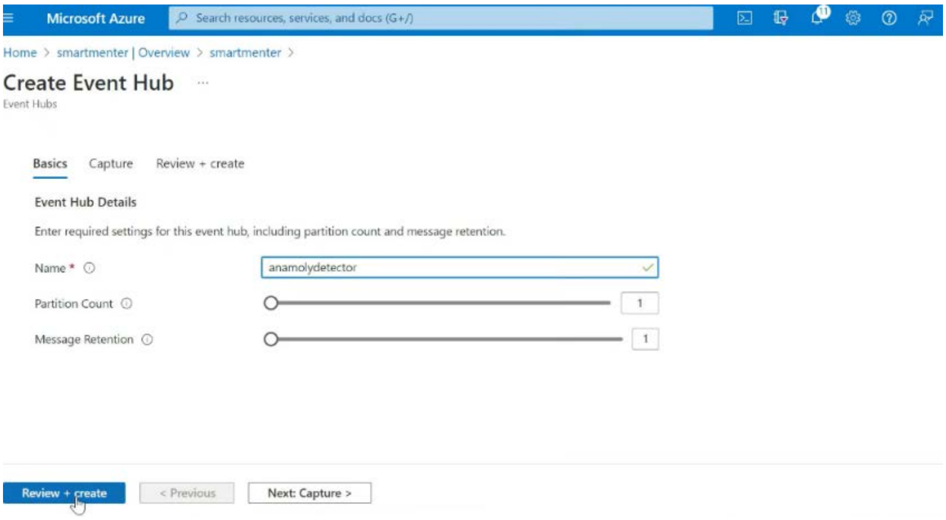
Resource group * IOTProject

Instance Details

Enter required settings for this namespace, including a price tier and configuring the number of units (capacity).

Namespace name * smartmenter .servicebus.windows.net

Creating container within event hub:


Microsoft Azure
Search resources, services, and docs (G+/)
Home > smartmenter | Overview > smartmenter >
Basics
Capture
Review + create
Review + create
< Previous
Next: Capture >

Create Event Hub

Event Hubs

Event Hub Details

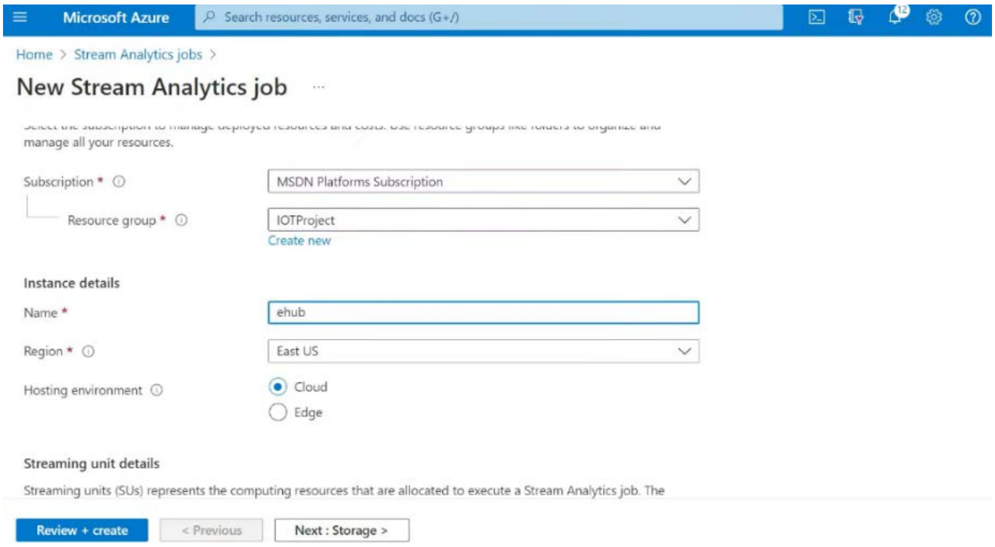
Enter required settings for this event hub, including partition count and message retention.

Name * anamolydetector

Partition Count 1

Message Retention 1

Create new stream analytics job:


Microsoft Azure
Search resources, services, and docs (G+/)
Home > Stream Analytics jobs >
Create new
Review + create
< Previous
Next : Storage >

New Stream Analytics job

Select the subscription to manage deployed resources and costs. Use resource groups like folders to organize and manage all your resources.

Subscription * MSDN Platforms Subscription

Resource group * IOTProject

Instance details

Name * ehub

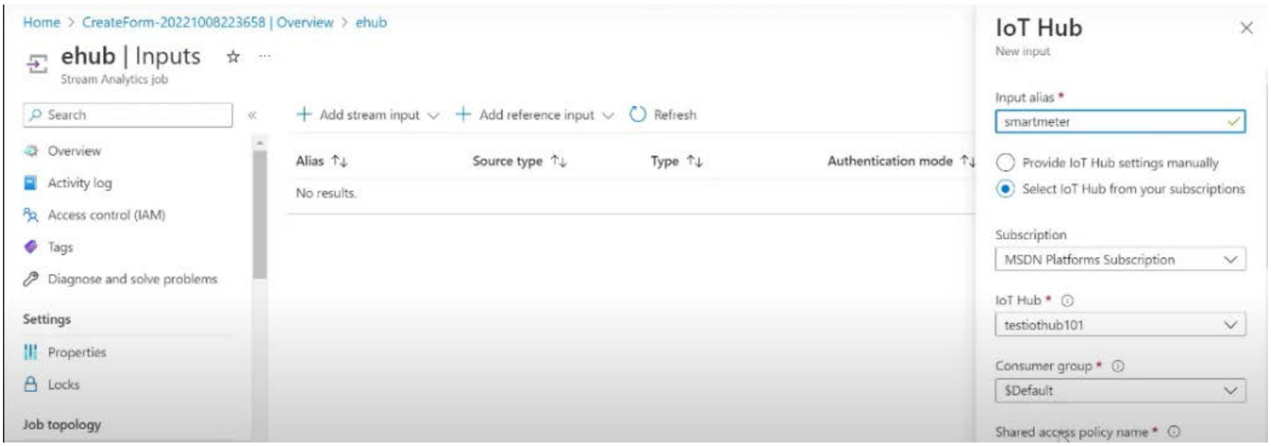
Region * East US

Hosting environment ● Cloud ○ Edge

Streaming unit details

Streaming units (SUs) represents the computing resources that are allocated to execute a Stream Analytics job. The

Input, Output, Query are as follows:


Home > CreateForm-20221008223658 | Overview > ehub

ehub | Inputs

Stream Analytics job

Alias	Source type	Type	Authentication mode
No results.			

IoT Hub

New input

Input alias * smartmeter

○ Provide IoT Hub settings manually

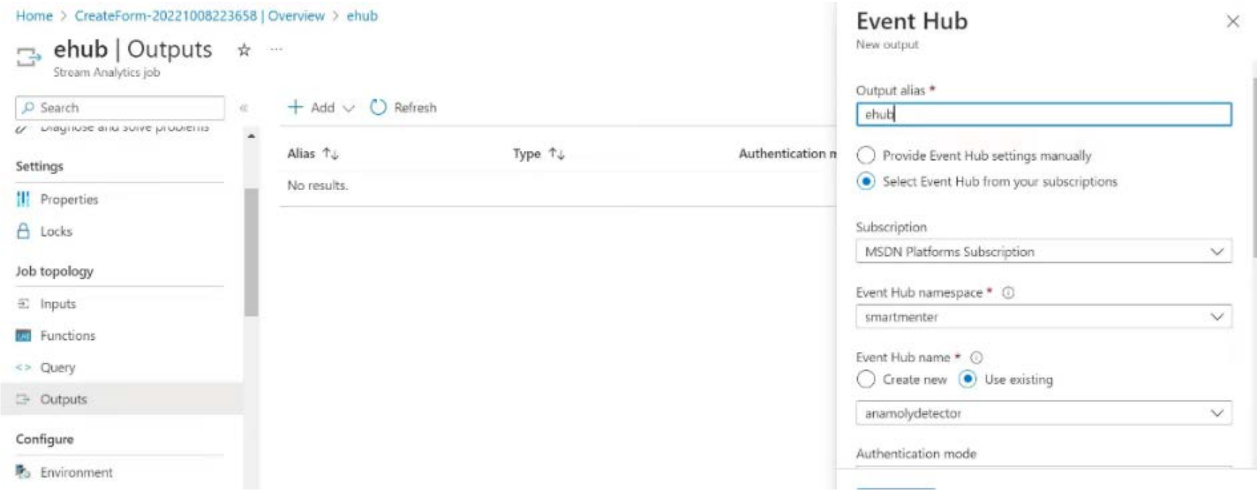
● Select IoT Hub from your subscriptions

Subscription: MSDN Platforms Subscription

IoT Hub *: testiothub101

Consumer group *: $Default

Shared access policy name *


Home > CreateForm-20221008223658 | Overview > ehub

ehub | Outputs

Stream Analytics job

Alias	Type	Authentication m
No results.		

Event Hub

New output

Output alias * ehub

○ Provide Event Hub settings manually

● Select Event Hub from your subscriptions

Subscription: MSDN Platforms Subscription

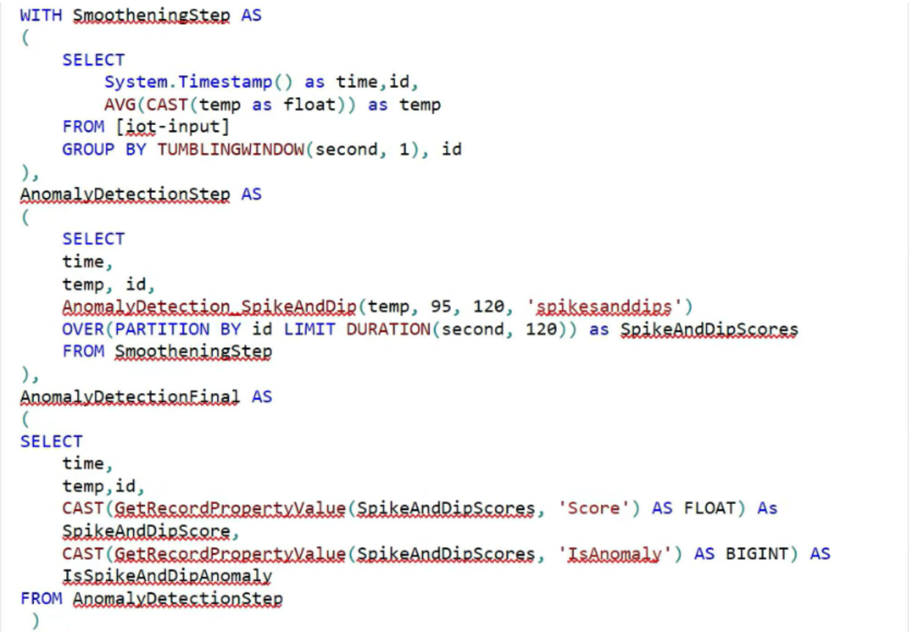
Event Hub namespace *: smartmenter

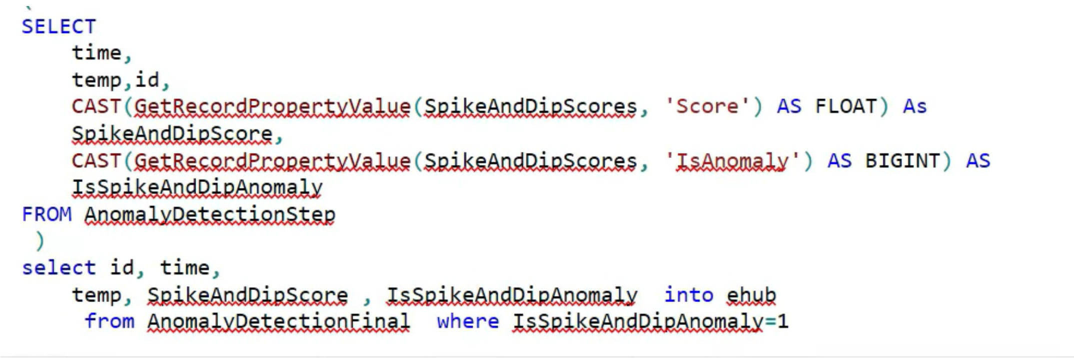
Event Hub name *: ○ Create new ● Use existing

anamolydetector

Authentication mode

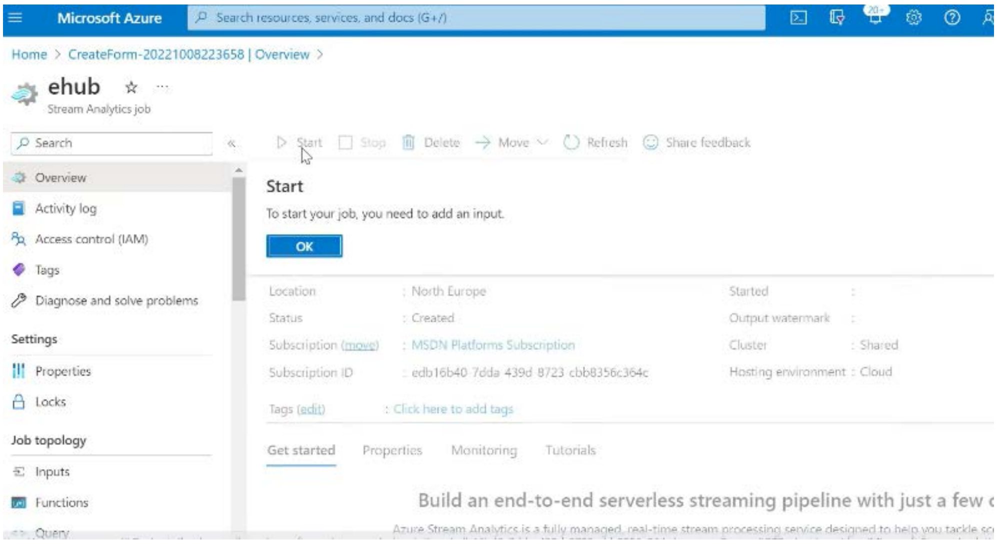
Search
Diagnose and solve problems
Settings
Properties
Locks
Job topology
Inputs
Functions
Query
Outputs
Configure
Environment
+ Add
Refresh


```
WITH SmootheningStep AS
(
    SELECT
        System.Timestamp() as time,id,
        AVG(CAST(temp as float)) as temp
    FROM [iot-input]
    GROUP BY TUMBLINGWINDOW(second, 1), id
),
AnomalyDetectionStep AS
(
    SELECT
    time,
    temp, id,
    AnomalyDetection_SpikeAndDip(temp, 95, 120, 'spikesanddips')
    OVER(PARTITION BY id LIMIT DURATION(second, 120)) as SpikeAndDipScores
    FROM SmootheningStep
),
AnomalyDetectionFinal AS
(
SELECT
    time,
    temp,id,
    CAST(GetRecordPropertyValue(SpikeAndDipScores, 'Score') AS FLOAT) As
    SpikeAndDipScore,
    CAST(GetRecordPropertyValue(SpikeAndDipScores, 'IsAnomaly') AS BIGINT) AS
    IsSpikeAndDipAnomaly
FROM AnomalyDetectionStep
 )
```



```
`
SELECT
    time,
    temp,id,
    CAST(GetRecordPropertyValue(SpikeAndDipScores, 'Score') AS FLOAT) As
    SpikeAndDipScore,
    CAST(GetRecordPropertyValue(SpikeAndDipScores, 'IsAnomaly') AS BIGINT) AS
    IsSpikeAndDipAnomaly
FROM AnomalyDetectionStep
 )
select id, time,
    temp, SpikeAndDipScore , IsSpikeAndDipAnomaly  into ehub
     from AnomalyDetectionFinal  where IsSpikeAndDipAnomaly=1
```

After query writing, press start:



Start

To start your job, you need to add an input.

Location : North Europe

Status : Created

Subscription (move) : MSDN Platforms Subscription

Subscription ID : edb16b40-7dda-439d-8723-cbb8356c364c

Tags (edit) : Click here to add tags

Started :

Output watermark :

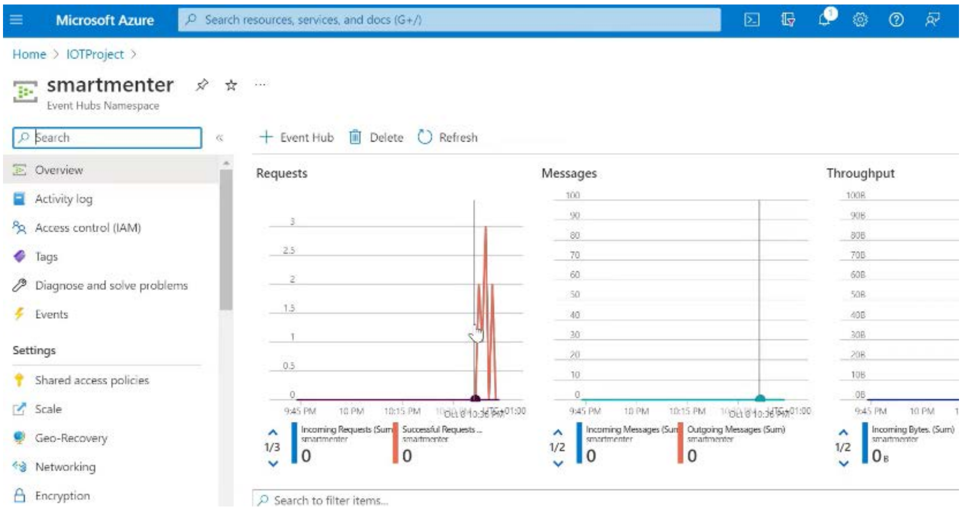
Cluster : Shared

Hosting environment : Cloud

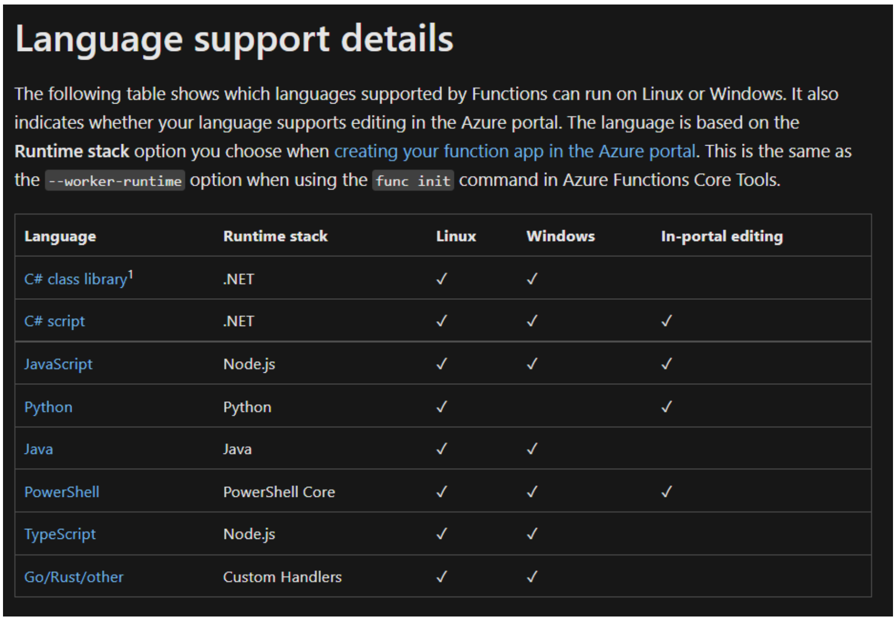
Build an end-to-end serverless streaming pipeline with just a few c

Azure Stream Analytics is a fully managed, real-time stream processing service designed to help you tackle sc

Data started flowing, we can see output:



- Create function app:
  Basics of **Azure Function**-
  It lets you run code in serverless environment without creating virtual machine or publish web application.

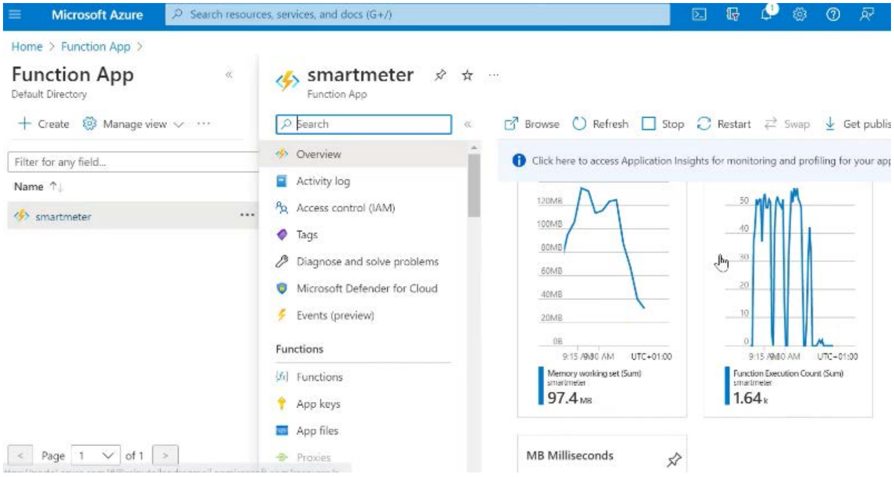


Language support details

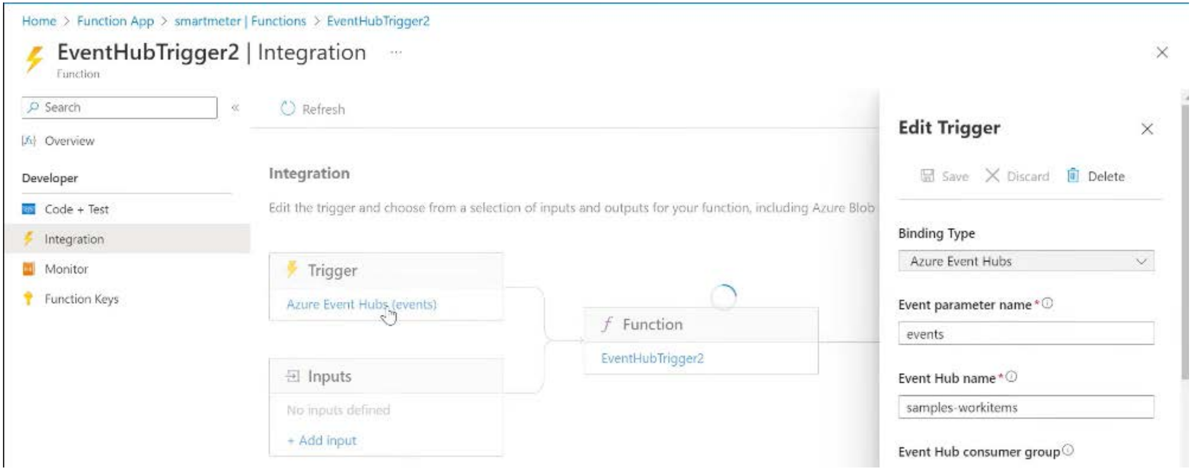
The following table shows which languages supported by Functions can run on Linux or Windows. It also indicates whether your language supports editing in the Azure portal. The language is based on the **Runtime stack** option you choose when creating your function app in the Azure portal. This is the same as the `--worker-runtime` option when using the `func init` command in Azure Functions Core Tools.

Language	Runtime stack	Linux	Windows	In-portal editing
C# class library[1]	.NET	✓	✓	
C# script	.NET	✓	✓	✓
JavaScript	Node.js	✓	✓	✓
Python	Python	✓		✓
Java	Java	✓	✓	
PowerShell	PowerShell Core	✓	✓	✓
TypeScript	Node.js	✓	✓	
Go/Rust/other	Custom Handlers	✓	✓	

Let's start creating it:



we need to write logic in Azure Function:


Home > Function App > smartmeter | Functions > EventHubTrigger2
EventHubTrigger2 | Integration
Function
Search
Overview
Developer
Code + Test
Integration
Monitor
Function Keys
Refresh
Integration

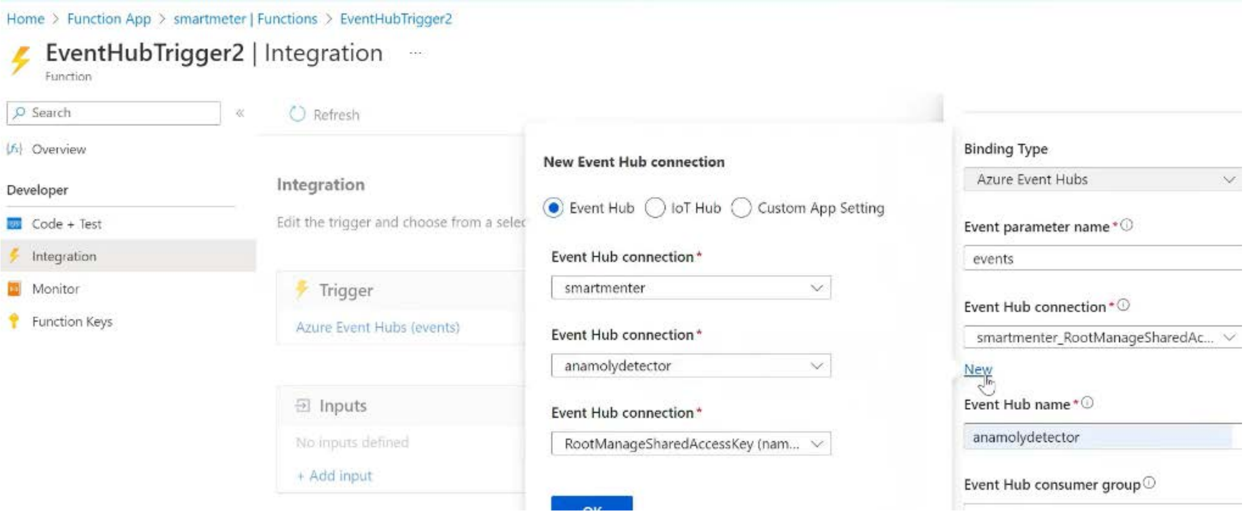
Edit the trigger and choose from a selection of inputs and outputs for your function, including Azure Blob

Binding Type: Azure Event Hubs

Event parameter name *: events

Event Hub name *: samples-workitems

Event Hub consumer group



Home > Function App > smartmeter | Functions > EventHubTrigger2

EventHubTrigger2 | Integration

Function

New Event Hub connection

● Event Hub ○ IoT Hub ○ Custom App Setting

Event Hub connection* smartmenter

Event Hub connection* anamolydetector

Event Hub connection* RootManageSharedAccessKey (nam...

Binding Type: Azure Event Hubs

Event parameter name*: events

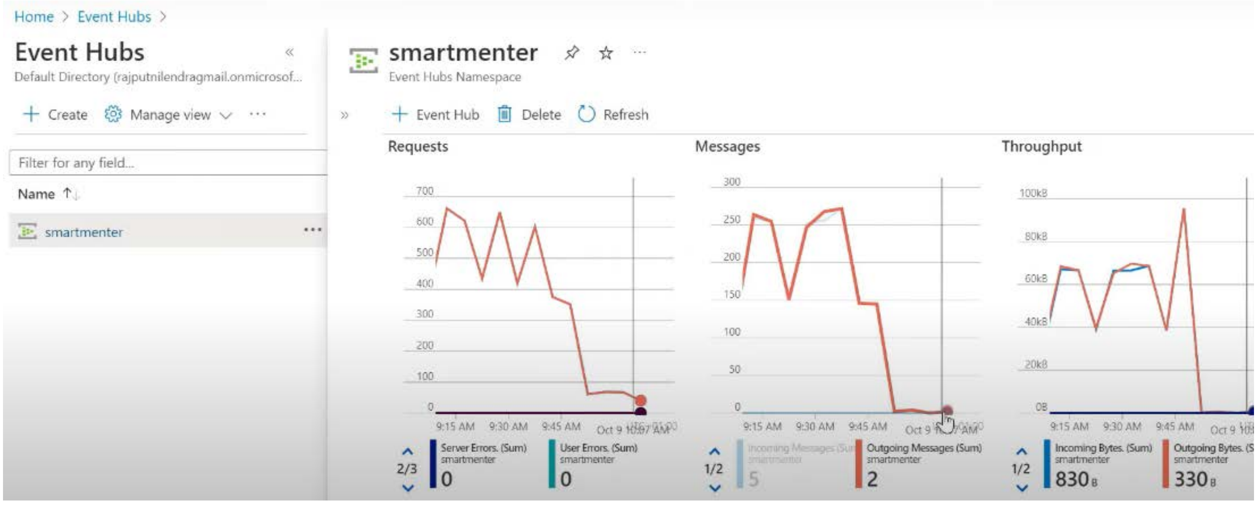
Event Hub connection*: smartmenter_RootManageSharedAc...

New

Event Hub name*: anamolydetector

Event Hub consumer group

Event hub has started detecting data:



Home > Event Hubs >

Event Hubs

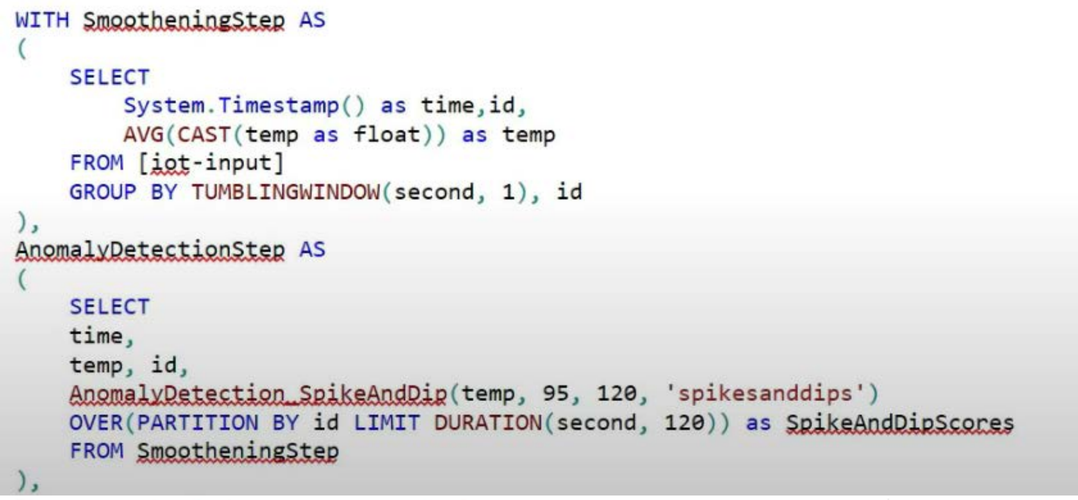
Default Directory (rajputnilendragmail.onmicrosof...

smartmenter

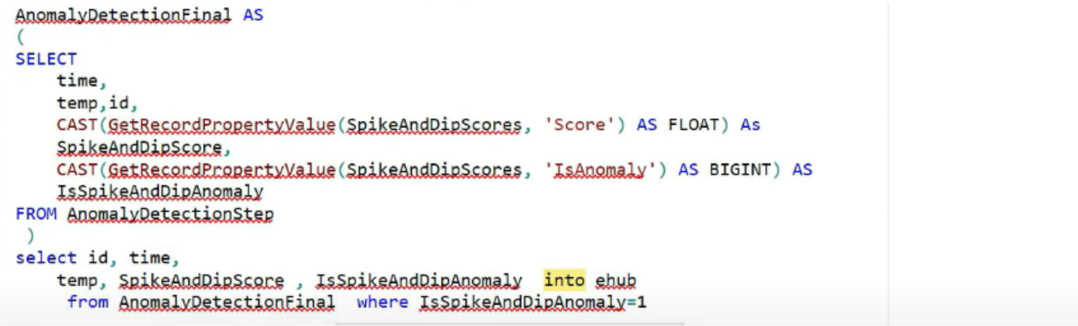
Event Hubs Namespace

+ Event Hub
Delete
Refresh
Requests
700
600
500
400
300
200
100
0
9:15 AM
9:30 AM
9:45 AM
Oct 9 10:07 AM
2/3
Server Errors. (Sum) smartmenter 0
User Errors. (Sum) smartmenter 0
Messages
300
250
200
150
100
50
0
9:15 AM
9:30 AM
9:45 AM
Oct 9
1/2
Incoming Messages (Sum) smartmenter 5
Outgoing Messages (Sum) smartmenter 2
Throughput
100kB
80kB
60kB
40kB
20kB
0B
9:15 AM
9:30 AM
9:45 AM
Oct 9
1/2
Incoming Bytes. (Sum) smartmenter 830 B
Outgoing Bytes. (S smartmenter 330 B

- Now paste Query



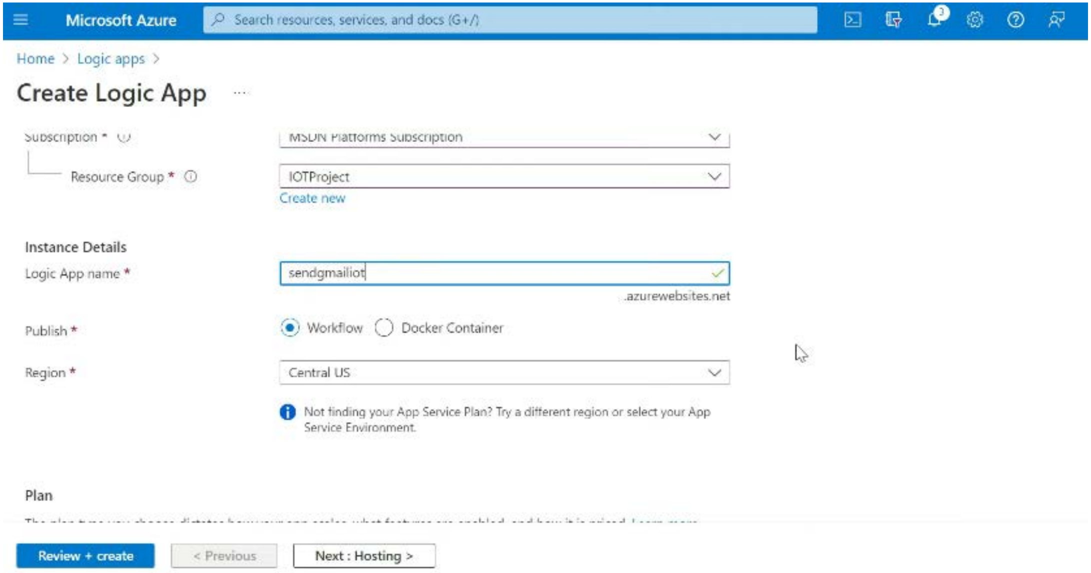
```
WITH SmootheningStep AS
(
    SELECT
        System.Timestamp() as time,id,
        AVG(CAST(temp as float)) as temp
    FROM [iot-input]
    GROUP BY TUMBLINGWINDOW(second, 1), id
),
AnomalyDetectionStep AS
(
    SELECT
    time,
    temp, id,
    AnomalyDetection_SpikeAndDip(temp, 95, 120, 'spikesanddips')
    OVER(PARTITION BY id LIMIT DURATION(second, 120)) as SpikeAndDipScores
    FROM SmootheningStep
),
```



```
AnomalyDetectionFinal AS
(
SELECT
    time,
    temp,id,
    CAST(GetRecordPropertyValue(SpikeAndDipScores, 'Score') AS FLOAT) As
    SpikeAndDipScore,
    CAST(GetRecordPropertyValue(SpikeAndDipScores, 'IsAnomaly') AS BIGINT) AS
    IsSpikeAndDipAnomaly
FROM AnomalyDetectionStep
 )
select id, time,
    temp, SpikeAndDipScore , IsSpikeAndDipAnomaly  into ehub
     from AnomalyDetectionFinal  where IsSpikeAndDipAnomaly=1
```

There is no anomaly detected currently.

- Write logic of app:



Subscription * MSDN Platforms Subscription

Resource Group * IOTProject

Create new

Instance Details

Logic App name * sendgmailiot .azurewebsites.net

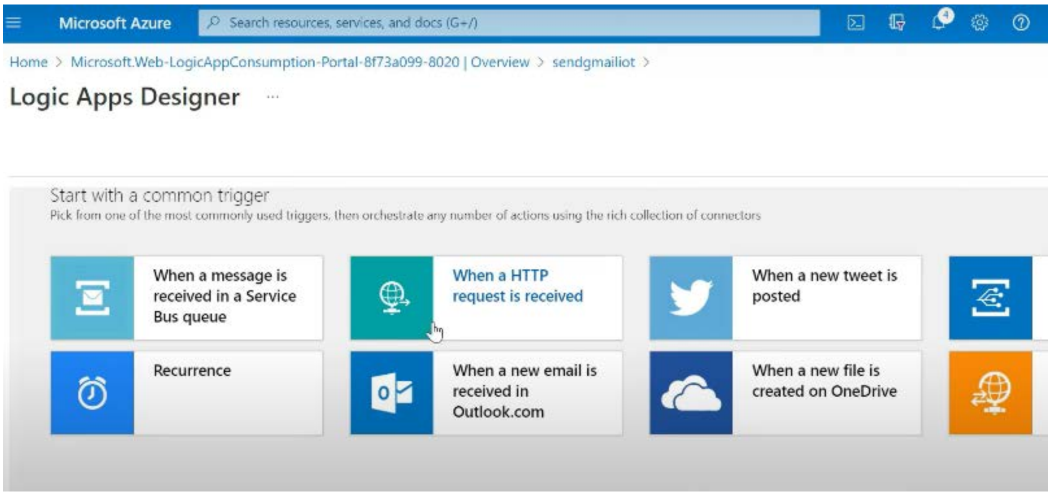
Publish * ● Workflow ○ Docker Container

Region * Central US

Not finding your App Service Plan? Try a different region or select your App Service Environment.

Plan

Click “go to resources”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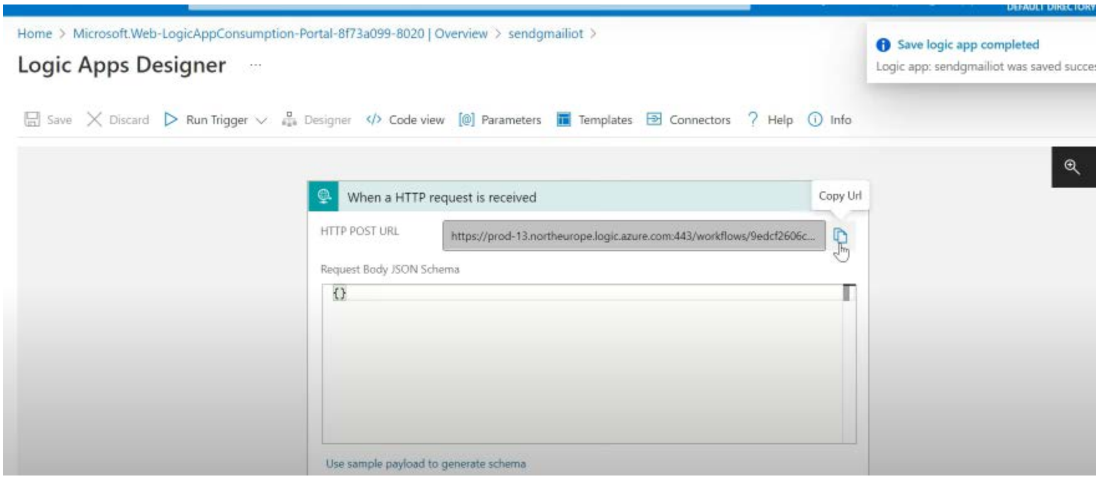
Logic Apps Designer
When a message is received in a Service Bus queue
When a HTTP request is received
When a new tweet is posted
Recurrence
When a new email is received in Outlook.com
When a new file is created on OneDrive

Start with a common trigger

Pick from one of the most commonly used triggers, then orchestrate any number of actions using the rich collection of connectors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Save
Discard
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Parameters
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Info
When a HTTP request is received
Copy Url
Use sample payload to generate schema

Save logic app completed

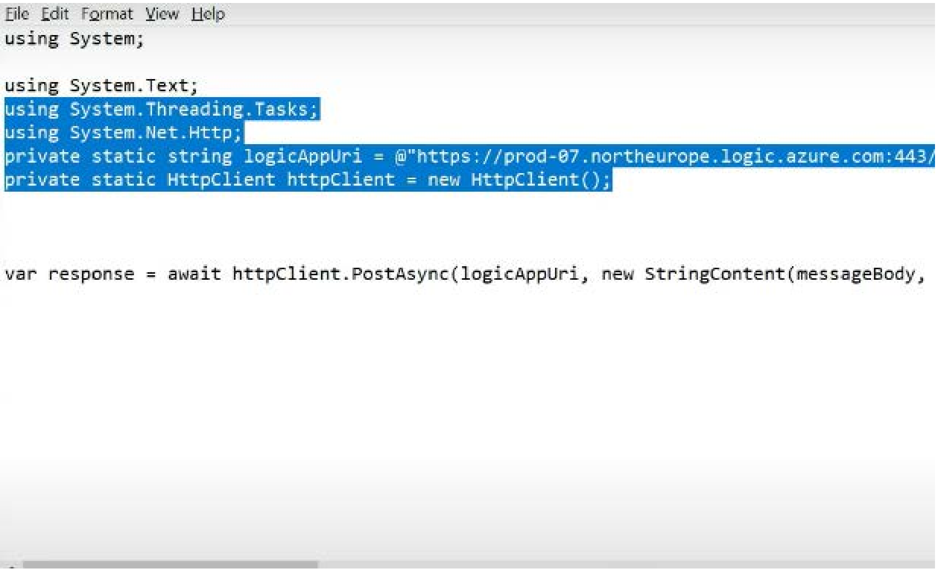
Logic app: sendgmailiot was saved succe

HTTP POST URL https://prod-13.northeurope.logic.azure.com:443/workflows/9edcf2606c...

Request Body JSON Schema

```
{}
```

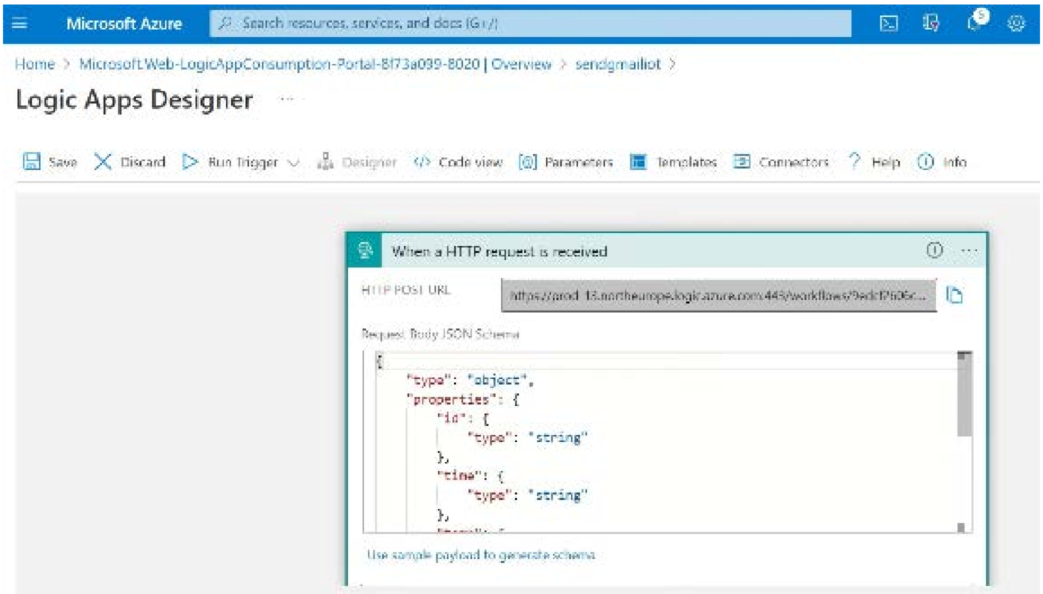
We need to add some code to existing one, paste URL just copied into function:



```
using System;

using System.Text;
using System.Threading.Tasks;
using System.Net.Http;
private static string logicAppUri = @"https://prod-07.northeurope.logic.azure.com:443/
private static HttpClient httpClient = new HttpClient();


var response = await httpClient.PostAsync(logicAppUri, new StringContent(messageBody,
```



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When a HTTP request is received

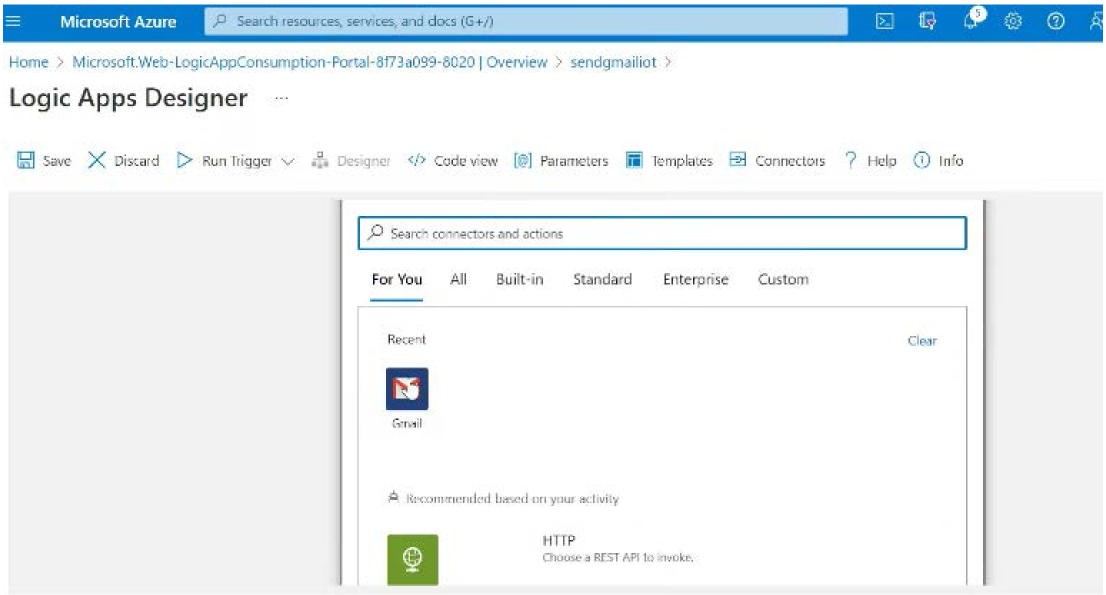
HTTP POST URL: https://prod-13.northeurope.logic.azure.com:443/workflows/9edcf2b06c...

Request Body JSON Schema

```
{
    "type": "object",
    "properties": {
        "id": {
            "type": "string"
        },
        "time": {
            "type": "string"
        },
```

Use sample payload to generate schema

❖ Create link between function and email.



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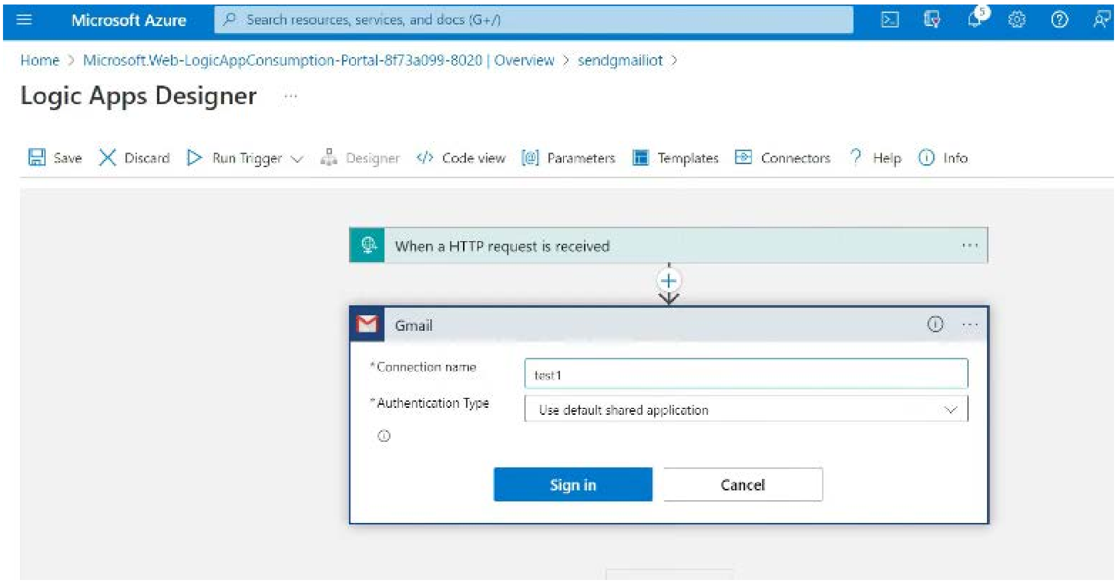
For You
All
Built-in
Standard
Enterprise
Custom
Recent
Clear
Gmail
Recommended based on your activity
HTTP
Choose a REST API to invoke.

Logic Apps Designer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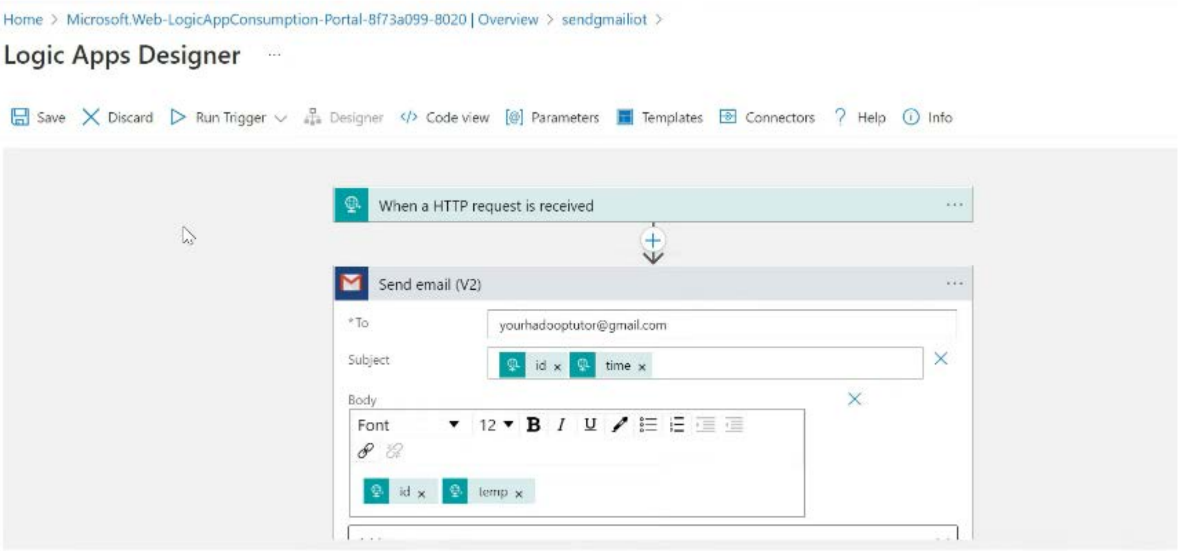
When a HTTP request is received
Gmail
Sign in
Cancel

*Connection name: test1

*Authentication Type: Use default shared application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Save
Discard
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Designer
Code view
Parameters
Templates
Connectors
Help
Info
When a HTTP request is received
Send email (V2)
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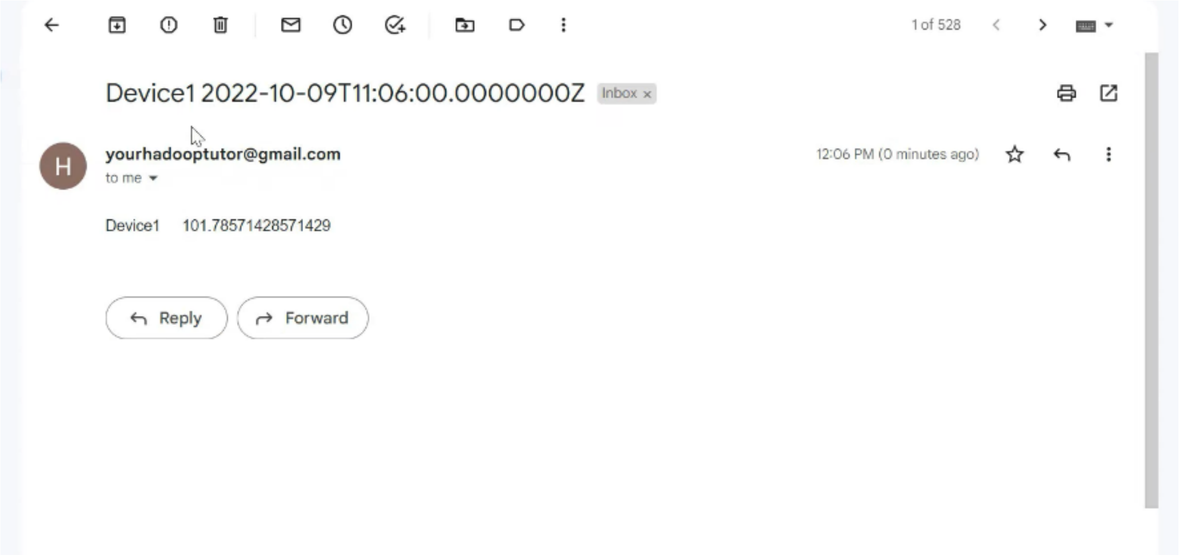
*To: yourhadooptutor@gmail.com

Subject: id × time ×

Body: id × temp ×

- ❖ As anomaly detected, email will be sent.
  Here, temperature is done 110 so the email is been sent.



Device1 2022-10-09T11:06:00.0000000Z

yourhadooptutor@gmail.com
to me

12:06 PM (0 minutes ago)

Device1 101.78571428571429

Hence, we have successfully created Temperature Alert.

➢ Source Code –

Github

Knowledge sharing:

- Use of databricks can process large amounts of data. Databricks is integrated with azure AD. It supports many languages (Scala, Python).
- IoT Hub provides device libraries, secure communication and meta-data.

Challenges faced:

1) While storing data, containers were not reflecting in storage account. Recreating storage account solved this issue.
2) Anomaly detection was not working. Changing in code required to make it work.
3) Changes in the graph were not visible. It was challenging task; change is anomaly code made graph into function.

Business Benefits:

1) Temperature alert can be used wherever we need to send alert to know, unusual happening beforehand.
2) In steel power plant alert can be set, through which temperature can be controlled.
3) It makes task more efficient and infallible.
4) In medical, storing medicines requires temperature check.
5) It focuses on automation hence, reduces manual work.
6) To avoid spoiling of grains framer stores it in certain temperature, automation can be applied.

I believe helping others through sharing knowledge, hence permission granted to Microsoft to share content on their platforms.

-By Amatulla Bohara