CSS 532 Internet of Things

HW2 Report

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1.Impelemation

1.1Implementation hierarchy

The whole architecture of my cloud services and programs are shown in fig1.

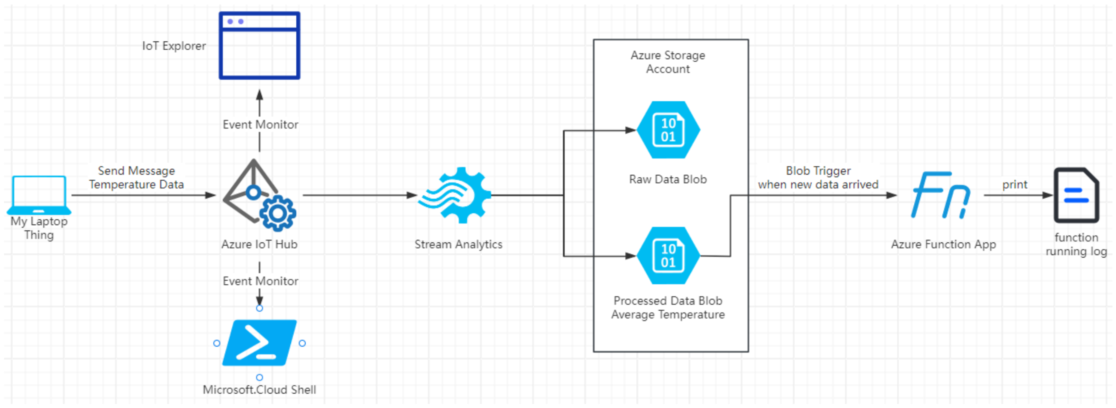


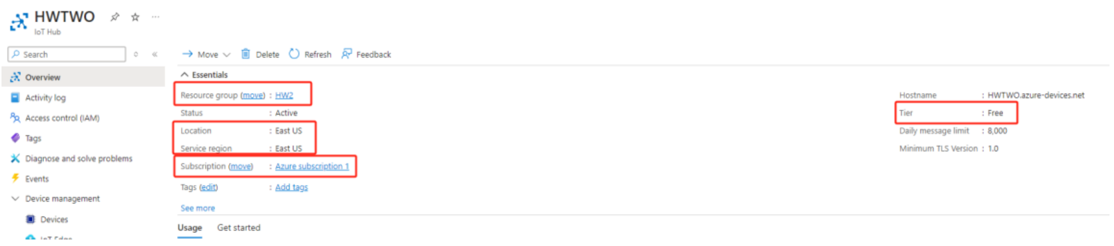
Fig1. Cloud Service and Program Architecture

My laptop is the only thing in this IoT network, which is the start of the whole program. When I run my IoT client program on my laptop, it sends an array of temperature data to the Azure IoT Hub. Meanwhile, the Azure CLI (running on Microsoft Cloud Shell) and IoT Explorer are monitoring the event triggered by my laptop. Once the event is precepted by those, user could easily observe the temperature data sent from my laptop. After that, Azure system analytics is going to do data processing. That includes raw data passing to Azure Blob file and calculating the average temperature data from that array of temperature data mentioned before and then passing it to another Azure Blob file. Finally, An Azure function keeps monitoring the blob file which is used for storing processed data. Once the newly arrived average temperature data is documented in that blob file, my function will download the whole blob file and print the data into the log, which could also be accessed by the user.

1.2Implementation Checklist

1.2.1 Configure your laptop as an IoT device, which can communicate with Azure IoT Hub.

This step is easier than what we did in hw1 on AWS IoT Core. First of all, create a IoT Hub under a certain resource group. User could create a IoT Hub on webpage or by Azure CLI. My IoT Hub is shown in fig2.

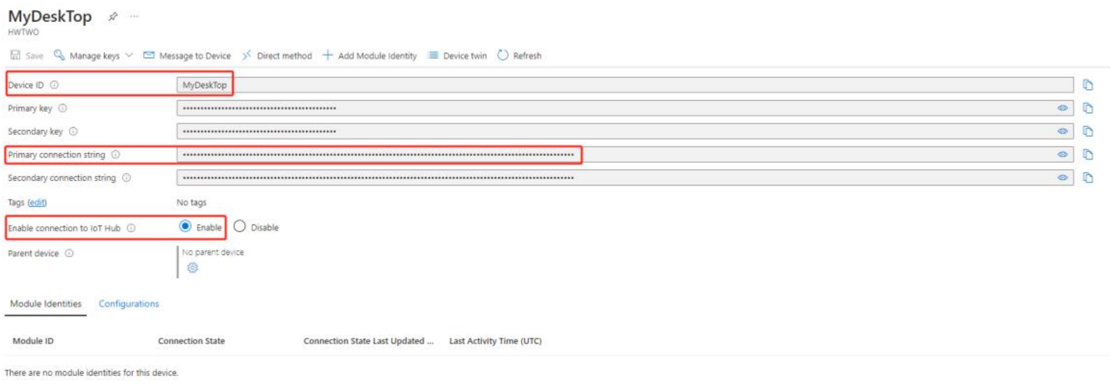


Resource group (move)	: HW2
Status	: Active
Location	: East US
Service region	: East US
Subscription (move)	: Azure subscription 1
Tags (edit)	: Add tags

Hostname	: HWTWO.azure-devices.net
Tier	: Free
Daily message limit	: 8,000
Minimum TLS Version	: 1.0

Fig2. My IoT Hub Configuration

After that, I created a device by the button, device, on the left column of the IoT Hub main page. By clicking on “Add Device” button and filling out a form, I got a virtual device information which contains credentials for further connection. My device configuration is shown in Fig3. Usually, the thing creator need to remember the connection string.



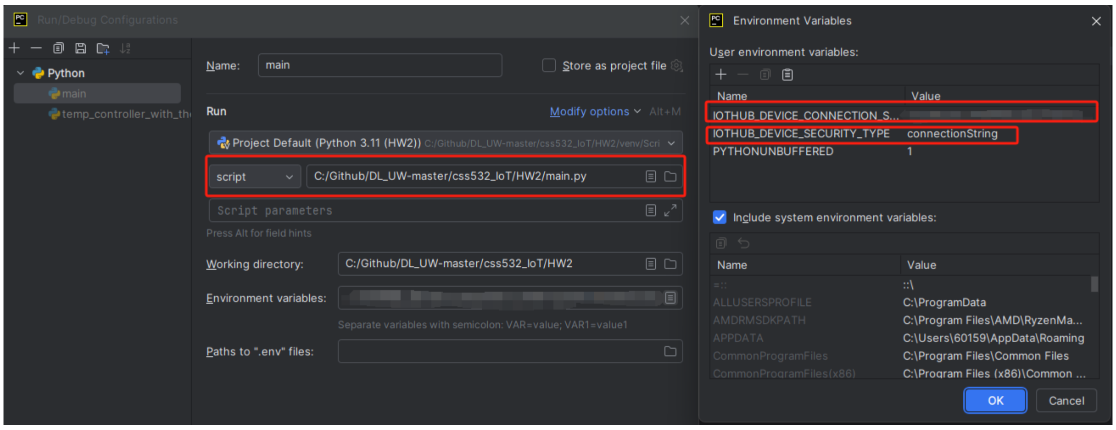
Device ID	MyDeskTop
Primary key	••
Secondary key	••
Primary connection string	••
Secondary connection string	••
Tags (edit)	No tags
Enable connection to IoT Hub	[✓ Enable] Disable
Parent device	No parent device

Module ID	Connection State	Connection State Last Updated ...	Last Activity Time (UTC)

There are no module identities for this device.

Fig3. My Device Configuration

Then, I downloaded the quick start demo of Azure IoT Hub and running it on my own computer. The key of identifying my laptop to the virtual thing I mentioned above, is adding connection string into my laptop’s system variables. If programs run on some IDE like PyCharm, user is suggested to adding those system variables into their running configuration since the usage of virtual environment. My system environment was set as in Fig4.



Run/Debug Configurations

- Python
  - main
  - temp_controller_with_th

Name: main
Store as project file: ☐

Run — Modify options (Alt+M)

Project Default (Python 3.11 (HW2)) C:/Github/DL_UW-master/css532_IoT/HW2/venv/Scri

script: C:/Github/DL_UW-master/css532_IoT/HW2/main.py

Script parameters

Press Alt for field hints

Working directory: C:/Github/DL_UW-master/css532_IoT/HW2

Environment variables: [redacted]

Separate variables with semicolon: VAR=value; VAR1=value1

Paths to ".env" files:

Environment Variables

User environment variables:

Name	Value
IOTHUB_DEVICE_CONNECTION_S...	[redacted]
IOTHUB_DEVICE_SECURITY_TYPE	connectionString
PYTHONUNBUFFERED	1

✓ Include system environment variables:

Name	Value
=::	::\
ALLUSERSPROFILE	C:\ProgramData
AMDRMSDKPATH	C:\Program Files\AMD\RyzenMa...
APPDATA	C:\Users\60159\AppData\Roaming
CommonProgramFiles	C:\Program Files\Common Files
CommonProgramFiles(x86)	C:\Program Files (x86)\Common ...

OK Cancel

Fig4. Environment Variables Configuration

The last thing of making my laptop communicating with the IoT Hub is just connection establishment. I achieved this in my code by Azure IoT SDK.

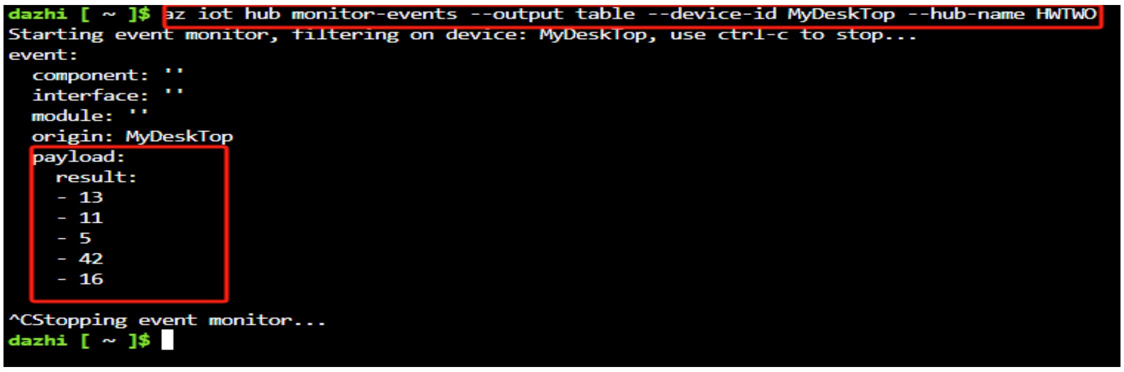
```
device_client = IoTHubDeviceClient.create_from_connection_string(
    conn_str, product_info=model_id
)
```

1.2.2 Configure Azure IoT Hub to receive messages from your device (laptop) and show the result in Azure IoT Hub console.

By coding with Azure IoT SDK, I got a program which could send message to the IoT Hub. Codes could be accessed within the zip file. The principle is using device client to send temperature data. An array of 5 number, each randomly generated.

If user want to review the message from the CLI, they should run the following command on Microsoft Cloud Shell: az iot hub monitor-events --output table --device-id {user_defined_devicde_id} --hub-name {user_defined_iot_hub_name}.

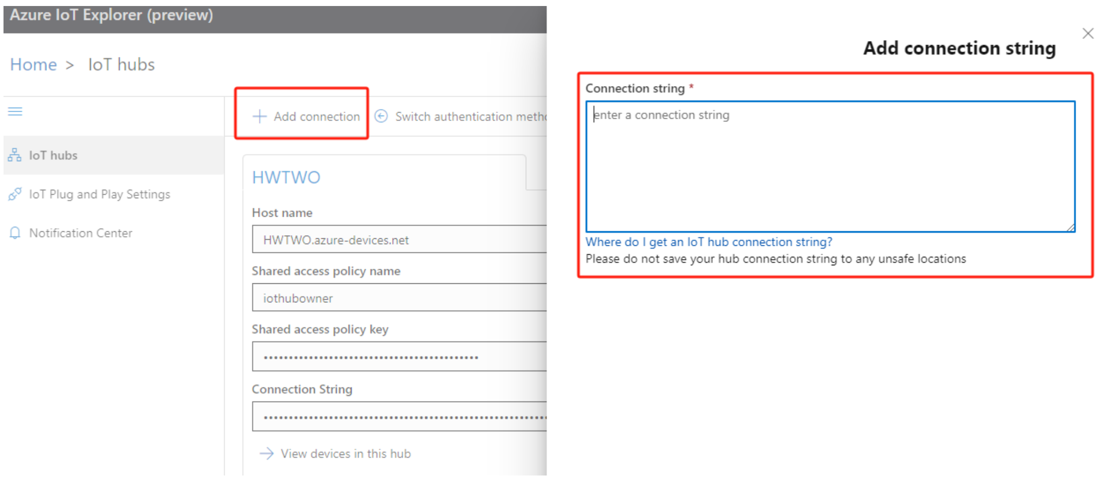
As a result, I could see my message as shown in fig5.



```
dazhi [ ~ ]$ az iot hub monitor-events --output table --device-id MyDeskTop --hub-name HWTWO
Starting event monitor, filtering on device: MyDeskTop, use ctrl-c to stop...
event:
  component: ''
  interface: ''
  module: ''
  origin: MyDeskTop
  payload:
    result:
    - 13
    - 11
    - 5
    - 42
    - 16

^CStopping event monitor...
dazhi [ ~ ]$
```

Fig5. CLI message result

If user want to see the message in IoT Explorer, a GUI tool for IoT Hub, user should obtain their IoT Hub connection string first and connect it via IoT Explorer. The connection details are shown in Fig6.


Azure IoT Explorer (preview)
Home > IoT hubs
Add connection
Switch authentication meth
IoT hubs
IoT Plug and Play Settings
Notification Center
HWTWO
View devices in this hub
Add connection string
Where do I get an IoT hub connection string?

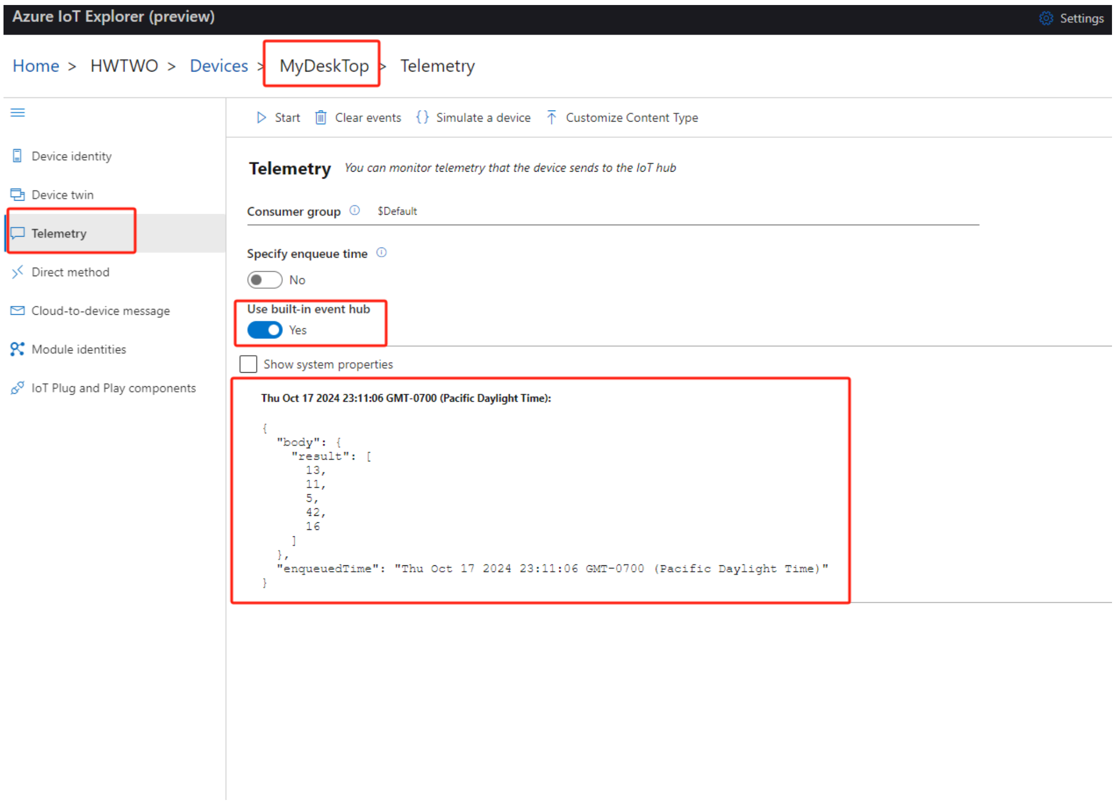
Host name: HWTWO.azure-devices.net
Shared access policy name: iothubowner
Shared access policy key: ••
Connection String: ••

Connection string *: enter a connection string

Please do not save your hub connection string to any unsafe locations

Fig6. Connecting IoT Hub via IoT Explorer

If a connection is established, user could select device/thing which is created before in the IoT Explorer. After getting into the device information, users are suggested to click telemetry on the left column. And once clicking start, the IoT Explorer will monitor event triggered by the specific device. If a message is sent by device, the message will be shown on the IoT Explorer as shown in fig7.


Azure IoT Explorer (preview)
Settings
Home > HWTWO > Devices > MyDeskTop > Telemetry
Start
Clear events
Simulate a device
Customize Content Type
Device identity
Device twin
Telemetry
Direct method
Cloud-to-device message
Module identities
IoT Plug and Play components
Telemetry
You can monitor telemetry that the device sends to the IoT hub

Consumer group: $Default
Specify enqueue time: No
Use built-in event hub: Yes
Show system properties

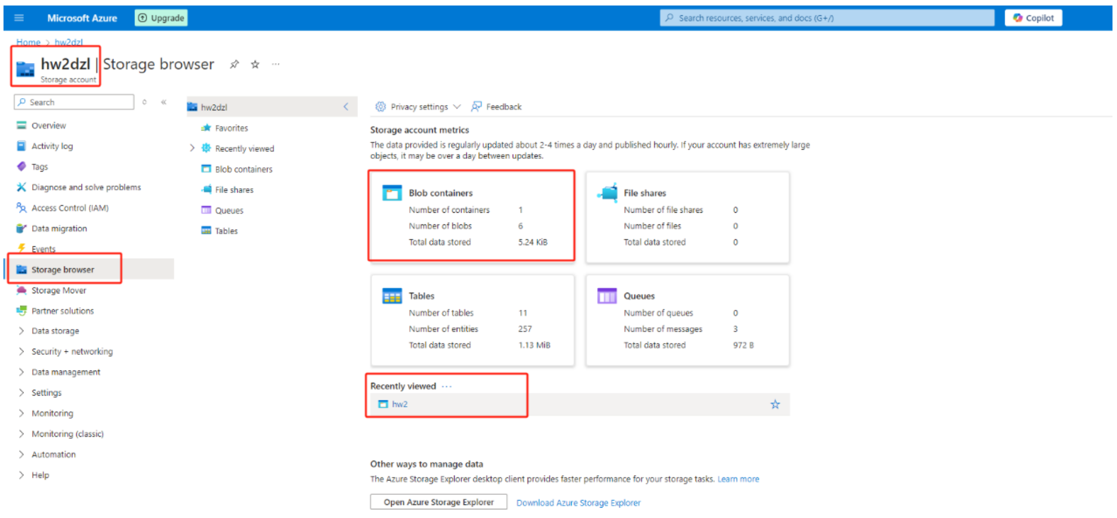
```
Thu Oct 17 2024 23:11:06 GMT-0700 (Pacific Daylight Time):

{
  "body": {
    "result": [
      13,
      11,
      5,
      42,
      16
    ]
  },
  "enqueuedTime": "Thu Oct 17 2024 23:11:06 GMT-0700 (Pacific Daylight Time)"
}
```

Fig.7 IoT Explorer Message Result

1.2.3 Connect Azure Stream Analytics to your Azure IoT Hub to process received messages from devices and save the raw data (the data shall be extracted from received messages) and the processed data (you should use Stream Analytics to process the data) into Azure Blob.

The key feature here is how to create a stream analytics flow and how to write a proper SQL codes by using the featured windows provided by Azure Strem Analytics.

The very first thing here is creating an Azure Storage Account. This Storage Account provides Blob Storage service. And users are supposed to create a container in an account first. This is very important for generating the output. The successful result should be like fig.8.



Storage account metrics

The data provided is regularly updated about 2-4 times a day and published hourly. If your account has extremely large objects, it may be over a day between updates.

Blob containers	
Number of containers	1
Number of blobs	6
Total data stored	5.24 KiB
File shares	
Number of file shares	0
Number of files	0
Total data stored	0
Tables	
Number of tables	11
Number of entities	257
Total data stored	1.13 MiB
Queues	
Number of queues	0
Number of messages	3
Total data stored	972 B

Recently viewed ···

hw2

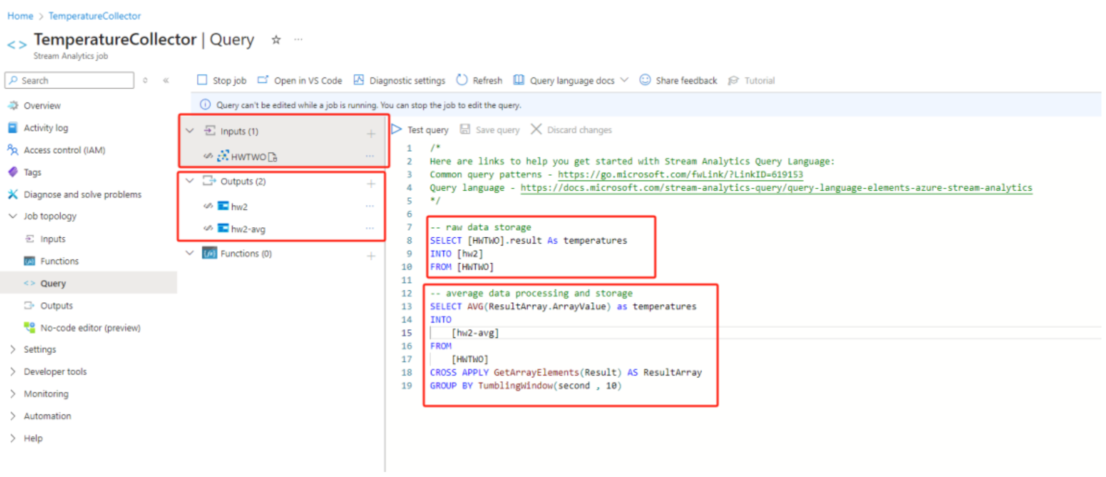
Other ways to manage data

The Azure Storage Explorer desktop client provides faster performance for your storage tasks.

Fig8. Azure Storage Account

The second thing is creating stream analytics for sure. Its input should be IoT Hub which exactly matches with the one we used before. However, I set two different outputs here. One for saving data to the raw data blob. The other one for storing data to the processed data blob.

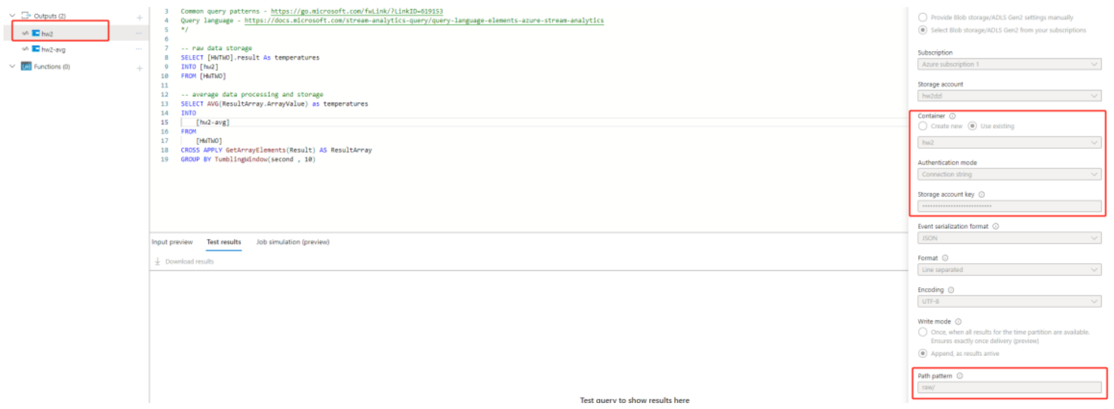
Then, I wrote SQL codes as shown in Fig9. Codes could also be accessed within the zip file. The first select sentence extract data from the message and store them into a blob file, which is the output named hw2. The second select sentence aggregate the data and calculate the average data and storing them into the other blob file, which is the output named hw2-avg.



```
/*
Here are links to help you get started with Stream Analytics Query Language:
Common query patterns - https://go.microsoft.com/fwLink/?LinkID=619153
Query language - https://docs.microsoft.com/stream-analytics-query/query-language-elements-azure-stream-analytics
*/

-- raw data storage
SELECT [HWTWO].result As temperatures
INTO [hw2]
FROM [HWTWO]

-- average data processing and storage
SELECT AVG(ResultArray.ArrayValue) as temperatures
INTO
    [hw2-avg]
FROM
    [HWTWO]
CROSS APPLY GetArrayElements(Result) AS ResultArray
GROUP BY TumblingWindow(second , 10)
```

Fig9. Stream Analytics Configuration

I differentiate the output by assigning results to different path, as shown in fig10.



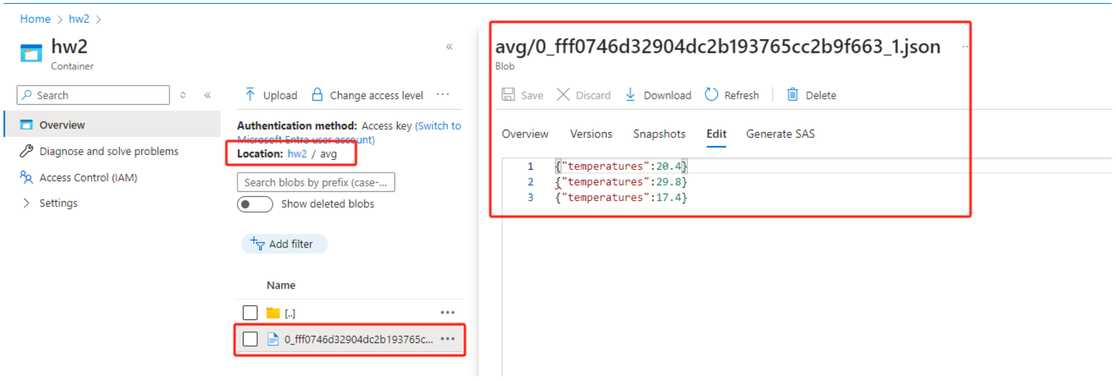
```
Common query patterns - https://go.microsoft.com/fwLink/?LinkID=619153
Query language - https://docs.microsoft.com/stream-analytics-query/query-language-elements-azure-stream-analytics
*/

-- raw data storage
SELECT [HWTWO].result As temperatures
INTO [hw2]
FROM [HWTWO]

-- average data processing and storage
SELECT AVG(ResultArray.ArrayValue) as temperatures
INTO
    [hw2-avg]
FROM
    [HWTWO]
CROSS APPLY GetArrayElements(Result) AS ResultArray
GROUP BY TumblingWindow(second , 10)
```

○ Provide Blob storage/ADLS Gen2 settings manually
[✓ Select Blob storage/ADLS Gen2 from your subscriptions]

Subscription: Azure subscription 1
Storage account: hw2dzl
Container: ○ Create new [✓ Use existing]
hw2
Authentication mode: Connection string
Storage account key: ****************************
Event serialization format: JSON
Format: Line separated
Encoding: UTF-8
Write mode: ○ Once, when all results for the time partition are available. Ensures exactly once delivery (preview)
[✓ Append, as results arrive]
Path pattern: raw/

Fig10. Output Configuration

After starting this job, I could send message to IoT Hub again. Under the influence of Stream Analytics, I should see two separate files in my Storage Account. As shown in Fig11. and Fig12. One thing I have to mention that is my output setting is appending new message to the previous line. So, we could see multiple lines of data generated from my computer and stored into the blob.

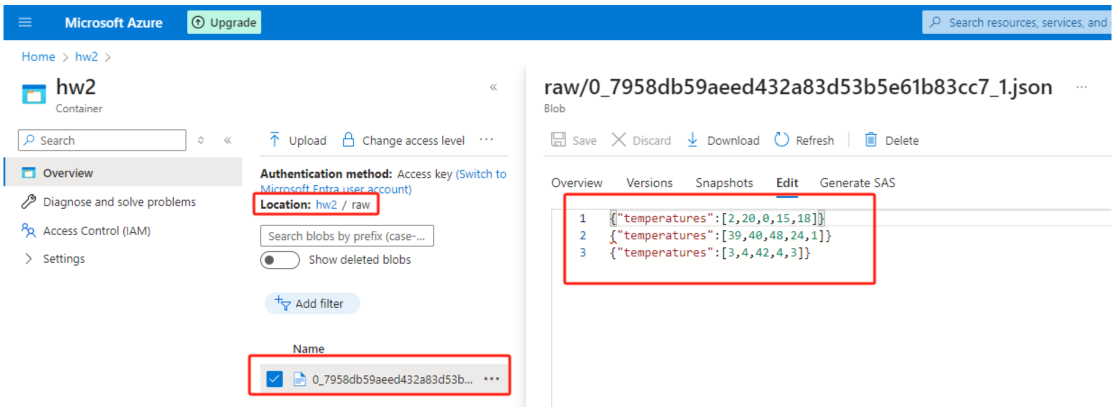


Authentication method: Access key (Switch to Microsoft Entra user account)
Location: hw2 / avg

avg/0_fff0746d32904dc2b193765cc2b9f663_1.json
Blob

```
{"temperatures":20.4}
{"temperatures":29.8}
{"temperatures":17.4}
```

Fig11. Average Temperature Data in Blob



Authentication method: Access key (Switch to Microsoft Entra user account)

Location: hw2 / raw

```
{"temperatures":[2,20,0,15,18]}
{"temperatures":[39,40,48,24,1]}
{"temperatures":[3,4,42,4,3]}
```

Fig12. Raw Temperature Data in Blob

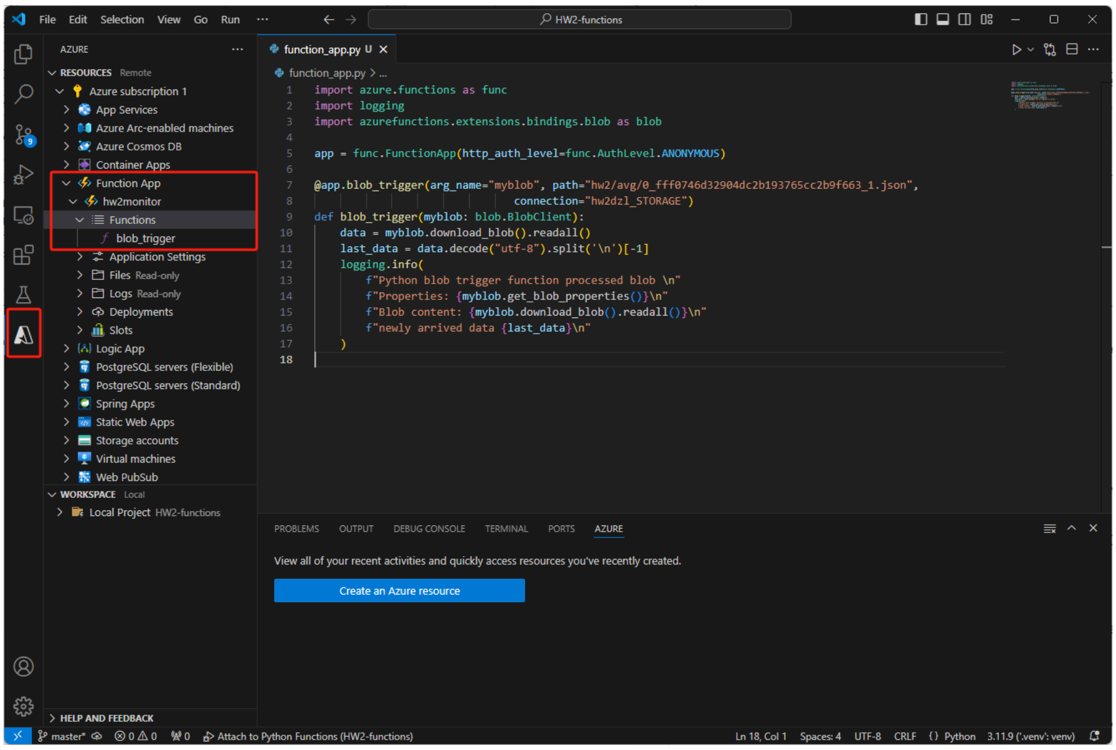
As a result, we could see two files in the Azure Blob.

1.2.4Connect Azure Functions to respond to Azure Blob events when new "processed data" is added. Your Azure Function may simply print out the content of newly added data, which is the "processed data" obtained in Step 3.

This step is a little bit harder than what we did in previous HW1 AWS lambda function. I think the difficulty comes from the totally different code editing ways.

In Azure, I do not know why I cannot get an online editor and finish those job. I have to download Visual Studio Code and modify my code on my local IDE and deploy them later on Azure Function App.

The first thing here is downloading different kind of prerequisites like azure function extensions and relating libraries for local debugging. The Azure function extension should be like in Fig13.

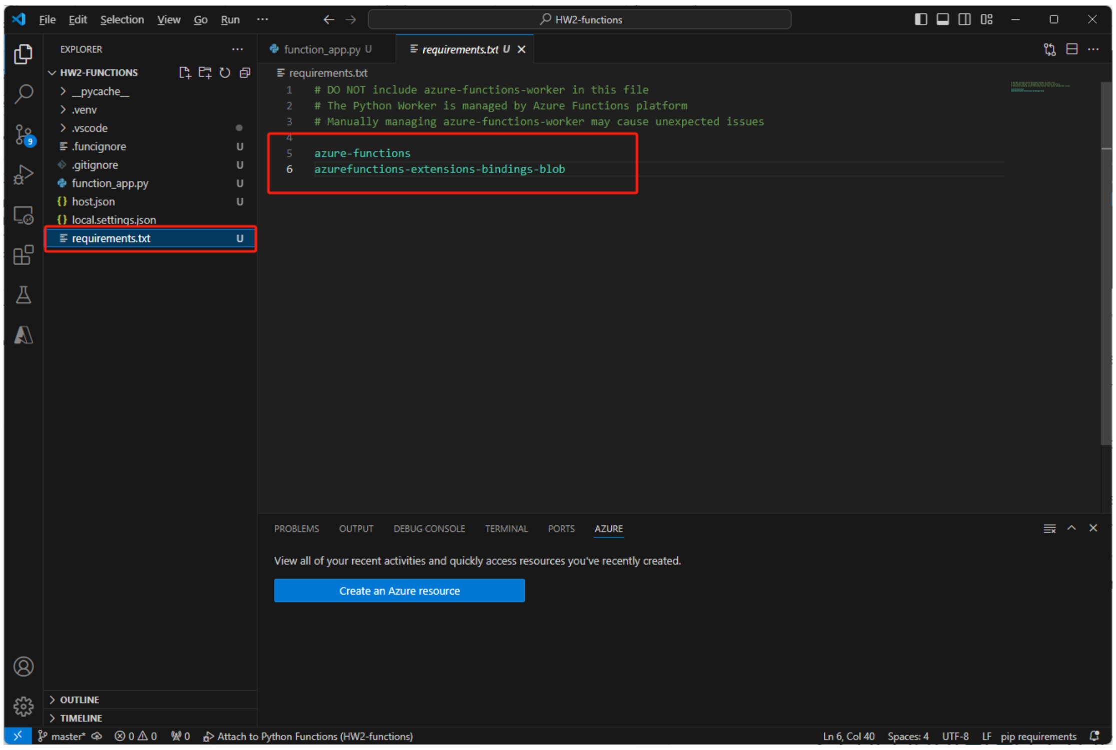


```python
import azure.functions as func
import logging
import azurefunctions.extensions.bindings.blob as blob

app = func.FunctionApp(http_auth_level=func.AuthLevel.ANONYMOUS)

@app.blob_trigger(arg_name="myblob", path="hw2/avg/0_fff0746d32904dc2b193765cc2b9f663_1.json",
                               connection="hw2dzl_STORAGE")
def blob_trigger(myblob: blob.BlobClient):
    data = myblob.download_blob().readall()
    last_data = data.decode("utf-8").split('\n')[-1]
    logging.info(
        f"Python blob trigger function processed blob \n"
        f"Properties: {myblob.get_blob_properties()}\n"
        f"Blob content: {myblob.download_blob().readall()}\n"
        f"newly arrived data {last_data}\n"
    )

```

View all of your recent activities and quickly access resources you've recently created.

Fig13. Azure Function Extension

When those coding are finished and tested locally, I utilize the Azure Function Extension to deploy my program in the cloud, which is responsible for printing the newly arrived data. Also, the source code of this program is accessible within the zip file too. However, as I mentioned that AWS lambda and Azure Function App are quite different. In AWS, they would usually make often-used dependencies like s3 SDK integrated. I.e. user do not have to download or manage such kind of SDK on their own. However, in Azure Function App, there is a very important but easily ignored file named requirement.txt. In our case, if we want to use blob client to read data in our file, we have to add dependency name in it. The requirement.txt file is shown in Fig14.



File Edit Selection View Go Run
HW2-functions
EXPLORER
HW2-FUNCTIONS
__pycache__
.venv
.vscode
.funcignore
.gitignore
function_app.py
host.json
local.settings.json
requirements.txt
function_app.py
requirements.txt
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE
View all of your recent activities and quickly access resources you've recently created.
Create an Azure resource
OUTLINE
TIMELINE
master* Attach to Python Functions (HW2-functions)
Ln 6, Col 40 Spaces: 4 UTF-8 LF pip requirements

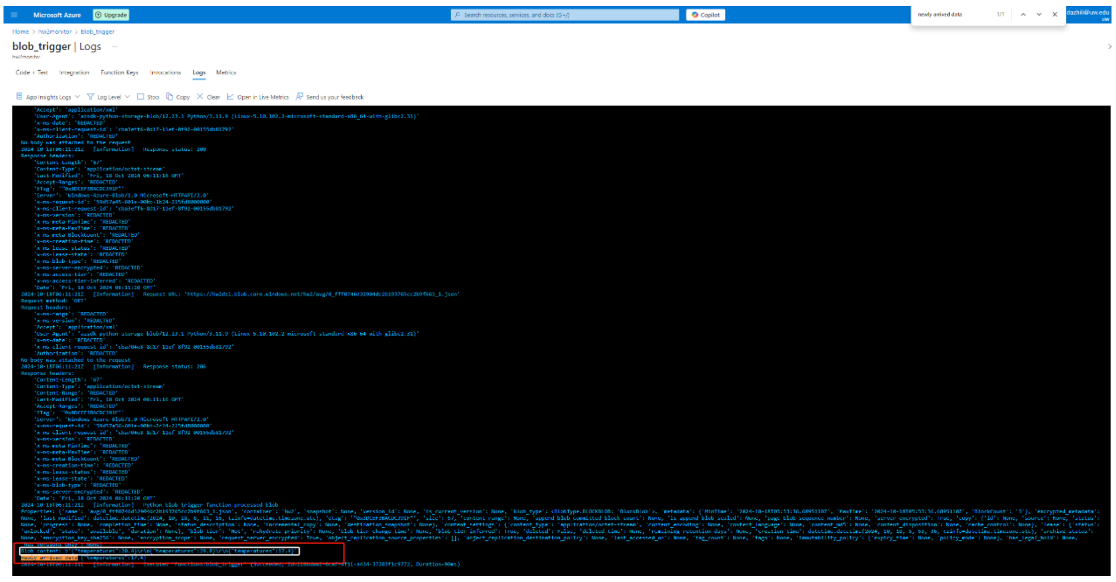
```
# DO NOT include azure-functions-worker in this file
# The Python Worker is managed by Azure Functions platform
# Manually managing azure-functions-worker may cause unexpected issues

azure-functions
azurefunctions-extensions-bindings-blob
```

Fig14. Azure Function App Dependency File

If this detail is missed, this program could be deployed on the cloud but not runnable. I will mention that later.

Finally, once the code is ready and I start the Azure Function App, I could send message to IoT Hub via my computer again. This time, I receive log information which prints out the newly arrived data. As I mentioned above, the way that I am adding output to the blob file is appending write. So, there are a whole bunch of data and the latest data in my log printed dedicatedly. The printing result is showed in Fig15.

This part is different from AWS two. In AWS lambda, we just select trigger event by cloud service and we will get an event for further data processing. However, in Azure Function App, I put the trigger into my code in a python decorator.



```
    'Accept': 'application/xml'
    'User-Agent': 'azsdk-python-storage-blob/12.23.1 Python/3.11.9 (Linux-5.10.102.2-microsoft-standard-x86_64-with-glibc2.31)'
    'x-ms-date': 'REDACTED'
    'x-ms-client-request-id': 'cba1eff6-8d17-11ef-8f92-00155db81792'
    'Authorization': 'REDACTED'
No body was attached to the request
2024-10-18T06:11:21Z   [Information]   Response status: 200
Response headers:
    'Content-Length': '67'
    'Content-Type': 'application/octet-stream'
    'Last-Modified': 'Fri, 18 Oct 2024 06:11:16 GMT'
    'Accept-Ranges': 'REDACTED'
    'ETag': '"0x8DCEF38ACDC391F"'
    'Server': 'Windows-Azure-Blob/1.0 Microsoft-HTTPAPI/2.0'
    'x-ms-request-id': '59d57a45-001e-00bb-1b24-215fd8000000'
    'x-ms-client-request-id': 'cba3eff6-8d17-11ef-8f92-00155db81792'
    'x-ms-version': 'REDACTED'
    'x-ms-meta-MinTime': 'REDACTED'
    'x-ms-meta-MaxTime': 'REDACTED'
    'x-ms-meta-BlockCount': 'REDACTED'
    'x-ms-creation-time': 'REDACTED'
    'x-ms-lease-status': 'REDACTED'
    'x-ms-lease-state': 'REDACTED'
    'x-ms-blob-type': 'REDACTED'
    'x-ms-server-encrypted': 'REDACTED'
    'x-ms-access-tier': 'REDACTED'
    'x-ms-access-tier-inferred': 'REDACTED'
    'Date': 'Fri, 18 Oct 2024 06:11:20 GMT'
2024-10-18T06:11:21Z   [Information]   Request URL: 'https://hw2dz1.blob.core.windows.net/hw2/avg/0_fff0746d32904dc2b193765cc2b9f663_1.json'
Request method: 'GET'
Request headers:
    'x-ms-range': 'REDACTED'
    'x-ms-version': 'REDACTED'
    'Accept': 'application/xml'
    'User-Agent': 'azsdk-python-storage-blob/12.23.1 Python/3.11.9 (Linux-5.10.102.2-microsoft-standard-x86_64-with-glibc2.31)'
    'x-ms-date': 'REDACTED'
    'x-ms-client-request-id': 'cba704e8-8d17-11ef-8f92-00155db81792'
    'Authorization': 'REDACTED'
No body was attached to the request
2024-10-18T06:11:21Z   [Information]   Response status: 206
Response headers:
    'Content-Length': '67'
    'Content-Type': 'application/octet-stream'
    'Content-Range': 'REDACTED'
    'Last-Modified': 'Fri, 18 Oct 2024 06:11:16 GMT'
    'Accept-Ranges': 'REDACTED'
    'ETag': '"0x8DCEF38ACDC391F"'
    'Server': 'Windows-Azure-Blob/1.0 Microsoft-HTTPAPI/2.0'
    'x-ms-request-id': '59d57a56-001e-00bb-2c24-215fd8000000'
    'x-ms-client-request-id': 'cba704e8-8d17-11ef-8f92-00155db81792'
    'x-ms-version': 'REDACTED'
    'x-ms-meta-MinTime': 'REDACTED'
    'x-ms-meta-MaxTime': 'REDACTED'
    'x-ms-meta-BlockCount': 'REDACTED'
    'x-ms-creation-time': 'REDACTED'
    'x-ms-lease-status': 'REDACTED'
    'x-ms-lease-state': 'REDACTED'
    'x-ms-blob-type': 'REDACTED'
    'x-ms-server-encrypted': 'REDACTED'
    'Date': 'Fri, 18 Oct 2024 06:11:20 GMT'
2024-10-18T06:11:21Z   [Information]   Python blob trigger function processed blob
Properties: {'name': 'avg/0_fff0746d32904dc2b193765cc2b9f663_1.json', 'container': 'hw2', 'snapshot': None, 'version_id': None, 'is_current_version': None, 'blob_type': <BlobType.BLOCKBLOB: 'BlockBlob'>, 'metadata': {'MinTime': '2024-10-18T05:53:36.6095110Z', 'MaxTime': '2024-10-18T05:53:36.6095110Z', 'BlockCount': '3'}, 'encrypted_metadata':
None, 'last_modified': datetime.datetime(2024, 10, 18, 6, 11, 16, tzinfo=datetime.timezone.utc), 'etag': '"0x8DCEF38ACDC391F"', 'size': 67, 'content_range': None, 'append_blob_committed_block_count': None, 'is_append_blob_sealed': None, 'page_blob_sequence_number': None, 'server_encrypted': True, 'copy': {'id': None, 'source': None, 'status':
None, 'progress': None, 'completion_time': None, 'status_description': None, 'incremental_copy': None, 'destination_snapshot': None}, 'content_settings': {'content_type': 'application/octet-stream', 'content_encoding': None, 'content_language': None, 'content_md5': None, 'content_disposition': None, 'cache_control': None}, 'lease': {'status':
'unlocked', 'state': 'available', 'duration': None}, 'blob_tier': 'Hot', 'rehydrate_priority': None, 'blob_tier_change_time': None, 'blob_tier_inferred': True, 'deleted': False, 'deleted_time': None, 'remaining_retention_days': None, 'creation_time': datetime.datetime(2024, 10, 18, 5, 53, 36, tzinfo=datetime.timezone.utc), 'archive_status':
None, 'encryption_key_sha256': None, 'encryption_scope': None, 'request_server_encrypted': True, 'object_replication_source_properties': [], 'object_replication_destination_policy': None, 'last_accessed_on': None, 'tag_count': None, 'tags': None, 'immutability_policy': {'expiry_time': None, 'policy_mode': None}, 'has_legal_hold': None,
'has_versions_only': None}
Blob content: b'{"temperatures":20.4}\r\n{"temperatures":29.8}\r\n{"temperatures":17.4}'
newly arrived data {"temperatures":17.4}
2024-10-18T06:11:21Z   [Information]   Executed 'Functions.blob_trigger' (Succeeded, Id=228b0aa2-0caf-4f11-a434-37283f1c9772, Duration=90ms)
```

Fig15. Azure Function App Log Printed Result

2.Encountered Problems

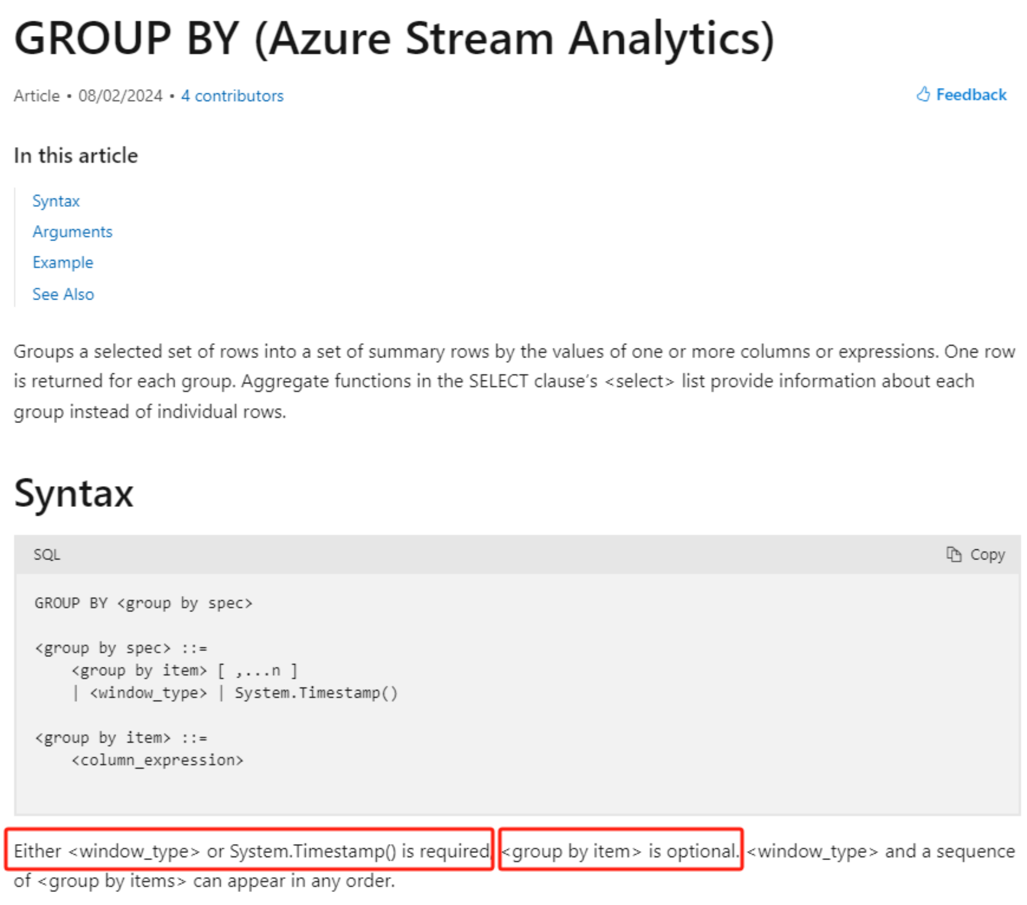
2.1 How to use the IoT SDK and hide my credentials

This part is difficult at finding the device demo provided by Azure. The device demo could be fluently downloaded in AWS by following the starter guide. However, things in Azure IoT are quite different. In Azure, the guideline does not provide any example code on how to use its SDK. I found the demo in a document which is hiding very deep. And it could not be runnable if user just downloads their demo. User are required to set system variables to use their demo. If a user starts with an IDE like PyCharm, which will provide virtual environment for different project, that used will spent a lot of time on searching why the demo could not be executed. This is exactly what I experienced in this homework. I finally overcome it with finding the problems first. I read all the code and find that connection_method is not specified, which I did specify in my computer environment variables. After thinking for a while, an idea came to my mind that I could add explicit environment variables at the run/debug configuration so that my program could 100% read that variable. Fortunately, this method works and I found I could hide my credentials like connection string into my system variables.

2.2 SQL grammar is different in Stream Analysis

Extracting raw data from the IoT-Hub and storing it into Azure Blob is quite simple.

However, when I tried to calculate the average data from a table of temperature data, which seems quite simple too, I failed all the times. No matter how I adjust the AVG() function provided by Stream Analytics, the online code editor always reported syntax error. This error is quite confusing that they did not tell exact where the problem is. I took a lot of time searching and finding documents on Azure. Finally I found that, AVG() function in Stream Analytics is just totally a different thing from what I learnt in database. Every group by clause should be followed by a window or timestamp. On the contrary, element is optional. The answer could be shown in fig16.



GROUP BY (Azure Stream Analytics)

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Feedback

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Groups a selected set of rows into a set of summary rows by the values of one or more columns or expressions. One row is returned for each group. Aggregate functions in the SELECT clause's <select> list provide information about each group instead of individual rows.

Syntax

SQL

Copy

```
GROUP BY <group by spec>

<group by spec> ::=
    <group by item> [ ,...n ]
    | <window_type> | System.Timestamp()

<group by item> ::=
    <column_expression>
```

Either <window_type> or System.Timestamp() is required. <group by item> is optional. <window_type> and a sequence of <group by items> can appear in any order.

Fig16. Azure Stream Analytics Group By Clause Usage Rules

2.3 Azure Function App deployment

The worst thing of serverless services is that they sometimes do not give enough debugging details. This time, I encountered a huge problem in Azure Function App. I attempted to run all the codes locally, and everything works totally correct. But every time I tried to deploy my code on the cloud service, it showed successful deployed. However, my program is not visible on the webpage and not working at all. I spent a lot of time finding why my program is missing. I tried to stop the function app. And then, I could only see a sentence of error which is also confusing saying that internal error. By searching that little information on the website, I gained nothing. Then I tried different codes which is only printing data incoming message not reading data from blob files. Unexpectedly, it worked. Then I tried to compare those two codes and did a bunch of testes. At the time when I did not import blob client, a dependency, the whole program worked correctly on the website. This clue gave me enough information on troubleshooting. I just kept going on Stream Analytics dependencies questions. Finally, I found the solution at requirements.txt. The documentation on Stream Analytics which is showing how to set a blob trigger did not mention it at all. So, when doing a project, try different ways to figure out what is missing.

2.4 Azure Function App local setting

When I tried to debug locally, errors just showed up every time. The error said I was missing the connection string, which is exactly lying in my local.setting.json file. I spent a lot of time on finding the problem. Finally, I saw a blog which is discussing the same problem. All the problem came from blob client, which is not reading connecting string except variable "AzureWebJobsStorage". The only thing I did was copying my connection string and pasting it to the value. Then locally debugging worked greatly. Although it did cost me a lot of time on finding the solution, it is worth to save a lot of time when the program does not go into my expectations.

3 Time Spent

I estimated this homework will cost me like 8 hours including report writing. However, I spent totally about 12 hours on this homework due to unfamiliar with Azure cloud services. That's what happens in doing a project that unexpected situations take most of time.