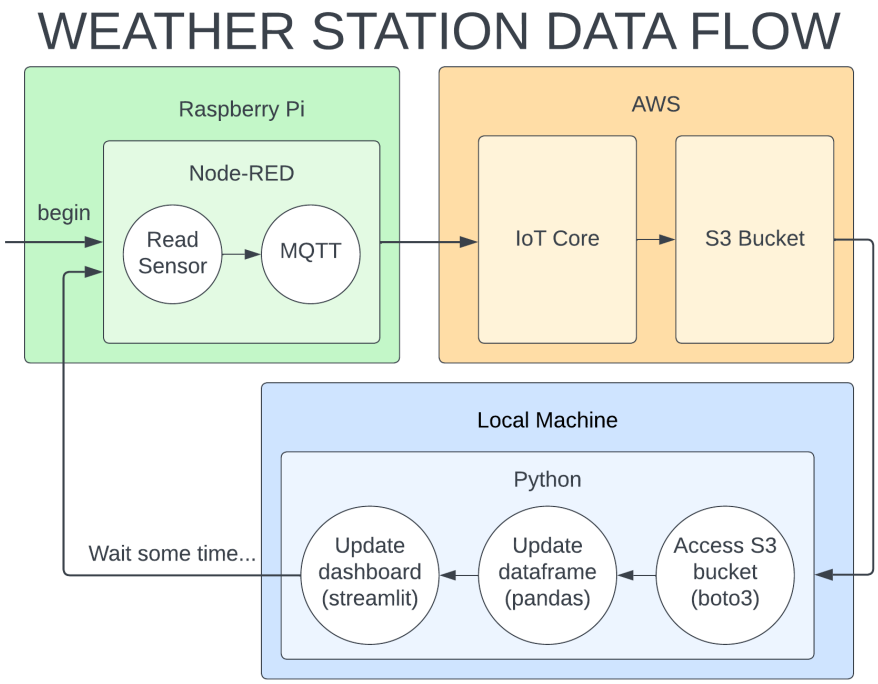
KENNESAW STATE UNIVERSITY

CPE 4040: DATA COLLECTION AND ANALYSIS

Lab 7: A Data Project Using NodeRED, AWS IoT, and Streamlit

Learning Objectives:

1. To build an end-to-end data project that collects sensor data and creates a web dashboard.
2. To learn how to interface sensor data with AWS IoT using Node-RED on a Raspberry Pi.
3. To learn how to create and store data in the AWS S3 buckets.
4. To develop a Streamlit application that can display the sensor data in a web dashboard.



AWS S3 (Simple Storage Service):

Amazon S3 is an *object* storage service that allows users to store files and any metadata that describe the files. A *bucket* is a container that stores the objects. To store an object in Amazon S3, you create a bucket and then upload the object to a bucket.

- What is Amazon S3?
- Creating, configuring, and working with Amazon S3 buckets

Streamlit:

Streamlit is an open-source app framework written in Python. It allows programmers to easily create web application for data visualization.

- Streamlit Website
- Streamlit Tutorial

Hardware and Software Requirement:

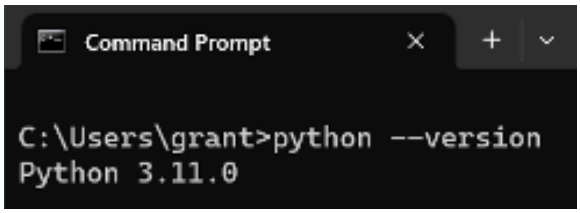
1. Temperature sensor (DHT-11, DHT-22, or DHT-20)
2. Resistors and bread board
3. Python scripts (available in D2L Assignment)

Lab Procedure:

1. Plug the power adapter into the Raspberry Pi and power it up. Next, open Remote Desktop Connection or SSH connection on your laptop and connect to the Raspberry Pi.

Section 1: Hardware and Software Setup

2. Open a terminal window on your computer and type "***python –version***" to make sure you have Python 3 installed. If not, go to https://www.python.org/downloads/ and download the proper release.



3. Install the following packages on your computer, if they are not already installed.

   Note: **You will research on how to install those packages**. The TA is available for support.

   - `Boto3`: an AWS Python Software Development Kit (AWS) to create, configure, and manage AWS services. We use Boto3 to interact with AWS S3.
   - `Streamlit`: will also install pandas and NumPy, if they are not installed.
   - `plotly`: a plotting library used by Streamlit.

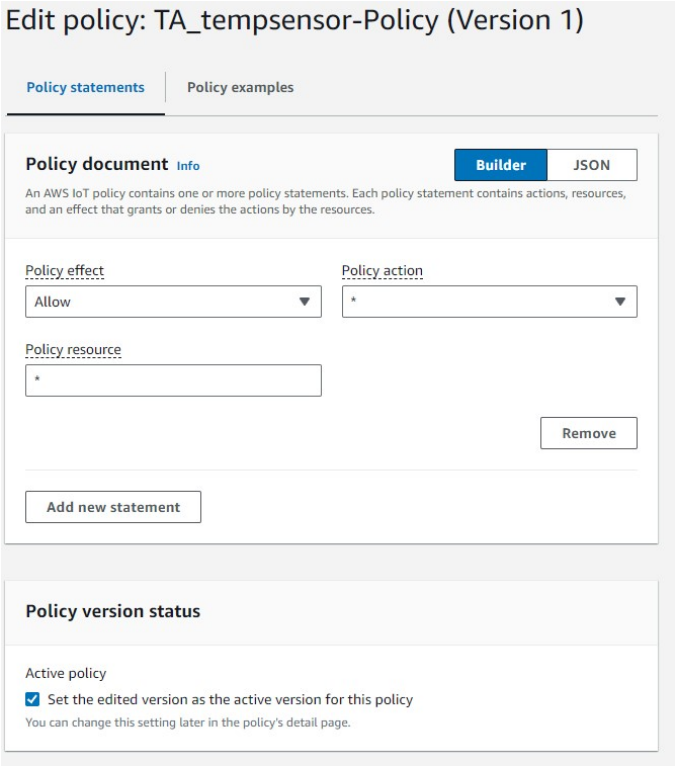
4. Go to https://docs.aws.amazon.com/cli/latest/userguide/getting-started-install.html and follow the instruction to download the AWS CLI (Command Line Interface) to your computer. After downloading and installing, type "***aws —version***" in your terminal to make sure it is installed properly. You may need to open a new terminal window for the command to be recognized.
5. Follow the instructions from Lab 4 to connect your temperature sensor to the Raspberry Pi.
6. Make sure the sensor is working properly using the ***digitalOut.py*** code from Lab 4.

Section 2: Configuring AWS IoT Core

Note: This section repeats the steps from Lab 6, so it should be familiar. The only difference is

we are now creating a thing for the temperature sensor, so keep that in mind when naming your thing and policies.

7. Log into your Amazon AWS account. Once you are logged in, navigate to the AWS Management Console. From there, search and open **IoT Core** under **Services**.
8. In the AWS IoT Core page, select **Connect One Device** from the **Connect** section in the menu pane. Follow the instructions to configure your Thing as you did in Lab 6. Ensure you unzip the file containing the certificates onto your Pi, and verify that your SDK is set to Python.
9. In the AWS IoT Core page, under **Security** click on **Policies**, and select the policy named <Your thing's name>-Policy. Click the **Edit Active Version** button, and configure **Policy Effect** to **Allow**, and configure **Policy Action** and **Policy Resource** to the wildcard (*). Remember to check the box in **Policy Version Status** to save these changes, then you can click the orange Save as new version button.

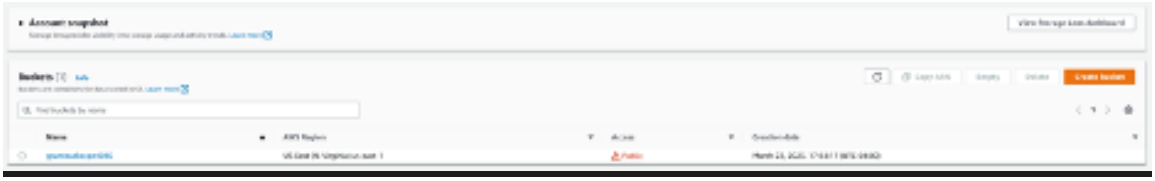


10. To attach the policy to your certificate, go to “Certificates” (under “Security”) in the AWS IoT Core page. Click the certificate you created and choose **Attach policy** from the **Actions** menu. Select the policy from the list and click **Attach policies**. Now AWS IoT is ready to receive data from the device.
11. Go back to the Raspberry Pi and create a folder named “cert” in your application folder for this lab. Transfer the device certificate, private key, and root CA files into the “cert” folder. Before transferring, you can rename the files as follows:
    - Device certificate: RaspberryPi-cert.pem

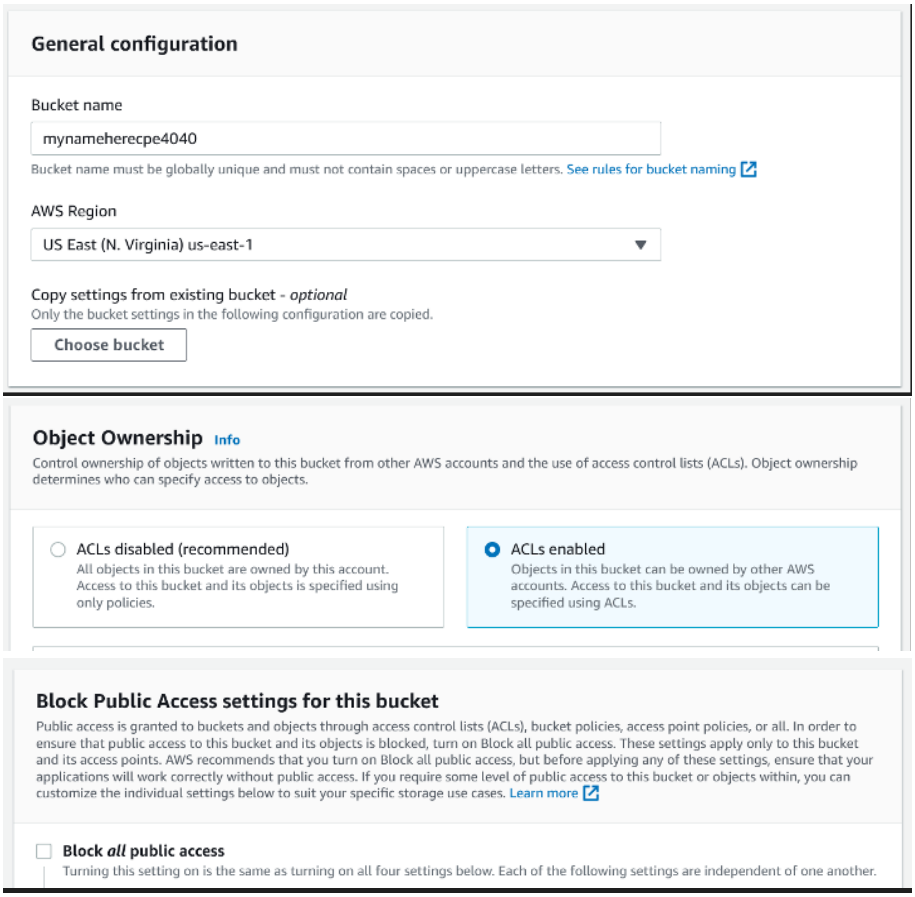
- Private key: RaspberryPi-private.pem.key
- Root CA: RootCA1.pem

Section 3: Setting up AWS S3 Bucket

12. Go to the AWS Management Console (https://console.aws.amazon.com/). Using the **Search** bar, look for and select **S3**.
13. On the S3 page, click **Create bucket**.



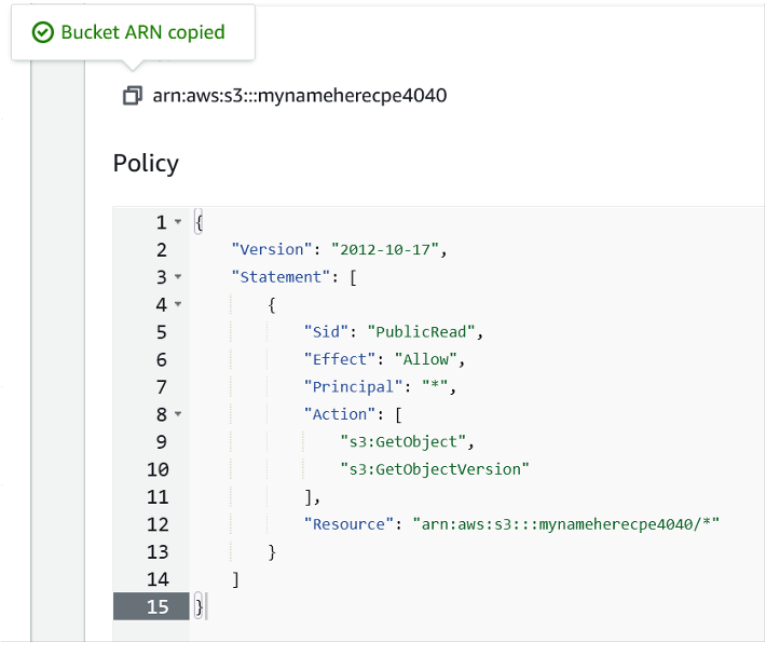
14. Enter a bucket name. **Note**: It must be a globally unique name with no uppercase letters or spaces. Under **Object Ownership** click **ACLs enabled**. Under **Block Public Access settings for this bucket**, uncheck the box **Block all public access**. Now, click **Create bucket**, then click the button to acknowledge your bucket will be public, and confirm.



15. Select the newly created bucket. Click on the **Permissions** tab. Next, click the edit button next to **Bucket policy**. Copy the following text into the policy text box. Click the copy button next to Bucket ARN and paste it into the resource field of the policy. Make sure to preserve

the “/” at the end. Then, **Save changes**.

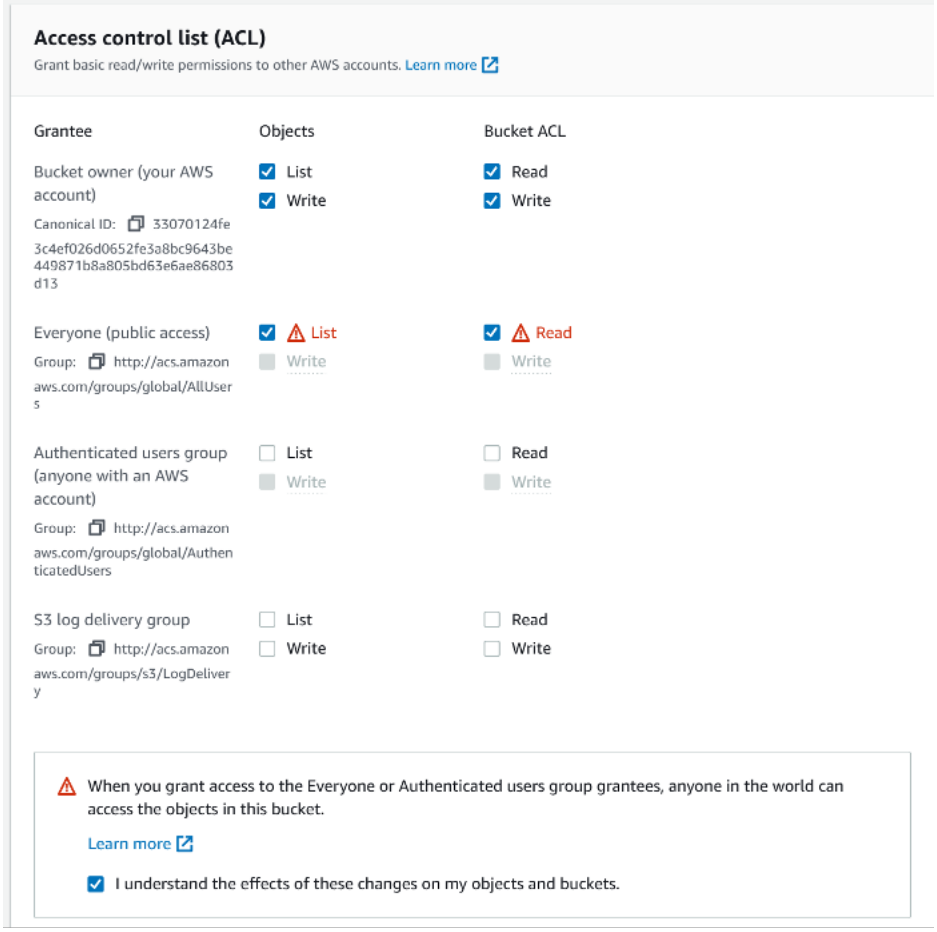
```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "PublicRead",
            "Effect": "Allow",
            "Principal": "*",
            "Action": [
                "s3:GetObject",
                "s3:GetObjectVersion"
            ],
            "Resource": "arn:aws:s3:::<Paste-Your-Bucket-Name-Here>/*"
        }
    ]
}
```



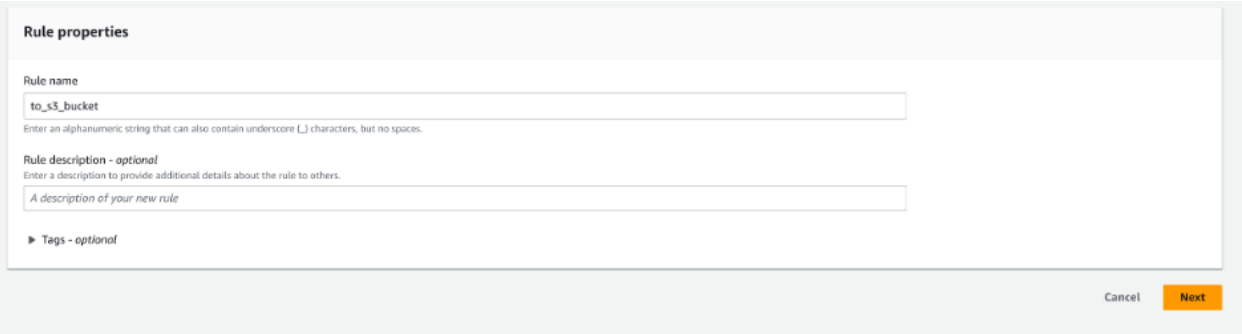
16. Scroll down to the CORS section and click the edit button. Paste the following text in the text box and **Save changes**.

```
[
    {
        "AllowedHeaders": [
            "Authorization"
        ],
        "AllowedMethods": [
            "GET"
        ],
        "AllowedOrigins": [
            "*"
        ],
        "ExposeHeaders": [],
        "MaxAgeSeconds": 3000
    }
]
```

17. Under **Access Control List**, click **Edit**. Click the check boxes to give the **List** and **Read** permissions to **Everyone (Public Access)**. Then click the box to acknowledge your bucket is public and **Save changes**.



18. Navigate to **IoT Core** in AWS. On the sidebar menu, click **Rules** under **Message Routing**. Then click **Create rule**. Give the rule a name then click **Next** .

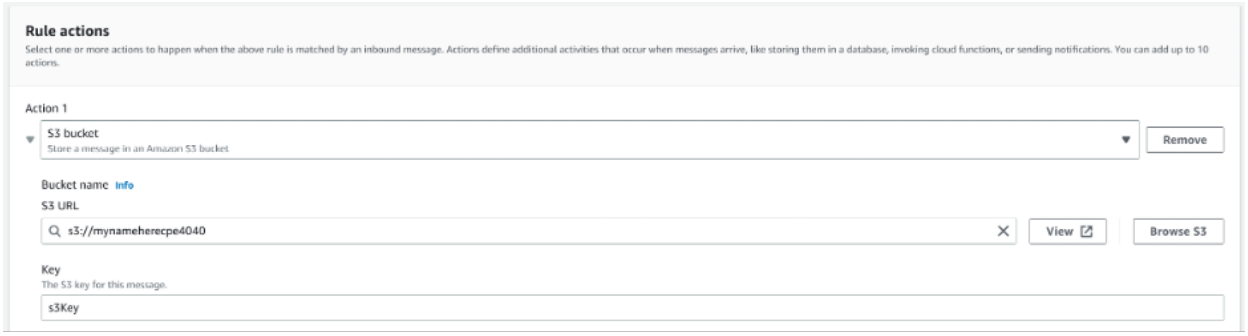


19. In **SQL Statement** text box, enter the following query:

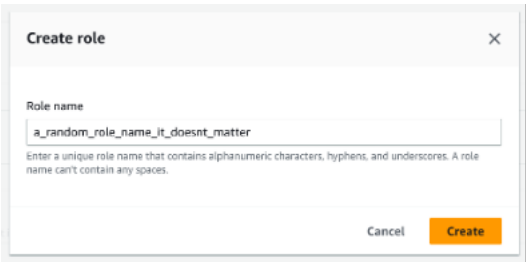
```
SELECT *, timestamp() AS timestamp FROM '<Your-incoming-IoT-Topic-Here>'
```

This will automatically add a timestamp to the JSON payload we send from NodeRED later. Make sure to change the topic name to something appropriate (i.e. “sensor”). Then click **Next.**

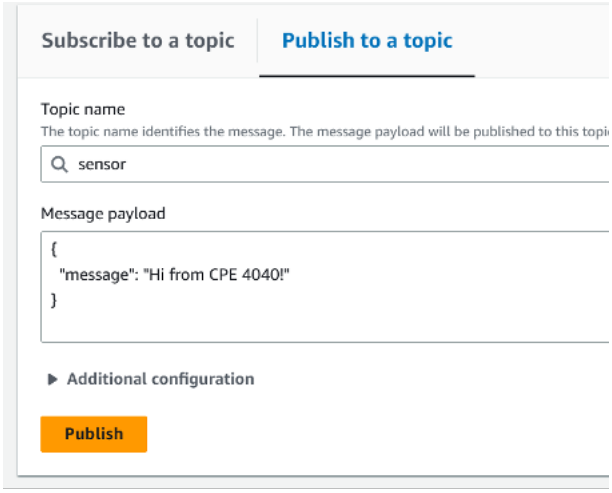
20. From the dropdown menu under **Rule actions**, search for and select **S3 bucket**. Next to Bucket name, click the **Browse S3** button and select the bucket you created. Under **Key**, enter a name. This “key” refers to a value in a “key-value” pair. You can choose any value for the key, but make sure to take note of what you choose.



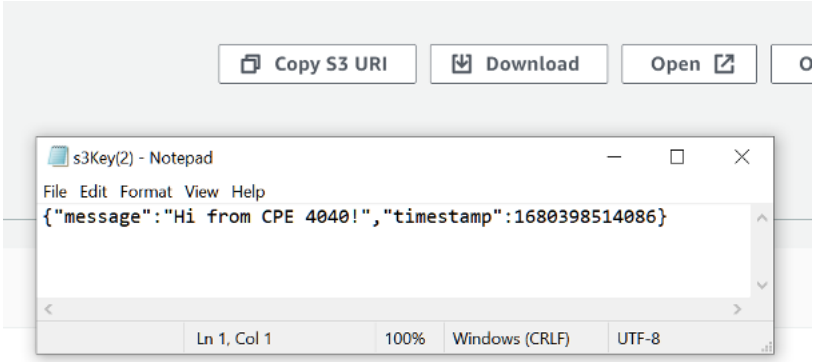
21. Go to **IAM Role** and select **Create new role** to begin creating a new role. Enter a name for the new role, then click **Next** and **Create** to complete the process.



22. In the sidebar menu, click **MQTT test client** under **Test**. Click the **Publish to a topic** tab. Enter the topic name you entered previously (i.e. ‘sensor’), and enter a custom message in the message field. Then click **Publish**.



23. In a separate tab, navigate back to the S3 page. Click on your bucket, then click on the Key object that you created. In the upper right click the **Download** button and open the file that is downloaded. You should see the message that you just sent, along with a timestamp.

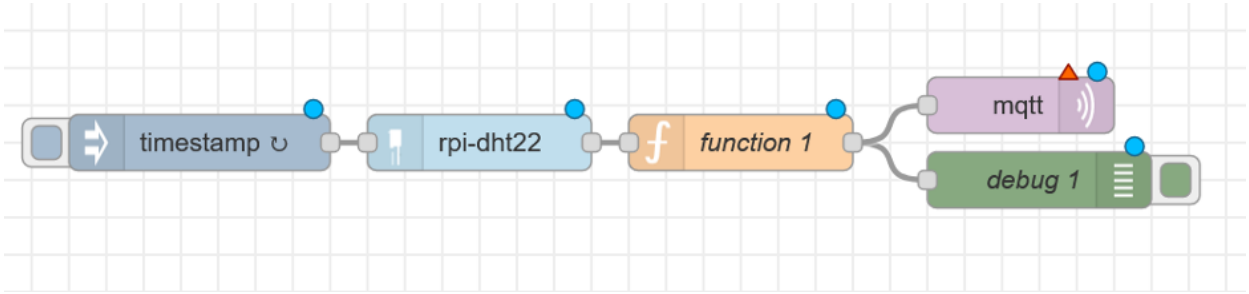


Section 4: Set Up NodeRED Flow to Send Sensor Data to S3 Bucket via MQTT

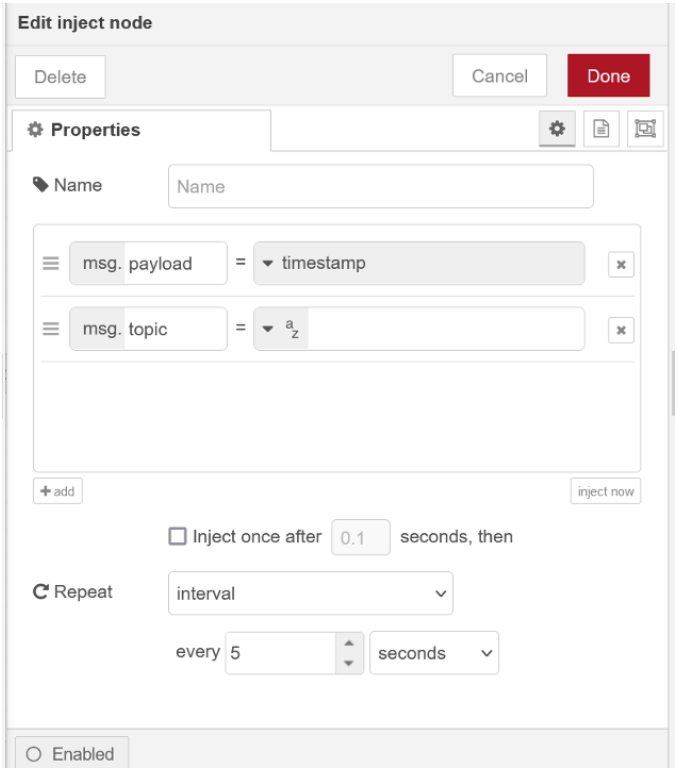
24. On your Raspberry Pi, start NodeRED and open the flow editor in a web browser. Please refer back to the Lab 5 assignment for detailed instructions.

25. In the Palette Manager, install **node-red-contrib-dht-sensor**. If you are using DHT-20, you will install **node-red-contrib-aht20** instead.

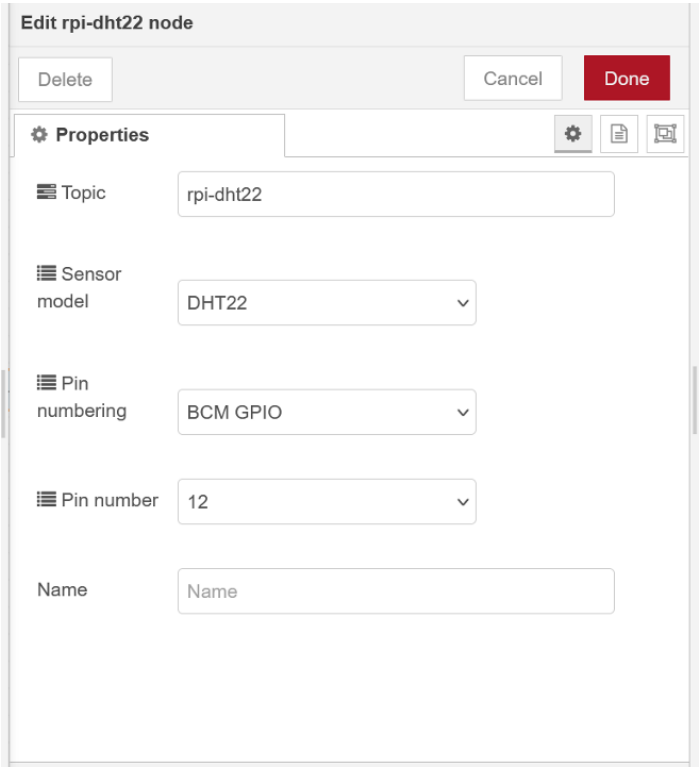
26. Create a flow by adding an **inject** node, **rpi-dht22** (or **aht20**) node, **function** node, **mqtt out** node, and **debug** node and connect them as shown.



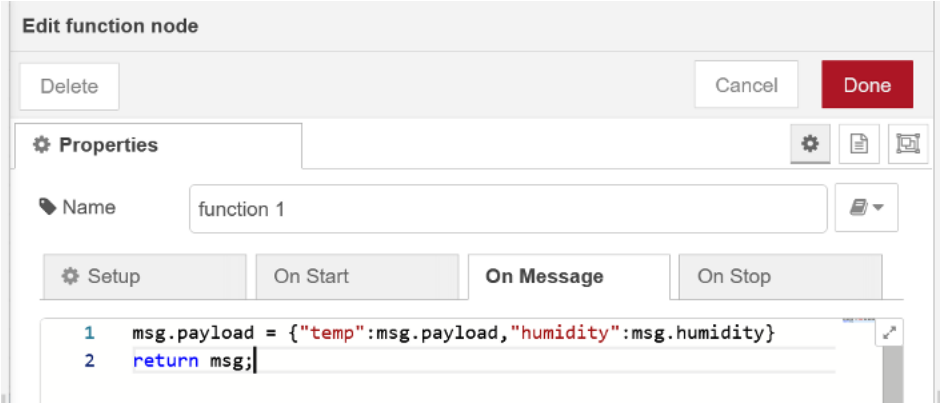
27. Edit the inject node to activate every 5 seconds.



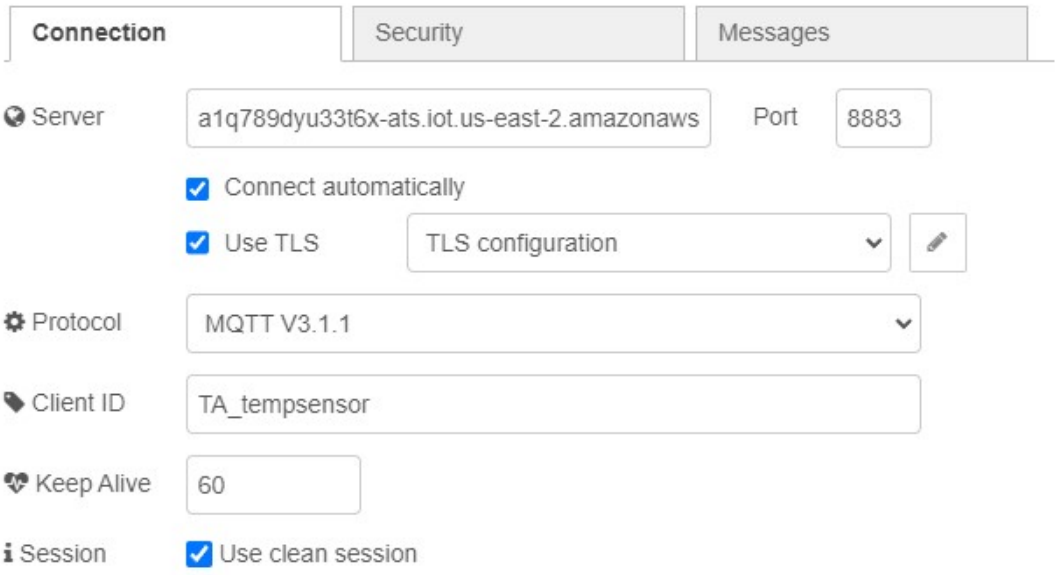
28. Edit the **rpi-dht** node to use GPIO pin 12. For **aht20**, nothing needs to be done.



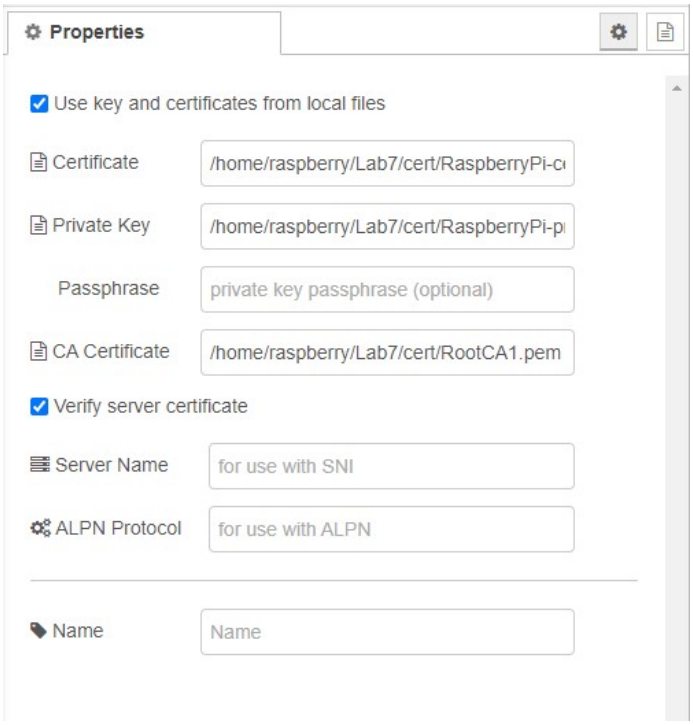
29. Edit the function node and add the following code.



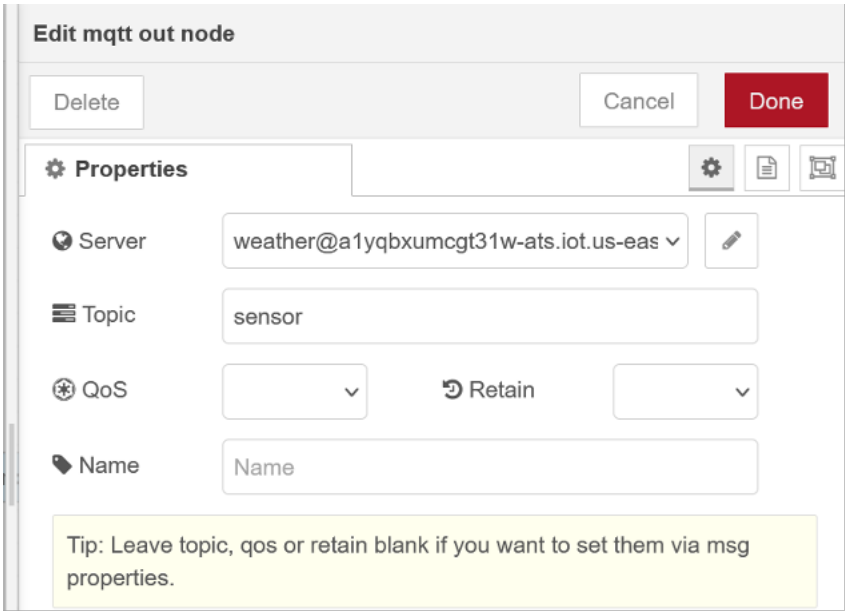
30. Edit the MQTT out node. Click the edit button next to server to add a new MQTT broker. Add the URL from AWS IoT -> Settings -> Device Data endpoint (refer back to Lab 6, Step 16). Add the device name in the Client ID field. Change Port to 8883.



31. Click button to Use TLS. Edit the configuration. Check the “Use key and certificates from local files” and copy the filepath to each of the certificate files from your Pi into the textboxes.



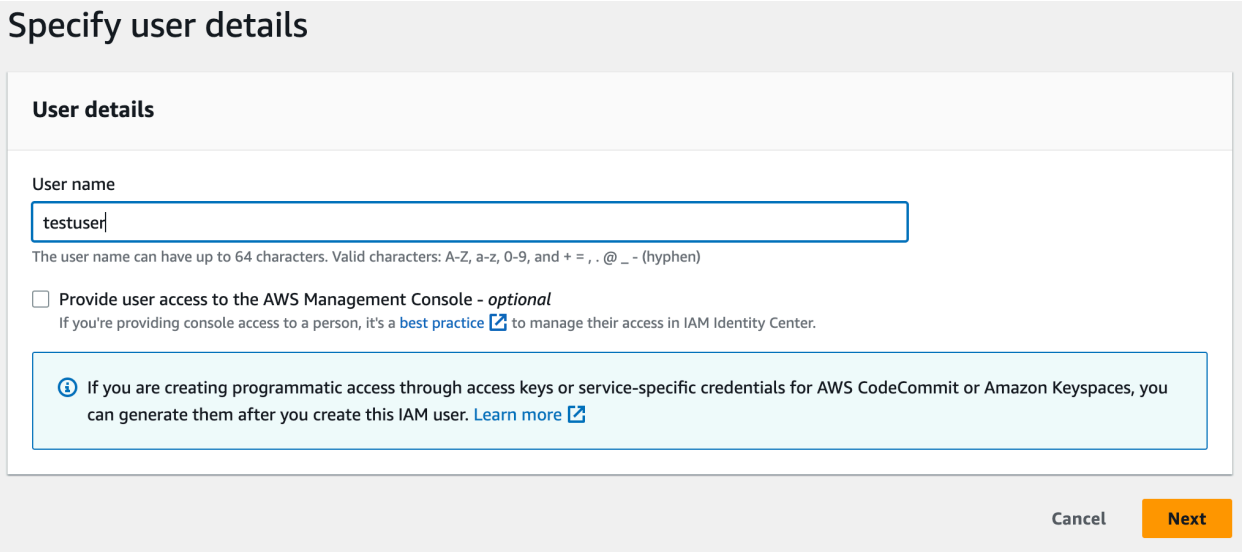
32. Add a topic in the topic field. Make sure to use the same topic as you configured in the S3 bucket.



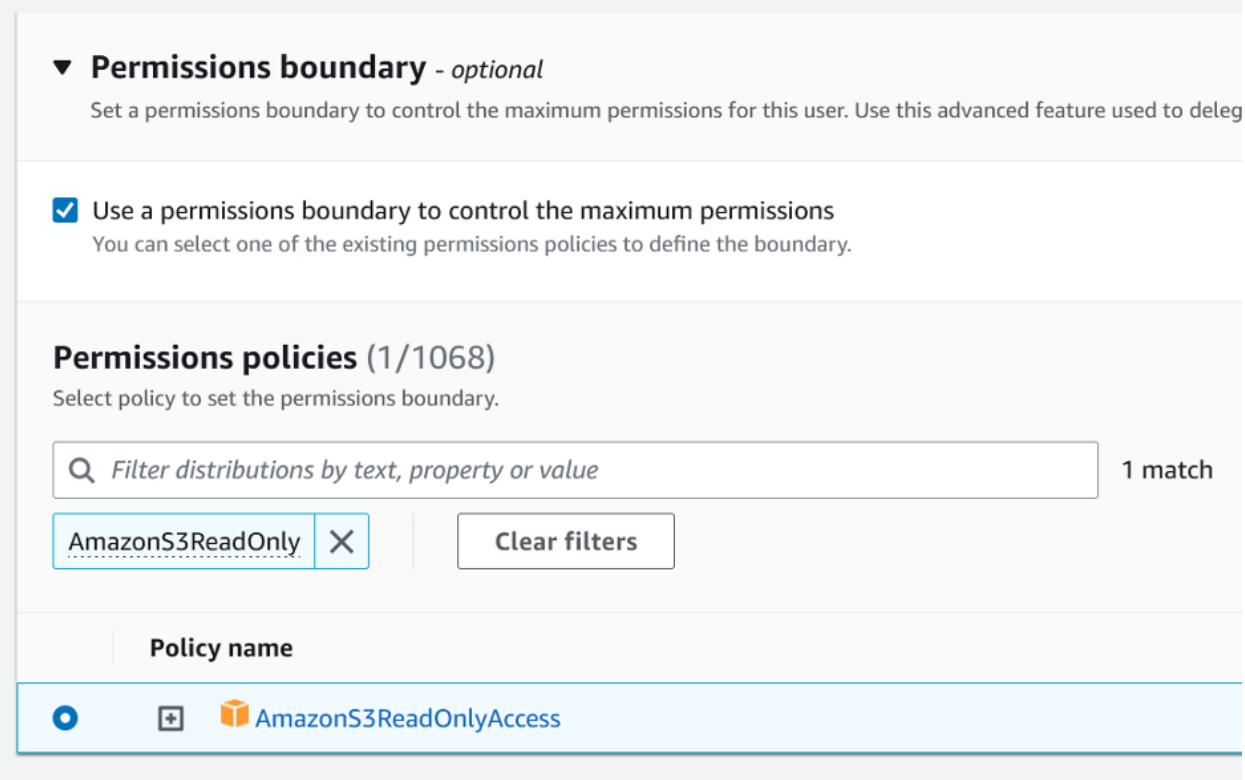
33. Deploy the flow and make sure all nodes are connected.

Section 5: Sending Data in S3 Bucket to Streamlit

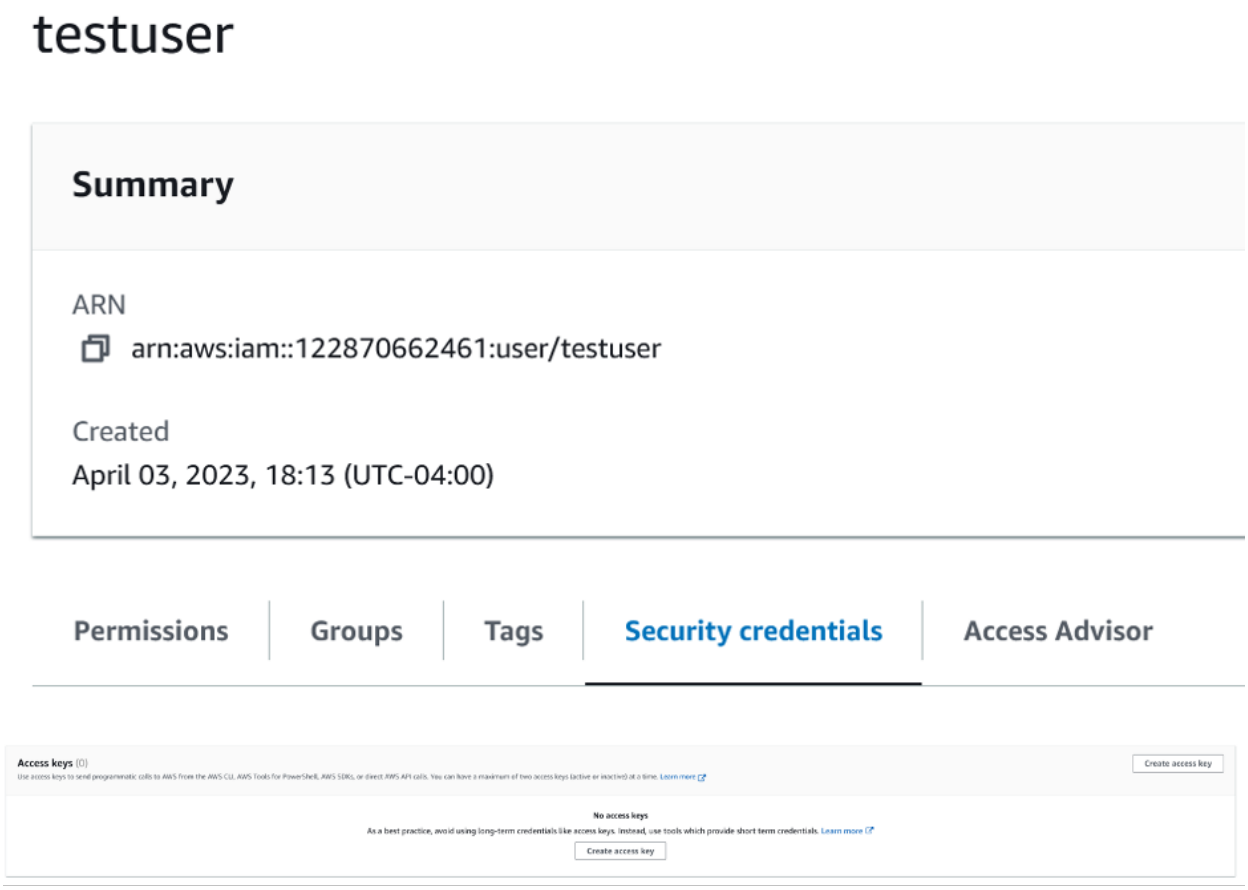
34. Go to the AWS Management Console (https://console.aws.amazon.com/). Using the **Search** bar, look for and select **IAM**, then click **Users** in the IAM sidebar menu. From here, click **Add Users**, enter a name for the user, and click **Next**.



35. Go to **Permissions Boundary**, select the checkbox, then search for **AmazonS3ReadOnlyAccess** in the filter box. Once selected, click "**Next**" and "**Create User**" to complete the process.



36. Select your newly created user, and click the **Security Credentials** tab. Under **Access Keys**, click **Create access key**.



37. From **Access key best practices & alternatives** page, choose the "Local code" option and click **Next** then **Create access key**. Copy the resulting **Access key** and **Secret access key** into a text file. **Important**: You will not be able to see the secret access key again, make sure you copy it now.

38. In your Windows/Mac command terminal, type "**aws configure**"

39. When prompted, enter your access and secret access keys. You may skip the other prompts by pressing Enter without typing anything. This creates a credentials file that will be used by the script. To make sure it was created, go to C:\Users\[user]\.aws to see the file. On Mac, it should be in /Users/[user]/.aws.

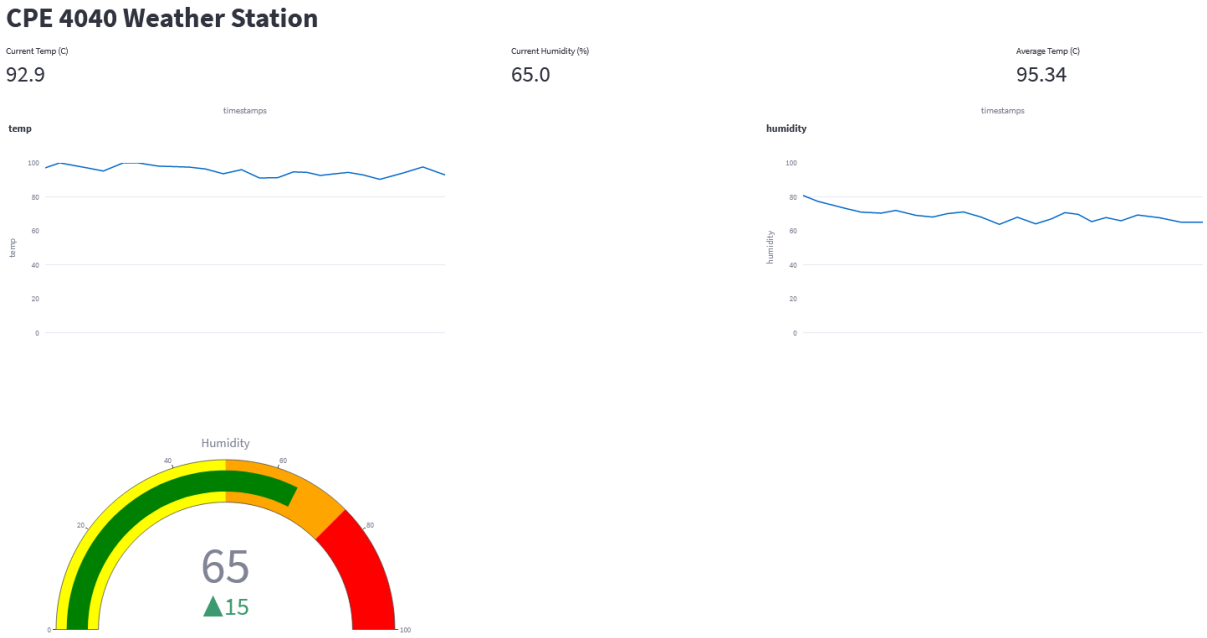
    Note: Make sure that no additional spaces or characters are added when pasting in these keys. It could cause some annoying errors to debug later!

40. Download the **app.py** script from D2L.

41. Open **app.py** in a text editor and edit the following lines with the name of your S3 bucket and the name of your object key.

```
AWS_S3_BUCKET = "MY_BUCKET" #edit this
AWS_S3_KEY_PREFIX = "MY_KEY_PREFIX" #edit this NOTE: refers to s3 object key
                                                    #not access key
```

42. To view your dashboard, run the script with the command '**streamlit run app.py**' and open the URL provided in a web browser. Once you've done this, you should see two line charts and a gauge on your dashboard, similar to ones shown below.



Lab Report

In the report, you will show screenshots of setup and results during critical steps in:

- Hardware and Software Setup
- Configuring AWS IoT Core
- Setting up AWS S3 Bucket
- Setting Up NodeRED Flow
- Sending Data in S3 Bucket to Streamlit

Attach your modified **app.py** code as well.

Use the lab report template and submit the report via D2L Assignment, in PDF format.