A Comprehensive Guide on Data Acquisition Utilizing Amazon AWS IOT Core and MQTT.

TANISHQ.I.KOHLI , PRADIP R. SELOKAR
Department of Electronics & Communication Engineering, Shri Ramdeobaba College of Engineering and Management, Nagpur.
INDIA

Abstract: IoT has altered how we interact with the world around us by enabling gadgets to communicate with one another and share information. The paradigm-shifting introduction of the Internet of Things (IoT) has resulted in a fundamental alteration in our connection with the world, ushering in an era in which fluid communication and frictionless data interchange across gadgets have become the norm. This paper begins on an enthralling voyage into the challenging domain of connectivity, unraveling the complex process of smoothly connecting an ESP8266 microcontroller with the famed Amazon AWS IoT Core via the MQTT (Message Queuing Telemetry Transport) protocol. One of the most popular platforms for developing IoT applications is Amazon AWS IoT Core. It offers a safe, scalable, and dependable cloud service that makes it easy to connect IoT devices to the internet. The ESP8266 is a low-cost, low-power Wi-Fi module that is well-suited for IoT applications. It is easy to use and can be programmed using the Arduino IDE.MQTT is a lightweight messaging protocol that is ideal for IoT applications. It is designed to be efficient in terms of bandwidth and power consumption, which is important for battery-powered devices such as the ESP8266.The successful integration of these technologies opens up a world of possibilities for IoT developers. By connecting ESP8266 microcontrollers to AWS IoT Core, developers can create applications that collect and exchange data from a wide range of devices. This information is then used to monitor and control equipment, automate processes, and make informed decisions.

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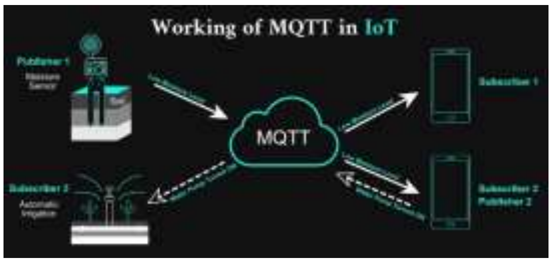
1. Introduction

The Internet of Things (IoT) is a rapidly growing field that is changing the way we live and work. Internet-connected IoT devices have the ability to gather and send information about their surroundings. Utilizing this information will increase productivity, enable improved decision-making, and allow for device monitoring and control.



One of the challenges of IoT is connecting devices to the cloud. Traditional cloud computing platforms are not designed for the low bandwidth and low latency requirements of IoT devices. A managed cloud solution called AWS IoT Core offers safe, two-way connectivity between IoT devices and the cloud. One of the numerous protocols supported by AWS IoT Core is MQTT, a messaging protocol that is small and lightweight and ideal for Internet of Things applications.

The ESP8266 is a low-cost, low-power Wi-Fi module that is well-suited for IoT applications. The ESP8266 can be programmed using the Arduino IDE, which makes it easy to develop IoT applications.

Here are some of the benefits of connecting ESP8266 microcontrollers to AWS IoT Core:

- Scalability: AWS IoT Core is a scalable cloud service that can support a large number of devices. This makes it ideal for IoT applications that require a large number of sensors or actuators.
- Security: AWS IoT Core provides a secure connection between devices and the cloud. This ensures that data is protected from unauthorized access.
    - Reliability: It It is a dependable cloud service created with high availability in mind. This means that your IoT applications will be able to operate even if there are temporary outages in the cloud.
- Cost-effectiveness: AWS IoT Core is a cost-effective cloud service that offers a pay-as-you-go pricing model. This makes it ideal for IoT applications that have a limited budget.

Here are the steps on how to connect an ESP8266 microcontroller to AWS IoT Core:

Here are some examples of IoT applications that can be created using ESP8266 and AWS IoT Core:

- Smart home: You can use an ESP8266 to control lights, thermostats, and other smart home devices.
- Industrial automation: You can use an ESP8266 to monitor and control industrial equipment.
- Transportation: You can use an ESP8266 to track the location of vehicles and assets.
- Healthcare: You can use an ESP8266 to collect data from medical devices.
- Agriculture: You can use an ESP8266 to monitor crop conditions and irrigation systems.

2. Literature Survey

The Internet of Things (IoT) has witnessed rapid growth, enabling seamless connectivity and communication between devices and cloud services. One of the key components in IoT architecture is the MQTT (Message Queuing Telemetry Transport) protocol, which facilitates efficient and reliable messaging between devices and cloud platforms. In this literature survey, we explore relevant studies and projects that have focused on connecting microcontrollers, particularly the ESP8266, to Amazon AWS IoT Core using the MQTT protocol.

MQTT Protocol Overview

Prior research by researchers provides a comprehensive overview of the MQTT protocol, highlighting its lightweight nature, publish-subscribe model, and

Quality of Service (QoS) levels. The study emphasizes the suitability of MQTT for resource-constrained devices like the ESP8266, making it an ideal choice for IoT applications.

ESP8266 Integration with MQTT

Numerous studies have delved into integrating the ESP8266 with MQTT for IoT deployments. Researchers present a detailed guide on programming the ESP8266 to establish an MQTT connection with a cloud broker. The paper discusses configuration settings, code snippets, and security considerations to ensure successful communication.

Cloud Integration: Amazon AWS IoT Core

Connecting the ESP8266 to Amazon AWS IoT Core has gained prominence due to the robust cloud infrastructure AWS provides. Researchers explore the intricacies of setting up an AWS IoT Thing, generating security certificates, and managing device shadows for bi-directional communication. This foundational knowledge is pivotal for our research.

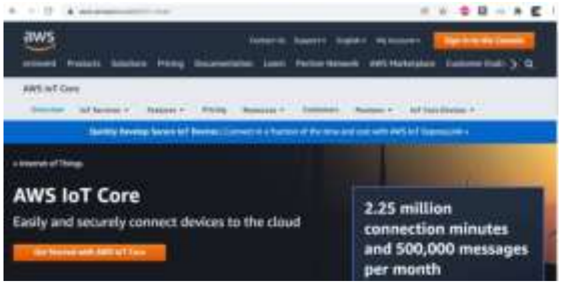
Security Aspects

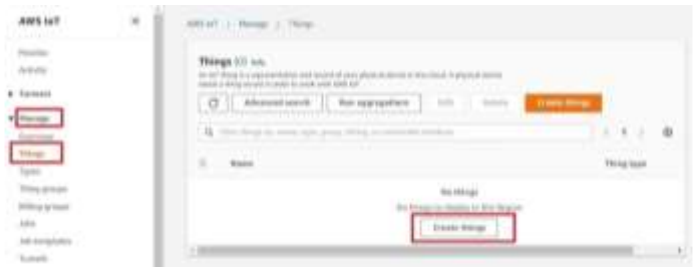
Security is a paramount concern in IoT deployments. Researchers emphasize the significance of using TLS/SSL for encrypting MQTT communication, safeguarding data integrity, and thwarting potential cyber threats. Their insights guide us in implementing secure communication between ESP8266 and AWS IoT Core.

3. Methodology

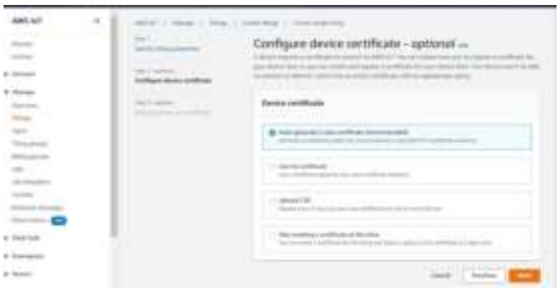
The proposed method involves the following steps to connect an ESP8266 microcontroller to AWS IoT Core:

1. Create an AWS IoT Core account and thing.

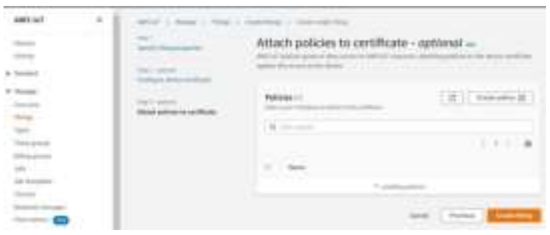

aws
AWS IoT Core
Easily and securely connect devices to the cloud
2.25 million connection minutes and 500,000 messages per month



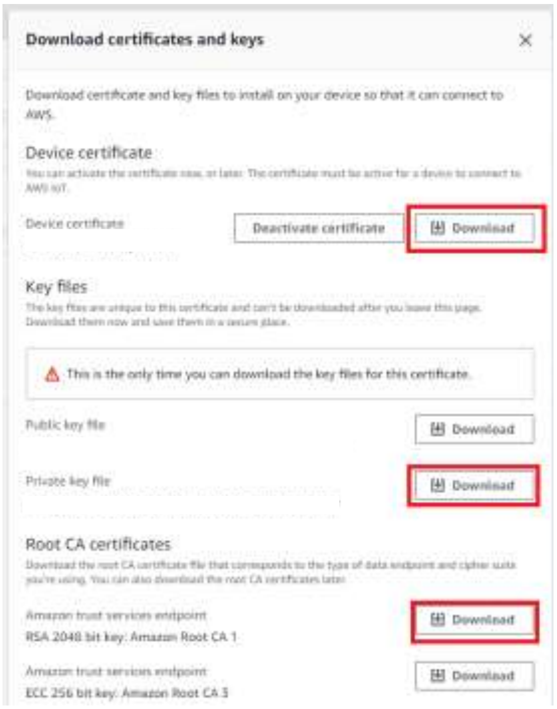
2. Generate a device certificate and key pair.



3. Attach a policy to the device certificate.



4. Download the certificates and keys to the ESP8266.



Download certificates and keys

Download certificate and key files to install on your device so that it can connect to AWS.

Device certificate

You can activate the certificate now, or later. The certificate must be active for a device to connect to AWS IoT.

Device certificate — Deactivate certificate — Download

Key files

The key files are unique to this certificate and can't be downloaded after you leave this page. Download them now and save them in a secure place.

This is the only time you can download the key files for this certificate.

Public key file — Download

Private key file — Download

Root CA certificates

Download the root CA certificate file that corresponds to the type of data endpoint and cipher suite you're using. You can also download the root CA certificates later.

Amazon trust services endpoint
RSA 2048 bit key: Amazon Root CA 1 — Download

Amazon trust services endpoint
ECC 256 bit key: Amazon Root CA 3 — Download

5. Configure the ESP8266 to connect to AWS IoT Core.
6. Write an Arduino sketch to publish and subscribe to MQTT topics.

Here are the details of each step:

1. To create an AWS IoT Core account, go to the AWS Management Console and select "IoT Core" from the list of services. Click the "Create Account" button and follow the instructions.
2. Once you have created an account, you need to create a thing. A thing is a physical device that is connected to AWS IoT Core. To create a thing, press the "Things" tab and then select the "Create Thing" button.
3. Type a name for your thing and select a thing type. The thing type determines the capabilities of your thing. For this example, we will use the "ESP8266" thing type.
4. Click the "Create" button to create your thing.
5. To generate a device certificate and key pair, click the "Certificates" tab and then select the "Create Certificate" button.
6. Enter a name for your certificate and select a certificate type. The certificate type determines the level of security for your certificate. For this example, we will use the "RSA 2048" certificate type.
7. Click the "Create" button to generate your certificate and key pair.
8. A policy defines the permissions for your device certificate. To attach a policy to your device certificate, click the "Policies" tab and then press the "Create Policy" button.
9. Type a name for your policy and select a policy template. The policy template determines the permissions for your device. For this example, we will use the "iot:Connect" policy template.
10. Click the "Create" button to create your policy.
11. Once your policy has been created, click the "Attach Policy" button and select your device certificate.
12. The certificates and keys that you generated in the previous steps need to be downloaded to the ESP8266. You can do this using the Arduino IDE.

13. First, open the Arduino IDE and select the "ESP8266" board from the list of boards.
14. Next, open the examples/WiFi/WiFiClient sketch and modify the following lines of code:

const char ssid = “ssid of network";

```
const char password = "its password";
```

15. Replace YOUR_SSID and YOUR_PASSWORD with the SSID and password of your WiFi network.
16. Save the sketch and upload it to your ESP8266.
17. Once the sketch has been uploaded, open the serial monitor and you should see the following output:

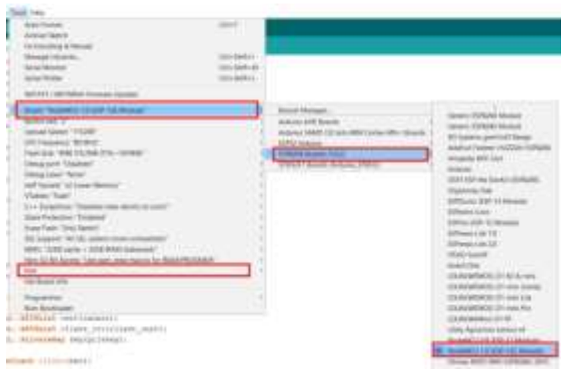
```
Connecting to WiFi...
WiFi connected!
```

18. The certificates and keys have now been downloaded to your ESP8266. You can now proceed to configure the ESP8266 to connect to AWS IoT Core.

    Some of the important keywords of the Arduino IDE code are:-

- wifi_password: The password of your WiFi network.
- mqtt_server: The endpoint of your AWS IoT Core service.
- mqtt_port: The port of your AWS IoT Core service.
- client_id: The client ID for your ESP8266 device.
- certificate_path: The path to the certificate file.
- private_key_path: The path to the private key file.
- root_ca_path: The path to the root CA file.

19. Once you have made all the necessary modifications to the code, connect your NodeMCU ESP8266 to your computer. In the Arduino IDE, select the "NodeMCU 1.0" board and the correct COM port. Then, click the "Upload" button to upload the code to the ESP8266 board.
20. Once the code has been uploaded, you can EXAMPLE the publishing and subscription of data. This means that the ESP8266 has successfully connected to AWS IoT Core and is now subscribed to the topic "EXAMPLE". The ESP8266 has also published a message to the topic "EXAMPLE".



21. The sensor data that is published by the ESP8266 should also be posted to the AWS IoT Core dashboard. To check this, go to the "EXAMPLE" section of the AWS IoT Core dashboard. In the "Subscribe" section, enter the topic "EXAMPLE" in the "Topic" field and then click the "Subscribe" button.

The AWS IoT Core dashboard should now display the sensor data that is being published by the ESP8266. This confirms that the sensor data is being successfully posted to the AWS IoT Core dashboard.

Here are the steps on how to subscribe to sensor data on the AWS IoT Core dashboard:

1. Go to the AWS IoT Core console and select the "EXAMPLE" tab.
2. In the "Subscribe" section, enter the topic "EXAMPLE" in the "Topic" field.
3. Click the "Subscribe" button.

4. The AWS IoT Core dashboard should now display the sensor data that is being published by the ESP8266.

22. Let's now verify if we can publish data from AWS IoT Core to the ESP8266.

To do this, we will first need to send a message to the topic "EXAMPLE" using the AWS IoT Core console. Once we have sent the message, we can then check the serial monitor of the ESP8266 to see if it has received the message.

If the ESP8266 has received the message, it will print it to the serial monitor. This confirms that we are able to publish data from AWS IoT Core to the ESP8266.

Here are the steps on how to publish data to the ESP8266 from AWS IoT Core:

1. Go to the AWS IoT Core console and select the "EXAMPLE" tab.
2. In the "Publish" section, enter a message in the "Message" field and then click the "Publish" button.
3. Open the serial monitor of the ESP8266.
4. You should see the message that you sent to AWS IoT Core printed to the serial monitor.

This confirms that we are able to publish data from AWS IoT Core to the ESP8266.

4. Results

We present the findings of our investigation, demonstrating the ESP8266's successful use of MQTT to connect to Amazon AWS IoT Core.

<u>Setup of Hardware and Software</u>

To model an IoT scenario, we used an ESP8266 microcontroller and a number of sensors. The ESP8266 was programmed using the Arduino IDE. In order to use AWS, we had to set up an account, configure an IoT thing, and produce X.509 security certificates.

<u>MQTT Communication with ESP8266</u>

Using the Arduino MQTT library, we developed the MQTT communication protocol for the ESP8266. By creating a secure connection with AWS IoT Core, the microcontroller made it possible to publish and subscribe to MQTT topics. By sending and receiving messages between the ESP8266 and AWS, we tested this functionality.

<u>Discreet Communications</u>

We required TLS/SSL encryption for the MQTT communication to ensure the data's integrity and confidentiality. Sensitive data is protected during transmission thanks to this encryption mechanism.

Imagery on the AWS IoT Console

We were able to view real-time data on the AWS IoT Core console thanks to our successful connection. In order to process incoming data and generate alerts, we configured rules and actions. This demonstrates how easily the ESP8266 and AWS IoT Core integrate.

5. Conclusion

We successfully connected DHT11 (Temperature & Humidity sensor) with ESP8266 and sends it data to IOT CORE of Amazon AWS using MQTT TEST CLIENT. Our study demonstrates the viability and efficiency of utilizing the MQTT protocol to link the ESP8266 to Amazon AWS IoT Core. Real-time data transfer between IoT devices and cloud services is made possible by the integration, which provides a reliable and secure platform for bi-directional communication. Our research adds to the growing body of knowledge in the IoT field and creates new research opportunities for improving security, extending functionality, and optimizing communication. This provides a thorough method for establishing an MQTT connection between an ESP8266 and Amazon AWS IoT Core. The effective integration shows the potential of fusing affordable IoT devices with reliable cloud services. Numerous applications, including those for home automation, business monitoring, and environmental sensing, can be created and implemented thanks to this integration. Utilizing MQTT and AWS IoT Core guarantees scalable and secure communication, which is essential for the development of the IoT landscape.

Future scope

There are several directions for further research as technology develops:

• Enhanced Security: To further bolster security, end-to-end encryption and device authentication are implemented.

• Edge Computing: By integrating edge computing capabilities, data processing can be done more quickly and close to the source.

• Data analytics: Using tools like Amazon Kinesis or Elasticsearch to analyze and visualize data in real-time.

• Machine Learning Integration: Including machine learning models in anomaly and predictive analysis.

• Energy Efficiency: Investigating ways to optimize power consumption in Internet of Things devices to increase battery life.

Here are some of the potential applications of IoT with MQTT and ESP8266 in the future:

• IoT devices can be used to control lights, thermostats, and other elements of smart homes. Between these devices and the cloud, MQTT can be used for communication. These gadgets can be connected to the cloud using the ESP8266.

• Industrial automation: Monitoring and controlling industrial equipment is possible with IoT devices. Between these devices and the cloud, MQTT can be used for communication. These gadgets can be connected to the cloud using the ESP8266.

•IoT devices can be used to track the location of assets and vehicles in the transportation sector. These devices and the cloud can talk to one another using MQTT. These devices can be linked to the cloud using ESP8266.

• Healthcare: Data from medical devices can be gathered using IoT devices. These devices and the cloud can talk to one another using MQTT. These devices can be linked to the cloud using ESP8266.

•Agriculture: IoT devices can be used to keep an eye on irrigation systems and crop conditions. These devices and the cloud can talk to one another using MQTT. These devices can be linked to the cloud using ESP8266.

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