

End-to-End MQTT Cloud Setup (Google Cloud VM + Mosquitto + TLS)

This document is a **complete, repeatable, step-by-step guide** for setting up a secure MQTT broker in the cloud using **Google Cloud Compute Engine (Always Free tier)** and **Mosquitto**, exactly following what we did today.

The goal is: - A **cloud-hosted MQTT broker** - Secure remote connections from anywhere in the world - TLS encryption (MQTTS on port 8883) - Username/password authentication - A setup suitable for IoT (Raspberry Pi, ESP32, backend services)

No Python client code is included yet, by design.

0. Conceptual Overview (What You Are Building)

Architecture:

```
[Raspberry Pi / IoT Device]
    |
    | MQTTS (TLS, TCP 8883)
    v
[ Google Cloud VM ]
  ├── Mosquitto (MQTT Broker)
  └── (Later) FastAPI Service
```

- Devices publish data securely over the internet
- Mosquitto acts as the message hub
- Backend services (FastAPI later) consume MQTT locally

This is **real cloud computing** and **industry-standard IoT architecture**.

1. Create Google Cloud Account

1. Go to: <https://cloud.google.com>
2. Create a Google Cloud account
3. Enable **Billing** (credit card required, but free tier is \$0)
4. Create a new **Project**

Billing must be enabled even for free resources.

2. Create the Always-Free VM Instance

Required Free-Tier Conditions (VERY IMPORTANT)

Setting	Value
Machine type	e2-micro
vCPU / RAM	1 shared core, 1 GB RAM
Region	us-central1 OR us-east1 OR us-west1
Disk	Standard persistent disk \leq 30 GB
VM count	1

If **any** of these are wrong, you will be charged.

Steps

1. Go to **Compute Engine** → **VM Instances** → **Create Instance**
2. Ignore presets
3. Set:
4. **Series:** E2
5. **Machine type:** e2-micro
6. Region: us-central1 (recommended)
7. Boot disk:
8. Ubuntu or Debian
9. Standard persistent disk
10. Size \leq 30 GB
11. Networking: keep default
12. Click **Create**

The UI may show ~\$7/month. This is list price. Free tier credits cancel it to \$0.

3. Connect to the VM

1. In VM Instances list, click **SSH**
 2. A browser terminal opens
 3. You are now logged into your cloud Linux server
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4. Update the System

```
sudo apt update && sudo apt upgrade -y
```

- `apt` = Linux package manager
- `-y` = auto-confirm "yes"

5. Install Mosquitto (MQTT Broker)

```
sudo apt install -y mosquitto mosquitto-clients
```

Enable and start the service:

```
sudo systemctl enable mosquitto  
sudo systemctl start mosquitto
```

Check status:

```
sudo systemctl status mosquitto
```

You should see: - **Active: active (running)** - No errors

6. Create MQTT Users (Authentication)

Each device gets its own MQTT user.

Create the first user (creates the password file)

```
sudo mosquitto_passwd -c /etc/mosquitto/passwd greenhouse-broker
```

- You will be prompted for a password
- Password is hashed (not stored in plaintext)

Add more users later (NO -c)

```
sudo mosquitto_passwd /etc/mosquitto/passwd raspi-1
```

`-c` is used **only once**.

7. Create TLS Certificates (Encryption)

Create certificates directory

```
sudo mkdir -p /etc/mosquitto/certs
cd /etc/mosquitto/certs
```

Create Certificate Authority (CA)

```
sudo openssl genrsa -out ca.key 2048
sudo openssl req -x509 -new -nodes -key ca.key -sha256 -days 3650 -out ca.crt
```

Create Server Certificate

```
sudo openssl genrsa -out server.key 2048
sudo openssl req -new -key server.key -out server.csr
sudo openssl x509 -req -in server.csr
    -CA ca.crt -CAkey ca.key -CAcreateserial
    -out server.crt -days 3650
```

When asked for **Common Name (CN)**, use: - Your VM **external IP address**

8. Secure Certificate Permissions

```
sudo openssl x509 -req -in server.csr -CA ca.crt -CAkey ca.key -CAcreateserial -out server.crt -days 3650 -sha256
```

```
sudo chown mosquitto:mosquitto /etc/mosquitto/certs/server.key /etc/mosquitto/
certs/server.crt
sudo chmod 600 /etc/mosquitto/certs/server.key
sudo chmod 644 /etc/mosquitto/certs/server.crt /etc/mosquitto/certs/ca.crt
```

```
sudo chown mosquitto:mosquitto /etc/mosquitto/passwd
sudo chmod 640 /etc/mosquitto/passwd
```

9. Configure Mosquitto Listeners (LOCAL + SECURE REMOTE)

At this stage we configure **two listeners**:

- **1883** → Plain MQTT, **LOCAL ONLY** (FastAPI ↔ Mosquitto inside the VM)
- **8883** → MQTT over TLS, **REMOTE ACCESS** (Raspberry Pi / external clients)

This separation is a **best practice** in real systems.

9.1 Create Mosquitto Configuration File

```
sudo nano /etc/mosquitto/conf.d/default.conf
```

Paste **exactly**:

```
# =====  
# LOCAL MQTT (NO TLS)  
# =====  
listener 1883 127.0.0.1  
protocol mqtt  
  
allow_anonymous false  
password_file /etc/mosquitto/passwd  
  
# =====  
# SECURE REMOTE MQTT (TLS)  
# =====  
listener 8883  
protocol mqtt  
  
allow_anonymous false  
password_file /etc/mosquitto/passwd  
  
cafile /etc/mosquitto/certs/ca.crt  
certfile /etc/mosquitto/certs/server.crt  
keyfile /etc/mosquitto/certs/server.key  
  
tls_version tlsv1.2
```

Important details: - `127.0.0.1` means port **1883** is **NOT** reachable from the internet - Only **8883** is exposed externally - Both listeners use authentication

Save and exit.

9.2 Restart Mosquitto

```
sudo systemctl restart mosquitto  
sudo systemctl status mosquitto --no-pager
```

You should see: - Active: active (running) - No TLS or permission errors

10. TLS CERTIFICATE FIX (SAN – Subject Alternative Name)

Why this step exists

When connecting via **IP address**, modern TLS requires that the server certificate contains the IP inside a **Subject Alternative Name (SAN)** field.

Without this, clients (Python, browsers, mobile apps) will fail with:

```
certificate verify failed: IP address mismatch
```

This step was required after the first TLS test failed.

10.1 Create SAN configuration file

```
sudo nano /etc/mosquitto/certs/san.cnf
```

Paste (replace IP if yours changes):

```
[req]
prompt = no
distinguished_name = dn
req_extensions = req_ext

[dn]
CN = 34.55.246.208

[req_ext]
subjectAltName = @alt_names

[alt_names]
IP.1 = 34.55.246.208
DNS.1 = localhost
```

10.2 Regenerate server certificate with SAN

```
cd /etc/mosquitto/certs

sudo openssl genrsa -out server.key 2048
sudo openssl req -new -key server.key -out server.csr -config san.cnf

sudo openssl x509 -req
    -in server.csr
    -CA ca.crt -CAkey ca.key -CAcreateserial
    -out server.crt -days 3650
    -extfile san.cnf -extensions req_ext
```

10.3 Fix permissions again

```
sudo chown mosquitto:mosquitto server.key server.crt
sudo chmod 600 server.key
sudo chmod 644 server.crt ca.crt
```

Restart Mosquitto:

```
sudo systemctl restart mosquitto
```

```
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## 10. Open Cloud Firewall (CRITICAL)

In Google Cloud Console:

1. Go to **VPC Network → Firewall Rules**
2. Create rule:
    - Name: allow-mqtts
    - Direction: Ingress
    - Source IP ranges: 0.0.0.0/0
    - Protocols: tcp:8883
3. Save

> Do NOT open port 1883 in production.

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## 11. Test TLS Locally on the VM
```

```
```bash
openssl s_client -connect <VM_EXTERNAL_IP>:8883 -CAfile /etc/mosquitto/certs/
ca.crt
```

You should see:

```
Verify return code: 0 (ok)
```

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## 12. Test MQTT Subscription on the VM

```
mosquitto_sub
-h <VM_EXTERNAL_IP>
-p 8883
-t '#'
-v
-u greenhouse-broker
-P <PASSWORD>
--cafile /etc/mosquitto/certs/ca.crt
```

This confirms: - Broker is reachable globally - TLS works - Authentication works

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## 13. What You Have Achieved

✓ Always-free cloud VM ✓ Secure MQTT broker ✓ TLS encryption ✓ Authentication ✓ Firewall protection ✓ Global access

This setup can now safely accept MQTT data from **anywhere in the world**.

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## 14. What Comes Next (Later)

- FastAPI subscribing to MQTT locally
  - PostgreSQL / time-series storage
  - Device certificates
  - Topic-level ACLs
  - Monitoring & logging
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## 15. Key Takeaway

This is **real cloud IoT infrastructure**, not a toy setup.

What you built today mirrors how production IoT systems work.

You can now repeat this entire process confidently.

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**End of documentation**