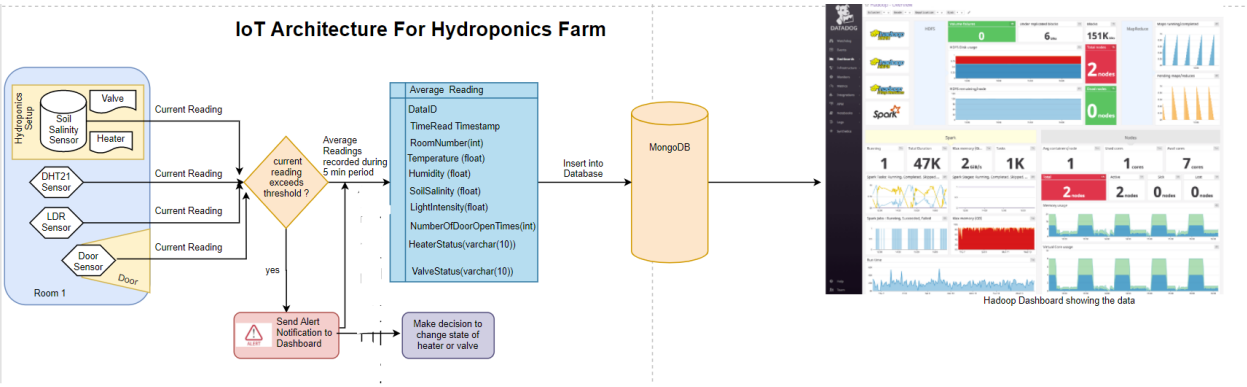
HANNAH BOADIWAA LORMENYO

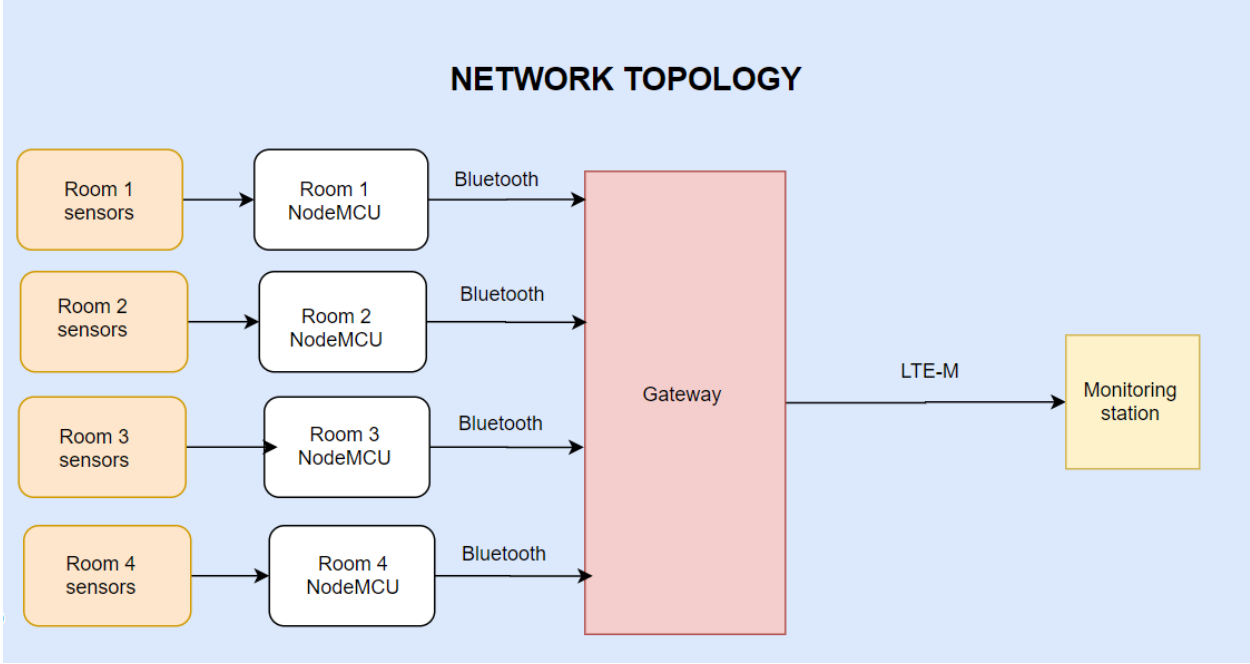
IOT FINAL EXAM

PART A

For each hydroponics farm, a door switch magnet will be used at the door to check the number times the door is opened. An LDR and a DHT sensor will be placed in every room to measure the light intensity, temperature, and humidity of the room. There will also be a heater to regulate the temperature of the room when necessary. A soil salinity sensor will be placed in the hydroponics solution to measure the soil salinity of the solution. After gathering the data from the sensors, the NodeMCU sends the data to an LTE-M gateway via bluetooth. This gateway is responsible to processing the data and then transmitting the data to the monitoring station. For instance, when the threshold for the different sensors is exceeded, the gateway sends an alert to the dashboard for an action to be taken. Also, the gateway takes the average readings recorded during every 5 minutes period and sends it to the monitoring station using LTE-M. At the monitoring station, the data is stored in a MongoDB cloud database to ensure the persistence of data. In the database, the time stamp is recorded as well as the temperature, humidity, light intensity, door switch magnet status, the heater status, the soil salinity, and the room number. Afterwards, the data is retrieved from the

database and displayed on a dashboard**.** The image below shows the snippet of the architecture for one room. The entire architecture can be found in the image files attached to the submissions.





ii. Reasons for Design

a. **MongoDB:** I choose MongoDB because it is flexible. Since the IoT system of the hydroponics farm is liable to changes (for example the addition of new sensors like sensors for measuring oxygen and pH levels) it is best to use a database that can easily be changed without causing much effect on the database. One more reason is that MongoDB is much more scalable. IoT is a big data issue because the IoT systems have a high data ingestion rate, the data is voluminous, and it has a wide variety. MongoDB is globally known for its efficiency with Big Data since it can easily scale as the data grows.

b. **Real Time Data Processing in the Cloud:** To ensure real time data processing and data analytics, I included Hadoop in the design. Hadoop will consume the data from MongoDB and perform analytics using machine learning and other algorithms in real time. This would help the MIS manager make very informed decisions in real time. He/She can detect problems and provide solutions before they happen using prescriptive analysis on the data. Using the Hadoop platform with MongoDB in the cloud ensures scalability and security. Also, it is low-cost and saves time compared to the use of in-house resources which are costly.

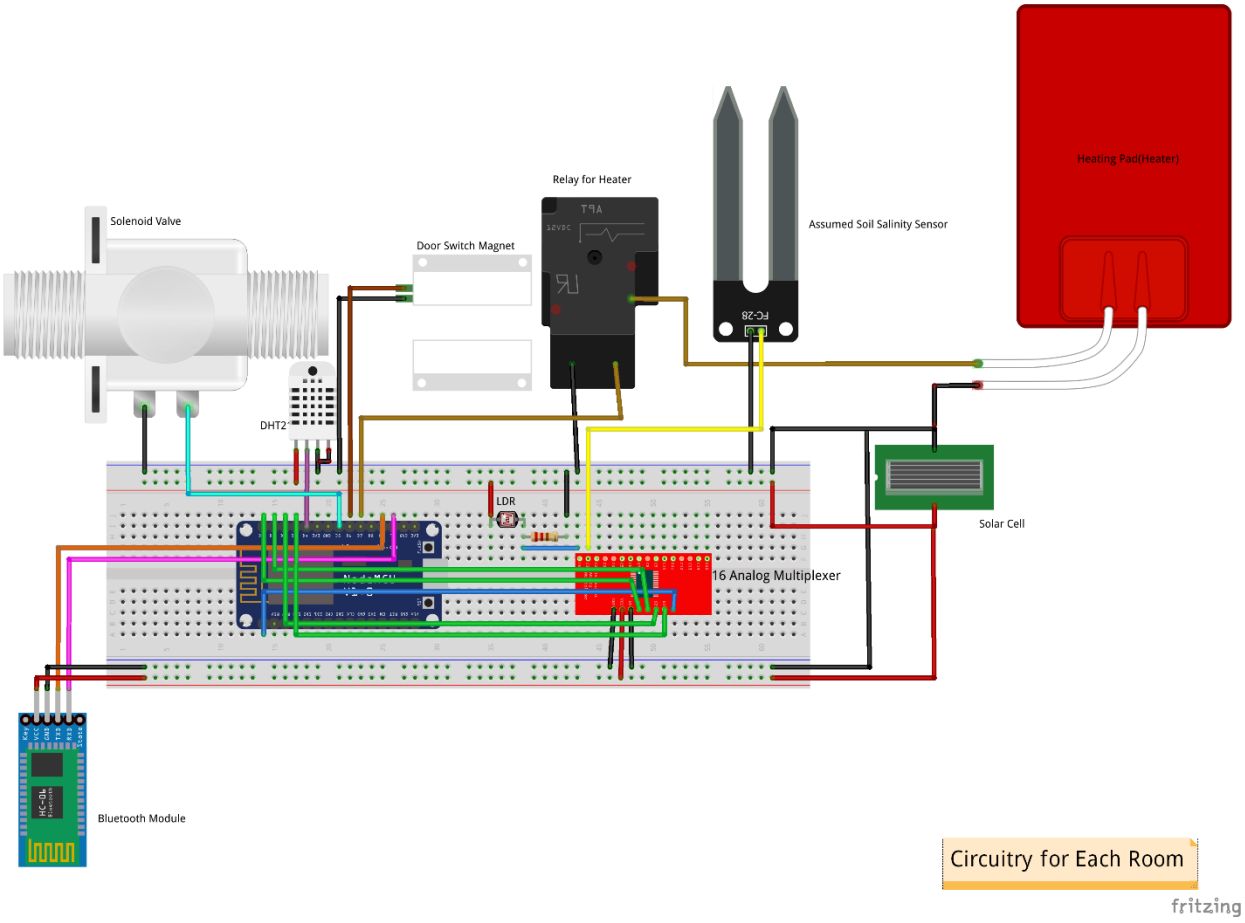
c. **Access Technology:** All the sensors will be connected to NodeMCU interfaced with a Bluetooth module. The NodeMCU sends the sensor data to the gateway via a Bluetooth connection. Bluetooth was chosen because the gateway will be in a short range. Since the monitoring station is 15km away from the farm, it is best to use a gateway which can overcome the limitations of the constrained network and transmit the data to a station at a further distance. This transmission will be done via LTE-M. LTE-M has better coverage

and is very responsive. Since the MIS manager would like to process the data in real time and make decisions accordingly, the actuators can quickly respond to the decisions due to this LTE-M connection. LTE-M is also low cost and low-power.

d. **Security**: JSON Web Tokens will be used to authenticate the devices in the network. For every data that is sent from the device to the database, a token will be added to the request which confirms the identity and rights of the device in the network. This will help to prevent unauthorized penetrations into the network. This authentication will also be included at the dashboard. To view the dashboard, users will be required to log in with the credentials given by the company. The physical security of set up is also necessary. All the rooms will be locked at all times and there will be a supervisor who will be physically present at the farm to keep watch.

e. Data frequency: The data is recorded in real time but only the average of the readings recorded in the 5-minute window period is inserted into the database. This is meant to reduce the ingestion rate and the volume of data accumulated over time. When any of the readings exceed the respective threshold set by the manager, an alert is sent to the manager via the dashboard for him/her to take an action [turn heater on/off or open/close solenoid valve].

iii. The circuitry can be seen below:



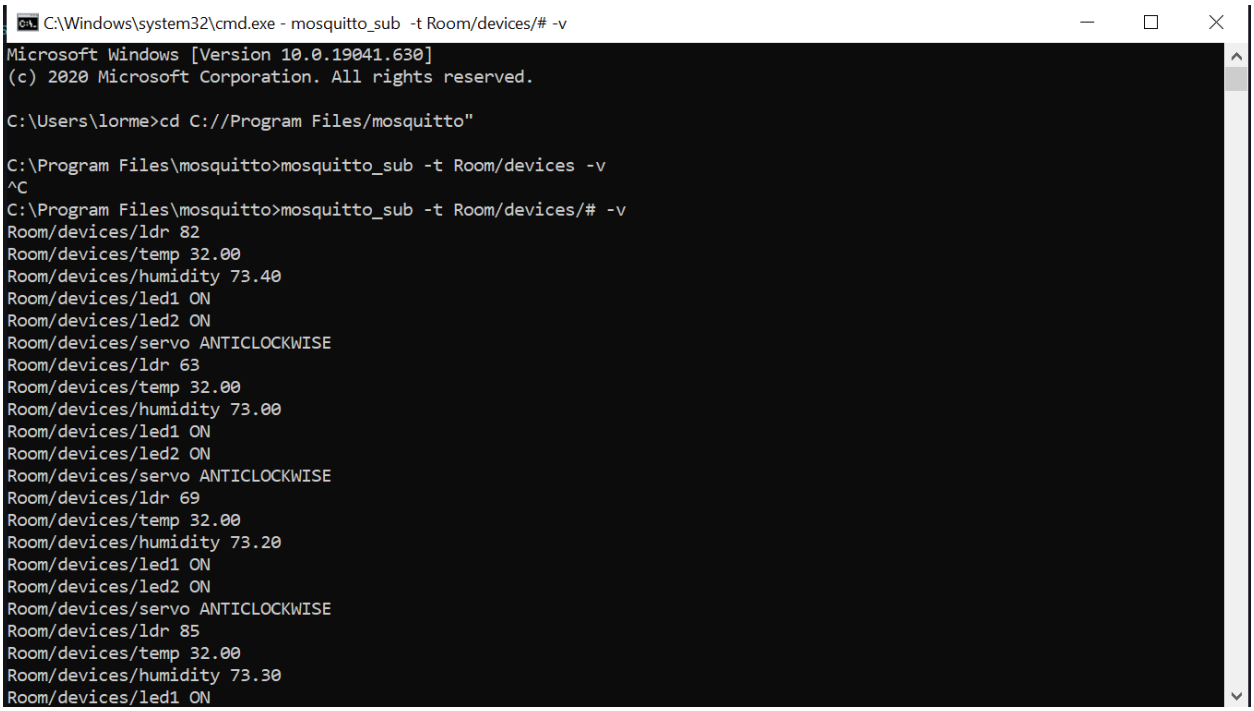
Components used:

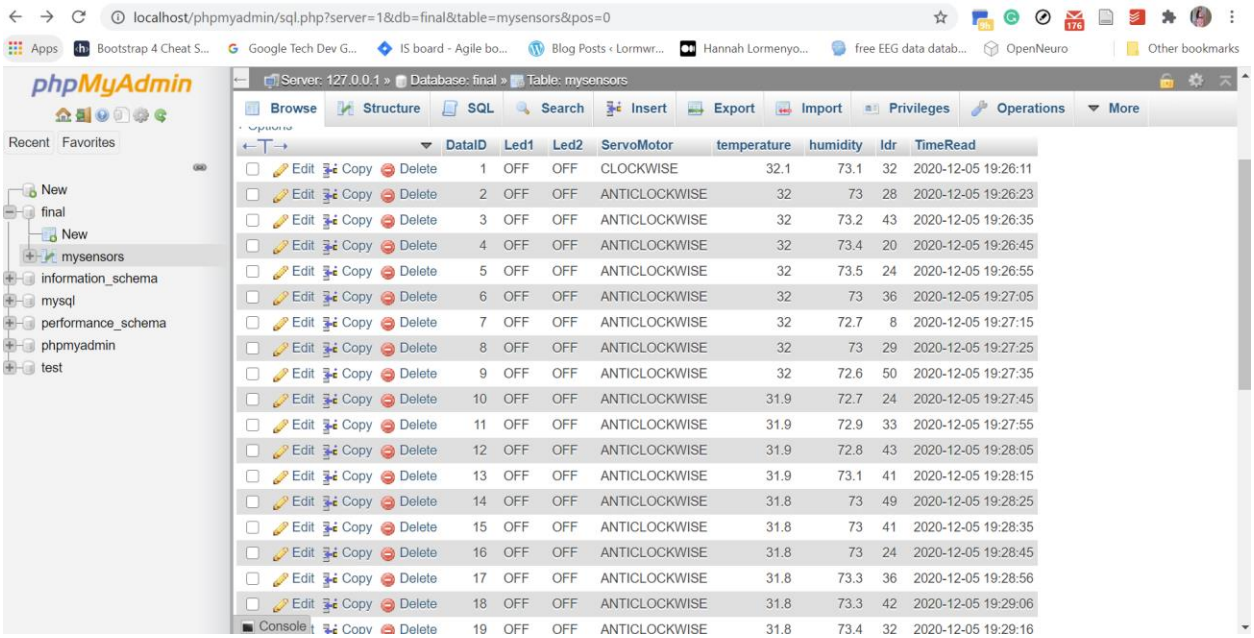
1. Solar cell
2. NodeMCU (x4)
3. DHT21 (x4)
4. LDR (x4)
5. Solenoid valve(x4)
6. Relay(x4)
7. Door Switch Magnet(x4)

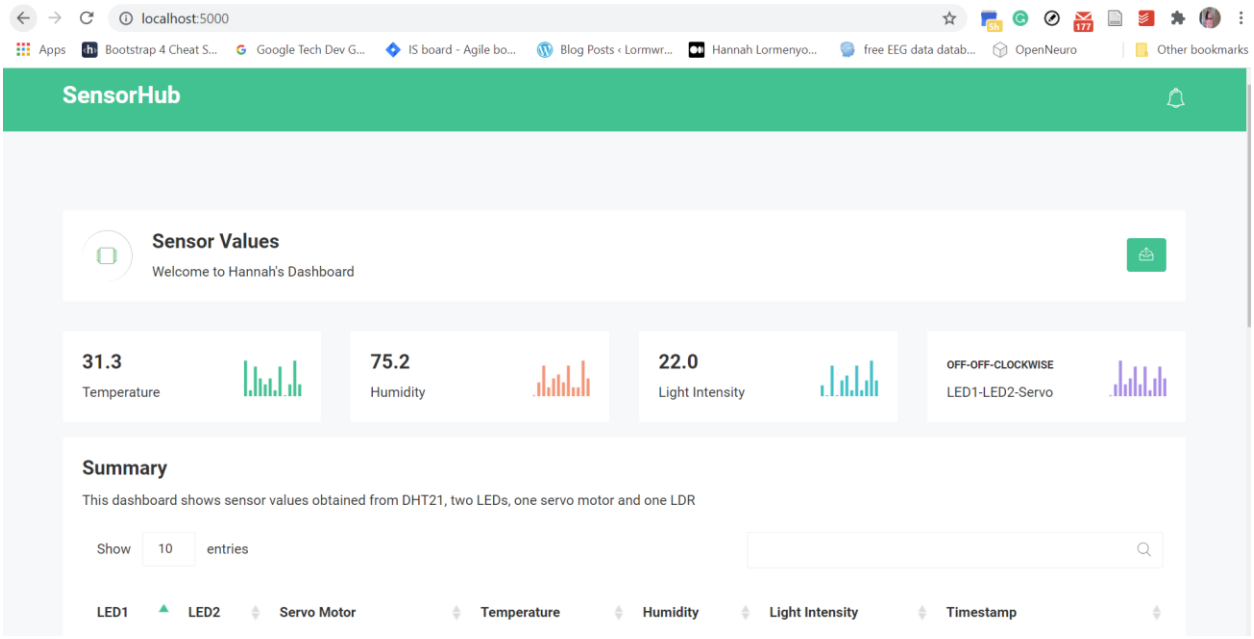
8. Heater(x4)
9. Soil Salinity sensor (x4)
10. Connecting wires
11. Bluetooth Module HC-06 (x4)

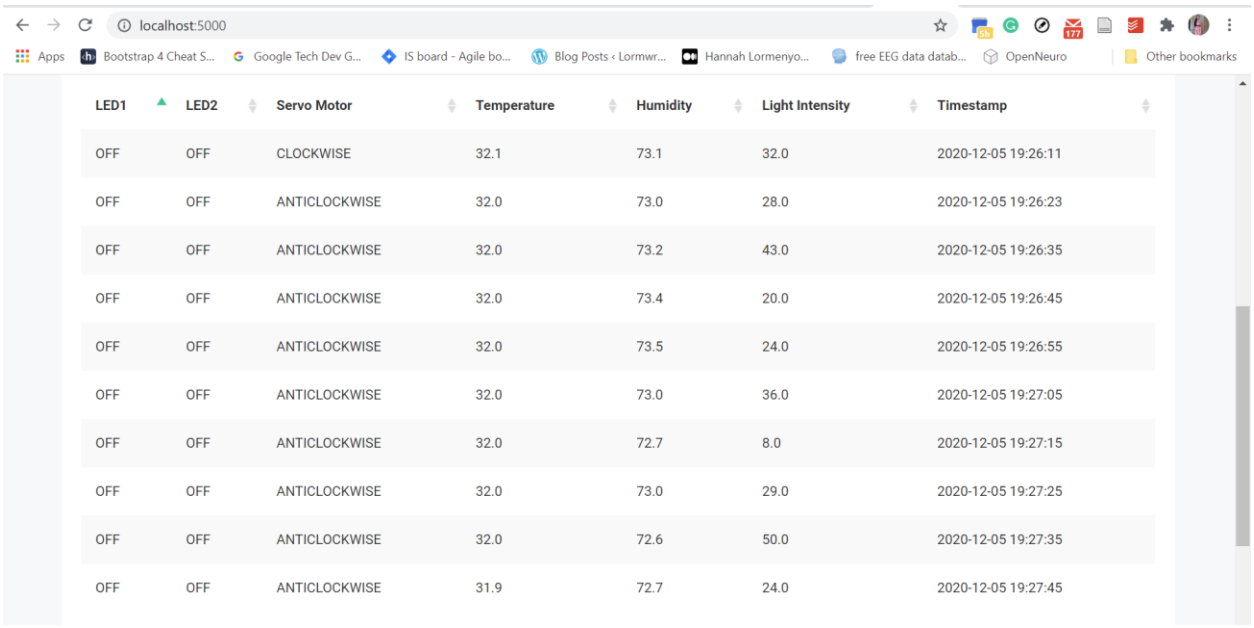
PART B

You can find the dashboard here: https://mysensors.herokuapp.com/




localhost/phpmyadmin/sql.php?server=1&db=final&table=mysensors&pos=0
phpMyAdmin
Recent Favorites
New
final
New
mysensors
information_schema
mysql
performance_schema
phpmyadmin
test
Server: 127.0.0.1 » Database: final » Table: mysensors
Browse Structure SQL Search Insert Export Import Privileges Operations More
DataID Led1 Led2 ServoMotor temperature humidity ldr TimeRead
1 OFF OFF CLOCKWISE 32.1 73.1 32 2020-12-05 19:26:11
2 OFF OFF ANTICLOCKWISE 32 73 28 2020-12-05 19:26:23
3 OFF OFF ANTICLOCKWISE 32 73.2 43 2020-12-05 19:26:35
4 OFF OFF ANTICLOCKWISE 32 73.4 20 2020-12-05 19:26:45
5 OFF OFF ANTICLOCKWISE 32 73.5 24 2020-12-05 19:26:55
6 OFF OFF ANTICLOCKWISE 32 73 36 2020-12-05 19:27:05
7 OFF OFF ANTICLOCKWISE 32 72.7 8 2020-12-05 19:27:15
8 OFF OFF ANTICLOCKWISE 32 73 29 2020-12-05 19:27:25
9 OFF OFF ANTICLOCKWISE 32 72.6 50 2020-12-05 19:27:35
10 OFF OFF ANTICLOCKWISE 31.9 72.7 24 2020-12-05 19:27:45
11 OFF OFF ANTICLOCKWISE 31.9 72.9 33 2020-12-05 19:27:55
12 OFF OFF ANTICLOCKWISE 31.9 72.8 43 2020-12-05 19:28:05
13 OFF OFF ANTICLOCKWISE 31.9 73.1 41 2020-12-05 19:28:15
14 OFF OFF ANTICLOCKWISE 31.8 73 49 2020-12-05 19:28:25
15 OFF OFF ANTICLOCKWISE 31.8 73 41 2020-12-05 19:28:35
16 OFF OFF ANTICLOCKWISE 31.8 73 24 2020-12-05 19:28:45
17 OFF OFF ANTICLOCKWISE 31.8 73.3 36 2020-12-05 19:28:56
18 OFF OFF ANTICLOCKWISE 31.8 73.3 42 2020-12-05 19:29:06
19 OFF OFF ANTICLOCKWISE 31.8 73.4 32 2020-12-05 19:29:16


localhost:5000
SensorHub
Sensor Values
Welcome to Hannah's Dashboard
31.3
Temperature
75.2
Humidity
22.0
Light Intensity
OFF-OFF-CLOCKWISE
LED1-LED2-Servo
Summary
This dashboard shows sensor values obtained from DHT21, two LEDs, one servo motor and one LDR
Show 10 entries
LED1 LED2 Servo Motor Temperature Humidity Light Intensity Timestamp



LED1	LED2	Servo Motor	Temperature	Humidity	Light Intensity	Timestamp
OFF	OFF	CLOCKWISE	32.1	73.1	32.0	2020-12-05 19:26:11
OFF	OFF	ANTICLOCKWISE	32.0	73.0	28.0	2020-12-05 19:26:23
OFF	OFF	ANTICLOCKWISE	32.0	73.2	43.0	2020-12-05 19:26:35
OFF	OFF	ANTICLOCKWISE	32.0	73.4	20.0	2020-12-05 19:26:45
OFF	OFF	ANTICLOCKWISE	32.0	73.5	24.0	2020-12-05 19:26:55
OFF	OFF	ANTICLOCKWISE	32.0	73.0	36.0	2020-12-05 19:27:05
OFF	OFF	ANTICLOCKWISE	32.0	72.7	8.0	2020-12-05 19:27:15
OFF	OFF	ANTICLOCKWISE	32.0	73.0	29.0	2020-12-05 19:27:25
OFF	OFF	ANTICLOCKWISE	32.0	72.6	50.0	2020-12-05 19:27:35
OFF	OFF	ANTICLOCKWISE	31.9	72.7	24.0	2020-12-05 19:27:45

PART C

The notebook can be found here:

https://colab.research.google.com/drive/18DrViL3kXp8pCfcy8hnMibyd_6Luf1WN?usp=sharing

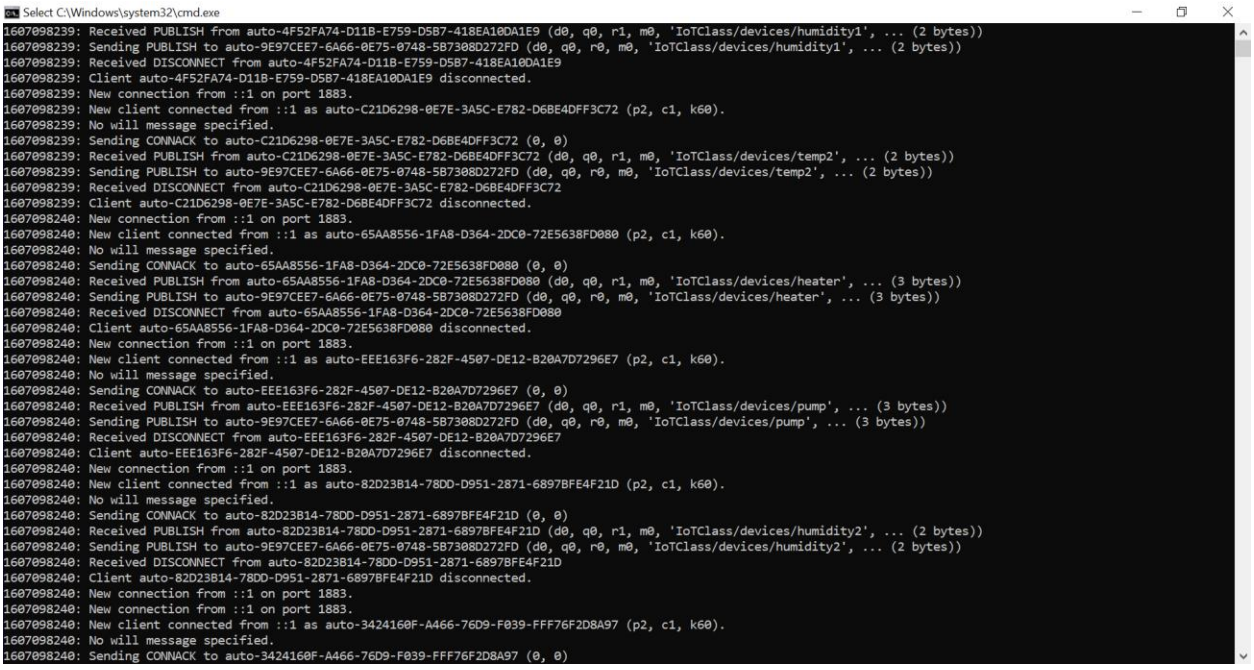


Figure 1: MQTT server

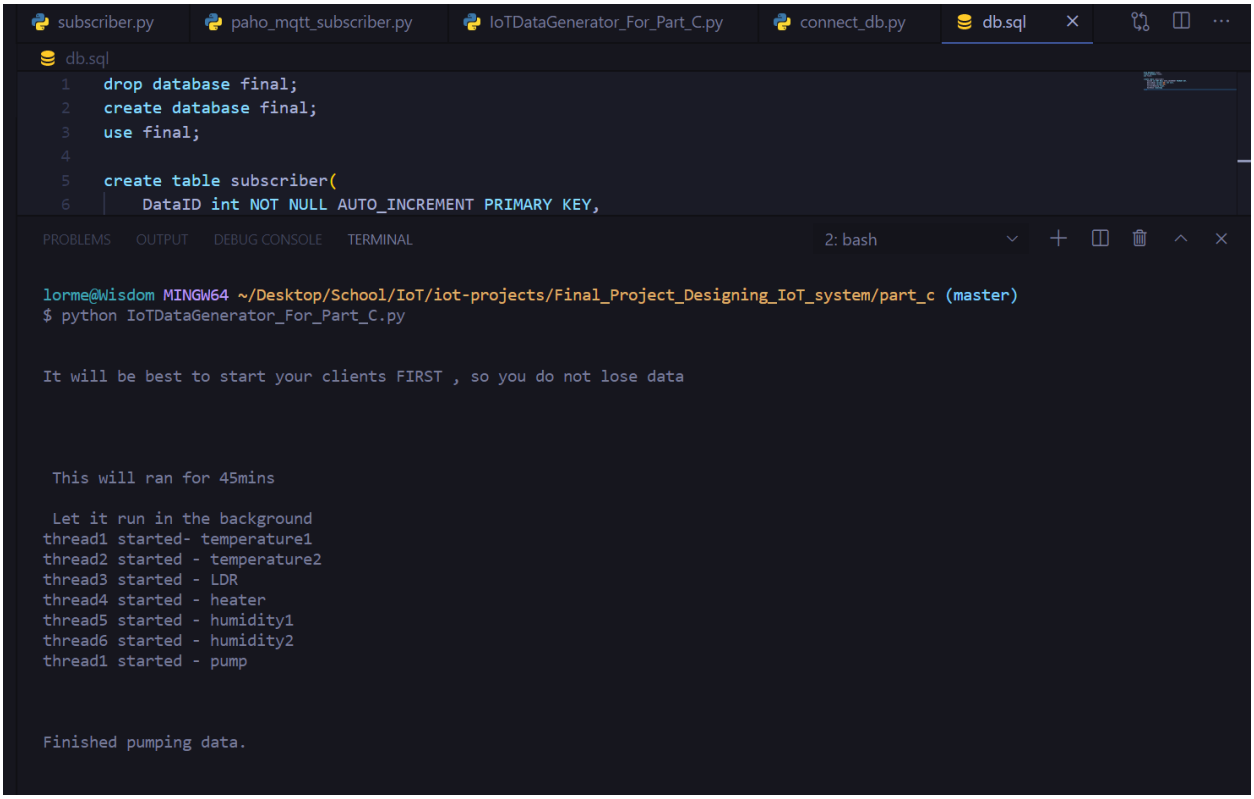


Figure 2: Data Generator

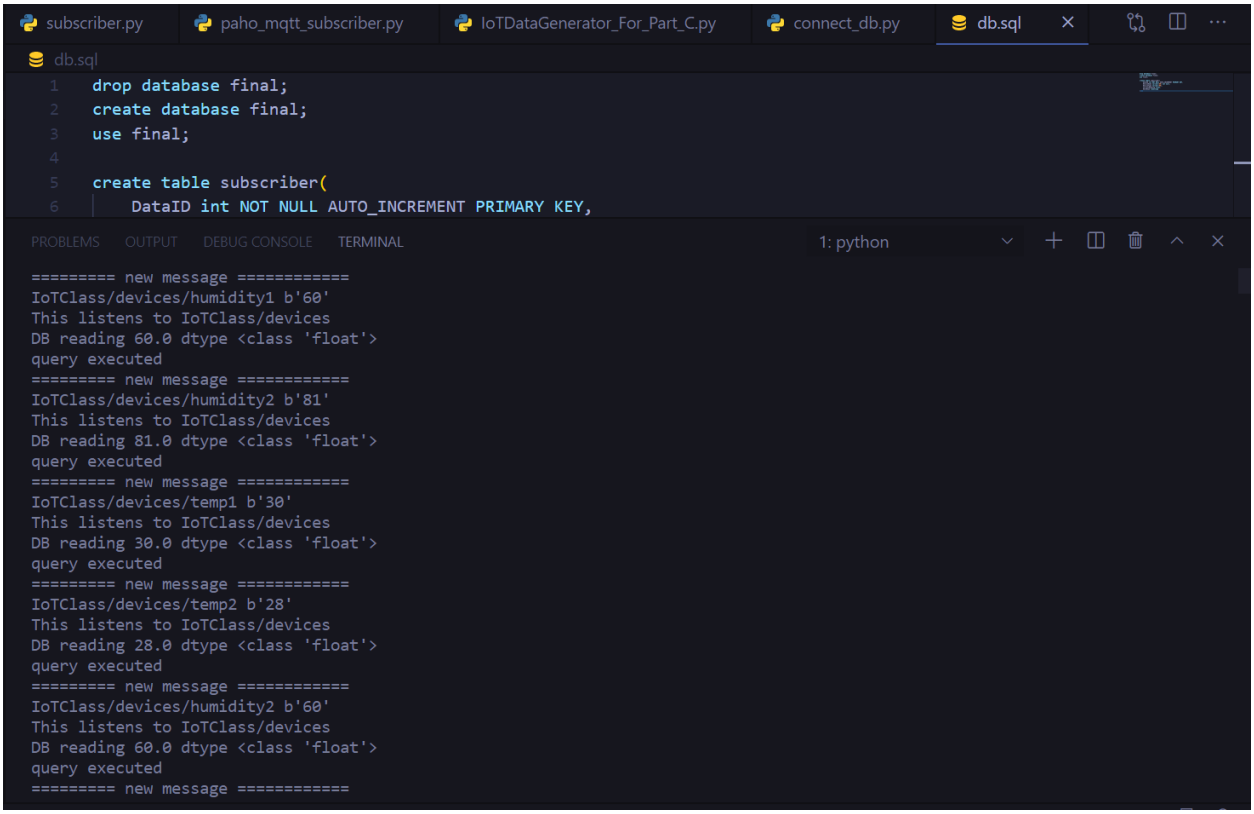
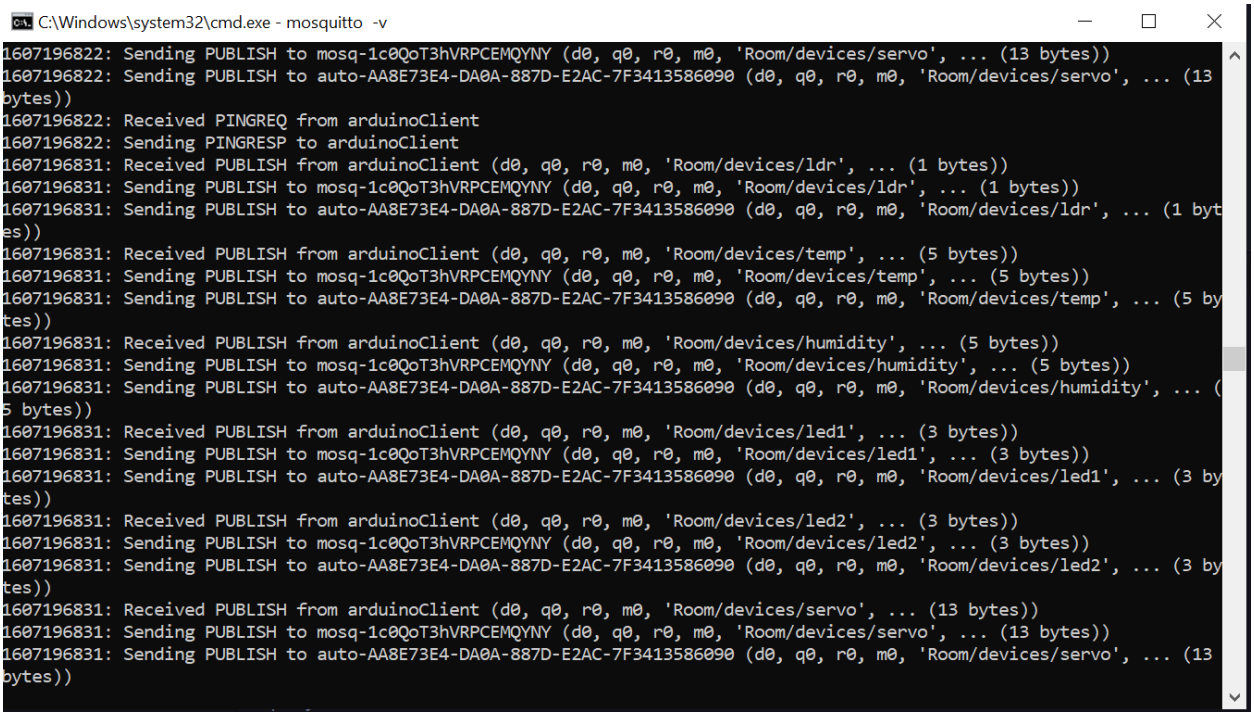
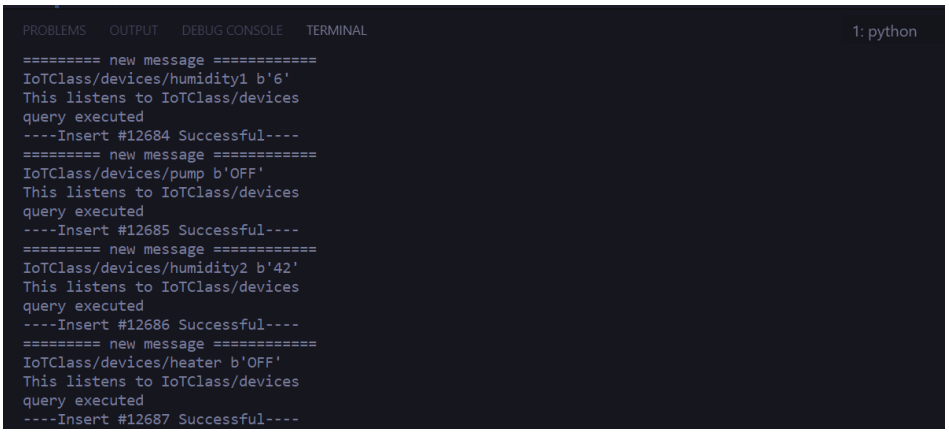
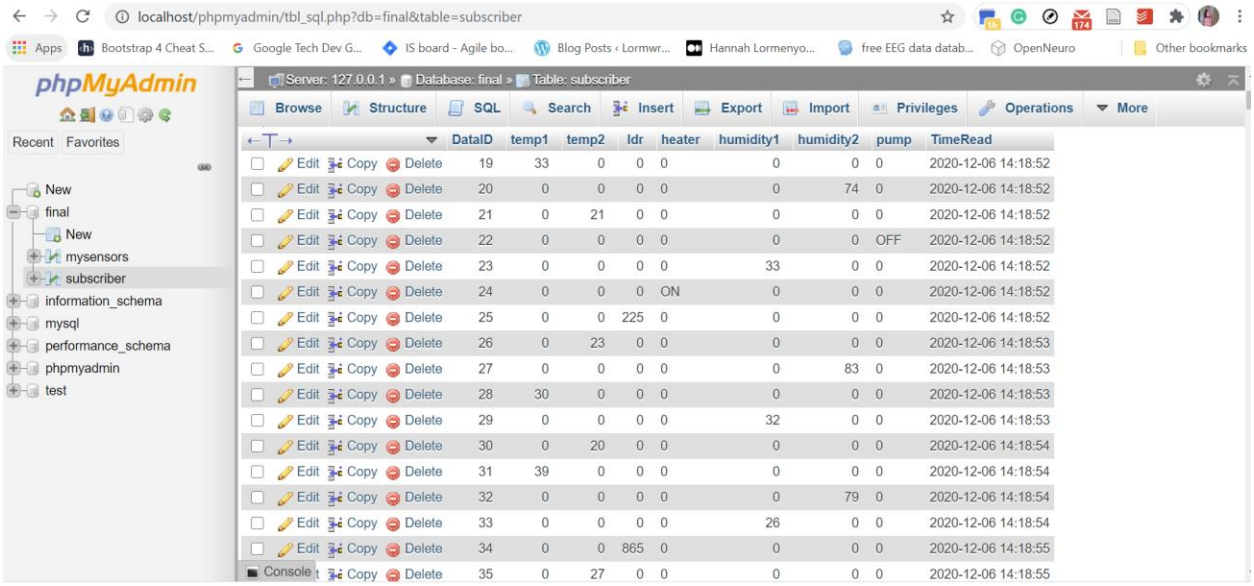
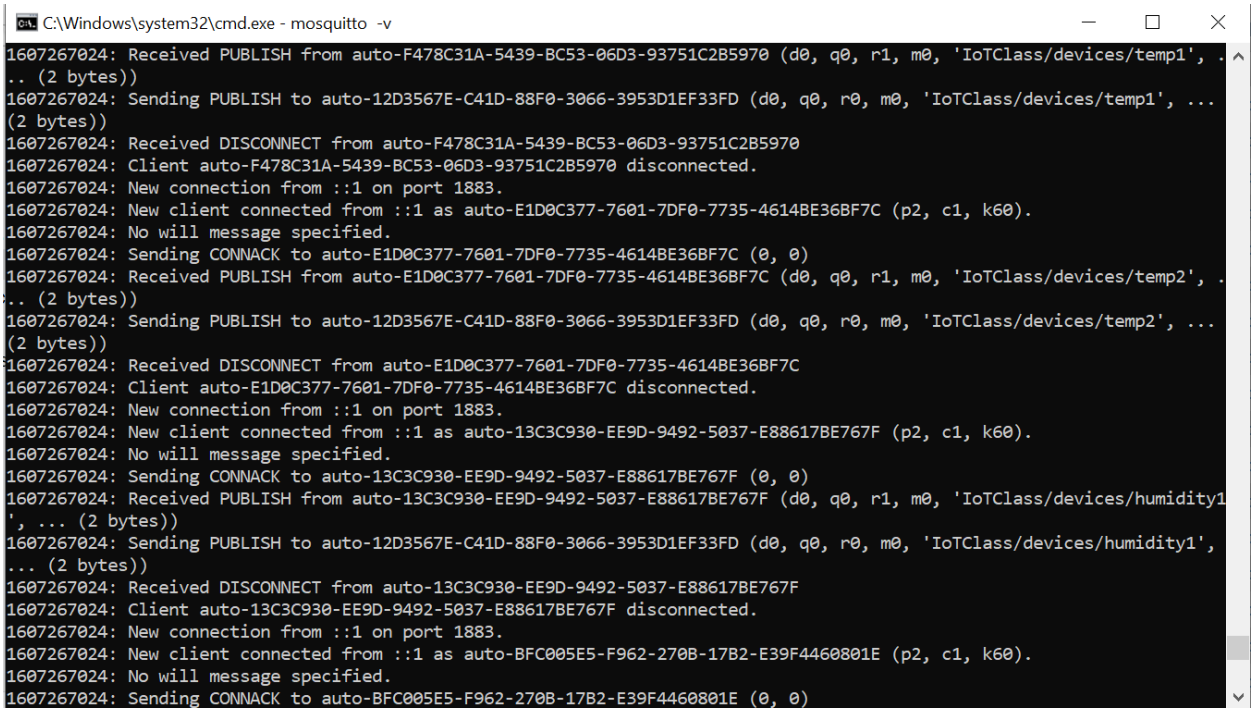


Figure 3: Subscriber


C:\Windows\system32\cmd.exe - mosquitto -v
1607196822: Sending PUBLISH to mosq-1c0QoT3hVRPCEMQYNY (d0, q0, r0, m0, 'Room/devices/servo', ... (13 bytes))
1607196822: Sending PUBLISH to auto-AA8E73E4-DA0A-887D-E2AC-7F3413586090 (d0, q0, r0, m0, 'Room/devices/servo', ... (13 bytes))
1607196822: Received PINGREQ from arduinoClient
1607196822: Sending PINGRESP to arduinoClient
1607196831: Received PUBLISH from arduinoClient (d0, q0, r0, m0, 'Room/devices/ldr', ... (1 bytes))
1607196831: Sending PUBLISH to mosq-1c0QoT3hVRPCEMQYNY (d0, q0, r0, m0, 'Room/devices/ldr', ... (1 bytes))
1607196831: Sending PUBLISH to auto-AA8E73E4-DA0A-887D-E2AC-7F3413586090 (d0, q0, r0, m0, 'Room/devices/ldr', ... (1 bytes))
1607196831: Received PUBLISH from arduinoClient (d0, q0, r0, m0, 'Room/devices/temp', ... (5 bytes))
1607196831: Sending PUBLISH to mosq-1c0QoT3hVRPCEMQYNY (d0, q0, r0, m0, 'Room/devices/temp', ... (5 bytes))
1607196831: Sending PUBLISH to auto-AA8E73E4-DA0A-887D-E2AC-7F3413586090 (d0, q0, r0, m0, 'Room/devices/temp', ... (5 bytes))
1607196831: Received PUBLISH from arduinoClient (d0, q0, r0, m0, 'Room/devices/humidity', ... (5 bytes))
1607196831: Sending PUBLISH to mosq-1c0QoT3hVRPCEMQYNY (d0, q0, r0, m0, 'Room/devices/humidity', ... (5 bytes))
1607196831: Sending PUBLISH to auto-AA8E73E4-DA0A-887D-E2AC-7F3413586090 (d0, q0, r0, m0, 'Room/devices/humidity', ... (5 bytes))
1607196831: Received PUBLISH from arduinoClient (d0, q0, r0, m0, 'Room/devices/led1', ... (3 bytes))
1607196831: Sending PUBLISH to mosq-1c0QoT3hVRPCEMQYNY (d0, q0, r0, m0, 'Room/devices/led1', ... (3 bytes))
1607196831: Sending PUBLISH to auto-AA8E73E4-DA0A-887D-E2AC-7F3413586090 (d0, q0, r0, m0, 'Room/devices/led1', ... (3 bytes))
1607196831: Received PUBLISH from arduinoClient (d0, q0, r0, m0, 'Room/devices/led2', ... (3 bytes))
1607196831: Sending PUBLISH to mosq-1c0QoT3hVRPCEMQYNY (d0, q0, r0, m0, 'Room/devices/led2', ... (3 bytes))
1607196831: Sending PUBLISH to auto-AA8E73E4-DA0A-887D-E2AC-7F3413586090 (d0, q0, r0, m0, 'Room/devices/led2', ... (3 bytes))
1607196831: Received PUBLISH from arduinoClient (d0, q0, r0, m0, 'Room/devices/servo', ... (13 bytes))
1607196831: Sending PUBLISH to mosq-1c0QoT3hVRPCEMQYNY (d0, q0, r0, m0, 'Room/devices/servo', ... (13 bytes))
1607196831: Sending PUBLISH to auto-AA8E73E4-DA0A-887D-E2AC-7F3413586090 (d0, q0, r0, m0, 'Room/devices/servo', ... (13 bytes))


PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
1: python
========= new message ============
IoTClass/devices/humidity1 b'6'
This listens to IoTClass/devices
query executed
----Insert #12684 Successful----
========= new message ============
IoTClass/devices/pump b'OFF'
This listens to IoTClass/devices
query executed
----Insert #12685 Successful----
========= new message ============
IoTClass/devices/humidity2 b'42'
This listens to IoTClass/devices
query executed
----Insert #12686 Successful----
========= new message ============
IoTClass/devices/heater b'OFF'
This listens to IoTClass/devices
query executed
----Insert #12687 Successful----


localhost/phpmyadmin/tbl_sql.php?db=final&table=subscriber
phpMyAdmin
Recent Favorites
New
final
New
mysensors
subscriber
information_schema
mysql
performance_schema
phpmyadmin
test
Server: 127.0.0.1 » Database: final » Table: subscriber
Browse Structure SQL Search Insert Export Import Privileges Operations More
DataID temp1 temp2 ldr heater humidity1 humidity2 pump TimeRead
Edit Copy Delete 19 33 0 0 0 0 0 0 2020-12-06 14:18:52
Edit Copy Delete 20 0 0 0 0 0 74 0 2020-12-06 14:18:52
Edit Copy Delete 21 0 21 0 0 0 0 0 2020-12-06 14:18:52
Edit Copy Delete 22 0 0 0 0 0 0 OFF 2020-12-06 14:18:52
Edit Copy Delete 23 0 0 0 0 33 0 0 2020-12-06 14:18:52
Edit Copy Delete 24 0 0 0 ON 0 0 0 2020-12-06 14:18:52
Edit Copy Delete 25 0 0 225 0 0 0 0 2020-12-06 14:18:52
Edit Copy Delete 26 0 23 0 0 0 0 0 2020-12-06 14:18:53
Edit Copy Delete 27 0 0 0 0 0 83 0 2020-12-06 14:18:53
Edit Copy Delete 28 30 0 0 0 0 0 0 2020-12-06 14:18:53
Edit Copy Delete 29 0 0 0 0 32 0 0 2020-12-06 14:18:53
Edit Copy Delete 30 0 20 0 0 0 0 0 2020-12-06 14:18:54
Edit Copy Delete 31 39 0 0 0 0 0 0 2020-12-06 14:18:54
Edit Copy Delete 32 0 0 0 0 0 79 0 2020-12-06 14:18:54
Edit Copy Delete 33 0 0 0 0 26 0 0 2020-12-06 14:18:54
Edit Copy Delete 34 0 0 865 0 0 0 0 2020-12-06 14:18:55
Console Copy Delete 35 0 27 0 0 0 0 0 2020-12-06 14:18:55


C:\Windows\system32\cmd.exe - mosquitto -v
1607267024: Received PUBLISH from auto-F478C31A-5439-BC53-06D3-93751C2B5970 (d0, q0, r1, m0, 'IoTClass/devices/temp1', ... (2 bytes))
1607267024: Sending PUBLISH to auto-12D3567E-C41D-88F0-3066-3953D1EF33FD (d0, q0, r0, m0, 'IoTClass/devices/temp1', ... (2 bytes))
1607267024: Received DISCONNECT from auto-F478C31A-5439-BC53-06D3-93751C2B5970
1607267024: Client auto-F478C31A-5439-BC53-06D3-93751C2B5970 disconnected.
1607267024: New connection from ::1 on port 1883.
1607267024: New client connected from ::1 as auto-E1D0C377-7601-7DF0-7735-4614BE36BF7C (p2, c1, k60).
1607267024: No will message specified.
1607267024: Sending CONNACK to auto-E1D0C377-7601-7DF0-7735-4614BE36BF7C (0, 0)
1607267024: Received PUBLISH from auto-E1D0C377-7601-7DF0-7735-4614BE36BF7C (d0, q0, r1, m0, 'IoTClass/devices/temp2', ... (2 bytes))
1607267024: Sending PUBLISH to auto-12D3567E-C41D-88F0-3066-3953D1EF33FD (d0, q0, r0, m0, 'IoTClass/devices/temp2', ... (2 bytes))
1607267024: Received DISCONNECT from auto-E1D0C377-7601-7DF0-7735-4614BE36BF7C
1607267024: Client auto-E1D0C377-7601-7DF0-7735-4614BE36BF7C disconnected.
1607267024: New connection from ::1 on port 1883.
1607267024: New client connected from ::1 as auto-13C3C930-EE9D-9492-5037-E88617BE767F (p2, c1, k60).
1607267024: No will message specified.
1607267024: Sending CONNACK to auto-13C3C930-EE9D-9492-5037-E88617BE767F (0, 0)
1607267024: Received PUBLISH from auto-13C3C930-EE9D-9492-5037-E88617BE767F (d0, q0, r1, m0, 'IoTClass/devices/humidity1', ... (2 bytes))
1607267024: Sending PUBLISH to auto-12D3567E-C41D-88F0-3066-3953D1EF33FD (d0, q0, r0, m0, 'IoTClass/devices/humidity1', ... (2 bytes))
1607267024: Received DISCONNECT from auto-13C3C930-EE9D-9492-5037-E88617BE767F
1607267024: Client auto-13C3C930-EE9D-9492-5037-E88617BE767F disconnected.
1607267024: New connection from ::1 on port 1883.
1607267024: New client connected from ::1 as auto-BFC005E5-F962-270B-17B2-E39F4460801E (p2, c1, k60).
1607267024: No will message specified.
1607267024: Sending CONNACK to auto-BFC005E5-F962-270B-17B2-E39F4460801E (0, 0)