MAE 6291
Internet of Things for Engineers

Prof. Kartik Bulusu, MAE Dept.

Week 12 [04/16/2025]	• Guest lecture: **Innovation @ IOT+Human Behaviour+Finance** by Anurag Bhatnagar, CEO and Co-Founder, ShiftAltCap - Investment banking firm. • MQTT using ThingSpeak	• Using SenseHat with MQTT • In-class Raspberry Pi Lab – ThingSpeak MQTT

git clone https://github.com/gwu-mae6291-iot/spring2025_codes.git

GW School of Engineering & Applied Science
THE GEORGE WASHINGTON UNIVERSITY

Spring 2025

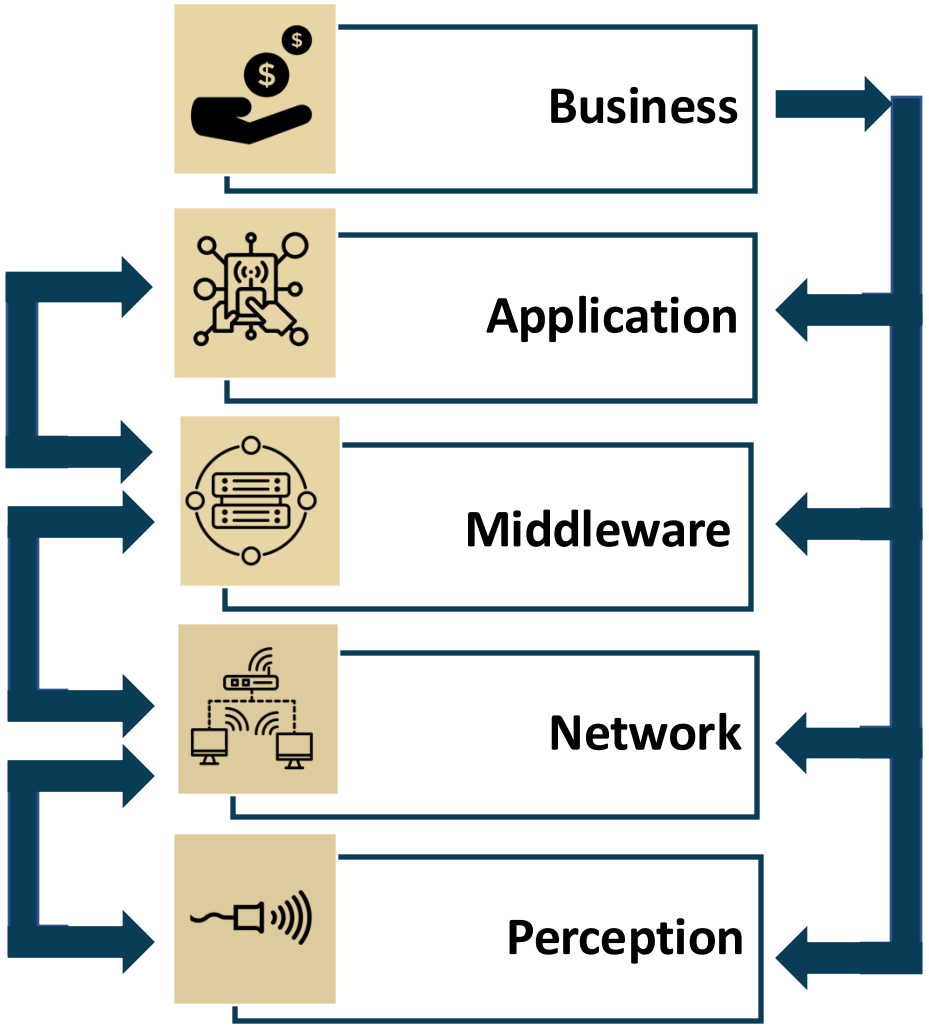
Photo: Kartik Bulusu

Final projects
[Things to remember]

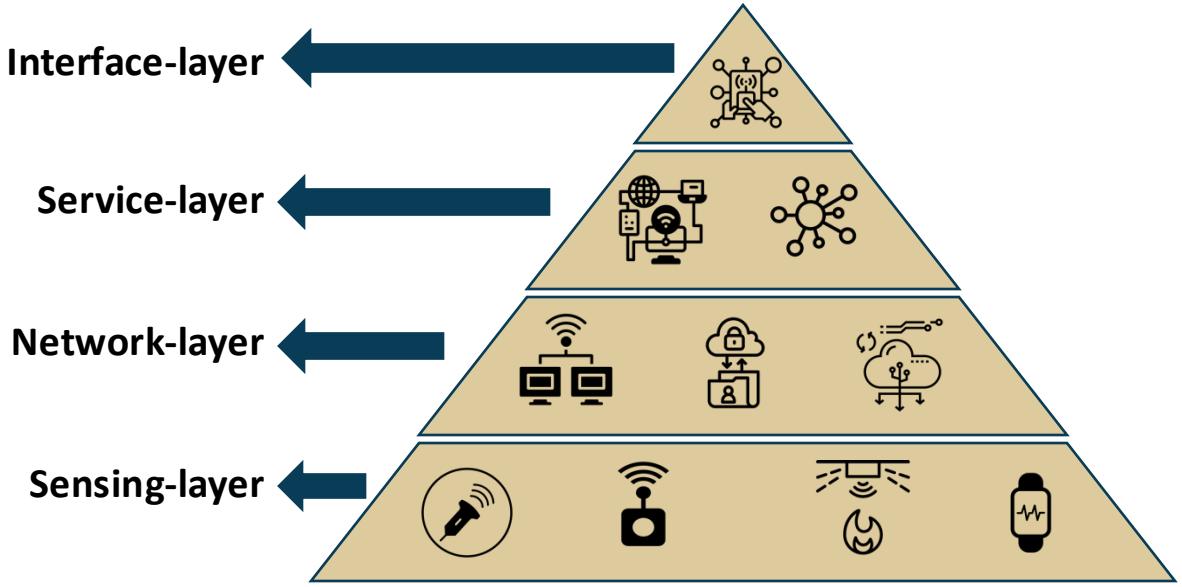
Expectations on student deliverables:

1. **[Upload by 11:00 AM on April 23, 2025]** Final project presentation **[25 points]**
2. **[Upload by 11:00 AM on April 23, 2025]** Final project 2-minute video **[25 points]**
3. **[April 23, 2025]** Final project demo **[Tied to #1]**
4. **[Upload by April 24, 2025]** Executive summary **[10 points]**
5. **[Upload on April 28, 2025]** Final project written report **[25 points]**
6. **[Upload on April 30, 2025]** Journal paper reviews by Grad students **[10 points]**
7. **[On Google form]** Share the Github repo of midterm and final projects **[Tied to #1]**
8. **Attendance and no extension**

The 5-Layer IoT Architecture



Service-oriented IoT Architecture

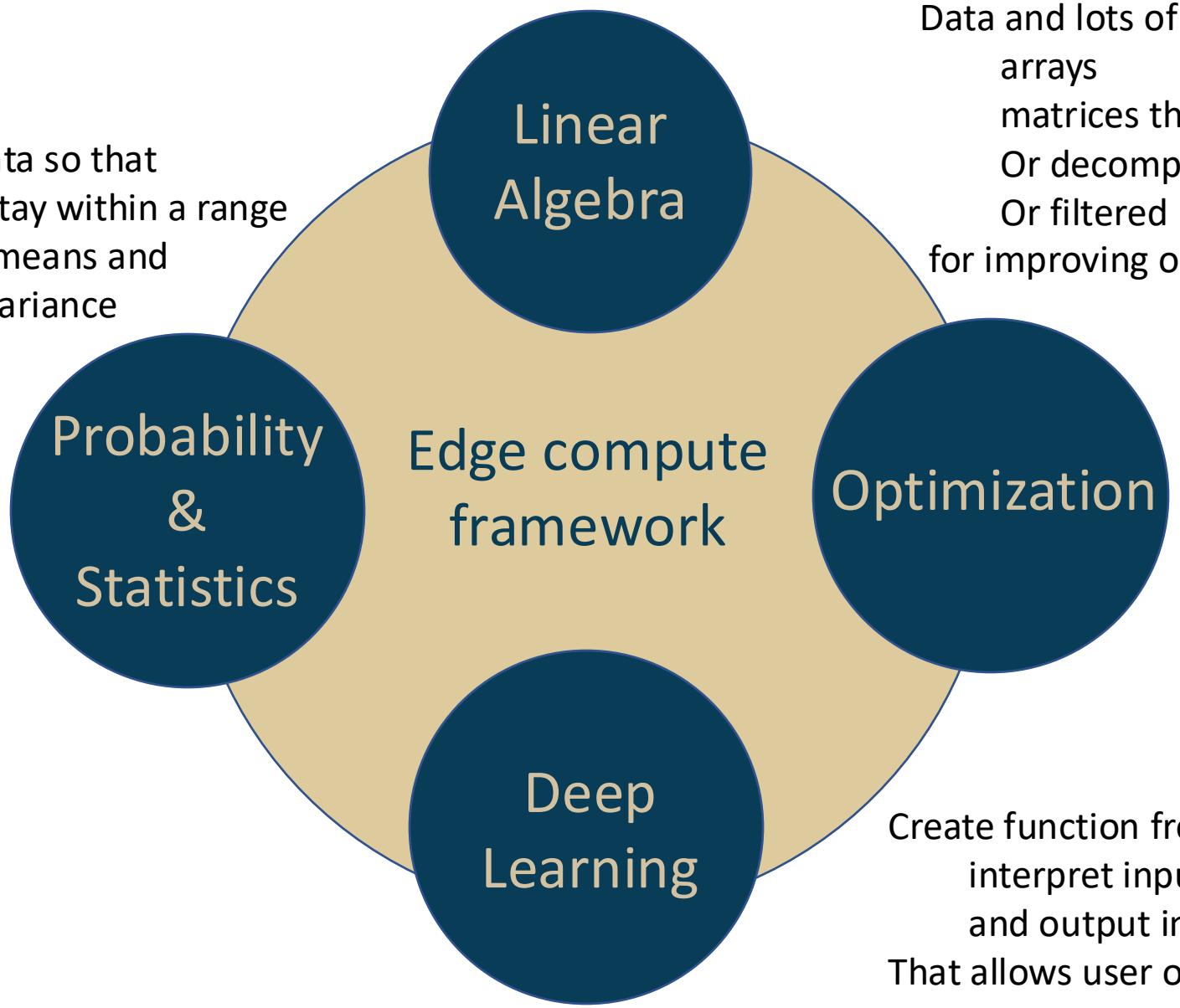


Sources:
sensor by Carolina Cani:, sensor by Pham Duy Phuong Hung, sensor by Tippawan Sookruay, sensor by Lorenzo: https://thenounproject.com/browse/icons/term/sensor
wifi network by Matthias Hartmann:: https://thenounproject.com/browse/icons/term/wifi-network/
application by Chaowalit Koetchuea: https://thenounproject.com/browse/icons/term/application/
IoT Architecture layers: https://www.startertutorials.com/blog/iot-architecture-layers.html

Source:
https://youtu.be/Cx5Z-OslNWE
Strang, G., Linear Algebra and Learning from Data (2019)

Data and lots of data
arrays
matrices that are special and can be factored
Or decomposed
Or filtered
for improving our understanding of the physical phenomena

Monitor data so that
they stay within a range
means and
variance

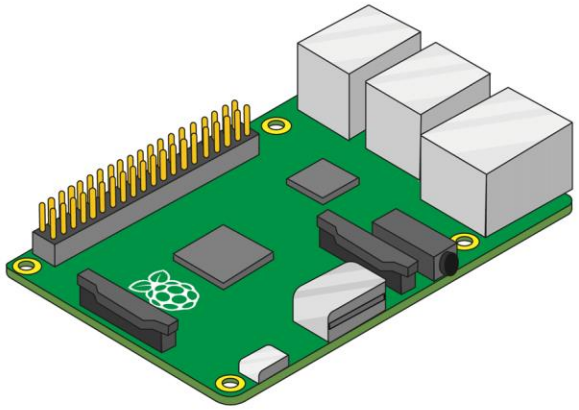


Finding matrices
that transform data
and minimize errors
Memory intensive process that usually
happens at cloud-level

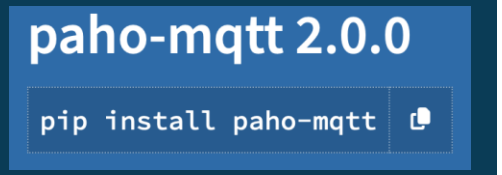
Create function from data at cloud-level
interpret input data at edge-level
and output information at edge-level
That allows user or system to take decisions

Topics to be covered today

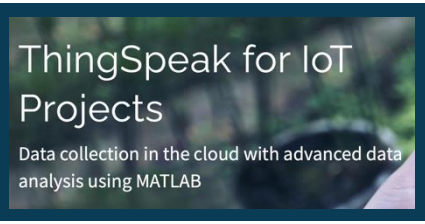
Hardware:
SenseHat



IoT Strategy #1:
Paho-MQTT with senseHat



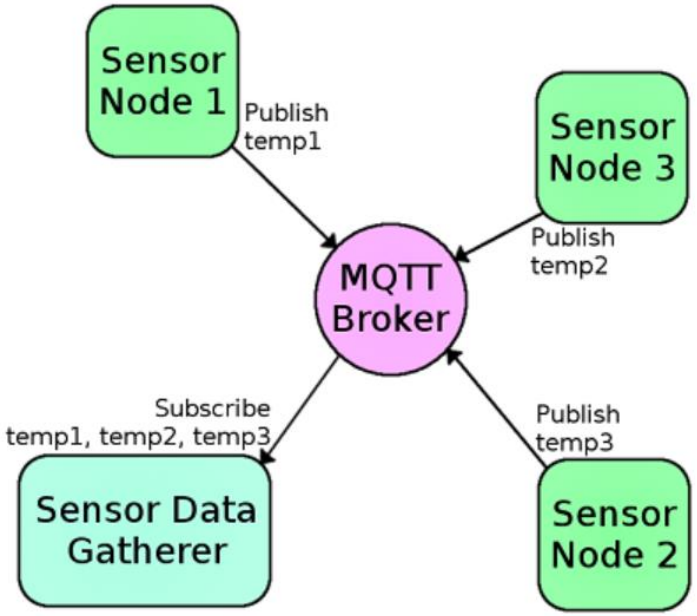
IoT Strategy #2:
Thingspeak with senseHat



Recap MQTT with senseHat
Message Queuing Telemetry Transport

Goal: To understand how publishing and subscribing works practically

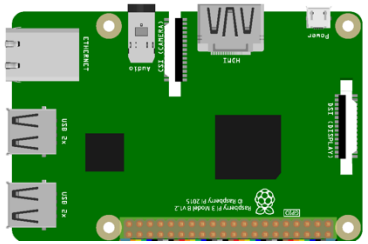
MQTT paradigm



Hardware

Broker

- The broker is the server
- It distributes the information to the interested devices connected to the server.

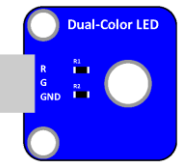


Client

- The device that connects to broker to send or receive information.

SUNFOUNDER
Flame Sensor Module

SUNFOUNDER
PulseSensor Heart Rate Monitoring Sensor Module



SUNFOUNDER
Analog Hall Sensor Module

Messaging

Topic

- The name that the message is about.
- Clients publish, subscribe, or do both to a topic.

Subscribe

- Clients tell the broker which topic(s) they're interested in.

Publish

- Clients that send information to the broker to distribute to interested clients based on the topic name.

QoS

- Quality of Service to the broker
- Integer value ranging from. 0-2.

Source: https://learn.sparkfun.com/tutorials/introduction-to-mqtt#the-basics

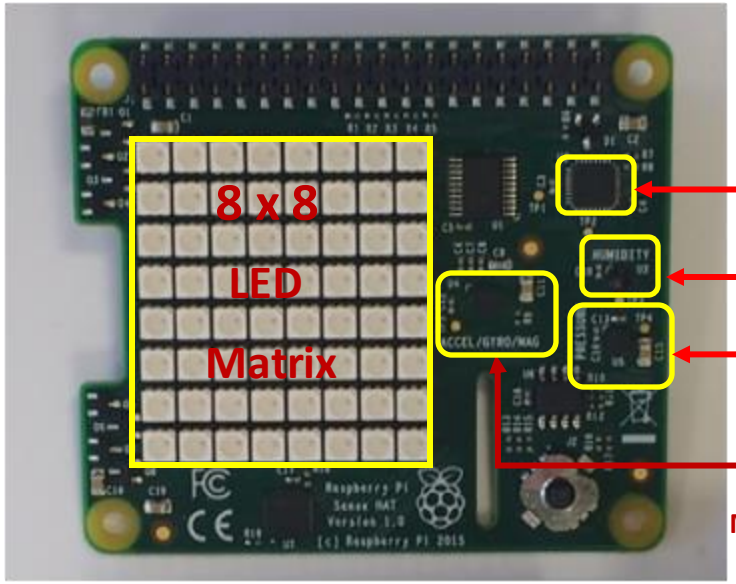
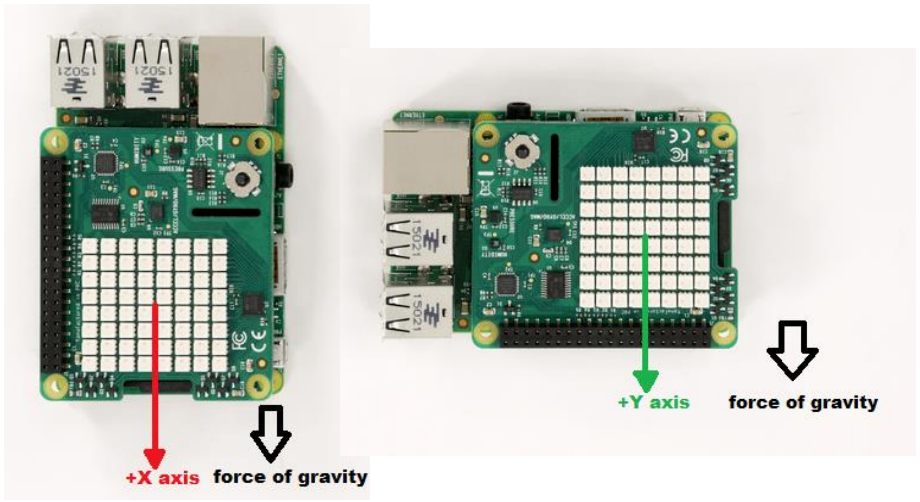


Image source: https://projects.raspberrypi.org/en/projects/getting-started-with-the-sense-hat/2

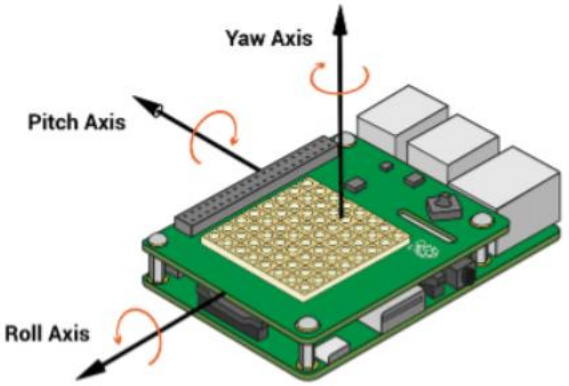
- The Sense HAT has a variety of sensors that can be read from:

"Temperature"	reads temperature in degrees Celsius
"Humidity"	reads humidity in % RH
"Pressure"	reads atmospheric pressure in millibars
"Rotation"	reads gyroscopic motion in revolutions per second
"Acceleration"	reads acceleration in terms of standard accelerations due to gravity on Earth's surface
"Orientation"	reads orientation relative to magnetic north in degrees
"Magnetic Field"	reads strength and direction of a magnetic field around the sensor in microteslas

- The gyroscope, accelerometer, and magnetometer sensors return a list of three values that corresponds to $\{roll, pitch, yaw\}$, as oriented according to the following image:



Source: https://www.mathworks.com/help/supportpkg/raspberrypi/examples/auto-rotate-an-image-displayed-on-sense-hat-led-matrix.html



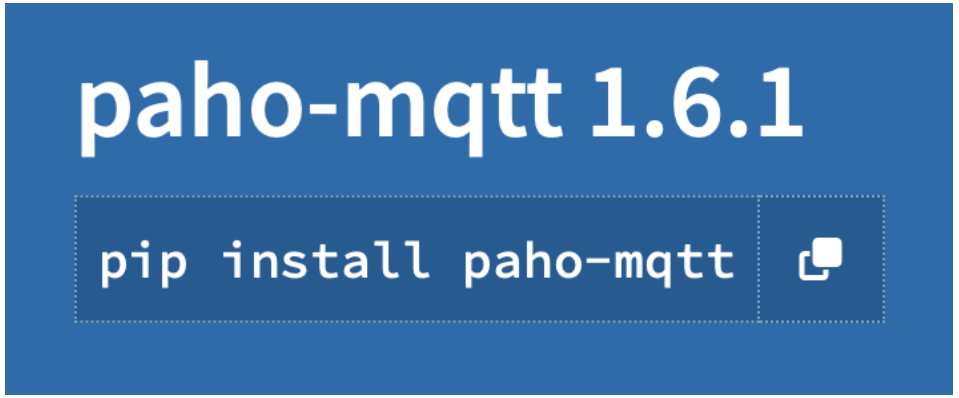
Source: https://reference.wolfram.com/language/ref/device/SenseHAT.html

Starting point for further exploration:

[Link for "Getting started with the Sense HAT"]

Source:
https://www.eclipse.org/paho/
https://pypi.org/project/paho-mqtt/

Eclipse paho - Another open source MQTT broker



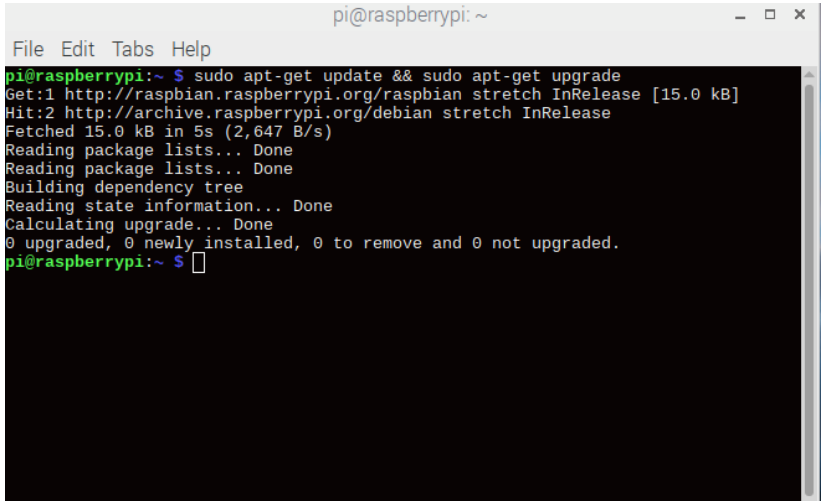
Eclipse-paho provides a client class which enable applications to connect to an MQTT broker to publish messages, and to subscribe to topics and receive published messages.

It also provides some helper functions to make publishing one off messages to an MQTT server very straightforward.

Step-2: Install paho-mqtt & psutil libraries

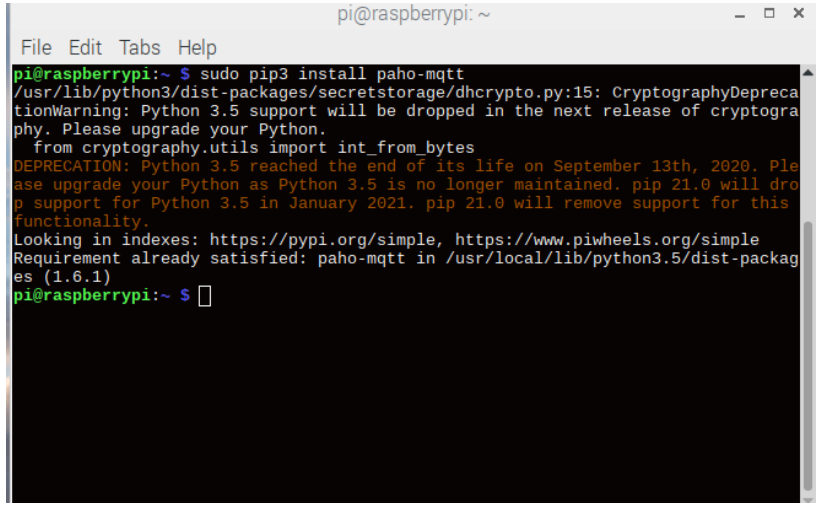
Source:
https://towardsdatascience.com/iot-made-easy-esp-micropython-mqtt-thingspeak-ce05eea27814
https://nothans.com/thingspeak-tutorials/update-a-thingspeak-channel-using-mqtt-on-a-raspberry-pi
https://pypi.org/project/paho-mqtt/
https://pypi.org/project/psutil/

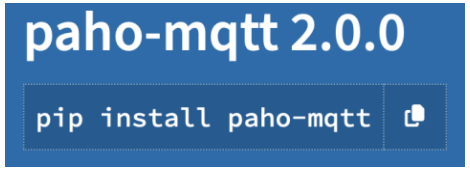
sudo apt-get update && sudo apt-get upgrade



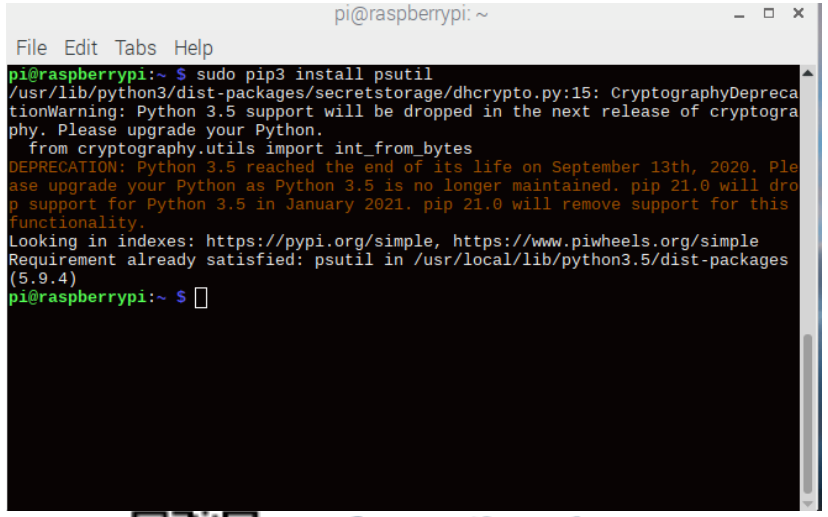
sudo pip –upgrade install psutil

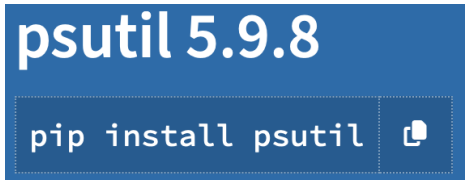
sudo pip install paho-mqtt





sudo pip install psutil





psutil (process and system utilities) is a cross-platform library for retrieving information on **running processes** and **system utilization** (CPU, memory, disks, network, sensors) in Python

Explore MQTT with ThingSpeak IoT Analytics [10 points]

Source:
https://thingspeak.com/

Thingspeak – An IoT analytics platform

ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud.

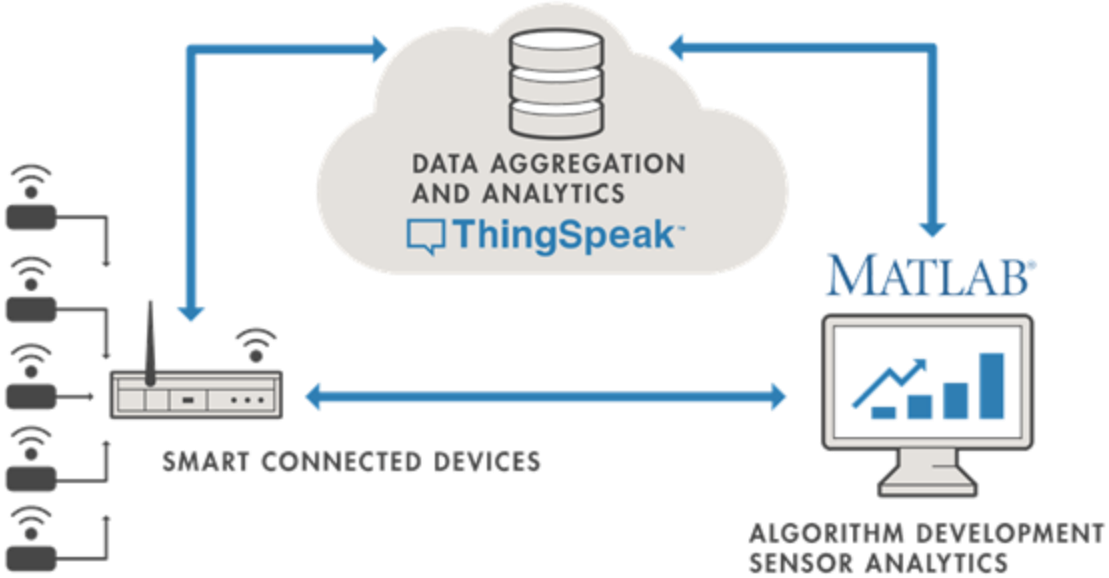
You can send data to ThingSpeak from your devices, create instant visualization of live data, and send alerts.

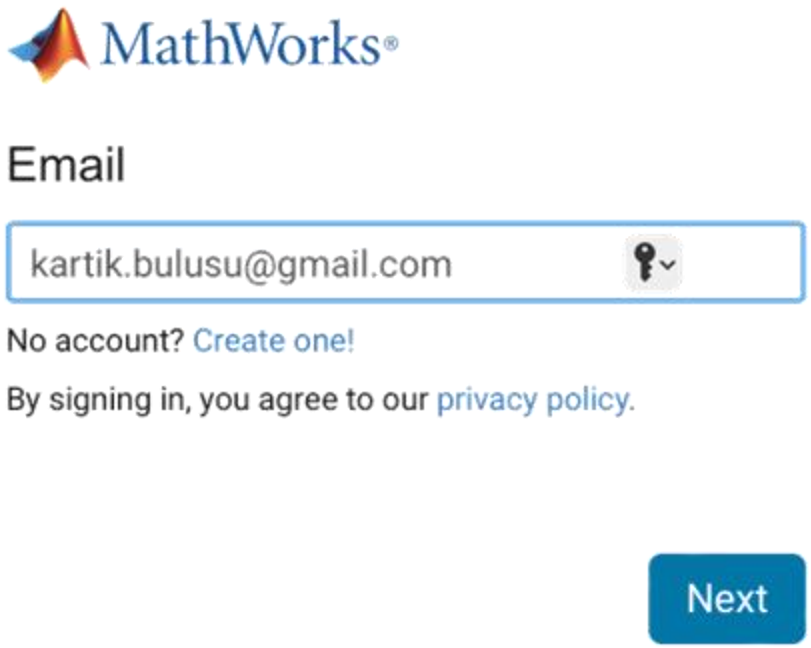
Source:
https://thingspeak.com/

Create a Thingspeak account:
https://thingspeak.com/login?skipSSOCheck=true

To use ThingSpeak, you must sign in with your existing MathWorks account or create a new one.

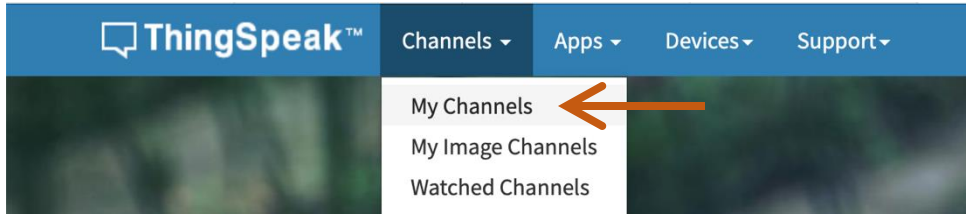
Non-commercial users may use ThingSpeak for free.

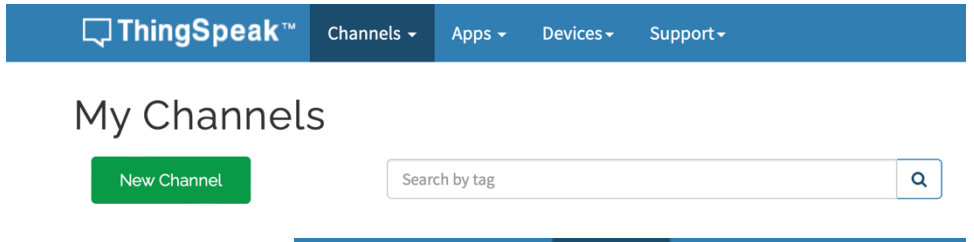


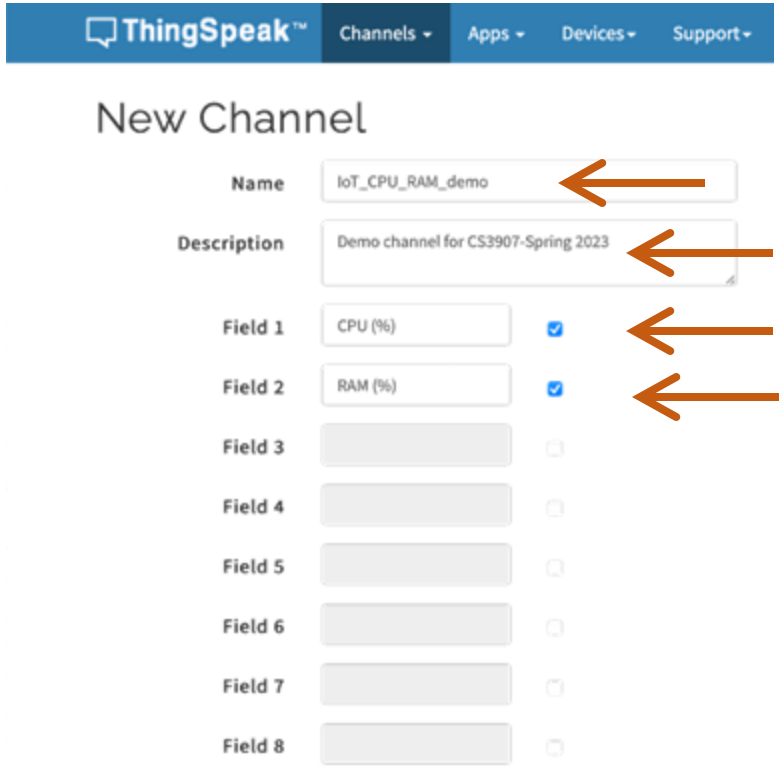


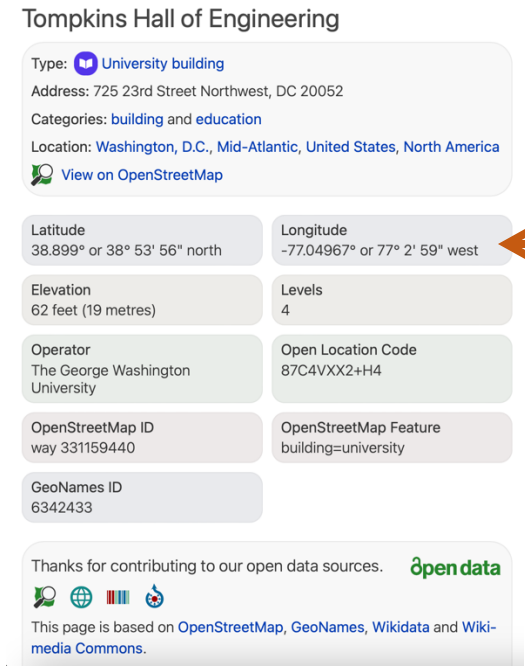
Step-3: Build the ThingSpeak channels

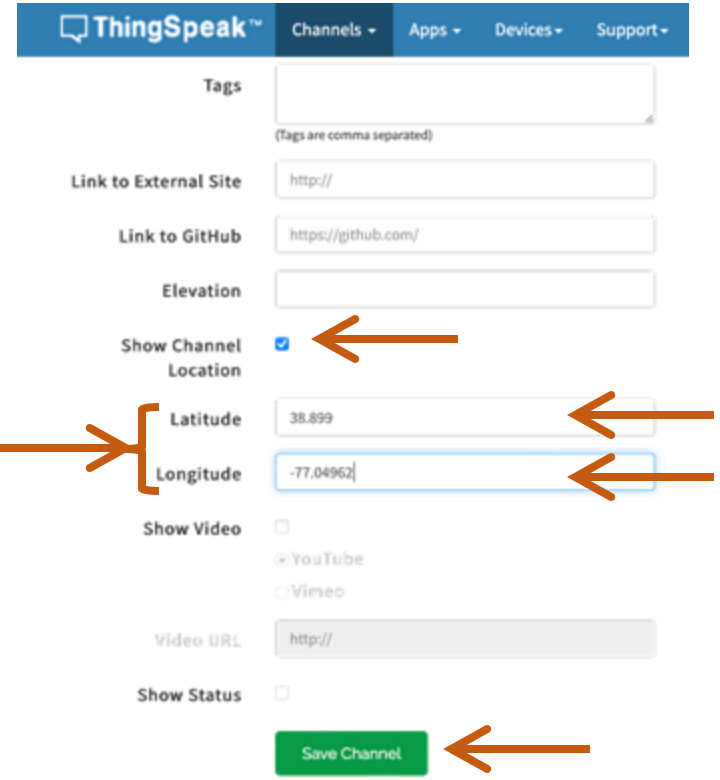
Source:
https://towardsdatascience.com/iot-made-easy-esp-micropython-mqtt-thingspeak-ce05eea27814
https://nothans.com/thingspeak-tutorials/update-a-thingspeak-channel-using-mqtt-on-a-raspberry-pi
https://www.mathworks.com/help/thingspeak/collect-data-in-a-new-channel.html
https://mapcarta.com/25030544

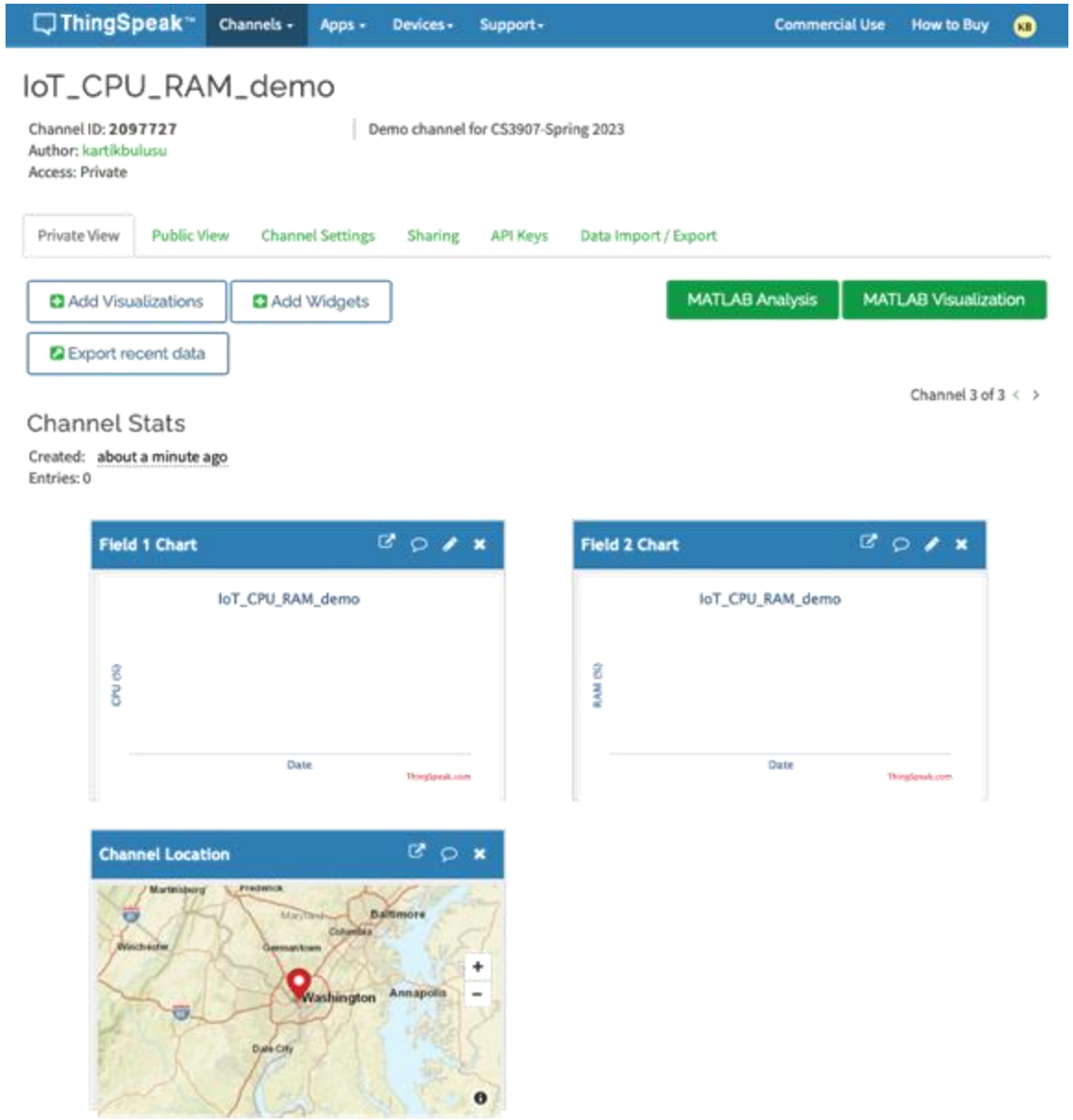




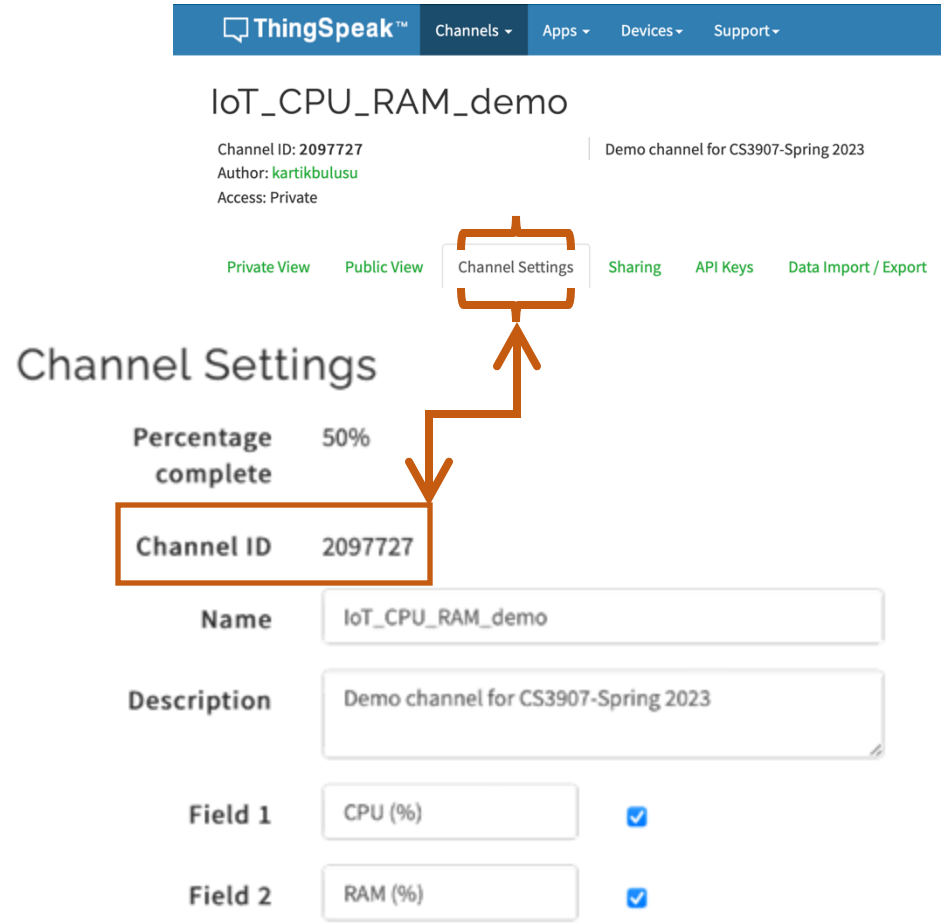






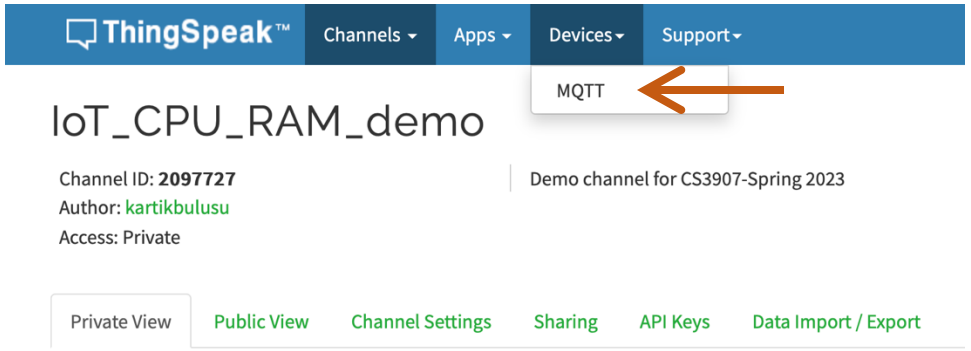


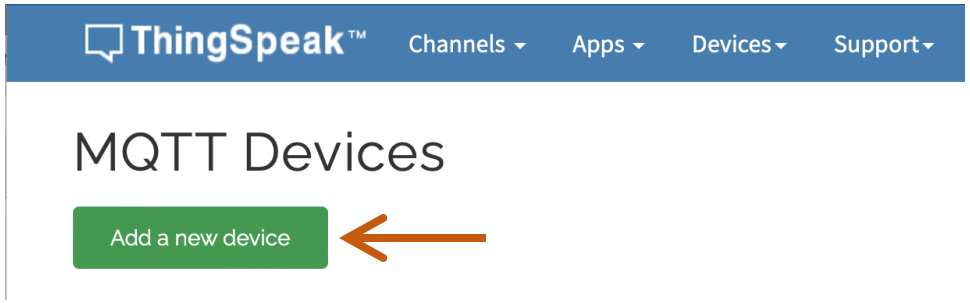
- Familiarize yourself with the panel
- Note down the Channel ID

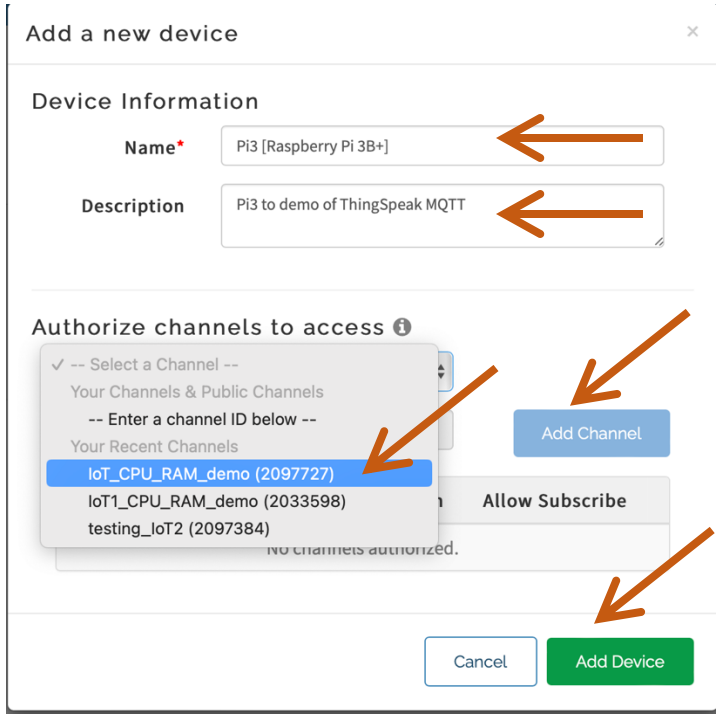


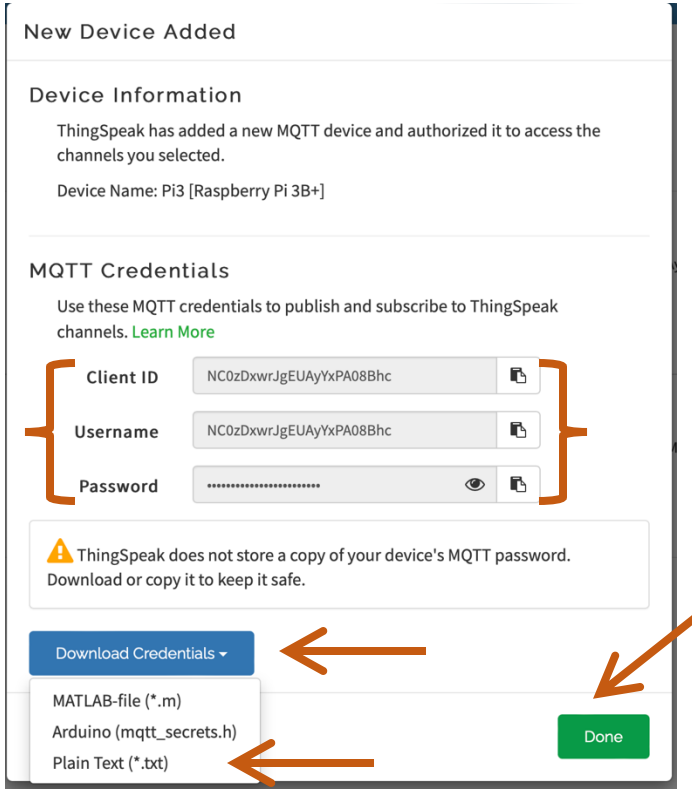
Step-4: Add MQTT device –Raspberry Pi

Source:
https://towardsdatascience.com/iot-made-easy-esp-micropython-mqtt-thingspeak-ce05eea27814
https://nothans.com/thingspeak-tutorials/update-a-thingspeak-channel-using-mqtt-on-a-raspberry-pi
https://www.mathworks.com/help/thingspeak/collect-data-in-a-new-channel.html
https://mapcarta.com/25030544









Graded in-class lab
Download codes from shared-drive and demonstrate
[10 points]


Photo: Kartik Bulusu
Someone should summarize what we learned today