

Lesson 5 – Cloud computing basics

- S.P. Chong

Objectives

- In this lesson, you will learn some basic **cloud computing** concepts.
- You will then learn to **set up** an **account** with a public cloud service provider e.g. **Thingspeak**.
- You will next learn to program an Arduino UNO, to **send data** from a sensor to the cloud platform.
- After that, you will learn to send an event-triggered **notification**, through **Twitter**, for instance.

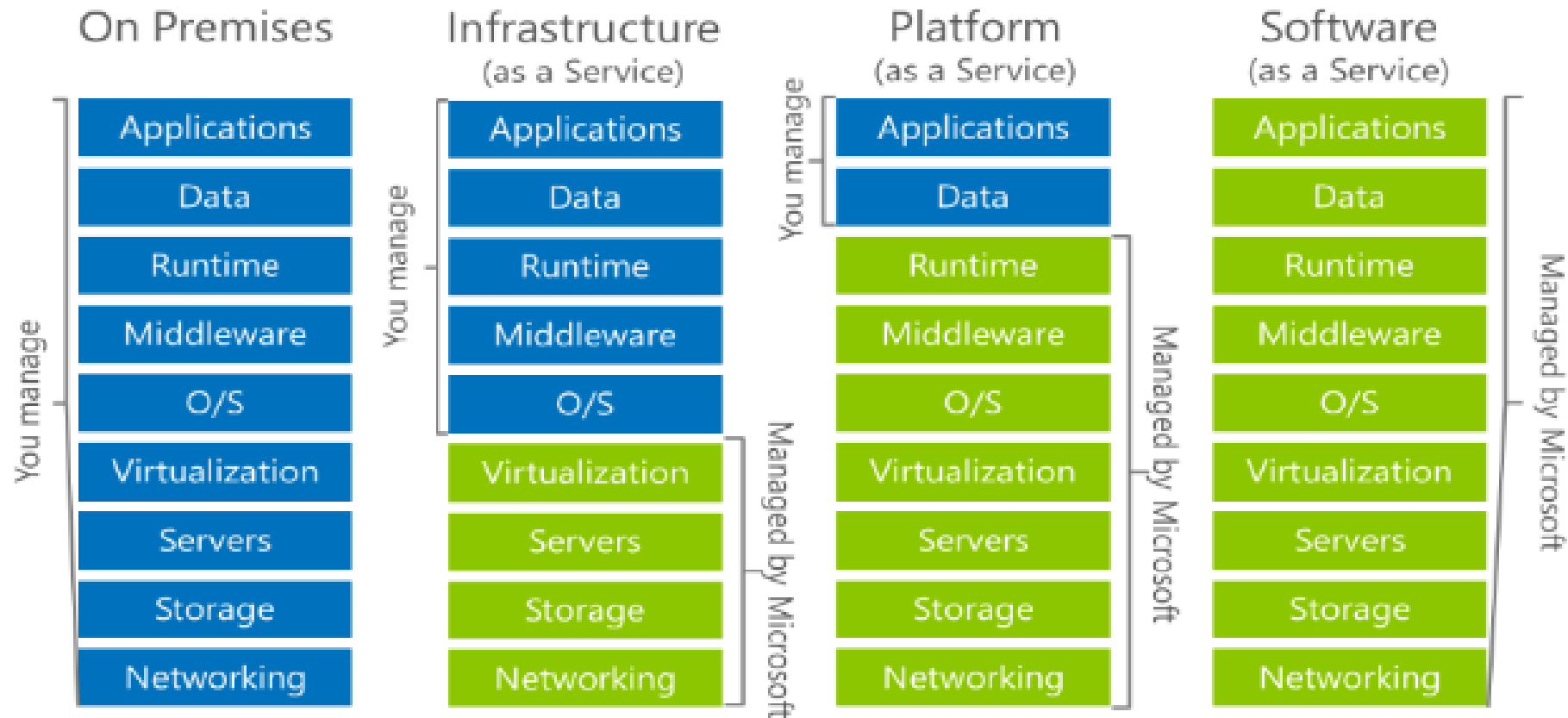
What is cloud computing?

- In the past, companies and organisations maintain their **own servers** e.g. database servers, file servers, web servers, mail servers etc.
- This means a lot of man-hours spent to maintain and update the high-end **computers, software packages & storage spaces** (hard disks etc.).
- Nowadays, many companies and organisations have started to use cloud computing services provided by **AWS** (Amazon Web Services), Microsoft's **Azure & Google Cloud**.
- What this means is, they simply pay for the use of the processors & storage spaces in the cloud.
- Of course high-speed **internet connection** is required for this to be possible.



What is cloud computing? (cont.)

- As an example, Microsoft offers these 4 choices:



What is cloud computing? (cont.)

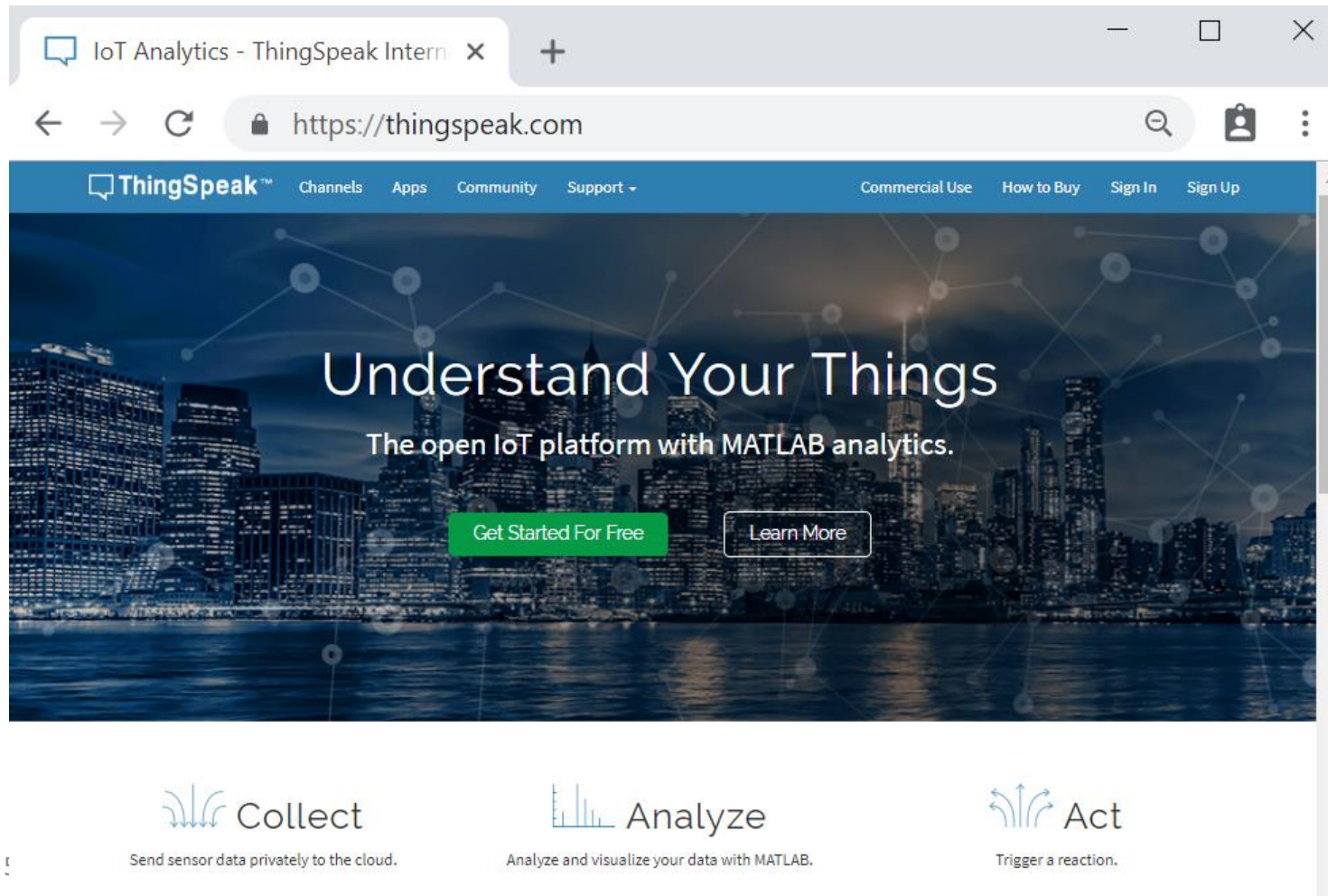
- Cloud computing provides a **cost effective, flexible** option for businesses to deploy software solutions.
- When applications run in the cloud, organizations no longer have to make major investments in **infrastructure**. These costs are now a predictable **monthly subscription**, so you only pay for what you actually use.

Some of the benefits the Cloud brings are:

- Reduced hardware and software acquisition costs.
- Ability to focus on the core business vs technology.
- Improved cash flow under Pay for Use payment models.
- Eliminating software upgrade and update processes.
- Improved accessibility to applications remotely.
- Continuous availability to new updates and new features

Setting up a Cloud platform (e.g. Thingspeak)

- Let's see how we can set up **Thingspeak**, a cloud platform for uploading sensor data.



You can create a Thingspeak account at www.thingspeak.com

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

Sign Up - ThingSpeak IoT

https://thingspeak.com/users/sign_up

ThingSpeak™ Channels Apps Community Support Commercial Use How to Buy Sign In **Sign Up**

Sign up for ThingSpeak

It is free to sign up for ThingSpeak. Free accounts offer a fully functional experience on ThingSpeak with limits on certain functionality. Commercial users may sign up for a time-limited free evaluation. To send data faster to ThingSpeak or to send more data, consider our [paid license options](#) for commercial, academic, home and student usage. To start using ThingSpeak you must create a new MathWorks account, or, click cancel and log in using an existing MathWorks account.

Create MathWorks Account

Email Address
EP0401CSP@gmail.com ✓

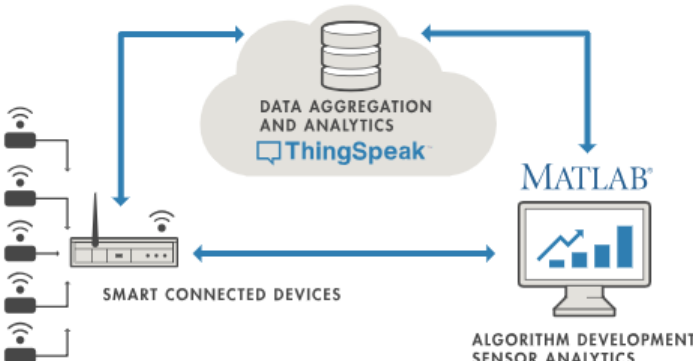
To access your organization's MATLAB license, use your school or work email.

Location
Singapore ▼

First Name
EP0401 ✓

Last Name
CSP ✓

Continue



Click Sign Up, fill in the Email Address etc., and click Continue.

Personal Email Detected

⚠ To use your organization's MATLAB, enter your work or university email

Email Address

EP0401CSP@gmail.com

☒ Use this email for my MathWorks Account

You may need to tick the box and click Continue.

Setting up a Cloud platform (e.g. Thingspeak) (cont.)



Important MathWorks Account Information

Thank you for registering with MathWorks!

Verify your email address by clicking this link:

Verify your email

An email has been sent to you. Open that email and click Verify your email.

A new tab will open to inform you "Your profile was verified".



MathWorks Account

 **Your profile was verified**

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

Sign Up - ThingSpeak IoT

https://thingspeak.com/users/sign_up

ThingSpeak™ Channels Apps Community Support Commercial Use How to Buy Sign In Sign Up

Sign up for ThingSpeak

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Verify Your MathWorks Account

To finish creating your account, complete the following steps:

1. Go to your inbox for EP0401CSP@gmail.com.
2. Click the link in the email we sent you.
3. Click Continue.

Didn't receive the email?

- Check your spam folder.
- [Send me the email again.](#)
- If you still have not received the email, Contact [Customer Support](#)

Continue

Back to the Thingspeak tab, click Continue.

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

Sign Up - ThingSpeak IoT

https://thingspeak.com/users/sign_up

ThingSpeak™ Channels Apps Community Support Commercial Use How to Buy Sign In Sign Up

Sign up for ThingSpeak

It is free to sign up for ThingSpeak. Free accounts offer a fully functional experience on ThingSpeak with limits on certain functionality. Commercial users may sign up for a time-limited free evaluation. To send data faster to ThingSpeak or to send more data, consider our [paid license options](#) for commercial, academic, home and student usage. To start using ThingSpeak you must create a new MathWorks account, or, click cancel and log in using an existing MathWorks account.

Finish your Profile

User ID
EP0401CSP ✓ ?

Password
***** ✓

☒ I accept the Online Services Agreement

[See our privacy policy for details.](#)

Continue

SMART CONNECTED DEVICES

DATA AGGREGATION AND ANALYTICS
ThingSpeak

MATLAB®

ALGORITHM DEVELOPMENT
SENSOR ANALYTICS

Enter your User ID and Password, tick the box and click Continue.

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

Signed in successfully. X

Sign-up successful

Congratulations, you have successfully linked your MathWorks account to ThingSpeak. Use the same email address for subsequent logins to ThingSpeak.

Email ID: ep0401csp@gmail.com

Welcome to ThingSpeak!

OK

Click OK to start using Thingspeak.

My Channels - ThingSpeak IoT X +

https://thingspeak.com/channels

ThingSpeak™ Channels Apps Community Support Commercial Use How to Buy Account Sign Out

My Channels

New Channel

Search by tag

Click New Channel to create a channel for uploading sensor data.

Help

Collect data in a ThingSpeak channel from a device, from another channel, or from the web.

Click **New Channel** to create a new ThingSpeak channel.

Click on the column headers of the table to sort by the entries in that column or click on a tag to show channels with that tag.

Learn to [create channels](#), explore and transform data.

Learn more about [ThingSpeak Channels](#).

Examples

- [Arduino](#)
- [Arduino MKR1000](#)
- [ESP8266](#)
- [Raspberry Pi](#)
- [Netduino Plus](#)

Upgrade

Need to send more data faster?

Need to use ThingSpeak for a commercial project?

Upgrade

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

The screenshot shows the 'New Channel' page on the Thingspeak website. The browser address bar shows 'https://thingspeak.com/channels/new'. The page has a blue header with 'ThingSpeak™' and navigation links for 'Channels', 'Apps', 'Community', 'How to Buy', 'Account', and 'Sign Out'. The main content area is titled 'New Channel' and contains a form with the following fields:

- Name:** A text input field containing 'Sensor data from AM2302'.
- Description:** A text input field containing 'Temperature & humidity data at 15 second intervals'.
- Field 1:** A text input field containing 'Temperature' with a checked checkbox.
- Field 2:** A text input field containing 'Humidity' with a checked checkbox.
- Field 3:** An empty text input field with an unchecked checkbox.
- Field 4:** An empty text input field with an unchecked checkbox.
- Field 5:** An empty text input field with an unchecked checkbox.
- Field 6:** An empty text input field with an unchecked checkbox.

Below the fields is a green 'Save Channel' button. To the right of the form, there is a 'Channel Settings' section with a note: 'Each channel includes eight fields that can hold any type of data, plus three fields for location data and one for status data. Once you collect data in a channel, you can use ThingSpeak apps to analyze and visualize it.' Below this, there is a section for 'ThingSpeak channel, specify the URL.' and a 'Show Channel Location' section with a sub-item 'Latitude: Specify the latitude position in decimal degrees. For example, the'.

Three instructional callouts are present:

- A blue box with the text 'Fill in the Name and Description.' pointing to the Name and Description fields.
- A blue box with the text 'Tick the 1st two boxes and enter Temperature for Field 1 and Humidity for Field 2.' pointing to the checkboxes for Field 1 and Field 2.
- A blue box with the text 'Click Save Channel.' pointing to the 'Save Channel' button.

The footer of the page contains links for 'Community | Documentation | Tutorials | Terms | Privacy Policy', social media icons, and the copyright notice '© 2018 The MathWorks, Inc.'.

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

The screenshot shows the Thingspeak interface for a channel named 'Sensor data from AM2302'. The channel ID is 645078, the author is ep0401csp, and the access is set to Private. The 'Sharing' tab is highlighted with a red box. Below the tabs are buttons for 'Add Visualizations', 'Add Widgets', 'Export recent data', 'MATLAB Analysis', and 'MATLAB Visualization'. The 'Channel Stats' section shows the channel was created and updated 'less than a minute ago' with 0 entries. At the bottom, there are two empty charts: 'Field 1 Chart' for Temperature and 'Field 2 Chart' for Humidity, both titled 'Sensor data from AM2302'.

You will see 2 charts
(Temperature &
Humidity) in the
channel just created.

The Access is now
Private. To change
this, click Sharing.

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

The screenshot shows a web browser window with the address bar displaying `https://thingspeak.com/channels/645078/sharing`. The page title is 'Channels - ThingSpeak IoT'. The main content area shows 'Sensor data from AM2302' with a 'Channel ID: 645078' highlighted in a red box. Below this, the 'Channel Sharing Settings' section has three radio button options: 'Keep channel view private', 'Share channel view with everyone' (which is selected and highlighted in a red box), and 'Share channel view only with the following users:'. A text input field for 'Email Address' is also visible. On the right, there is a 'Help' section and a 'Channel Sharing Settings' list.

Note the Channel ID, in this case 645078.

Tick the box “Share channel view with everyone”.

Channel ID: 645078
Author: ep0401csp
Access: Private

Temperature & humidity data at 15 second intervals.

Private View Public View Channel Settings Sharing API Keys Data Import / Export

Channel Sharing Settings

- ☐ Keep channel view private
- ☒ Share channel view with everyone
- ☐ Share channel view only with the following users:

Email Address

Help

ThingSpeak allows you to control who can view the data in your channel. Irrespective of the settings on this tab, reading data from or writing data to the fields of a channel requires the appropriate API key for the channel.

Channel Sharing Settings

- **Keep channel view private:** Selecting this option keeps your channel private. Only you will be able to see the channel view.
- **Share channel view with everyone:** Selecting this option makes the public view of your channel viewable by anyone browsing the ThingSpeak website.
- **Share channel view only with the following users:** Selecting this option shares the private view of your channel only with specific ThingSpeak users.

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

After this, anyone will be able to see this public channel by entering the Channel ID in a browser.

<https://thingspeak.com/channels/645078>

Sensor data from AM2302

Channel ID: **645078**
Author: [ep0401csp](#)
Access: Public

Temperature & humidity data at 15 second intervals.

[Export recent data](#) [MATLAB Analysis](#) [MATLAB Visualization](#)

Field 1 Chart: Sensor data from AM2302. Y-axis: Temperature. X-axis: Date.

Field 2 Chart: Sensor data from AM2302. Y-axis: Humidity. X-axis: Date.

Setting up a Cloud platform (e.g. Thingspeak) (cont.)

API Keys - ThingSpeak IoT

https://thingspeak.com/channels/645078/api_keys

ThingSpeak™ Channels Apps Community Support Commercial Use How to Buy Account Sign Out

Sensor data from AM2302

Channel ID: 645078
Author: ep0401csp
Access: Public

Private View Public View Channel Settings Sharing **API Keys** Data Import / Export

Write API Key

Key **HQJJMXALKCR5VURW**

Generate New Write API Key

Read API Keys

Key **FT881Y3XFYFVK9H2**

Note

Save Note Delete API Key

Generate New Read API Key

Click the API Keys tab.

Only people who know the Write API Key will be able to upload data to this channel.

- Write API Key: Use this key to write data to a channel. If you feel your key has been compromised, click Generate New Write API Key.
- Read API Keys: Use this key to allow other people to read data from your channel feeds and charts. Click Generate New Read API Key to generate a new Read API Key for the channel.
- Note: Use this field to enter information about the key, such as the user's name, add notes to keep track of users with access.

API Requests

Update a Channel Feed

```
GET https://api.thingspeak.com/update?api_key=HQJJMXALKCR5VURW&field=
```

Get a Channel Feed

```
GET https://api.thingspeak.com/channels/645078/feeds.json?results=2
```

Get a Channel Field

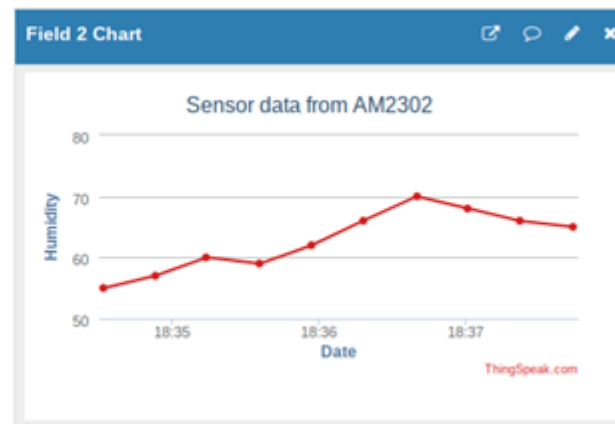
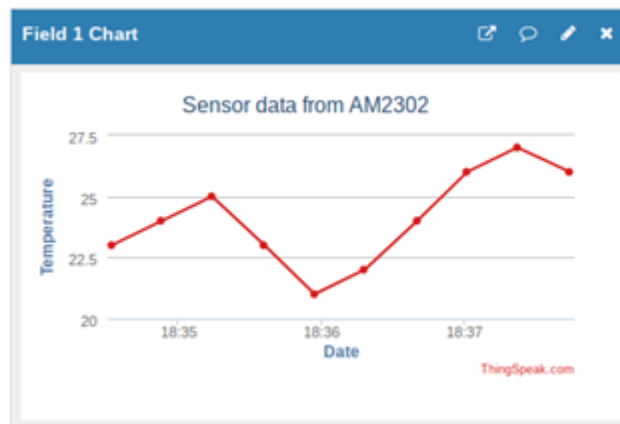
```
GET https://api.thingspeak.com/channels/645078/fields/1.json?results=
```

If you think that this “password” has been compromised, you can always generate a new one.

Read API Key is required for reading from a private channel. Anyone can read from a public channel.

Sending data to cloud for storage & visualization

- In Exercise 3.4 (Lesson 3), you have used ESP01 (a WiFi module) and written a program to upload potentiometer readings to a Thingspeak channel.
- In Exercise 2.9 (Lesson 2 part II), you have used DHT11 (a temperature & humidity sensor) and written a program to read from the sensor.
- The code are repeated below for your easy reference.
- You can easily combine these 2 programs, to upload the temperature & humidity readings to a Thingspeak channel. We will not give you the exact program though.



If your project requires uploading sensor data to Thingspeak, you will need to know how to do this.

Sending data to cloud for storage & visualization (cont.)

sketch_test_upload | Arduino 1.8.2

File Edit Sketch Tools Help



```
#include <SoftwareSerial.h>
```

```
#define DEBUG true
```

```
// LED at D13
```

```
int ledPin = 13;
```

```
// Potentiometer at A0
```

```
int potPin = 0;
```

```
// replace with your Thingspeak channel's API key!!!
```

```
String apiKey = "ABCD1234EFGH"; // *** Change this!
```

```
// UNO's D10 connected to ESP's TX
```

```
// UNO's D11 connected to ESP's RX via resistor network
```

```
SoftwareSerial ESP01(10, 11); // RX, TX
```

uploading

- A program to upload potentiometer readings to a Thingspeak channel.

```
void setup() {  
    pinMode(ledPin, OUTPUT);  
    Serial.begin(9600);  
    while (!Serial){  
    }  
    Serial.println("Starting...");  
    ESP01.begin(9600);  
}
```

Sending data to cloud for storage & visualization (cont.)

```
void loop() {  
  // Reset ESP8266, put it into mode 1 i.e. STA only, make it join hotspot / AP,  
  // establish single connection  
  Serial.println();  
  sendData("AT+RST\r\n",2000,DEBUG);  
  sendData("AT+CWMODE=1\r\n",2000,DEBUG);  
  sendData("AT+CWJAP=\"EEE-IoT\", \"howIknow@07\"\r\n",4000,DEBUG);  
  // *** Change these!  
  sendData("AT+CIPMUX=0\r\n",2000,DEBUG);  
  
  // Blink LED on board  
  digitalWrite(ledPin, HIGH);  
  delay(200);  
  digitalWrite(ledPin, LOW);
```

uploading

```
// Read potentiometer value  
int sensorValue = analogRead(A0); // 10 bit result: 0 - 1023  
float voltage = sensorValue * (5.0 / 1023.0); // 0V - 5V  
String temp = String(voltage); // convert to string  
Serial.println(temp);
```

Replace this part
with the code to read
from your sensor.

Sending data to cloud for storage & visualization (cont.)

uploading

```
// Send data length & GET string
ESP01.print("AT+CIPSEND=");
ESP01.println(getStr.length());
Serial.print("AT+CIPSEND=");
Serial.println(getStr.length());
delay(500);
if( ESP01.find( ">" ) )
{
    Serial.print(">");
    sendData(getStr,2000,DEBUG);
}
```



```
// Make TCP connection
String cmd = "AT+CIPSTART=\"TCP\", \"";
cmd += "184.106.153.149"; // Thingspeak.com's IP address
cmd += "\",80\r\n";
sendData(cmd,2000,DEBUG);
```

```
// Prepare GET string
String getStr = "GET /update?api_key=";
getStr += apiKey;
getStr += "&field1=";
getStr += temp;
getStr += "\r\n";
```

This part need to be changed, if you are sending more than one value at a time.

GET /update?api_key=ABCD...1234&field1=value1&field2=value2\r\n

```
// Close connection, wait a while before repeating...
sendData("AT+CIPCLOSE",16000,DEBUG); // thingspeak needs 15 sec delay between updates
}
```

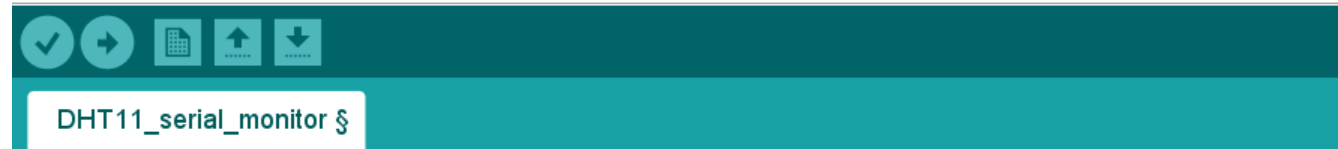
Sending data to cloud for storage & visualization (cont.)

- A program to read temperature & humidity from DHT11.

These parts need to be added to the previous program, if you are reading from a DHT11.

DHT11_serial_monitor | Arduino 1.8.2

File Edit Sketch Tools Help



// DHT11 (temperature humidity sensor) sample code

```
#include "DHT.h"
DHT dht(2, DHT11); // DHT22 for DHT22/AM2302/AM2321, or DHT21 for DHT21/AM2301
// data pin connected to pin 2
```

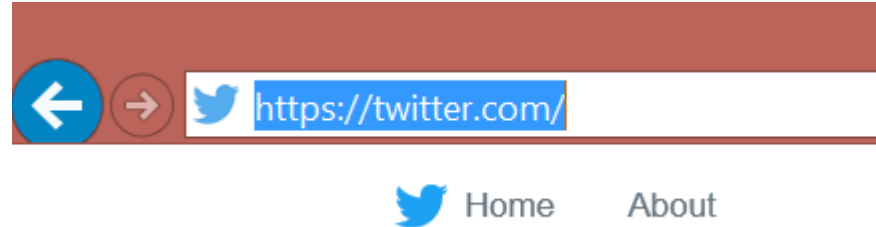
```
void setup() {
  Serial.begin(9600);
  dht.begin();
}
```

```
void loop() {
  delay(2000); // 2 seconds between samples
  float h = dht.readHumidity();
  float t = dht.readTemperature();
  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print("% Temperature: ");
  Serial.print(t);
  Serial.println("°C ");
}
```

reading sensor

Sending an event-triggered notification, through Twitter

- This part shows you how to send a tweet, when a pre-defined condition is met, using (Thingspeak's) ThingTweet and React apps.
- If you don't have a Twitter account, create one at Twitter.com:



The material presented here is based on the tutorial at:

<https://www.mathworks.com/help/thingspeak/act-on-your-data.html>

Sending an event-triggered notification, through Twitter (cont.)

- Link your Twitter account to your Thingspeak account as follows:

The image shows a sequence of steps to link a Twitter account to a Thingspeak account. It starts with a screenshot of the Thingspeak website's navigation bar, where the 'Apps' link is highlighted with a red box. A blue arrow points from this 'Apps' link to a larger screenshot of the 'ThingTweet' integration page. This page features a Twitter logo in a blue box at the top. Below it, the title 'ThingTweet' and the description 'Connect a device to Twitter® and send alerts.' are enclosed in a red rectangular box. A speech bubble points to the 'Apps' link in the first screenshot, and a blue arrow points from the 'ThingTweet' section to the final screenshot.

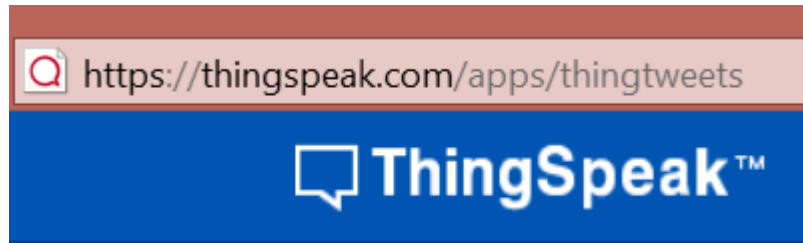
Click Apps, followed by ThingTweet...

ThingSpeak™ Channels ▾ Apps Blog Support ▾

← || → Actions

ThingTweet
Connect a device to Twitter® and send alerts.

Sending an event-triggered notification, through Twitter (cont.)



Apps / ThingTweet

Link Twitter Account



Authorize ThingTweet to use your account?

login email

password

☐ Remember me · [Forgot password?](#)

Authorize app

Cancel

Click Link Twitter Account, enter the login details, then click Authorize app.

Sending an event-triggered notification, through Twitter (cont.)



Apps / ThingTweet

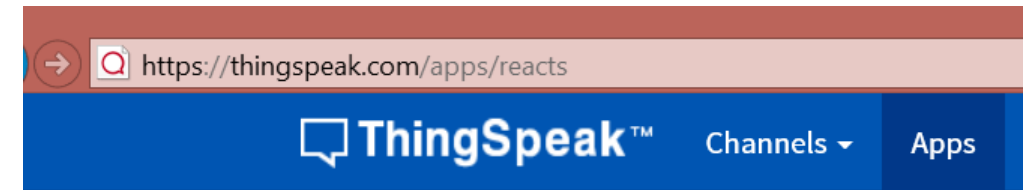
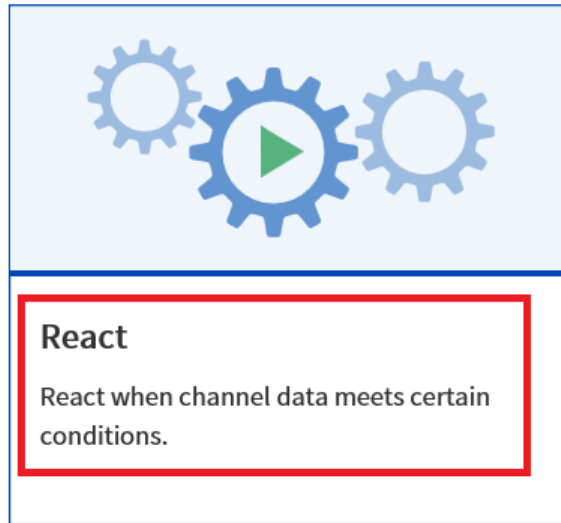
Link Twitter Account

Twitter Account	API Key	Action
spchong1	A0R30XBZSESIVQ7R	<div>Regenerate API Key</div> <div>Unlink Account</div>

(Back to ThingTweet...) This shows that the Twitter Account has been linked to Thingspeak.

Sending an event-triggered notification, through Twitter (cont.)

- Set up a “React”, a mechanism whereby a tweet will be sent automatically, if pre-defined conditions are met, as follows:



Apps / React

New React

Click Apps, followed by React, then New React...

Sending an event-triggered notification, through Twitter (cont.)

- The temperature data is checked every 10 minutes.
- If it exceeds 30 deg Celsius, ThingTweet will inform us via a tweet.

Fill in the details, then click Save React.

Apps / React / New

React Name

Condition Type

Test Frequency

Condition

If channel

field

Action

then tweet

using Twitter account

Options

☐ Run action only the first time the condition is met

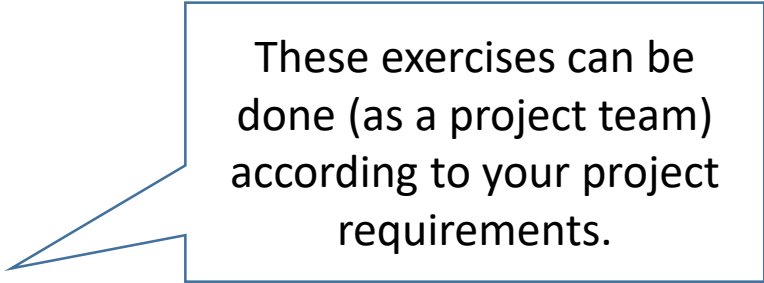
☒ Run action each time condition is met

Sending an event-triggered notification, through Twitter (cont.)

- Someone who follows this will be informed, if the pre-defined condition(s) is (are) met.



Lab Exercises



These exercises can be done (as a project team) according to your project requirements.

- Exercise 5.1 – Setting up your Thingspeak channel
- Exercise 5.2 – Uploading sensor readings to Cloud
- Exercise 5.3 – Linking up Thingspeak with your Twitter account
- Exercise 5.4 – Sending a tweet

Exercise 5.1 – Setting up your Thingspeak channel

Ref: slides 6 to 16.

Set up your Thingspeak account. After that, create a channel with one or more fields, for sensor data upload, depending on your project requirements.

Channels - ThingSpeak IoT

https://thingspeak.com/channels/new

ThingSpeak™ Channels Apps Community Support Commercial Use How to Buy Account Sign Out

New Channel

Name Sensor data from AM2302

Description Temperature & humidity data at 15 second intervals.

Field 1 Temperature ☒

Field 2 Humidity ☒

Field 3 ☐

Field 4 ☐

Field 5 ☐

Field 6 ☐

Help

Channels store all the data that a ThingSpeak application collects. Each channel includes eight fields that can hold any type of data, plus three fields for location data and one for status data. Once you collect data in a channel, you can use ThingSpeak apps to analyze and visualize it.

Channel Settings

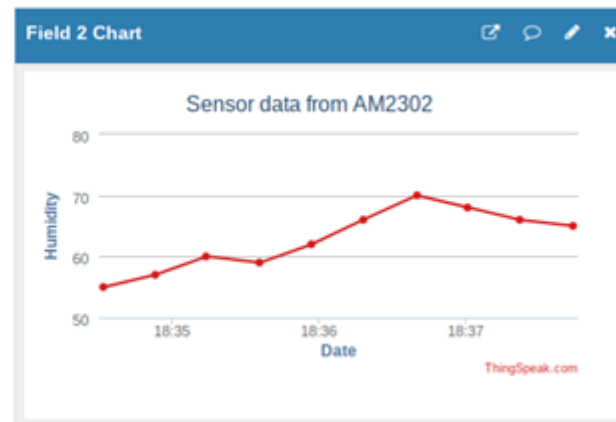
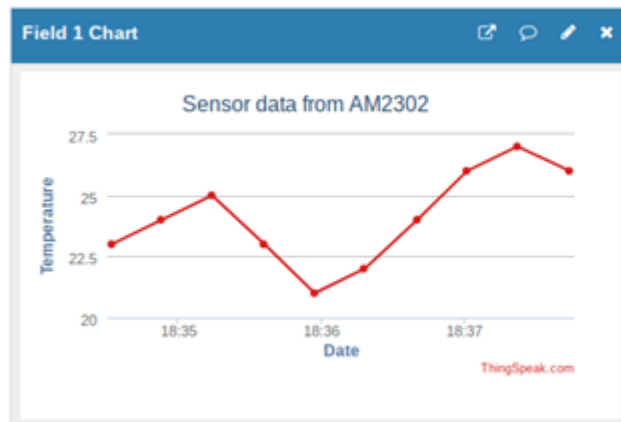
- Channel Name:** Enter a unique name for the ThingSpeak channel.
- Description:** Enter a description of the ThingSpeak channel.
- Field#:** Check the box to enable the field, and enter a field name. Each ThingSpeak channel can have up to 8 fields.
- Metadata:** Enter information about channel data, including JSON, XML, or CSV data.
- Tags:** Enter keywords that identify the channel. Separate tags with commas.
- Link to External Site:** If you have a website that contains information about your ThingSpeak channel, specify the URL.
- Show Channel Location:**
 - Latitude:** Specify the latitude position in decimal degrees. For example, the

A project with temperature & humidity sensor readings should have 2 fields like this.

Exercise 5.2 – Uploading sensor readings to Cloud

Ref: slides 7 to 21.

Write an Arduino program to send the sensor readings (depending on your project requirements) to your Thingspeak channel, once every 20 seconds.



Two charts from a project that uploads temperature & humidity readings.

Exercise 5.3 – Linking up Thingspeak with your Twitter account

Ref: slides 22 to 25.

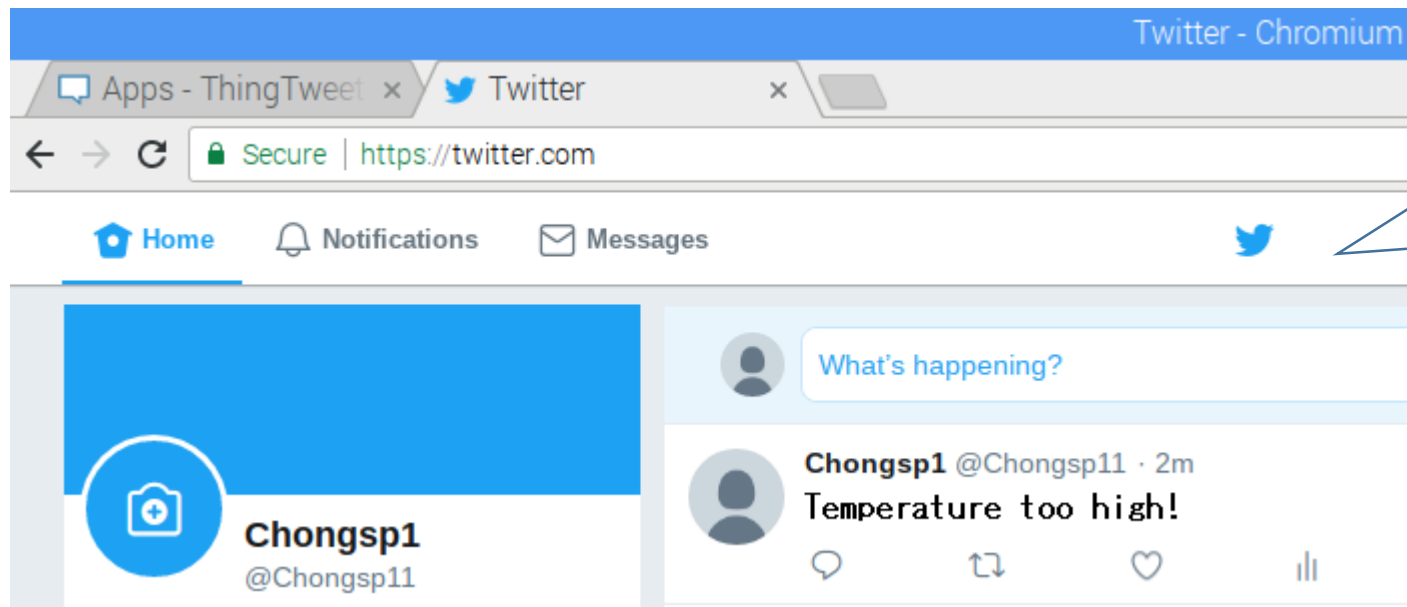
Create a Twitter account if you don't have one. Link it to your Thingspeak account.



Exercise 5.4 – Sending a tweet

Ref: slides 26 to 28.

Set up your Thingspeak's React, so that a tweet is sent when a certain condition is met.



A tweet from a project that requires someone to be notified when the temperature is too high.

