



.NET Core Embedded Dev. + Azure IoT Solution

WEI-TING SHIH (Thomas)



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ASP.NET MVC/ASP.NET core/Exchange server management
Azure Taiwan Meetup (First Wed. per month)

2017 Bot Framework @ Azure Taiwan Meetup #05

2017 PowerBI @ Sigfox UnaHack

2020 Azure Taiwan Meetup #35



一個論文還不知道在哪菸酒生
開發經驗卻跟新手沒兩樣，開發不漂亮但可 work

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Microsoft STUDY4 Build School

開發原由

一切從隔壁實驗室有個演算法以及好多隻大型電風扇開始



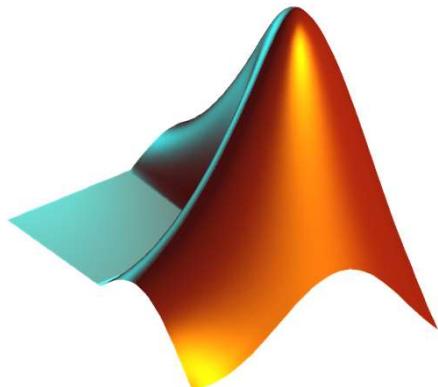
困境與解法



- 風力發電機
 - 國外生產商
 - 二手營運資料
 - 二手機械監測數據
 - 不給安裝自有設備
- 台電作法
 - 人工吊車上去看
 - 停機檢測
 - 人為辨識不客觀
- 期待結果
 - 外掛設備
 - 定期監測
 - 可推廣到離岸型
 - GUI監控頁面

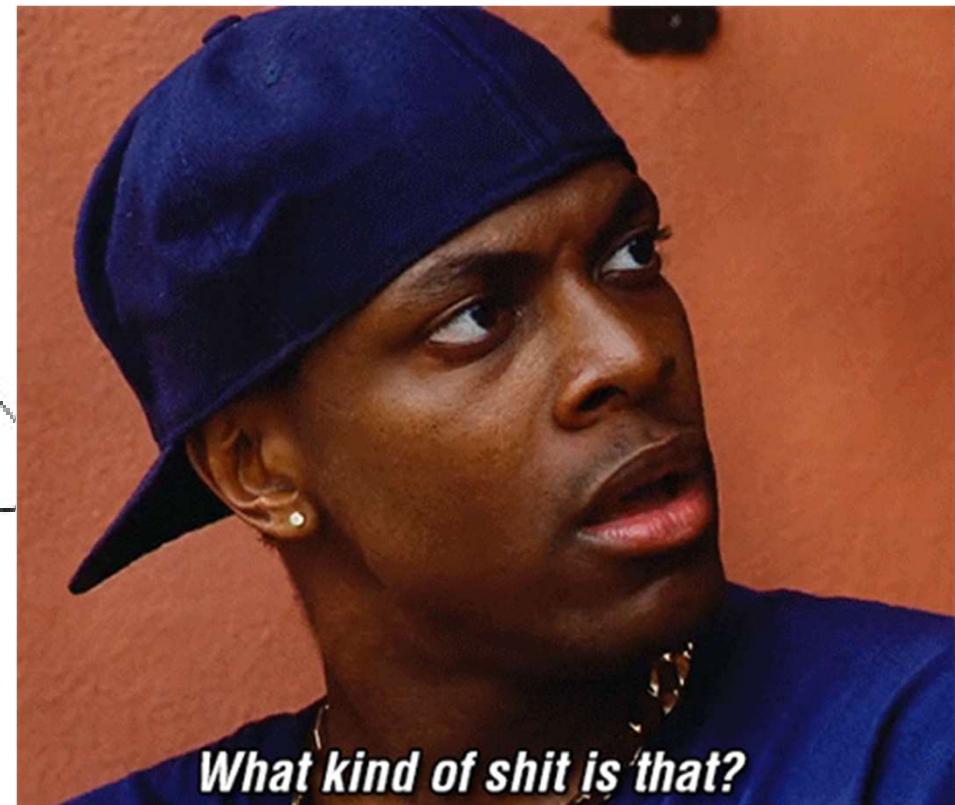
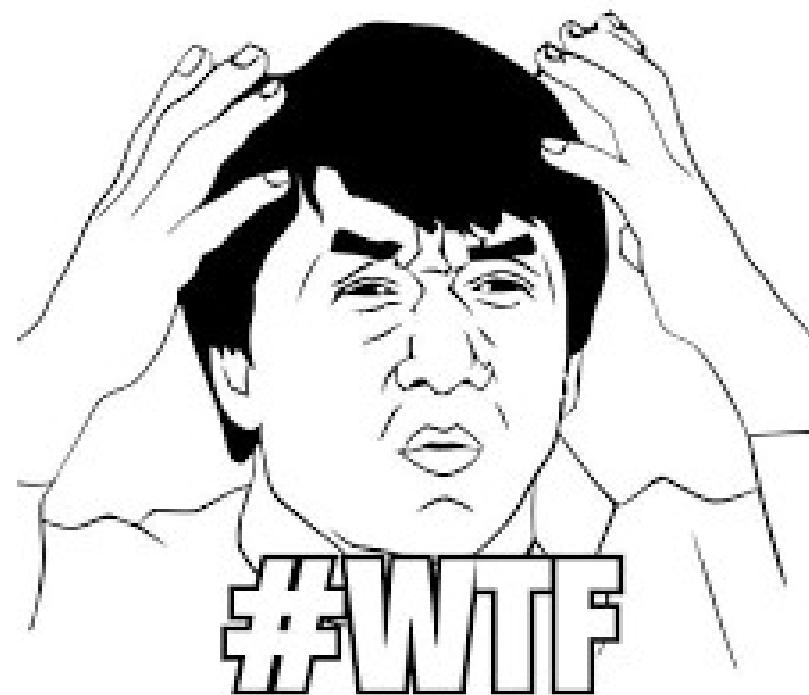
選擇困境

- 原演算法
(學術單位常用)

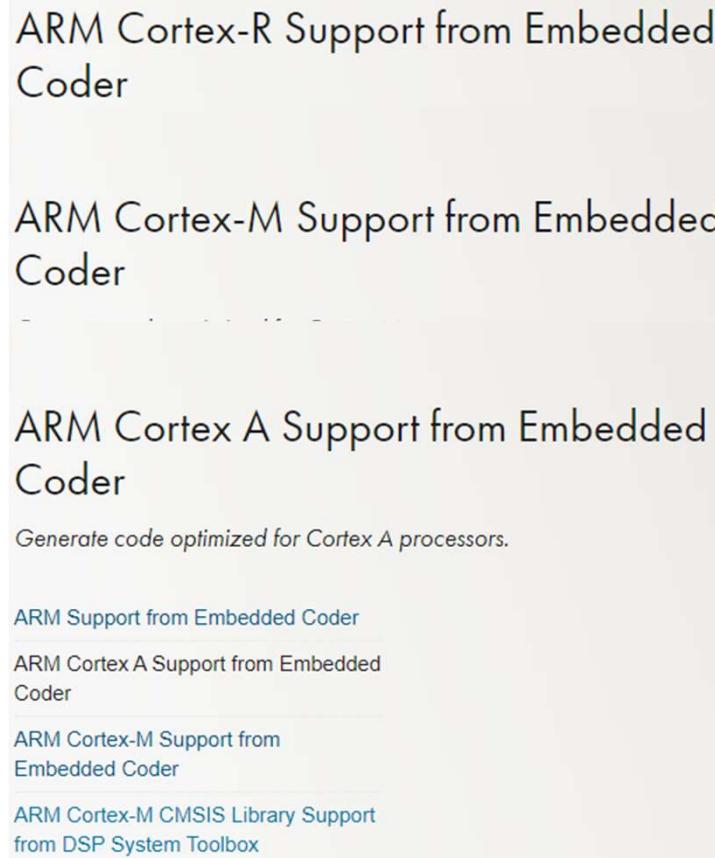


- 學生愛用

- 設備商



其實MATLAB有神秘武器，但！



ARM Cortex-R Support from Embedded Coder

ARM Cortex-M Support from Embedded Coder

ARM Cortex A Support from Embedded Coder

Generate code optimized for Cortex A processors.

[ARM Support from Embedded Coder](#)

[ARM Cortex A Support from Embedded Coder](#)

[ARM Cortex-M Support from Embedded Coder](#)

[ARM Cortex-M CMSIS Library Support from DSP System Toolbox](#)

- MATLAB Function要一直拆
- 拆完還不一定能轉出來
- 有些可轉C++不可轉C
- 有些可轉C不可轉C++

那我想辦法把Python套件裝進去可以了吧



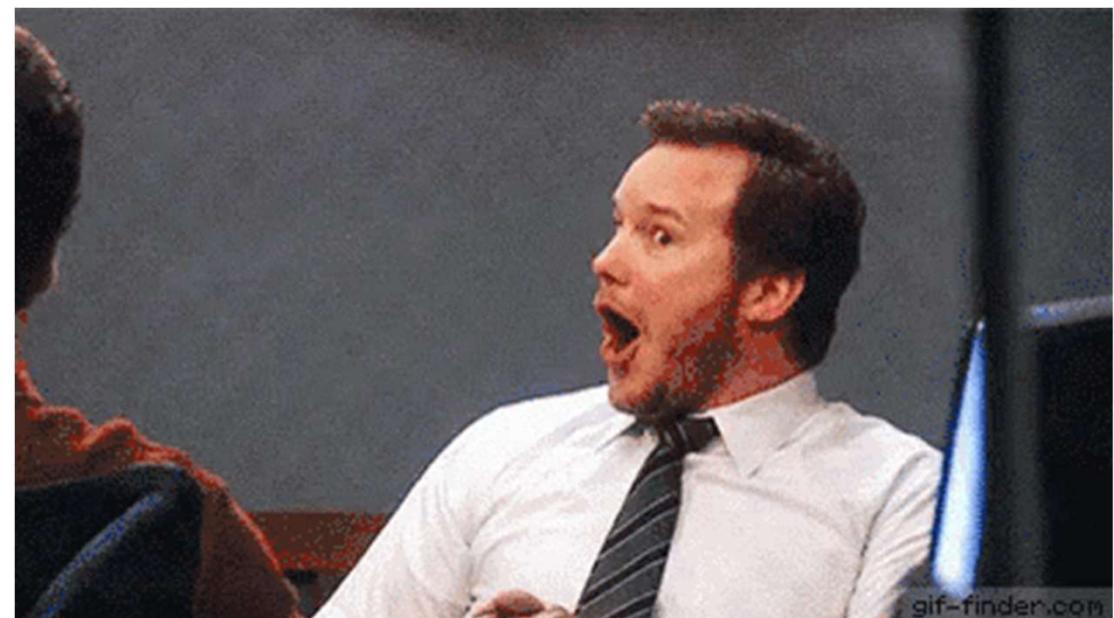
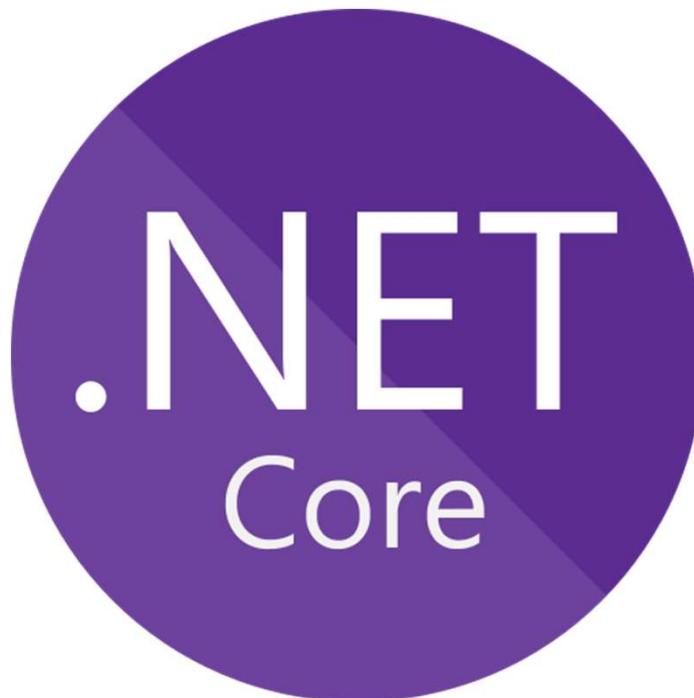
- Linux Distribution
- Created by Texas Instrument
- OpenEmbedded/Yocto Project



- Open PacKaGe Management
- 基於ipkg
- OpenEmbedded/OpenWrt
- 不支援TLS

1. 版本太舊不支援TLS，無法下載想要的套件
2. 裡面也沒有C Compiler
3. 設備公司採用x86環境+ARM compiler toolchain

正當我不知怎麼跟老闆說的時候

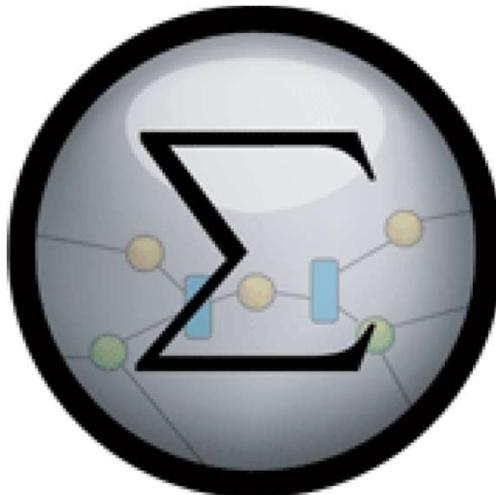


開工啦

- 打API用HttpClient
- 數學用Math.NET
- 無線傳輸用SerialPort(UART)



Math.NET



numerical computing

Math.NET Numerics aims to provide methods and algorithms for numerical computations in science, engineering and every day use. Covered topics include special functions, linear algebra, probability models, random numbers, interpolation, integral transforms and more.

computer algebra

Math.NET Symbolics is a basic opensource computer algebra library for .Net and Mono, written entirely in F#.

signal processing

Math.NET Filtering (previously Neodym) aims to provide a toolkit for digital signal processing, offering an infrastructure for digital filter design, applying those filters to data streams using data converters, as well as digital signal generators.

geometry

Math.NET Spatial aims to become a geometry library for .Net and Mono.

- <https://www.mathdotnet.com/>
- <https://xxx.mathdotnet.com/api/>
- 用於矩陣、向量運算很快

[MathNet.Numerics.IntegralTransforms](#)
[MathNet.Numerics.Integration](#)
[MathNet.Numerics.Interpolation](#)
[MathNet.Numerics.LinearAlgebra](#)
[MathNet.Numerics.LinearAlgebra.Complex](#)
[MathNet.Numerics.LinearAlgebra.Complex.Solvers](#)
[MathNet.Numerics.LinearAlgebra.Complex32](#)
[MathNet.Numerics.LinearAlgebra.Complex32.Solvers](#)

Fourier
FourierOptions
Hartley
HartleyOptions

Type **Fourier**
Namespace [MathNet.Numerics.IntegralTransforms](#)

Complex Fast (FFT) Implementation of the Discrete Fourier Transform (DFT).

Static Functions

[BluesteinForward](#) [BluesteinForward](#) [BluesteinInverse](#) [BluesteinInverse](#) [Forward](#) [Forward](#) [Forward](#) [Forward](#) [Forward](#) [Forward](#) [Forward2D](#) [Forward2D](#) [Forward2D](#) [ForwardMultiDim](#)
[ForwardMultiDim](#) [ForwardReal](#) [ForwardReal](#) [FrequencyScale](#) [Inverse](#) [Inverse](#) [Inverse](#) [Inverse](#) [Inverse](#) [Inverse](#) [Inverse2D](#) [Inverse2D](#) [Inverse2D](#) [Inverse2D](#) [InverseMultiDim](#)
[InverseMultiDim](#) [InverseReal](#) [InverseReal](#) [NaiveForward](#) [NaiveForward](#) [NaiveInverse](#) [NaiveInverse](#) [Radix2Forward](#) [Radix2Forward](#) [Radix2Inverse](#) [Radix2Inverse](#)

Public Static Functions

void **BluesteinForward**(Complex32[] samples, FourierOptions options)

Bluestein forward FFT for arbitrary sized sample vectors.

Obsolete: Use Forward instead. Will be dropped in version 5.0 and behave like Forward until then.

Parameters

Complex32[] samples

Sample vector, where the FFT is evaluated in place.

FourierOptions options

Fourier Transform Convention Options.

void **BluesteinForward**(Complex[] samples, FourierOptions options)

Bluestein forward FFT for arbitrary sized sample vectors.

Obsolete: Use Forward instead. Will be dropped in version 5.0 and behave like Forward until then.

Parameters

Complex[] samples



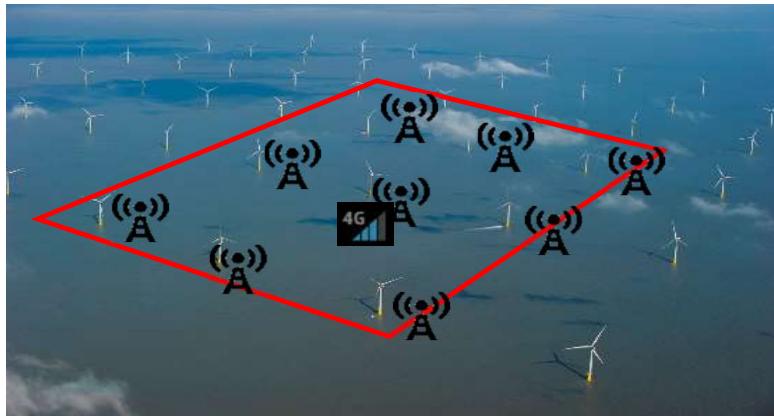
計算時間差異

```
New DataMatrix Loaded  
Data to 20s Matrix Done  
For loop Execution Time: 163 ms  
Data to 20s Matrix Done  
Vector Execution Time: 238 ms  
Ref Matrix loaded  
Gaussian Matrix Loaded  
Gaussian Vector Loaded  
STFT Started  
STFT Matrix Done  
Old Execution Time: 67390 ms  
STFT Started  
STFT Matrix Done  
New Execution Time: 30134 ms  
NewestSTFT Started  
STFT Matrix Done  
Newest Execution Time: 30987 ms  
All done
```

```
New DataMatrix Loaded  
Data to 20s Matrix Done  
For loop Execution Time: 509 ms  
Data to 20s Matrix Done  
Vector Execution Time: 1187 ms  
Ref Matrix loaded  
Gaussian Matrix Loaded  
Gaussian Vector Loaded  
STFT Started  
STFT Matrix Done  
Old Execution Time: 680123 ms  
STFT Started  
STFT Matrix Done  
New Execution Time: 626827 ms  
NewestSTFT Started  
STFT Matrix Done  
Newest Execution Time: 622639 ms  
All done
```



無線傳輸 和 為何LoRa (Long Range)

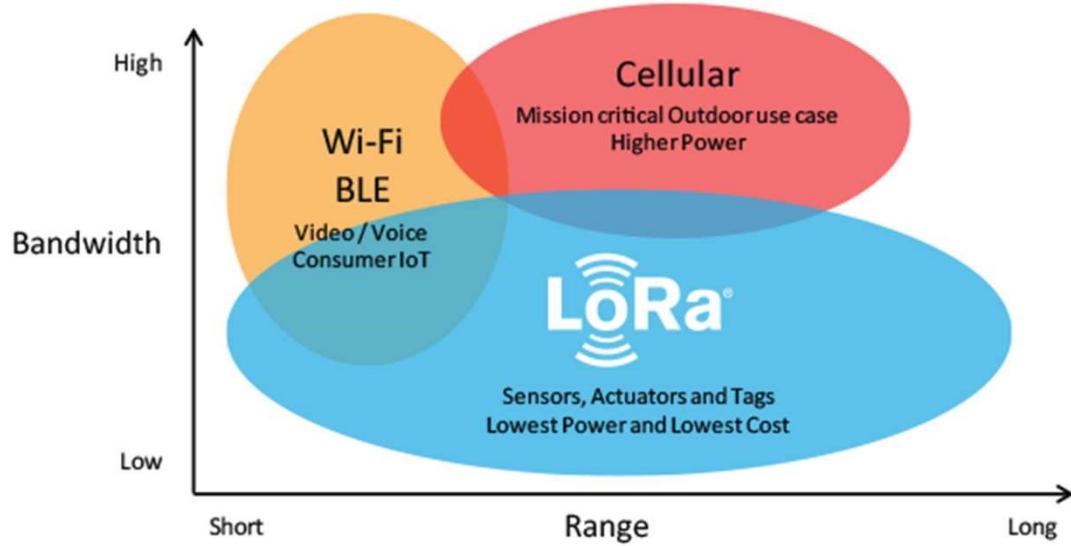


 通訊塔 4G  監控塔 LoRa



SAINT-BRIEUC BAY OFFSHORE WIND FARM 496 MW, BRITTANY (FRANCE)

LoRa (LongRange)



全球免費頻段運行

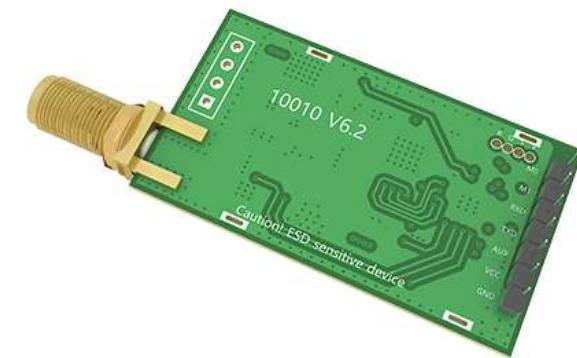
- 美國是915MHz
- 歐洲是868MHz
- 亞洲則為433MHz。

範圍是2km至5km，最長距離可達15km

- 低功耗
- 大容量
- 支持測距和定位



UART 最低4Pin
VCC, Tx, Rx, GND





Tx/Rx mode

Transparent transmission(Point to point)

Data sending is via transparent transmission,
the module comes with address



Module A and Module B have the same address and channel

Transparent transmission (Broadcasting)

Each one can act as transmitter to send out data

Transmitter: Data
Receiver: Data



Broadcast transmission

Set the address to 0xFFFF, the module can transmit data to all modules in target channel

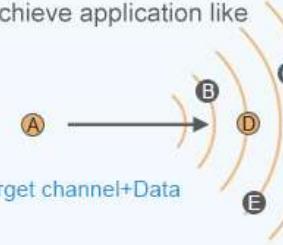
Transmitter: Transmitter:0xFFFF+Target channel+Data
Receiver: Data



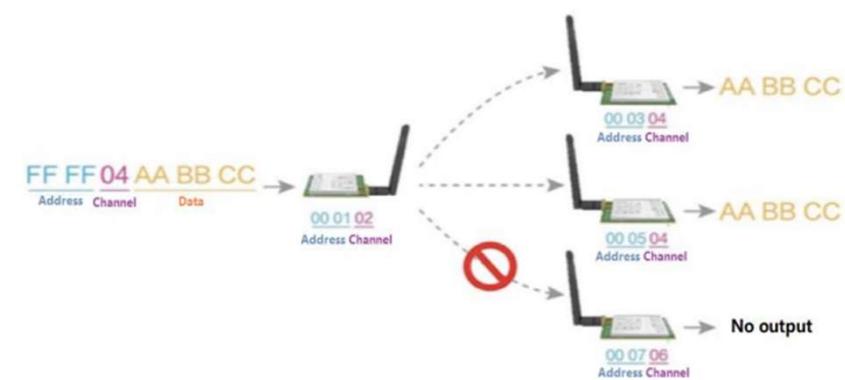
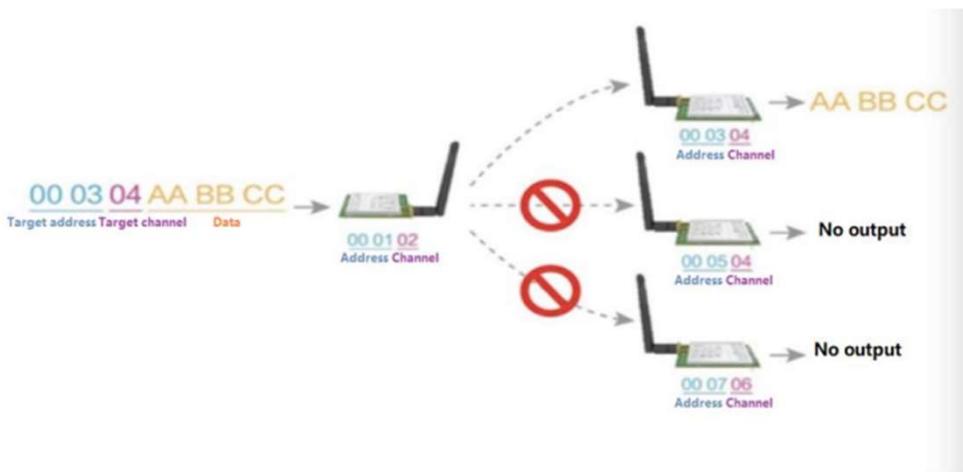
Fixed transmission

Each module can connect with other module in different addresses and channels to achieve application like networking, repeating etc.

Transmitter: Target address+Target channel+Data
Receiver: Data



Address Mode Change



https://github.com/xreef/LoRa_E32_Series_Library

Serial Port (UART) 傳送

```
var _serialPort =  
    new SerialPort("COM6", 9600, Parity.None, 8, StopBits.One);  
  
_serialPort.DtrEnable = true;  
  
_serialPort.Open();  
  
string message = "message you want";  
byte[] data = Encoding.UTF8.GetBytes(message);  
  
_serialPort.Write(data, 0, data.Length);
```

Serial Port (UART) 接收

```
var _serialPort =
    new SerialPort("COM6", 9600, Parity.None, 8, StopBits.One);
_serialPort.DtrEnable = true;
_serialPort.Open();

_serialPort.DataReceived += new SerialDataReceivedEventHandler(dataReceived);
Byte[] buffer = new Byte[2048];
Int32 length = (sender as SerialPort).Read(buffer, 0, buffer.Length);
Array.Resize(ref buffer, length);

string stringdata = Encoding.UTF8.GetString(buffer).ToString();
```

```
tom5707@WeiTing-SB:/mnt/c/ + ∨
tom5707@WeiTing-SB:/mnt/c/Users/tom57$ ssh root@192.168.1.60
root@192.168.1.60's password:
root@MCM204:~# cd Receive/
root@MCM204:~/Receive#
```

Serial Port (UART) 接收

```
switch (receivedValue){  
    case S:  
        tempList.Clear();  
        tempList.Add((Byte)receivedValue);  
        break;  
  
    case E:  
        tempList.Add((Byte)receivedValue);  
        parsevalue(tempList);  
        break;  
  
    case -1:  
        break;  
  
    default:  
        tempList.Add((Byte)receivedValue);  
        break;}  
  
if (tempList[0] == (Byte)S && tempList[tempList.Count - 1] == (Byte)E){  
    tempList.RemoveAt(0);  
    tempList.RemoveAt(tempList.Count - 1);  
    tempList.ToArray();  
  
    string stringdata = Encoding.UTF8.GetString(tempList.ToArray());  
    int ID = (int)Convert.ToInt32(stringdata.Substring(3, 2));  
    int Port = (int)Convert.ToInt32(stringdata.Substring(10, 2));  
    bool status = (stringdata.Last() == 'Y') ? true : false;  
    sendBackSucceed(ID, Port,_serialPort);  
    PushMessageToCloud(ID, status);  
    Console.WriteLine(stringdata);}
```

自己做確認接收

- 發送字元設計

發送：S+ID:xx+Condition:T/F+E

接收：確認資料發送S+ID:xx+E

確定S到E才是完整封包+字元數量驗證

確認後再送回收到的ID資料送回驗證

沒收到、無限次數傳送

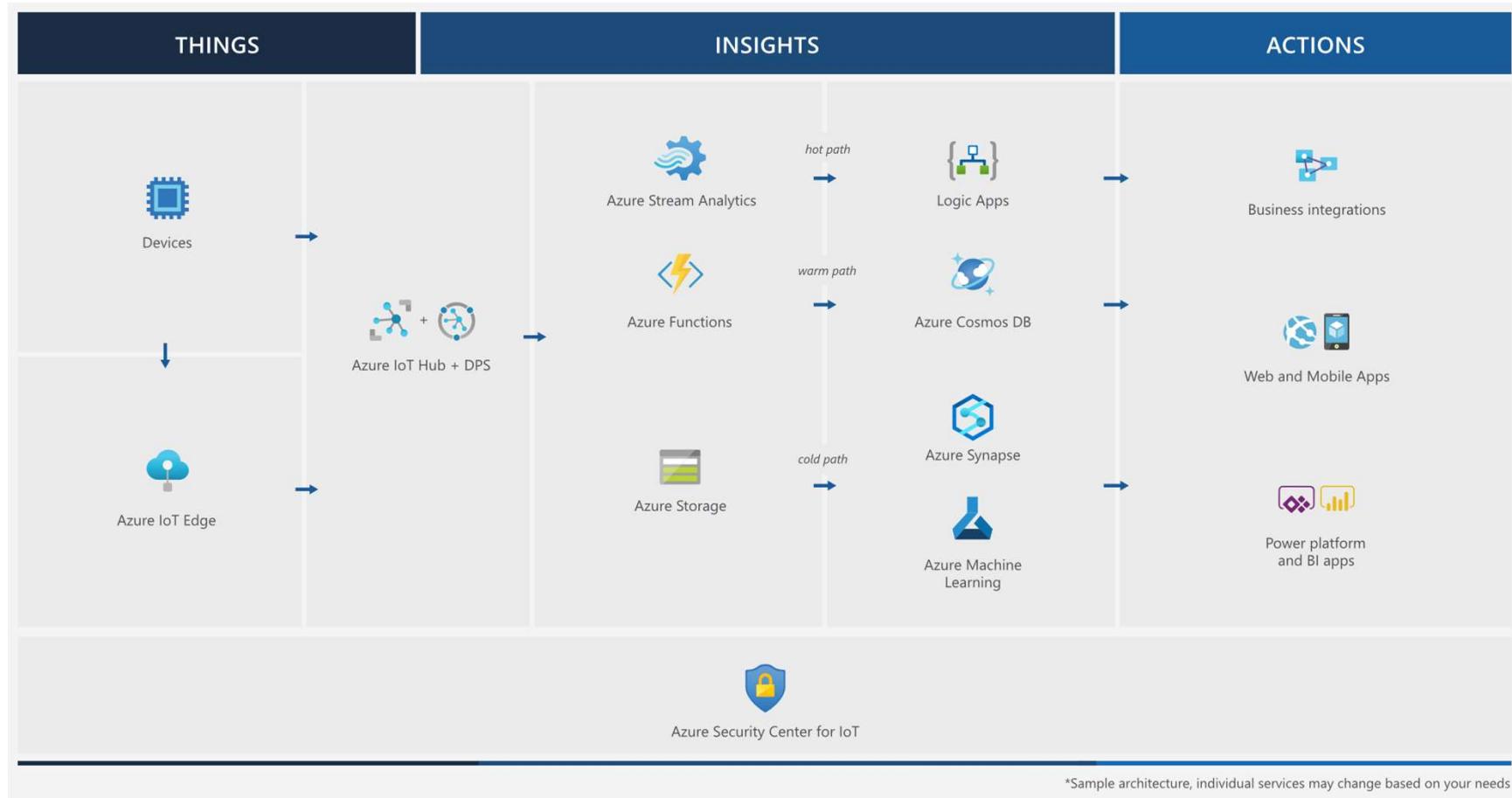




Microsoft STUDY4

B Build School

Azure IoT 參考架構



<https://docs.microsoft.com/zh-tw/azure/architecture/reference-architectures/iot>

IoT Routing

TurbineDataHub | Message routing 

IoT Hub

Search (Ctrl+ /) 

Messaging

File upload

Message routing 

Security

Overview

Security Alerts

Recommendations

Settings

Monitoring

Alerts

Metrics

Diagnostic settings

Logs

Workbooks

Automation

Tasks (preview)

Export template

Support + troubleshooting

Resource health 

Send data from your devices to endpoints that you choose.

Routes  Enrich messages

Choose which Azure services will receive your messages. You can add up to 10 endpoints to an IoT hub.

+ Add  Delete 

Event Hubs

Service Bus queue

Service Bus topic

Storage

Recommended for archiving data.

Name	Container name	Encoding format	Batch frequency(sec...)	Filename format	Authentication type	Status
Storage	statusstorage	JSON	60	{iothub}/{partition}/{...}	Key-based	Unknown

Azure IoT Hub

```
TransportType s_transportType = Microsoft.Azure.Devices.Client.TransportType.Http1;

string messageBody = @"{
    ""DeviceInfo"": {
        ""DeviceID"": "" + deviceID.ToString() + """",
        ""LocalTime"": "" + @DateTime.Now.ToString() + """",
        ""Turbine"": "" + status + """
    }
};

byte[] messageBytes = Encoding.UTF8.GetBytes(messageBody);
var message = new Microsoft.Azure.Devices.Client.Message(messageBytes);
message.ContentEncoding = "utf-8";
message.ContentType = "application/json";

DeviceClient deviceClient = DeviceClient.CreateFromConnectionString("DeviceConnctionString", s_transportType);
await Task.Delay(3000);
await deviceClient.SendEventAsync(message).ConfigureAwait(false);
Console.WriteLine($"No. ${deviceID} is completed");
```

儲存位置、結構

Authentication method: Access key (Switch to Azure AD User Account)

Location: statusstorage / TurbineDataHub / 01 / 2020 / 10 / 03 / 04

Search blobs by prefix (case-sensitive)

Name

 [..]

 16.json

 20.json

```
{ } {"EnqueuedTimeUtc":"2020-10-03T04:19:43. Untitled-1 ●
1  {"EnqueuedTimeUtc":"2020-10-03T04:19:43.7440000Z", "Properties":{}, "SystemProperties":{"connectionDeviceId":"TurbineDevice1",
2          "DeivceInfo":{
3              "DeviceID":"1",
4              "LocalTime":"10/3/2020 12:19:38",
5              "Turbine":"False"
6          }
7      }}
8  {"EnqueuedTimeUtc":"2020-10-03T04:19:44.2750000Z", "Properties":{}, "SystemProperties":{"connectionDeviceId":"TurbineDevice1",
9          "DeivceInfo":{
10             "DeviceID":"1",
11             "LocalTime":"10/3/2020 12:19:40",
12             "Turbine":"False"
13         }
14     }}
15 {"EnqueuedTimeUtc":"2020-10-03T04:19:44.2910000Z", "Properties":{}, "SystemProperties":{"connectionDeviceId":"TurbineDevice1",
16          "DeivceInfo":{
17              "DeviceID":"1",
18              "LocalTime":"10/3/2020 12:19:40",
19              "Turbine":"False"
20          }
21      }}
22 {"EnqueuedTimeUtc":"2020-10-03T04:19:46.5690000Z", "Properties":{}, "SystemProperties":{"connectionDeviceId":"TurbineDevice1",
23          "DeivceInfo":{
24              "DeviceID":"1",
25              "LocalTime":"10/3/2020 12:19:42",
26              "Turbine":"False"
27          }
28      }}
29 {"EnqueuedTimeUtc":"2020-10-03T04:19:46.6470000Z", "Properties":{}, "SystemProperties":{"connectionDeviceId":"TurbineDevice1",
30          "DeivceInfo":{
31              "DeviceID":"1",
32              "LocalTime":"10/3/2020 12:19:42",
33              "Turbine":"False"
34      }}
```

可是會有幾百台設備不定時計算、傳送
還是看你抵達Azure Cloud時間

目前解法(blob下載)

```
string connectionString = Environment.GetEnvironmentVariable("AZURE_STORAGE_CONNECTION_STRING");
BlobServiceClient blobServiceClient = new BlobServiceClient(connectionString);
BlobContainerClient containerClient = blobServiceClient.GetBlobContainerClient("containername");
using (FileStream downloadFileStream = File.OpenWrite("localpath")){
    await download.Content.CopyToAsync(downloadFileStream);
    downloadFileStream.Close();
}
```



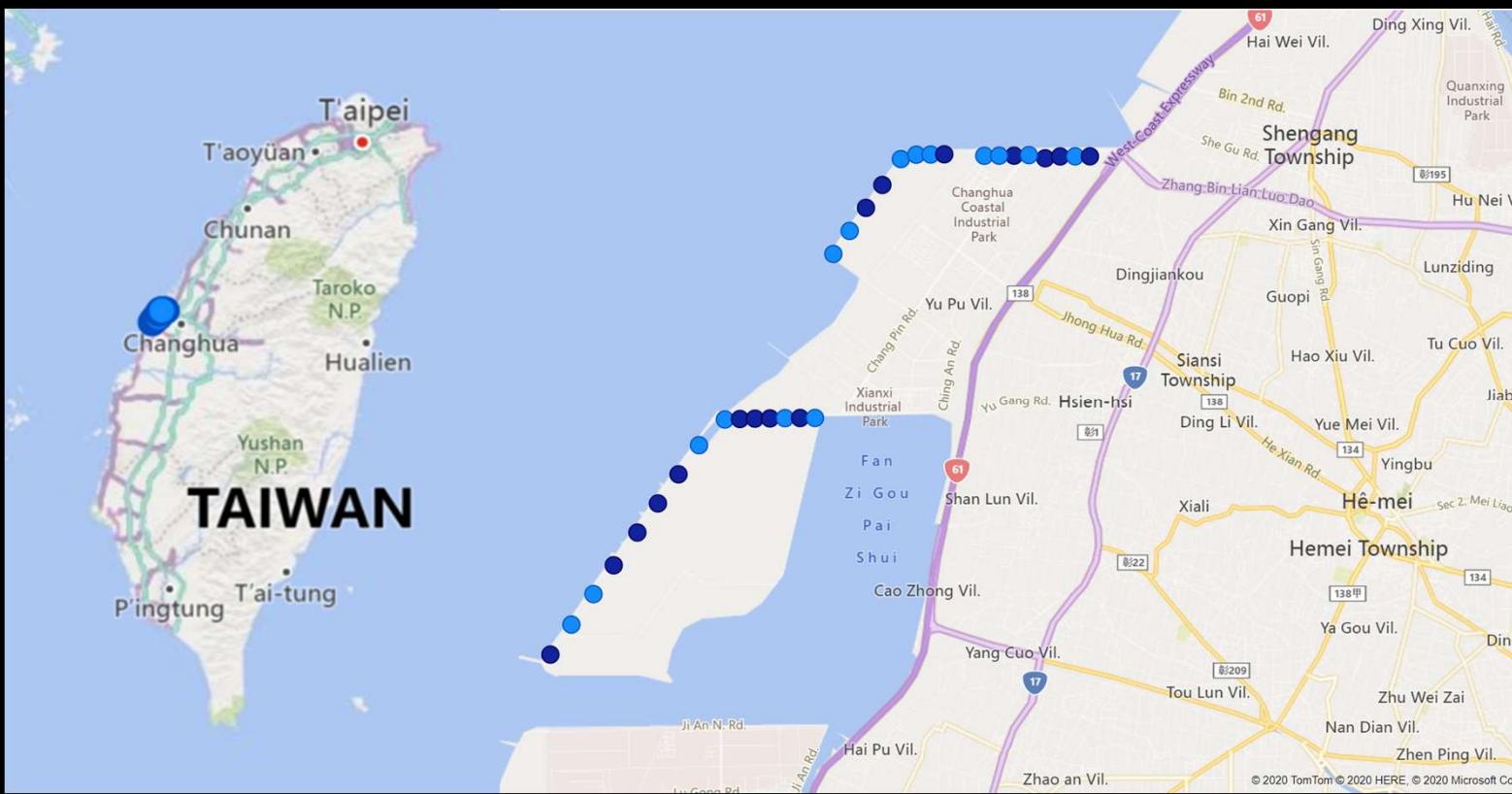
<https://docs.microsoft.com/zh-tw/azure/storage/blobs/storage-quickstart-blobs-dotnet>

REGEX 解決一切

```
{"EnqueuedTimeUtc":"2020-10-  
13T11:09:32.417000Z","Properties":{}, "SystemProperties": {"connectionDeviceId": "TurbineDevice1", "connectionAuthMethod": "{\\"scope\\":\\"device\\", \\"type\\":\\"sas\\", \\"issuer\\":\\"iothub\\", \\"acceptingIpFilterRule\\":null}", "connectionDeviceGenerationId": "637367054419844199", "contentType": "application/json", "contentEncoding": "utf-8", "enqueuedTime": "2020-10-  
13T11:09:32.417000Z"}, "Body": {  
    "DeviceInfo": {  
        "DeviceID": "24",  
        "LocalTime": "10/13/2020 19:09:28",  
        "Turbine": "False" } } }  
  
{"EnqueuedTimeUtc": "2020-10-  
13T11:09:35.487000Z", "Properties": {}, "SystemProperties": {"connectionDeviceId": "TurbineDevice1", "connectionAuthMethod": "{\\"scope\\":\\"device\\", \\"type\\":\\"sas\\", \\"issuer\\":\\"iothub\\", \\"acceptingIpFilterRule\\":null}", "connectionDeviceGenerationId": "637367054419844199", "contentType": "application/json", "contentEncoding": "utf-8", "enqueuedTime": "2020-10-  
13T11:09:35.487000Z"}, "Body": {  
    "DeviceInfo": {  
        "DeviceID": "25",  
        "LocalTime": "10/13/2020 19:09:31",  
        "Turbine": "True" } } }
```

Power BI 視覺化

ID	Lat	Long	Size	Status
1	24.158042	120.455788	1	TRUE
2	24.158040	120.453728	1	FALSE
3	24.158030	120.451649	1	TRUE
4	24.157798	120.449578	1	TRUE
5	24.158196	120.447310	1	FALSE
6	24.158125	120.445250	1	TRUE
7	24.158127	120.443180	1	FALSE
8	24.158112	120.441117	1	FALSE
9	24.124798	120.417605	1	FALSE
10	24.124788	120.415532	1	TRUE
11	24.124769	120.413442	1	FALSE
12	24.124740	120.411355	1	TRUE
13	24.124711	120.409274	1	TRUE
14	24.124664	120.407193	1	TRUE
15	24.124601	120.405103	1	FALSE
16	24.121353	120.401506	1	FALSE
17	24.117674	120.398653	1	TRUE
18	24.113997	120.395796	1	TRUE
19	24.110320	120.392942	1	TRUE
20	24.106178	120.389660	1	TRUE
21	24.102541	120.386851	1	FALSE
22	24.098686	120.383779	1	FALSE
23	24.094897	120.380864	1	TRUE
24	24.158299	120.435563	1	TRUE
25	24.158272	120.433669	1	FALSE
26	24.158252	120.431676	1	FALSE
27	24.157695	120.429536	1	FALSE
28	24.154419	120.426966	1	TRUE
29	24.151519	120.424689	1	TRUE
30	24.148597	120.422425	1	FALSE
31	24.145683	120.420161	1	FALSE



最終設備成果(專利申請中)





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Demo Time

LoRa Tx/Rx then push to Azure





Microsoft STUDY4 Build School

Thanks for joining!

Ask questions on Twitter using #dotNETConf



特別感謝

91APP
Technical Network



KKTIX



HackMD

MVP
Most Valuable
Professional

Microsoft

Build School

STUDY4
為學習而生

以及各位參與活動的你們





Microsoft

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