樹莓派-物聯網系統實作

Raspberry PI
Bluetooth

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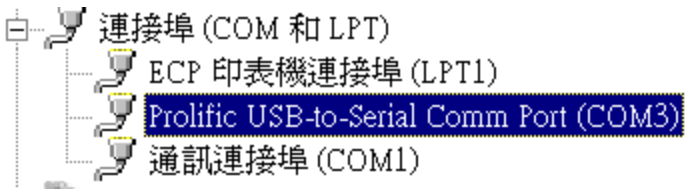
步驟1：電腦端準備 USB 轉 TTL 序列傳輸線

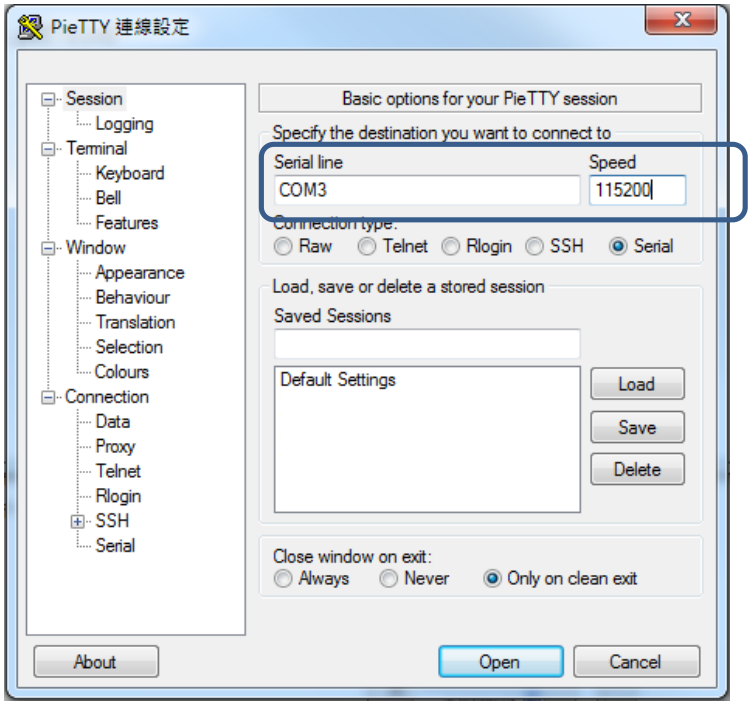
- **從序列埠登入到 Raspberry Pi**
  - 透過 USB 轉 TTL 序列傳輸線，就可以在不需要螢幕和鍵盤滑鼠的情況下登入 Raspberry Pi

- 有兩種晶片組
  - PL2303HX: 支援Windows XP/Vista/7, Linux
  - PL2303HXD:支援Windows 8/10, MAC
    - Driver: http://www.prolific.com.tw/US/ShowProduct.aspx?p_id=225&pcid=41

步驟2：電腦端準備 USB 轉 TTL 序列傳輸線 (for Windows)

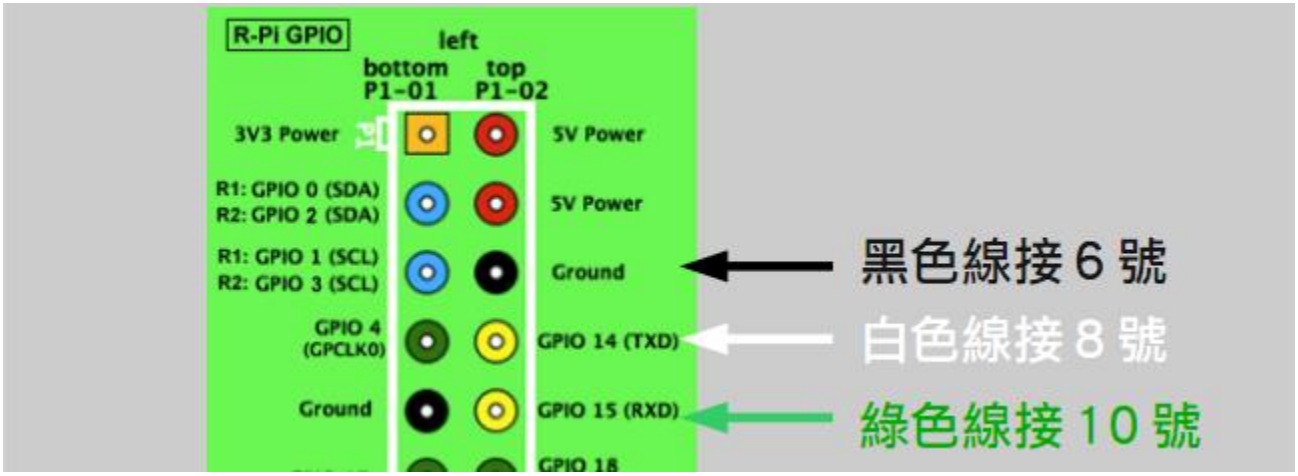
- 安裝完驅動, 在裝置管理員可發現多一個連接阜 (下圖為 COM3)
  - 我的電腦 -> 右鍵-> 內容-> 裝置管理員
- 使用putty連線 (設定Serial port 與 Speed)





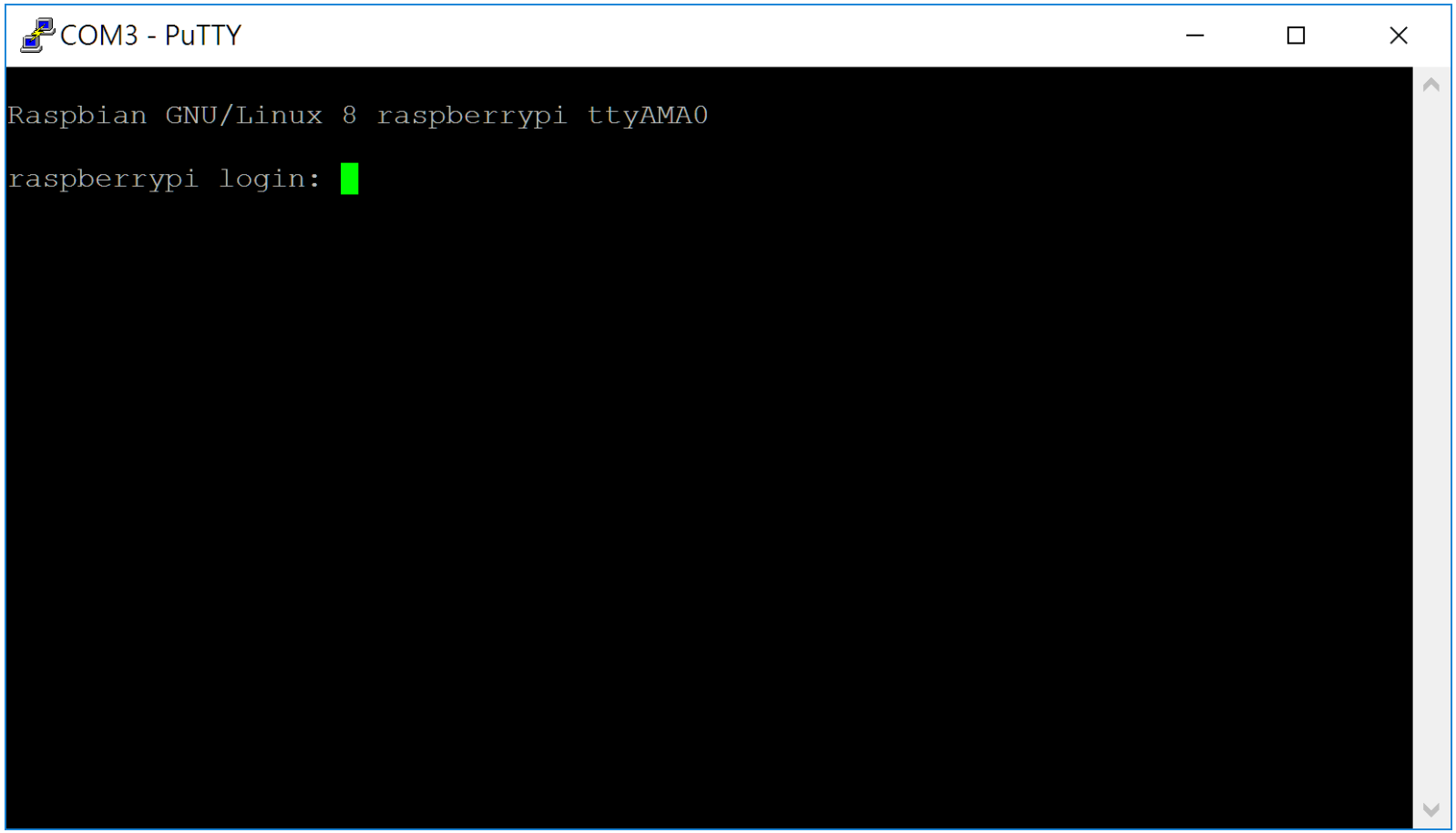
步驟3：將SD卡插到Raspberry PI並開機

- **從序列埠登入到 Raspberry Pi**
  - 透過 USB 轉 TTL 序列傳輸線，就可以在不需要螢幕和鍵盤滑鼠的情況下登入 Raspberry Pi
- **預設登入帳密**
  - ID: pi
  - PW: raspberry



https://www.raspberrypi.com.tw/tag/usb-to-ttl/

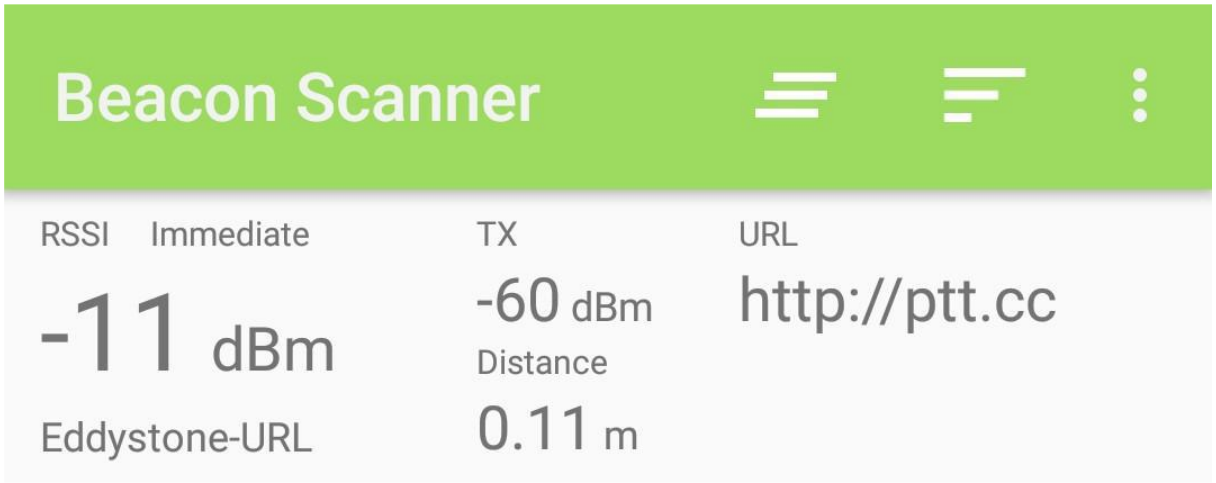
步驟4：將SD卡插到Raspberry PI並開機



還是沒有畫面? -> 電腦重開機試試

Outline

- BLE實驗
  - 藍牙BLE介紹
  - BLE廣播封包實作



藍牙 Bluetooth

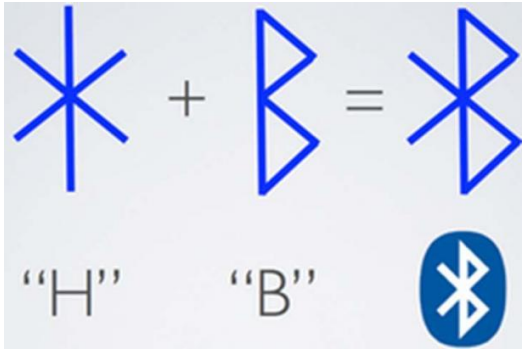
- 目的
  - 為了解決電腦與電器設備之間的傳輸問題
- 特色
  - 短距離無線技術 (10 - 100m)
  - 使用 2.4 至 2.485 GHz 的 ISM 頻段
- Bluetooth Classic: 802.15
- Bluetooth 4.0 Low Energy (BLE): 802.15.1
- Bluetooth 5.0: Faster, Further, for IoT

https://zh.wikipedia.org/zh-tw/%E8%97%8D%E7%89%99

藍牙起源

- 歷史
  - 十世紀國王的名字 (Harald Blåtand)
    - 統一了因宗教戰爭和領土爭議而分裂的挪威與丹麥而聞名於世
    - 喜歡吃藍莓，因此牙齒都變成藍色 (Blue tooth)
    - 另一說，他的牙齒很差，看起來像藍色(blue, dark, black)
    - 他喜歡穿藍色的服飾，當時的藍色有昂貴、尊爵、不凡的意思
  - 由 Ericsson 在 1994 年創製 ,希望為裝置間的通訊創造一組統一規則（標準化協定），以解決用戶間互不相容的移動電子裝置

不要寫成藍**芽**喔!



https://zh.wikipedia.org/zh-tw/%E8%97%8D%E7%89%99
https://en.wikipedia.org/wiki/Harald_Bluetooth

Bluetooth Low Energy (BLE)

- 一種無線個人區域網路 (Wireless PAN) 的技術
- 出現目的 : 低成本 , 低耗電 (CR2032 電池可用 1 年)
- BT4 分 Classic(BR/EDR), High Speed(HS), Low Energy

	Classic	BLE
Data Rate	1~3 Mbps	1 Mbps
Range	10 ~ 100 m	10 ~ 30 m
Power consumption	1 W	0.01 ~ 0.5 W
Connection time	5 s	0.1 s

Bluetooth™ 4.0 Low Energy

Bluetooth 5.0

- Mesh Networking: 一對一>>>多對多
- 出現目的 : IoT
- 室內導航、安全、抗干擾(New Algorithm)

	4.2	5.0
Data Rate	1 Mbps	2 Mbps
Range	1x	4x
Bandwidth	1x	8x

藍牙 + BLE

- 確認藍牙裝置是否有支援BLE功能
  - hciconfig -a hci0 features　　(尋找 **LE support**)

```
pi@raspberrypi:~$ hciconfig -a hci0 features
hci0:   Type: BR/EDR  Bus: USB
        BD Address: 00:1A:7D:DA:71:13  ACL MTU: 310:10  SCO MTU: 64:8
        Features page 0: 0xff 0xff 0x8f 0xfe 0xdb 0xff 0x5b 0x87
                <3-slot packets> <5-slot packets> <encryption> <slot offset>
                <timing accuracy> <role switch> <hold mode> <sniff mode>
                <park state> <RSSI> <channel quality> <SCO link> <HV2 packets>
                <HV3 packets> <u-law log> <A-law log> <CVSD> <paging scheme>
                <power control> <transparent SCO> <broadcast encrypt>
                <EDR ACL 2 Mbps> <EDR ACL 3 Mbps> <enhanced iscan>
                <interlaced iscan> <interlaced pscan> <inquiry with RSSI>
                <extended SCO> <EV4 packets> <EV5 packets> <AFH cap. slave>
                <AFH class. slave> <LE support> <3-slot EDR ACL>
                <5-slot EDR ACL> <sniff subrating> <pause encryption>
                <AFH cap. master> <AFH class. master> <EDR eSCO 2 Mbps>
                <EDR eSCO 3 Mbps> <3-slot EDR eSCO> <extended inquiry>
                <LE and BR/EDR> <simple pairing> <encapsulated PDU>
                <non-flush flag> <LSTO> <inquiry TX power> <EPC>
                <extended features>
        Features page 1: 0x03 0x00 0x00 0x00 0x00 0x00 0x00 0x00
```

Bluetooth 常用工具

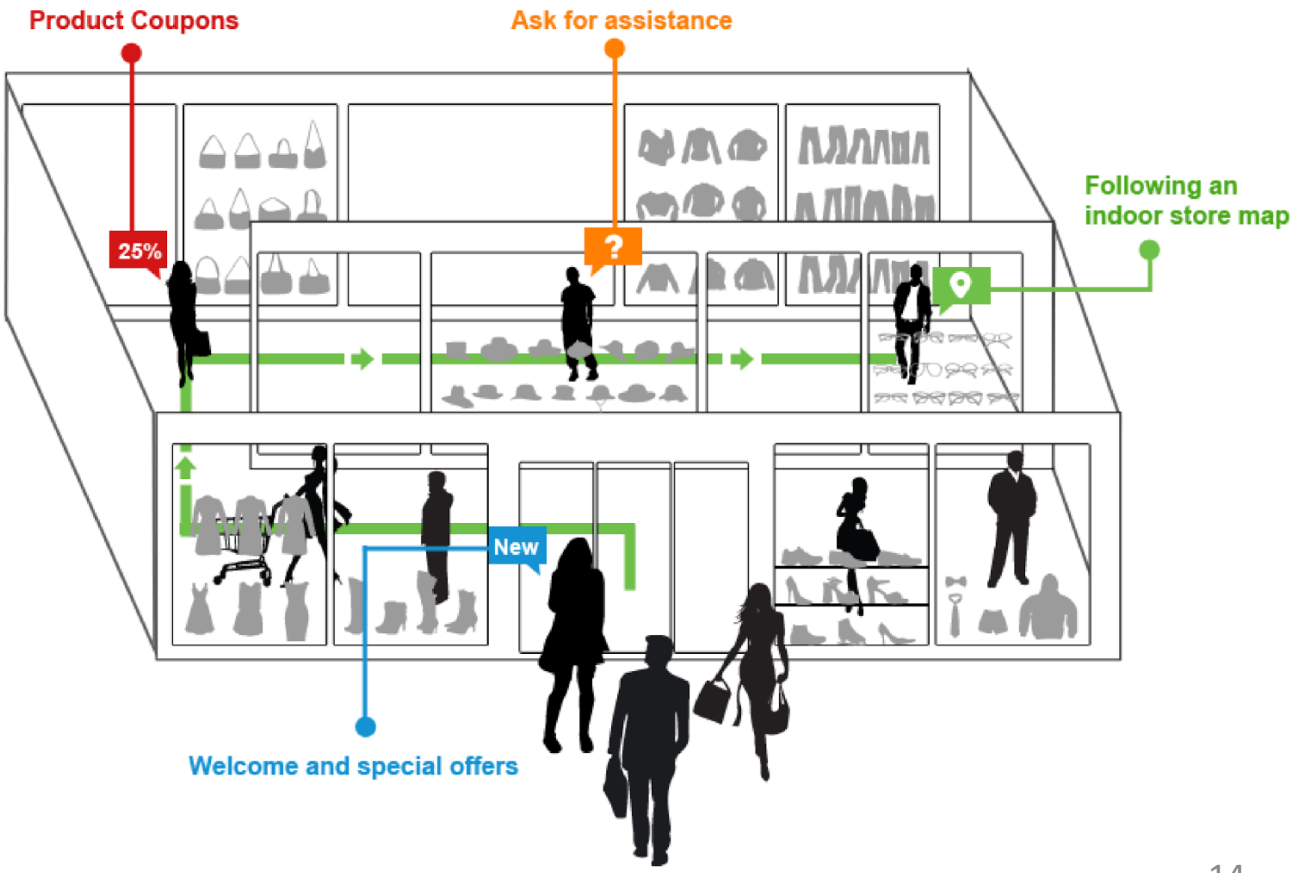
- bluetoothctl - bluetooth control tool
- hciconfig - configure Bluetooth devices
- hcitool - configure Bluetooth connections
- l2ping - Send L2CAP echo request and receive answer
- btmon - Bluetooth monitor
- gatttool - GATT tool

支援 BLE 的平台

- iOS5+ (iOS7+ preferred)
- Android 4.3+ (numerous bug fixes in 4.4+)
- Apple OS X 10.6+
- Windows 10/8 (XP, Vista and 7 only support Bluetooth 2.1)
- GNU/Linux Vanilla BlueZ 4.93+

BLE 的應用

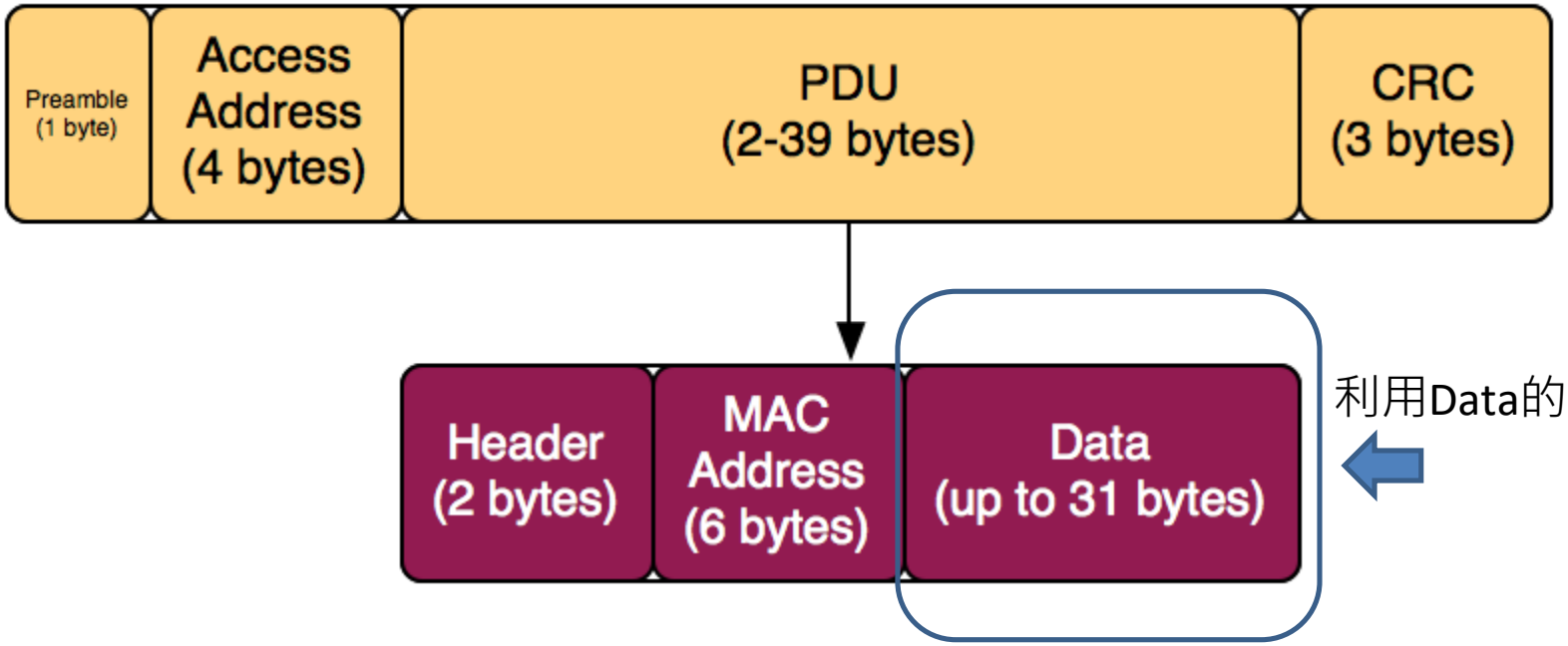
- 微型定位服務
- 推播訊息



https://learn.adafruit.com/pibeacon-ibeacon-with-a-raspberry-pi/overview

BLE frame format

- 1 byte preamble
- 4 byte access address
- 2-39 bytes advertising channel PDU
- 3 bytes CRC



http://www.warski.org/blog/2014/01/how-ibeacons-work/

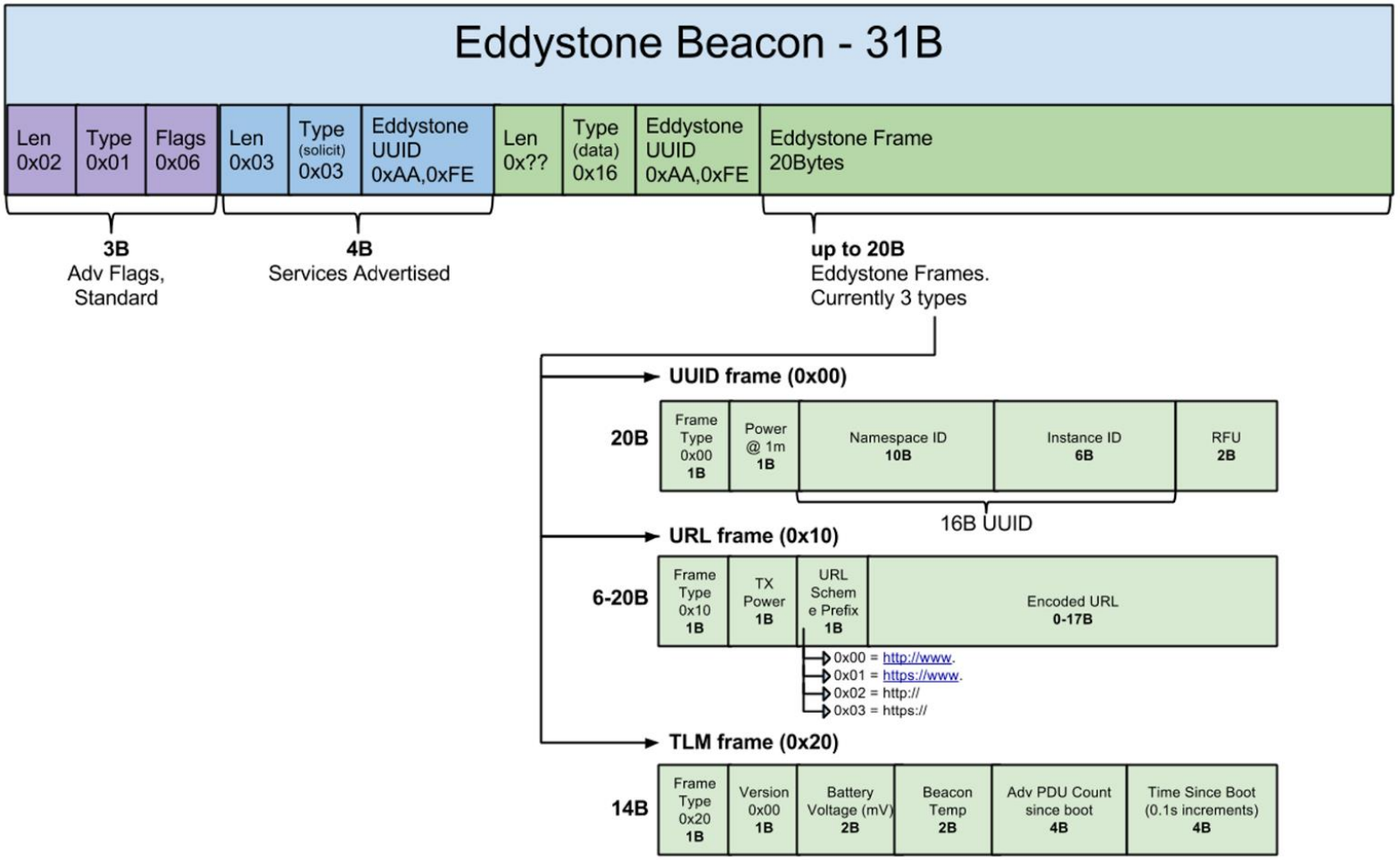
BLE 的應用 (Eddystone)

- Eddystone is a protocol specification that defines a Bluetooth low energy (BLE) message format for proximity beacon messages.

- Design Goals
  - Works well with Android and iOS Bluetooth developer APIs
  - Straightforward implementation on a wide range of existing BLE devices
  - Flexible architecture permitting development of new frame types
  - Fully compliant with the Bluetooth Core Specification

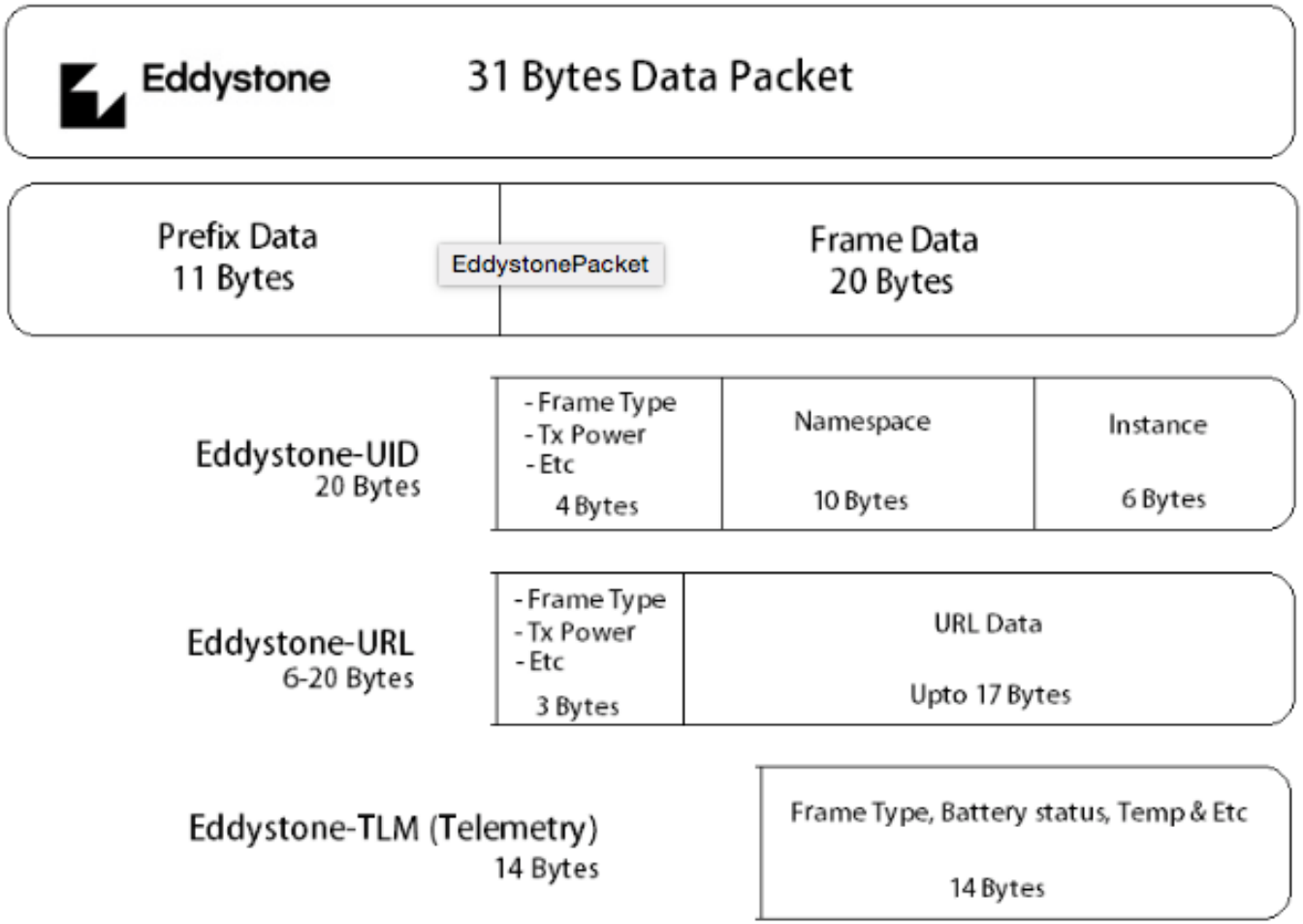
https://github.com/google/eddystone

Eddystone Frame format



https://developer.mbed.org/teams/Bluetooth-Low-Energy/code/BLE_EddystoneBeacon_Service/file/dfb7fb5a971b/Eddystone.h

Eddystone Frame format

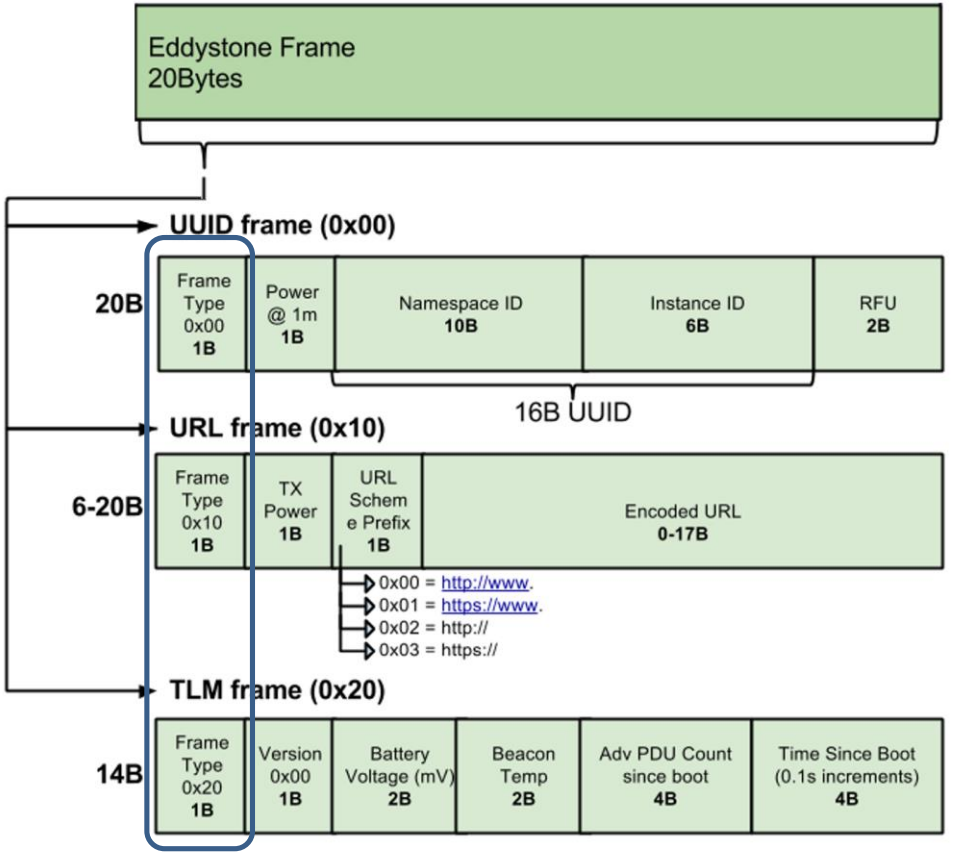


http://iosandi.blogspot.tw/2015/12/in-addition-to-my-previous-post-i-have.html

Eddystone Frame format

- Eddystone Protocol Specification

Frame Type	High-Order 4 bits	Byte Value
UID	0000	0x00
URL	0001	0x10
TLM	0010	0x20
EID	0011	0x30
RESERVED	0100	0x40



https://github.com/google/eddystone/blob/master/protocol-specification.md

Eddystone訊息

- Goal:
  - 利用PI的BLE, 產生Eddystone的廣告訊息
  - 依照網址建立一個符合Eddystone格式的frame

  - Eddystone網址格式
    - https://github.com/google/eddystone/tree/master/eddystone-url
  - ACSII table
    - https://zh.wikipedia.org/wiki/ASCII

Eddystone訊息

- 將網址轉換為Eddystone格式
  - Ex: http://ptt.cc
  - 利用ASCII table查詢數值

數值 (16進位)	網址
02	http://
70	p
74	t
74	t
2e	.
63	c
63	c

Decimal	Hex	Expansion
0	0x00	http://www.
1	0x01	https://www.
2	0x02	http://
3	0x03	https://

Eddystone訊息

- 使用 advertise-url 來傳送網址廣播
  - Source code
    - https://github.com/google/eddystone/blob/master/eddystone-url/implementations/linux/advertise-url
    - wget https://raw.githubusercontent.com/google/eddystone/master/eddystone-url/implementations/linux/advertise-url
  - 下載後
    - chmod +x advertise-url (新增執行權限)
    - sudo ./advertise-url -u http://ptt.cc (開始廣播)
    - sudo ./advertise-url -s (停止廣播)

Eddystone訊息

- 手機端可安裝app查看Eddystone訊息

iBeacon & Eddystone Scanner

flurp laboratories 工具

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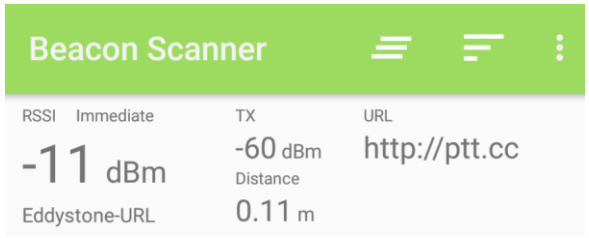
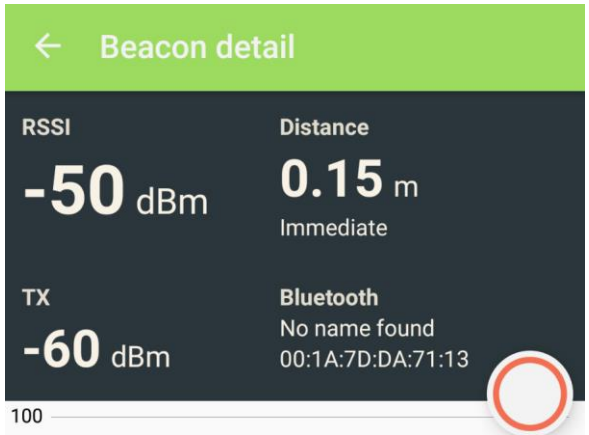
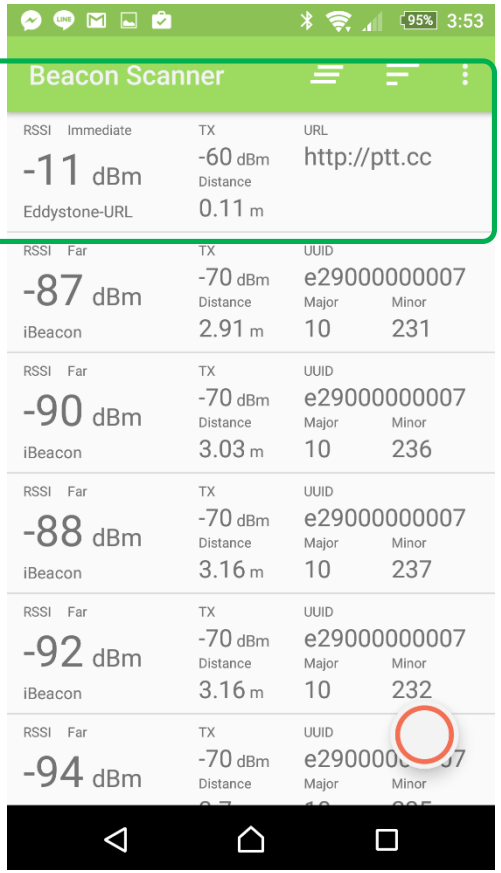
3+

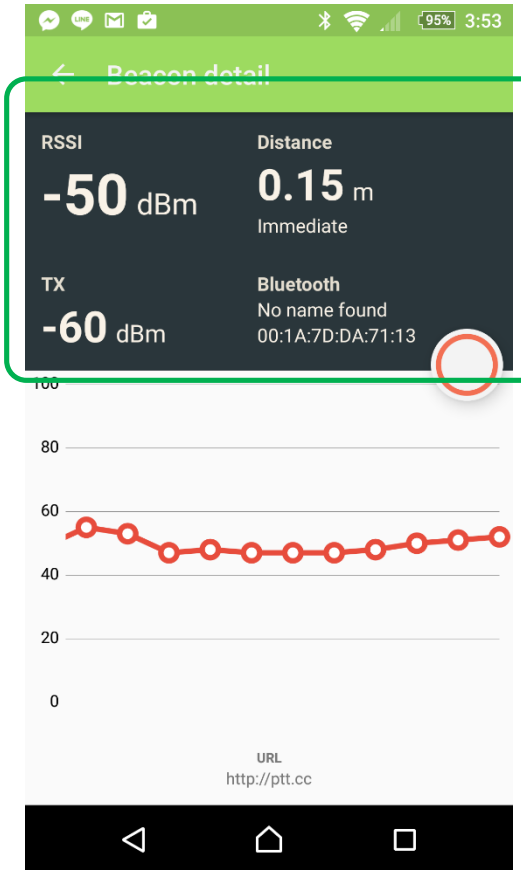
這個應用程式與您的部分裝置相容。

已安裝









Eddystone訊息

- 也可以使用bluetooth工具傳送網址廣播

sudo hciconfig hci0 leadv 3　　啟用藍牙的低耗能廣告(LE advertising)模式，並關閉掃描功能
sudo hciconfig hci0 noscan

sudo hcitool -i hci0 cmd 0x08 0x0008 14 02 01 1a 03 03 aa fe 0c 16
aa fe 10 ed **02 70 74 74 2e 63 63** 00 00 00 00 00 00 00 00 00 00 00

⬆ http://ptt.cc　　傳送Eddystone frame

sudo hciconfig hci0 noleadv　　停止廣告

Eddystone訊息

sudo hcitool -i hci0 cmd 0x08 0x0008 14 02 01 1a 03 03 aa fe 0c 16 aa fe 10 ed **02 70 74 74 2e 63 63** 00 00 00 00 00 00 00 00 00 00 00

- 0x08 0x0008: set the ad package
  - #OGF = Operation Group Field = Bluetooth Command Group = 0x08
  - #OCF = Operation Command Field = HCI_LE_Set_Advertising_Data = 0x0008
- 14: the ENTIRE following data packet in bytes (16進位的14 = 20 byte)

20 byte

- 02 01 1a: Eddystone Adv Flags
  - 0x06 - The device is BLE only. The full Bluetooth stack is not supported.
  - 0x1A - The device can be used as BLE as well as full Bluetooth Controller/Host simultaneously.
- 03 03 aa fe: Eddystone service adv
- 0c: length (12 byte)
- 16: type (data)
- aa fe: Eddystone UUID
- 10: URL frame type
- ed: TX power
- 02 70 74 74 2e 63 63: http://ptt.cc,共 7 byte

12 byte

- 00 00 00 00 00 00 00 00 00 00 00: 共 10 byte

Eddystone訊息

- Q1：
  - 產生Eddystone的廣告訊息
    - 網址http://bun.cm.nctu.edu.tw/
  - 網址轉換後的數值?
  - 手機抓取Eddystone截圖
- Q2：
  - 說明數值意義

數值 (16進位)	網址
???	???
???	???
???	???
???	???
???	???
???	???
???	???

Lab -Assignment

- Q1:
  - Generate Eddystone advertisement. (show the printscreen)
  - convert the URL to Eddystone format.
- Q2:
  - Use hcitool to send the same Eddystone advertisement.
  - Explain the meaning of values

Reference

- Raspberry Pi IoT無線傳輸技術介紹 – Bluetooth
  - https://www.slideshare.net/raspberrypi-tw/raspberry-pi-iot-bluetooth
- Eddystone
  - https://github.com/google/eddystone
- Eddystone Protocol Specification
  - https://github.com/google/eddystone/blob/master/protocol-specification.md
- Eddystone-URL Beacon Implementations
  - https://github.com/google/eddystone/tree/master/eddystone-url/implementations/