Android BLE in Action

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@Android笔记

Outline

- What’s Bluetooth Low Energy (BLE)
- BLE on Android
- BLE Applications
- Debug tools
- Best practice

Bluetooth intro.

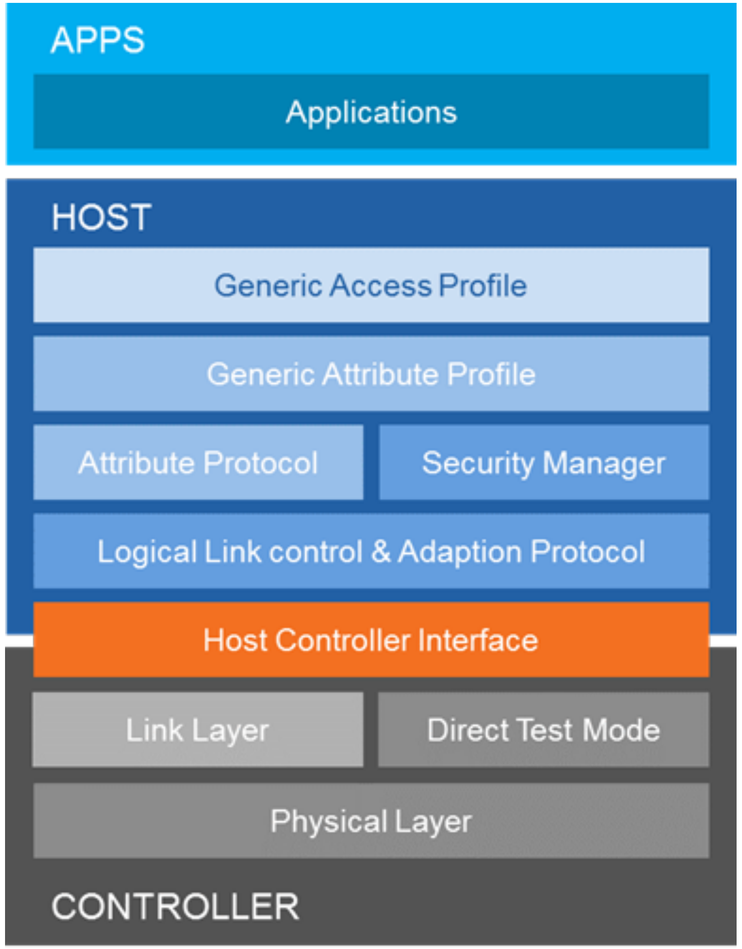
- What's Bluetooth™
  - Bluetooth SIG
  - Feature
    - Short distance
    - Up to 24Mbps
    - Multiple connections
  - History
    - v1.0 → v2.1 → v3.0 → **v4.0** → v5.0

What’s BLE

- What’s Bluetooth™ Low Energy
  - Low power
    - 15mA peak transmit, 1uA sleep
  - Low cost
  - Low latency connection (3ms)
  - High flexible (Multi-model)
  - High security (128bit AES CCM)

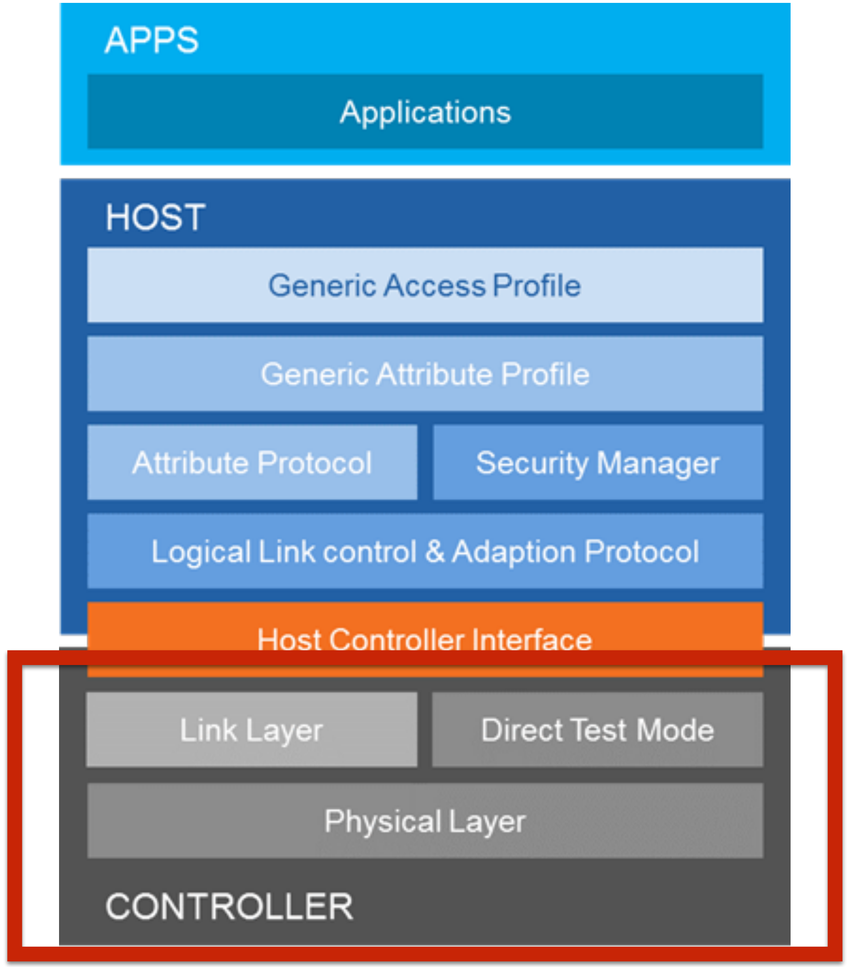
BLE stack — Arch.

- Controller
- Host
- APPS



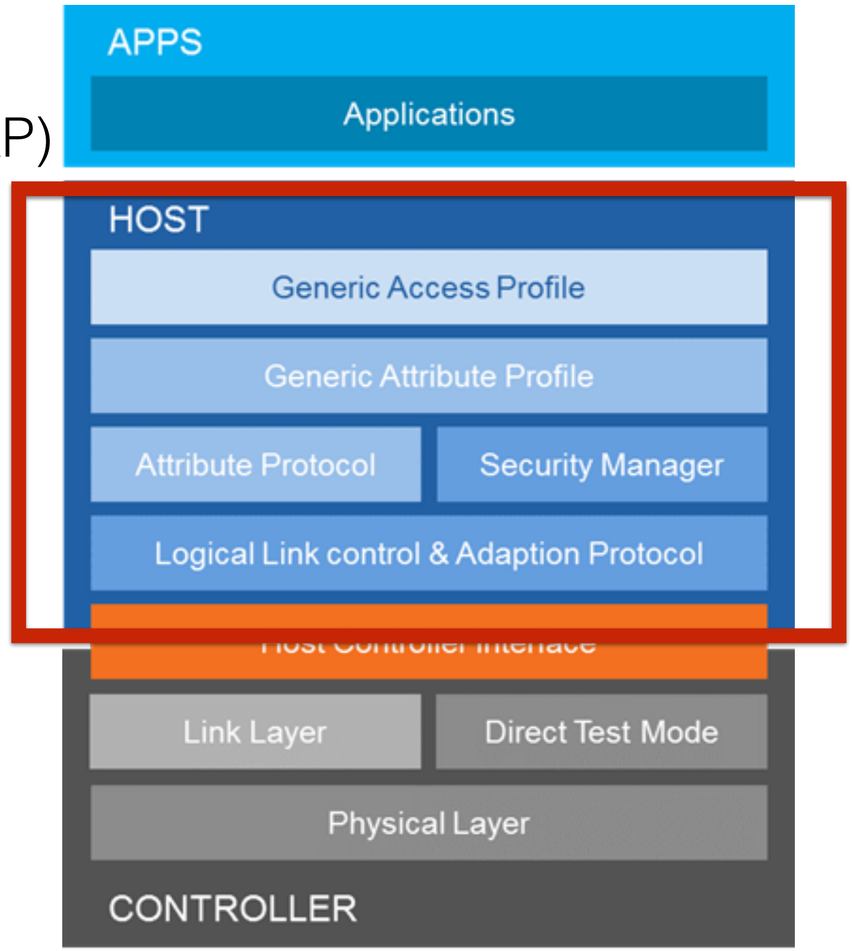
BLE stack — Controller

- Controller
  - Physical Layer
  - Link Layer
- HCI
  - Host Controller interface



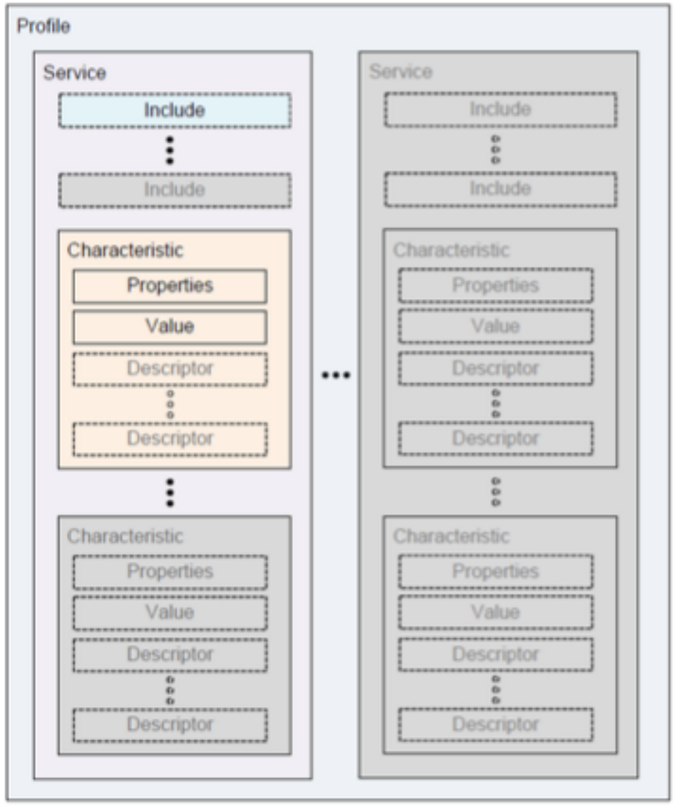
BLE stack — Host

- Host
  - Logical Link control & Adaption Protocol(L2CAP)
  - Security Manager
  - Attribute Protocol(ATT)
    - UUID
    - Simple — design for low energy
    - Data as attribute
    - C-S Architecture



What's BLE — ATT/GATT

- Host
  - Generic Attribute Profile (GATT)
    - Characteristic
      - One value, n descriptors
      - read/write/notify/indicate
    - Service
      - n characteristics
    - Profile
      - n services
      - Define by Bluetooth SIG



UUID

- 128 bits value
- 8-4-4-12 hex text
  - Printable/Case insensitive
  - e.g. 123e4567-e89b-12d3-a456-426655440000
- 16-bit / 32-bit UUID
  - 0000XXXX-0000-1000-8000-00805F9B34FB

What's BLE — GAP

- Generic Access Profile (GAP)
    - Define procedure
        - Advertising/Scan/Connect/Security
    - Define roles
        - Broadcaster/Observer
        - Peripheral/Central

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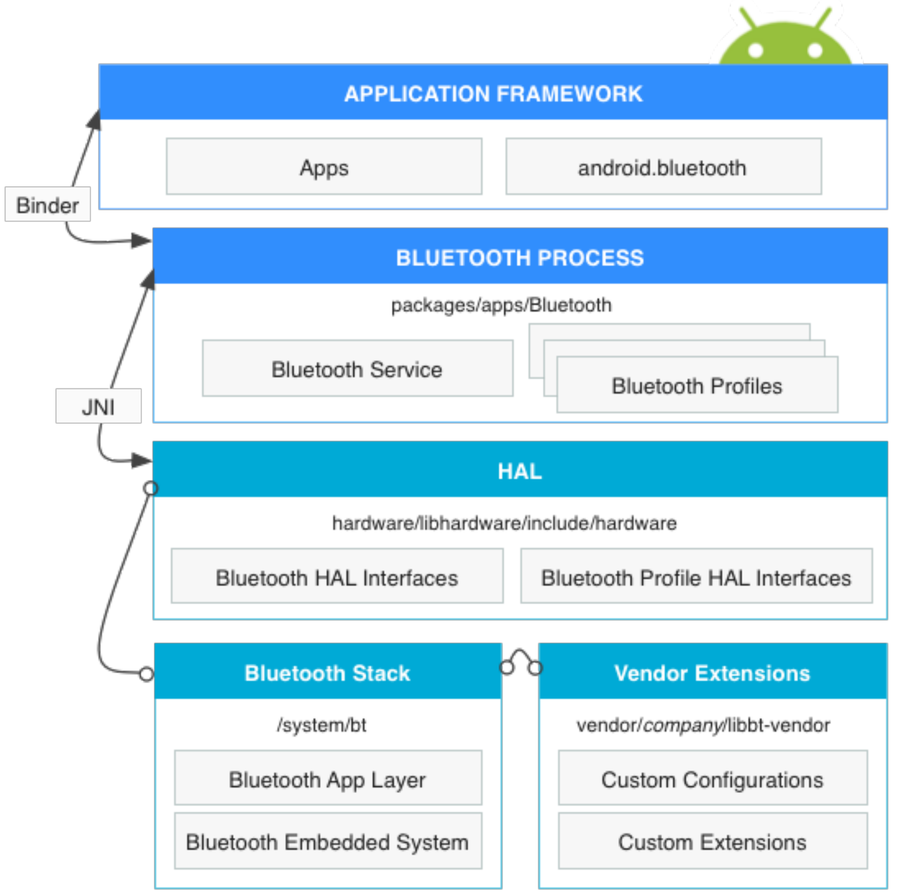
BLE on Android

- BLE support on Android
  - Central mode — Android 4.3+ (API level ≥ 18)
  - Peripheral mode — Android 5.0+ (API level ≥ 21)
- SDK API — android.bluetooth.(le)*
  - BluetoothGatt/BluetoothGattService/BluetoothGattCharacteristic
- Permisstions

```
<uses-permission android:name="android.permission.BLUETOOTH" />
<uses-permission android:name="android.permission.BLUETOOTH_ADMIN" />
<!-- Android 6.0+ Need location permission -->
<uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION" /> <!-- or -->
<uses-permission android:name="android.permission.ACCESS_FINE_LOCATION" />
```

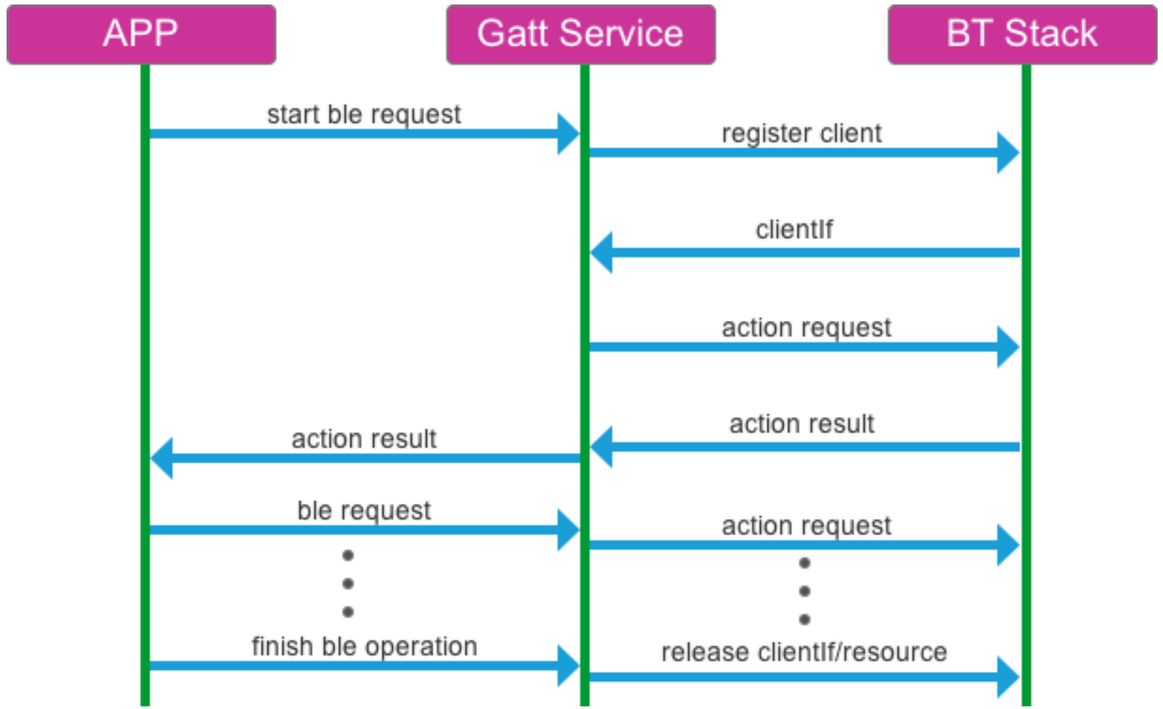
BLE on Android

- Architecture on Android
  - Hardware <—> HAL <—> Android
  - BT process <—> Binder <—> Apps
  - BT stack
    - BlueDroid/Vendor
  - Bluetooth process
    - com.android.bluetooth
  - APP



BLE on Android

- Asynchronous
  - Request/Response
  - Operation queue
- register/unregister client
  - 32 client at most



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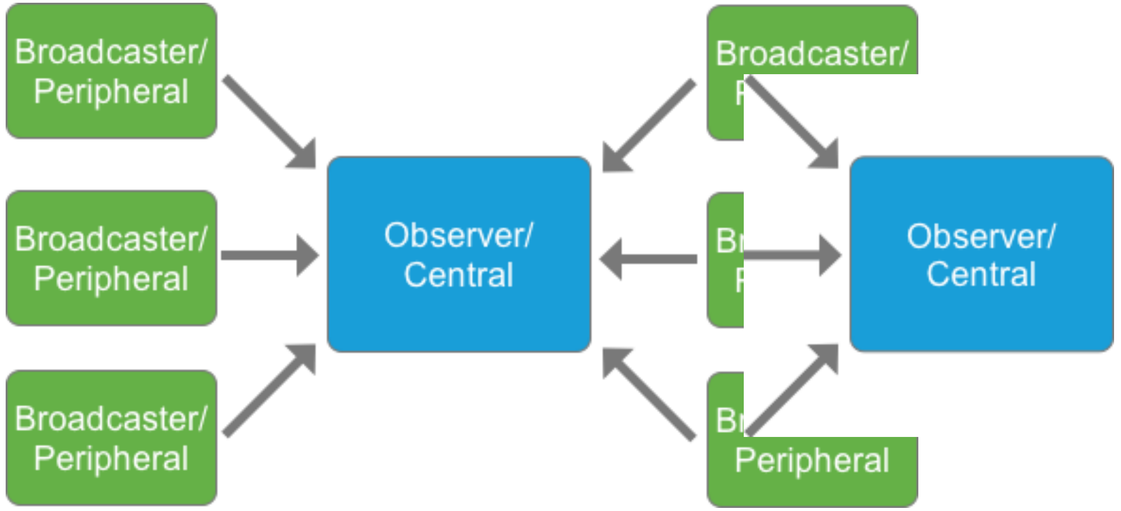
BLE applications

- None-connection/Beacon
  - Observer/Broadcaster
  - Broadcast data/RSSI
- Connection
  - Peripheral/Central
  - Profiles/Services

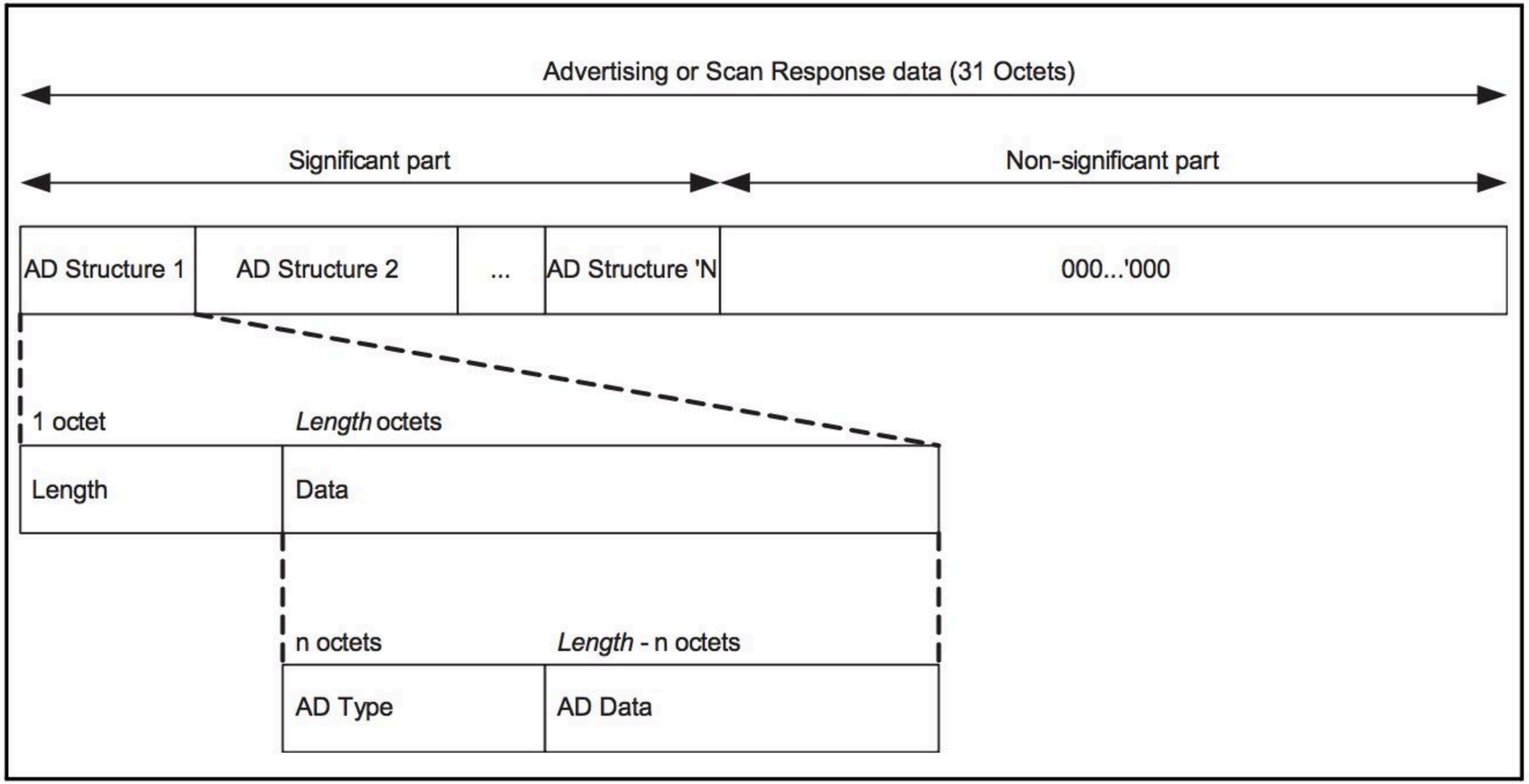
BLE App. — Beacon

- Eddystone
- iBeacon
- Mesh — IoT



Advertising

-
-



Raw data:

```
0x0201041BFF5701007CD96CCE3A50EA
7D9CA02F63F2F55D7602F59F4D839C61
0A094D492042616E6420320302E0FE071
6E0FEB20D0000
```

Details:

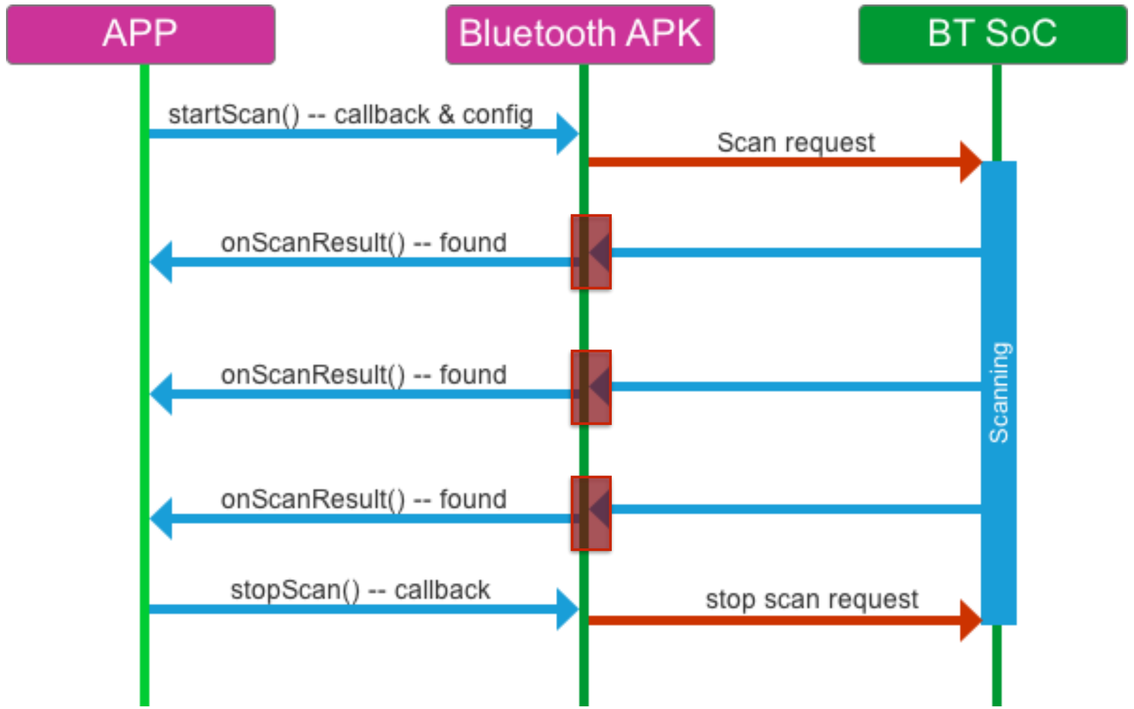
LEN.	TYPE	VALUE
2	0x01	0x04
27	0xFF	0x5701007CD96CCE3A50EA7D9CA 02F63F2F55D7602F59F4D839C61
10	0x09	0x4D492042616E642032
3	0x02	0xE0FE
7	0x16	0xE0FEB20D0000

BLE app. — Observer

```
// Device scan callback.
private BluetoothAdapter.LeScanCallback mLeScanCallback =
        new BluetoothAdapter.LeScanCallback() {
    @Override
    public void onLeScan(final BluetoothDevice device, int rssi,
            byte[] scanRecord) {
        // Do something with the device
    }
};

private BluetoothAdapter mBluetoothAdapter = ...;
mBluetoothAdapter.startLeScan(mLeScanCallback);
...
mBluetoothAdapter.stopLeScan(mLeScanCallback);


// Or Classic discover mode
mBluetoothAdapter.startDiscovery()
```

Scan best practice

- Use new API on Android
- Scan as less as possible
  - Power drain
  - Slowdown connection
- Scan as specific as possible
- Stop scan appropriately
  - ClientIf leak

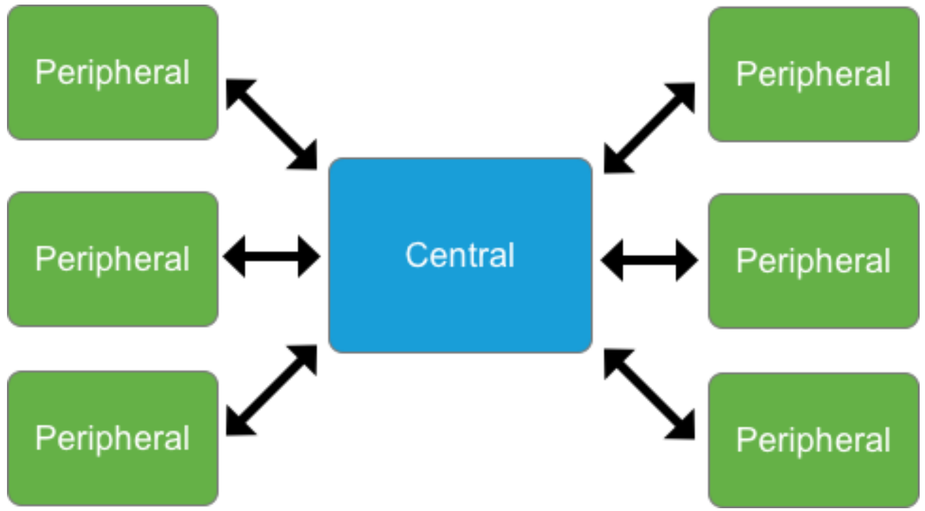


BLE App. — Broadcaster

```
// Related API classes
import android.bluetooth.le.AdvertiseCallback;
import android.bluetooth.le.AdvertiseData;
import android.bluetooth.le.AdvertiseSettings;
import android.bluetooth.le.BluetoothLeAdvertiser;

private BluetoothAdapter mBluetoothAdapter = ...;
private AdvertiseCallback mAdvertiseCallback = ...;
private BluetoothLeAdvertiser mLeAdvertiser =
    mBluetoothAdapter.getBluetoothLeAdvertiser();

// Advertise configuration
AdvertiseData advData = ...;
AdvertiseData respData = ...;
AdvertiseSettings advSettings = ...;

// start
mLeAdvertiser.startAdvertising(advSettings, advData, respData,
                mAdvertiseCallback);

...
// stop
mLeAdvertiser.stopAdvertising(mAdvertiseCallback);
```

BLE app. — Connection

- Topology
  - 1 central
  - n peripheral

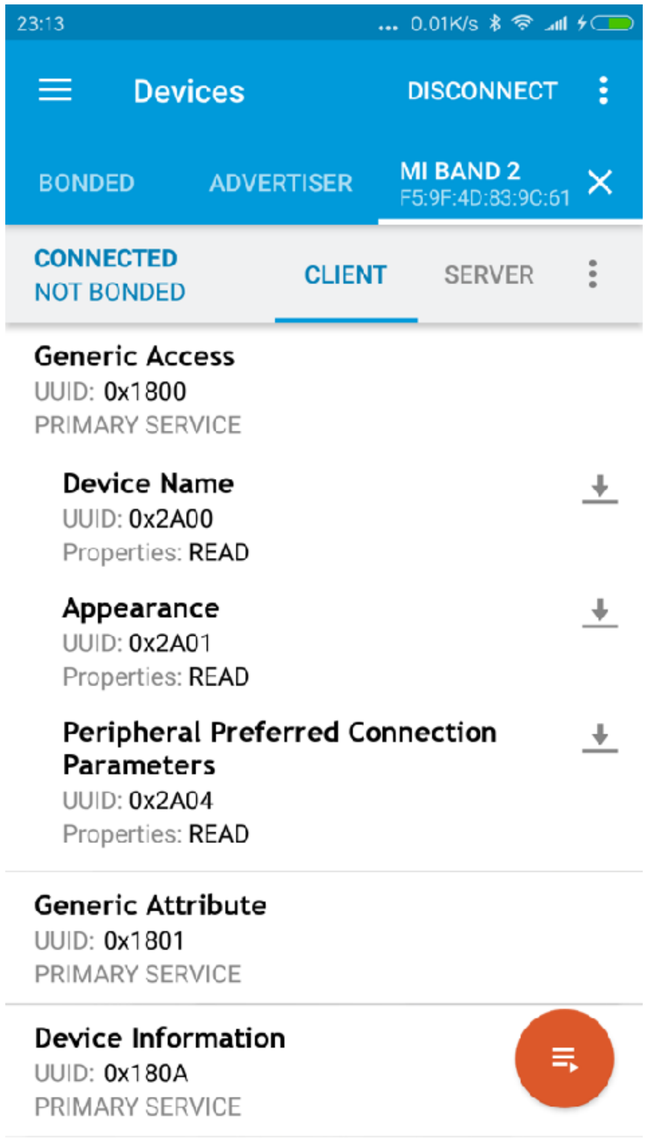


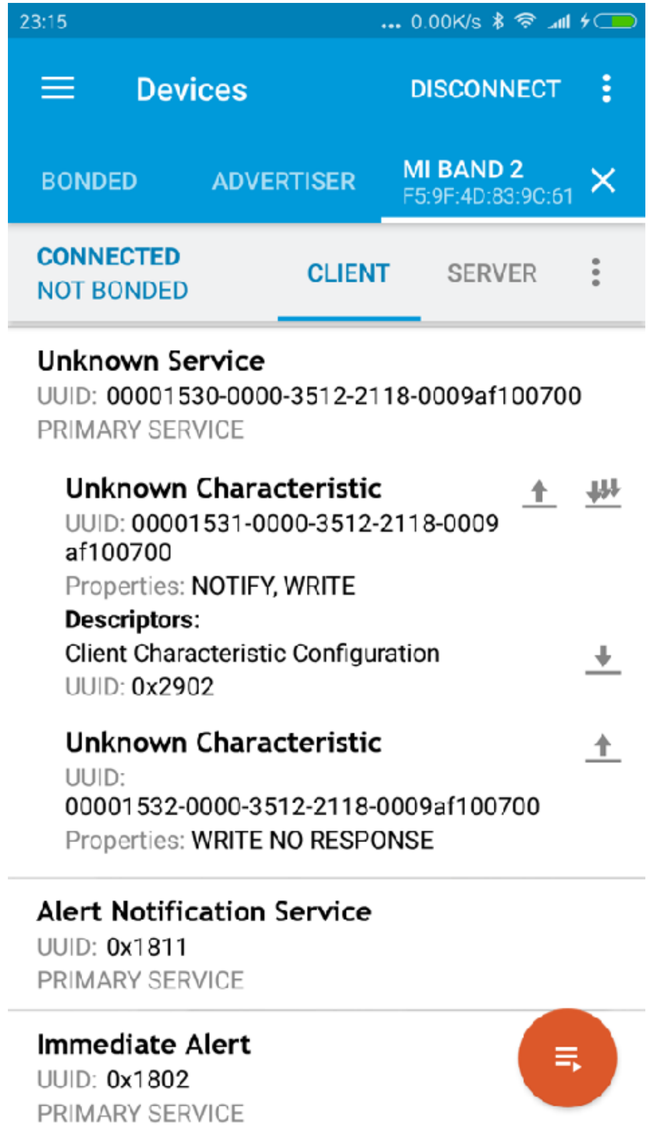
BLE App. — Connection

- Procedure
  - GAP — Central → Peripheral
  - Connection Parameters
- GATT connection
  - Service/Characteristic/Descriptor
  - Characteristic-W/R/N/I

GATT connection

- Example
  - Adopted Service
  - Adopted Characteristic
  - Assigned Service/Charact.
  - Custom Service/Charact.



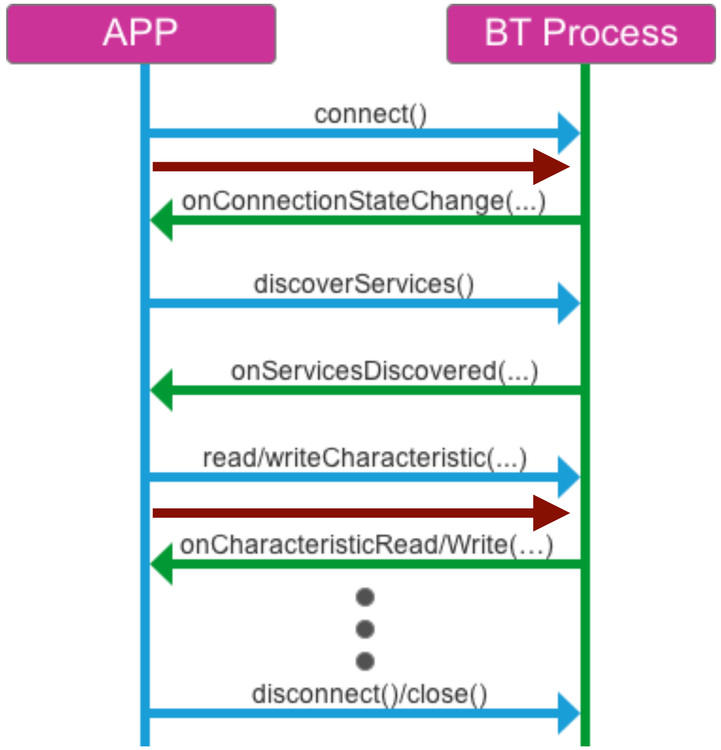


BLE App. — Central

```
// BLE related class
import android.bluetooth.BluetoothAdapter;
import android.bluetooth.BluetoothDevice;
import android.bluetooth.BluetoothGatt;
import android.bluetooth.BluetoothGattCallback;
import android.bluetooth.BluetoothGattCharacteristic;
import android.bluetooth.BluetoothGattDescriptor;
import android.bluetooth.BluetoothGattService;
import android.bluetooth.BluetoothProfile;

private BluetoothDevice mDevice;
private BluetoothGattCallback mCallback = new BluetoothGattCallback() {
  ...
};

// Connect
private BluetoothGatt mGatt = mDevice.connectGatt(context, false,
    mCallback);

// Disconnect
mGatt.disconnect();

// Close connection
mGatt.close();
```

GATT Connection

- BLE operation sequence
  - Asynchronous
    - Request/Response
  - In sequence
    - Only 1 request ongoing



Connection Best Practice

- One connecting request
  - Connection manager
  - Connection reques queue
- One R/W request
  - wait/notify
  - Asynchronous → Synchronous

BLE App. — Peripheral

```
// BLE preipheral releated classes
import android.bluetooth.BluetoothGattCharacteristic;
import android.bluetooth.BluetoothGattServer;
import android.bluetooth.BluetoothGattServerCallback;
import android.bluetooth.BluetoothGattService;
import android.bluetooth.BluetoothManager;

private BluetoothManager mBluetoothManager = ...;
private BluetoothAdapter mBluetoothAdapter = ...;
private BluetoothGattServerCallback mGattServerCallback = ...;
private BluetoothGattServer mGattServer =
    mBluetoothManager.openGattServer(mContext, mGattServerCallback);;

// Start server
mGattServer = mBluetoothManager.openGattServer(mContext, mGattServerCallback);

// Stop
mGattServer.clearServices();
mGattServer.close();
```

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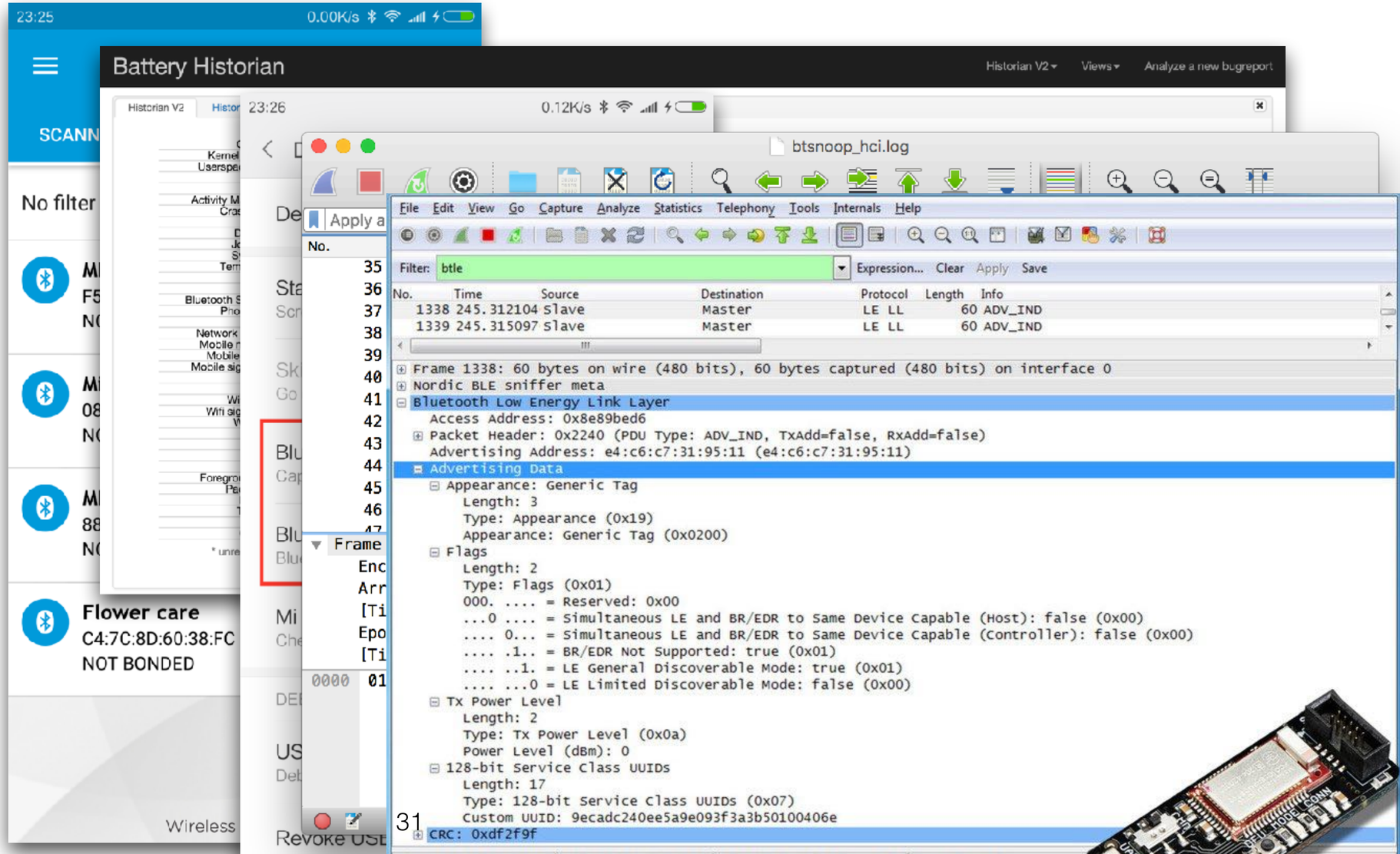
Debug tools

- BLE Test apps
  - nRF Connect
- Battery usage
  - Battery-historian
- Bluetooth log
  - Logcat
  - BT HCI log
- BT sniffer



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Best practices

- Less resources
  - Less connections
  - Less scan
  - Less clientIf
  - Less connected time
  - Less advertise
  - Less server
  - Less parallel request
  - Less work in callback

Best practices

- More testing
  - Various BT vendors
  - Various ROMs
  - Various peripherals
- More …

Read More

- Bluetooth core specification v4.1
- https://www.bluetooth.com/
- http://www.race604.com/tag/bluetooth/
- http://noahklugman.com/talks/ble_presentation.pdf
- https://developer.android.com/guide/topics/connectivity/bluetooth-le.html

Thanks