Outsmarting Bluetooth Smart

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Quick Note

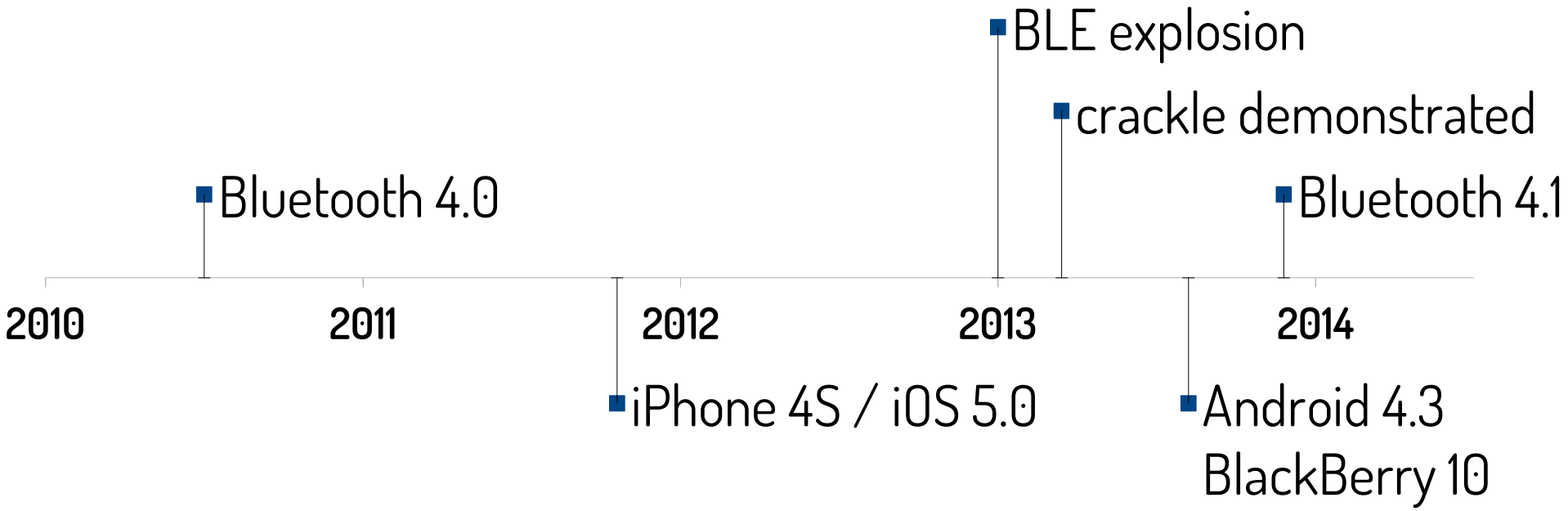
Bluetooth Smart

Bluetooth Low Energy

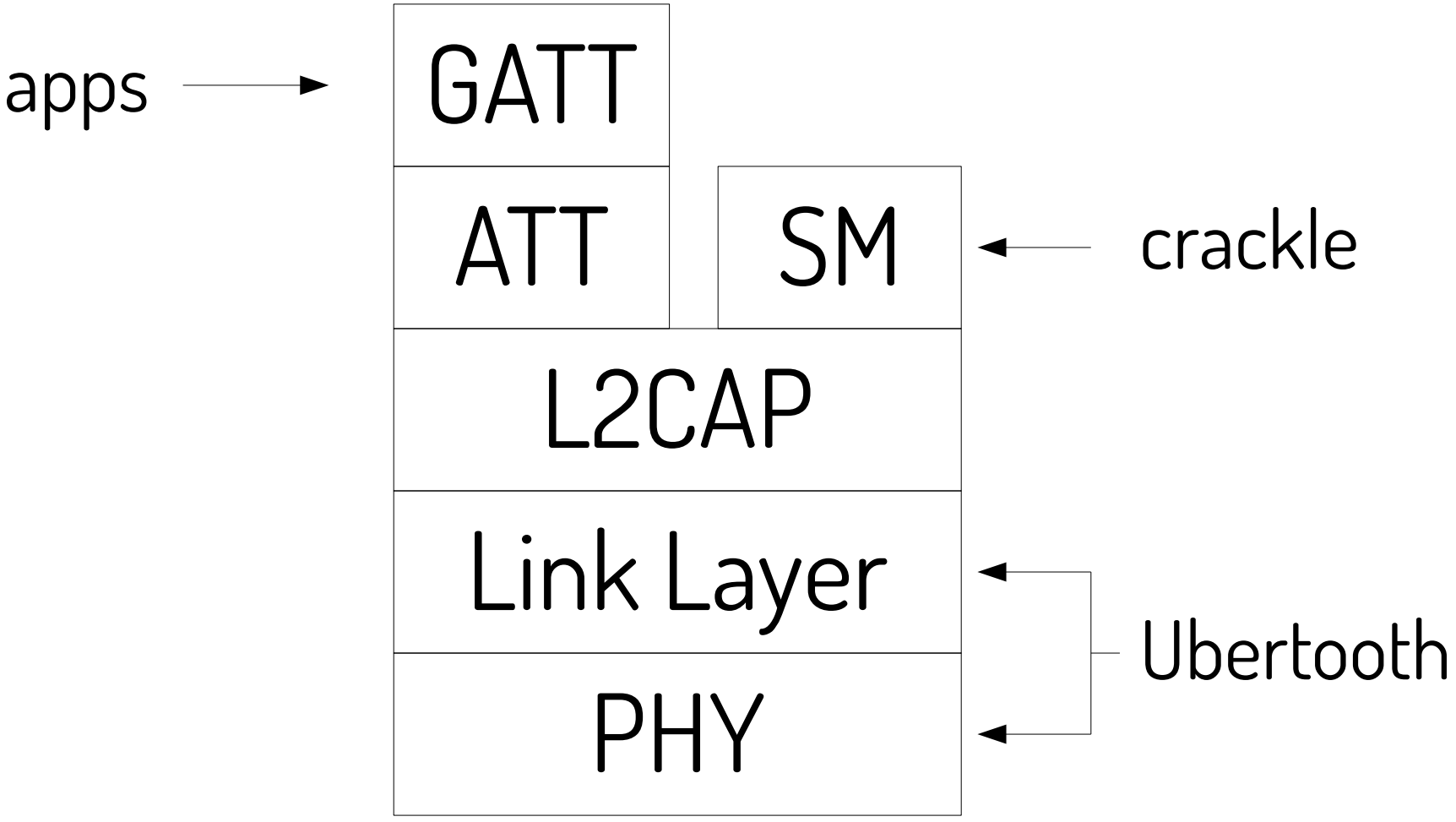
BLE

all the same thing!

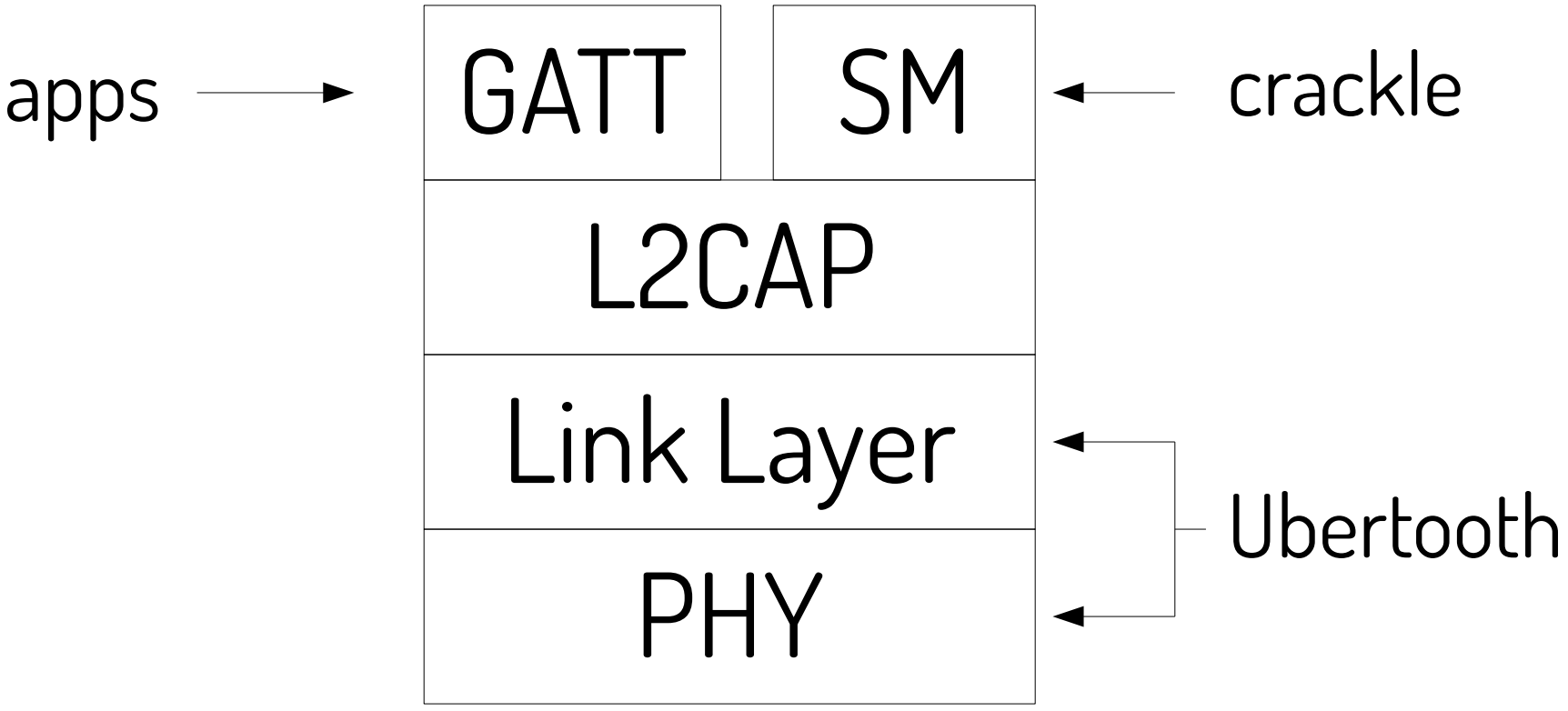
A Brief History of BLE



BLE Stack



Simplified BLE Stack



GATT: Characteristics

- Name – value pair
- With certain operations

Temperature – read
Lightbulb illumination - write

Implementation detail: name is UUID

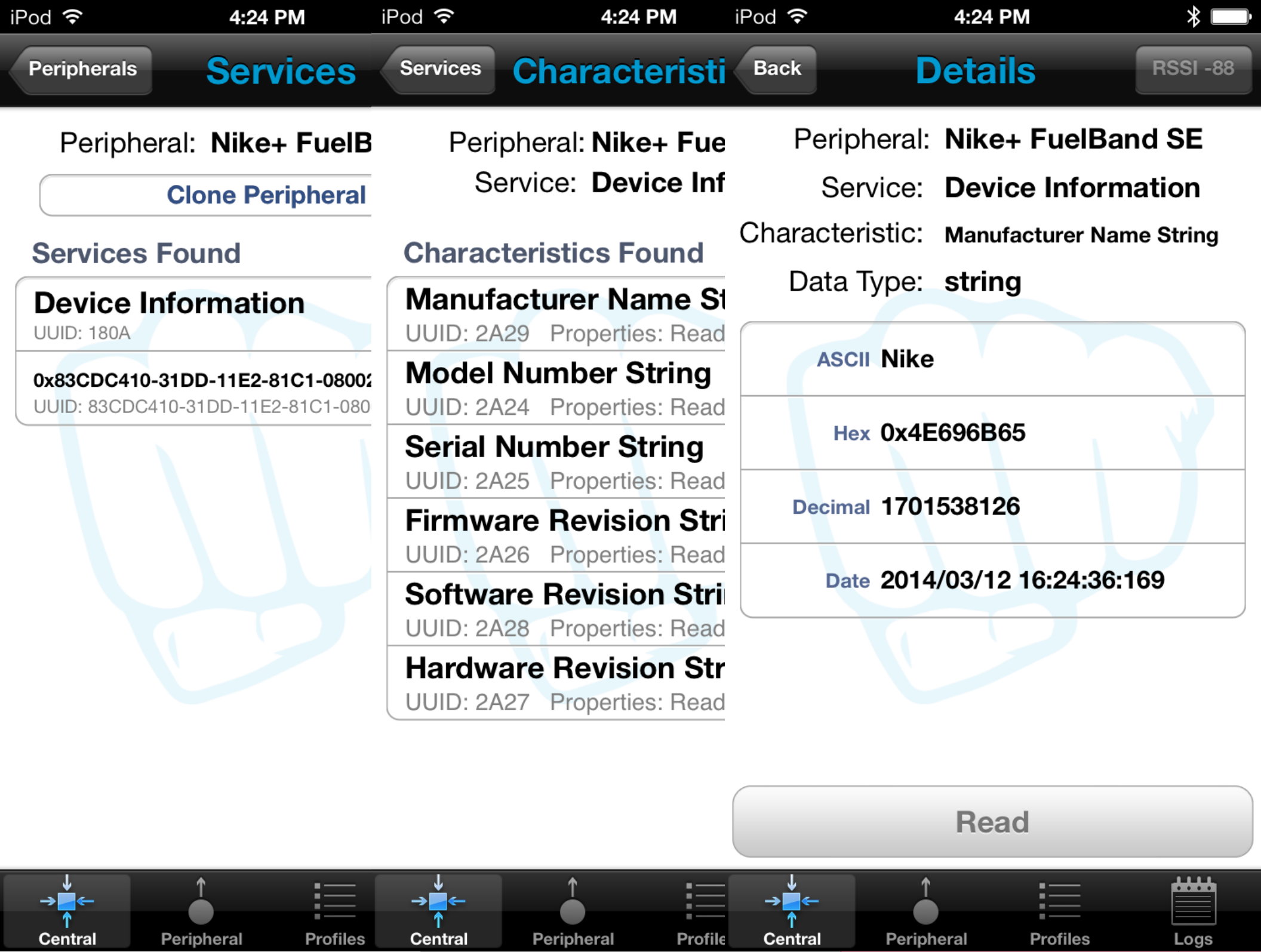
GATT: Services

→ Group of related characteristics

Heart rate service
Temperature service
Device information service

Talking to Devices

- LightBlue
- gatttool


iPod
4:24 PM
Peripherals
Services
Peripheral: Nike+ FuelB
Clone Peripheral
Services Found
Device Information
UUID: 180A
0x83CDC410-31DD-11E2-81C1-08002
UUID: 83CDC410-31DD-11E2-81C1-080
Central
Peripheral
Profiles
iPod
4:24 PM
Services
Characteristi
Peripheral: Nike+ Fue
Service: Device Inf
Characteristics Found
Manufacturer Name St
UUID: 2A29 Properties: Read
Model Number String
UUID: 2A24 Properties: Read
Serial Number String
UUID: 2A25 Properties: Read
Firmware Revision Stri
UUID: 2A26 Properties: Read
Software Revision Stri
UUID: 2A28 Properties: Read
Hardware Revision Str
UUID: 2A27 Properties: Read
Central
Peripheral
Profile
iPod
4:24 PM
Back
Details
RSSI -88
Peripheral: Nike+ FuelBand SE
Service: Device Information
Characteristic: Manufacturer Name String
Data Type: string
ASCII Nike
Hex 0x4E696B65
Decimal 1701538126
Date 2014/03/12 16:24:36:169
Read
Central
Peripheral
Profiles
Logs

Goal: Understand a Device

1) Sniff it

2) Connect with gatttool or LightBlue

3) Dump HCI using hcidump

4) Disassemble the app

5) Clone the device

Clues in the App

```
MOV             R0, #(selRef_UUIDWithString_ - 0xD2EB0) ; selRef_UUIDWithString_
MOV             R8, #(classRef_CBUUID - 0xD2EB2) ; classRef_CBUUID
ADD             R0, PC ; selRef_UUIDWithString_
ADD             R8, PC ; classRef_CBUUID
LDR             R5, [R0] ; "UUIDWithString:"
LDR.W           R0, [R8] ; _OBJC_CLASS_$_CBUUID
MOV             R2, #(cfstr_86130247E942_1 - 0xD2EC2) ; "8[redacted]2-4FE5-AA46-111111111111"
ADD             R2, PC  ; "8[redacted]2-4FE5-AA46-111111111111"
MOV             R1, R5
BLX             __CBUUID_UUIDWithString__
MOV             R7, R7
BLX             _objc_retainAutoreleasedReturnValue
MOV             R1, #(_OBJC_IVAR_$_[redacted]BluetoothManager.[redacted]ServiceUUID - 0xD2ED8) ; CBUUID *[redacted]
```

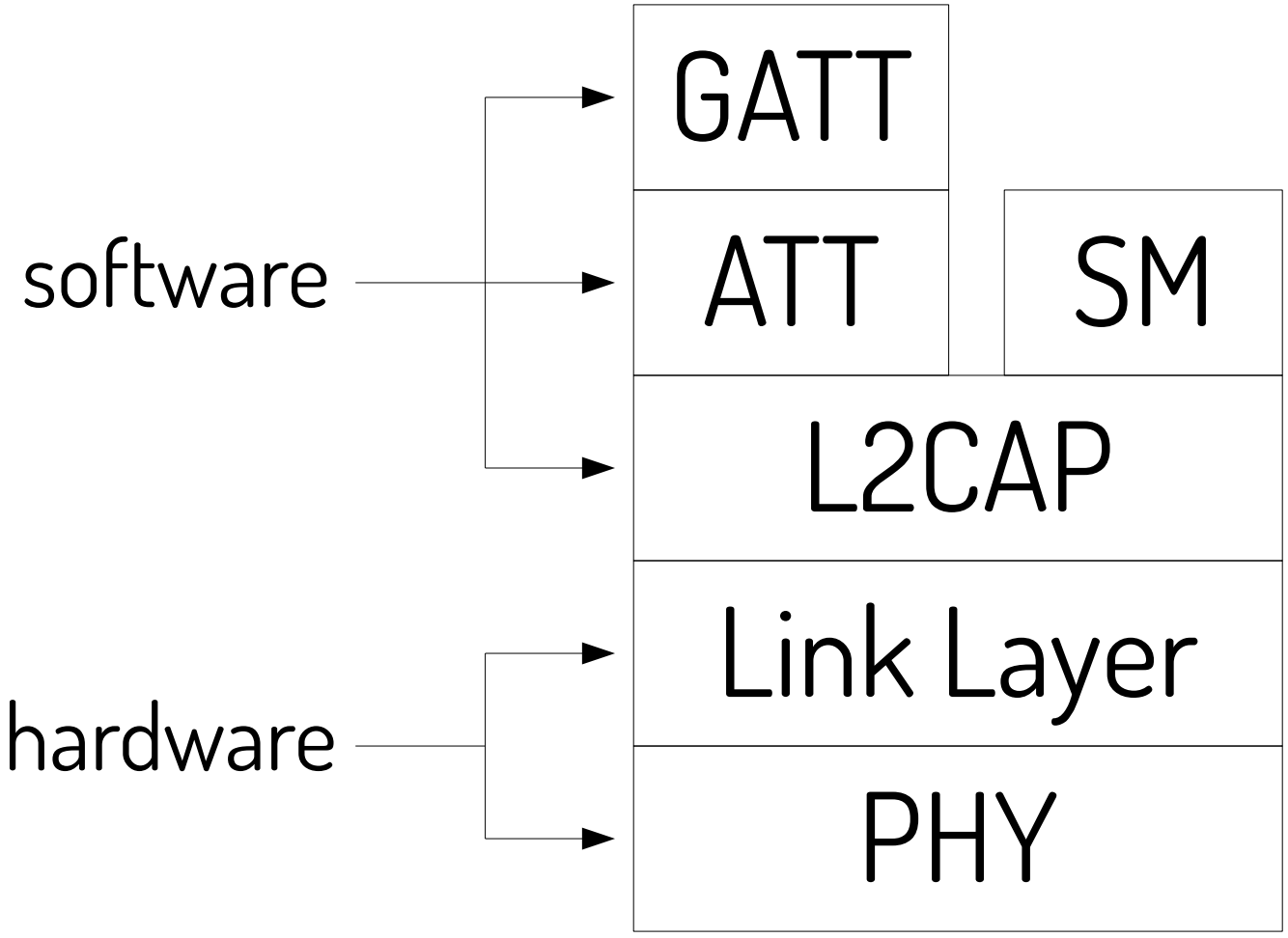
“8XXXXXXX-XXX2-4FE5-AA46-111111111111”
“0x0979”
CBUUID *xxxxxxDataStreamCharUUID

```
MOV             R1, R5
ADD             R2, PC  ; "0x0979"
BLX             __CBUUID_UUIDWithString__
MOV             R7, R7
BLX             _objc_retainAutoreleasedReturnValue
MOV             R1, #(_OBJC_IVAR_$_[redacted]BluetoothManager.[redacted]DataStreamCharUUID - 0xD2F0A) ; CBUUID
ADD             R1, PC  ; CBUUID *[redacted]DataStreamCharUUID;
LDR             R6, [R1] ; CBUUID *[redacted]DataStreamCharUUID;
```

Clone the Device

- BLE devices are role-flexible
- This includes BlueZ

BLE Stack



Length Fields Aplenty

00 17 xx xx xx xx 22 00 02 01 06
03 02 0d 18 06 ff 6b 00 01 00 00
02 0a 00

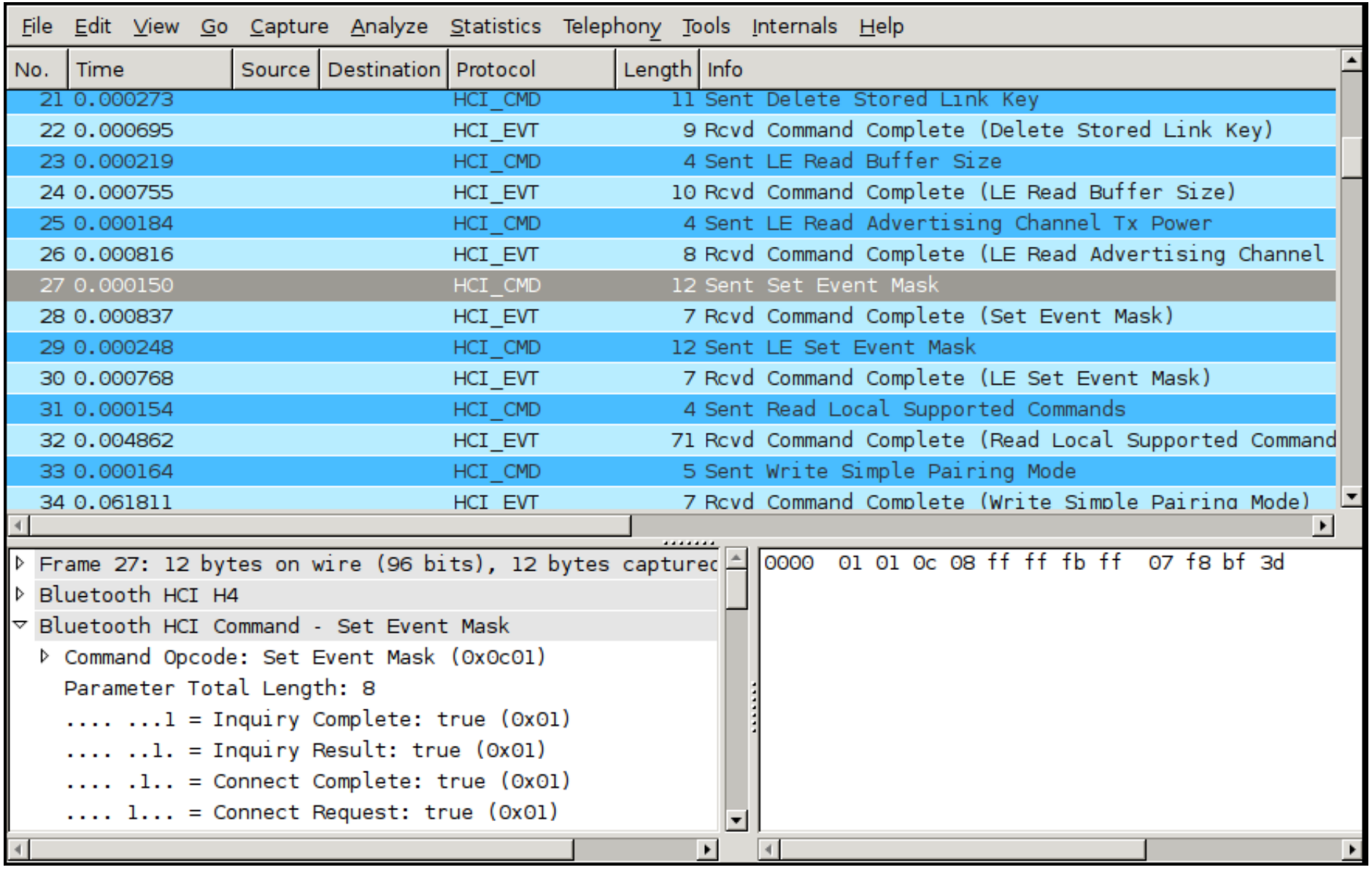
advertising

06 09 05 00 04 00 0c 20 00 2c 00

data

PLZ FUZZ ME

HCI H4


File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
No. Time Source Destination Protocol Length Info
21 0.000273 HCI_CMD 11 Sent Delete Stored Link Key
22 0.000695 HCI_EVT 9 Rcvd Command Complete (Delete Stored Link Key)
23 0.000219 HCI_CMD 4 Sent LE Read Buffer Size
24 0.000755 HCI_EVT 10 Rcvd Command Complete (LE Read Buffer Size)
25 0.000184 HCI_CMD 4 Sent LE Read Advertising Channel Tx Power
26 0.000816 HCI_EVT 8 Rcvd Command Complete (LE Read Advertising Channel
27 0.000150 HCI_CMD 12 Sent Set Event Mask
28 0.000837 HCI_EVT 7 Rcvd Command Complete (Set Event Mask)
29 0.000248 HCI_CMD 12 Sent LE Set Event Mask
30 0.000768 HCI_EVT 7 Rcvd Command Complete (LE Set Event Mask)
31 0.000154 HCI_CMD 4 Sent Read Local Supported Commands
32 0.004862 HCI_EVT 71 Rcvd Command Complete (Read Local Supported Command
33 0.000164 HCI_CMD 5 Sent Write Simple Pairing Mode
34 0.061811 HCI_EVT 7 Rcvd Command Complete (Write Simple Pairing Mode)
Frame 27: 12 bytes on wire (96 bits), 12 bytes captured
Bluetooth HCI H4
Bluetooth HCI Command - Set Event Mask
Command Opcode: Set Event Mask (0x0c01)
Parameter Total Length: 8
....1 = Inquiry Complete: true (0x01)
.... ..1. = Inquiry Result: true (0x01)
.... .1.. = Connect Complete: true (0x01)
.... 1... = Connect Request: true (0x01)
0000 01 01 0c 08 ff ff fb ff 07 f8 bf 3d

Fuzz Platform: Linux

- Raw HCI (somehow?)
- BlueZ

Raw HCI: HCI_USER_SOCKET

- SOCK_RAW for Bluetooth
- In Linux 3.13

Scapy-based fuzzer

- Scapy rules
- No seriously, it rules

- Status
  - Able to establish connections
  - Basic communication
  - Generative fuzzing using Scapy's fuzz()

HCI_USER_SOCKET Availability

- Right now, at this moment:
  - Fedora 20
  - Arch (since Jan or Feb)
  - Debian Unstable
- Coming soon:
  - Ubuntu Trusty (next month)
  - Debian Testing (probably)
- Others:
  - Kali: nope, 1.0.6 is still 3.12
  - Pentoo: liveCD is older, but you can install >= 3.13 from Portage

Attack Platform: Linux BlueZ

- Very good code!
- Mutative fuzzing

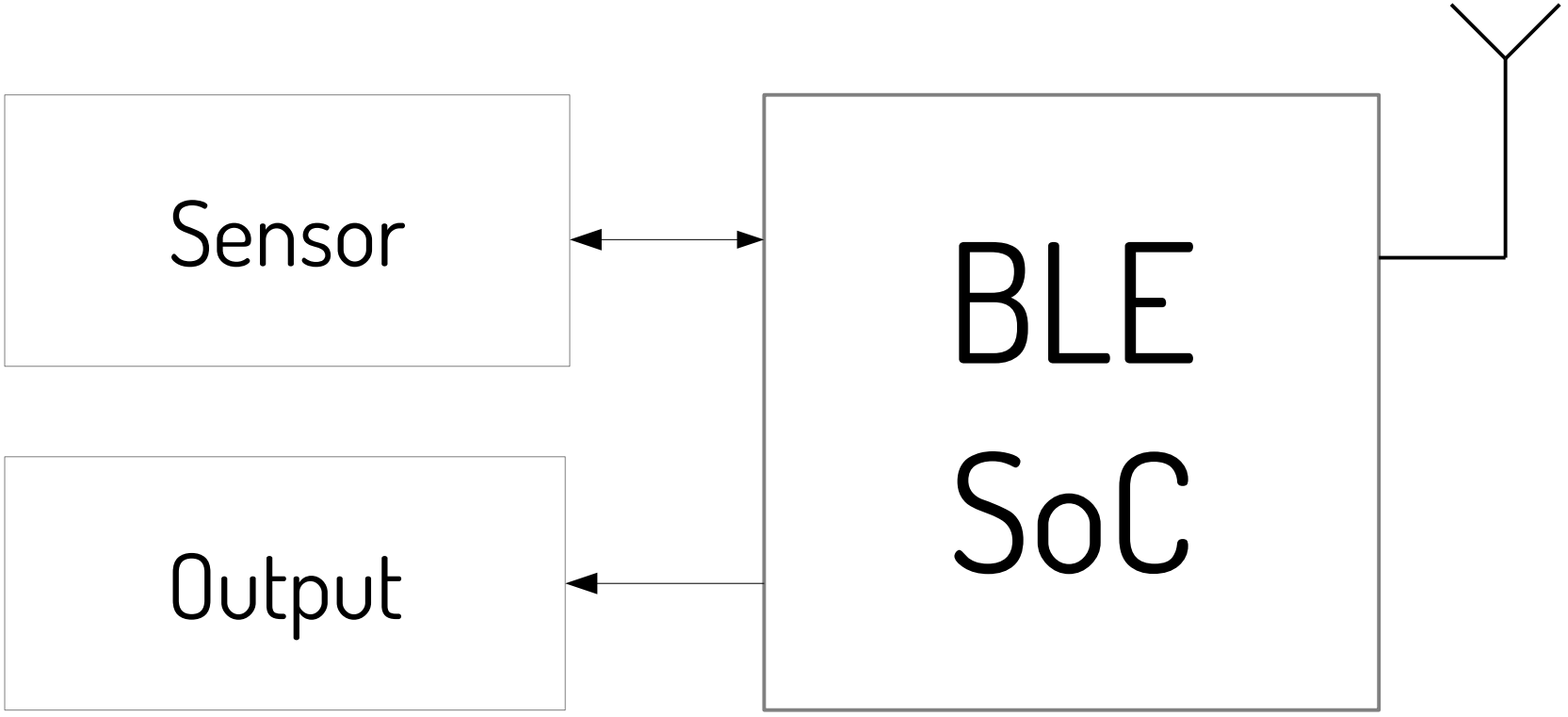
gatttool scripting ftw!

```
guint g_attrib_send(...) {
    ...

    opcode = pdu[0];

    c->opcode = opcode;
    c->expected = opcode2expected(opcode);
    c->pdu = g_malloc(len);

    fuzz(pdu, len);

    memcpy(c->pdu, pdu, len);
```

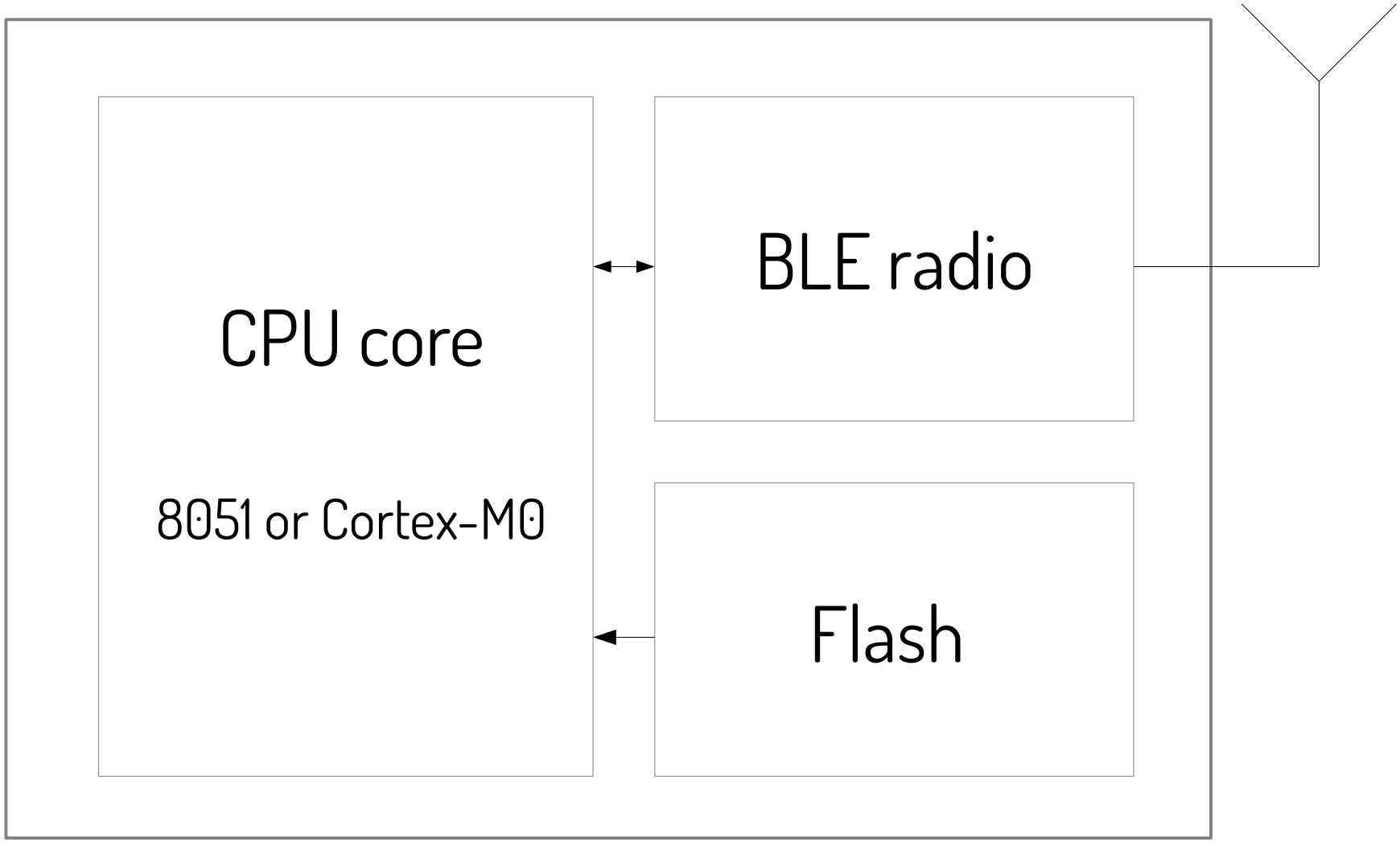
~~Victims~~ Targets

- Smartphones
  - Android: Bluedroid
  - iOS
  - Windows Phone 8.1
  - BlackBerry 10
- Devices
  - TI
  - Nordic

Generic BLE Device



BLE System-on-Chip



Primary Target: Bluedroid

```
~/bluedroid $ git grep memcpy | wc -l
729
```

Bluedroid on the Phone

```
$ ps | grep bluetooth
bluetooth 13201 871   862128 28940 ffffffff \
00000000 S com.android.bluetooth
```

CAP_NET_ADMIN: Almost as good as root

Source: Nexus 4 running Android 4.3

CAP_NET_ADMIN

- Perform various network-related operations:
  - interface configuration;
  - administration of IP firewall, masquerading, and accounting
  - modify routing tables;
  - bind to any address for transparent proxying;
  - set promiscuous mode;
  - use setsockopt(2) to set the following socket options: SO_DEBUG...

Source: capabilities(7) man page

Fuzz process

- Script gatttool to send lots of data
- Use modified fuzzing BlueZ
- Log packets with btmon
- Watch adb logcat for crash
- Tweak BlueZ to send evil packet once it's identified

DEMO

- DEMO
  - demo
    - demo
  - demo
- DeMo
  - Demooooooooooooooo

Vuln Details

```
F/libc    (19174): FORTIFY_SOURCE: memcpy buffer overflow. Calling abort().
F/libc    (19174): Fatal signal 11 (SIGSEGV) at 0xdeadbaad (code=1), thread 19956
```

```
void gatt_process_notification(tGATT_TCB *p_tcb, UINT8 op_code,
                               UINT16 len, UINT8 *p_data)
{
    ...

    GATT_TRACE_DEBUG0("gatt_process_notification ");


    STREAM_TO_UINT16 (value.handle, p);
    value.len = len - 2;
    memcpy (value.value, p, value.len);
```

FORTIFY_SOURCE

```
extern "C" void *__memcpy_chk(void *dest, const void *src,
                size_t copy_amount, size_t dest_len)
{
    if (__predict_false(copy_amount > dest_len)) {
        __fortify_chk_fail("memcpy buffer overflow",
                           BIONIC_EVENT_MEMCPY_BUFFER_OVERFLOW);
    }

    return memcpy(dest, src, copy_amount);
}
```

Timeline

- 2013-09-30: Notified Google
- 2013-10-07: Fix committed
- 2013-10-30: Bluedroid tagged release 4.4 r0.9
- 2013-10-31: Android 4.4 released

Not fixed in 4.3

See also: Colin and John's talk on wednesday

Bluedroid on PC

- It's just C, why not?
- GDB: Single-stepping through packet parsing code
- In theory can be combined with HCI_USER_SOCKET

```
$ ps aux | grep bluedroid
mikeryan  4168  0.2  0.0  60552  1480 pts/5    Sl+  10:41   0:00 ./bluedroid
```

How Do You Pronounce “BlueZ”?

“That is the one single mystery. Nobody knows.”

– Marcel Holtmann, BlueZ maintainer

Thanks

- Marcel Holtmann
- BlueZ team
- Google

- CanSecWest
- iSEC Partners

Thank You

Mike Ryan

iSEC Partners

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https://lacklustre.net/