Analyzing the security of a Fitbit wearable

Bechir BOUALI & Baptiste Neveu

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Project Objectives

- Get hardware access
- Dump the firmware
- Dynamic analysis using Avatar²

Reach the PCB

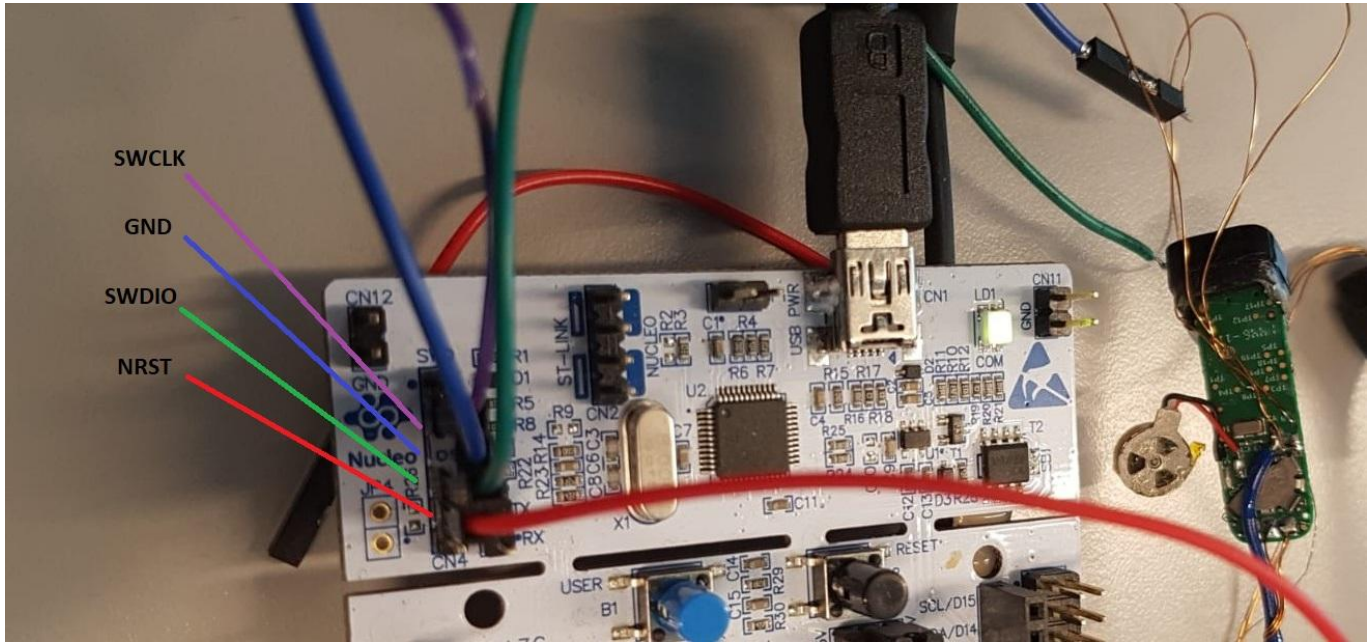
- Melt the plastic that protect the PCB
- Extra attention to :
  - the bluetooth antenna
  - every tiny part of the PCB

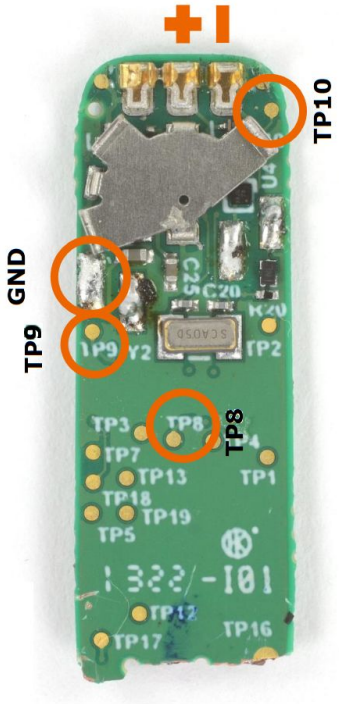
Connection to the Fitbit

- Setup connection between the debug adapter and the board

SWD pins	ST-LINK-V2-1 pins	Fitbit test points
SWDCLK	Pin 2	TP8
SWDIO	Pin 4	TP9
GND	Pin 3	GND
NRST	Pin 5	TP10

Connection to the Fitbit

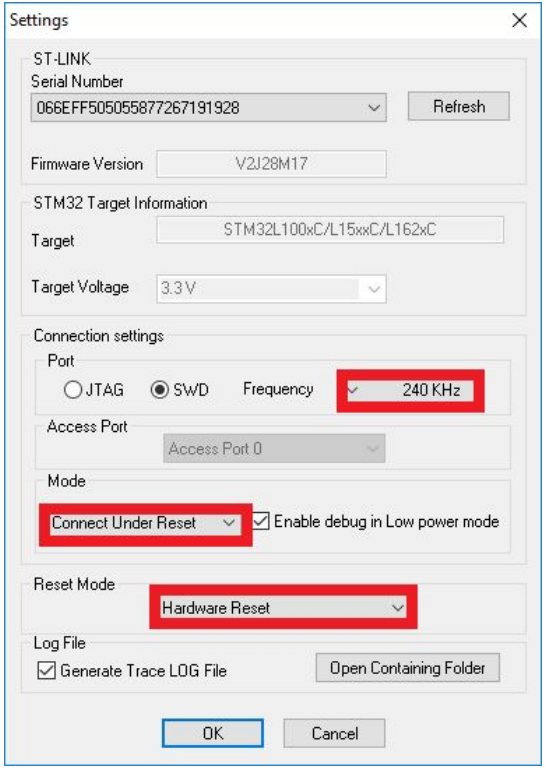




Source: Fitbit firmware hacking by Classen et al.

Dump the firmware

- Using openocd:
  - openocd -f fitbit.cfg
  - telnet 127.0.0.1 4444
  - dump_image firmware.bin 0x0 0x40000
- Using ST-Link Utility:
- Same firmware image



Static analysis of the firmware

- Focus on the bluetooth functions:
  - Library closed to Arduino BLE Breakout Board
  - IDC script to get the address:
    - 0x0800EE62: get_bluetooth_id
    - 0x08012C44: exti_bluetooth_record
    - 0x08018868: rf_record_bluetooth
    - 0x080214A0: printf_bluetooth_id
    - 080187A8: bluetoot_record_sth
    - The bluetooth stack BSL is located at 0x080036E0

Dynamic analysis of the firmware: GDB

- GDBServer hosted by openOCD
  - Run openOCD first
  - Connect to GDB
- Default firmware
  - Device crashes: reconfiguration of GPIO pins
  - Flash a custom firmware with a GDB Backdoor
- Set breakpoints for the past addresses

$arm-none-eabi-gdb

$gdb target extended-remote 127.0.0.1:3333

$gdb monitor halt

$gdb hb *0x0800EE62

$gdb hb *0x08012C44

$gdb hb *0x08018868

$gdb hb *0x080214A0

$gdb continue

Dynamic analysis of the firmware: Avatar²

- Breakpoint avatar² script:
  - Set to the 0x0800EE62 (get_bluetooth_id function)
  - Pairing with the App
  - Three hits:
    - First & second hit: called by the “bluetooth_record” function
    - Third hit: “send_bt_id_c0” function

```
 python avatar-hitbr.py
hardware breakpoint at 0x0800EE62
waitting for the breakpoint
hit it 1 times
My caller function at 0x80187d9
waitting for the breakpoint
hit it 2 times
My caller function at 0x80187d9
waitting for the breakpoint
hit it 3 times
My caller function at 0x800ee55
State transfer finished, emulator $pc is: 0x800ee62
```

Dynamic analysis of the firmware: Avatar²

- Testing bluetooth functions while execution transferred to the emulator
  - Reaching another breakpoint at 0x08012C44: exti_bluetooth_record

```
In [16]: fitbit.set_breakpoint(0x08012C44,hardware=True)
Out[16]: 2

In [17]: fitbit.cont()
Out[17]: True

In [18]: fitbit.get_status()
Out[18]: {'state': <TargetStates.STOPPED: 4>}

In [19]: fitbit.regs.pc
Out[19]: 134294596

In [20]: hex(134294596)
Out[20]: '0x8012c44'
```

Dynamic analysis of the firmware: Avatar²

- Jumping to the instruction at 0x0800EE6C where cpu load the address where the fitbit mac address stored

```
p:0800EE62 ; signed int __fastcall get_bluetooth_id(int mac_addr_dst, unsigned __int8 mac_addr_len)
p:0800EE62 get_bluetooth_id                ; CODE XREF: send_bt_id_c0+2A↑p
p:0800EE62                                 ; bluetoot_record_sth+2C↓p ...
p:0800EE62                 PUSH            {R7,LR} ; returns bluetooth id or r0=0 if error
p:0800EE64                 UXTB            R1, R1  ; Unsigned extend byte to word
p:0800EE66                 CMP             R1, #6  ; Set cond. codes on Op1 - Op2
p:0800EE68                 BCC             loc_800EE76 ; Branch
p:0800EE6A                 MOVS            R2, #6  ; length
p:0800EE6C                 LDR             R1, =bt_mac_address ; Load from Memory
p:0800EE6E                 BL              memcpy2_wrapper ; Branch with Link
p:0800EE72                 MOVS            R0, #0  ; Rd = Op2
p:0800EE74                 B               locret_800EE78 ; Branch
p:0800EE76 ; ---------------------------------------------------------------------------
```

Dynamic analysis of the firmware: Avatar²

- Fitbit mac address: cc:d1:fa:82:9b:03

```
[NEW] Device CC:D1:FA:82:9B:03 Flex
```

```
In [28]: hex(fitbit.regs.pc)
Out[28]: '0x800ee6e'

In [29]: hex(fitbit.regs.r1)
Out[29]: '0x200049f0'

In [30]: hex(fitbit.read_memory(0x200049f0,8,1,False))
Out[30]: '0xccd1fa829b03'

In [31]:
```

Demo time!

Conclusion & Further work

- We were able to cover the majority of the project objectives
- Do another patch to enable pairing between App and fitbit
- Using avatar-panda module

Enough Debugging
Time to be debugged

Questions ?