Totem Health Patch
Embedded System Guide

Totem Open Health
Product: Totem Health Patch
Version: 1-EN
Datum: 02-08-2016
User guide for use of 'Totem Health Patch'

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Totem logo

Abstract – **Totem is the company behind the Totem Health Patch. An open-source smart wearable very well suited for medical research, education and hobbyist programmers. In this document, the flashing firmware on the Totem Health Patch in combination with how the sensor works is thoroughly explained. Among others, these questions will be answered: "What is the Totem Health Patch?", "What do I need to get the Health patch up and running?" and "What are important factors to take in to account when flashing (new) firmware?"**

I. Introduction

In the open source world, almost anything is possible. Some say: "You can only be fully in control when the device is open source." To continue, the software and hardware of the Totem Health Patch are open. Therefore, the sensor is well-suited for education, health-sector and (hobbyist) programmers. The Totem Health Patch is a wearable device with arguably the most necessary sensors – accelerometer, gyroscope and temperature sensor- for motion analysis. With these sensors in combination with the Bluetooth Low Energy© (BLE) module, SD-Card reader/writer and a microcomputer, the user has got all the tools needed to perform motion analysis. For example, the SD-Card can be used to store raw data for statistical analysis. This document shows how the Totem Health Patch can be setup and function as a smart tracking device.

II. Requirements

Here, a list of requirements in order to use and program the Totem Health Patch:

- Totem Health Patch
- Internet access
- Totem Programming Rig
- J-Link Programming module

III. Setup before programming

The Totem health Patch is programmed with a J-Link programming module. The programming module flashes the compiled .hex file on to the nRF51822 chip. The .hex file is generated using the *ARM® mbed™* web-compiler. Moreover, the online mbed environment (Figure 1) is used as development tool for the Totem Health Patch. This guide explains step-by-step how the Totem Health Patch can be programmed with your own firmware or one of the examples available.

A. Mbed

Click on the following link to go to the mbed environment.

https://developter.mbed.org/account/login/?next=/

Create a mbed account, or log in if you already have one. Press the compiler button, and start developing.
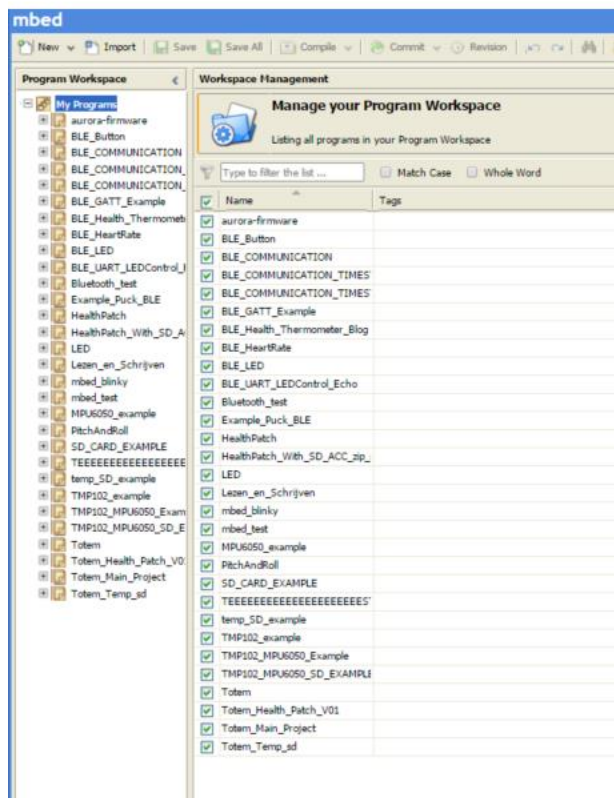

Figure 1 Mbed developing environment.

B. Required software to flash firmware

With the nRFgo Studio, firmware is flashed on to the Health Patch. Install the following for a Microsoft Windows 64 bit installation:

https://www.nordicsemi.com/kor/nordic/products/nRFgo-Studio/nRFgo-Studio-Win64/14964

In order to send a generated .hex file through the J-Link for flashing, install the following JLink driver:

https://www.segger.com/jlink-software.html

C. Setup of the Programming Rig

The Programming rig (Figure 2) is a docking station for the Totem Health Patch. The Totem Health Patch can easily be taken out of the enclosure to be ready for receiving firmware. The Rig provides a handy tool to easily flash (newly created) firmware on to the Totem Health Patch (Figure 4). Due to the Rig, there is no need to solder the Totem Health Patch PCB on to the Programming Module. Moreover, the Rig provides a
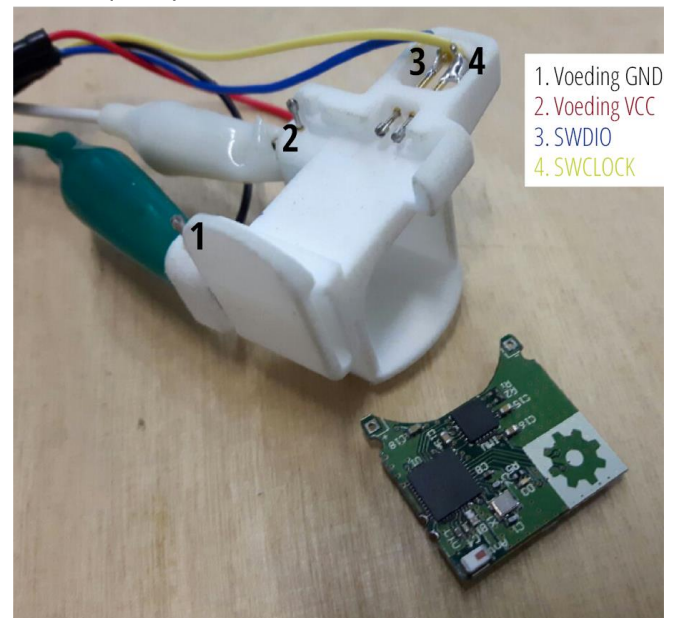
tool to quickly test software.

1. Voeding GND
2. Voeding VCC
3. SWDIO
4. SWCLOCK

Figure 2 Programming Rig.

The Rig has four connector dots – two of which are for referencing voltage, namely, the vcc(+) and gnd(-). Note: the battery has to be inserted while programming. The Programming Module functions as a power source for the Totem Health Patch. Therefore, it is not possible to flash software without the battery.

The following figure (Figure 3) shows how the Rig needs to be attached to the J-Link. Female connector plugs are attached to the Rig for ease of use.
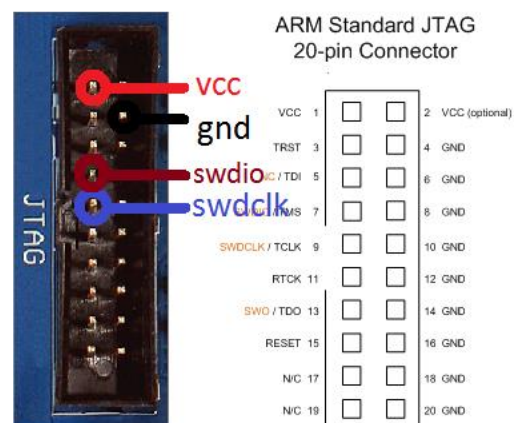

Figure 3 Cable attachment of the J-Link Programming Module.

When the hardware is correctly attached and the Health Patch is correctly mounted in the Rig, the J-Link LED turns on (green). Subsequently, In nRFgoStudio, the tab "nRF5x Programming" can be opened to flash

the Totem Health Patch.

Figure 4 Overview of the J-Link Programming Module with Rig.

IV.   Flashing firmware

A.   Flashing using the J-Link

In the mbed software environment, code is compiled to a .hex file. Before compiling a specific programmer needs to be selected in the upper right corner. For the Totem Health Patch select: "Nordic nRF51822 MCU", see Figure 5.
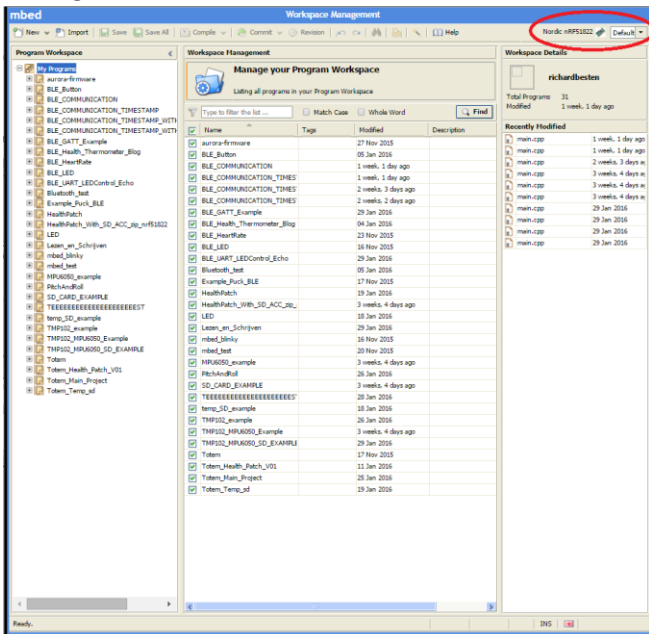

Figure 5 Nordic Platform .

It is now possible to program using the mbed web application,a nd everything is setup correctly. Using the button "NEW – NEW PROGRAM" it is relatively easy to program (new) firmware. To continue, it is also possible to upload a whole program in mbed. Please go to:

 https://github.com/wemaketotem

for currently available versions of the firmware and examples for the Totem Health Patch. When you have

successfully written firmware, compile it to a .hex. The .hex file will automatically be downloaded from the web-browser. Subsequently, the .hex file can be opened in nRFgoStudio (Figure 6) to be flashed on the Totem Health Patch.

It is necessary to erase memory before trying to flash (newly) created firmware. If not all of the 256kGB memory is available, then flashing does not work. Erase the memory by pressing "erase all". To continue, the firmware compiled in mbed is selected by pressing "Browse…". Finally, the firmware is flashed by pressing "program".
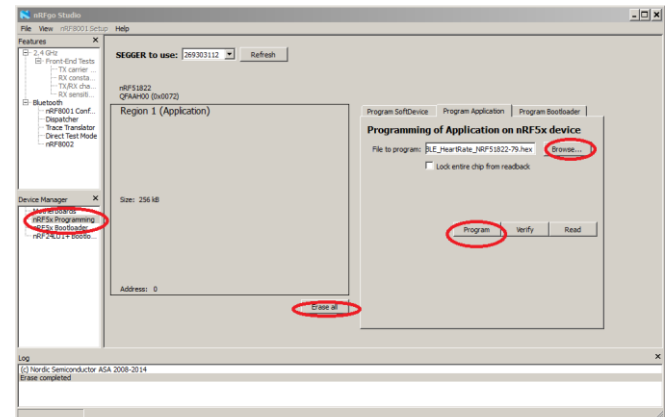

Figure 6 nRFgoStudio Device Programming.

B.   Flashing over the air (FOTA)

Instead of flashing the device using the J-Link Programmer + Rig, it is also possible to flash the Totem Health Patch using Bluetooth. You are required to set-up mbed and your smartphone, which takes some time. However, that time is quickly regained due to the easier method of flashing firmware.

Flashing Over The Air (FOTA) uses a different platform on mbed "Nordic nRF51822 FOTA" (Figure 7).
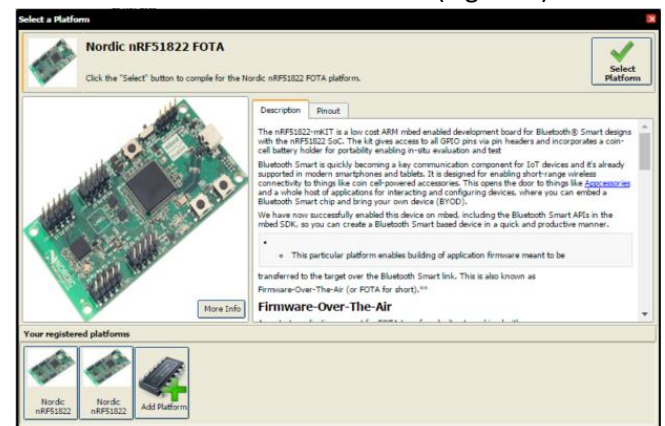

Figure 7 FOTA platform.

Before being able to flash the device using Bluetooth, you need to flash the FOTA bootloader on the device (available here:
https://github.com/wemaketotem/health-sensor-

aurora-ble-fota-bootloader). This is done using the programming rig, and the method described above. The only difference from flashing firmware is that you have to select the bootloader programming option in nRFgoStudio. This should only be done once. However, sometimes, when flashing the Totem device over Bluetooth, the device stays in application mode and is not able to go back to bootloader mode. When this happens, you simply have to reflash the bootloader using the programming rig.

After flashing the Totem device with with correct bootloader it is discoverable on the "nRF Connect" application (which you can download in the appstore), see Figure 8. The name of the Totem device is: "DefaultApp" followed by a mac address. The application is able to flash firmware on to the Totem device. The following shows the steps to flash firmware using the "nRF Connect" app.
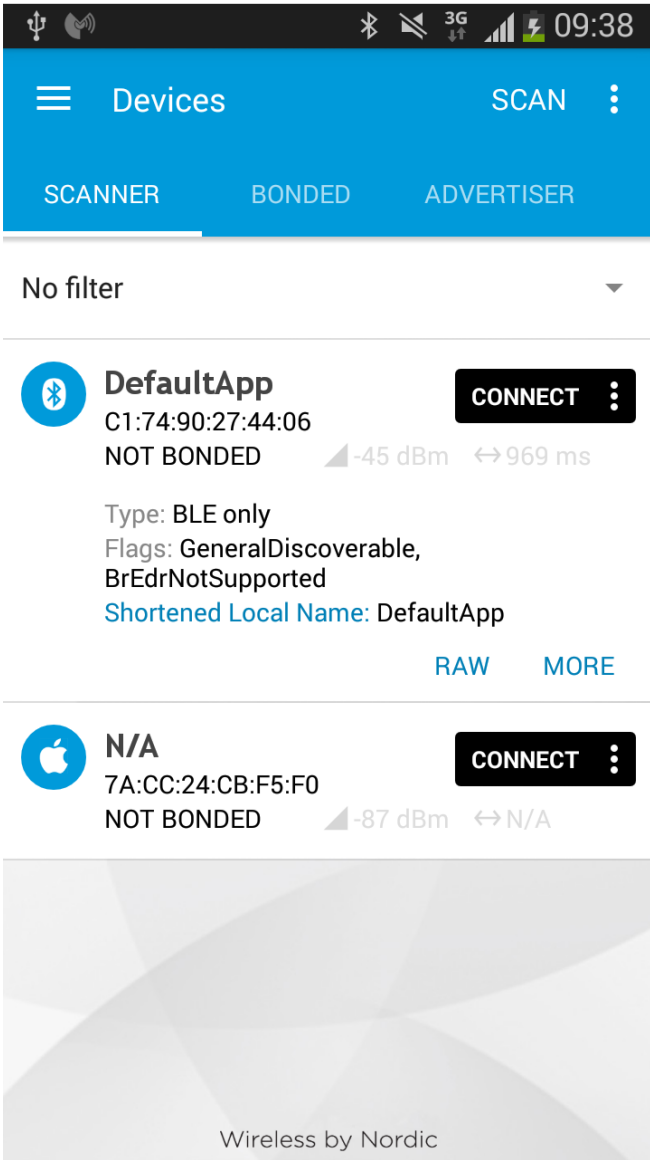

Figure 8 nRF Connect App.

Connect to the device using the "connect" button. After connection, you need to bring the health patch to Device Firmware Update (DFU) mode. Click on the upwards arrow next to "DFU Control Point" under the header: "Device Firmware Update Service" (Figure 9).
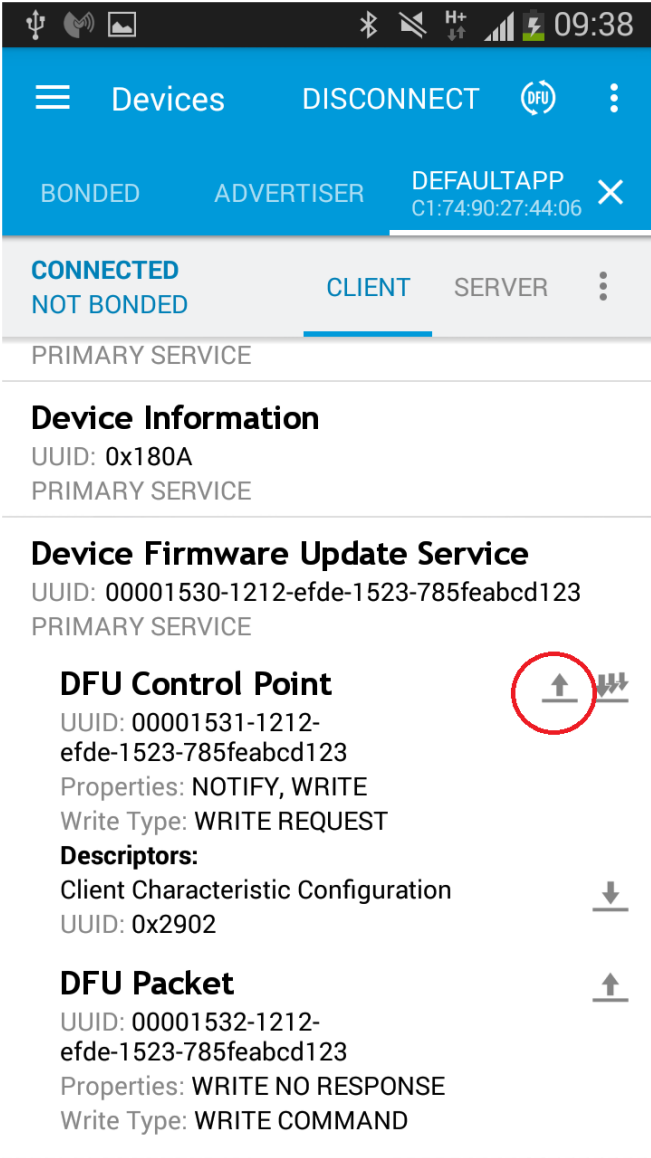

Figure 9 Device FIrmware Update Service.

Next, select Application (0x04), see Figure 10, followed by "send".
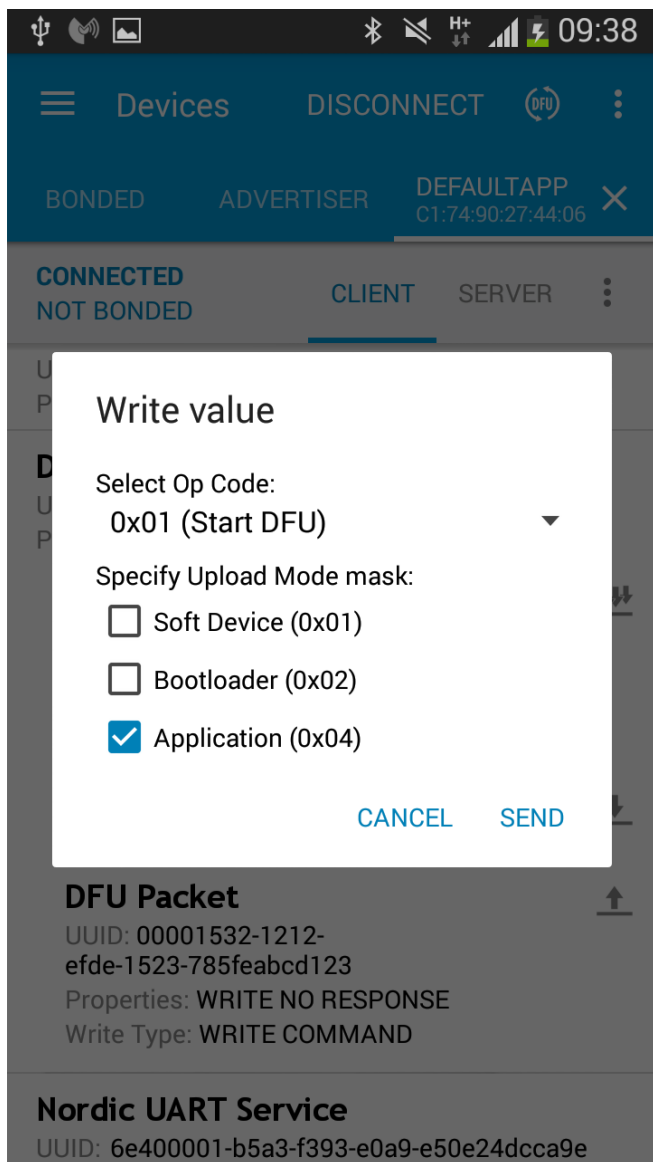
Figure 10 Application (0x04).

Now, the Totem device will automatically disconnect. Close the current link rescan for 'new' devices. The name of the Totem device changed to "DfuTarg", see Figure 11. Connect the application with the DFU target device.
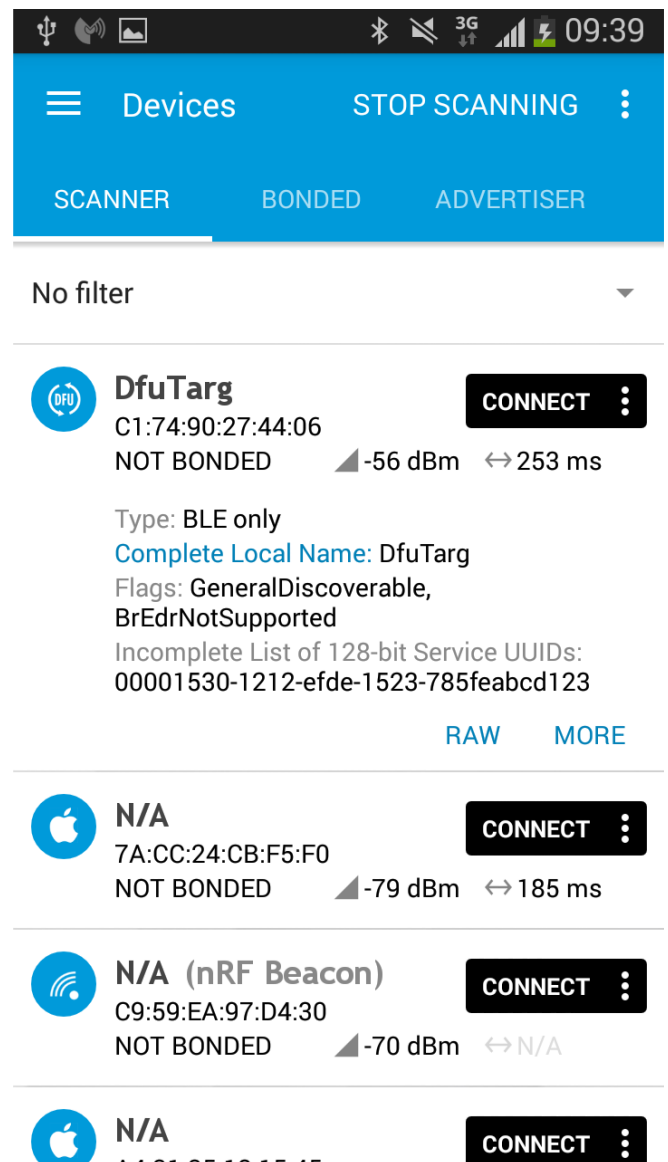

Figure 11 DfuTarg.

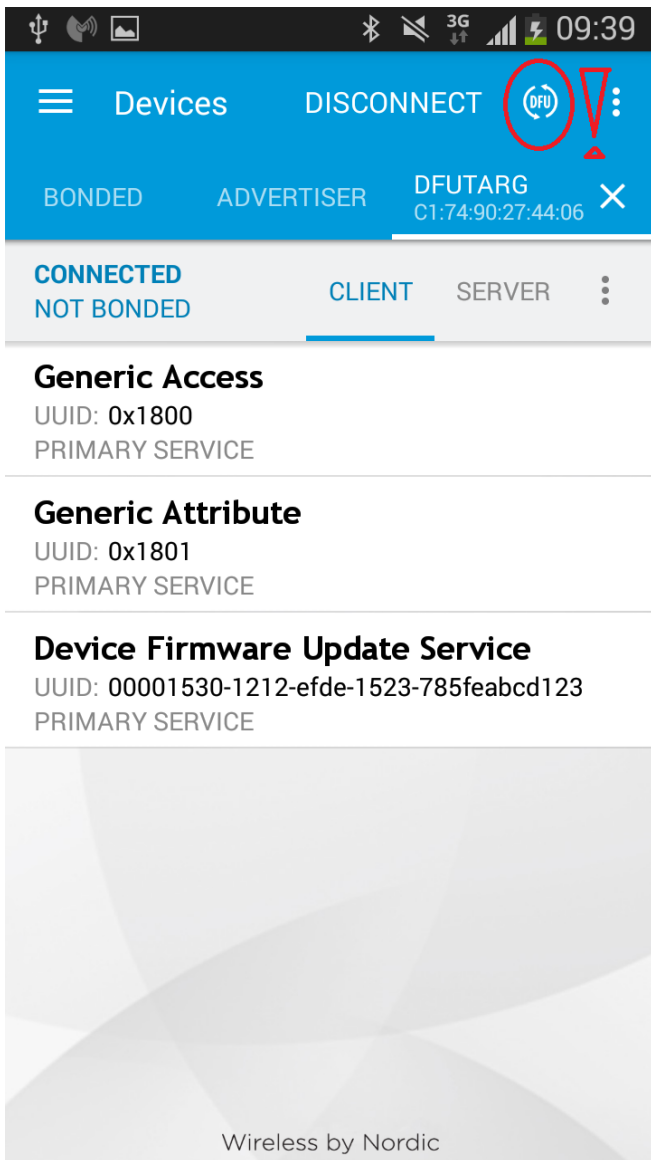Now click on the small icon at the top right corner (Figure 12).

Figure 12 DFU.

Now select "Application" (see Figure 13). You are directed to a file location e.g. the file manager or dropbox.
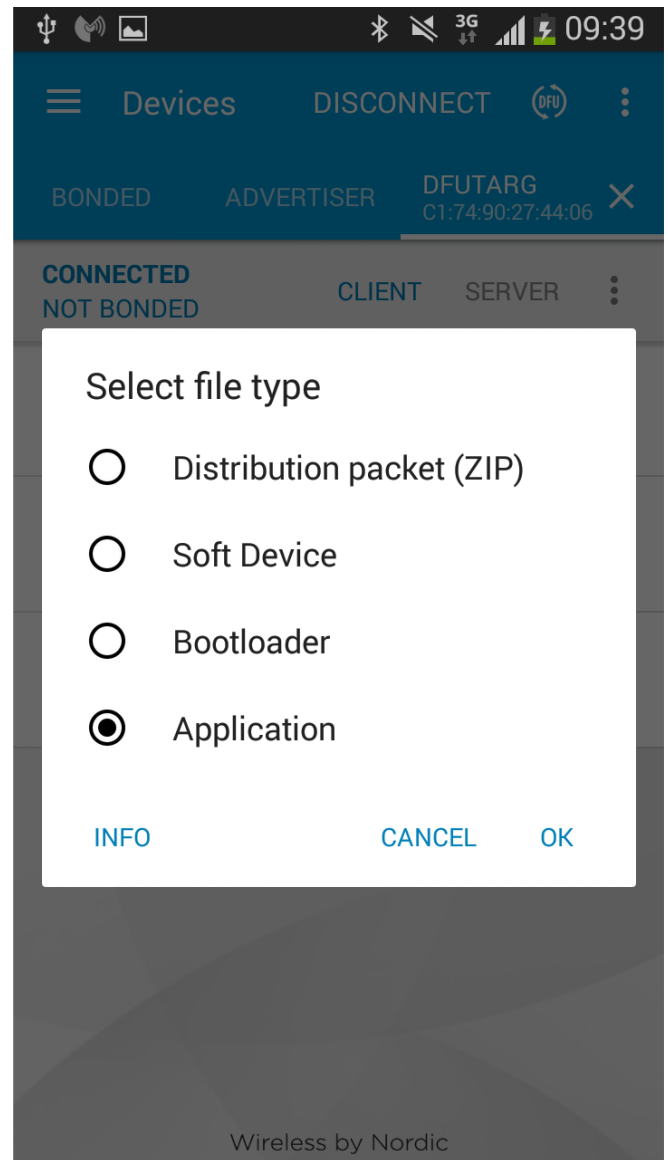

Figure 13 Select Application.

Select your precompiled ota.hex file from the list (Figure 14).
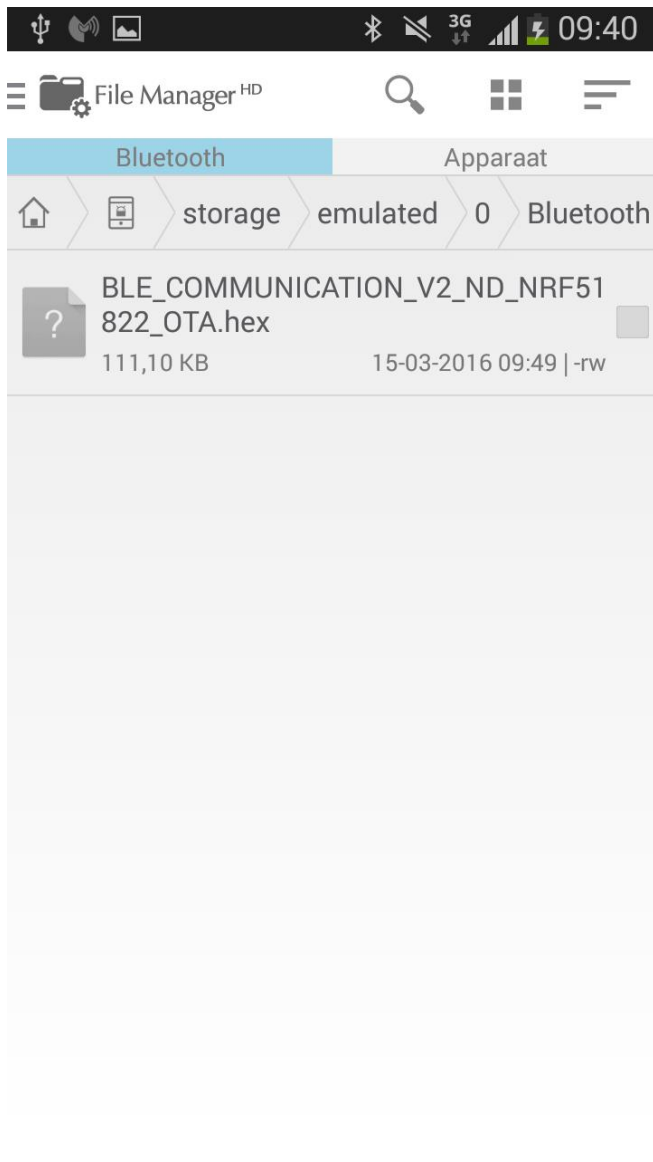
Figure 14 File manager

The device will now ask you if the device needs a init packet (Figure 15), select NO. There is no need for the *.bat file using the currently available software (S110, nRF51822 7.0.0).
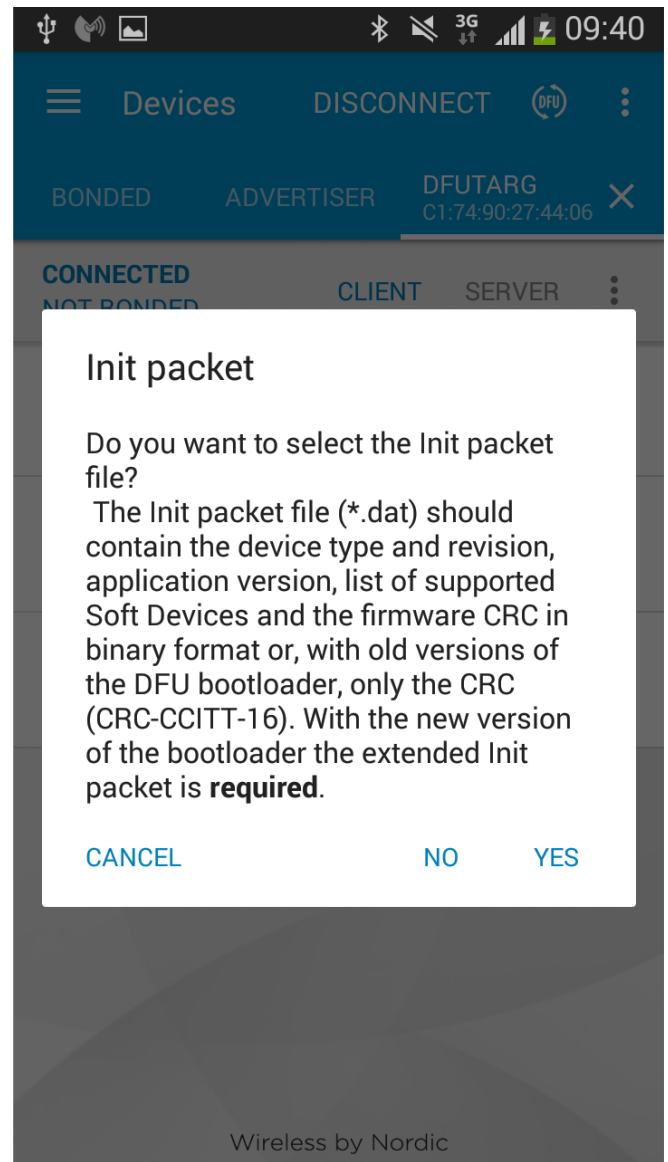

Figure 15 Init packet.

Now the Totem device will be flashed. The progress is shown on your screen (Figure 16).
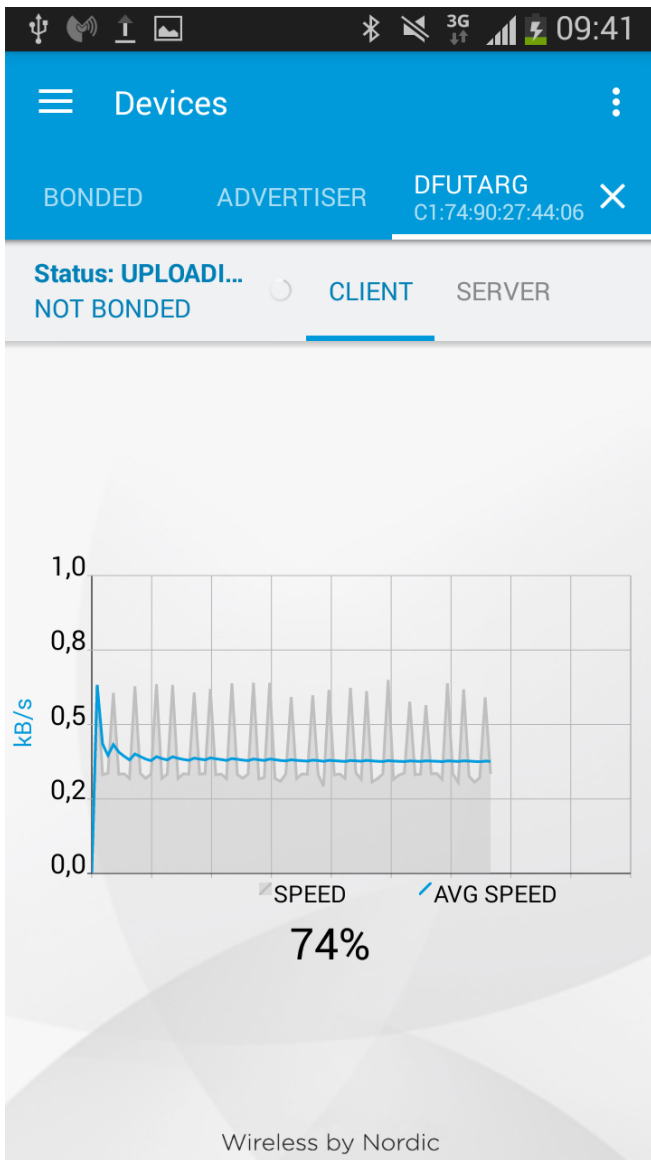
Figure 16 Uploading firmware.

After flashing the firmware, the device will automatically disconnect. Rescan for 'new' devices

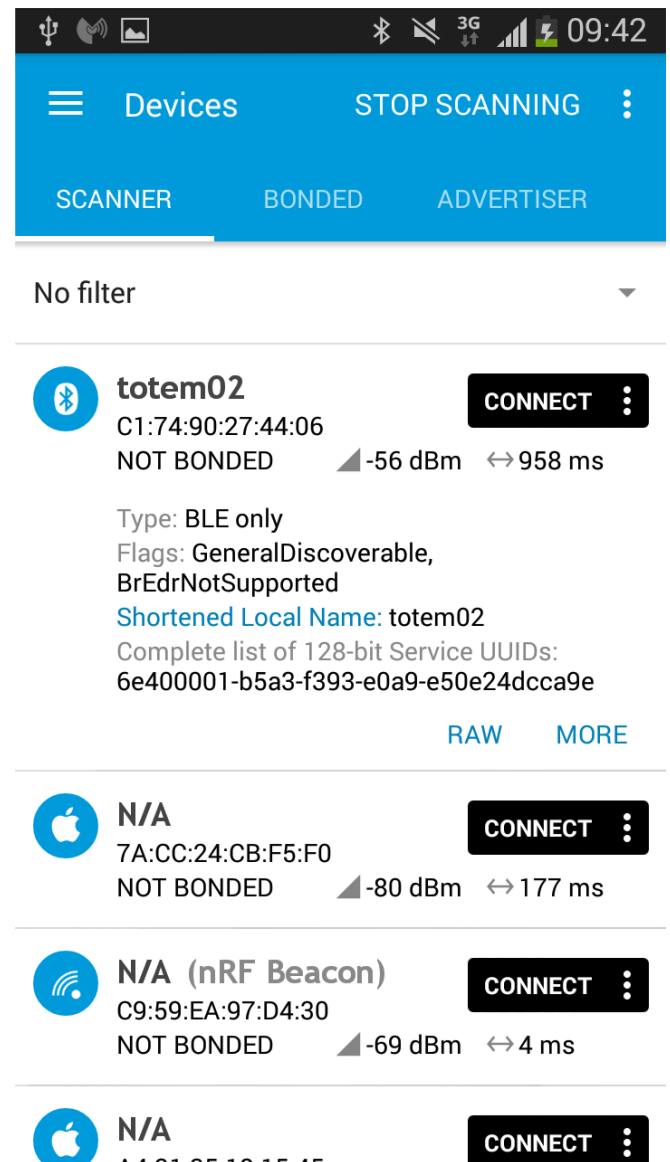and the Totem device should pop up under the following name: totem02 ,see Figure 17).

Figure 17 totem02.

The Totem device is now ready to use with the open source Totem app. Below, the steps show how to install and use the application.

V.   Totem Open App

Save the APK file (available here: https://github.com/wemaketotem/health-sensor-aurora-app-android) on an android device. Subsequently, click on the APK file to install the application. You might be prompted to change your device settings to allow application installs from unknown sources (Figure 18).
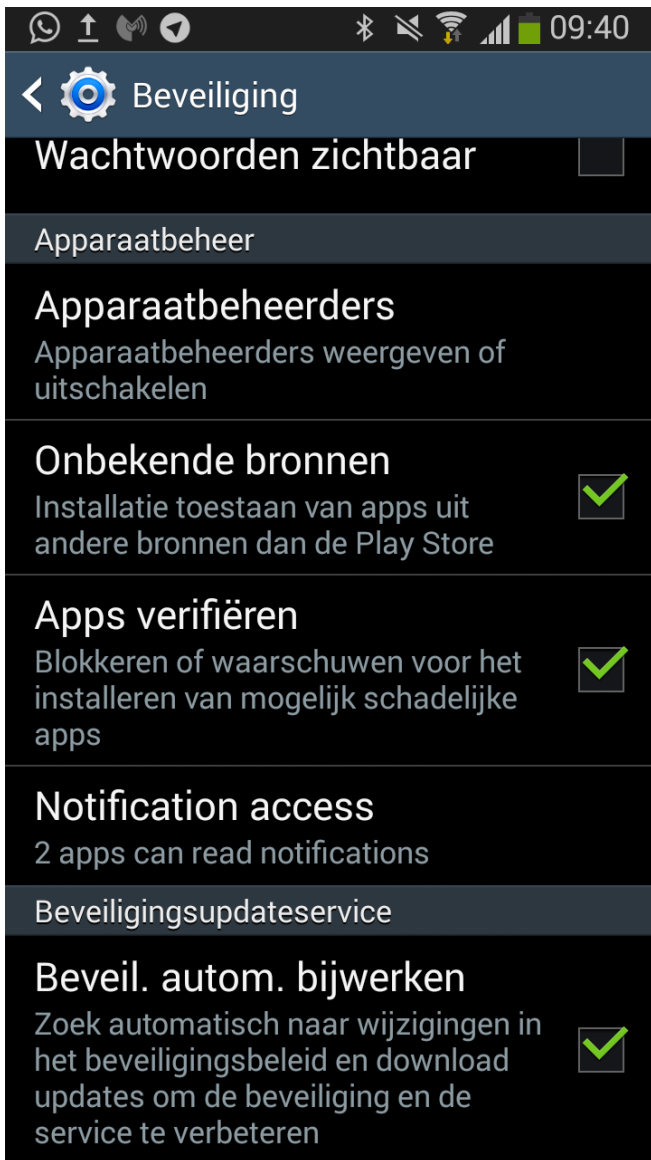
Figure 18 Application install from unknown sources "onbekende bronnen".

After successfully installing the Application, you can search for active devices flashed with firmware version 2.0 (available here: https://github.com/wemaketotem/health-sensor-aurora-firmware/tree/firmware-v2).

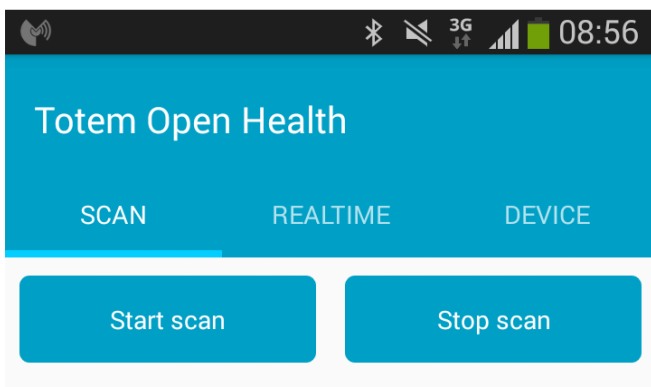The application is shown in Figure 19.

Figure 19 Totem Open Health Application.

Insert the SD-Card in the Totem device. Subsequently, insert the battery. The Totem device now initialises the MPU6050 and checks if an SD-Card is present which allows for reading and writing. When the battery is inserted before the SD-Card, the Totem device is not able to write/read. This will result in a blinking LED, until an SD-Card is inserted.

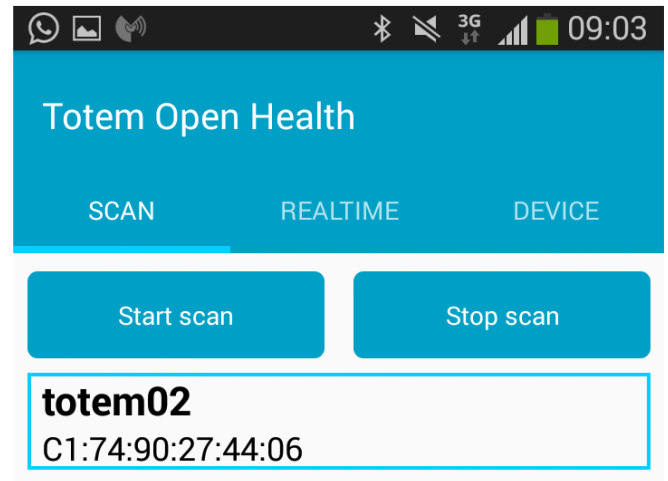Now click "Start scan", and your device will show up, see Figure 20.

Figure 20 Device visible.

Please note that if someone is using another sensor within Bluetooth range, that is not connected yet, that one will also show up on the list. Either remember the MAC – address or rename your device using the embedded software (mbed). Subsequently, select your device from the list.

Please note that with one android device you are only able to connect to one sensor. When using multiple sensors, you do need to have multiple android devices.

After being connected to the device, the app will show the following (Figure 21).
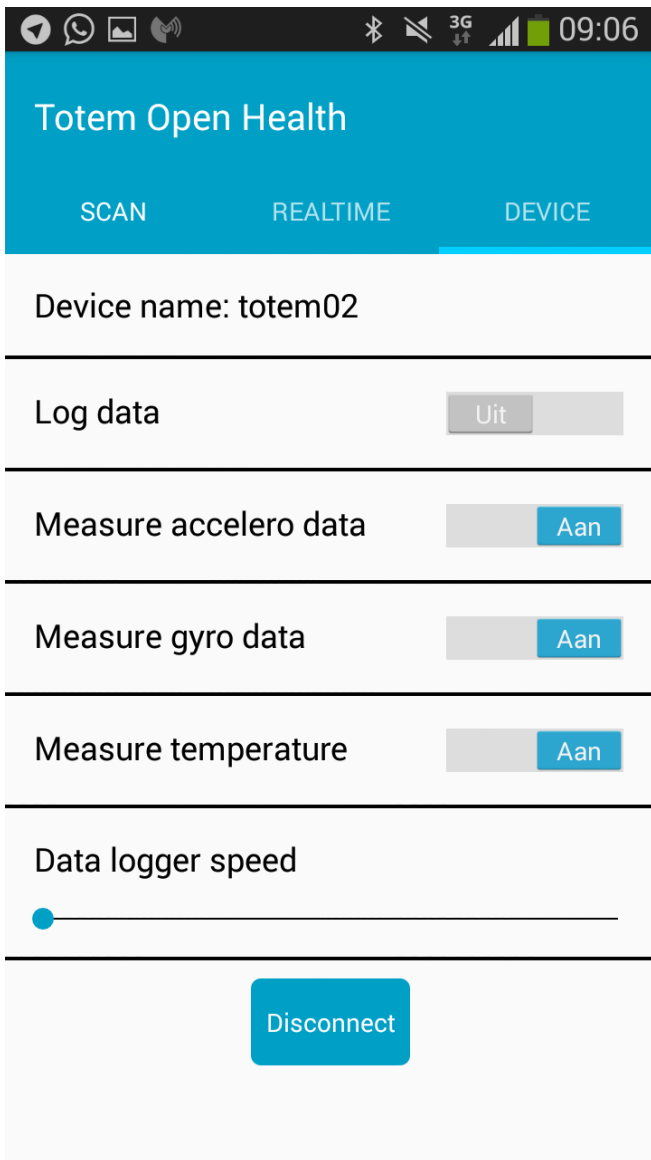
Figure 21 Connected device.

Now, please wait for at least 10 seconds to let the Totem device and android device connect properly. Moreover, during this time, the android device sends the UNIX Timestamp to the Totem Device. The UNIX Timestamp can be used to synchronise multiple devices.

In the menu of the application you are able to select which sensor(s) you would like to use. Also, select your data logger speed (sample frequency). Subsequently press "Log data" to start the measurement, and "Log data" again to stop the measurement. A comma separated value file (csv- file) is saved on the SD-Card with the following name: 0-session-counter-data. If you start a new measurement without taking the battery nor the SD-Card out, the 'name value' increments – to 1-session-counter-data, etc..

Please note that if you take the SD-Card or the Battery out between measurements without taking the data from the SD-Card, you have to start the whole

measurement process again, and will therefore overwrite currently stored data. To recap, follow these 17 steps to acquire data:

1. Remove the battery and SD card from your Totem Health Sensor.
2. Erase all files from the SD card, and if necessary format to FAT with your PC.
3. Insert the SD card into the Totem Health Sensor.
4. Insert the battery into the Totem Health Sensor, make sure to align the + on the battery with the + symbol on the case of the Sensor.
5. Close/kill the Totem Open Health app if it is running.
6. Start the Totem Open Health app.
7. Press "Start scan" in the app.
8. Select your Totem Health Sensor from the list, it should be there.
9. Wait until the app is connected.
10. WAIT AT LEAST 10 seconds before doing anything in the app.
11. Now, you can configure the sensors and data logger speed as you like.
12. Select "Log data" to start a measurement.
13. Measure for AT LEAST 30 seconds.
14. Select "Log data" in the app to STOP the current measurement.
15. Remove the SD card from your Totem Health Sensor, and put it in your PC.
16. Remove the battery from your Totem Health Sensor.
17. Go back to step 1, rinse and repeat.

Figure 22 Totem Open Health Kit.