BLE Logger / Oscilloscope

Degree programme: BSc in Electrical Engineering and Information Technology | Specialisation: Embedded Systems
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Many wearable devices use Bluetooth Low Energy (BLE), a wireless technology that uses short-range radio, in order to communicate with their companion devices. BLE is known for its low power consumption, which makes it ideal for wearables that need to operate for long periods of time without having to be charged. The goal of this project was to acquire sensor data on a wearable prototype, to send it over BLE and to show it on a time graph in real time, like an oscilloscope.

Introduction

Wearables like smartwatches continually improve every year. Many offer similar features to smartphones, even though they still mostly rely on a companion device. They are also getting more powerful, which can be advantageous, but can also negatively impact the wearable's battery life. However, if wearables like smartwatches and smartphones work in tandem, then there is no need to always have the same processing power in the pocket and on the wrist. The wearable can focus on the data acquisition, while handing over most of the algorithmic power to the smartphone. This can make wearable devices more power-efficient and affordable.

Goal

The focus of this Bachelor's thesis was the development of the firmware of a wearable that acquires data from different sensors (e.g. accelerometer, magnetometer, temperature sensor, battery voltage) and sends that data over BLE. This task required becoming familiar with the BLE protocol. Another goal of this project was the development of the BLE Logger app that visualizes the sensor data on a graph in real time, like an oscilloscope. The Android app is also able to configure the measurement parameters of the sensors on the wearable (e.g. power mode, range, etc.).
Furthermore, a wearable hardware prototype was developed during the thesis (see figure 1), even though the focus of the thesis was the software development of the firmware on a development kit and the BLE Logger app on Android.

Concept

The firmware was developed on Nordic's nRF52 SoC. This SoC was evaluated with the sensors during the project study based on their power consumption. The SoC supports multiple wireless protocols including BLE with its SoftDevice protocol stack. The SoC supports FreeRTOS, which provides a reliable way to run multiple concurrent tasks for the BLE communication, data acquisition, and the sensor configuration.
The accelerometer and magnetometer data is acquired using a SPI serial interface. The battery status is read with an ADC.
The firmware utilizes two BLE custom characteristics to communicate with the smartphone. One is used for the sensor data transfer to visualize the data on the app and another is used to configure the sensors on the wearable from the app (see figure 2).

Results

The BLE Logger app is able to scan the area for devices, and it connects to the wearable within seconds, when its firmware is advertising. After the connection is established, the sensor data is visualized in real time in their corresponding time graphs. It also shows the instantaneous values in text format (including the set measurement range). Furthermore, the firmware is able to send sensor data every second for 1908 h (around 80 days) on a small 450 mAh battery.
In the future, the app could be extended with smart algorithms that analyze the sensor data (e.g. activity recognition).

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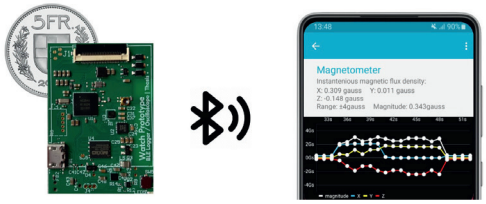

Figure 1: The wearable and the BLE app communicate with BLE

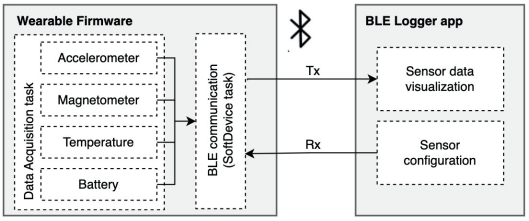

Figure 2: Block diagram of the firmware and Android app