IoT Coursework Setup Instructions

Introduction

The coursework involves using an embedded development board to interface with an inertial sensor. The dev board can then communicate wirelessly with an Android app, which you will develop.

The rest of this document describes the setup required to run a reference program, which has been provided for you and has the following functionality:

- Flashes an LED on the dev board
- Sends debugging information to the PC over serial
- Communicates with the Inertial Measurement Unit (IMU) breakout board
- Streams sensor data over Bluetooth Low Energy (BLE)

It is important to reproduce this behaviour before starting to modify the code running on the dev board, as it will rule out basic problems early on.

Git repository

The firmware images referred to in this document are available from the following GitHub repository: https://github.com/specknet/mbed-iot. Source code and other documents will be added there during the project.

NRF52-DK

You have been provided with a Nordic NRF52-DK board, which we will use with the mbed embedded development platform.

Updating the bootloader

1. Download the **0246_sam3u2c_mkit_dk_dongle_nrf5x_0x5000.bin** bootloader image.
2. Switch off the dev board.
3. Connect to your PC via USB.
4. Whilst holding down the rest button, turn on the dev board.
5. It should appear as a mass storage device.
6. Copy the bootloader image to the MSD.
7. Turn the board off and on again.
8. It should now be in a state where you can flash a program file.

Flashing the board

First make sure that you can run a basic program on the dev board. You can always return to this example later to verify that your board is still working. The following firmware .hex files are available from the following GitHub repository:

1. Download the **BLE_LED_NRF52_DK.hex** firmware image.
2. Switch on the dev board and connect it to your PC via USB. It should appear as a mass storage device.
3. Copy the firmware to the mass storage device.
4. Turn the board off and on again to run the program.
5. LED1 on the dev board should start to flash once per second.

If this example fails to run you may need to reflash the bootloader on your dev board, as described above.

MPU-9250

The InvenSense MPU-9250 is an IMU motion tracking board containing a 3-axis accelerometer, gyroscope and magnetometer. These sensors can be used together to provide full 3D motion tracking.

Wiring

You have been provided with an MPU-9250, which is mounted on a Sparkfun breakout board. This can be connected to the dev board using the I^2C interface. You should make the following connections using jumper cables:

Connection	Dev board	MPU breakout board
Power	VDD	VDD
Ground	GND	GND
I^2C Clock	P0.27	SCL
I^2C Data	P0.26	SDA

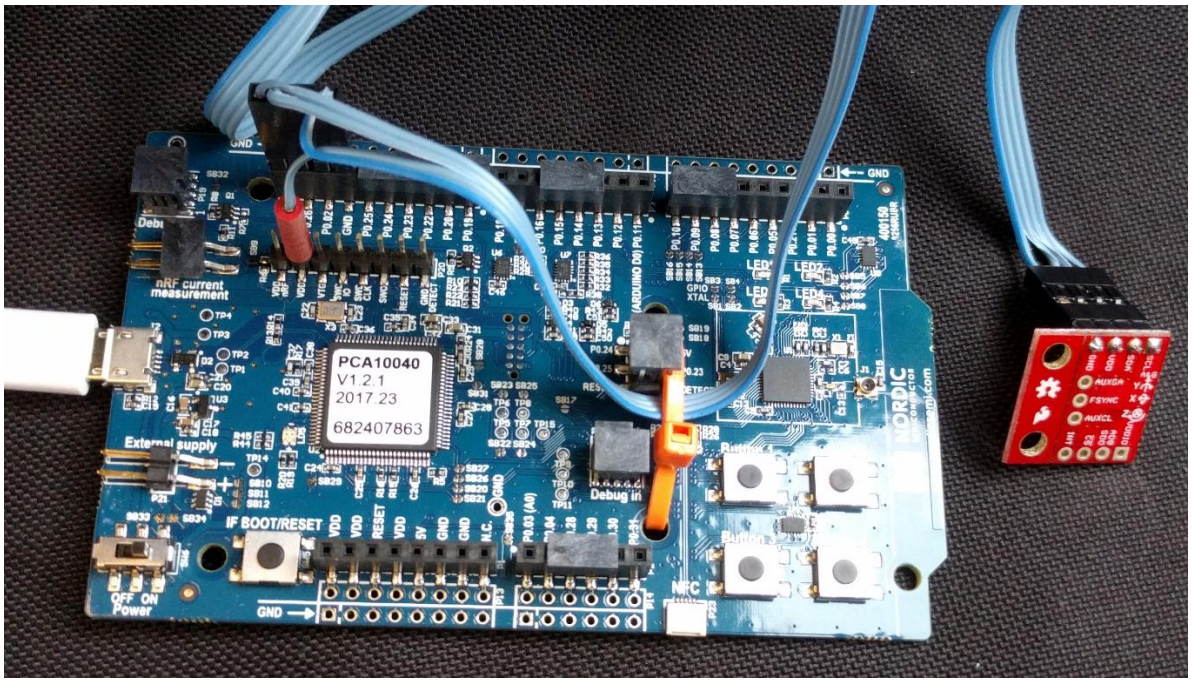


Figure 1: Connecting the MPU breakout board to the NRF52-DK

Testing communication

The provided **I2C_HelloWorld_Mbed_NRF52_DK.hex** program tests communication between the NRF52-DK and the PC (via USB-serial port) and the MPU-9250 (via I^2C).

1. Connect the dev board to the PC via USB and switch on.
2. Using a terminal application, open a connection to the J-Link CDC serial port using the following settings:
    a. Baud rate: 9600
    b. 8 bits

c. Stop bits: 1

3. Copy the above .hex file to the NRF52-DK mass storage device.
4. The program should now run and display gyro output from the MPU. The values should be close to zero when static and increase when you rotate the sensor.

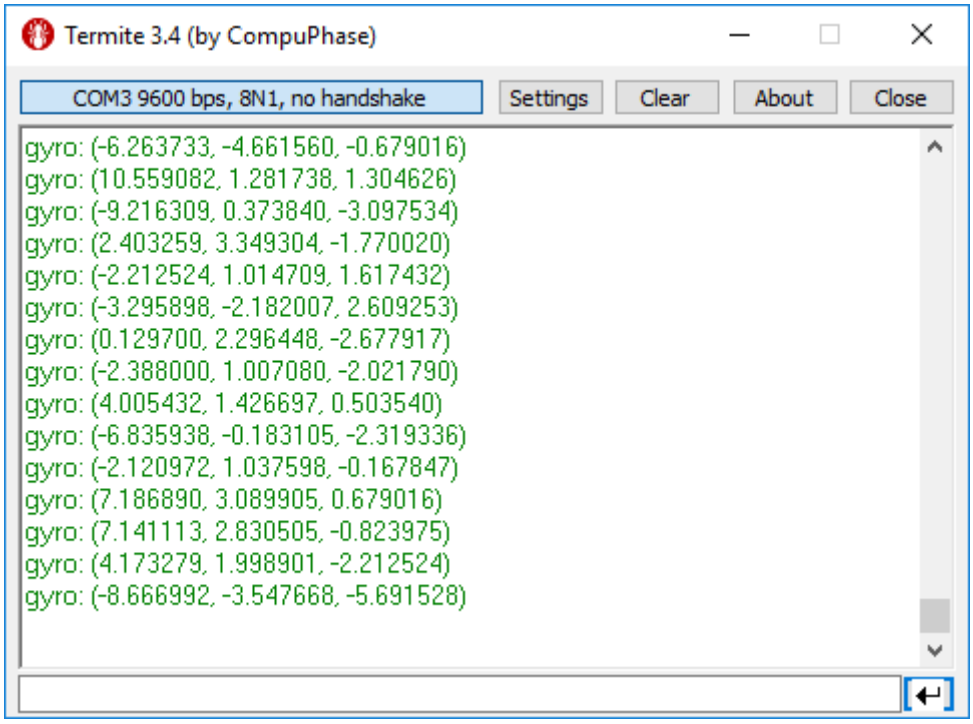


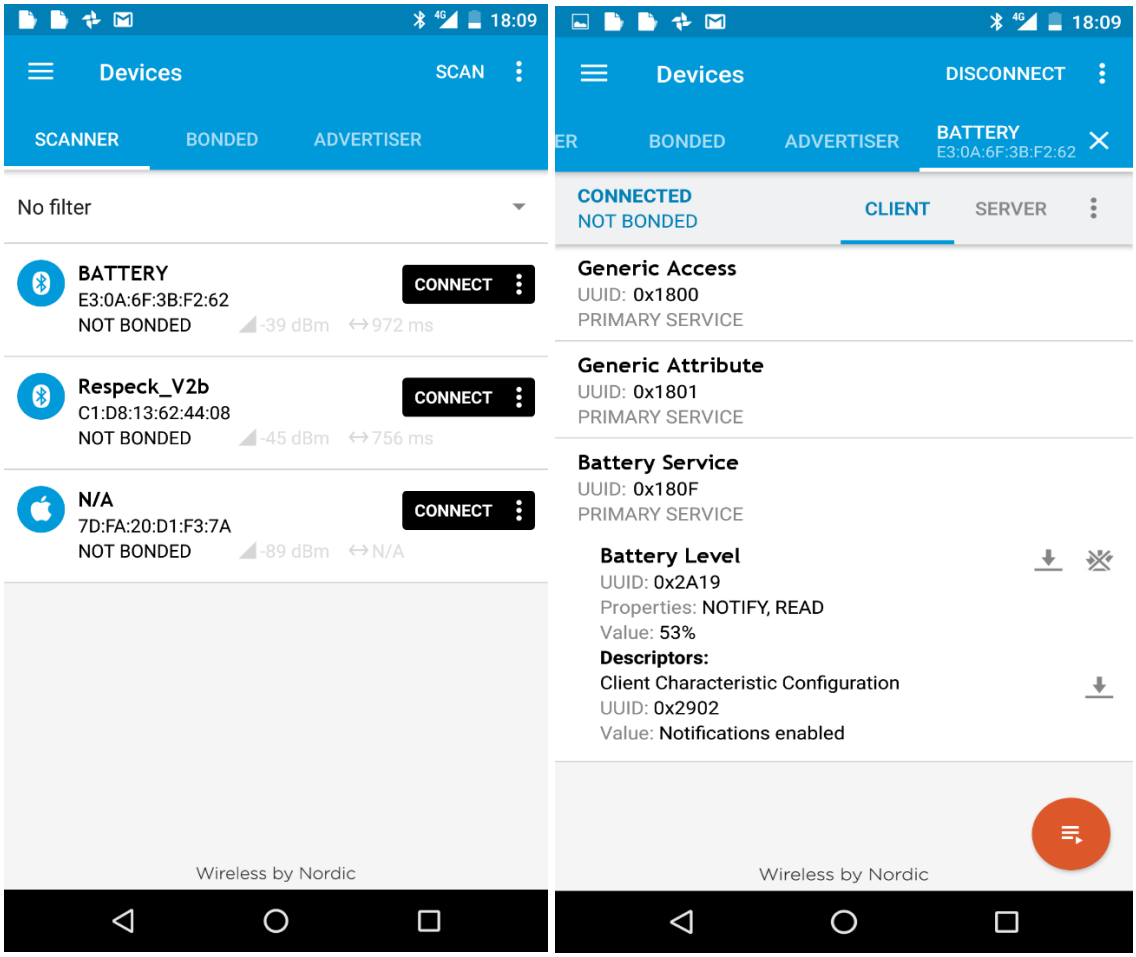
Figure 2: Expected serial output when testing MPU comms

Testing BLE communication

We recommend using the excellent Nordic nRF Connect app for BLE debugging. This allows you to see the services provided by your BLE device, stream data from notifications and log it to a file. https://www.nordicsemi.com/eng/Products/Nordic-mobile-Apps/nRF-Connect-for-mobile-previously-called-nRF-Master-Control-Panel

Try loading the supplied **mbed-os-example-ble-BatteryLevel_NRF52_DK.hex** BLE example. This will send fake battery level values, for testing the Bluetooth communication.

1. Copy the .hex firmware image to your dev board as described earlier.
2. The dev board should now be discoverable over BLE, with the name “BATTERY”.
3. Open *nRF Connect* on your phone and scan for devices.
4. Press the *connect* button for the “BATTERY” device.
5. Expand the *Battery Service* and click the multiple down arrow icon next to *Battery Level* to stream battery percentage notifications.



Mbed development platform

We will use the mbed development platform to compile firmware to run on the NEF52-DK board, which is fully supported in mbed OS 5. See the handbook for more information: https://docs.mbed.com/docs/mbed-os-handbook/en/latest/

Online compiler

We recommend that you use the mbed online IDE and compiler for your firmware development.

Once you've registered for an account and set your hardware to the NRF52-DK you'll have access to your own workspace. This will allow you to compile code and download the resulting firmware image to copy to the dev board. There is also an in-built version control system for you to use for your mbed projects.

Example code

The OS5 mbed-os-exanple projects are a good starting point for your own firmware.

https://os.mbed.com/teams/mbed-os-examples/code/

We recommend starting with the blinky example, which flashes LED1 as seen in the first test program above.

https://os.mbed.com/teams/mbed-os-examples/code/mbed-os-example-blinky/

You can use the *Import into compiler* button to import the project into your own workspace in the mbed online compiler. Now try to compile and run the blinky example on your board.

Local toolchain

Although it is possible to set up an embedded toolchain on your local machine, this can be tricky. You are free to attempt this at your own risk, but we won't be providing any support!

Libraries

There are several mbed libraries for communicating with the MPU-9250, which are available from the online compiler. The test firmware uses this one:
https://developer.mbed.org/teams/Edutech/code/MPU9250/

Debugging

There are several methods of debugging that you may find useful:

- LEDs – 4 of these can be switched on and off and is probably the simplest way to view output from your code
- Buttons – There are 4 buttons on the mbed board to you can set to perform actions in your firmware
- Serial output – As tested in the above example, provides more detailed output when connected to a PC
- BLE – More likely to be used for the final output of your firmware, but you can also send values for debugging
- If everything seems broken, please check the coin cell battery voltage on the board!

Mbed bugs

Mbed is not perfect and you may experience compile errors or other bugs. Please share these and any solutions on piazza. Often rolling back the mbed-os library to the previous version using the *Revisions* option in the online compiler will fix build errors.