# AN5247
# Application note

## Over-the-air application and wireless firmware update for STM32WB Series microcontrollers

## Introduction

This document describes the procedure for over-the-air (OTA) firmware update on ST32WB devices with Bluetooth® Low Energy (BLE) connection. It explains how to use the OTA application provided within the STM32Cube firmware package.

This application can update the user application, the wireless firmware and the firmware upgrade service.

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# 1 Glossary

| | |
|---|---|
| BLE | Bluetooth® Low Energy (Bluetooth® standard) |
| CPU1 | Cortex® M4 (executes user application) |
| CPU2 | Cortex® M0+ (executes FUS and wireless firmware) |
| IDE | Integrated development environment |
| IPCC | Inter-processor communication controller |
| FUS | Firmware update service |
| OTA | Over-the-air firmware update |
| SBRSA | Option byte - Secure backup RAM start address |
| SBRV | Option byte - Secure boot reset vector |
| SFSA | Option byte - Secure Flash memory start address |
| SIG | Bluetooth® special interest group |
| SNBRSA | Option byte - Secure non-backup RAM start address |

# 2 Reference documents

[1] RM0434: Multiprotocol wireless 32-bit MCU Arm®-based Cortex®-M4 with FPU, Bluetooth® Low-Energy and 802.15.4 radio solution

[2] AN5185: STM32WB ST firmware upgrade services

[3] UM2288: STM32CubeMonitor-RF software tool for wireless performance measurements

All these documents are available on *www.st.com.*

# 3 OTA application on STM32WB devices

## 3.1 Over-the-air firmware update

### 3.1.1 Principle

Updating firmware during device lifetime is mandatory to guarantee state-of-art performance, to update the application with new features or corrected patches, and to keep the highest security level.

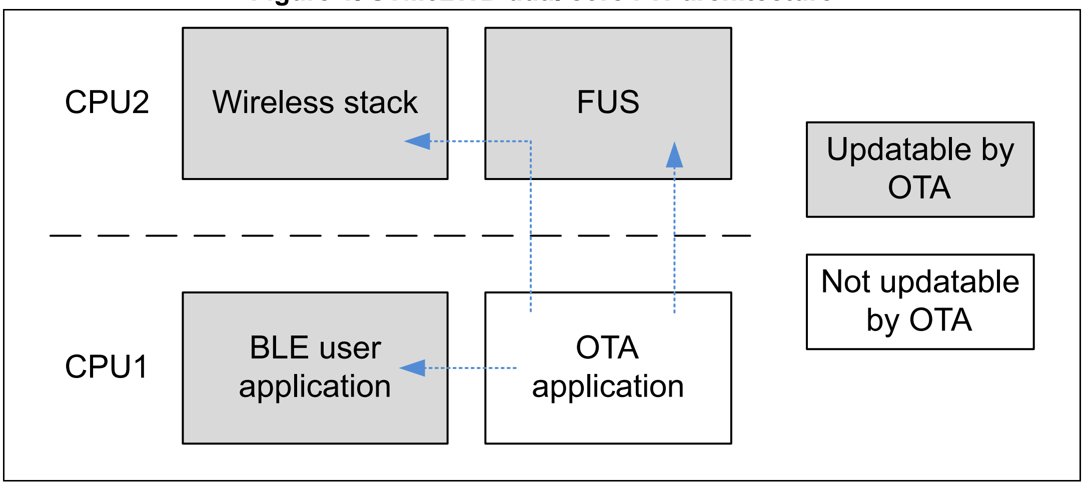
#### User application, wireless firmware and FUS update

The STM32WB Series microcontrollers are based on a dual Arm®[(a)] core.

The user application runs on CPU1 (Cortex® M4), while wireless firmware and FUS run on CPU2 (Cortex® M0+). The three applications can be updated independently.

As wireless and FUS are delivered in encrypted format, their update procedure relies on the STM32WB secure firmware for decryption and installation in the protected area of the Flash memory.

**Figure 1. STM32WB dual core FW architecture**




#### Over the air

Update of firmware can be done thanks to typical physical links such as USB, UART or I2C but this procedure requires a physical access with specific connectors on the device. Thanks to OTA it is possible to remotely update the firmware by using a wireless connection. In this application note, the wireless connection uses the BLE protocol.

a. Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

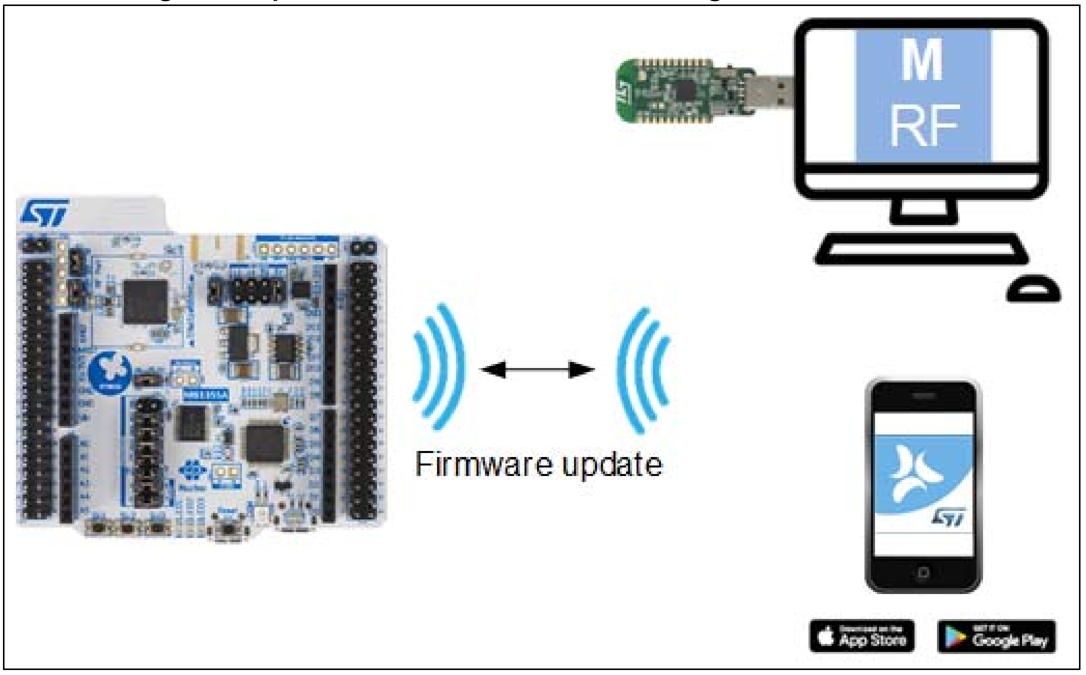
### Update clients

Update procedure follows a client/server architecture. It is initiated by an external client and the device acts as a server, responding to the request by installing the new firmware.

In this application note two examples (see *Figure 2*) of BLE-based OTA clients provided by STMicroelectronics are presented:

- ST BLE Sensor: a mobile application for Android™ or iOS devices
- STMCubeMonitor-RF: a PC tool communicating with a BLE USE dongle configured in HCI transparent mode

**Figure 2. Update of STM32WB firmware through BLE connection**



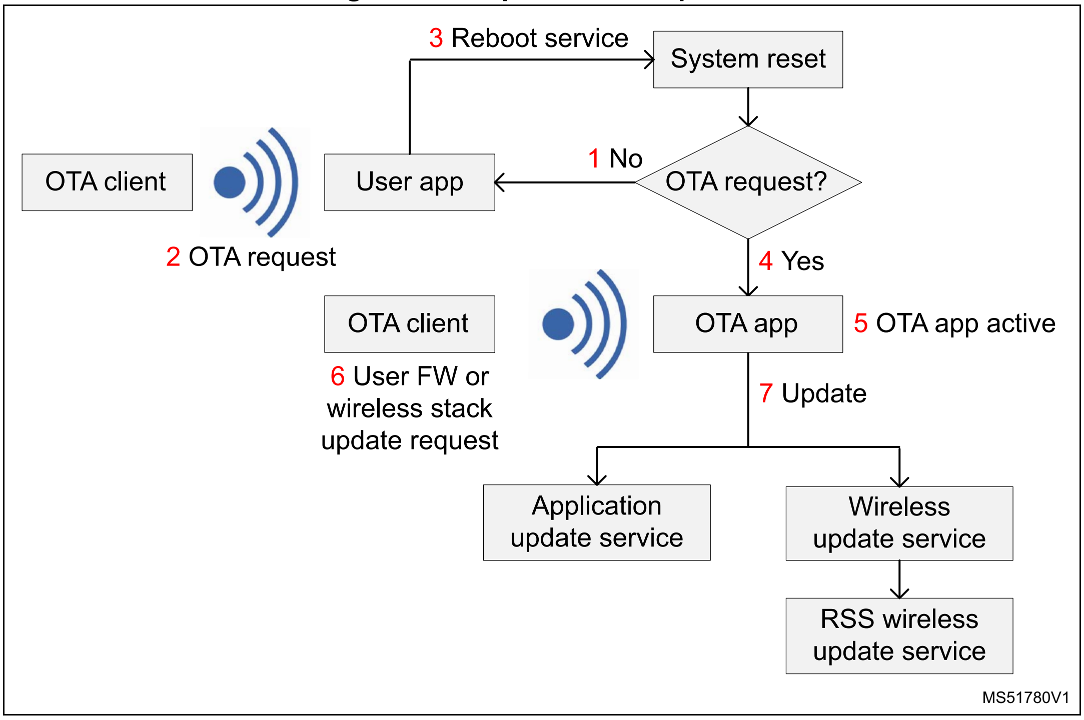
### 3.1.2 OTA application

OTA application is designed as a standalone application with BLE services for managing firmware transfer on client request, and its installation at the right place in the Flash memory. It is active and executed by CPU1 after an OTA request has been received by the user application.

The sequence is shown in *Figure 3*, where the numbers in red indicate the different stages.

Initial state is the user application running (1). When an OTA request is received (2), a system reset is triggered (3) and the OTA application becomes active (4) listening for client requests (5). Different services are provided for the update of wireless firmware or user application (6 and 7).

**Figure 3. OTA procedure sequence**



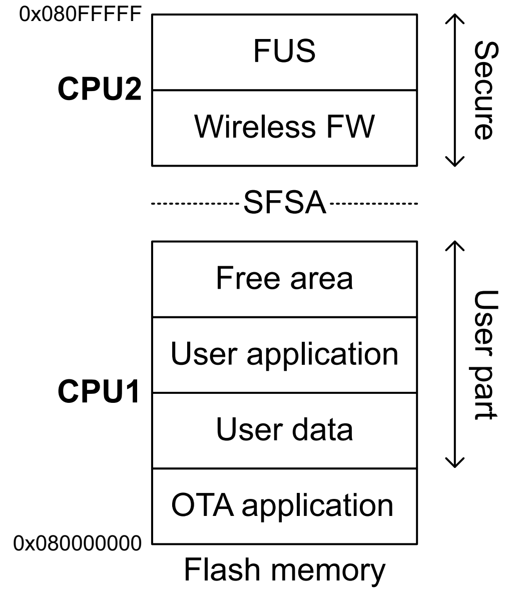

*Note: With this firmware architecture, the current user application is responsible for receiving OTA requests for both the user application and the wireless firmware. This is the entry point of the procedure. OTA application then communicates with the client to update either one or the other firmware.*

### 3.1.3 Memory architecture

The Flash memory of STM32WB is split in two parts, a user and a secure one. The user part is accessible by CPU1 and contains the OTA application as well as the user application code and data. The secure part is accessible by CPU2 only, and contains FUS and the wireless firmware. This part is not accessible by the debug port, by the user application or by the bootloader. The boundary between the two areas is given by the option byte SFSA, the memory above is secure (see *Figure 4*). The SFSA value depends on the wireless firmware size, it is adjusted during the install procedure.

The location of firmware involved on the OTA procedure is shown in *Figure 4*.

**Figure 4. Simplified memory map of applications**




### FUS

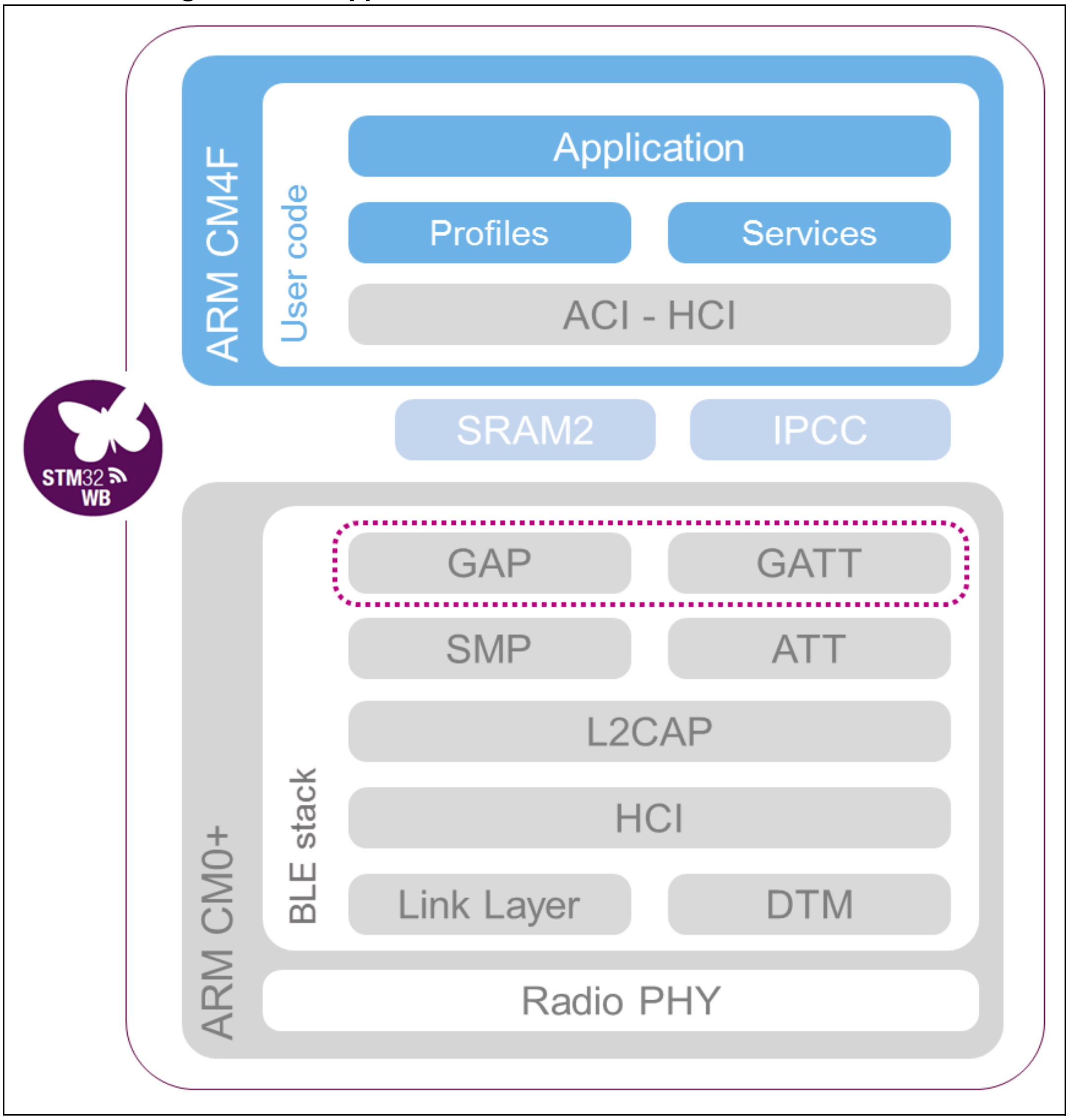
FUS is stored at the top of the Flash memory. It embeds the secure firmware for wireless firmware decryption and authentication. It also offers a secure storage for cryptographic keys. Refer to *[2]* for a detailed description of its features.

### Wireless firmware

It is stored just below FUS. This firmware drives the RF part of the MCU. Several protocols are supported: full BLE stack, BLE HCI only layer, Thread MTD, Thread FTD, concurrent mode (BLE + Thread FTD) and MAC 802.15.4 (low-level access to RF MAC). All stacks are available on *www.st.com*.

For BLE, the stack implements the real-time aspects. It contains the LE controller and LE host needed to manage all real time link layer and radio PHY interaction (*Figure 5*).

**Figure 5. BLE application and wireless firmware architecture**




### User application and data

This is the main user application. It is the applicative part of the device, implementing the BLE profiles and services relying on a wireless protocol. Communication between the user application and the wireless part is done through a mailbox system implemented thanks to the SRAM2 and IPCC hardware blocks (*Figure 5*). It is stored just above the OTA application in the user Flash memory.

For convenience, a sector for application data not be erased during firmware update can be reserved between the two applications.

*Note: A free area of the Flash memory must be available for the new wireless image download in case of updates.*

### OTA application

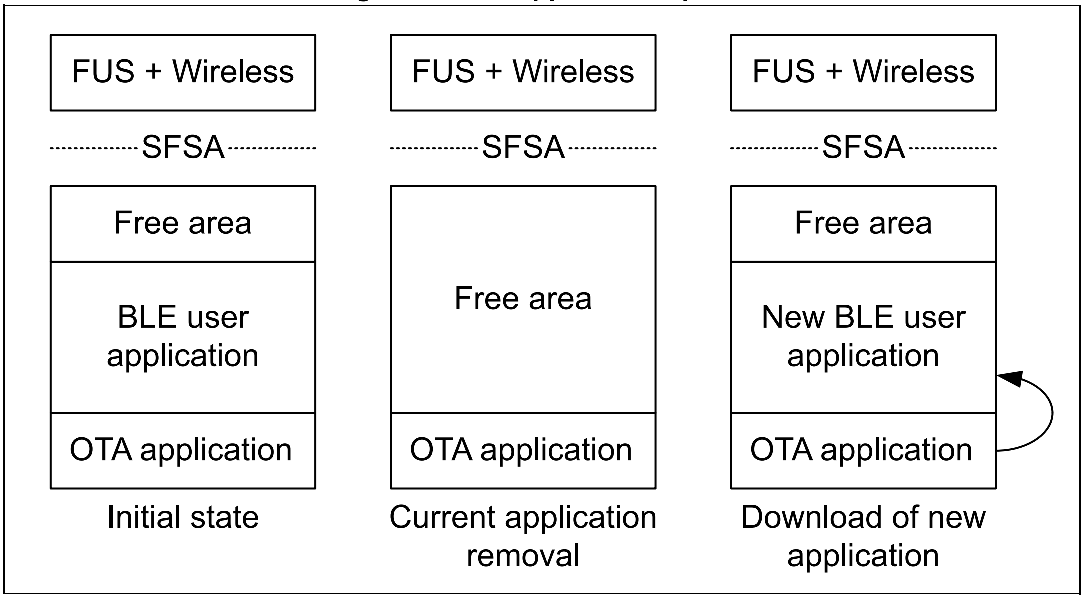
It is stored in the six first sectors of the Flash memory ([0x08000000: 0x08006000]). It is the active process just after a system reset (CPU1 boot address is at the beginning of the Flash memory). If no OTA request has been issued, the application jumps directly to the user application after having checked it has been fully programmed, otherwise the OTA application is running and is ready to receive commands from the client.

*Note: OTA application must be not be removed; if a problem occurs during the procedure, the device cannot recover. It is advised to set a write protection around the OTA application.*

### 3.1.4 User application update

Figure 6 shows the sequence of operation performed by OTA application once a request has been sent for user application update.

**Figure 6. User application update**




First, the sectors receiving the new firmware are deleted. This procedure is mandatory to be able to reprogram the Flash memory. It is advised to write-protect areas containing application data that need to remain unchanged.

The second step consists in downloading the new image. When firmware transfer is complete, OTA application jumps to the new application.

### 3.1.5 Wireless firmware update

Wireless firmware is delivered encrypted and signed. A secure FUS firmware is required to decrypt the stack and install it within the secure part of the Flash memory.

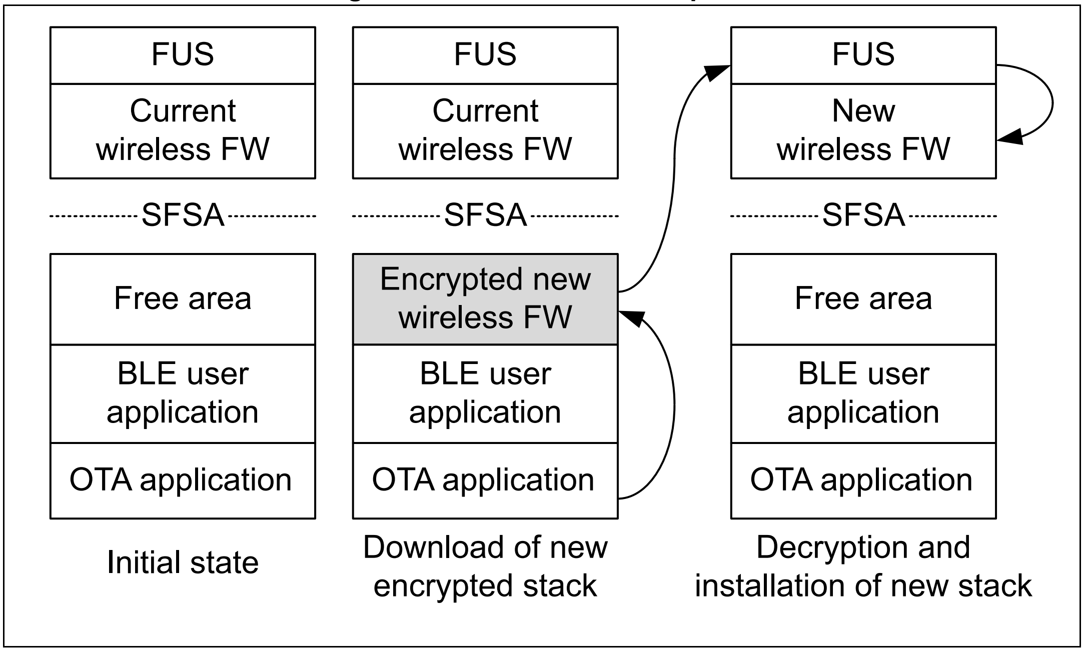
First step of the wireless installation is the same as for user application: sectors of the user Flash memory needed to store the encrypted image are deleted (“Free area” in Figure 7).

In the second step, OTA application downloads the encrypted stack (including the new firmware, in gray in Figure 7) and FUS update service is requested.

The third step is performed by the FUS running on CPU2. It authenticates, decrypts and installs the stack. Option bytes related to security boundary (SFSA, SBRSA and SNBRSA) and reset vector (SBRV) are automatically set at the end of the install.

The current wireless firmware is replaced only after all authentication and integrity checks have been passed to secure the connection capability of the device.

**Figure 7. wireless firmware update**




## 3.2 BLE service and characteristics for firmware update

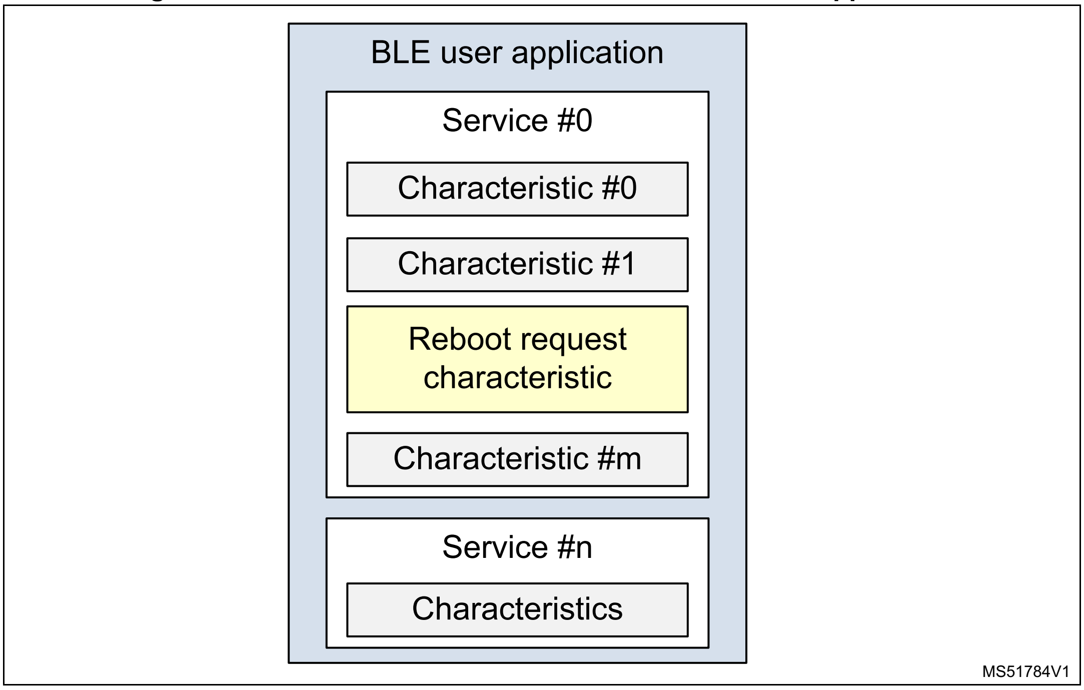
### 3.2.1 BLE application – Reboot request characteristics

#### BLE service and characteristics

The user application considered in this application note is a BLE application. It supports specific GATT services: either standard ones defined for SIG profiles (such as beacon, heart rate) or user-defined ones. These services own a set of characteristic values with specific access rights.

The developer has the possibility of extending the number of characteristics used by a service, even the standardized ones. In order to call the OTA application from the user a “reboot characteristic” (yellow box in *Figure 8*) is added to a service supported by the application. When this characteristic is written by the client through the BLE protocol the user application jumps to the OTA application.

**Figure 8. OTA reboot characteristic added in BLE user application**




### Reboot request

Reboot request has three different fields to be notified by the client:

1. the boot mode, either user application restart or jump to OTA application
2. the first sector index where the new application is downloaded
3. the number of sectors to be deleted (size of new firmware with 4 KBytes granularity

The service in which the characteristic is included depends upon the user application.

**Table 1. Reboot request characteristics**

<table>
<tr><td colspan="5">Service</td></tr>
<tr><td>One of the BLE user application</td><td>UUID</td><td colspan="3">-</td></tr>
<tr><td colspan="5">Characteristics</td></tr>
<tr><td rowspan="7">Base address</td><td>Function</td><td colspan="3">Request device reboot for OTA application</td></tr>
<tr><td>Size</td><td colspan="3">3</td></tr>
<tr><td>Mode</td><td colspan="3">Write</td></tr>
<tr><td>UUID</td><td colspan="3">0000FE11-8e22-4541-9d4c-21edae82ed19</td></tr>
<tr><td rowspan="3">Fields</td><td>0</td><td>Boot Mode:</td><td>0x00 Application<br>0x01 OTA application</td></tr>
<tr><td>1</td><td>Sector Index</td><td>0xXX -> 0x080XX000</td></tr>
<tr><td>3</td><td>Number of sectors to erase</td><td>0x00 – 0xFF</td></tr>
</table>

### 3.2.2 OTA application - Service and characteristics

OTA application is a standard BLE application. It provides a specific service with characteristics to fulfill the update.

**Table 2. OTA Service and characteristics declaration**

<table>
<tr><td colspan="5">Service</td></tr>
<tr><td>OTA FW Update</td><td>UUID</td><td colspan="3">0000FE20-cc7a-482a-984a-7f2ed5b3e58f</td></tr>
<tr><td colspan="5">Characteristics</td></tr>
<tr><td rowspan="6">Base address</td><td>Function</td><td colspan="3">Address to store the file</td></tr>
<tr><td>Size</td><td colspan="3">4</td></tr>
<tr><td>Mode</td><td colspan="3">Write</td></tr>
<tr><td>UUID</td><td colspan="3">000FE22-8e22-4541-9d4c-21edae82ed19</td></tr>
<tr><td rowspan="2">Fields</td><td>0</td><td>Actions</td><td>0x00: STOP all upload<br>0x01: START wireless file upload<br>0x02: START user application file upload<br>0x07: File upload finished<br>0x08: Cancel upload</td></tr>
<tr><td>1-3</td><td>Address</td><td>0x007000</td></tr>
<tr><td rowspan="5">File upload confirmation reboot</td><td>Function</td><td colspan="3">Confirm the reboot of the application after file uploaded</td></tr>
<tr><td>Size</td><td colspan="3">1</td></tr>
<tr><td>Mode</td><td colspan="3">Indicate</td></tr>
<tr><td>UUID</td><td colspan="3">0000FE23-8e22-4541-9d4c-21edae82ed19</td></tr>
<tr><td>Fields</td><td>0</td><td>0x01</td><td>Reboot</td></tr>
<tr><td rowspan="5">OTA raw data</td><td>Function</td><td colspan="3">Data to transfer file (split by 20 bytes)</td></tr>
<tr><td>Size</td><td colspan="3">20</td></tr>
<tr><td>Mode</td><td colspan="3">Write without response</td></tr>
<tr><td>UUID</td><td colspan="3">0000FE24-8e22-4541-9d4c-21edae82ed19</td></tr>
<tr><td>Fields</td><td>0-19</td><td colspan="2">Raw data</td></tr>
</table>

This service is recognized by the client application after an advertising sequence.

### 3.2.3 Advertising

Availability of the reboot request has to be advertised when the connection between the device and the client is established.

The information is added in a manufacturer specific advertising field (type 0xFF). The encapsulated structures are described in the next tables. Reboot request capability is specified in GroupB features (bit 13).

**Table 3. AD structure - Main**

| AD Field Name | AD Type | AD Len | Record size |
|---|---|---|---|
| TX_POWER_LEVEL | 0x0A | 2 | 3 |
| COMPLETE_NAME | 0x09 | 8 | 9 |
| MANUF_SPECIFIC | 0xFF | 13 | 14 |
| FLAGS | 0x01 | 2 | 3 |

**Table 4. AD structure - Manufacturer specific field**

<table>
<tr><th>Byte</th><th>Name</th><th>Value</th><th>Comment</th></tr>
<tr><td>0</td><td>Length</td><td>8</td><td>-</td></tr>
<tr><td>1</td><td>Type</td><td>0xFF</td><td>Manufacturer specific</td></tr>
<tr><td>2</td><td>Version</td><td>0x01</td><td>-</td></tr>
<tr><td>3</td><td>ID</td><td>0x00 - 0xFF</td><td>0x86 for OTA loader</td></tr>
<tr><td>4</td><td rowspan="2">Feature group A</td><td rowspan="4">Bit field</td><td rowspan="2">Reserved</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td><td rowspan="2">Feature group B</td><td rowspan="2">0x20 for OTA enabled device</td></tr>
<tr><td>7</td></tr>
<tr><td>8-13</td><td>Public device address</td><td>Bytes</td><td>Optional</td></tr>
</table>

**Table 5. AD structure – Group B features**

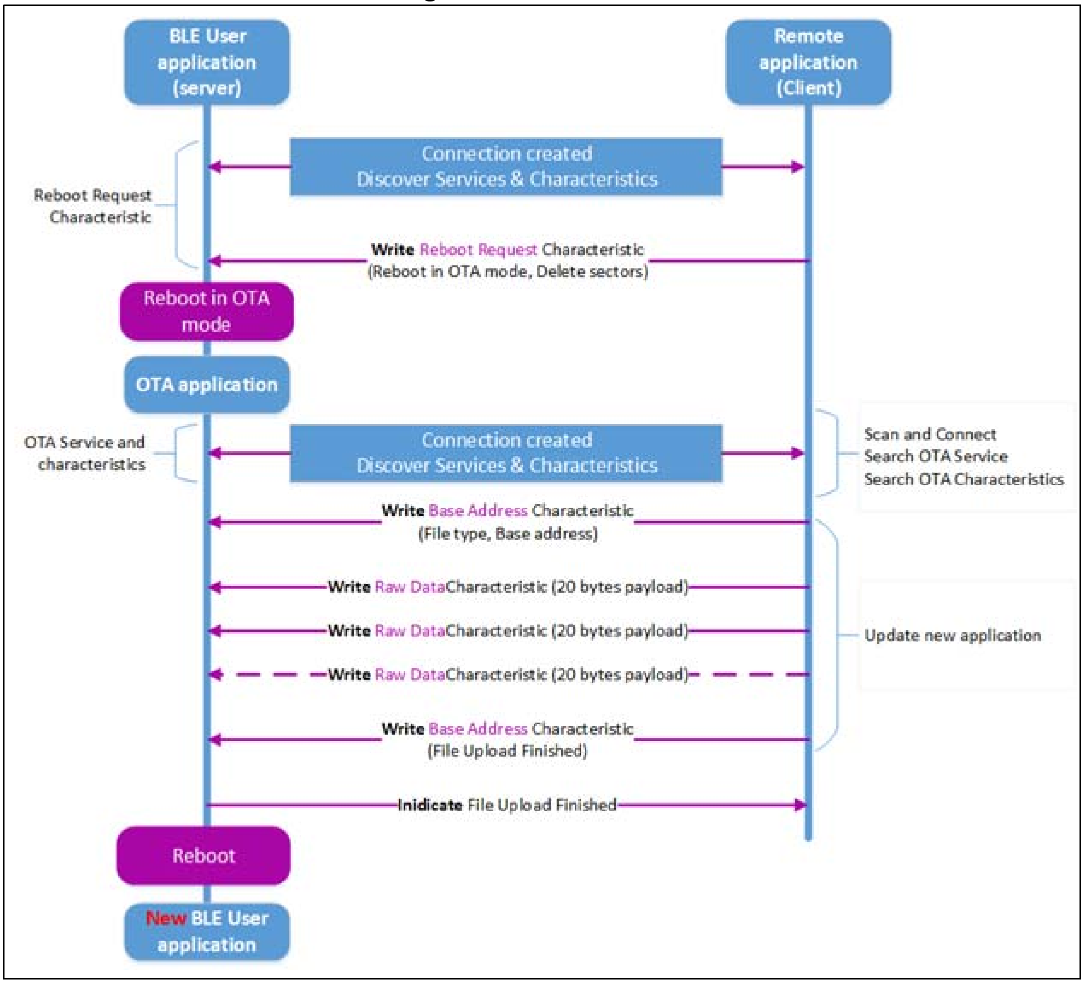
| Bit(s) | Field |
|---|---|
| 15 | Reserved |
| 14 | Thread support |
| 13 | OTA reboot request |
| 12-0 | Reserved |

## 3.3 Flow description

*Figure 9* details the messages and data exchanges between the device and the client during an update procedure.

The first connection is made by the user application. It advertises a Reboot request characteristic to the client (step 1). When the client requests for a device reboot a new connection is established, this time between OTA application and the client (step 2).

**Figure 9. OTA dataflow**




## 3.4 Wireless and FUS update procedure

Wireless stack and FUS are encrypted. After their download a FUS service is called to decrypt and install at the right place the new firmware.

The new wireless stack may be moved from its download area by FUS to optimize memory space.

If the new FUS image size is larger than existing one, the upgrade may result in moving the wireless stack lower in Flash memory (address defined by FUS). If a user code is written in the sectors close to the wireless stack start sector, these sectors risk to be erased during this operation. For details refer to [2].

## 3.5 Updater clients

OTA request comes from a BLE client with dedicated applications. STMicroelectronics provides two clients with this capability:

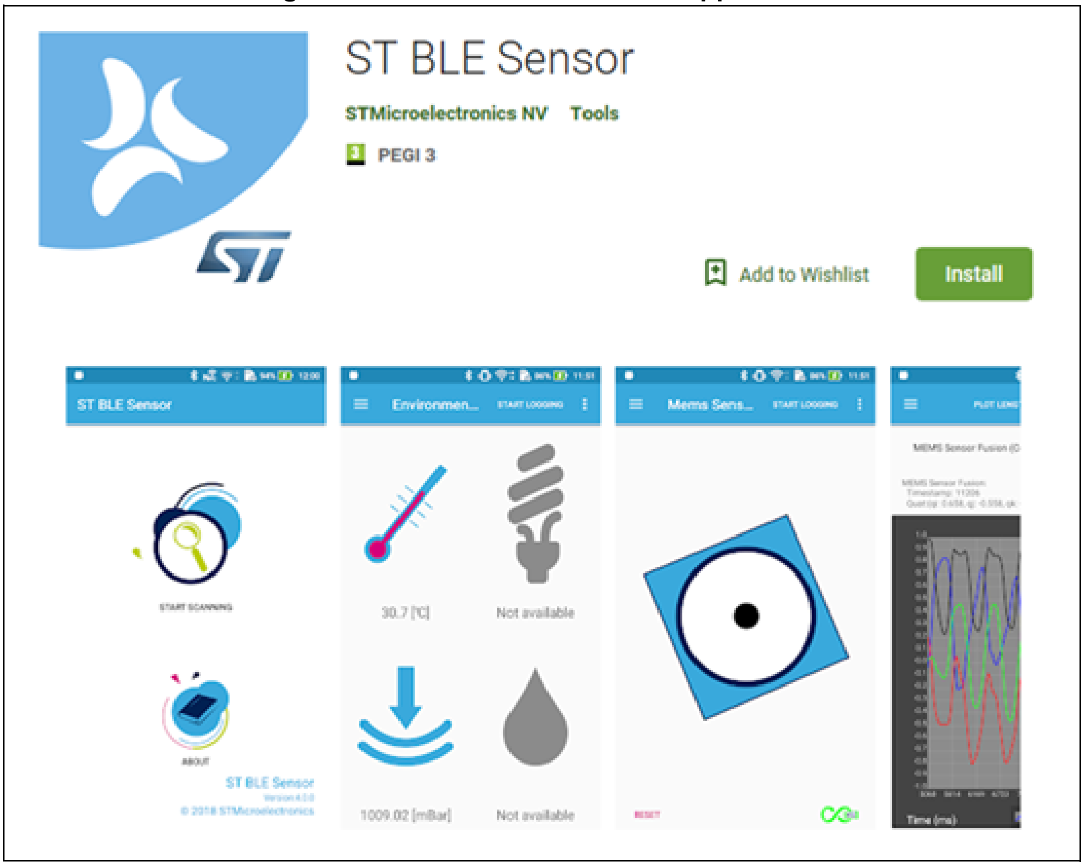
1. ST BLE Sensor, a mobile application that supports both types of update (application and wireless firmware)
2. STM32CubeMonitor RF, a PC tool that allows the user to update its application with a dongle featuring a BLE transparent mode implementation.

### 3.5.1 ST BLE Sensor

The ST BLE Sensor application is used in conjunction with an ST development board and firmware compatible with the BLE protocol. It gives access to all sensor data available on board that can be logged to different cloud providers. It supports also the firmware OTA update procedure.

The application is available on both App Store® and Google Play™ (*Figure 10*). In addition, both SDK and application source code are freely available at dedicated pages on https://github.com.

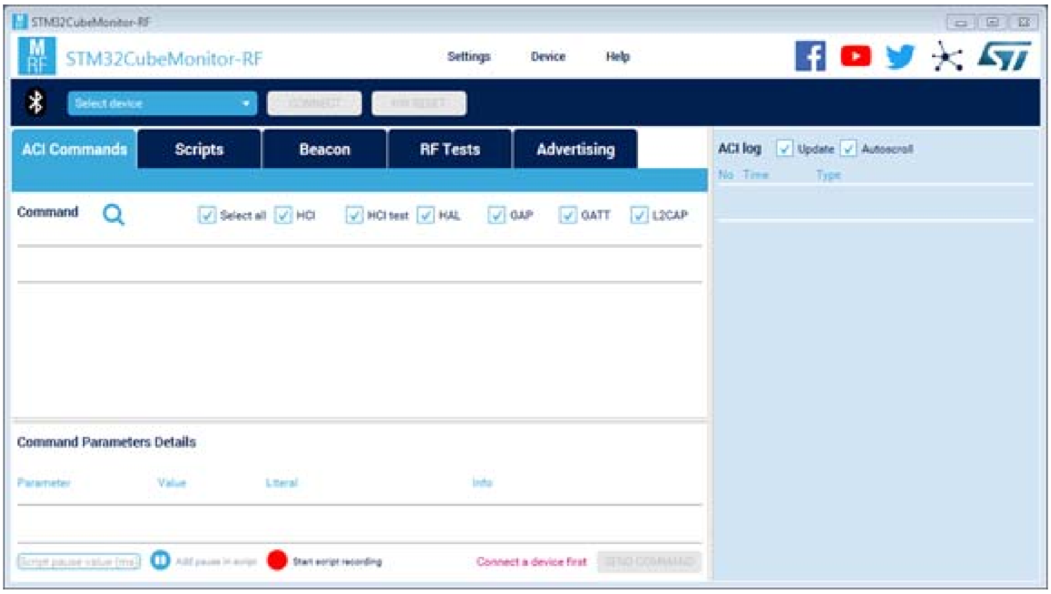
**Figure 10. ST BLE Sensor mobile application**



### 3.5.2 STM32CubeMonitor-RF

STM32CubeMonitor-RF (*Figure 11*) is a software tool, which helps designers to test their products based on STM32 microcontrollers.

**Figure 11. STM32CubeMonitor-RF**

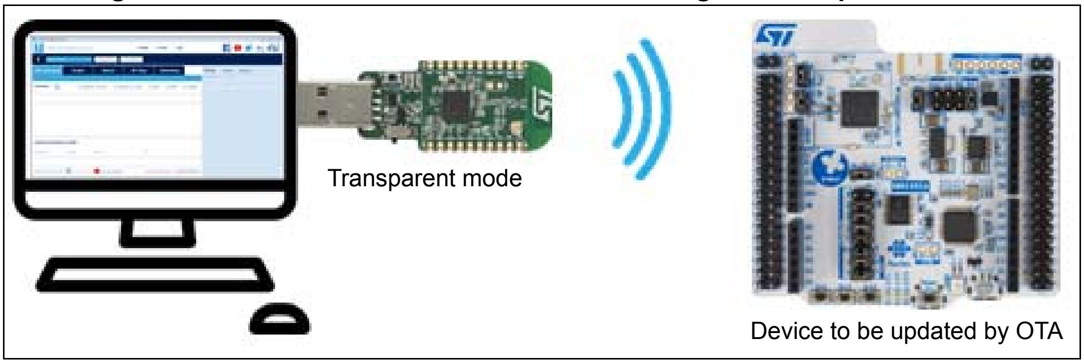



The tool performs the following operations:

- sends and receives test packets to check the efficiency of radio frequency boards and compute packet error rate (PER)
- sends commands to a Bluetooth® low energy (BLE) controller for standardized tests
- sends and receives BLE commands for fast application prototyping
- configures a variety of beacons via BLE commands
- transfers data over-the-air (OTA) from one device to another, in order to configure or program a remote device without wired connection
- sends commands to an OpenThread device for application prototyping.

STM32CubeMonitor-RF is usually connected to the targeted device STM32WB device through UART (physical link). OTA operation however requires the use of a STM32WB55 USB dongle loaded with a special firmware called ‘transparent mode’ (*Figure 12*). Data and command sent/received by the PC tool are directly transmitted to the HCI interface of the device to be updated. The firmware of “transparent mode” application is provided within STM32Cube_FW_WB package.

**Figure 12. STM32CubeMonitor-RF with USB dongle in transparent mode**




The OTA procedure with STM32CubeMonitor-RF is detailed in *Section 4.3*.

# 4 OTA step by step

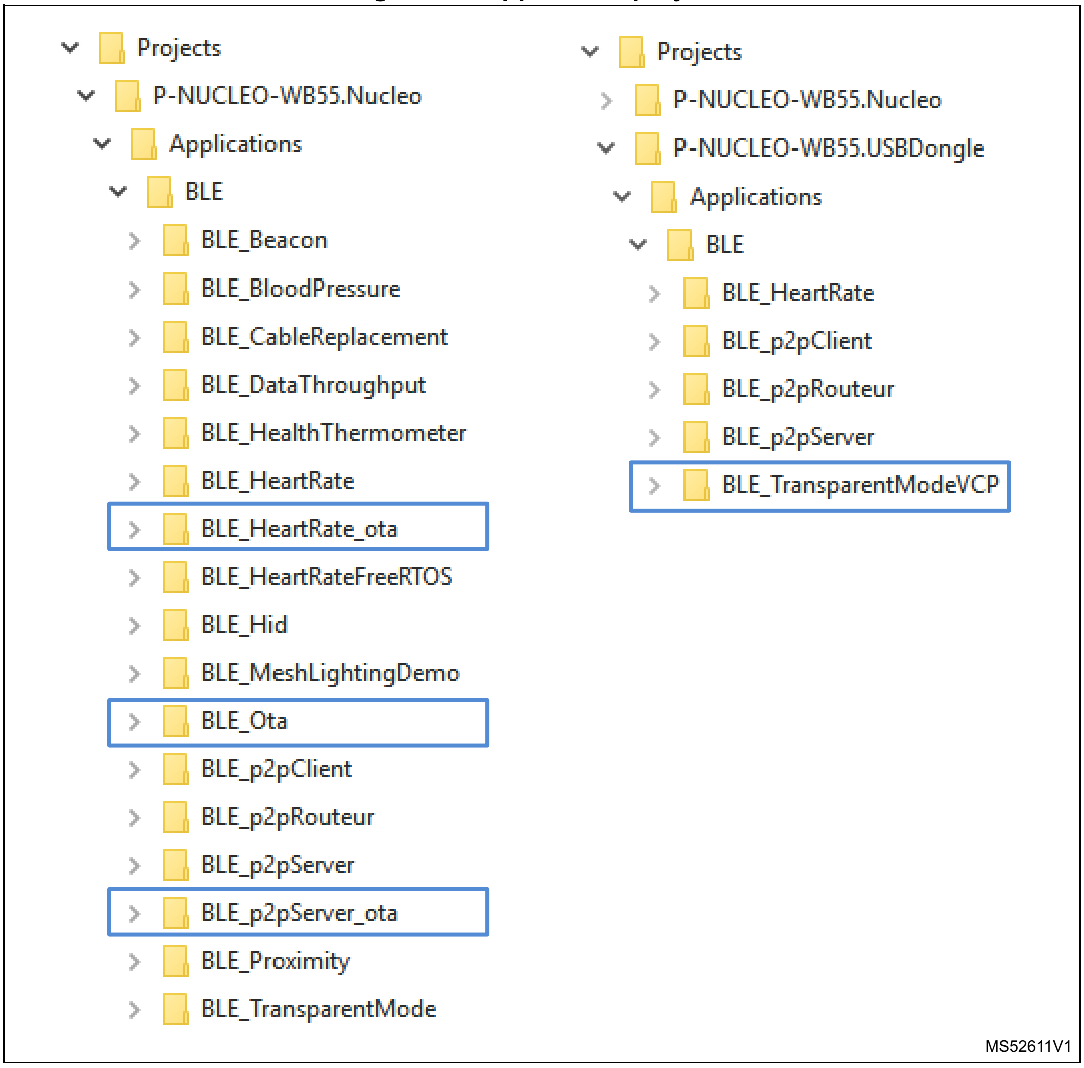
This section describes how to update firmware of a STM32WB device on Nucleo-WB55RG board. Two use-cases are described:

1. user application with ST BLE Sensor mobile application
2. user application with STM32CubeMonitor-RF tool and USB dongle.

Three applicative projects plus the dongle transparent mode firmware (highlighted in *Figure 13*) are considered in this document. They are all provided within the STM32Cube_FW_WB package available on *www.st.com*.

The target device is a Nucleo board, porting to all STM32WB devices and boards is straightforward.

**Figure 13. Applicative projects**

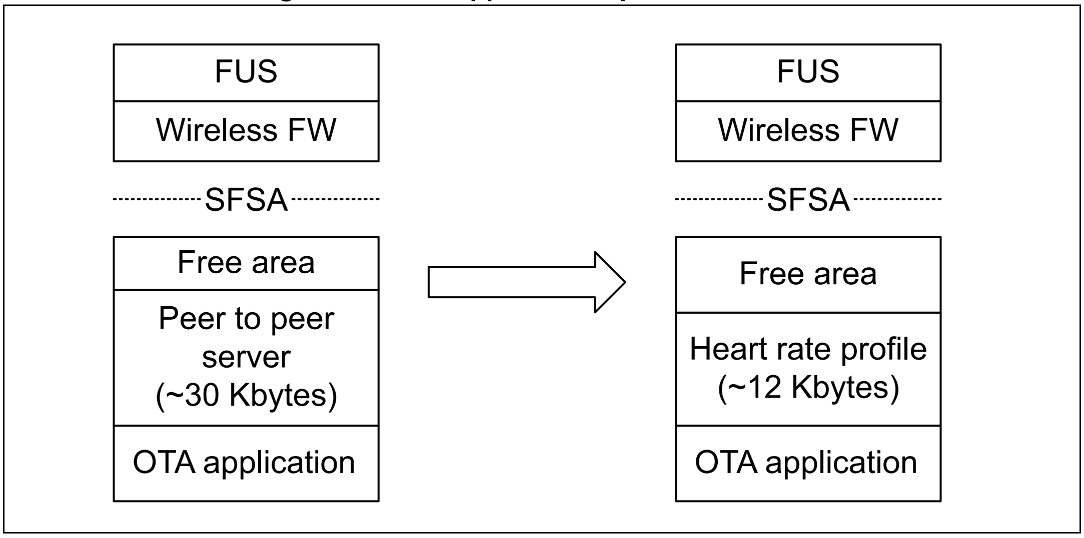


## 4.1 Project setup

### 4.1.1 User applications

The example developed here considers a device functionality modification. The device is initially programmed with peer-to-peer server application then, after the update, it supports the typical heart rate profile (*Figure 14*).

**Figure 14. User application update - Use case**




Both are BLE applications providing services, with the characteristics defined in *Table 6*.

A Reboot request, as defined in *Section 3.2.1* is added to their main service. Even if the use-case presented here uses this capability for the peer-to-peer server, it is added in the Heart profile too for future updates.

**Table 6. Services and characteristics of example applications**

| Application | Service (UUID) | Characteristics |
|---|---|---|
| Peer-to-peer server | P2P_SERVICE 0000FE40-cc7a-482a-984a-7fed5b3e58f | P2P_WRITE_CHAR |
| | | P2P_NOTIFY |
| | | REBOOT REQUEST |
| Heart rate SIG profile | DEVICE_INFORMATION_SERVICE (0x180A) | MANUFACTURER_NAME |
| | | MODEL_NUMBER |
| | | SERIAL_NUMBER |
| | | HARDWARE_REVISION… |
| | HEART_RATE_SERVICE (0x180D) | HEART_RATE_MEASUREMENT |
| | | SENSOR_LOCATION |
| | | CONTROL_POINT |
| | | REBOOT REQUEST |

Table 6. Services and characteristics of example applications (continued)

| Application | Service (UUID) | Characteristics |
|---|---|---|
| OTA application | OTAS_SVC 0000fe20-cc7a-482a-984a-7f2ed5b3e58f | OTA_BASE_ADR_CHAR |
| | | OTA_CONF_CHAR: |
| | | OTA_RAW_DATA_CHAR |

### Add REBOOT_REQUEST characteristic

For both applications the file ble_conf.h must be modified to include the new characteristic. Set BLE_CFG_OTA_REBOOT_CHAR to 1 to add it.

```
/*************************************************************************
 * Over The Air Feature (OTA) - STM Proprietary
 *************************************************************************/
#define BLE_CFG_OTA_REBOOT_CHAR           1 /**< REBOOT OTA MODE
CHARACTERISTIC */
```

### Change linker file

To take into account the new memory placement of the user application (above OTA application), the linker file must be modified. The binary is generated with a reset vector moved up from seven sectors.

IAR™ ICF file

A four bytes offset on SRAM1 is added because the first 32-bit word is used by the “Reboot request” characteristic to indicate an OTA request after a system reboot.

```
/*-CPU Vector Table- Without OTA support*/
define symbol __ICFEDIT_intvec_start__ = 0x08000000;
/*-Memory Regions-*/
define symbol __ICFEDIT_region_ROM_start__ = 0x08000000;
define symbol __ICFEDIT_region_ROM_end__   = 0x0807FFFF;
define symbol __ICFEDIT_region_RAM1_start__ = 0x20000004;
define symbol __ICFEDIT_region_RAM1_end__   = 0x2002FFFF;

/*-CPU Vector Table- With OTA application*/
define symbol __ICFEDIT_intvec_start__ = 0x08007000;
/*-Memory Regions-*/
define symbol __ICFEDIT_region_ROM_start__ = 0x08007000;
define symbol __ICFEDIT_region_ROM_end__   = 0x0807FFFF;
define symbol __ICFEDIT_region_RAM1_start__ = 0x20000004;
define symbol __ICFEDIT_region_RAM1_end__   = 0x2002FFFF;
```

Keil® scatter file

```
/*-CPU Vector Table- Without OTA support*/
LR_IROM1 0x08000000 0x00080000  {    ; load region size_region
  ER_IROM1 0x08000000 0x00080000  {  ; load address = execution address
```

```
    *.o (RESET, +First)
    *(InRoot$$Sections)
    .ANY (+RO)
  }
  RW_IRAM1      0x20000004 0x2FFFC   {  ; RW data
    .ANY (+RW +ZI)
  }

/*-CPU Vector Table- With OTA application*/
LR_IROM1 0x08007000 0x260 {     ; load region size_region
  ER_IROM1_LOW 0x08007000 0x260   {  ; load address = execution address
 *.o(RESET, +First)
 *.o (TAG_OTA_START)
  }

  RW_IRAM1 0x20000004 0x0002FFFC  {  ; RW data
    .ANY (+RW +ZI)
  }
```

### Delete the VTOR table configuration

When the application is expected to be downloaded by OTA, the SCB→VTOR must be not modified as it has already been set to the correct value by the BLE_Ota application before jumping to the current application.

Comment out this line of code in SstemInit():

```
// SCB->VTOR = VECT_TAB_OFFSET;
```

### Compilation and programming

Compile and download peer-to-peer application in the Nucleo board.

Compile Heart rate application. The generated binary is downloaded by the OTA client. With EWARM IDE, the file is available in the project under EWARM/with_ota/Exe directory BLE_HeartRate_ota.bin.

Copy this binary to the smartphone running the ST BLE Sensor application.

## 4.1.2 OTA application

OTA application setup is straightforward. Compile and download the binary at the beginning of Flash memory (0x08000000).

To check if the full firmware has been written, a magic keyword is written at the end of the firmware. At startup, the Ble_Ota application checks whether this magic keyword is there or not at the end of the application thanks to CheckFwAppValidity() function.

In case of a reset during upload (which could result in a partial image to be written), the magic keyword is not there and the corrupted application is ignored by the Ble_Ota startup.

As the application length information is not present, the address of the magic keyword is written at address 0x0800 7140.

To make the calculation transparent to the user, two constants are defined in the firmware:

- one holds the address of the magic keyword and is associated with section TAG_OTA_START
- the other one holds the magic keyword and is associated with TAG_OTA_END.

## 4.2 Firmware update with ST BLE Sensor

### 4.2.1 Device connection

Check the device correct behavior by initiating a Peer-to-peer connection with the smartphone hosting ST BLE Sensor application.

#### Device Bluetooth MAC address

MAC address of Nucleo board is set from the device unique ID. It can be retrieved at addresses 0x 0x1FFF7580 and 0x1FFF7584.

**Table 7. Example (device Bluetooth MAC address = 80:E1:25:00:50:D6)**

| Register address | Value | Field |
|---|---|---|
| 0x1FFF7580 | 0xXX0050D6 | LSB part of MAC @ |
| 0x1FFF7584 | 0xXX80E125 | MSB part of MAC @ |

### Connection

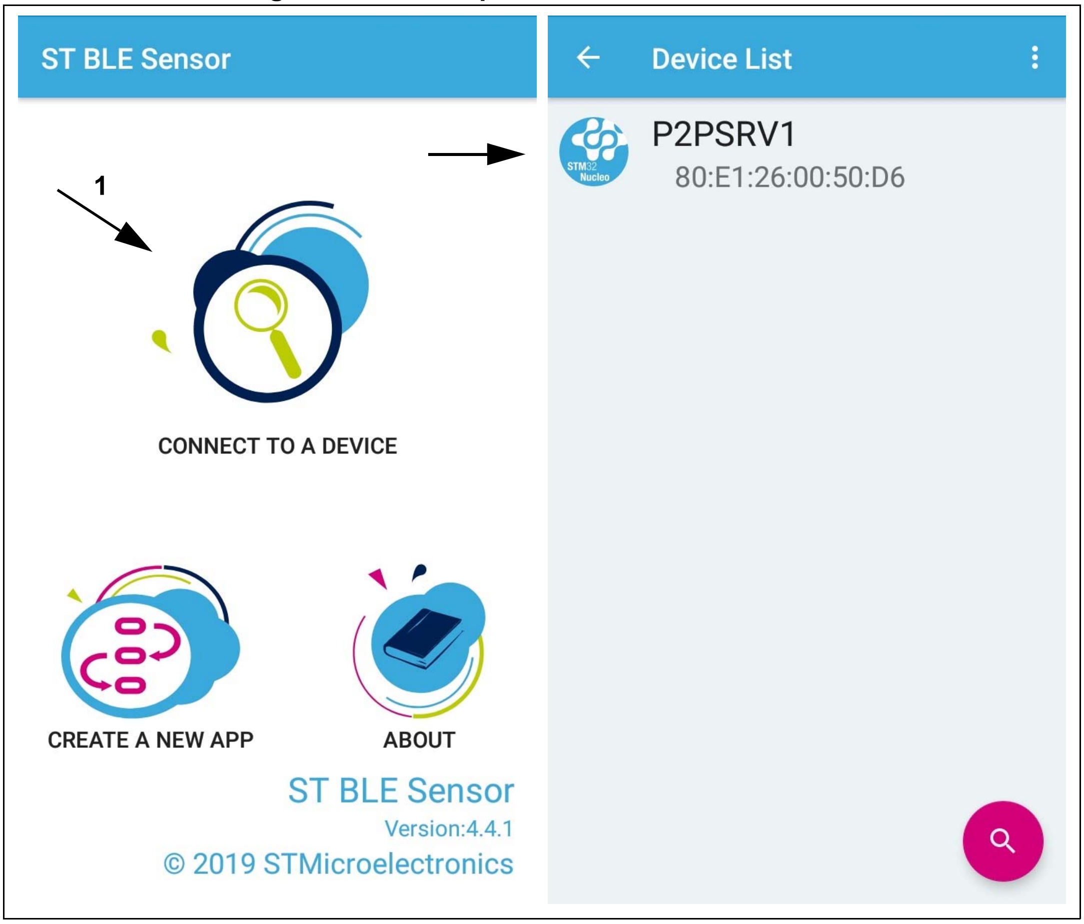
Follow the steps listed below.

1. Press the reset button (SW4) of the Nucleo board to start the device advertising (peripheral role).

*Note: The green led (LED2) of the Nucleo board has to blink during the smartphone scan. If this is not the case, it is because the advertising stops after 1 minute. Press the Nucleo board reset button (SW4) to start again the advertising.*

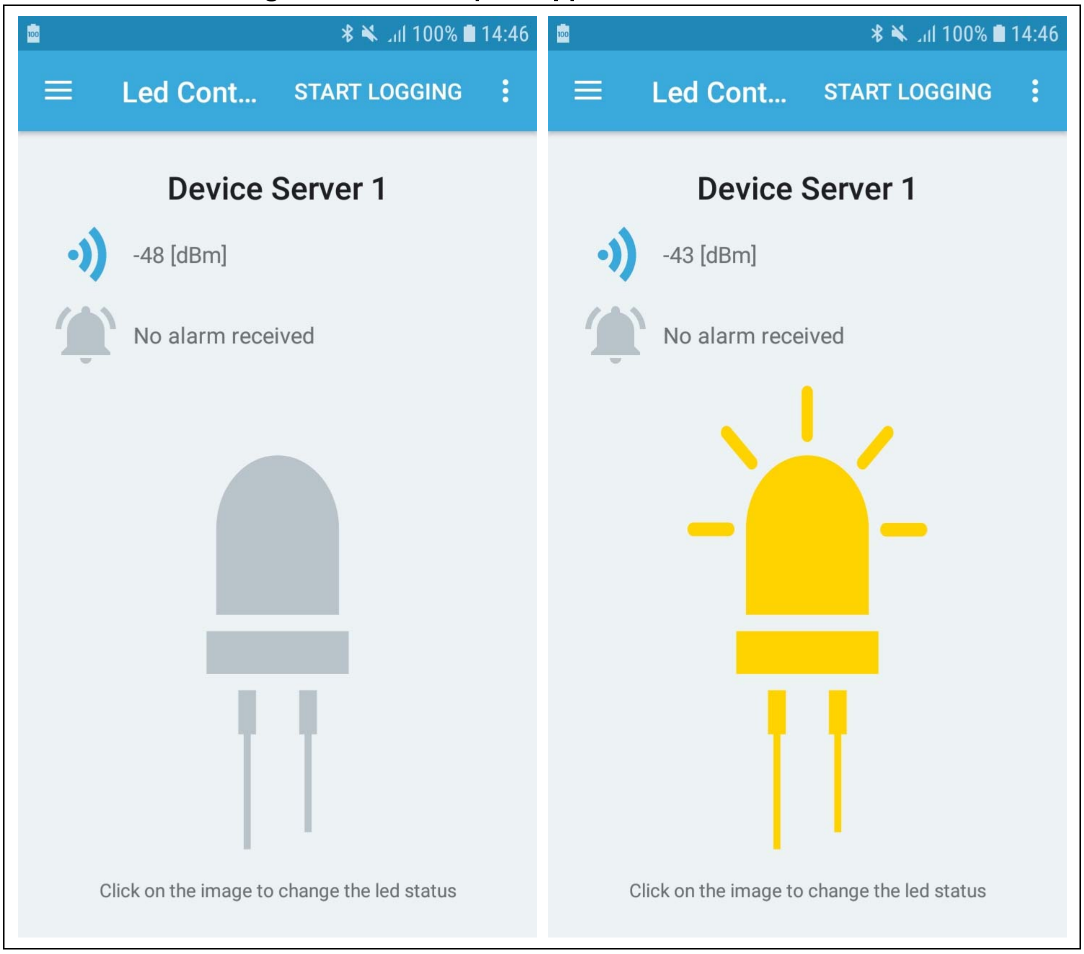
2. The smartphone plays the central role, it must scan to detect the device. Click on “Connect to a device”. A device named “P2PSRV1” is detected, as shown in *Figure 15*. Check that the BD Address corresponds to your board.

**Figure 15. Peer-to-peer server device detection**




3. Click on “P2PSRV1” to create the connection with the Nucleo board.
4. When the application main menu appears, the smartphone and the Nucleo board are connected.
5. LED1 (blue) of Nucleo board can be switched on and off by clicking on the LED picture (*Figure 16*).

Figure 16. Peer-to-peer application / LED switch

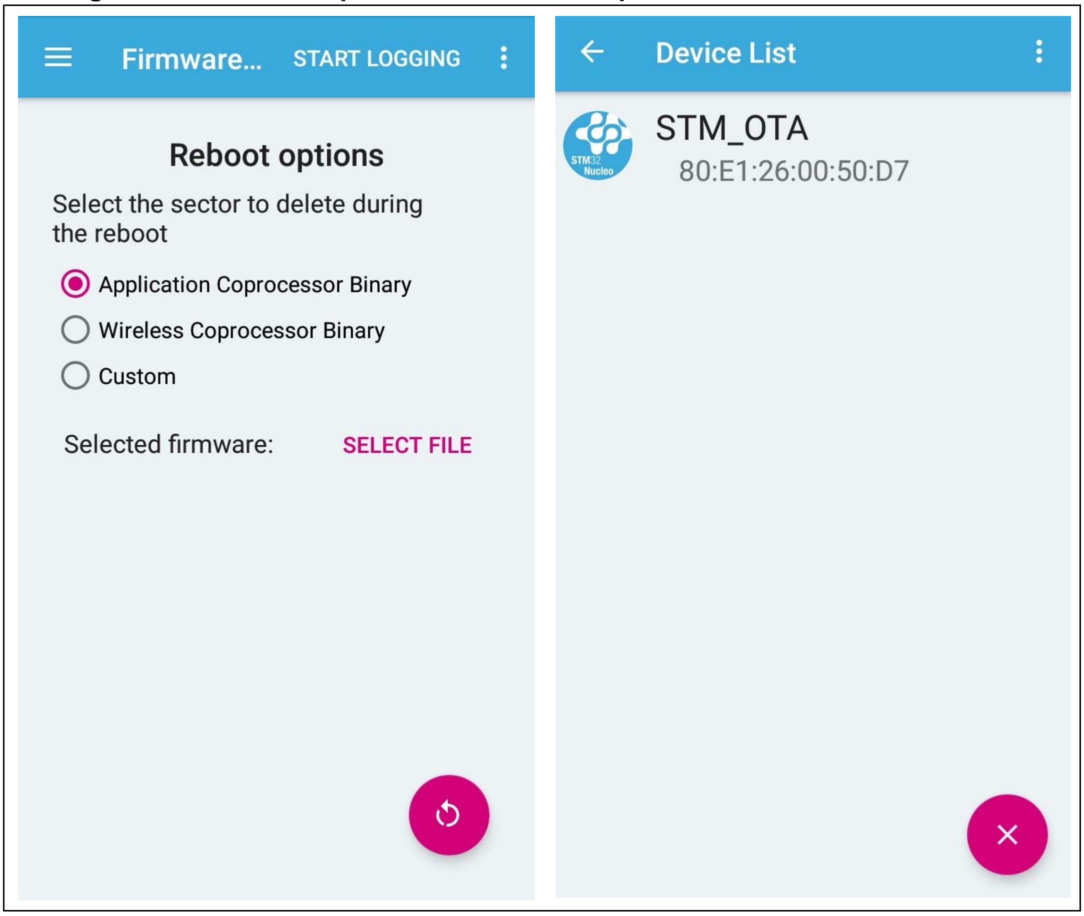


### 4.2.2 Update of user application

After checking the peer-to-peer functionality, swipe to the left to get the firmware Update panel (left side of *Figure 17*). Select “Application” and click on the Reboot sign at the screen bottom. You do not need to select the file name at this step.

Re-scan to find the new service (right side of *Figure 17*). Note that Bluetooth MAC address is intentionally modified for OTA application by increasing the first byte. This is to ensure that the client launches a new discovering phase to detect new services.

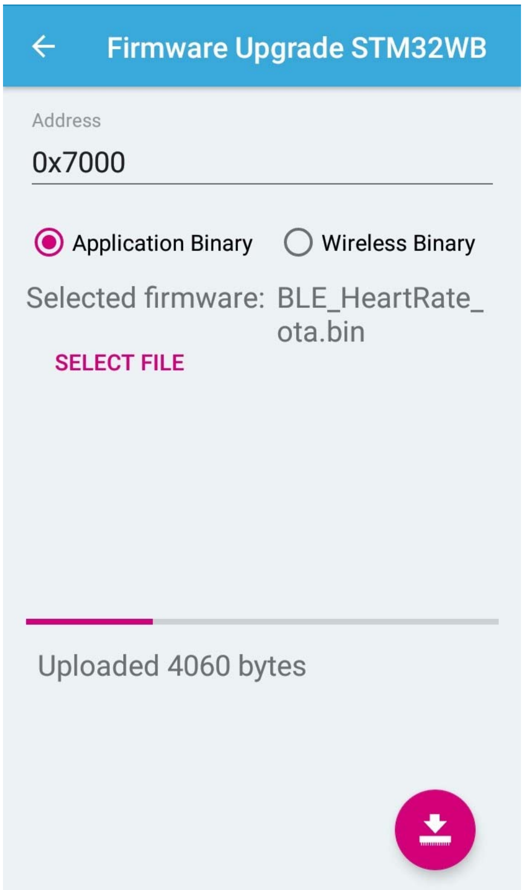
**Figure 17. Firmware update ST BLE Sensor panel and OTA service detected**



After connection with STM_OTA application (*Figure 18*), enter the address where the new application is downloaded (0x7000 in this case).

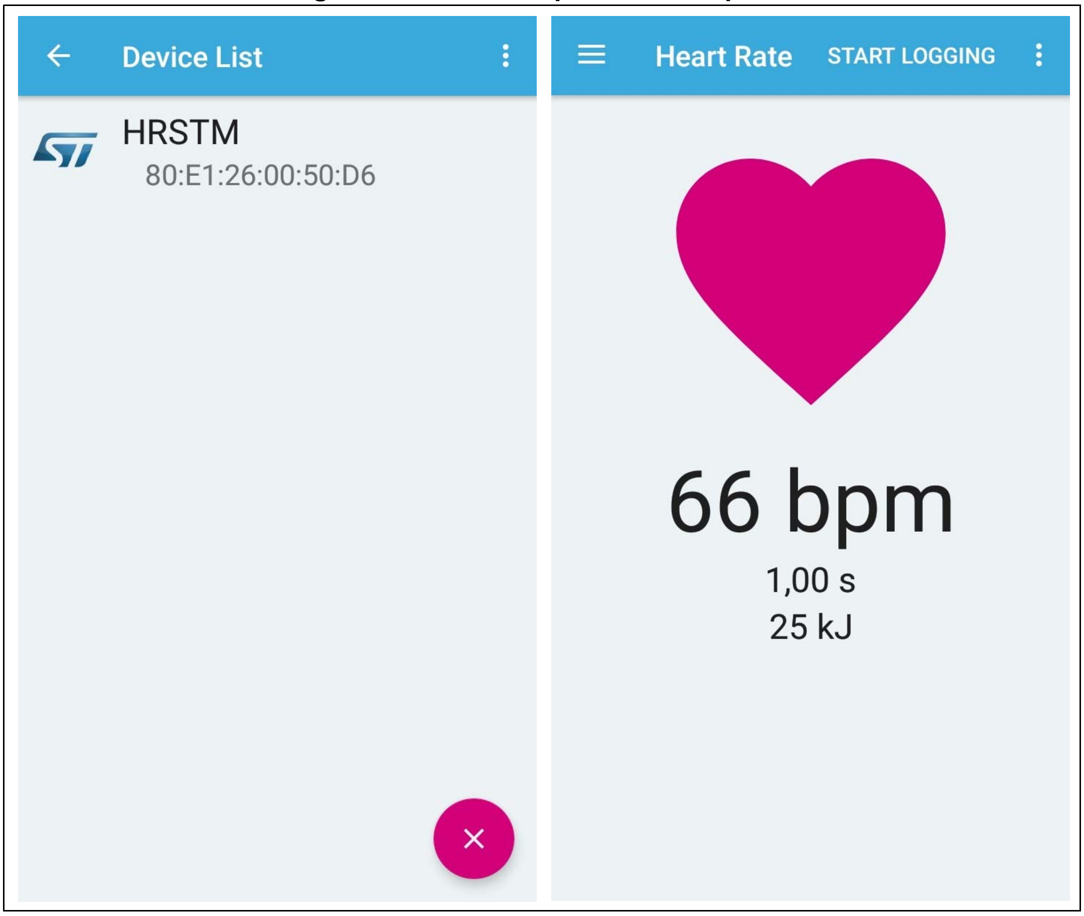
Choose “Select File” and enter the heart rate application binary that you have transferred before in the smartphone. Select the download button; the progress of the upload appears on the screen and finally a pop up window is displayed with the time elapsed (see the right side of *Figure 18*).

**Figure 18. Download of new application**




Connect again to the device (same initial Bluetooth address) and verify the functionality (*Figure 19*).

**Figure 19. Heart rate profile after update**

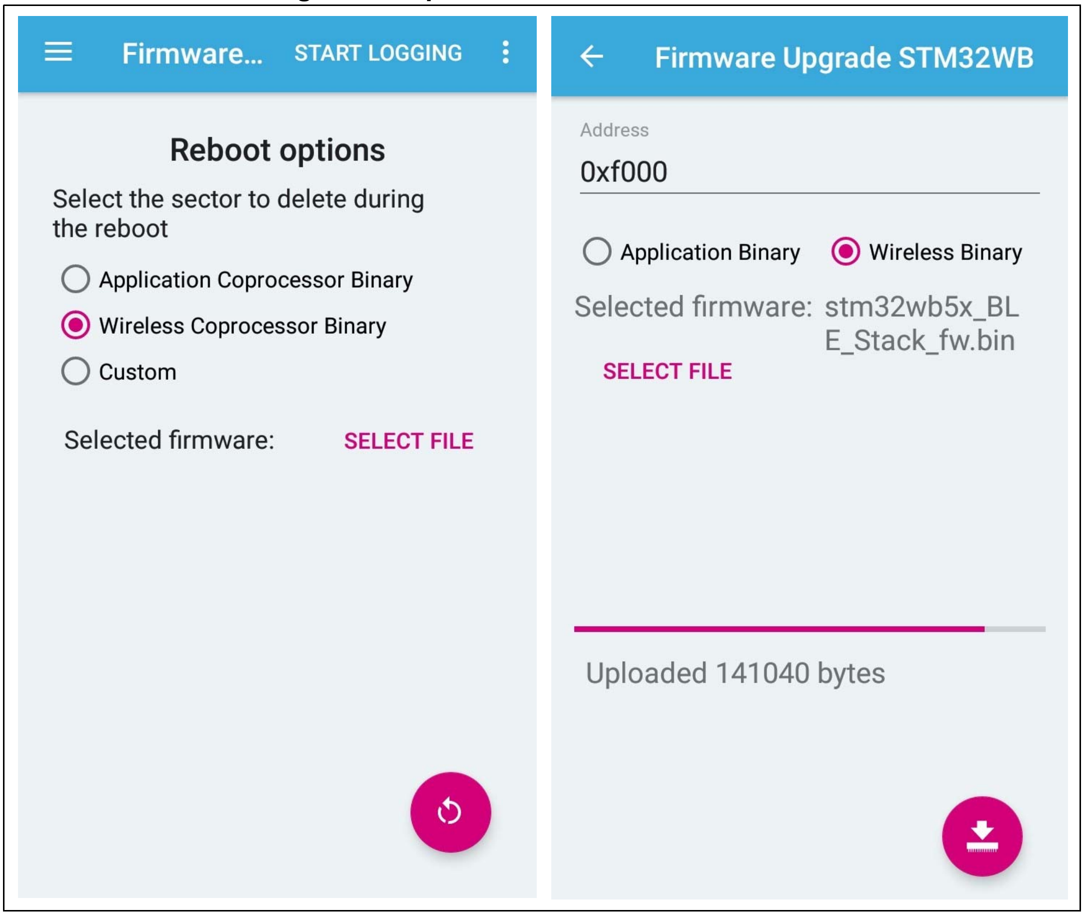


### 4.2.3 Update of wireless stack or FUS

For CPU2 firmware upgrade, select “Wireless Coprocessor Binary” option (left side of *Figure 20*) and select the right binary. Wireless stack and FUS firmware are delivered in STM32Cube_FW_WB packages available on https://github.com or on *www.st.com*.

Once downloaded (right side of *Figure 20*), the new firmware is decrypted and installed by the current FUS.

**Figure 20. Update of wireless stack or FUS**




## 4.3 Firmware update with STM32CubeMonitor-RF

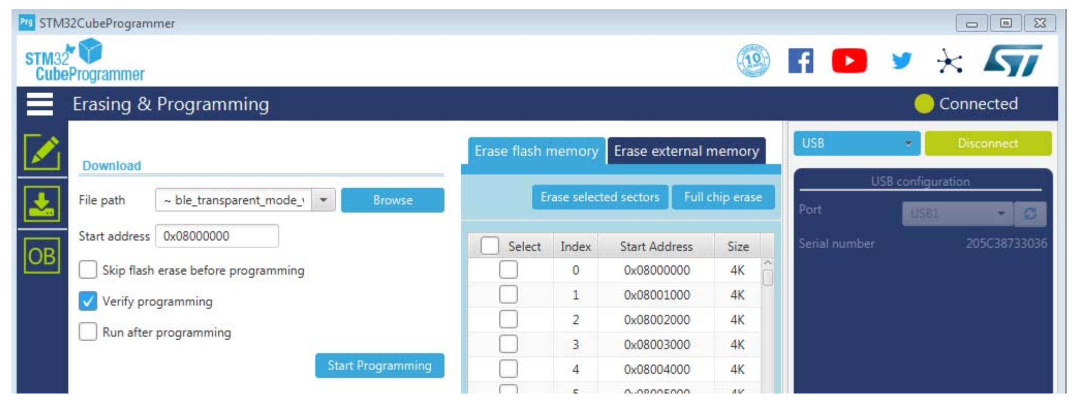
### 4.3.1 Transparent mode

STM32CubeMonitor-RF transmits HCI commands and data to the targeted Nucleo board through a Bluetooth device to simulate a true OTA application. The USB dongle, provided with the Nucleo STM32WB package is configured in “transparent mode” for this purpose.

1. Open and compile ~\Projects\NUCLEO-WB55.USBDongle\Applications\BLE\BLE_TransparentModeVCP project.
2. Once programmed, move back the BOOT0 switch to 0.

The USB Dongle can be easily programmed in USB-DFU mode with STMCubeProgrammer (version 2.0 and above) tool (*Figure 21*). To access DFU mode, move the BOOT0 switch to 1 (to the right on *Figure 21*).

**Figure 21. USB Dongle programming in USB DFU mode with STM32CubeProgrammer**




### 4.3.2 Update of the user application

1. Open STM32CubeMonitor-RF and select the COM port emulated by the USB dongle. Connect the device.
2. Make sure the Nucleo board is correctly configured with OTA application and peer-to-peer server profile (*Section 4.1*)
3. On the upper menu, click on “Device” and “OTA Updater”
4. Let the Advertising filter box selected and click on “SEARCH FOR DEVICES
5. At the end of the scanning, click on “Select device” and choose your device (P2PSRV1-OTA enabled with the right Bluetooth address)
6. Select CPU1 for user application (*Figure 22*) or CPU2 for wireless or FUS update (*Figure 23*).
7. Browse for the right binary file and select “Update”

Figure 22. Update of the user application

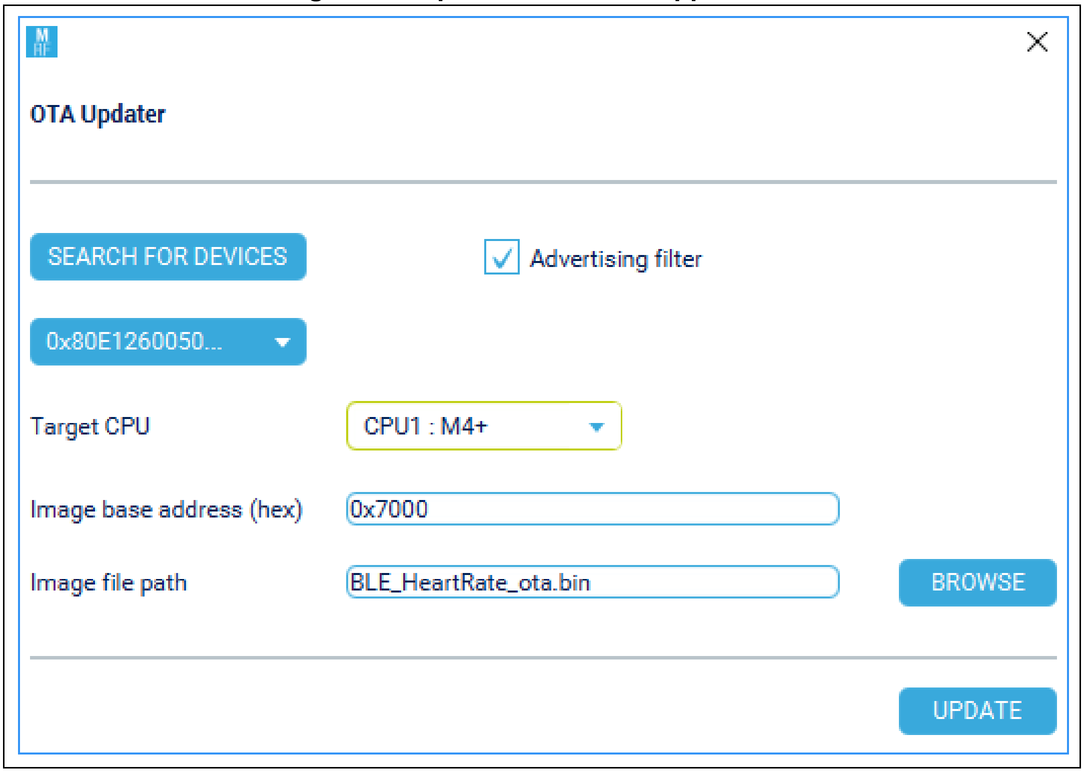
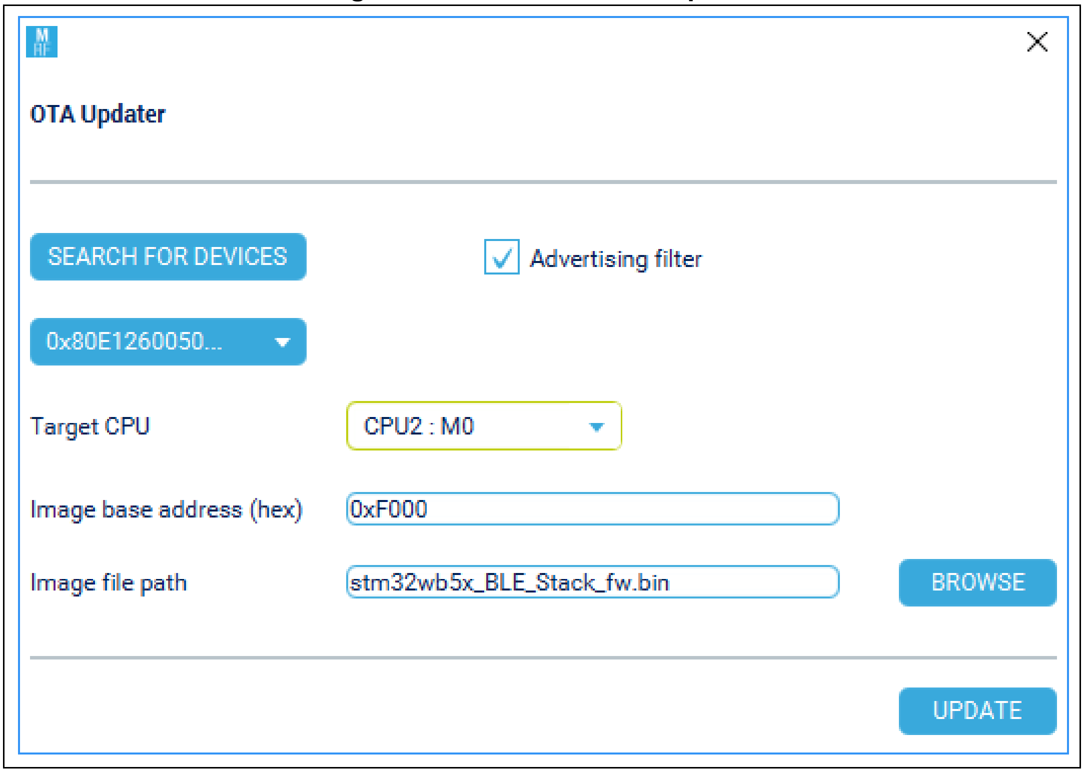



Figure 23. Wireless or FUS update



# 5 Conclusion

This document note shows how to update firmware using the BLE protocol.

OTA relies on a dedicated application embedded in the Flash memory in addition to the user BLE application. The OTA service is called from the current user application following a BLE request sent by one of the two clients provided by ST (mobile application and STM32CubeMonitor-RF development tool).

The user application, the wireless firmware and the FUS can be updated independently.

# 6 Revision history

**Table 8. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 21-Feb-2019 | 1 | Initial release. |
| 07-Jun-2019 | 2 | Updated *Introduction*, *User application, wireless firmware and FUS update*, *Section 4.2.2: Update of user application*, *Section 4.3: Firmware update with STM32CubeMonitor-RF*, *Section 4.3.2: Update of the user application* and *Section 5: Conclusion*.<br>Updated *Table 2: OTA Service and characteristics declaration*, *Table 4: AD structure - Manufacturer specific field*, *Table 6: Services and characteristics of example applications* and *Table 7: Example (device Bluetooth MAC address = 80:E1:25:00:50:D6)*.<br>Updated *Figure 1: STM32WB dual core FW architecture*, *Figure 13: Applicative projects*, *Figure 15: Peer-to-peer server device detection*, *Figure 17: Firmware update ST BLE Sensor panel and OTA service detected*, *Figure 18: Download of new application* and *Figure 19: Heart rate profile after update*.<br>Added *Section 3.4: Wireless and FUS update procedure* and *Section 4.2.3: Update of wireless stack or FUS*. |
| 18-Feb-2021 | 3 | Replaced RSS with FUS throughout the whole document.<br>Updated *Section 1: Glossary*, *Section 3.1.1: Principle* and *Section 4.1.2: OTA application*.<br>Updated *Figure 1: STM32WB dual core FW architecture*, *Figure 4: Simplified memory map of applications*, *Figure 6: User application update*, *Figure 7: wireless firmware update* and *Figure 14: User application update - Use case*.<br>Minor text edits across the whole document. |