Project	Active and Assisted Living Programme AAL-2016 – Living with Dementia	

“CARELINK for Dementia suffers and their community”

Deliverable D3.3 Sensor Suite Development

Work package:	WP3 – Platform and Sensor Implementation
Prepared By/Enquiries To:	Jorge Calado, Rafael Rodrigues, Joana Andrade, Fernando Ferreira, João Sarraipa - Uninova
Reviewer:	Philip O’Brien
Status:	Final
Date:	01/10/2020
Version:	FINAL
Classification:	Public

Authorised by:

Gary McManus
WIT

Reviewed by:

Philip O’Brien
WIT

Authorised date: __01_/_10_/_2020_

Project Funding Support

This project would not be possible without the support of the Ambient Assisted Living Joint Programme. The work has been promoted under the project CARELINK, AAL-CALL-2016-049 funded by AAL JP, and co-funded by the European Commission and National Funding Authorities of Ireland, Belgium, Portugal and Switzerland.

Partner	Country	National Funding Body	Logo
WATERFORD INSTITUTE OF TECHNOLOGY (WIT)	IRELAND	ENTERPRISE IRELAND	ENTERPRISE IRELAND
INSTITUTO DE DESENVOLVIMENTO DE NOVAS TECNOLOGIAS (UNINOVA)	PORTUGAL	FUNDAÇÃO PARA A CIÊNCIA E A TECNOLOGIA	FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR
U-SENTRIC	BELGIUM	IWT AGENTSCHAP VOOR INNOVATIE DOOR WETENSCHAP EN TECHNOLOGIE	iwt
OPEN SKY DATA SYSTEMS LTD	IRELAND	ENTERPRISE IRELAND	ENTERPRISE IRELAND
AKADEMIE BERLINGEN	SWITZERLAND	FEDERAL DEPARTMENT OF ECONOMIC AFFAIRS, EDUCATION AND RESEARCH EAER	Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra
CREAGY AG	SWITZERLAND	FEDERAL DEPARTMENT OF ECONOMIC AFFAIRS, EDUCATION AND RESEARCH EAER	Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra

Disclaimer:

This document reflects only authors' views. Every effort is made to ensure that all statements and information contained herein are accurate. However, the Partners accept no liability for any error or omission in the same. EC or AAL is not liable for any use that may be done of the information contained therein.

CARELINK Project Profile

Contract No.: **AAL-2016-049**

Acronym:	CARELINK
Title:	CARELINK for Dementia suffers and their community.
URL:	www.carelink-aal.org
Twitter	@Carelink_aal
LinkedIn Group	Carelink
Facebook Page	http://www.facebook.com/Carelink
Start Date:	01/08/2017
Duration:	30 months

Partners

TSSG	WATERFORD INSTITUTE OF TECHNOLOGY (WIT) - [COORDINATOR]	IRELAND
UNINOVA	UNINOVA - INSTITUTO DE DESENVOLVIMENTO DE NOVAS TECNOLOGIAS (UNI)	PORTUGAL
u-sentric design, for people	U-SENTRIC (USE)	BELGIUM
opensky YOUR VISION.REALISED.	OPEN SKY DATA SYSTEMS LTD (OSD)	IRELAND
AKADEMIE Offen für Neues BERLINGEN	AKADEMIE BERLINGEN (AKA)	SWITZERLAND
CREAGY	CREAGY AG (CRE)	SWITZERLAND

Document Control

This deliverable is the responsibility of the Work Package Leader. It is subject to internal review and formal authorisation procedures in line with ISO 9001 international quality standard procedures.

Version	Date	Author(s)	Change Details
0.1	14/12/2020	Jorge Calado	Initial draft for review.
0.2	07/07/2020	Jorge Calado	Final draft for review.
1.0	01/10/2020	Gary McManus	Approved Final release.

Executive Summary

Objectives

This deliverable specifies and details the Sensor Suite to be developed within the CARELINK Project. This specification includes the hardware design, based on requirements gathered from WP2 and aims at providing the first draft of the prototype sensor pack, the state of the implementation development and the strategy for using different smart devices as sensor packs that will interact with the Platform. The objective is to promote a controlled and strategically designed interaction that will technically establish communication between devices and the platform. The devices will be configured to provide the appropriate information so that it will be possible to perform the tracking and pattern recognition algorithms, to be run remotely at the platform, along with other algorithms that will be used along with the knowledge base and the carers advisement.

The goals of this deliverable are the following:

- Using the conclusions of the Deliverable 2.2 to set the components of the sensor pack prototypes.
- Deploy a functioning custom hardware prototype pack.
- Deploy a functioning prototype pack using existing hardware solutions, such as a smartphone and smartwatch.
- Integrate the custom hardware prototype pack with the platform, defined in deliverable D3.1, defining protocols for the communication of the Person with Dementia (PwD) data, and for receiving commands to actuate according to the proposed environments and instantiated for each scenario of operation.

Results

The results produced by this deliverable will be available with the implementation and deployment of a customized hardware solution, with modularity and interoperability between localization, communication and sensing modules, using development boards and standard development devices (e.g. Arduino). Additionally, the implementation of a smartwatch/smartphone application will also be studied, offering alternative means of monitoring and integration with the platform.

Table of Contents

TABLE OF FIGURES

TABLES

1 INTRODUCTION

The use cases of technological devices and solutions for dementia patients is a growing ecosystem, that becomes possible by two factors: the increased miniaturization and reduction in costs for devices that already provide location and communication technologies. This is the case of commonly used devices such as smartphones and smartwatches, containing highly advanced and reliable hardware that can be worn daily and are well accepted. In line with this, small devices, even sensor chips, are also available to be integrated in sensor packs along with some processing and communication capabilities.

The modularization and interoperability of System-on-a-Chip (SoC) enables the deployment of development environments focused on energy efficiency and intelligent data gathering and processing.

The resulting conclusions of the state-of-the-art survey lead to the deployment of a custom hardware solution, presented section 3. The assembly of such solution is used for testing the capabilities of each module, including the power consumption rates, environment operability and usability.

Additionally, an implementation using existing commercial devices, namely a smartwatch and a smartphone, is presented in section 4. The profiles developed for the energy management of the different device's usage in the distinct use case scenarios is presented in section 5. An overview of the operational models used for the prototype's implementations functioning, communication and integration to the Carelink Platform is depicted in section 6 as well as the integration of the prototype devices with the platform. Finally, the concluding remarks of the implementations are made in section 7.

2 ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
ECG	Electrocardiogram
BLE	Bluetooth Low Energy
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications
LoRa	Long Range (Long Range Wide Area Network communications)
LTE	Long-Term Evolution mobile communications
MQTT	Message Queue Telemetry Transport
PwD	Person/People with Dementia
TTFF	Time to First Fix

3 CUSTOM HARDWARE PROTOTYPE SOLUTION

3.1 First Stage Prototype Hardware: Arduino-Based GPS and GSM

The first iteration of the prototyping hardware is based on an Arduino development board, comprised by an Arduino Uno controller and an Adafruit FONA 808 Shield with GSM/GPRS and GPS capabilities. The FONA 808 is a Quad-band 850/900/1800/1900MHz GSM cellular module, integrated with the GPS Mt3337 chipset, with tracking sensitivity of -165dBm, TTFF of 32s (cold start), 5s (warm start) and 1s (hot start), and an accuracy of approximately 2.5 meters.

The initial configuration is depicted in Figure 1, and shows the board and the shield stacked together, with the connected GSM and GPS antennas and also a 1350mAh lithium ion polymer battery.

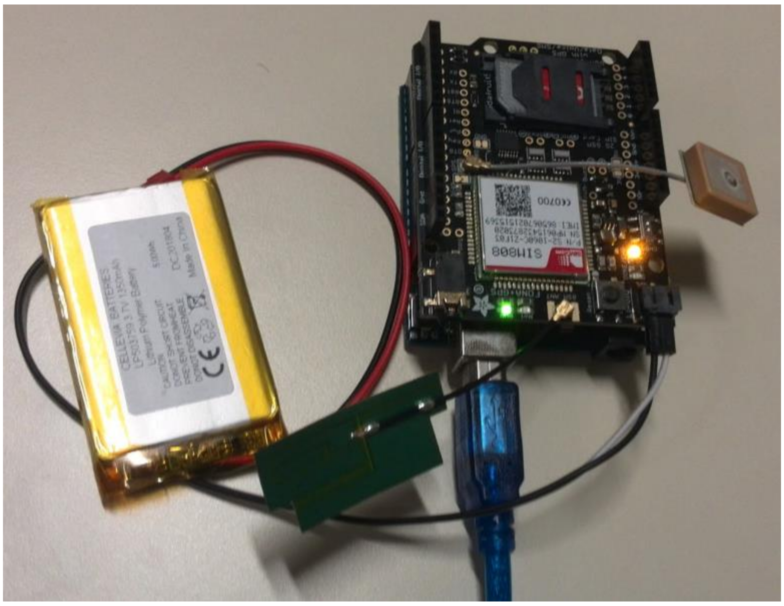


Figure 1 - FONA 808 Development Board

Initial testing of each module power consumption will be deployed using the measuring techniques described in [1], specific for microcontroller-based systems, with a wide dynamic range of power modes and fast current variations.

Additionally, Wi-Fi, Bluetooth, and LoRa communication modules can be interchangeably connected to the Arduino board, to test the best suitable configuration for connectivity and autonomy maximizations.

Error! Reference source not found. Testing will focus the different consumption rates depending on the combination of configurations of the modules and of each module operating mode.

3.2 Second Stage Prototype Hardware: Pycom, Sodaq and Rak Boards

The second stage iteration of the prototype is based on the smaller size boards format (usually called "feather"), with approximate dimensions of 55 x 22 (mm).

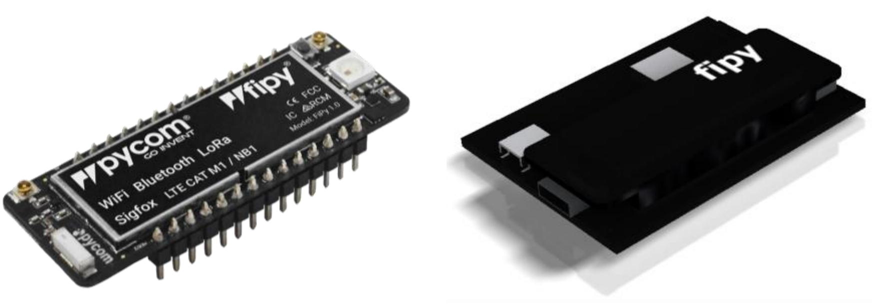


Figure 2 – Pycom fipy board and fipy+pytrack kit

As an example, the Pycom FiPy board, depicted in Figure 2, offers both Wi-Fi, BLE and cellular LTE CAT M1/NB1, with the Fipy offering additional LoRa and SigFox capabilities, which makes them ideal for the requirements of reducing the size of the prototype. Kit dimensions: 56.9x40.4x15.9 [mm]

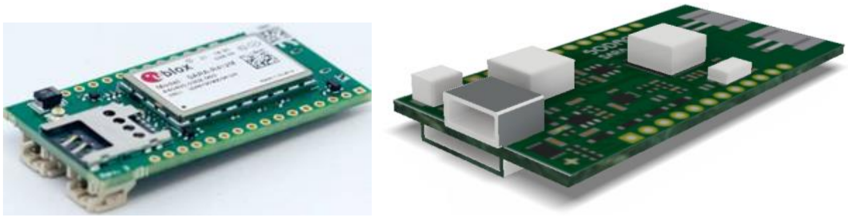


Figure 3 - Sodaq Sara SFF R412M

Another example is the Sodaq Sara SFF R412M board, depicted in Figure 3, that utilizes NB-IoT and LTE-M networks with EGPRS fallback and integrated GPS, Accelerometer and Magnetometers, Grove Connectors, JST connectors and Arduino compatible open source software. Dimensions: 51.1X25.6X6.9 [mm]

Figure 4 - iTracker Pro RAK8212

Another alternative board that was considered was the iTracker Pro RAK8212, depicted in Figure 4, which is a versatile developer board aimed at aiding in quick prototypes using NB-IoT. The board includes a vast array of connectivity options (NB-IoT, BLE 5.0 and GPS) and sensors like an accelerometer, a light sensor and a barometric sensor. At the heart of the module is the venerable Nordic nRF52832 BLE processor. The NB-IoT connectivity is provided by the Quectel BG96 module. The iTracker module is Arduino friendly and can be programmed using the IDE. The board also provides flexible low power consumption development along with myriad of application option ranging from telemetry to live tracking and environment sensing.

Table 1 - Prototype Boards Components Comparison

Board Name	Adafruit FONA 808 Shield	Pycom FiPy	Pycom Pytrack	SODAQ SARA SFF R412M	iTracker Pro RAK8212
Size (mm)	69 x 54 x 17	55 x 20 x 12	55 x 35 x 10	50 x 24.5 x ?	43 x 38 x 18
GSM	✓				
GPRS	✓			✓	
WiFi		✓			
BLE		✓			✓
LoRa		✓			
Sigfox		✓			
LTE-NB1		✓		✓	✓
LTE-CAT M1		✓		✓	✓
GNSS	✓		✓	✓	✓
Accelerometer			✓	✓	✓
Temperature					✓
Pressure					✓
Humidity					✓
Magnetic				✓	✓
Light					✓

The availability of the boards and respective supporting documentation, their size and footprint, technological capabilities and usability in user trials, were the determining factors for choosing the boards to be used in the field trials. The Fona 808 Shield and Arduino, although great for swapping components for different testing scenarios, is unusable due to its bigger size compared to the alternatives. The Rak 8212 was also discarded, due to acquisition and shipping logistics, it proved to be unreliable for prototyping in the timeframe of the project. Thus, the Pycom Fipy + Pytrack combo and the Sodaq Sara SFF R412M were the chosen boards.

The Pycom combo was chosen due to the greater number of radio technologies, 6, that provide multiple fallback capabilities in case one technology fails. The Sodaq R412M was chosen for having the smallest size footprint, while also having one fallback communication option, from LTE to GPRS.

3.2.1 Detailed boards measurements

To design and model the casings for the hardware boards, respective antennas and batteries, different measurements of the board's components were required, in order to study the possible configurations arrangements and viable solutions. To this end the detailed metrics of the boards were collected and are represented in Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Table 2, Table 3, Figure 10 and Figure 11.

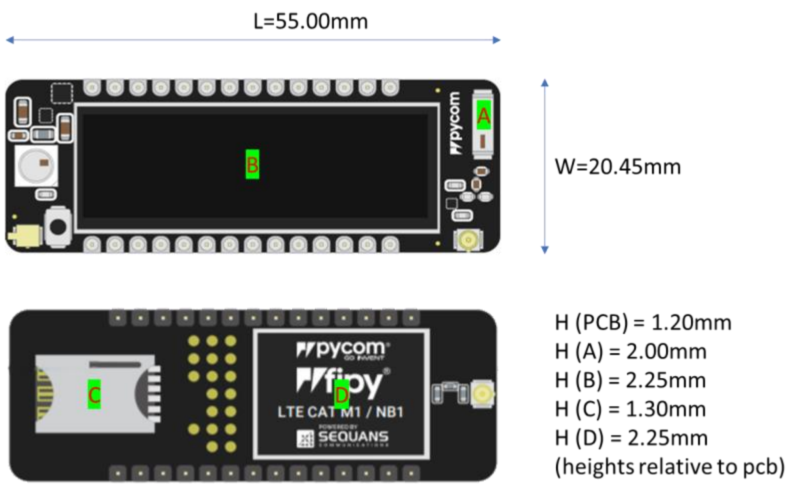


Figure 5 - Fipy dimensions

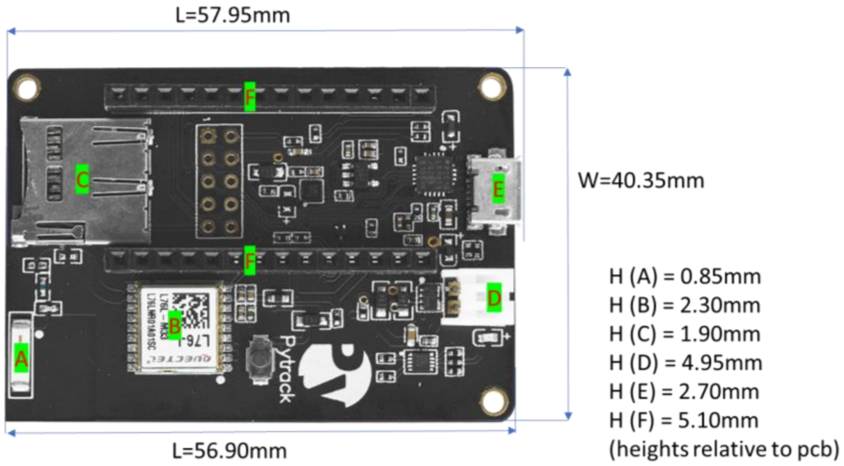


Figure 6 - Pytrack dimensions (1)

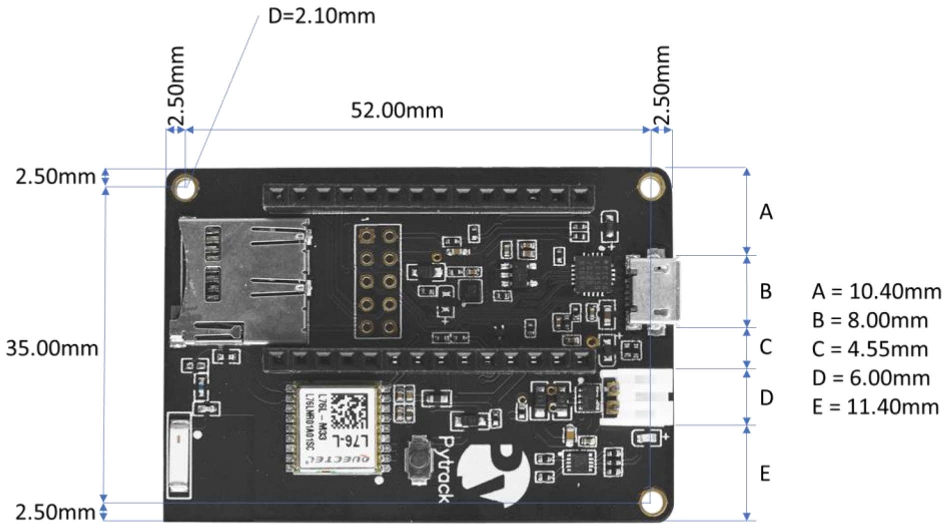


Figure 7 - Pytrack dimensions (2)

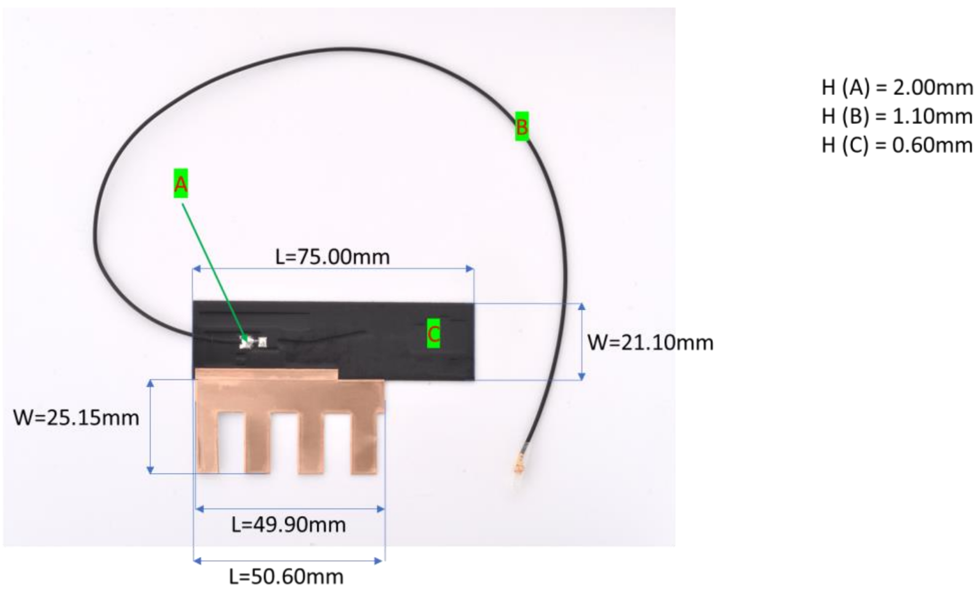


Figure 8 - Pycom LTE Antenna Dimensions

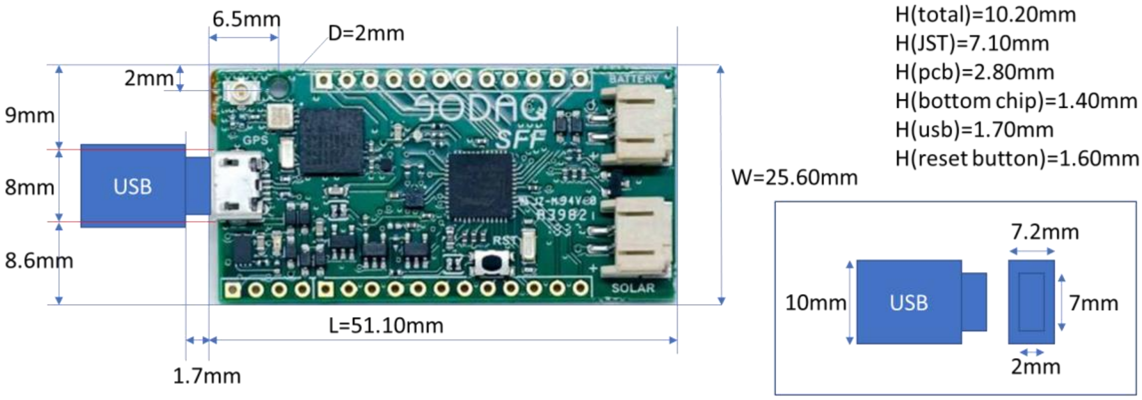


Figure 9 - Sodaq Sara SFF R412M Dimensions

Table 2 - LiPo Batteries Dimensions

	320mAh	400mAh	560mAh	660mah	800mAh	Sodaq 800mAh	1000mAh
W=	29.50mm	30.00mm	34.00mm	33.05mm	34.00mm	29.70mm	33.85mm
L (body+cable fold)=	42.20mm	37.90mm	39.70mm	40.30mm	53.75mm	50.00mm	55.60mm
L (cable length)=	137mm	137mm	57.90mm	45.20mm	60.75mm	120mm	44.55mm
H=	4.00mm	4.60mm	4.80mm	5.40mm	4.20mm	7.10mm	5.20mm

Table 3 - LTE, Wifi, LoRa and GPS Antennas Dimensions

	FXUB63	FXUB66	Molex 105262	Anaren 868	Sodaq LTE	Sodaq GPS
Functionality	NB; LoRa; Wi-Fi	NB; LoRa; Wi-Fi	LoRa	LoRa	GPRS; NB	GPS
W=	21.10mm	5.60mm	10.00mm	0.70mm	7.65mm	15.10mm
L=	96.10mm	120.80mm	79.00mm	94mm	31.10mm	15.10mm
H=	2.00mm	1.75mm	1.40mm	0.70mm	2.20mm	6.50mm
Coord length=	160mm	160mm	94.50mm	94mm	96mm	53mm

Figure 10 - Sodaq External GPS Antenna

Figure 11 - 800mAh Battery

3.3 Devices Hardware Housing

During this study, two situations were analysed, the insole and a box with a clip for a belt or for an arm band.

3.3.1 Insole Integration

After choosing the insole as a wearable tracking device a layout study was performed. As the natural movement of the foot is folded in the front area and all the electronic components have to be properly protected the chosen place to allocate these components was in the heel zone, the green area in Figure 12**Error! Reference source not found.**, since it is the most stable are on the insole.

Figure 12 - Insole Usable Area (green: rigid, blue: flexible)

A set of design specifications were defined during this study, such as:

- Lightweight – so that the person does not get tired while using the insole.
- Thin - so that the insole can be inserted in any kind of shoe.
- Ergonomic - the insole should be comfortable so it can be effective.
- Waterproof - to protect all the electronic components inside the insole.

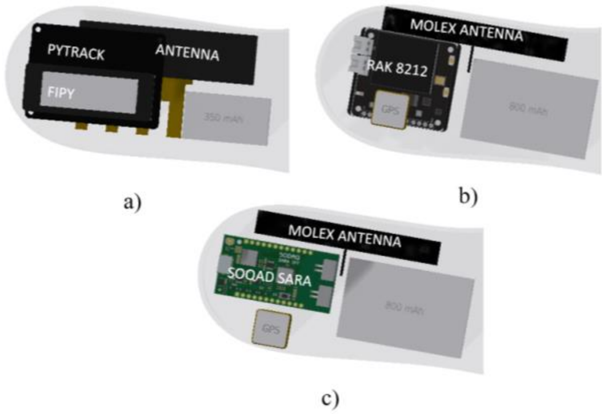


Figure 13 – Initial Layout Study: a) PYCOM KIT; b) RAK 8212; c) SOQAD SARA

During the initial study three layouts were analysed, depicted in Figure 13. The first, a), uses a shield with GPS, PYTRACK, a shield with Bluetooth, FIPY, a battery of 350 mAh and an antenna, these components are from PYCOM except from the battery. The second option, b), used a Bluetooth, RAK8212, shield with a LoRa antenna, Molex, as well as a GPS Antenna. And finally, the third, c), also used a Bluetooth, SOQAD SARA, as well as a LoRa antenna, Molex, and a GPS antenna. Both the second and the third options have an 800 mAh battery. In the **Error! Reference source not found.** it is noticed that the third option uses less area than the other two options.

In all the layout options the electronic components will be place on a rigid housing under the heel area. It is the reason this study is mainly focus on the heel area.

After the layout study a material was selected in order to build the heel housing, this material is based on polypropylene (PP).

The PP is flexible olefin polymer that resists breakage. This material is soft and non-brittle and offer a good cushioning and shock absorption performance, which means that is suitable for this application.

Since the insole is meant to be ergonomic and comfortable on top of the electronic housing will be placed a proper insole made with ergonomic features, such as lateral arch as a support and a block heel to prevent the foot moving.

In all of the layout options the electronic components will be place on a rigid housing under the heel area. It is the reason this study is mainly focus on the heel area.

After the layout study a material was selected in order to build the heel housing, this material is based on polypropylene (PP).

The PP is flexible olefin polymer that resists breakage. This material is soft and non-brittle and offer a good cushioning and shock absorption performance, which means that is suitable for this application.

Since the insole is meant to be ergonomic and comfortable on top of the electronic housing will be placed a proper insole made with ergonomic features, such as lateral arch as a support and a block heel to prevent the foot moving.

After rearranging and optimizing the components and layout positioning of the insole the final arrangement was achieved, using the Sodaq board as the most viable insole solution. However, a solution using the Pycom board was also developed for comparison of the usability, between the two different sizes.

On Figure 14 and Figure 15, the SOQAD SARA SFF insole final layout is presented. In this solution an 800 mAh battery was used as well as an LTE antenna, that is not represented in the image due to its small dimensions.

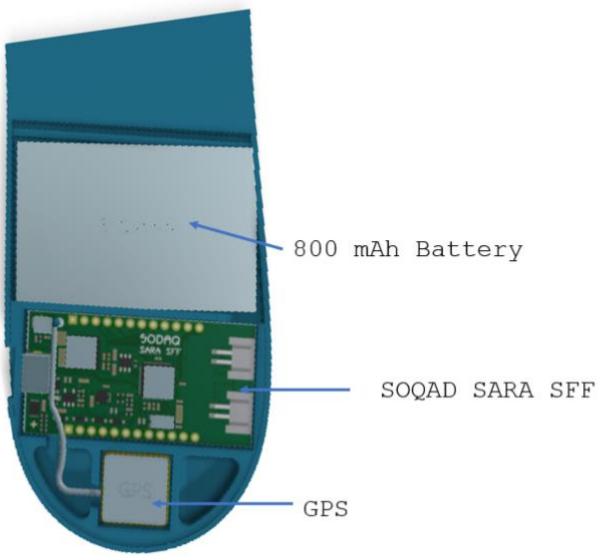


Figure 14 - 3D Model of Sodaq Insole Hardware Layout (Top View)

The height of this insole is 9.5 mm which means that it is usable as an insole. On Figure 15, in the left we can see the insole with a cover and on the right the insole is without a cover. As it is noticed on the left a USB opening was created, so the user can recharge the device when is needed. On the top of this "heel box" another insole is placed, that is called a comfort insole, so that the person wearing it feels comfortable with the device.

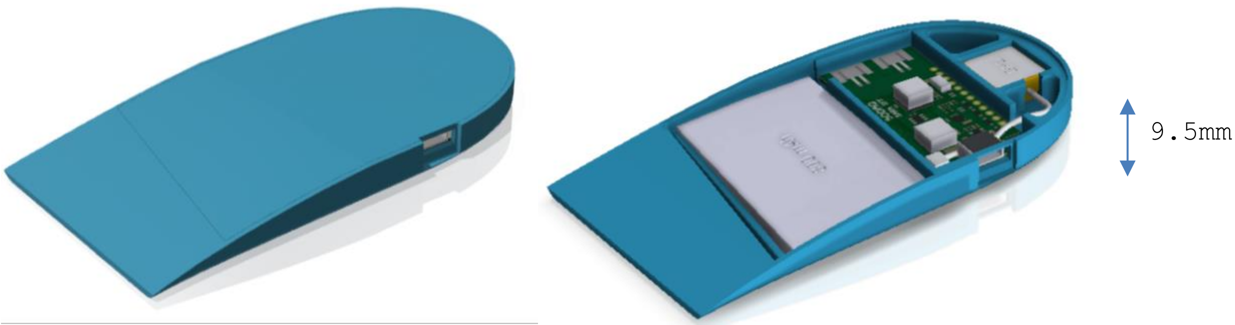


Figure 15 - 3D Model of Sodaq Insole Hardware Layout (Isometric View)

Figure 16 – Physical Prototype of Sodaq Insole

The PYCOM insole is just a case study, since the height is around 18 mm it is not possible to use it as an insole. However, the case was studied to draw this conclusion. In Figure 17 the insole layout is displayed.

Figure 17 - 3D Model of Pycom Insole Hardware Housing Layout

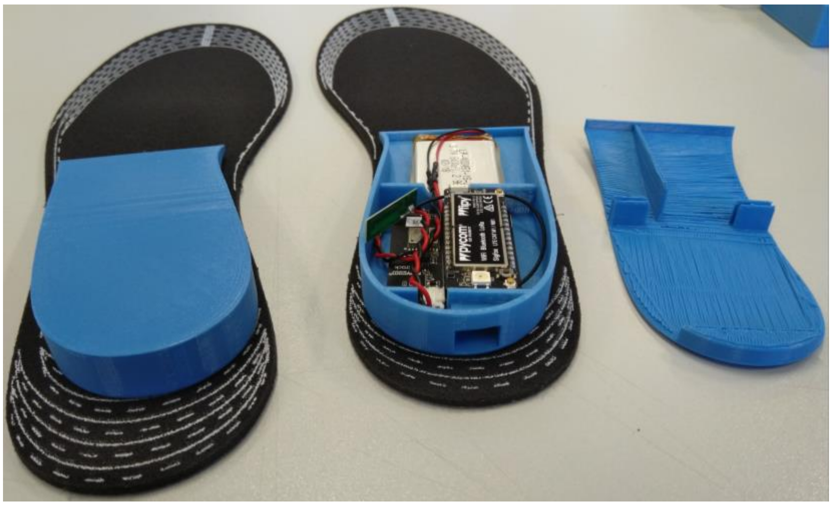


Figure 18 - Physical Prototype of Pycom Insole

Like the SOQAD insole the PYCOM insole has an opening for the USB charger. On the previous insole the USB port was placed on the side, and in this case is placed on the back.

3.3.2 Boxes Integration

After studding the insole application, the tracking device applied in a box with belt clips was another option for a wearable tracking device.

On Figure 19, we can see how the SOQAD box is assembled. First there is a cover that allows the user to clip it on a belt, in the middle all the electronics are placed, such as the shield and the battery (800 mAh), and on the bottom goes the lower cover with proper designed spaces to fit the electronic parts. The box has a port to charge the battery through USB system.

Dimensions: 60X48X15.5 [mm]

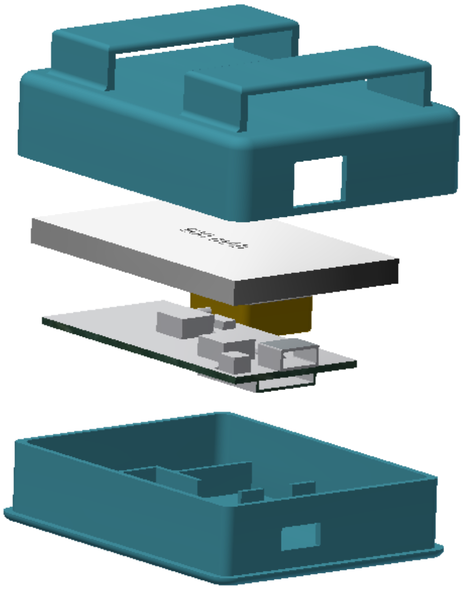


Figure 19 - 3D Model Sodaq Box Hardware Layout

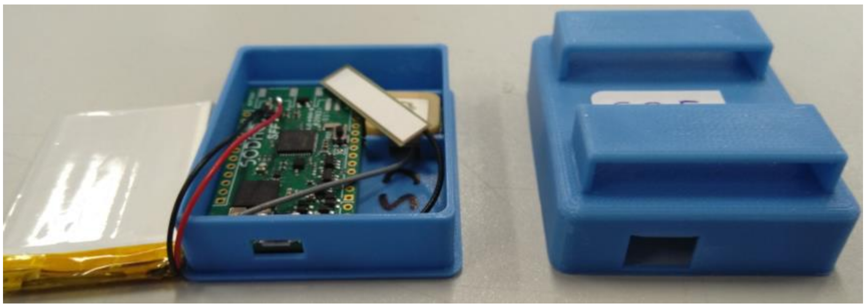


Figure 20 - Physical Prototype of Sodaq Belt Box

Figure 21 presents the PYCOM box. The method of construction is the same as the SOQAD box. The cover with a belt clip and the bottom with docking points to place the electronics. In the middle goes the boards and the battery (800 mAh).

Dimensions: 68X48X23 [mm]

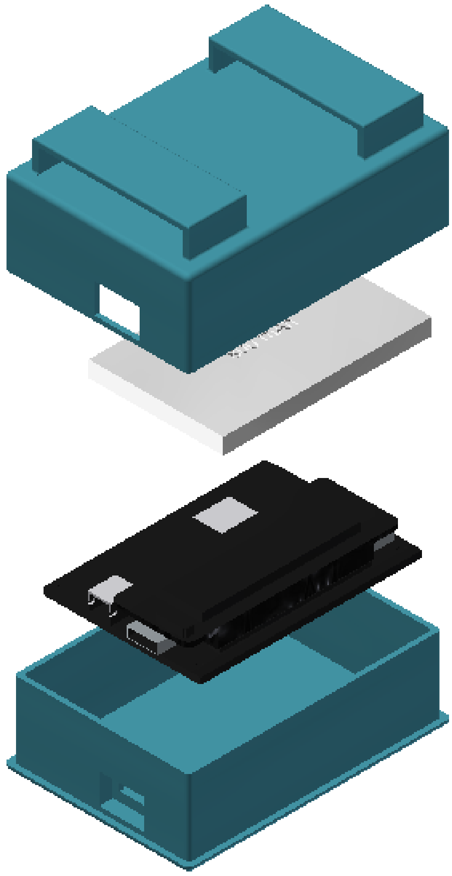


Figure 21 - 3D Model Pycom Box Hardware Layout

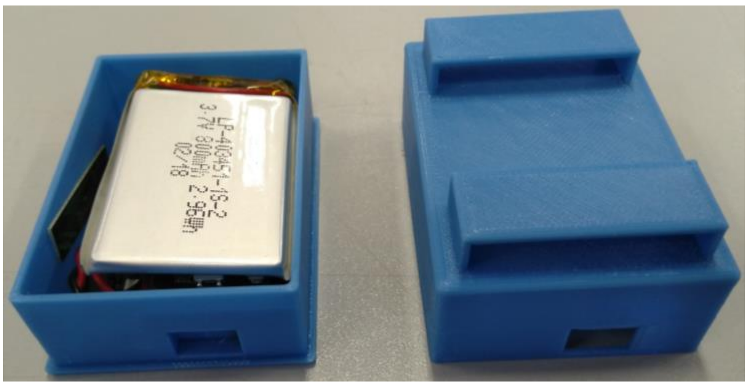


Figure 22 - Physical Prototype of Pycom Belt Box

4 SMARTWATCH AND SMARTPHONE BASED SENSOR PACK SYSTEM

The smartphone or smartwatch can be considered as obvious choices for devices that can track behaviour and locate a person, mainly because of its GPS functionality, but also because it allows for a ready to use solution that, with selective criteria, can be also a low-cost solution. Additionally, the option to receive and deliver messages and information to other people, makes for viable solutions.

Another feature, the fall detection service, can become a critical aspect to ensure safety and on-time emergency rescue for those patients. The detection can be made using a simple accelerometer in a smartphone or a smartwatch.

The proposed solution uses the above-mentioned hardware which includes accelerometers, gyroscope heartrate sensors, communications, all included in a commercial smartphone and also on a smartwatch.

Among the functionalities implemented, the analysis of data from accelerometers and gyroscopes allows an identification of risky situations associated with falling or fainting, which can trigger a request for emergency procedures to check a patient and, if needed, to provide appropriate health support. This feature is implemented using a machine learning algorithm for fall detection that thoroughly analyses data resulting from the movements of a person in order to detect if a fall event has occurred or is occurring.

The development of the proposed system results in an architecture that uses the smartwatch's sensors as input and performs a real-time assessment of risk. Departing from the established requirements, it is emphasized the remote execution of the evaluation, or local running predefined algorithms, both cases in real-time but issuing low expenditure of energy. Adding the requirement of privacy, local data analysis has a double benefit of avoiding energy consumption with transmission, also avoiding the disclosure of data, if sent and analysed remotely. A compromise must be reached between all those parameters which must rely on minimizing transmission, optimizing algorithms and using data collected to further improve the accuracy of the algorithm.

In the present case, tests were performed using a Huawei 2 smartwatch [2]. In the sensor stage data is collected from the Gyroscope, Axial Accelerometers [X, Y, Z] and GPS. The first set of sensors is used to determine if the person suffered a fall and the GPS is then used to evaluate position to enable request for support along with the detection of wandering behaviour. The second stage analyses raw data from the sensors, using algorithms and neural networks that improve accuracy with usage. In this data analysis, position is also verified against known routes, stored in a data base, that may contain routes or geofences of places to avoid or are out of acceptable premises. In the case of geofences, a map with possible or forbidden positions must be previously established. In the case of routes, a buffer establishes the premises beyond those a person is, apparently lost or wandering perhaps without knowing it. New routes can be added, and such database can have a dynamic behaviour as the person needs or wants to change routines. At the top stage, is the decision support system where, after receiving notification of a given risk, assessment is made against the consent previously given by the patient and carers along with clinical advice. If the risk is real, decision is taken, wherein a first period (e.g. 10 to 30 seconds) the person is warned about identified risks of wandering or a possible fall. If the person reacts by tapping on the "Dismiss" button, system will assume as a statement that everything is normal and safe and therefore, emergency procedures are not issued.

After the pre-established period, if there is no response from the user, or "Help" button is pressed, the watch starts sending a beacon and local messages issuing a remote message with location to chosen targets (e.g. family, informal carers, emergency services). That choice respects parameters of consent and the agreement made with the person, the family and tutors or carers.

In the proposed architecture, no remote analytical services are executed while the person is away thus protecting his/her privacy and saving energy. The system lags in collecting data from the sensors according to established parameters, thus saving energy by using a lower sampling rate that, nevertheless, allows to monitor if the route is deviating and if a fall was detected. This strategy of saving energy is also supported by the avoidance of artificial intelligence, data mining or deep learning in the local setup. Such evaluation processes occur after daily routine, when secure transmission is established and only impact in future system improvements.

The early tests performed while using the smartwatch, focused on the sensor's response to a falling body from standing position. Figure 23 shows the smartwatch screens depicting the developed application when a fall is detected.

Figure 23 - Application screens for fall detection and configuration

The location tracking uses the smartwatch GPS to record the patient usual routes, current whereabouts and closeness to dangerous areas.

A possible way to minimize some of the accuracy problems is through the concept of geofencing. It allows for the detection of entering and leaving the so-called geofences, which are predefined geographical areas as can be seen next exemplified in Figure 24.

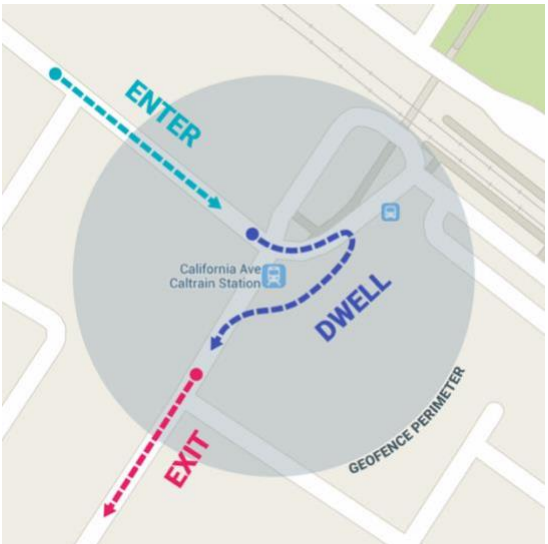


Figure 24 - Geofencing example

When the case of a wandering event is detected, the application issues a notification screen, as depicted in Figure 25, requesting user confirmation.

Figure 25 - Wandering notification confirmation

In the case of an individual that is confused, lost or with any cognitive limitation he/she will most likely ignore the smartwatch screen but case she/he feels in danger, it is possible to tap the screen to request immediate help. That results in messaging the coordinates to the person that was previously associated with the system as primary help contact. If the person does not return to the safe boundary within an established time (e.g. 10 minutes case the nearby boundaries do not present significant risks) in the same manner, the person registered in the system will receive a warning message, signalling the distress with the GPS coordinates of the patient in danger.

5 ENERGY MANAGEMENT PROFILES

The following scenarios were proposed for the use case of the energy profiles to be deployed in the power management of the smart monitoring solution for PwD's.

5.1 Initial Draft

The presented scenarios are a result of a combination of three sets of conditions:

1. The location the PwD can safely be in, which can be:
    - their home;
    - outside, in a regular location that is familiar to them;
    - outside, in an irregular location that is not usual or hasn't been registered in the system but is not marked as dangerous.
2. If the PwD is accompanied or alone.
3. The status of the condition of the PwD, which can be:
    - normal;
    - warning (situations that can be a precursor for dangerous behaviour or a safety issue of the PwD);
    - alert (emergency situations such as wandering in dangerous zones, erratic behaviour, health risks, etc…).

The multiplication of the three location types, with the accompanied/alone status, and the three statuses for the PwD results in eighteen distinct scenarios, depicted in Figure 26 as a proposed example, in which different power settings can be applied in order to maximize the autonomy of the smart monitoring solution.

The device's components are distinguished as follows:

- Wireless (Wi-Fi, Bluetooth, other close-range communication modules);
- GNSS (Global Navigation Satellite System);
- Cellular (mobile network and long-range communication modules);
- Sensors (biometric sensing modules).

Status of the Person with Dementia	Home		Outside (regular location)		Outside (irregular location)	
	Alone	Accompanied	Alone	Accompanied	Alone	Accompanied
Normal	Wireless on GNSS off Cellular off Sensors 15 min	Wireless on GNSS off Cellular off Sensors 15 min	Wireless off GNSS 15 min Cellular on Sensors 30 min	Wireless on GNSS 30 min Cellular off Sensors 30 min	Wireless off GNSS 10 min Cellular on Sensors 10 min	Wireless on GNSS 15 min Cellular off Sensors 30 min
Warning	Wireless on GNSS off Cellular off Sensors 5 min	Wireless on GNSS off Cellular off Sensors 5 min	Wireless off GNSS 10 min Cellular on Sensors 10 min	Wireless on GNSS 15 min Cellular off Sensors 10 min	Wireless off GNSS 5 min Cellular on Sensors 5 min	Wireless on GNSS 10 min Cellular off Sensors 5 min
Alert	Wireless on GNSS off Cellular on Sensors 1 min	Wireless on GNSS off Cellular off Sensors 1 min	Wireless off GNSS 5 min Cellular on Sensors 5 min	Wireless on GNSS 10 min Cellular off Sensors 5 min	Wireless off GNSS 1 min Cellular on Sensors 1 min	Wireless on GNSS 5 min Cellular off Sensors 1 min

Figure 26 – Example of an energy profile

Each component of the device can, therefore, be managed to only be used when the scenario requires it, using a specific profile configuration, and each configuration can be tuned to the user and the device specifications.

5.2 Implementation

To optimize Carelink device's power autonomy, the configuration of each device's components (communication, tracking and sensors) is modified by the platform, using a set Energy Profiles, that adjust the modes of operation to the conditions of the PwD.

Using the platform as a manager of the energy settings has three major benefits. First, it frees the devices from the processing required to determine the conditions to apply each profile, which by itself already saves a considerable amount of power. Secondly, it enables tweaking the components configurations remotely, in real-time, without the need to recall the devices to update the settings physically. Thirdly, it empowers the Carelink system with the possibility to adjust the Energy Profiles of a device to the respective PwD's usage habits, by pre-emptively adapting the configurations to regular actions, creating a personalization of the system around the PwD needs.

Depending on the conditions the PwD is in, there is a need for a higher or lower interval of time, of the status messages sent between the device and the platform, or from the data polled by the device's sensors. These conditions can be the "Location" of the PwD, the "Time" of the day, if the PwD is "Accompanied" by a carer, and the overall "Wellbeing" of the PwD.

5.2.1 Location Condition

The Location of the PwD can be used as a condition to set three different scenarios of utilization of the device, while the PwD is safe. These locations are the PwD "Home", outside "Regular Locations" and outside "Irregular Locations".

The "Home" is, supposedly, the safest environment the PwD can be in (wandering wise), and thus the need for constant updates is not so strong.
Following the same reasoning, outside the home is when the PwD can be presented with more opportunities to wander, especially if the surroundings are not familiar.
A PwD can have a set of safe zones, designated here by "Regular Locations", where it is usual and safe for

him/her to go daily or weekly. In this usage scenario a constant rate of status updates is required simply to validate that the PwD is maintained in a safe zone.
Similarly, an "Irregular Location" is the one that is unfamiliar or is unusual because it isn't a part of the PwD routine, or simply because the location hasn't been registered in the system, but is not necessarily dangerous. In this scenario, if the PwD is in, or enters an "Irregular Location", which can more easily trigger wandering episodes or simply the possibility of getting lost, then it calls for faster update intervals from the device, in order to have a timely response when predicting or detecting possible dangerous situations or behaviours.

5.2.2 Time Condition

The "Time" of the day is also a good indicator to consider in combination with the location conditions. If the PwD uses certain locations only during specific hours, any deviation from the norm can be representative of anomalies in behaviour, that may require additional increased monitoring. On the opposite scenario, if the time and location match a pattern then the monitoring rate can be more relaxed.
As a practical example, a PwD that leaves the home in the middle of the night to go to a regular location, is displaying a risky behaviour that should trigger an alert and faster status updates.
Likewise, during the bedtime, if the PwD is sleeping, then the time interval between updates can be the longest, due to the extend time of inactivity, saving more battery.

5.2.3 Accompanied Condition

If the device has the capability to detect the carer nearby (i.e. by action of the carer, marking said proximity in the Carelink platform; by using Bluetooth pairing between the device and the carer smartphone; or by matching the location of the carer smartphone with the PwD device), then it can be assumed that, since there is already a supervision of a carer nearby, the PwD has more means of support, and thus the status updates can be less frequent, while the "Accompanied" status is maintained. This functionality also aids in avoiding false wandering detections and maximizes the understanding of the involvement and environment of the PwD.
A practical example can be the carer taking the PwD to a Doctor's appointment in an irregular location. In this scenario the irregular location condition can be "overruled" because of the presence of the carer.

5.2.4 Wellbeing Condition

Lastly, the "Wellbeing" of the PwD can be defined by the analysis of the device's sensors (if the sensor capabilities are present and supported by the device). The device's sensors can, for example, range from accelerometers, temperature sensors, ECG, heart rate, GSR, EMG, among others.
If the onboard sensors detect abnormalities in the reported signals, consistent with possible health hazardous situations, or if the A.I. in the platform detects wandering events or signals that indicate possible dangerous behaviour of the PwD, then according to each situation, the necessity to acquire more precise detailed data requires the device to increase the rate of status updates to the platform and from the sensors.
Some practical examples, using the accelerometer data, are the activity/inactivity detection, useful for changing the device operation into/out of sleep mode, or for detecting falls.

5.2.5 Results

Given the multitude of usage conditions that can be used to constrain the Energy Profiles, as well as the different components of a given device (communication, tracking and sensors), the different component's configurations (enabled/disabled, polling sample rates, messaging time intervals), and the distinct hardware devices, a multi-dimensional matrix of profiles was designed, that includes the settings for each component, that best suit the scenario of utilization, the urgency of the time interval between status updates, and the optimization of power consumption.

The Energy Profile to be used by the device is communicated by the MQTT broker, using the schema defined in the MQTT Specs topic "[deviceId]/configuration/energyProfile".

It consists in two parameters ("sr" and "active") for each component of the device (at this point in the implementation, the Pycom devices components are: "gnss", "lteNB", "lora", "wifi"; in the case of the Sodaq devices, the components are: "gnss", "lteNB").

These parameters change according to a set of conditions based on the "Location" of the PwD, the "Time" of day, if the PwD is "Accompanied", and the "Wellbeing" of the PwD.

The "Location" type is to be calculated by the platform (analysing the GPS data), and can be one of three options: "Home", outside in a "Regular" zone (also known as safe zone), outside in an "Irregular" or unusual zone (not necessarily dangerous).

The "Time" of day, for now, is defined only by the bedtime and daytime. E.g.: daytime from 08:00 to 21h59, and bedtime from 22h00 to 07h59.

The "Accompanied" condition is set by the device (if supported) when reporting the status to the MQTT broker topic "[deviceId]/status". It is simply a Boolean variable.

The "Wellbeing" condition can only be used if sensors are present in the devices, which as of this moment, only comprises an accelerometer. The accelerometer data can be used to detect activity/inactivity of the PwD and also to detect falls. At this point in the implementation there is not enough data to set this condition.

Given the 3 types of locations, 2 types of times, 2 types of accompanied status, and an undefined number of wellbeing types (2 at least), results in at least 24 different energy profile's conditions sets (for one device), 48 in total (for the 2 devices).

A platform API was created to add/change the parameters data of the aforementioned energy profiles in real-time.

A platform service analyses the GPS data to determine the location type, the corresponding time of day, and rule in which conditions the device is in, what is the corresponding energy profile, and if there is a change of the energy profile, publishing to the MQTT topic "[deviceId]/configuration/energyProfile", the correct component's parameters.

6 FUNCTIONAL PROTOTYPES IMPLEMENTATION AND PLATFORM INTEGRATION

This chapter presents an overview of the operational models for the functional prototype's implementations, communications and integrations to the Carelink Platform.

6.1 Functional Prototype Implementation

The general overview of the device's operations workflow is presented in the diagram in Figure 27.

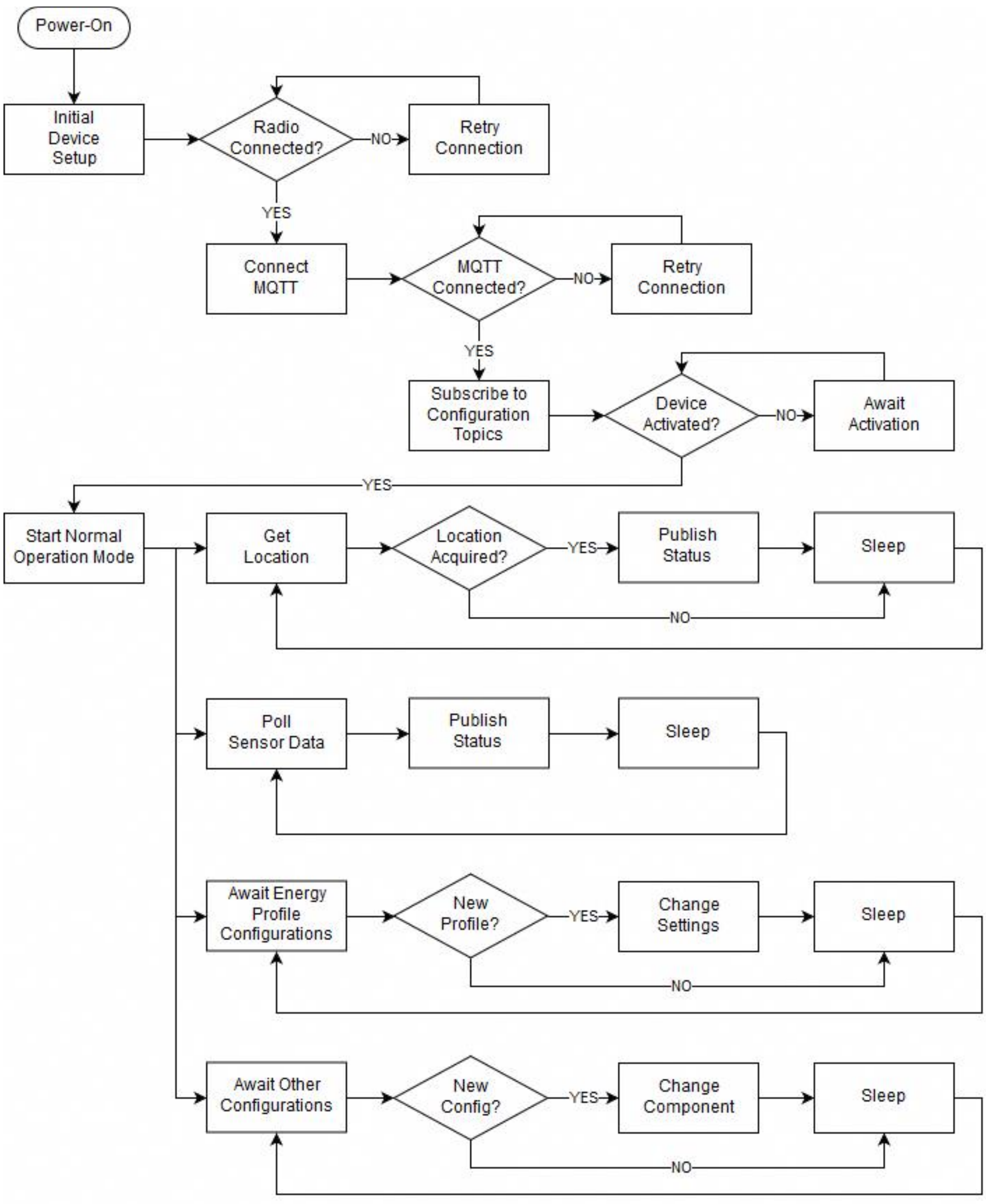


Figure 27 - Device Operation Workflow Overview

Upon power-up the device executes the initial setup configurations and then attempts to connect to the online platform services, using MQTT messaging protocol.

If the device is activated, it starts the normal operation mode, fetching the location and/or sensor data, and publishing regular status updates.

Additionally, in the normal operation mode, the device also listens on MQTT topics for new energy profiles and other configurations.

The initial connection, depicted in Figure 28, attempt checks for Narrow Band IoT network connection availability. If this connection fails, the device falls back to the availability of the LoRa network connection. (If this connection also fails it falls back to Wi-Fi connection).

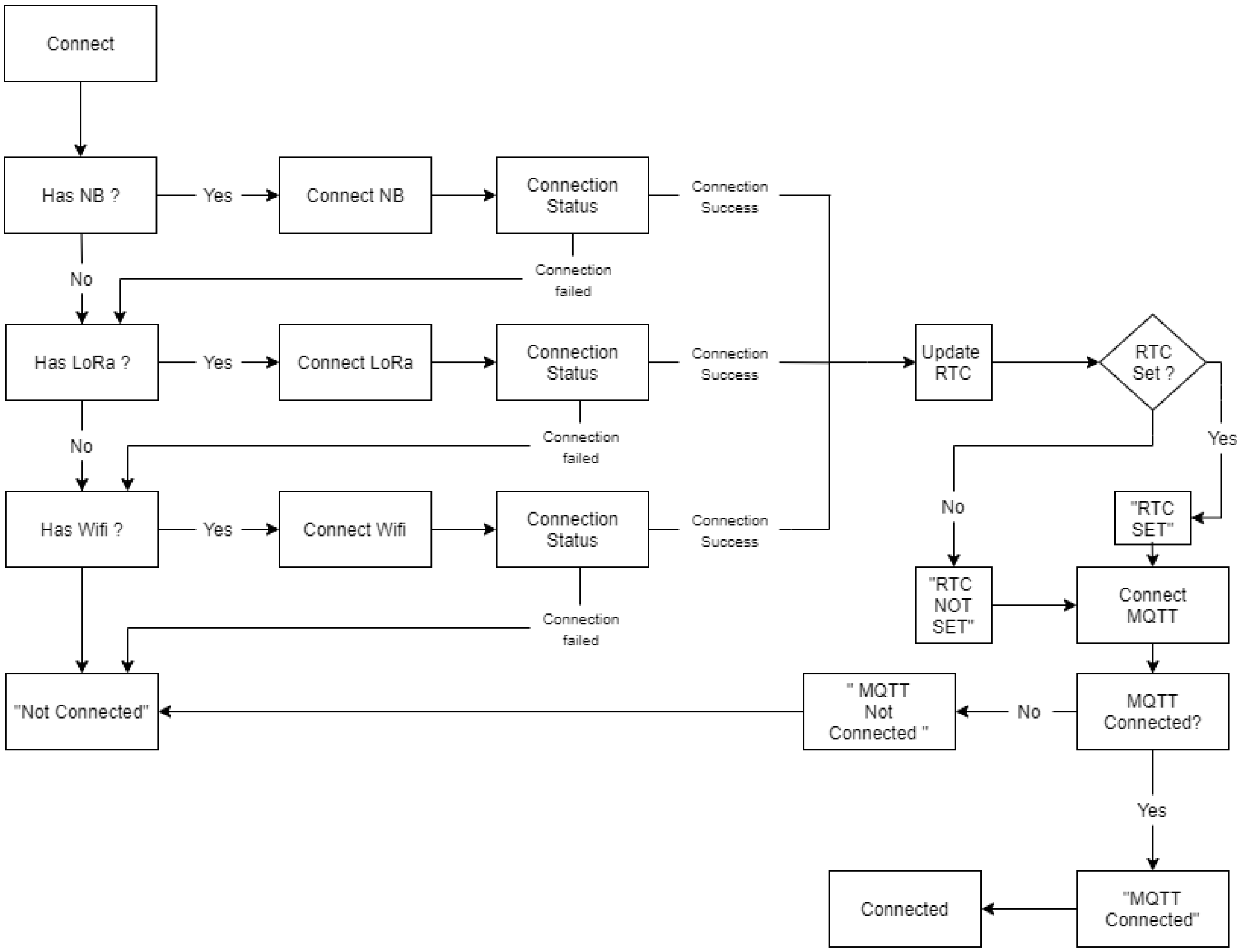


Figure 28 - Device Operation Workflow Overview: Connect Detail

After a successful network connection, the device clock (RTC) is updated and the connection to the MQTT message broker is attempted.

The result is a binary state of the device: "connected" or "not connected".

The NB connection workflow, depicted in Figure 29, first attempts the "attach" operation to the NB network in a set of sequential timed-out operations, followed by the "connect" operation in another set of sequential timed-out operations.

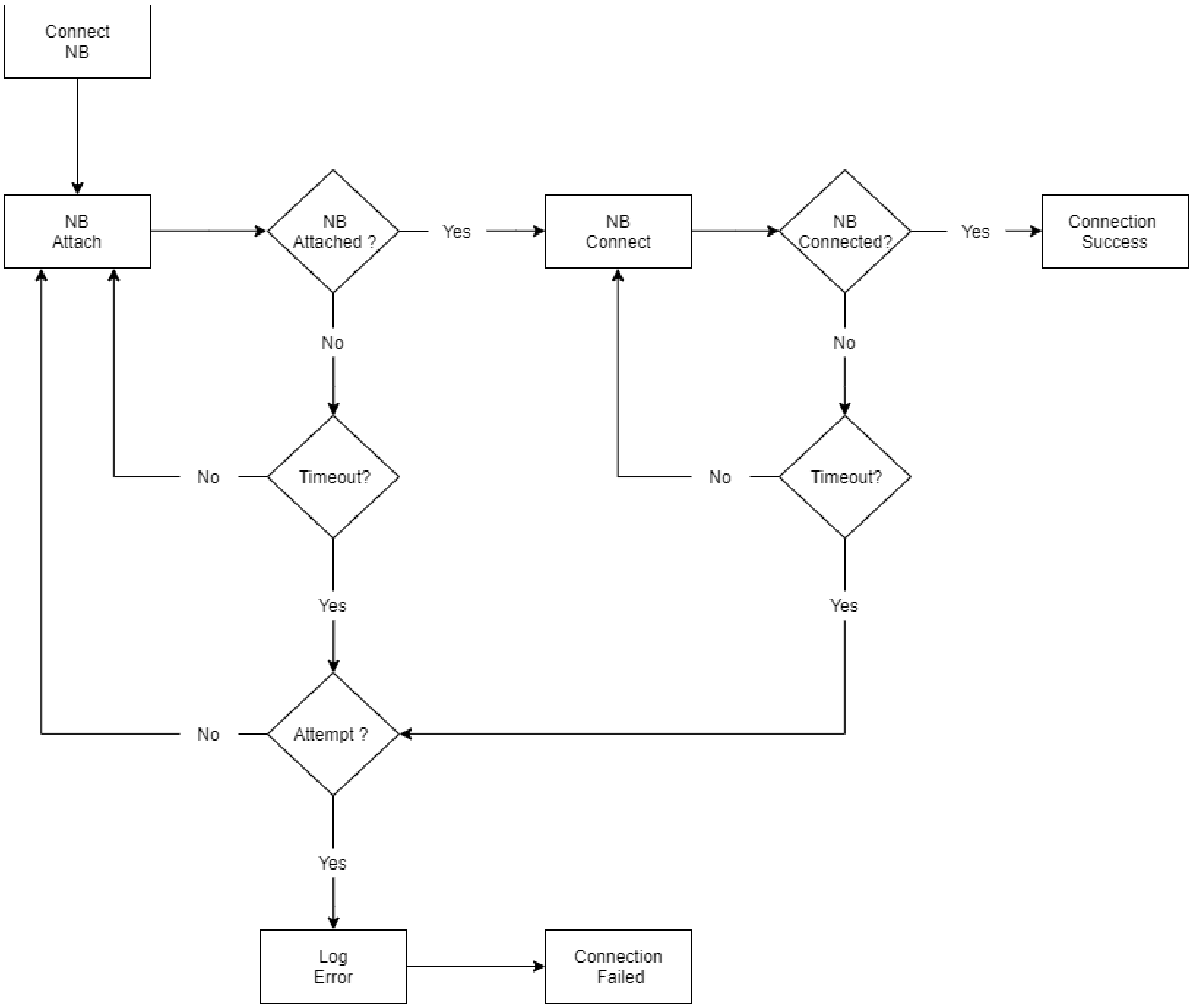


Figure 29 - Device Operation Workflow Overview: Connect NB Detail

In case the any of these operations times-out a new attempt of the NB connection workflow is started.

If the maximum number of attempts is exceeded the resulting state is "connection failed", otherwise is the "connection success".

The LoRa connection workflow, depicted in Figure 30, starts with the configuration of the device class and channels. After activation, the connection is made either by ABP or by OTAA authentication.

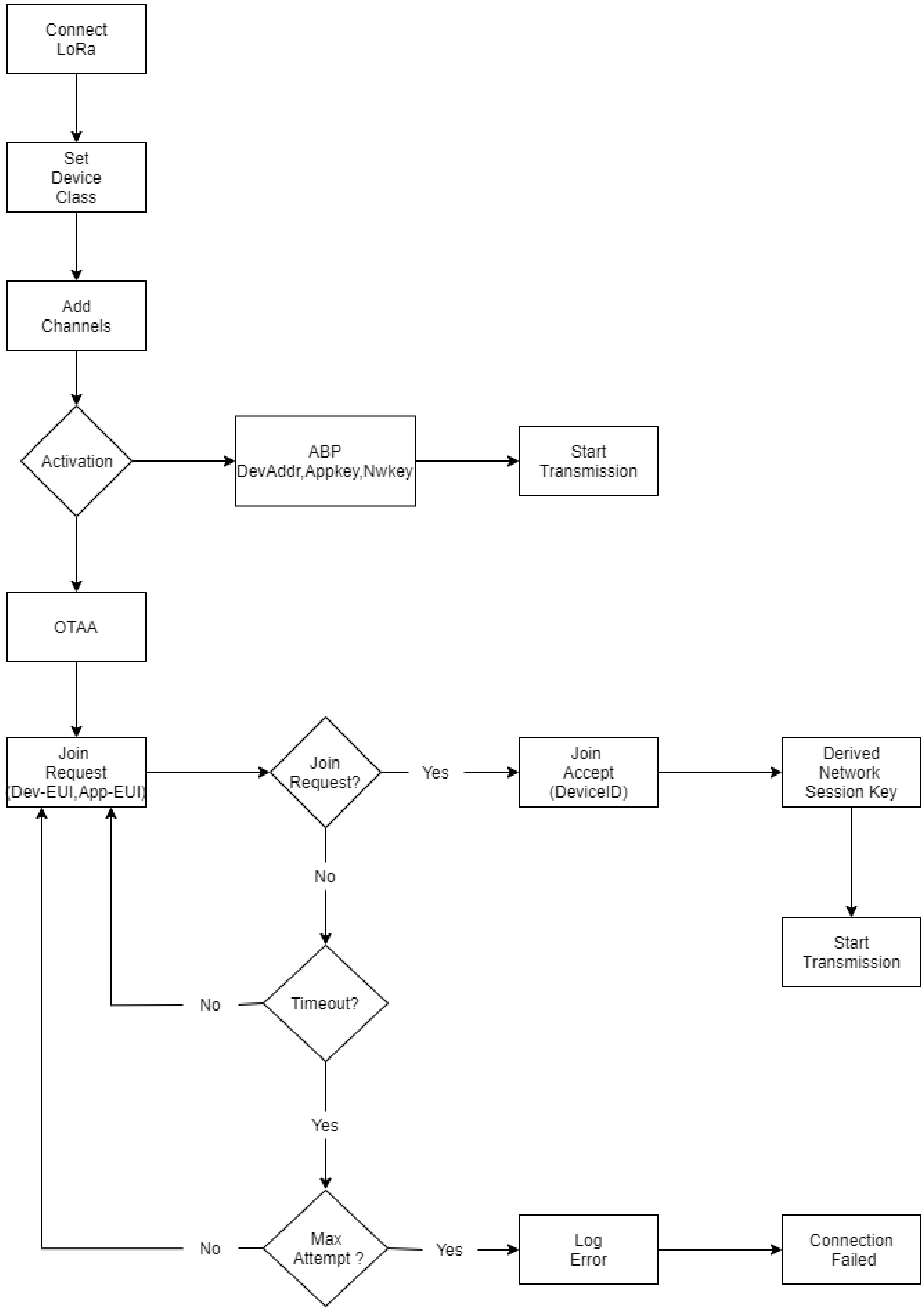


Figure 30 - Device Operation Workflow Overview: Connect LoRa Detail

The "OTAA Join" request uses the device and application EUI keys, and retries if the "join" is not completed after a timeout window.

If the maximum number of attempts is exceeded the resulting state is "connection failed", otherwise the session is established correctly, resulting in "connection success".

If the RTC is not yet set on the device, an attempt to synchronize the clock is made until it times-out, or the maximum number of attempts is exceeded, as shown in Figure 31.

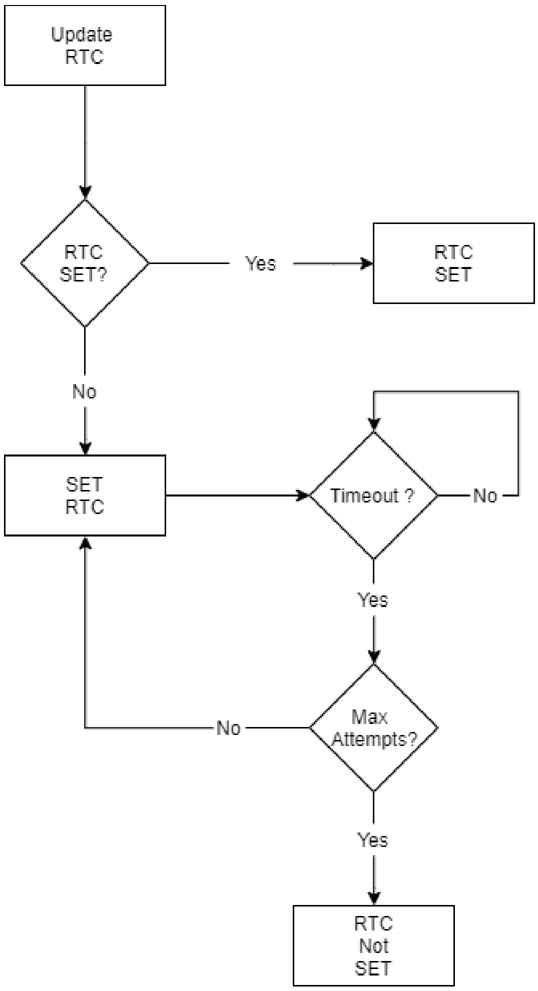


Figure 31 - Device Operation Workflow Overview: RTC Update Detail

If the maximum number of attempts is exceeded the resulting state is "RTC Not Set", otherwise the resulting state is "RTC Set", indicating the correct synchronization of the device's clock.

6.2 Platform Integration

The platform integration with each prototype will attend the specifications, defined in Deliverables D2.2 "Hardware Requirements: Platform and Devices" and D3.1 "Platform software", for the platform, and each prototype specifications, defined in sections 3 and 4. The resulting integration will take into consideration the energy requirements of each module of the prototype and the efficiency and security of the communications between the platform and the devices.

The Carelink Ontology model represents the conditions, rules and assertions, required for the interoperability, configuration and management of the user's, hardware feature's and device's profiles.

Depicted in Figure 32, is a simplified diagram of the ontology model, where the classes are represented in yellow, their respective datatype properties are represented in green, and the object properties are represented in blue, which characterize the relationships and rules of the classes. The cardinality of each relation, either of the datatype or object properties, is represented as mathematical inequalities over the arrows.

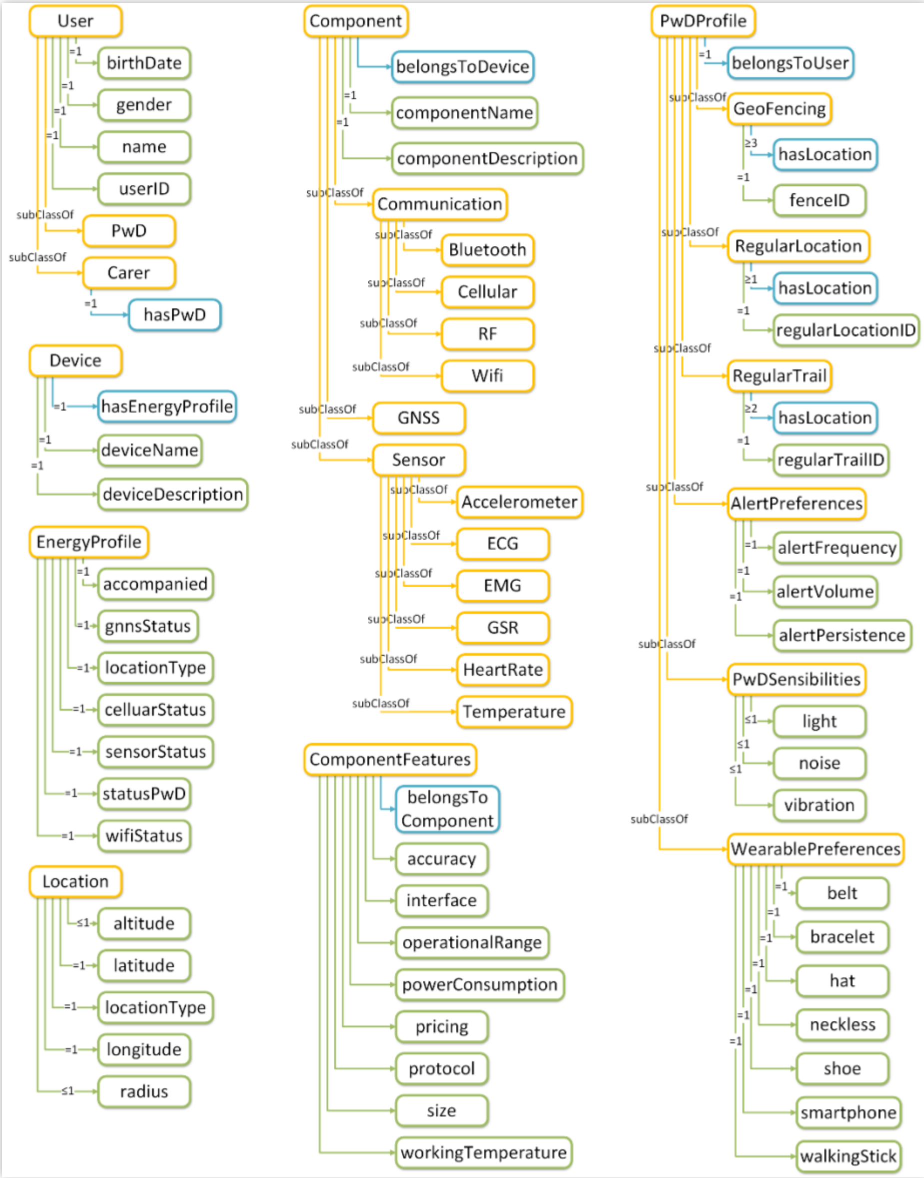


Figure 32 Carelink Ontology Model Diagram

There are seven proposed primary classes, namely *User, EnergyProfile, Location, Device, PwDProfile, Component and ComponentFeatures.*

The *User* class represents the identification of the target audience of the Carelink system, i.e. the *PwD* and the *Carer*.

The *PwDProfile* represents the aggregation of the *PwD* preferences, his usual location history and settings, and is used to tune the Carelink solution to each individual need and requirement. These include *GeoFencing, RegularLocation, RegularTrail,* which are supported by the *Location* class, and the *AlertPreferences, PwDSensibilities and WearablePreferences*, which tailor the device application to the PwD needs.

The *Device* class represents the physical solution that will accompany the *PwD*, which is comprised of different components and features, each represented in the *Component* and *ComponentFeatures* classes. A *Component* type can be *Communication* (either *Cellular, Wifi, Bluetooth* or *RF*), *GNSS* or *Sensor* (either an *Accelerometer, ECG, EMG, GSR, HeartRate* and/or *Temperature* sensors).

The *EnergyProfile* class represents the conditions and status of the device for the implementation of a smart adaptable energy management service, that can enable or disabling each *Component* depending on whether or not it is required.

A lightweight messaging protocol is required (preferably one that can ensure confidentiality, integrity, and availability), due to the fact that maximization of energy consumption can require reducing the load and processing power on the device, using the platform whenever possible. The proposed protocol, Message Queuing Telemetry Transport (MQTT), satisfies these conditions and integrates easily with the platform stream-processing software, Apache Kafka.

A document has been prepared, called "Carelink Device MQTT Specifications" (current version 3.0.1, appended as Appendix A – Carelink Device MQTT Specifications), specifying the MQTT messages payload and configurations, as well as detailed explanation of the distinct modes of operation, and the requirements needed from each type of device and from the platform.

7 CONCLUSIONS

The implementation of a custom hardware prototype has been achieved with two commercially available development boards, which reduces the cost compared with the option of building a solution from the ground up. The energy efficiency of the prototype was tested by measuring the current consumption of each configuration of the modules and their respective operating mode.

An alternative implementation of a monitoring and support application using a smartwatch or smartphone was also tested, with the successful detection of fall situations. Although the integration with the platform was not pursued for this prototype, using the instructions for 3rd party development integration (available in course #3 of the training material) a case model for the platform integration can be continued.

Furthermore, the communication between the prototype devices and the platform is specified in an open document, making use of the MQTT messaging protocol, for lightweight processing on the device side, thus reducing the energy consumption, and enabling the future integration of additional smart devices that meet the project use case criteria.

The profiling of the component's energy management is adjusted dynamically taking into consideration the input from the analysis of the tests to different configurations, operating modes and usage scenarios of each individual user, thus tailoring an efficient energy consumption model, that can ensure maximized battery life, adequate for the specificity of each case.

Following the validation of the prototypes in the trials with real PwDs, the next step will be the improvement towards a closeness to the user needs and comfort which will focus on the reduction of the dimensions of the modules and the arrangement towards acceptance which consists in adopting a format suitable for wearable integration. To this end, the design of the specifications of a fully proprietary hardware solution will be initiated, in order to enable if the production of a device for the final consumer, after the conclusion of the Carelink project is profitable.

8 REFERENCES

[1] Di Nisio, Attilio & Di Noia, Tommaso & Guarnieri Calò Carducci, Carlo & Spadavecchia, M. (2016). High Dynamic Range Power Consumption Measurement in Microcontroller-Based Applications. IEEE Transactions on Instrumentation and Measurement. 65. 1-9. 10.1109/TIM.2016.2549818.

[2] "HUAWEI WATCH 2 | Wearables | HUAWEI Global." [Online]. Available: https://consumer.huawei.com/en/wearables/watch2/. [Accessed: 22-Jun-2018].

9 APPENDICES

Appendix A – Carelink Device MQTT Specifications

In this appendix, the specifications of the MQTT control packets ("connect", "publish" and "subscribe"), to be used by the Carelink devices, are specified, along with the device's modes of operation.

Carelink Device MQTT Specifications

This document aims to define the specifications of the MQTT control packets ("connect", "publish" and "subscribe"), to be used by the Carelink devices.

NOTE: The specifications are meant to be device agnostic and thus some considerations need to be observed, specifically in the standards and nomenclature used, as well as in the interoperability of some variables and features across different devices.

Autor: Jorge Calado (jsc@uninova.pt)

Document version: 3.0.1 – 2019-05-31

Table of Contents

Standards and nomenclature used

DateTime timestamps using ISO8601 UTC extended format (e.g. YYYY-MM-DDThh:mm:ssZ).

Location coordinates using the format WGS 84 (in Decimal Degrees).

Json notation for payload messages.

Geojson feature collection for definition of geographical areas.

Common Variables

Name	*Type*	*Description*	*Required*
[deviceId]	string	unique alphanumeric string for device identification	true

NOTICE: A user can have multiple devices. A device can only be associated with one user at a time.

Connect Packet

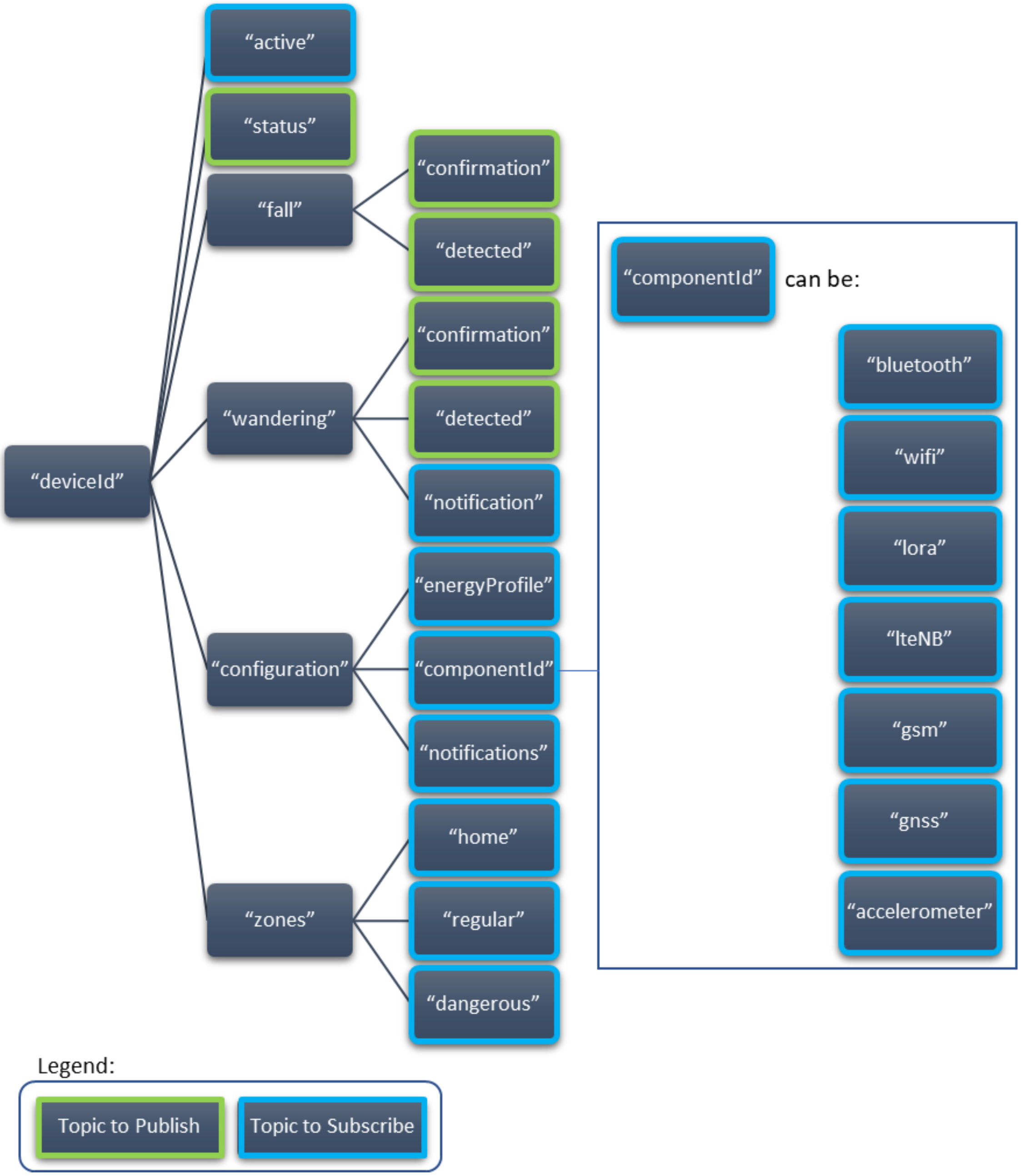
Connect Flags:

Clean Session	false
Will Qos	2
Will Flag	true
Will Retain	true
Keep Alive	600

Connect Payload:

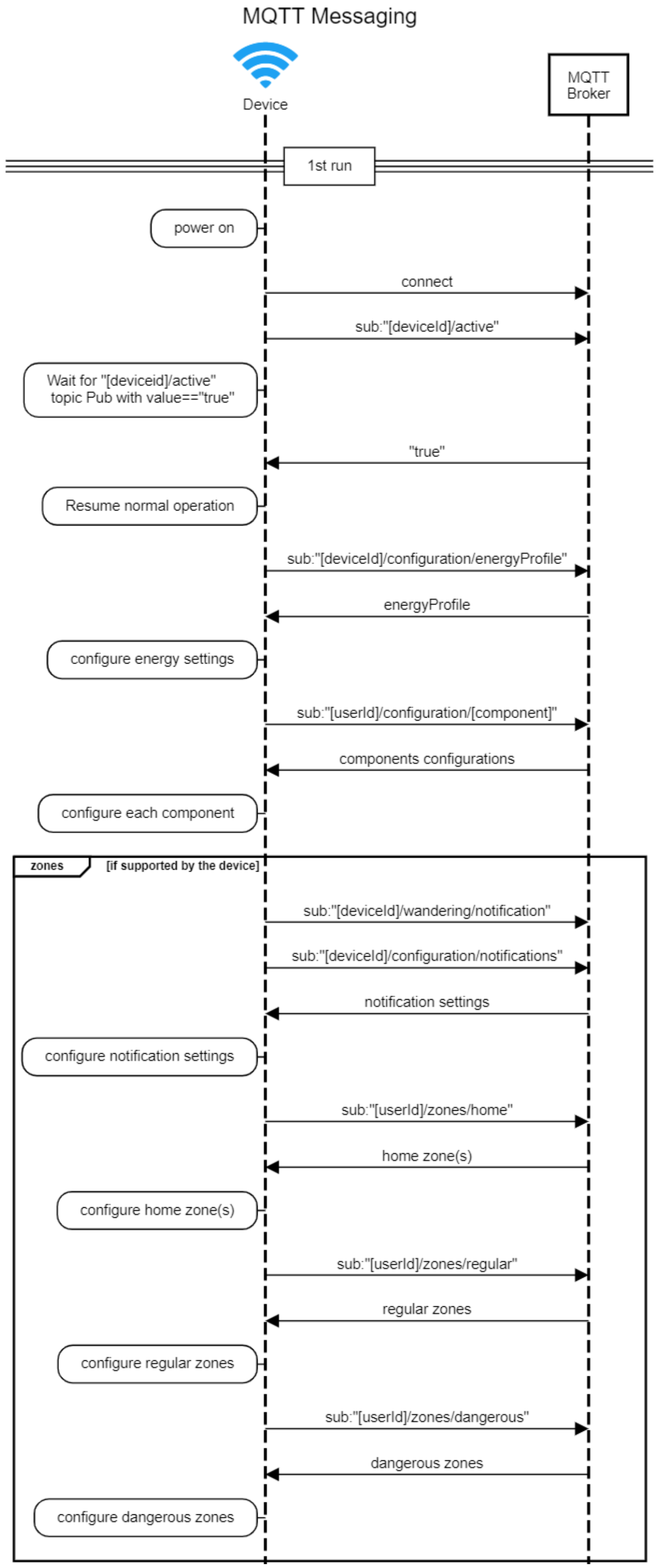
Client Identifier	unique random mqtt identifier
Will Topic	"[deviceId]/status"
Will Message	"LW: Unexpected disconnection"
Username	"deviceId"
Password	"mqtt password"

MQTT Pub-Sub Topics Dendrogram

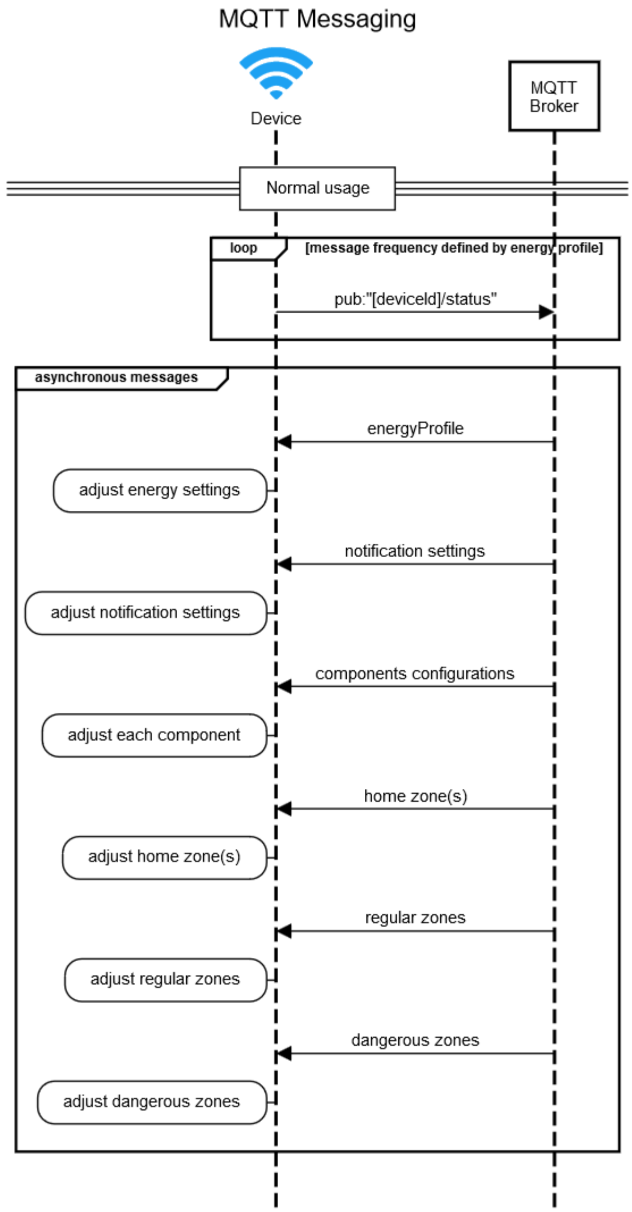


MQTT Messages Sequence Diagrams

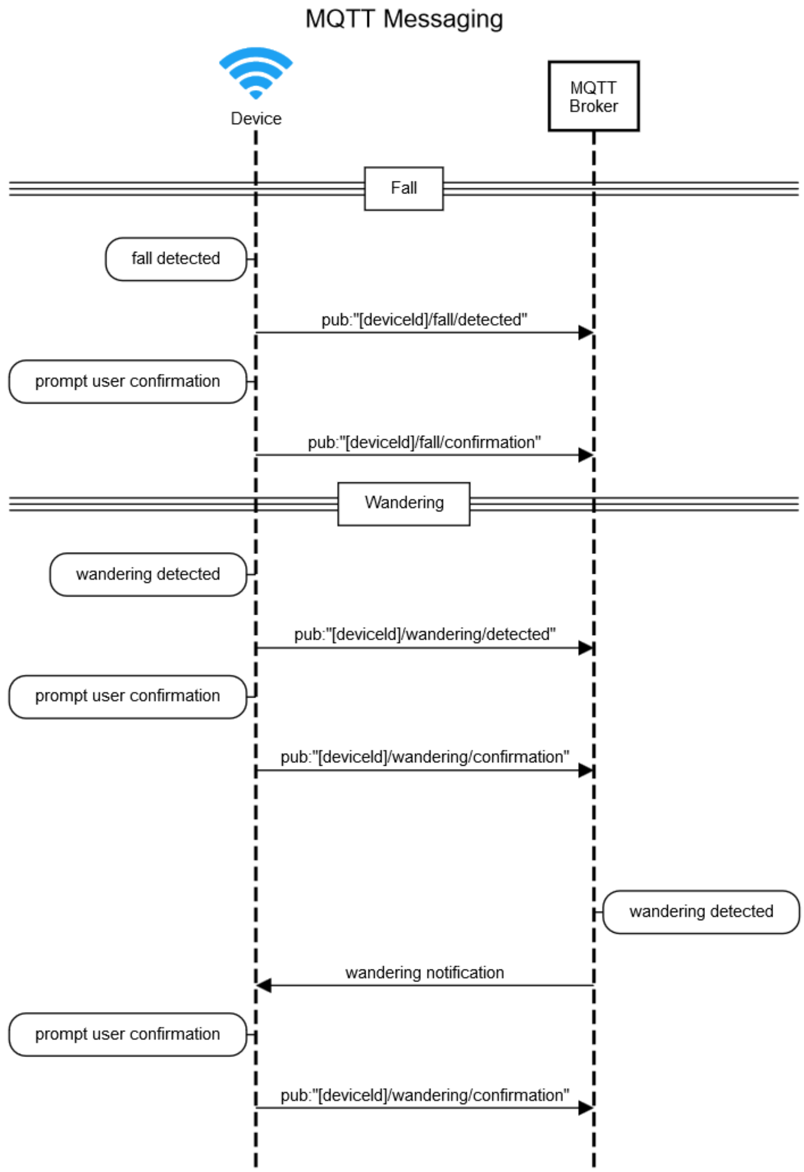
Device power-up



Normal usage



Fall/Wandering



Publish Topics

"[deviceId]/status"

"[deviceId]/fall/confirmation"

"[deviceId]/fall/detected"

"[deviceId]/wandering/confirmation"

"[deviceId]/wandering/detected"

"[deviceId]/status"

QoS	0
Retain	false

Payload (compressed JsonObject):
"{"timestamp":"YYYY-MM-DDThh:mm:ssZ","location":{"lat":float,"lon":float,"alt":float,"hdop":float,"vdop":float,"pdop":float},"batteryLevel":integer,"accompanied":boolean,"sensor":{"accelerometer":"x, y, z"}}"

Name	*Type*	*Description*	*Required*
timestamp	string	timestamp with the dateTime when data was recorded	true
location	json object	json object with latitude, longitude, altitude coordinates	true
lat	float	latitude coordinates	true
lon	float	longitude coordinates	true
alt	float	altitude coordinates	true
hdop	float	horizontal dilution of precision	false
vdop	float	vertical dilution of precision	false
pdop	float	positional dilution of precision	false
batteryLevel	integer	value of battery level in mAh	true
accompanied	boolean	indicator if device is paired with carer smartphone	false
sensor	json object	json object with the sensors available on the device	false
accelerometer	string	x, y, z axis acceleration values	false

"[deviceId]/fall/confirmation"

QoS	2
Retain	false

Payload (compressed JsonObject):
"{"status":boolean,"timestamp":"YYYY-MM-DDThh:mm:ssZ","location":{"lat":float,"lon":float,"alt":float},"batteryLevel":integer,"sensor":{"accelerometer":"x, y, z","heartrate":integer,"temperature":integer}}"

Name	*Type*	*Description*	*Required*
status	boolean	indicator if fall confirmation was positive or negative	true
timestamp	string	timestamp with the dateTime when data was recorded	true
location	json object	json object with latitude, longitude, altitude coordinates	true
lat	float	latitude coordinates	true
lon	float	longitude coordinates	true
alt	float	altitude coordinates	true
batteryLevel	integer	value of battery level in mAh	true
sensor	json object	json object with the sensors available on the device	false
accelerometer	string	x, y, z axis acceleration values	false
heartrate	integer	heart rate value in bpm	false
temperature	integer	Temperature value in degree Celsius	false

"[deviceId]/fall/detected"

QoS	2
Retain	false

Payload (compressed JsonObject):
"{"timestamp":"YYYY-MM-DDThh:mm:ssZ","location":{"lat":float,"lon":float,"alt":float},
"batteryLevel":integer,"sensor":{"accelerometer":"x, y, z","heartrate":integer,"temperature":integer}}"

Name	*Type*	*Description*	*Required*
timestamp	string	timestamp with the dateTime when data was recorded	true
location	json object	json object with latitude, longitude, altitude coordinates	true
lat	float	latitude coordinates	true
lon	float	longitude coordinates	true
alt	float	altitude coordinates	true
batteryLevel	integer	value of battery level in mAh	true
sensor	json object	json object with the sensors available on the device	false
accelerometer	string	x, y, z axis acceleration values	false
heartrate	integer	heart rate value in bpm	false
temperature	integer	Temperature value in degree Celsius	false

"[deviceId]/wandering/confirmation"

QoS	2
Retain	false

Payload (compressed JsonObject):
"{"status":boolean,"timestamp":"YYYY-MM-DDThh:mm:ssZ","location":{"lat":float,"lon":float,
"alt":float},"batteryLevel":integer,"sensor":{"accelerometer":"x, y, z","heartrate":integer,
"temperature":integer}}"

Name	*Type*	*Description*	*Required*
status	boolean	indicator if wandering confirmation was positive or negative	true
timestamp	string	timestamp with the dateTime when data was recorded	true
location	json object	json object with latitude, longitude, altitude coordinates	true
lat	float	latitude coordinates	true
lon	float	longitude coordinates	true
alt	float	altitude coordinates	true
batteryLevel	integer	value of battery level in mAh	true
sensor	json object	json object with the sensors available on the device	false
accelerometer	string	x, y, z axis acceleration values	false
heartrate	integer	heart rate value in bpm	false
temperature	integer	Temperature value in degree Celsius	false

"[deviceId]/wandering/detected"

QoS	2
Retain	false

Payload (compressed JsonObject):

"{"timestamp":"YYYY-MM-DDThh:mm:ssZ","location":{"lat":float,"lon":float,"alt":float},"batteryLevel":integer,"sensor":{"accelerometer":"x, y, z","heartrate":integer,"temperature":integer}}"

Name	*Type*	*Description*	*Required*
timestamp	string	timestamp with the dateTime when data was recorded	true
location	json object	json object with latitude, longitude, altitude coordinates	true
lat	float	latitude coordinates	true
lon	float	longitude coordinates	true
alt	float	altitude coordinates	true
batteryLevel	integer	value of battery level in mAh	true
sensor	json object	json object with the sensors available on the device	false
accelerometer	string	x, y, z axis acceleration values	false
heartrate	integer	heart rate value in bpm	false
temperature	integer	Temperature value in degree Celsius	false

Subscribe Topics

"[deviceId]/wandering/notification"

"[deviceId]/active"

"[deviceId]/zones/home"

"[deviceId]/zones/regular"

"[deviceId]/zones/dangerous"

"[deviceId]/configuration/energyProfile"

"[deviceId]/configuration/notifications"

"[deviceId]/configuration/[component]"

"[deviceId]/wandering/notification"

QoS	2
Retain	false

Payload (compressed JsonObject):
"{"notification":"Wandering detected! Device: [deviceId];"}"

Name	*Type*	*Description*	*Required*
notification	string	notification of detected wandering event, of user wearing the device [deviceId]	true

"[deviceId]/active"

QoS	1
Retain	true

Payload (compressed JsonObject):
"bool"

Name	*Type*	*Description*	*Required*
bool	boolean	bool==true indicates the device can start normal activity bool==false indicates the device to cease normal activity	true

"[deviceId]/zones/home"

QoS	1
Retain	true

Payload (compressed GeoJson Feature Collection):
"{"type":"FeatureCollection","features":[{"type":"Feature","properties":{"id":"home"},"geometry":{"type":"Polygon","coordinates":[[[lon,lat],[lon,lat],[lon,lat],[lon, lat]]]}}]}"

Name	*Type*	*Description*	*Required*
id	string	identifier of home zone(s)	true
lon	float	longitude coordinates	true
lat	float	latitude coordinates	true

"[deviceId]/zones/regular"

QoS	1
Retain	true

Payload (compressed GeoJson Feature Collection):
"{"type":"FeatureCollection","features":[{"type":"Feature","properties":{"id":"regular1"},"geometry":{"type":"Polygon","coordinates":[[[lon,lat],[lon,lat],[lon,lat],[lon, lat]]]}}]}"

Name	*Type*	*Description*	*Required*
id	string	identifier of regular zone(s)	true
lon	float	longitude coordinates	true
lat	float	latitude coordinates	true

"[deviceId]/zones/dangerous"

QoS	1
Retain	true

Payload (compressed GeoJson Feature Collection):
"{"type":"FeatureCollection","features":[{"type":"Feature","properties":{"id":"dangerous1"},"geometry":{"type":"Polygon","coordinates":[[[lon,lat],[lon,lat],[lon,lat],[lon, lat]]]}}]}"

Name	*Type*	*Description*	*Required*
id	string	identifier of dangerous zone(s)	true
lon	float	longitude coordinates	true
lat	float	latitude coordinates	true

"[deviceId]/configuration/energyProfile"

QoS	1
Retain	true

Payload (compressed JsonObject):

"{"gnss":{"active":boolean,"sr":integer},"lteNB":{"active":boolean,"sr":integer},"wifi":{"active":boolean,"sr":integer},"lora"{"active":boolean,"sr":integer}}"

Name	*Type*	*Description*	*Required*
active	boolean	Indicator if component is powered on or off	true
sr	integer	sampling rate (in seconds)	true

"[deviceId]/configuration/notifications"

QoS	1
Retain	true

Payload (compressed JsonObject):

"{"frequency":integer,"persistence":integer,"volume":integer}"

Name	*Type*	*Description*	*Required*
frequency	integer	frequency of the notifications displayed on the device	true
persistence	integer	persistence display time of the notifications	true
volume	integer	volume of the audio notifications	true

"[deviceId]/configuration/wifi"

QoS	1
Retain	true

Payload (compressed JsonObject):

"{"ssid":"wifi name","wlanpw":"wifi password"}"

Name	*Type*	*Description*	*Required*
ssid	string	wifi service set identifier of home network	true
wlanpw	string	wifi password	true

"[deviceId]/configuration/lteNB"

QoS	1
Retain	true

Payload (compressed JsonObject):
"{"apn":"telecom apn","band":integer}"

Name	*Type*	*Description*	*Required*
apn	string	LTE-NB access point name	true
band	integer	LTE-NB frequency band number	true

TO-DO:

"[deviceId]/configuration/gsm"

QoS	1
Retain	true

Payload (compressed JsonObject):
"{"a":"a","b":integer}"

Name	*Type*	*Description*	*Required*
a	string		true
b	integer		true

"[deviceId]/configuration/bluetooth"

QoS	1
Retain	true

Payload (compressed JsonObject):
"{"a":"a","b":integer}"

Name	*Type*	*Description*	*Required*
a	string		true
b	integer		true

"[deviceId]/configuration/lora"

QoS	1
Retain	true

Payload (compressed JsonObject):
"{"a":"a","b":integer}"

Name	*Type*	*Description*	*Required*
a	string		true
b	integer		true

"[deviceId]/configuration/gnss"

QoS	1
Retain	true

Payload (compressed JsonObject):
"{"a":"a","b":integer}"

Name	*Type*	*Description*	*Required*
a	string		true
b	integer		true

"[deviceId]/configuration/accelerometer"

QoS	1
Retain	true

Payload (compressed JsonObject):
"{"a":"a","b":integer}"

Name	*Type*	*Description*	*Required*
a	string		true
b	integer		true