End-of-Study Internship Report

Module Code: IS.3001-1

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"I, the undersigned Stéphane BOUDAUD, internship supervisor of the student Isep, Fahadh Mohamed JAHEER HUSSAN, attest to having read the specifications of the Isep internship report, to have read and evaluated this report with regard to the specifications and practices of my employer, and authorised its transmission to Isep."

Date: 22nd August 2024

Signature:

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Abeeway

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All quotations from sources are properly cited with accurate references within the text. Furthermore, all referenced works are included in the bibliography at the conclusion of this report.

Fahadh Mohamed JAHEER HUSSAN

Biot, 22nd August 2024

Acknowledgements

I am deeply grateful to several individuals whose steadfast support, guidance, and camaraderie have profoundly enhanced my internship experience at Abeeway.

First and foremost, I extend my heartfelt appreciation to Stéphane BOUDAUD, my mentor at Abeeway. His invaluable guidance and expertise have been pivotal in my professional growth and the successful completion of this project. Stéphane's approachable demeanor and eagerness to share his knowledge have made our interactions both enlightening and enjoyable.

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Their constant availability and willingness to help me with any doubts or challenges I faced have been invaluable throughout this journey. Additionally, I wish to acknowledge the contributions of all my colleagues and team members at Abeeway, who have fostered a collaborative and innovative atmosphere.

Lastly, I extend my deepest gratitude to my family and friends for their unwavering encouragement and support during the demanding phases of this project.

This internship has been a collective effort, and I am profoundly thankful to everyone who has contributed to its success.

Internship Summary

During my six-month internship at Abeeway in Biot, I worked as a Junior Software Engineer Intern. My role focused on the testing of the Asset Tracker 3 (AT3) firmware, an advanced asset tracking application that leverages acquisition technologies such as Bluetooth, WiFi, and GPS to enhance location tracking capabilities. This firmware is engineered to transmit location data via LoRa for further processing and analysis.

A primary objective of my internship was to develop an automated testing tool to evaluate the functionalities of the AT3 firmware. My contributions included creating and refining this tool to test various firmware features, identifying inefficiencies, and reporting bugs. Additionally, I was involved in presenting test results through a user interface developed using Qt.

This internship has been instrumental in advancing my software development skills, and I am eager to elaborate on the detailed implementation and impact of these tools in my final report.

Chapter 1

Introduction

During my internship at Abeeway in Biot, I served as a Junior Software Engineer within the firmware development team. This team is engaged in the development of the Asset Tracker 3 (AT3) firmware, an advanced solution designed to enhance tracking capabilities. My primary objective was to develop an automated testing tool to validate the firmware, ensuring that all features operate as expected with each new release.

The automated testing tool I developed plays a crucial role in verifying that the firmware meets established quality standards and functions correctly. By automating the testing process, this tool enhances efficiency, consistency, and scalability, streamlining continuous testing efforts. Furthermore, I created a user interface to effectively display and analyze test results, facilitating clearer insights into the firmware's performance.

This internship provided me with a valuable opportunity to gain practical experience in software development, troubleshooting, and automation tool creation, contributing significantly to my professional growth.

1.1 Company Overview

Abeeway, established in 2014, specializes in engineering geolocation and real-time tracking solutions for businesses and individuals. The company is known for its innovative products, including low-power IoT trackers, LoRaWAN gateways, and real-time mapping solutions. Serving industries like agriculture, logistics, security, and telecommunications, Abeeway has a global presence through partners and distributors in over 60 countries and employs approximately 20 people.

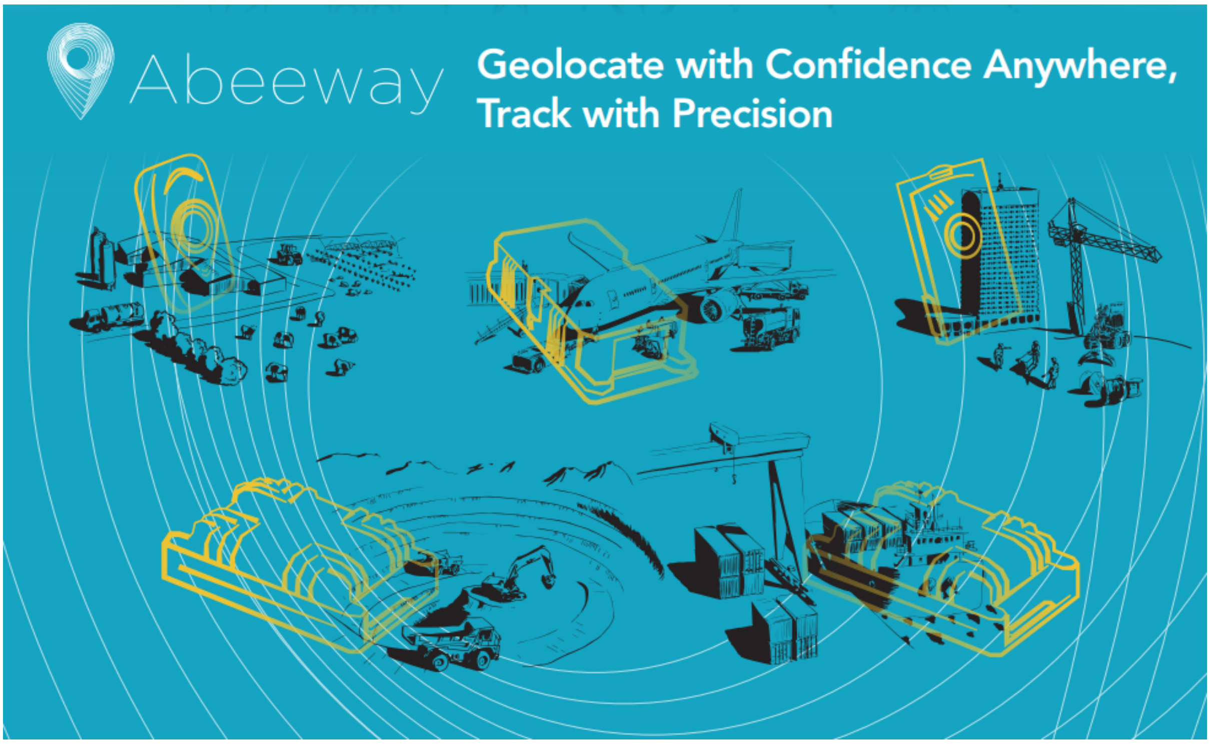


Figure 1.1: Abeeway Tracking

1.1.1 History

Abeeway was founded in 2014 with a focus on providing low power cutting-edge geolocation and real-time tracking solutions. In 2017, the company became a part of the Actility group, further strengthening its capabilities and market reach. Since its inception, Abeeway has been dedicated to advancing geolocation technology, offering a range of innovative products that cater to diverse industry needs. The integration into the Actility group has enabled Abeeway to expand its global footprint and continue its growth as a key player in the geolocation and IoT sectors.

1.1.2 Products

All Abeeway products utilize common hardware and share a unified backend infrastructure for data collection and analysis. They operate on the AT2 (Asset Tracker 2) firmware. And abeeway has extensive expertise in LPWAN technologies, including LoRa, LTE-M, and NB-IoT, as well as indoor and outdoor geolocation.

The ThingParkX Location Engine enhances accuracy and reliability by integrating various positional technologies such as GPS, LP-GPS, Wi-Fi, and BLE. It performs advanced post-processing algorithms to deliver precise location information.

Abeeway provides tools for managing tracker configurations and behavior through the Abeeway Device Manager and mobile application. These tools facilitate the encoding and decoding of tracker payloads.

The mobile application communicates directly with the LoRaWAN® network server to interact with Abeeway trackers. Additionally, the Abeeway Driver Docker service integrates with the application framework to support the encoding and decoding of uplink and downlink messages.

Location data is stored using ThingParkX IoT Core, ensuring robust and reliable data management.

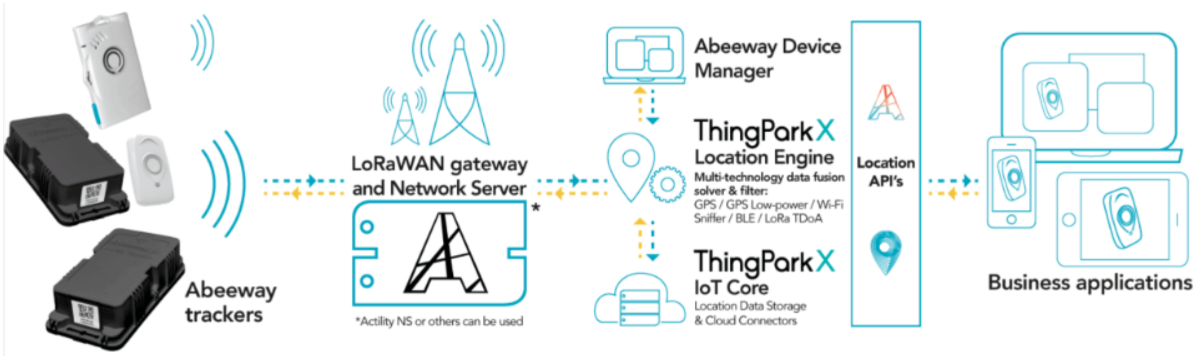


Figure 1.2: ThingPark architecture

Micro Tracker

The Abeeway Micro Tracker, featuring GPS, Low-power GPS, Wi-Fi Sniffer, BLE, and LoRaWAN TDoA, is a compact and durable device for tracking valuables, people, or pets. Its small size and long battery life make it suitable for various applications.

Figure 1.3: Abeeway Micro Tracker

Smart Badge

The Abeeway Smart Badge is a versatile, ID card-format tracker equipped with GPS, Low-power GPS, Wi-Fi Sniffer, BLE, and LoRaWAN TDoA technologies. It provides accurate indoor and outdoor geolocation and is ideal for tracking, zone notifications, and workforce safety. Features include a panic button and an 80dB buzzer for danger zones.

Figure 1.4: Abeeway Smart Badge

Compact Tracker

The Abeeway Compact Tracker offers robust asset tracking with GPS, Low-power GPS, Wi-Fi Sniffer, BLE, and LoRa TDoA technologies. Its compact and durable design suits harsh environments, providing seamless tracking for both heavy-duty and small equipment with long battery life.

Figure 1.5: Abeeway Compact Tracker

Industrial Tracker

The Abeeway Industrial Tracker combines GPS, Low-power GPS, Wi-Fi Sniffer, BLE, and LoRaWAN TDoA technologies in a rugged, high-battery-capacity device. Designed for harsh environments, it is ideal for tracking heavy-duty assets, inventory, or livestock.

Figure 1.6: Abeeway Industrial Tracker

Geoloc Module

The Abeeway LBEU5ZZ1WL Geolocation Module is a multi-technology LPWAN module designed for IoT battery-powered tracking solutions, reducing Total Cost of Ownership (TCO). Co-developed with Murata and featuring technology from Semtech and STMicroelectronics, it integrates a high-performance GNSS receiver (GPS, GLONASS, Beidou, Galileo) with patented ultra-Low-Power GPS (LP GPS) mode. This module simplifies PCB design, lowers certification and testing costs, and accelerates time-to-market.

Figure 1.7: Abeeway Geoloc Module

1.1.3 Organization

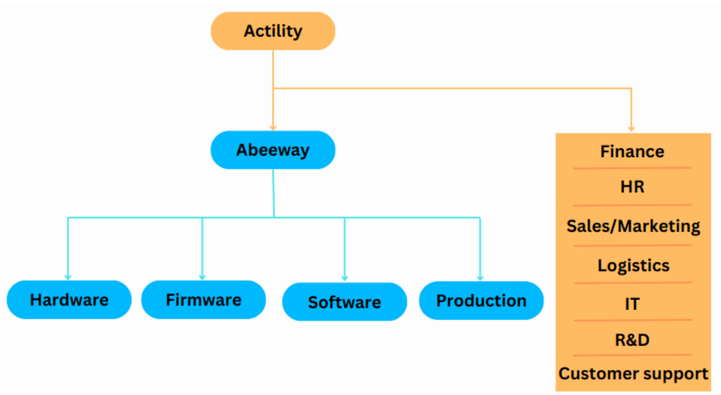


Figure 1.8: Abeeway Organization Chart

Abeeway is a subsidiary of Actility, with shared services across key functions including HR, finance, sales, logistics, and marketing.

Abeeway is made up of four (04) departments:

- **Hardware :** is responsible of the design, development, and implementation of electronic devices and systems.
- **Firmware :** is responsible of developing the low-level software that directly controls and interacts with hardware components.
- **Software :** for developing applications and higher-level software that interacts with hardware components, providing functionality, user interfaces, and overall control systems for electronic devices.
- **Production :** is managing the manufacturing processes, ensuring the efficient and quality production of electronic devices and systems, from assembly to quality control and distribution.

1.1.4 Work environment

At Abeeway, the office is situated in Sophia Antipolis, a prominent technology and business park known for its high concentration of high-tech companies, research institutions, academic campuses, and startups. The team comprises approximately eight members, with many working remotely. During my internship, I was based onsite at Sophia Antipolis. This arrangement allowed me to collaborate closely with the core team members and engage directly with ongoing projects. Despite the presence of remote colleagues, the onsite setup facilitated seamless communication and integration into the team's workflow, providing a valuable opportunity to contribute effectively to the firmware testing processes.

Under the leadership of Stéphane Boudaud, Abeeway conducts weekly meetings with every team. These meetings are typically held on Tuesdays and serve as a vital platform for communication and collaboration among all team members. During these sessions, each team presents their ongoing work, shares insights, and discusses new projects. This communicative environment ensures that progress is continuously monitored and any issues are promptly addressed.

The weekly meetings foster a culture of openness and teamwork, allowing for the exchange of ideas and feedback. As part of these meetings, I have the opportunity to present my work on the development and testing of the Asset Tracker 3 (AT3) firmware. Presenting my progress allows me to receive valuable feedback from my colleagues, which helps me improve my work and align it with the overall project goals.

Overall, the weekly team meetings under Stéphane Boudaud's leadership play a crucial role in driving the success of our projects by promoting continuous improvement and fostering a collaborative work environment.

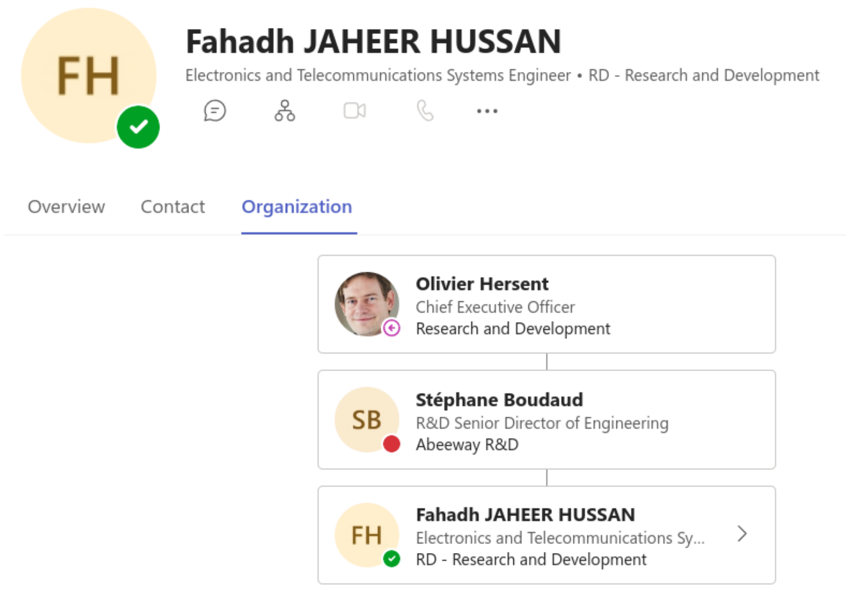


Figure 1.9: Author's Profile on Abeeway

1.2 Acronyms and abbreviations

- **AT3** - Asset Tracker 3
- **LTE-M** - Long Term Evolution for Machines
- **NB-IoT** - Narrowband Internet of Things
- **LPWAN** - Low Power Wide Area Network
- **GNSS** - Global Navigation Satellite System
- **GPS** - Global Positioning System
- **LoRa** - Long Range Radio
- **SOS** - Save Our Souls (Emergency signal)
- **EVK** - Geolocation Module Evaluation Kit
- **CLI** - Command Line Interface
- **SDK** - Software Development Kit
- **MQTT** - Message Queuing Telemetry Transport
- **QA** - Quality Assurance

Chapter 2

Objective of Internship

In previous tracker models such as the Smart Badge, Compact Tracker, Micro Tracker, and Industrial Tracker, specific components were used for each 5 critical functions: the LoRa transceiver, Application MCU, and multi-constellation GNSS receiver, WIFI transceiver, BLE transceiver were individually mounted on the PCB of each device. These trackers operated using the AT2 (Asset Tracker 2) firmware.

However, Abeeway and Murata have developed a new geolocation module that integrates these features into a single package. This module combines the LR1110 transceiver to support Lora/WIFI sniffer, STM32WB chipset (BLE and MCU), and GNSS receiver into one compact unit, this requires new AT3 (Asset Tracker 3) firmware.

Figure 2.1: Abeeway Geoloc Module

The goal of this new geolocation module is to simplify the integration of all LPWAN and geolocation features into a single component and the AT3 firmware is designed to be highly configurable to support a variety of use cases in geolocation applications.

The transition to the AT3 firmware requires thorough testing to ensure that the complex integrated module performs efficiently and reliably. This testing is crucial to validate that the new firmware can fully utilize the integrated module's capabilities with external sub systems such as sensors, and meet performance expectations.

The main objective of internship is to test this firmware features like acquisition, payloads, gnss, lora, wifi, ble and report any inefficiencies. I have been tasked with creating an automated testing tool for Asset Tracker 3 firmware using Python. This tool allows us to run numerous tests as needed and ensures the consistency of the Asset Tracker 3 firmware. The testing tool should generate result files and debug files.

2.1 Geoloc Module

The Abeeway LBEU5ZZ1WL Geolocation Module is a multi-technology fused location LP-WAN module designed as the ideal platform to develop a wide range of IoT battery-powered tracking solutions, minimizing the Total Cost of Ownership (TCO) of IoT geolocation use cases. It is s co-developed and manufactured by Murata, and integrates leading-edge technology from Semtech and STMicroelectronics.

This LoRaWAN fused location module contains a high-performance multi-constellation GNSS receiver (GPS, GLONASS, Beidou, and Galileo) and supports a patented ultra- Low – Power GPS (LP GPS) mode

- **STM32WB MCU :** High-performance microcontroller with an integrated Bluetooth 5.x Low Energy transceiver.
- **Multi-Constellation GNSS Receiver :** Supports GPS, GLONASS, Beidou, and Galileo for accurate geolocation.
- **LR1110 Semtech Transceiver :** Provides LoRa and FSK sub-GHz radio, low-power Wi-Fi, and GNSS reception.

The Geoloc module uses GNSS, BLE, and Wi-Fi to obtain location data, transmitting it to the server via the LR1110 (LoRa). This makes the module effective for indoor and outdoor tracking applications, offering precise and reliable geolocation.

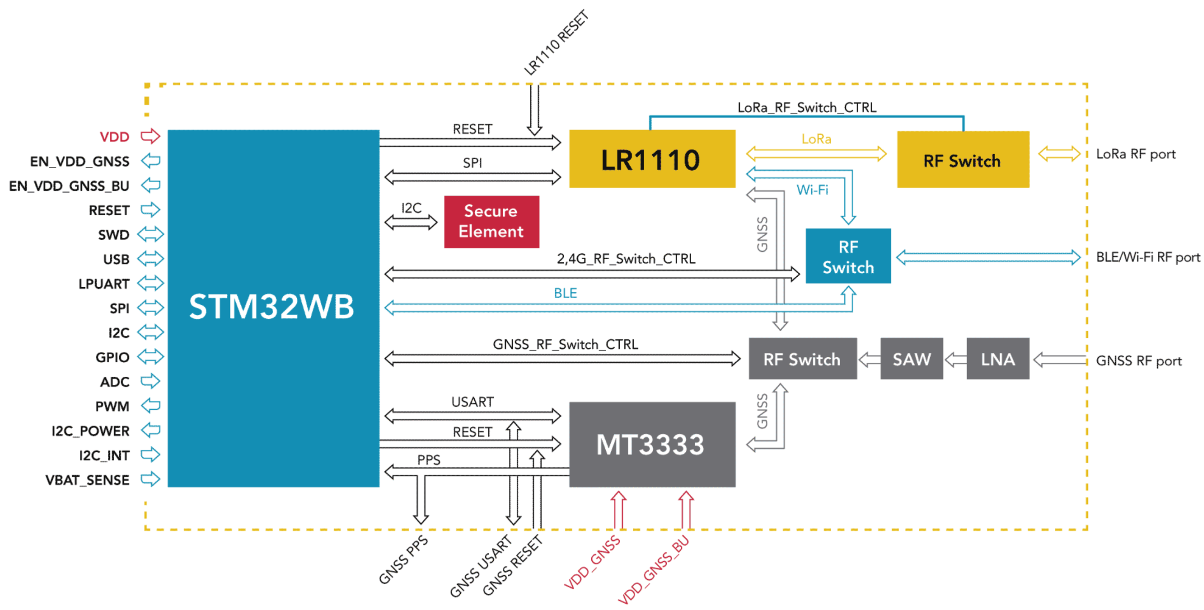
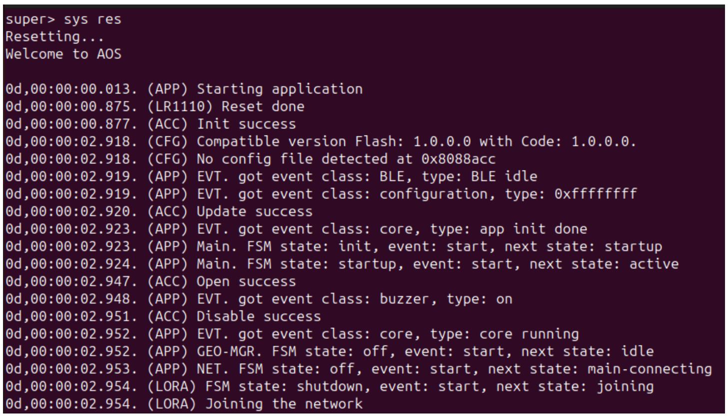


Figure 2.2: Abeeway geoloc module block diagram

2.2 Overview of AT3 Firmware

The Asset Tracker 3 (AT3) firmware is designed to provide comprehensive and versatile tracking capabilities through multiple operating modes and advanced geolocation technologies. **It supports various operating modes, including standby (LoRaWAN™ heartbeat only), motion tracking, permanent tracking, start/end motion tracking, and activity tracking.** These modes allow for tailored tracking solutions based on specific use cases, such as periodic position updates, configurable motion detection, and position on demand, **which conserves power by providing location data only when requested.**

AT3 firmware leverages a range of geolocation technologies to ensure accurate positioning in diverse environments. It supports GPS for precise outdoor positioning, low power GPS (LPGPS) for quick positioning in outdoor and daylight indoor conditions, Wi-Fi for indoor and urban area positioning, and BLE for indoor positioning with beacon filtering capabilities. **The firmware also includes features such as SOS support, shock detection, and configurable motion detection to enhance its utility in various scenarios.** AT3 firmware can be accessed via CLI as shown in Figure 2.3.



```
super> sys res
Resetting...
Welcome to AOS

0d,00:00:00.013. (APP) Starting application
0d,00:00:00.875. (LR1110) Reset done
0d,00:00:00.877. (ACC) Init success
0d,00:00:02.918. (CFG) Compatible version Flash: 1.0.0.0 with Code: 1.0.0.0.
0d,00:00:02.918. (CFG) No config file detected at 0x8088acc
0d,00:00:02.919. (APP) EVT. got event class: BLE, type: BLE idle
0d,00:00:02.919. (APP) EVT. got event class: configuration, type: 0xffffffff
0d,00:00:02.920. (ACC) Update success
0d,00:00:02.923. (APP) EVT. got event class: core, type: app init done
0d,00:00:02.923. (APP) Main. FSM state: init, event: start, next state: startup
0d,00:00:02.924. (APP) Main. FSM state: startup, event: start, next state: active
0d,00:00:02.947. (ACC) Open success
0d,00:00:02.948. (APP) EVT. got event class: buzzer, type: on
0d,00:00:02.951. (ACC) Disable success
0d,00:00:02.952. (APP) EVT. got event class: core, type: core running
0d,00:00:02.952. (APP) GEO-MGR. FSM state: off, event: start, next state: idle
0d,00:00:02.953. (APP) NET. FSM state: off, event: start, next state: main-connecting
0d,00:00:02.954. (LORA) FSM state: shutdown, event: start, next state: joining
0d,00:00:02.954. (LORA) Joining the network
```

Figure 2.3: CLI of the AT3 Firmware

AT3 firmware supports LoRaWAN™ Class A radio for efficient data transmission and can also utilize LTE-M and LTE NB-IoT networks. **The AT3 firmware can send data using either LTE or LoRaWAN**. If one network becomes unavailable, it seamlessly switches to the other, ensuring continuous and reliable data transmission regardless of network conditions. Additionally, the AT3 firmware includes GNSS constellation selection, temperature and battery monitoring, and advanced power management features to ensure reliable and efficient operation.

Overall, the AT3 firmware offers a robust and adaptable solution for real-time tracking and geolocation, catering to a wide range of applications and environments. After obtaining the location data, it sends the information to ThingPark for further analysis. The data is processed using an algorithm to determine the accurate position.

2.3 Geolocation Module Evaluation kit (EVK)

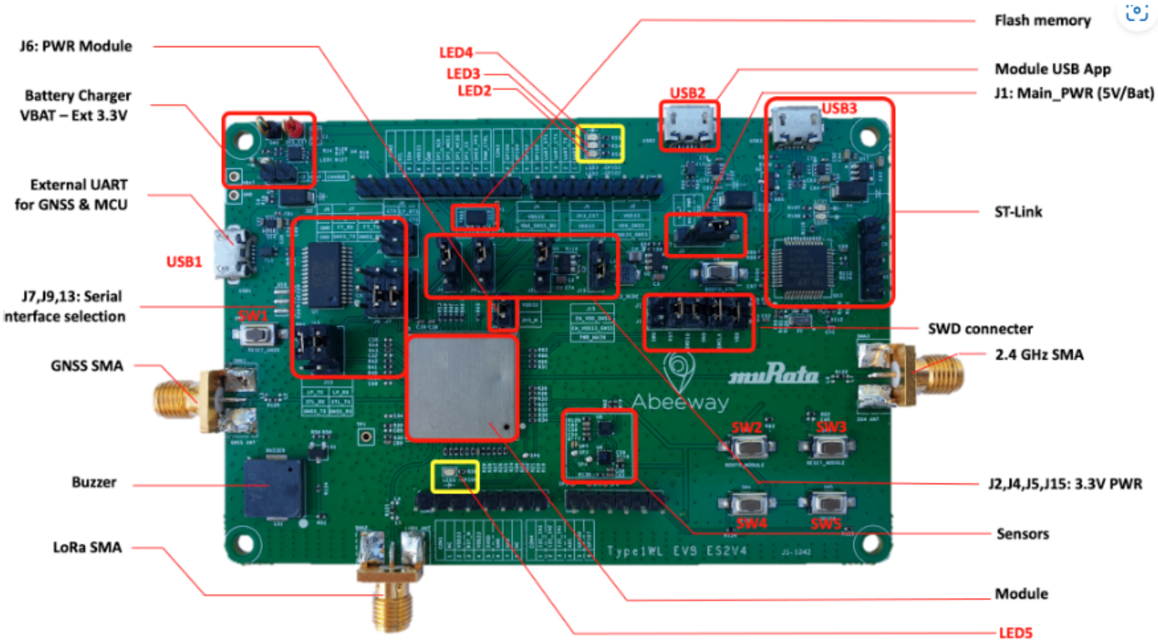


Figure 2.4: Geolocation Module Evaluation kit (EVK)

To test the firmware, I used the Geolocation Module Evaluation Kit (EVK). This EVK is designed to facilitate the development of applications using the geolocation module, including additional features such as LEDs, buttons, and sensors. It is an invaluable tool for assessing the module's performance and accelerating the development process.

The EVK includes a comprehensive SDK that provides all the necessary board-related drivers, allowing device manufacturers to concentrate on developing their application firmware. The module evaluation kit supports all functionalities of the geolocation module, including:

- All radio systems accessible with SMA connectors: LoRaWAN, WiFi sniffing, BLE sniffing, GNSS.
- Digital interfaces such as I2C, LPUART, UART and SPI.
- GPIOs are connected to an Arduino style connector, buttons and LEDs.
- Rich power management circuit with LDO and charger to support external dc source, primary or secondary battery.
- MEMS : accelerometer and pressure sensor attached to I2C interface.
- 3x USB port to supply board.
- ST-LINK interfaces for programming and debugging the STM32Microcontroller embedded in the geoloc module.

This extensive set of features makes the EVK particularly useful for thorough evaluation and rapid application development, ensuring that all aspects of the module's performance can be tested effectively.

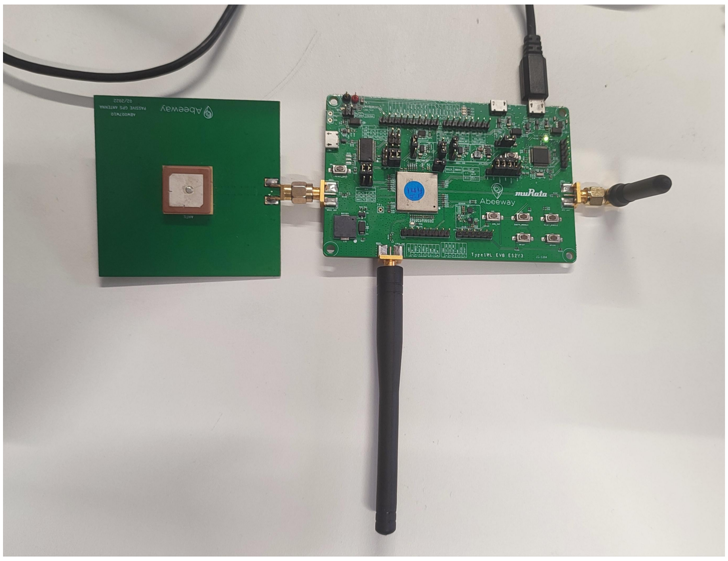


Figure 2.5: Abeeway EVK

Figure 2.5 shows the geolocation module evaluation kit (EVK) equipped with a GNSS antenna, LoRa antenna, and Bluetooth/WI-FI antenna, connected to a PC via USB.

Chapter 3

Project Description (6 Months)

During my internship, I worked closely with the firmware team to gain a comprehensive understanding of how the AT3 firmware operates. My primary objective was to test the various functionalities and features of the AT3 firmware, and to report any bugs or inefficiencies.

3.1 Summary of Internship Activities

The specific tasks I undertook included:

- Understanding and testing geolocation acquisitions in the AT3 Firmware.
- Developing a generic QA core algorithm for automated testing.
- Developing a user interface to facilitate access to the generic QA core algorithm.
- Validating geolocation acquisitions using the generic QA core algorithm.
- Validating payload data with the generic QA core algorithm.
- Validating uplink functionality using MQTT with the generic QA core algorithm.
- Validating downlink functionality using MQTT with the generic QA core algorithm.

These activities allowed me to thoroughly test and validate the AT3 firmware, ensuring its reliability and efficiency.

3.1.1 Understanding and testing geolocation acquisitions in the AT3 Firmware

Objective:

The primary objective was to thoroughly understand the AT3 firmware's functionalities and configurations, particularly focusing on geolocation acquisition events. This involved configuring and manually testing the firmware to ensure that acquisition events, such as GNSS, BLE, and Wi-Fi, occur at the expected intervals.

Analysis:

To gain a comprehensive understanding of the AT3 firmware, the initial step was to flash the firmware and BLE stack onto the Evaluation Kit (EVK) using STM32CubeProgrammer.

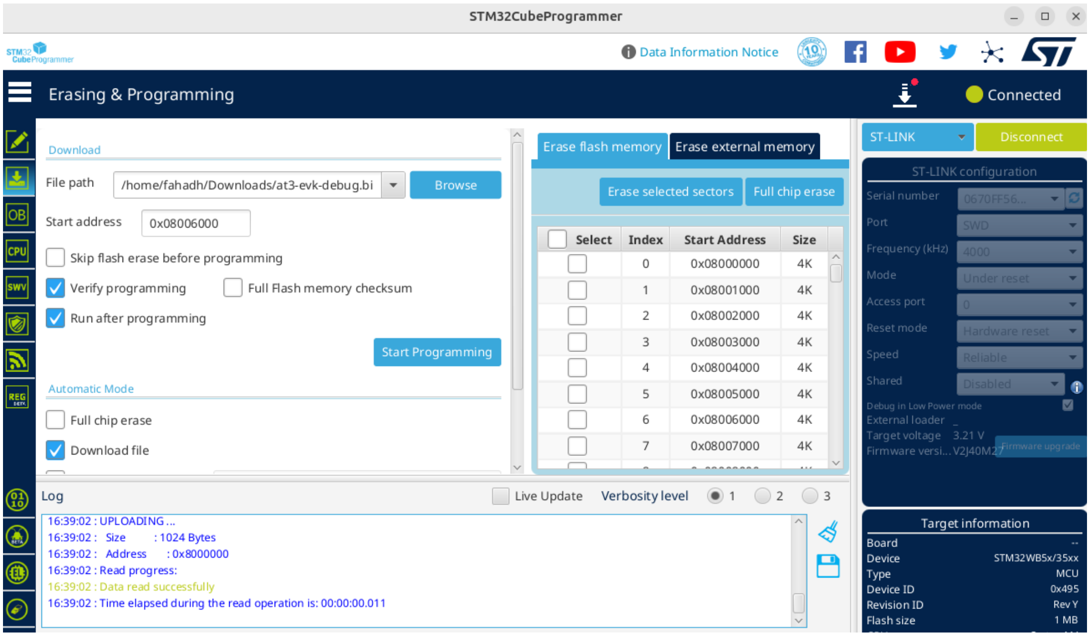


Figure 3.1: Flashing AT3 firmware using STM32cubeprogrammer in EVK

Following this, I explored the firmware's operations through its command-line interface (CLI), which provided insights into various commands and their functionalities. The figure 3.2 shows the low power firmware architecture achieved through a hierarchical and modular structure, where the AT3 application manages the overall operation and interacts with various modules triggered by interrupts.

The application architecture consists of two main layers: **the Application Node Interface (ANI) and the Core.** The ANI connects the application with underlying services, managing specific functions like sensors and communication. The Core layer oversees system management, including state control, event handling, geolocation, networking, and device monitoring. The application operates within a single thread using FreeRTOS, ensuring synchronized actions and stability. This design ensures efficient interaction between hardware and software for reliable performance.

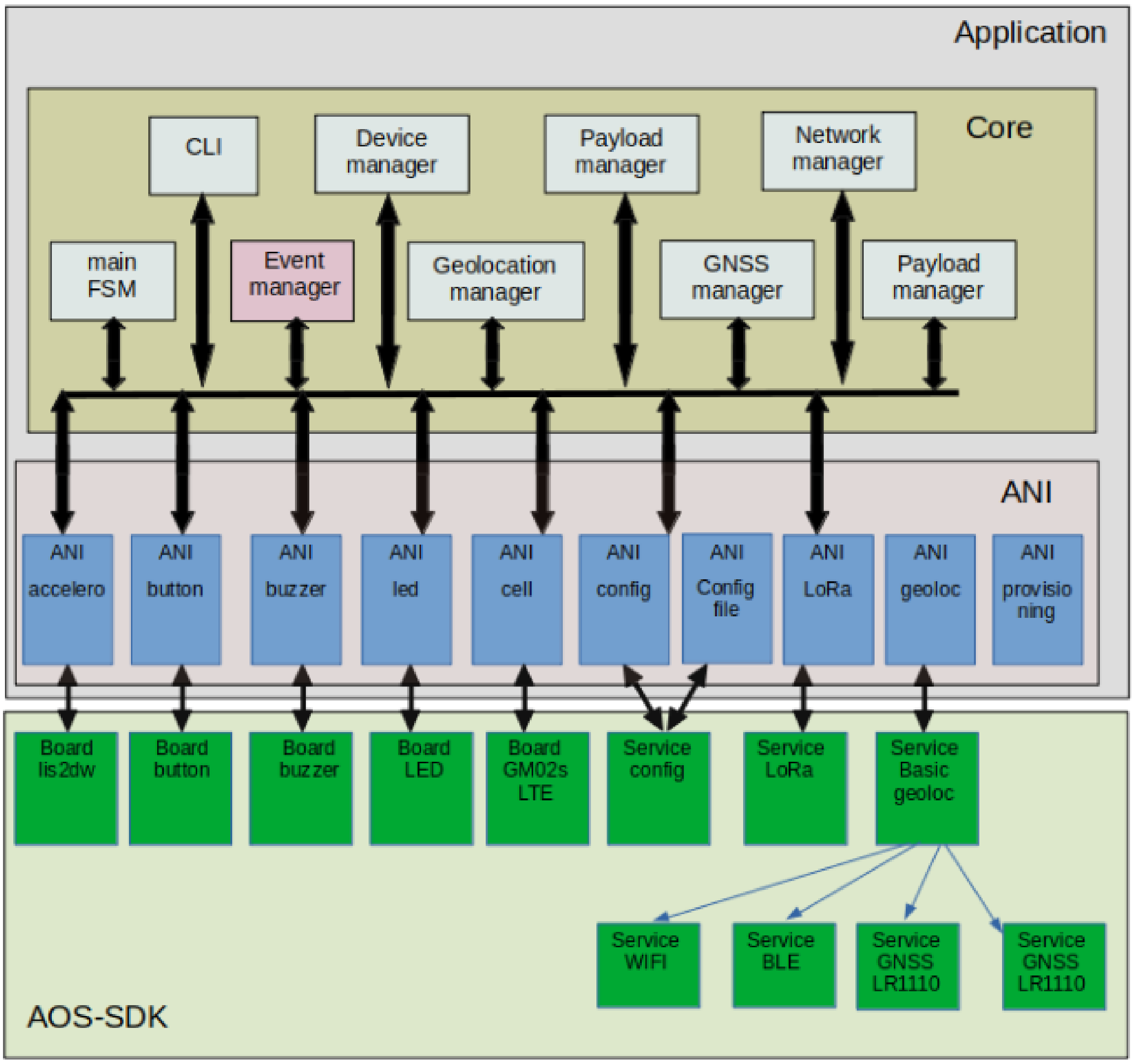


Figure 3.2: AT3 Application

The AT3 firmware is organized into different functional groups. The Geoloc group, in particular, allows configuration of different acquisition technologies. For instance, parameters within this group dictate whether GNSS, BLE, or Wi-Fi acquisition technologies are enabled.

The configuration values for acquisition technologies are as follows:

06: GNSS
03: BLE
02: Wi-Fi

```
super> conf sh gr 2
Group 2 (geoloc)
 Full ID   ID    Name                        Type      Value
 0x0200    0     geoloc_motion_period        Integer   600        (0x00000258)
 0x0201    1     geoloc_static_period        Integer   600        (0x00000258)
 0x0202    2     geoloc_sos_period           Integer   600        (0x00000258)
 0x0203    3     geoloc_motion_nb_start      Integer   1          (0x00000001)
 0x0204    4     geoloc_motion_nb_stop       Integer   1          (0x00000001)
 0x0205    5     geoloc_start_stop_period    Integer   600        (0x00000258)
 0x0206    6     geoloc_gnss_hold_on_mode    Integer   0          (0x00000000)
 0x0207    7     geoloc_gnss_hold_on_timeout Integer   0          (0x00000000)
 0x0208    8     geoloc_profile0_triggers    Integer   0          (0x00000000)
 0x0209    9     geoloc_profile1_triggers    Integer   0          (0x00000000)
 0x020a    10    geoloc_profile2_triggers    Integer   0          (0x00000000)
 0x020b    11    geoloc_gbe_profile0_techno  Array     {06,00,00,00,00,00}
 0x020c    12    geoloc_gbe_profile1_techno  Array     {06,00,00,00,00,00}
 0x020d    13    geoloc_gbe_profile2_techno  Array     {06,00,00,00,00,00}
OK
super>
```

Figure 3.3: AT3 Geolocation Group

By default, the Geoloc group is set to GNSS with the configuration **06,00,00,00,00,00**. However, this setting can be modified to include or prioritize other acquisition technologies as needed.

For the manual tests, I designed and executed test cases to verify geolocation acquisition events. The goal was to ensure that these events—such as BLE, Wi-Fi, and Gnss acquisitions—occurred at the intended intervals. Test cases were created for various scenarios, including both static and dynamic conditions of the tracker, to measure the timing intervals accurately.

```
0d,00:01:46.565. (GNSS) MT. TRACK-GLO, Nb sat: 4, 86/0 71/29 87/0 85/23
0d,00:01:46.567. (GNSS) MT. TRACK-GAL, Nb sat: 0,
0d,00:01:47.573. (GNSS) MT. TRACK-GPS, Nb sat: 10, 8/36 21/32 2/31 27/26 32/23 37/0 10/0 14/0 3/0 22/0
0d,00:01:47.579. (GNSS) MT. TRACK-GLO, Nb sat: 4, 86/0 71/29 87/0 85/23
0d,00:01:47.581. (GNSS) MT. TRACK-GAL, Nb sat: 0,
0d,00:01:47.666. (GNSS) MT. TTFF in 49s
0d,00:01:47.666. (GNSS) MT. Setting system time to 8/5/2024 08:32:30
0d,00:01:47.667. (GNSS) MT. FIX: 3d, ehpe 53.90, 5 sats - 43.6159933 7.0666633 ALT=11540
0d,00:01:49.584. (GNSS) MT. FIX: 3d, ehpe 49.90, 5 sats - 43.6159883 7.0666533 ALT=11630
0d,00:01:50.580. (GNSS) MT. FIX: 3d, ehpe 46.80, 5 sats - 43.6159850 7.0666450 ALT=11730
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0d,00:02:02.616. (GNSS) MT. FIX: 3d, ehpe 32.80, 5 sats - 43.6159500 7.0665866 ALT=11770
0d,00:02:03.614. (GNSS) MT. FIX: 3d, ehpe 31.80, 5 sats - 43.6159466 7.0665866 ALT=11770
0d,00:02:04.609. (GNSS) MT. FIX: 3d, ehpe 31.80, 5 sats - 43.6159433 7.0665833 ALT=11770
0d,00:02:05.617. (GNSS) MT. FIX: 3d, ehpe 30.90, 5 sats - 43.6159350 7.0665750 ALT=11780
0d,00:02:06.614. (GNSS) MT. FIX: 3d, ehpe 31.00, 5 sats - 43.6159350 7.0665766 ALT=11830
0d,00:02:07.616. (GNSS) MT. FIX: 3d, ehpe 30.20, 5 sats - 43.6159316 7.0665700 ALT=11900
0d,00:02:07.617. (GNSS) MT. Convergence timeout:20s
0d,00:02:07.617. (GEO) MT GNSS result type gnss, status: success
0d,00:02:07.617. (GNSS) MT. GNSS fix complete
0d,00:02:07.618. (GNSS) MT. RF switch event: released
0d,00:02:07.618. (GNSS) MT. Set power to standby
0d,00:02:07.619. (GEO) Geolocation results. Nb techno: 1
0d,00:02:07.619. (GEO)  -Techno gnss, geoloc status: success. Techno status: fix success
0d,00:02:07.620. (APP) EVT. got event class: geolocation, type: done
0d,00:02:07.620. (APP) GEO-MGR. FSM state: acquiring, event: done, next state: wait-timer
0d,00:02:07.621. (APP) GEO-MGR. Process result for triggers 0x00000004
0d,00:02:07.622. (APP) GEO-MGR. FSM state: wait-timer, event: complete, next state: idle
0d,00:02:07.622. (APP) GEO-MGR. Process trigger. Active trigger: prev: 0x0, processed: 0x0, new: 0x0. Cur prio: -1, New_p
0d,00:02:07.623. (APP) EVT. got event class: geolocation, type: complete
0d,00:02:07.625. (LR1110) TX.Size: 23. Rqst DR: DR0, Actual: DR0. Actual ADR: no
0d,00:02:07.628. (LORA) TX request status: success
0d,00:02:07.629. (LORA) TX (Port: 19, DR 0, TX#1): 10 64 78 31 8a 00 04 19 ff 43 54 04 36 45 e4 00 77 08 b0 00 11 1e 65
0d,00:02:07.630. (LORA) TX queued
0d,00:02:13.790. (LORA) RX LoRa event: TX success
```

Figure 3.4: Gnss Acquisition

Figure 3.4 illustrates the GNSS acquisition process, which retrieves latitude and longitude coordinates and sends these payloads to the server via LoRa.

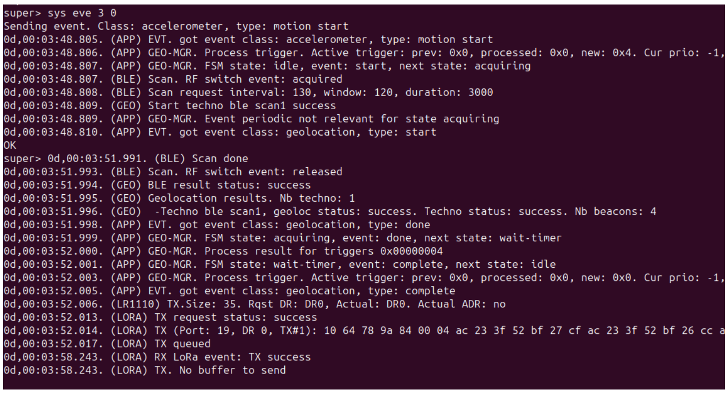


Figure 3.5: Ble Acquisition

Figure 3.5 illustrates the BLE acquisition process, which captures the MAC addresses of the nearest BLE beacons and sends these MAC addresses to the server via LoRa.

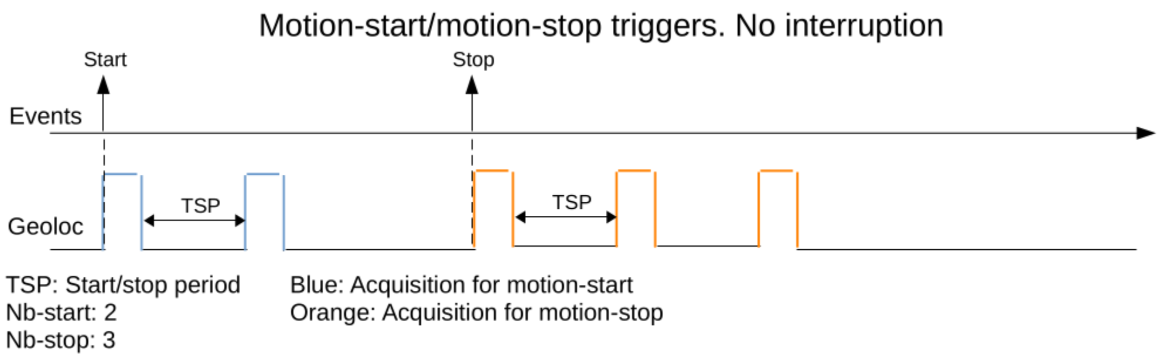


Figure 3.6: Acquisition events during motion start and motion stop

For instance Fig 3.6, according to the AT3 firmware configuration, when motion starts, there should be a 2-acquisition TSP (Time Slot Period) interval, and when motion ends, there should be a 3-acquisition TSP interval.

Other example:

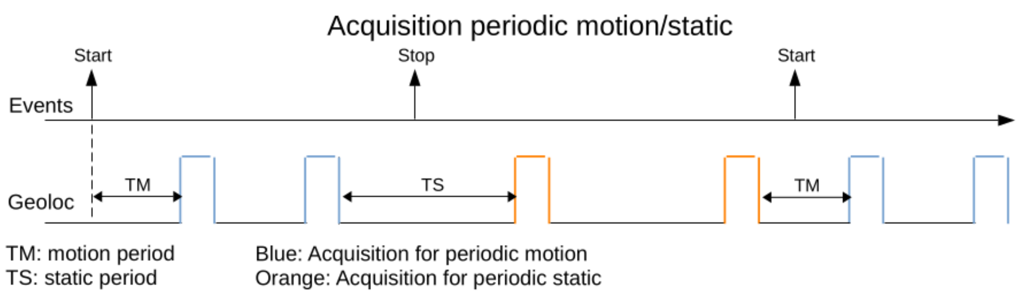


Figure 3.7: Acquisition events during periodic motion and periodic static

Challenges:

The testing process presented several challenges:

Firmware Configuration: Configuring the firmware to utilize different acquisition technologies and understanding their specific operations was complex. The detailed study of technical documentation and iterative testing were essential to navigate these configurations.

Timing Measurement: Accurately measuring the timing between acquisition events required a deep understanding of the firmware's scheduling and configuration. Ensuring that the timing matched the expected intervals was challenging, especially when dealing with different profiles and triggers.

Bug Identification: During testing, a discrepancy was identified between the expected and actual timing intervals, indicating a potential bug in the firmware's timing calculations. This required reporting the issue to the firmware development team for further investigation.

Conclusion:

Through detailed analysis and manual testing, I successfully understood the AT3 firmware's operations and verified its geolocation acquisition events functionalities. The tests confirmed that the firmware's acquisition events generally occurred as expected, though a bug was discovered that affected timing accuracy. This issue has been reported to the firmware development team for resolution. The experience provided a solid foundation for understanding and evaluating the firmware.

3.1.2 Developing a generic QA core algorithm for automated testing

Objective:

Manual testing of the AT3 (Asset Tracker 3) firmware was proving to be time-consuming due to the extensive number of test cases required for each new release. Given the need to validate numerous aspects of the firmware consistently, it became clear that an automated solution was essential.

To address this, the primary objective was to develop a generic QA core algorithm to streamline and expedite the testing process.

The generic QA core algorithm was designed to efficiently execute a wide range of test cases, generate comprehensive result and debug files, and be scalable for future test additions. By replacing manual testing with this automated approach, significant time savings and increased testing efficiency were achieved, ensuring that the AT3 firmware could be validated thoroughly and consistently with each new release.

Analysis:

To develop a generic QA core algorithm for testing the AT3 firmware, the algorithm must interact with the firmware by sending commands and receiving responses. The core of the automation process relies on command execution and response validation. Here's how it was structured:

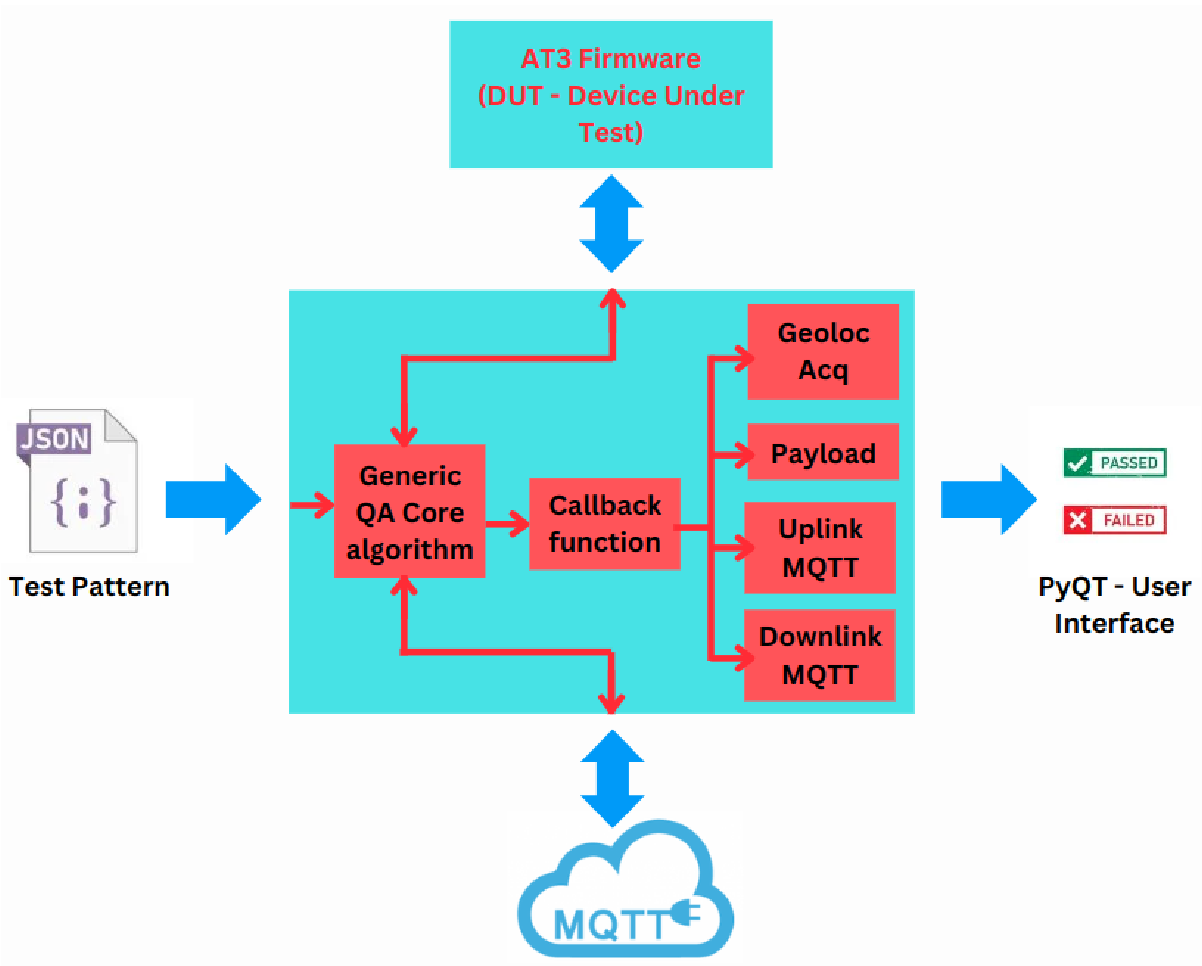


Figure 3.8: Diagram of generic QA core algorithm

1. Command and Response Management: The algorithm needed to handle the communication between the testing interface and the AT3 firmware. This involved sending specific commands to the firmware and waiting for its responses. To manage this efficiently, a JSON configuration file was created.

This file defines various test states, each representing a specific command to be sent, the expected response, and the criteria for validation.

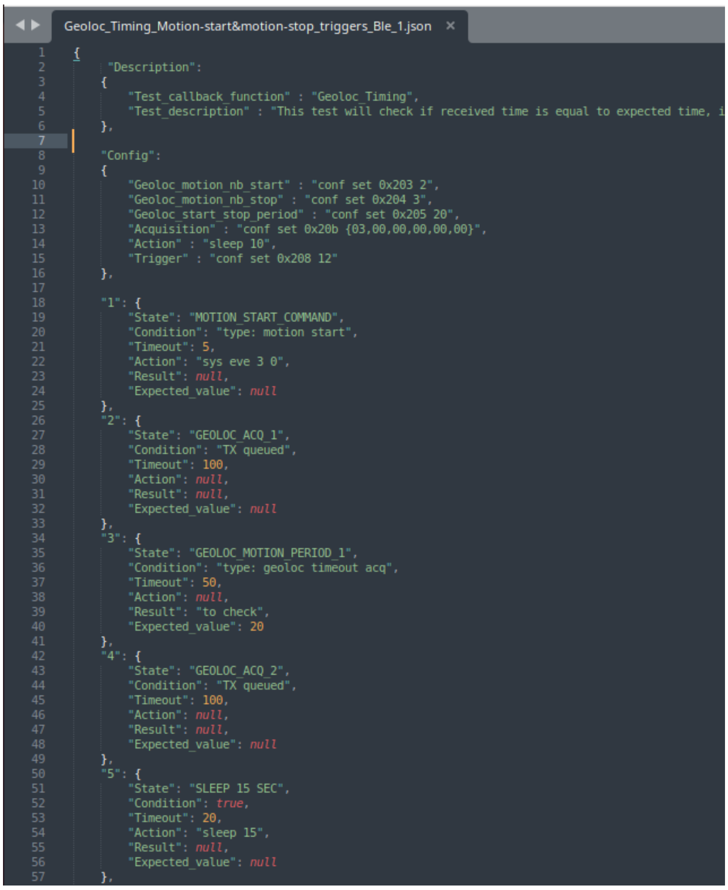


Figure 3.9: Test case in Json

2. State Management: Each state in the JSON file includes:

- **State** - Name of the test state
- **Condition** - The expected response from the AT3 firmware
- **Timeout** - The time limit for each state
- **Action** - The command to be sent to the firmware
- **Result** - Whether the result should be checked (e.g., "to check")
- **Expected Value** - The value that should be verified against the response

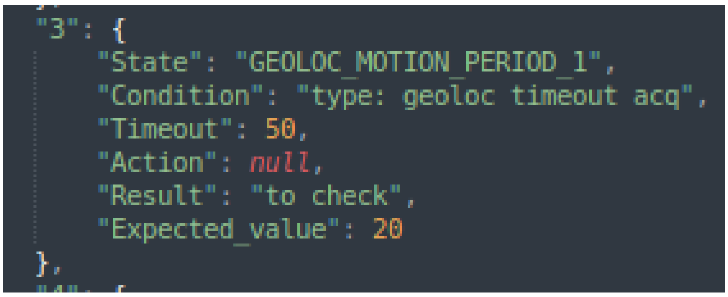


Figure 3.10: State in Json

During the test, the algorithm sends the command, waits for the response, and then compares it with the expected value using **callback function.** If the actual response matches the expected value, the state is considered passed; otherwise, it is marked as failed.

3. Callback Functions: To handle different types of tests, the algorithm uses callback functions. Each test may require specific validation logic, so different callback functions are defined to perform these checks. When a test is executed, the tool calls the appropriate callback function to carry out the required validation and produce the result.

4. MQTT Integration: The algorithm leverages MQTT for tests requiring comparison between firmware results and server data. This integration helps validate uplink and downlink functionalities, ensuring that the communication between the firmware and server operates correctly.

5. Result Recording: As the algorithm executes each state, it writes the test results to a result file. This file logs whether each state passed or failed based on the comparison of actual and expected values. The failures are classified into three types: result fail, timeout fail, and loop fail. Additionally, a debug file is generated, which contains detailed information about the firmware's behavior during the test. This helps in tracing any issues that may arise.

In summary, the generic QA core algorithm was designed to systematically send commands to the AT3 firmware, validate the responses, and log results for further analysis. The use of a JSON configuration file, state management, and callback functions ensured a flexible and scalable testing process.

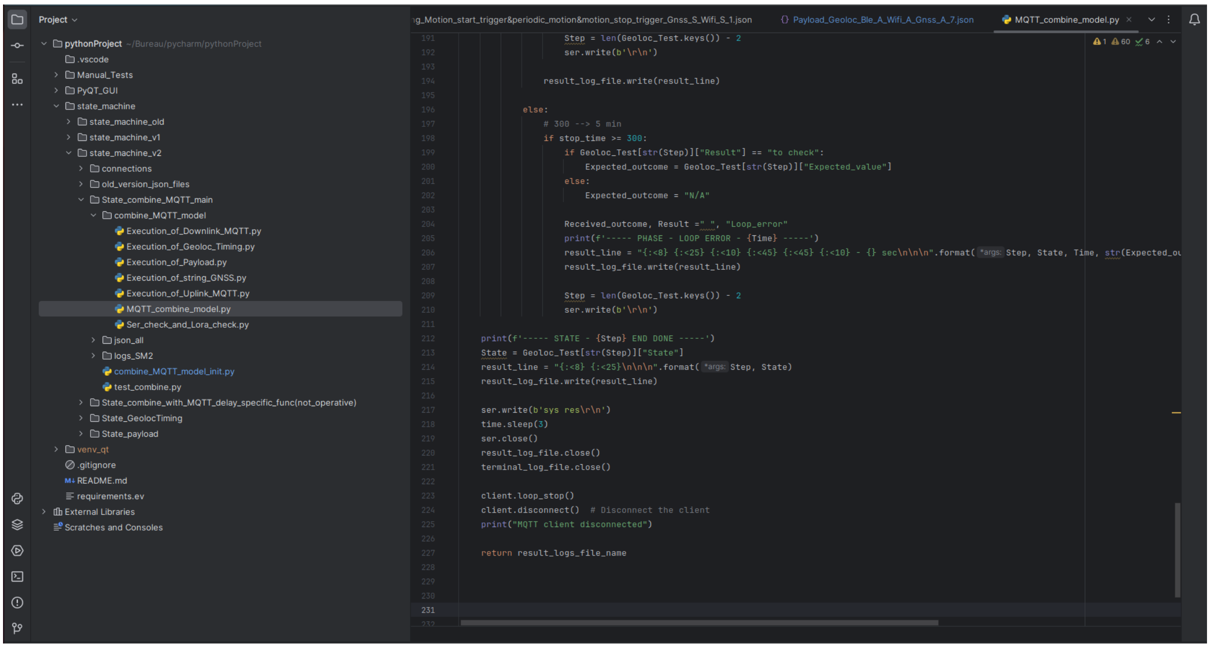


Figure 3.11: Generic QA core algorithm

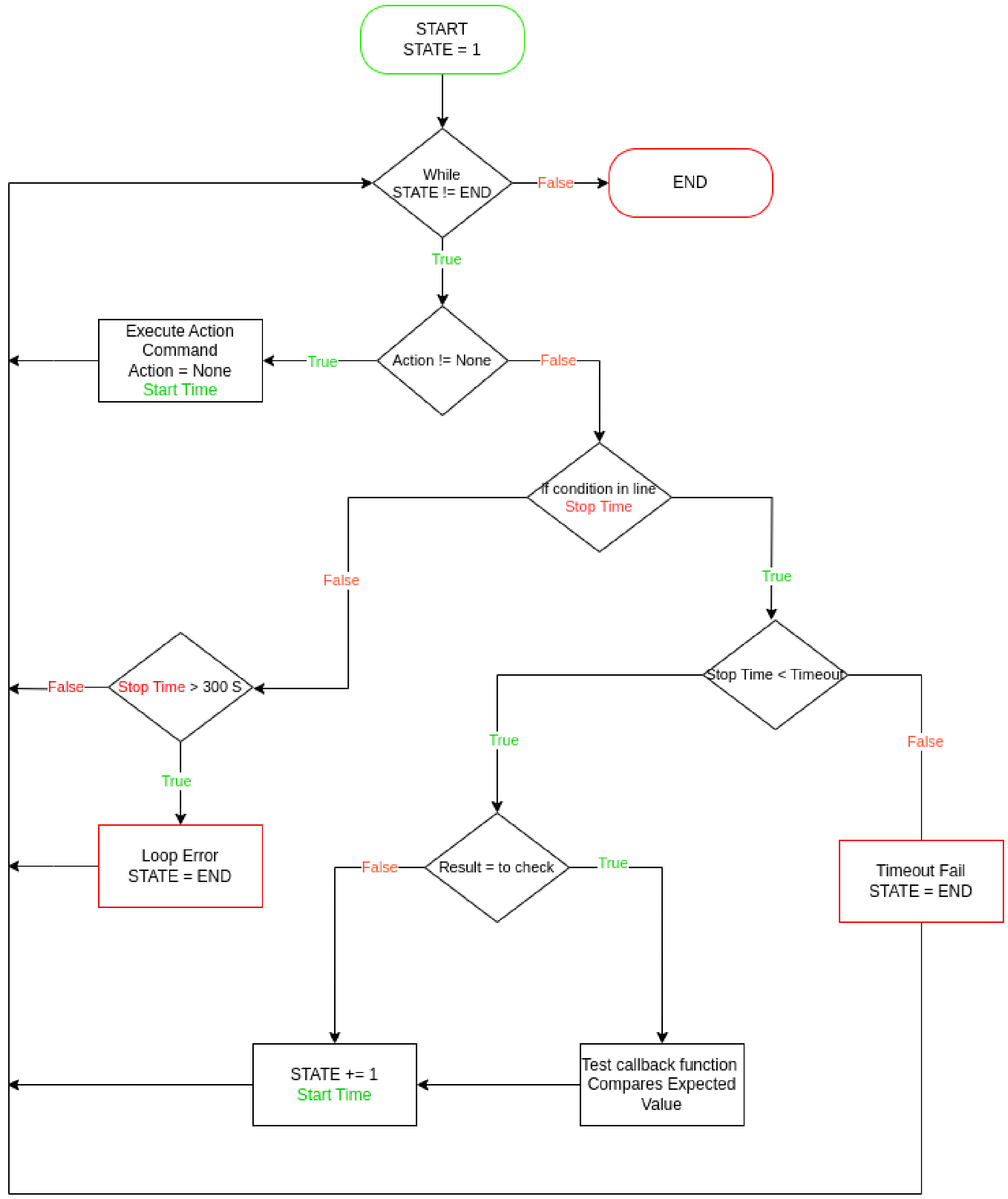


Figure 3.12: Block Diagram of the generic QA core algorithm for AT3 Testing

Challenges:

Developing a generic QA core algorithm required strong programming skills and posed the challenge of creating a flexible solution without hard coding specific test cases. Ensuring the tool's adaptability and accuracy across various scenarios was a key difficulty.

Conclusion:

The generic QA core algorithm was successfully developed, enabling efficient execution of various tests and identification of firmware inefficiencies. This tool significantly reduces testing time and is adaptable for future testing needs.

3.1.3 Developing a user interface to facilitate access to the generic QA core algorithm

Objective: With the generic QA core algorithm completed, the next step was to create a user-friendly interface to enable the firmware development team to easily access the tool, view result and debug files, and modify JSON configuration files. The goal was to streamline the testing process and make it more accessible for ongoing firmware validation.

Analysis:

To achieve this, I utilized PyQt, a set of Python bindings for the Qt application framework. PyQt allows for the creation of cross-platform applications with graphical user interfaces. The user interface (UI) was designed to provide several key functionalities:

- **Test Selection:** Users can select multiple test cases by choosing different JSON configuration files, allowing them to run various tests in a single session.
- **Execution Control:** Users can start and stop tests directly from the UI, providing more control over the testing process.
- **Trace Viewing:** The UI enables users to view real-time traces during test execution. **File Management:** Users can access and review result files and debug files, and make modifications to JSON configurations as needed.

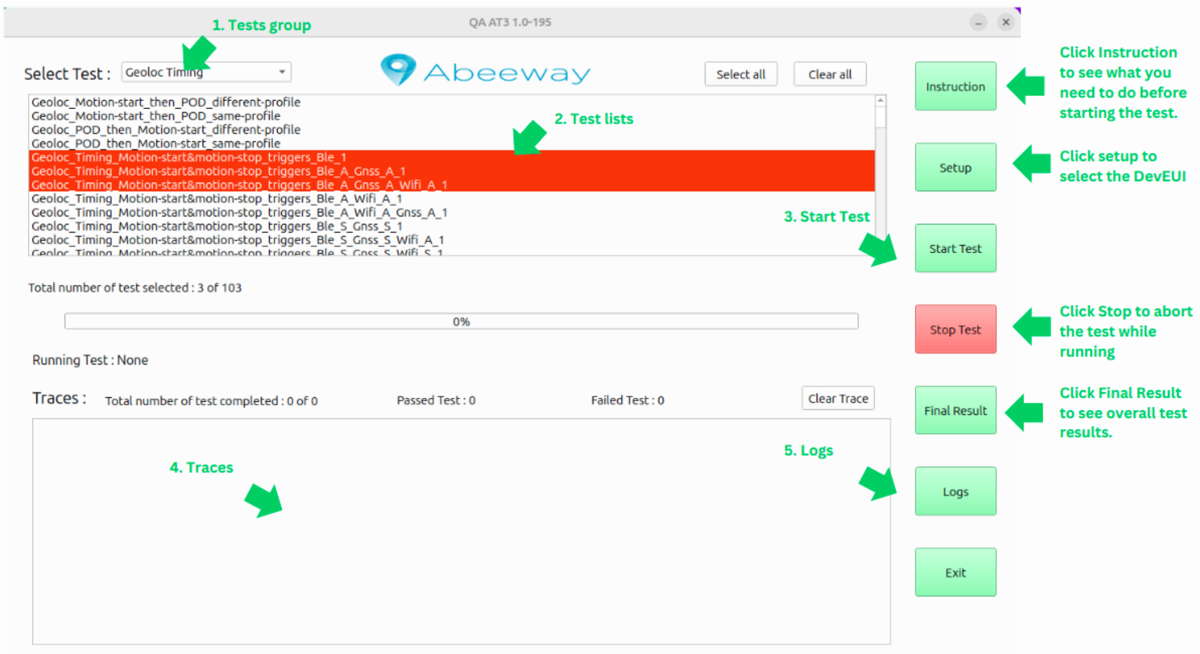


Figure 3.13: Main Window of user interface

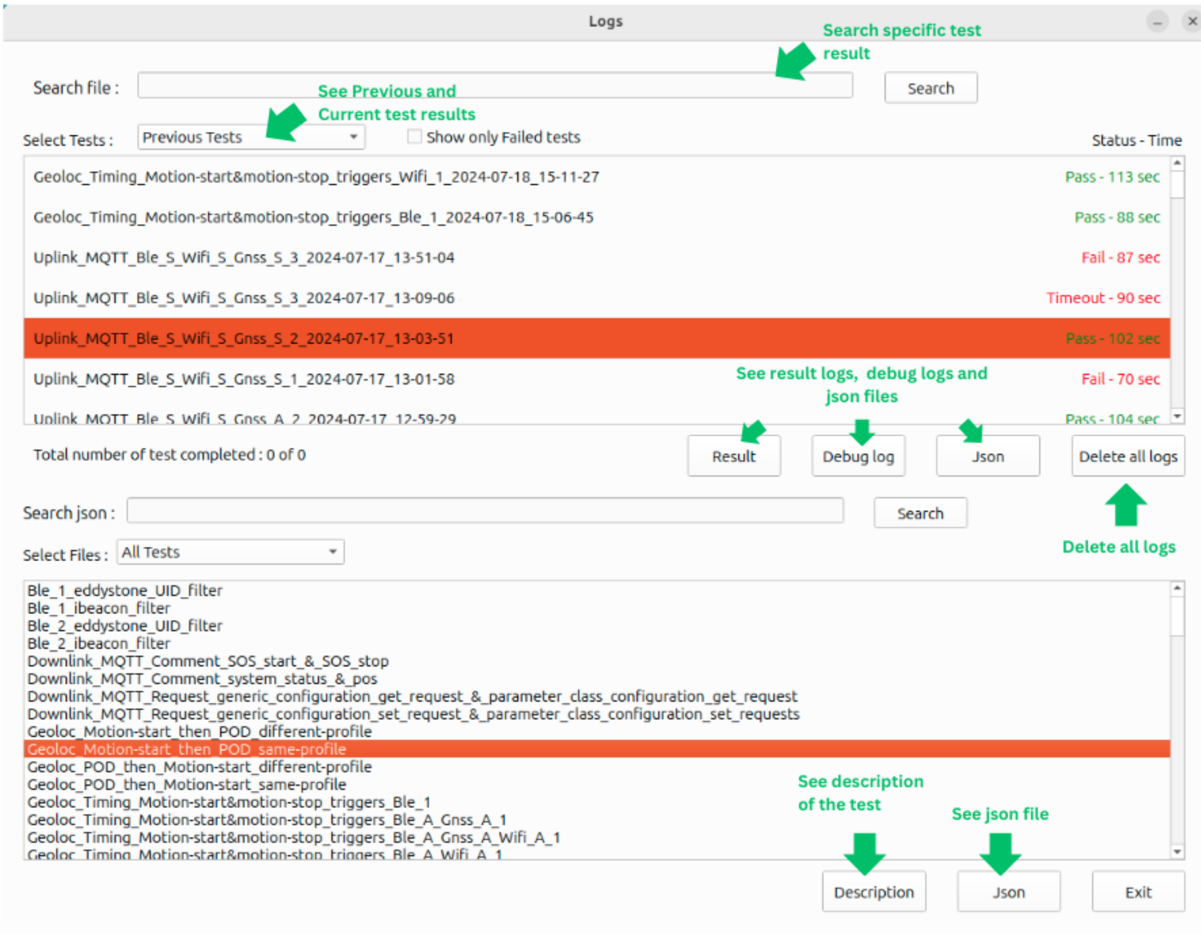


Figure 3.14: Log Window of user interface

Challenges:

Learning PyQt posed a challenge due to its complexity and the need to integrate various components smoothly. Creating a responsive and functional UI required a deep understanding of PyQt's features and effective design principles. However, through persistent effort and research, these challenges were addressed, resulting in a fully functional interface.

Conclusion:

The development of the user interface has significantly enhanced the usability of the generic QA core algorithm. Firmware development team members can now efficiently access the user interface, execute tests, and review results with ease. This interface is crucial for detecting inefficiencies and verifying firmware performance, especially after major upgrades. The successful implementation of the UI has streamlined the testing process, making it more efficient and user-friendly.

3.1.4 Validating geolocation acquisitions using the generic QA core algorithm

Objective:

The primary objective was to validate the geolocation acquisitions events occur at the expected intervals, as outlined in the manual tests, by employing a generic QA core algorithm. This algorithm was designed to streamline the testing process, generate a result file, and create a debug file to facilitate thorough analysis.

Analysis:

In manual testing, geolocation acquisitions events were evaluated to ensure accurate acquisition timings. To automate these tests, I created a JSON configuration file outlining various scenarios. This file allowed the generic QA core algorithm to simulate acquisitions and measure timing intervals. The algorithm compared the actual timings of acquisition events to the expected ones and produced result and debug files for analysis.

Challenges:

Using the generic QA core algorithm to measure timing of acquisition event introduced several complexities. Challenges included ensuring the algorithm correctly interpreted the JSON test cases and accurately captured timing data. Despite these difficulties, persistent troubleshooting and refinement of the tool allowed for successful measurement of timing intervals.

Description of the test:
This test will check if received time is equal to expected time, it will do ble skip on success acquisition, Skip on success means if one acquisit
Based on the trigger configuration - 12 (Trigger in motion start (bit 2 = 4) and Trigger in motion stop (bit 3 = 8), (bit 2 + bit 3 = 12)). When mot
should be around 20 seconds.

Step	State	Time(s)	Expected_outcome	Received_outcome	Result
1	MOTION_START_COMMAND	0.05	N/A	N/A	
2	GEOLOC_ACQ_1	3.32	N/A	N/A	
3	GEOLOC_MOTION_PERIOD_1	19.92	20	19.92	Pass
4	GEOLOC_ACQ_2	3.39	N/A	N/A	
5	SLEEP 15 SEC	15.00	N/A	N/A	
6	MOTION_STOP_COMMAND	0.03	N/A	N/A	
7	GEOLOC_ACQ_3	3.35	N/A	N/A	
8	GEOLOC_STATIC_PERIOD_1	19.91	20	19.91	Pass
9	GEOLOC_ACQ_4	3.34	N/A	N/A	
10	GEOLOC_STATIC_PERIOD_2	19.91	20	19.91	Pass
11	END				

Test Result : Pass
Total Test Time : 88 sec

Figure 3.15: Generated Geolocation acquisitions result file

Conclusion:

The implementation of the generic QA core algorithm facilitated successful validation of geolocation acquisition event timing intervals. By automating the testing process, the algorithm not only provided accurate timing measurements but also generated comprehensive result and debug files. This approach significantly enhanced the efficiency of the testing process and provided valuable insights into the performance of the AT3 firmware.

3.1.5 Validating payload data with the generic QA core algorithm

Objective:

The primary objective was to validate the payload data transmitted by the AT3 firmware based on various acquisition events, including Bluetooth (BLE), Wi-Fi, and GNSS. The goal was to ensure that the transmitted payload matches the expected format and content.

Analysis:

The validation process involved checking the payloads sent by the AT3 firmware after completing acquisitions using BLE, Wi-Fi, and GNSS technologies. For BLE and WI-FI acquisitions, the firmware transmits payloads containing the detected BLE beacon MAC addresses and WI-FI MAC addresses. For GNSS, it transmits latitude and longitude coordinates.

To validate these payloads, several aspects were examined:

- **Payload Type:** Determining whether the payload is a single frame or multi-frame.
- **Acquisition Result:** Determining whether the acquisition is success or failure.
- **Sequence Number:** Verifying the sequence number of each payload to ensure proper order and uniqueness.
- **Data Accuracy:** Comparing the received payload data with the expected values, such as MAC addresses for BLE, Wi-Fi, and latitude/longitude for GNSS.

The generic QA core algorithm was used to automate these checks, comparing the actual payload data against the expected results to ensure accuracy.

Challenges:

Several challenges were encountered during the testing:

- **BLE Configuration:** Configuring BLE acquisitions to detect and filter specific beacons proved challenging. Ensuring the received MAC address matched the expected address required careful configuration and testing.
- **Payload Sequencing:** Each payload includes a sequence number that varies with each transmission. Tracking and validating these sequence numbers against expected values required a deep understanding of the AT3 firmware's technical documentation.

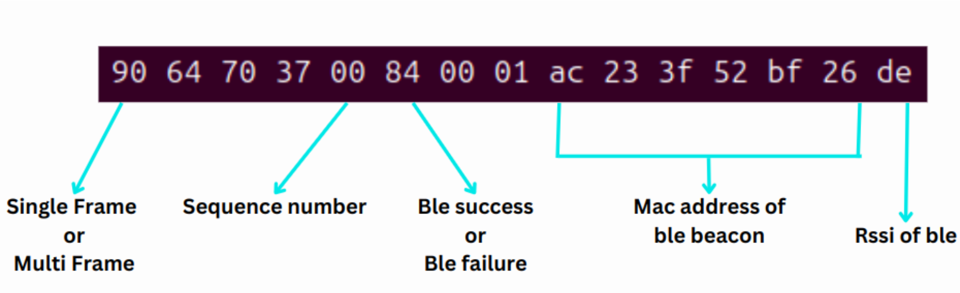


Figure 3.16: Payload of bluetooth acquisition

Conclusion:

The validation process was successful, confirming that the payload data transmitted by the AT3 firmware matched the expected values. This testing helped identify any discrepancies or errors in the payload data, ensuring the accuracy and reliability of the firmware's data transmission capabilities.

```
Description of the test:
 This test will check if received payload is equal to expected payload, Based on the acquisition configuration 83,82,06, We will get bluetooth always done
done means - always do the acquisition.

In this test, it will check, (I) On BLE success, BLE and WIFI (success or failure) are reported
-> Frame 1: Multi-frame set (byte at index 0 > 0x80). M-header (index 4): Group= 0, FID=0, last = 0), BLE report (value 0x04 at index 5), mac address of b
Frame 2: Multi-frame set (byte at index 0 > 0x80). M-header (index 4): Group= 0, FID=1, last = 1), WIFI success or failure report (value 0x03 or 0x43 at i

(II) On BLE failure, WIFI failure, GNSS success. BLE,WIFI and GNSS are reported
-> Frame 1: Multi-frame set (byte at index 0 > 0x80). M-header (index 4): Group= 1, FID=0, last = 0), BLE failure report (value 0x44 at index 5),
Frame 2: Multi-frame set (byte at index 0 > 0x80). M-header (index 4): Group= 1, FID=1, last = 0), WIFI success or failure report (value 0x03 or 0x43 at i
Frame 3: Multi-frame set (byte at index 0 > 0x80). M-header (index 4): Group= 1, FID=2, last = 1), GNSS success report (value 0x0a at index 5), latitude a

(III) On BLE failure, WIFI failure, GNSS failure. BLE and WIFI are reported
-> Frame 1: Multi-frame set (byte at index 0 > 0x80). M-header (index 4): Group= 2, FID=0, last = 0), BLE failure report (value 0x44 at index 5),
Frame 2: Multi-frame set (byte at index 0 > 0x80). M-header (index 4): Group= 2, FID=1, last = 1), WIFI failure report (value 0x43 at index 5).
```

Step	State	Time(s)	Expected_outcome	Received_outcome	Result
1	EVENT_START_COMMAND	0.11	N/A	N/A	
2	BLE_SUCCESS	3.10	N/A	N/A	
3	TRANSMIT_1_BLE	32.35	90 xx xx xx 00 04 xx xx ac 23 3f 52 bf 27	90 64 18 a0 00 04 00 01 ac 23 3f 52 bf 27	Pass
4	TRANSMIT_1_WIFI	6.26	90 xx xx xx 11 x3 xx xx	90 64 18 a0 11 03 00 01	Pass
5	SLEEP_5_SEC	5.00	N/A	N/A	
6	BLE_FAILURE_CONFIG	0.03	N/A	N/A	
7	WIFI_FAILURE_CONFIG	0.03	N/A	N/A	
8	EVENT_START_COMMAND	0.01	N/A	N/A	

Figure 3.17: Generated Payload result file

3.1.6 Validating Uplink Functionality Using MQTT with the generic QA core algorithm

Objective:

The primary objective was to validate the uplink functionality of the AT3 firmware by comparing the payloads sent from the firmware to the server via MQTT. This involved ensuring that the uplink data transmitted by the firmware matched the data received and recorded by the MQTT broker.

Analysis:

In LoRaWAN, each device has a unique identifier called DEVEUI. When the AT3 firmware transmits an uplink payload, it sends this data to the MQTT broker, with DevEUI serving as the topic under which the payload is published. To validate the uplink functionality, I retrieved the payload from the MQTT broker and compared it against the payload generated by the firmware. This comparison was facilitated by the generic QA core algorithm, which automated the process of checking payload consistency.

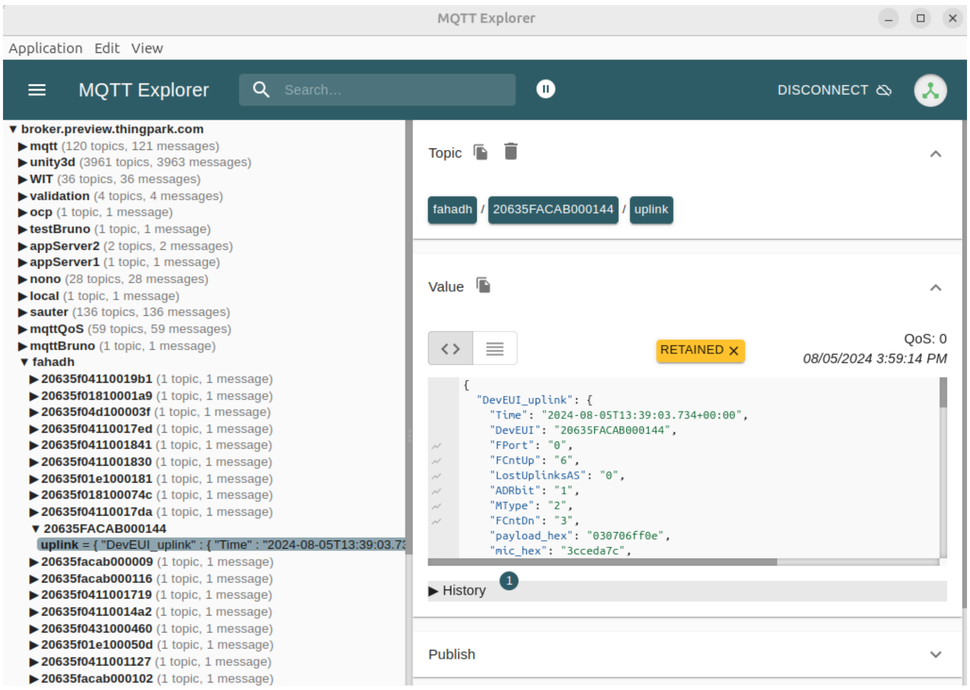


Figure 3.18: MQTT Explorer

```
"4": {
    "State": "LORA_RX",
    "Condition": "LoRa event: TX success",
    "Timeout": 15,
    "Action": null,
    "Result": "to check",
    "Expected_value": {"FPort" : 15, "SpFact" : 11, "payload_hex" : "10 xx xx xx 04 xx xx ac 23 3f 52 bf 27"}
},
```

Figure 3.19: State in uplink Test

Challenges:

A notable challenge during this testing was a synchronization issue between the uplink payloads received from MQTT and those generated by the firmware. To address this, a Last In, First Out (LIFO) queue mechanism was employed. This approach ensured that the most recent uplink payload from MQTT was compared with the latest payload generated by the firmware, thereby resolving timing discrepancies.

Conclusion:

The uplink payloads were successfully compared between the MQTT broker and the firmware. During this testing phase, **a discrepancy was identified where the spreading factor reported by the firmware did not match the data observed in MQTT. This issue was promptly reported to the firmware development team for further investigation.** The results from this testing provided valuable insights and confirmed that the generic QA core algorithm effectively validated uplink functionality, with accurate results being produced.

```
4        LORA_RX                  3.51

     Expected outcome :
     {'FPort': 15, 'SpFact': 11, 'payload_hex': '10 xx xx xx 04 xx xx ac 23 3f 52 bf 27'}

     Received outcome :
     {'FPort': 15, 'SpFact': 11, 'payload_hex': '10 01 17 54 04 00 01 ac 23 3f 52 bf 27'}      Pass


5        TRANSMIT_2_BLE           0.06       N/A                                        N/A
```


```
{
  "DevEUI_uplink" : {
    "Time" : "2024-07-15T13:39:39.324+00:00",
    "DevEUI" : "20635FACAB000144",
    "FPort" : "15",
    "FCntUp" : "4",
    "LostUplinksAS" : "0",
    "MType" : "2",
    "FCntDn" : "1",
    "payload_hex" : "10011754040001ac233f52bf27d6ac233f2af76ec0ac233f287046b0ac233f2af76aaf",
    "mic_hex" : "0948af1e",
    "Lrcid" : "000000CB",
    "LrrRSSI" : "-49.000000",
    "LrrSNR" : "13.500000",
```


Figure 3.20: Generated Uplink Test result file

3.1.7 Validating downlink functionality using MQTT with the generic QA core algorithm

Objective:

The primary objective is to validate the downlink functionality of the AT3 firmware by publishing payloads via MQTT to the server. This process involves changing parameters or activating SOS features from the AT3 firmware and verifying the response to ensure the downlink is functioning correctly. Each time a downlink is published, the firmware should be tested to confirm that the downlink is processed as expected.

Analysis:

To test the downlink functionality, the DevEUI is used as the MQTT topic to publish the payload. After sending the downlink payload to the MQTT server, the firmware must receive this downlink. This is accomplished by sending a system event command from the firmware to trigger the reception of the downlink message. Following this, the changed parameters or acivating SOS features in the AT3 firmware are checked to confirm that they reflect the changes specified by the downlink payload. The test is deemed successful if the reception of the downlink message in the firmware match the expected values.

```json
"2": {
    "State": "GENERIC_SET_PUBLISH",
    "Condition": true,
    "Timeout": 10,
    "Action": "publish 100002002100000000507012100000 1f4",
    "Result":  null,
    "Expected_value": null
},
```

Figure 3.21: State in downlink Test

Challenges:

One challenge encountered was understanding how to correctly change parameters, activate SOS features etc.. using the downlink payload. This process requires a detailed understanding of how to format and send the correct payload to achieve the desired changes in the firmware. Comprehensive knowledge of the AT3 firmware's technical documentation was essential to address this challenge effectively.

Conclusion:

The downlink functionality was successfully validated using MQTT. The process involved publishing downlink payloads and verifying the resulting changes in the AT3 firmware. This testing confirmed that the downlink feature operates correctly, with results showing that the firmware responded to the downlink payload as expected.

```
Description of the test:
 In this test, it will publish the downlink payload via MQTT publish, and checks the result in AT3. To receive the downlink in AT3, we needs to send system event command.

(I) payload : 10000200210000000a080121000001f4 - changed parameter in different class (geoloc_motion_period - min value, net_reconnection_spacing - correct value)  ,

(II) payload : 1001020221000001f40521000001f4 - changed parameter in same class (geoloc_sos_period - max value, geoloc_start_stop_period - correct value)

Step    State                  Time(s)   Expected_outcome                           Received_outcome                           Result


1       MOTION_STOP_COMMAND    0.06      N/A                                        N/A


2       GENERIC_SET_PUBLISH    0.03      N/A                                        N/A


3       SLEEP_10_SEC           10.00     N/A                                        N/A


4       SYS_EVENT_COMMAND      0.06      N/A                                        N/A


5       DOWNLINK_RECEIVED      5.32      N/A                                        N/A


6       TRANSMIT_RESPONSE      2.60

     Expected outcome :
     xx xx xx xx xx 00 02 00 02 08 01 00

     Received outcome :
     a0 64 74 a3 30 00 02 00 02 08 01 00     Pass


7       SLEEP_10_SEC           10.00     N/A                                        N/A
```

Figure 3.22: Generated Downlink Test result file

3.2 JIRA in Firmware Testing

JIRA, developed by Atlassian, is a project management and issue-tracking tool that helps teams manage tasks, bugs, and project progress. In firmware testing, JIRA is used to document and track issues identified during testing.

During my internship, I used JIRA to:

Receive and Review Tickets: Address tickets related to AT3 firmware issues.

Analyze Issues: Diagnose problems based on ticket details.

Provide Solutions: Offer solutions or workarounds and update tickets with findings.

Track Progress: Monitor ticket status to ensure timely resolution.

JIRA's structured approach streamlined issue management and ensured effective communication and resolution of firmware problems. Once issues were resolved, the firmware development team would update the code and release new versions on GitLab, ensuring continuous improvement and refinement of the AT3 firmware.

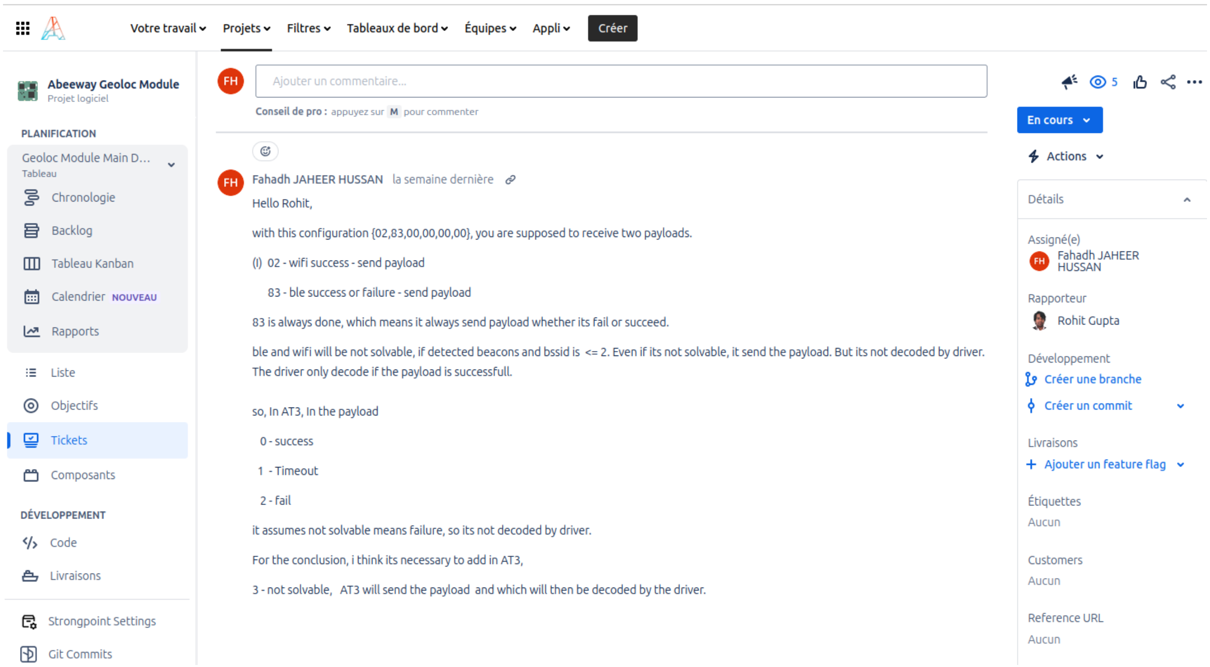


Figure 3.23: Jira

3.3 Personal Contribution

During my internship at Abeeway, I made significant contributions to testing of the Asset Tracker 3 (AT3) firmware. My work focused on optimizing the firmware's performance and reliability through comprehensive testing tool.

Development of an generic QA core algorithm:

I designed and implemented a generic QA core algorithm to automate the testing of the AT3 firmware. This tool streamlined the testing process, enabling the execution of various test cases efficiently and producing detailed results and debug files. This automation not only reduced manual testing time but also ensured consistent and thorough validation of firmware functionalities.

Validation of Firmware Functionalities:

I conducted extensive testing to validate different aspects of the AT3 firmware, including geolocation acquisition events, payload data, uplink and downlink functionalities, and Bluetooth operations. Over 100 test cases were created to cover these areas comprehensively. By developing and utilizing the generic QA core algorithm, I was able to identify and document inefficiencies and bugs, contributing to the firmware's overall improvement.

Development of a User Interface:

To facilitate easier access and operation of the testing tool, I developed a user interface using PyQt. This interface allowed the firmware development team to interact with the tool more effectively, manage test configurations, and review test results and logs, thereby enhancing the testing workflow.

3.4 Encountered Difficulties and Solutions

During my internship, I faced and resolved several key challenges:

Firmware Configurations were complex, which I managed through detailed documentation and iterative testing to fine-tune settings. Uplink Synchronization Issues were addressed by implementing a LIFO queue, aligning the timing between the firmware and MQTT broker.

Payload Data Validation challenges were met by creating specific test cases and referring to technical documentation to ensure accurate results. The PyQt was tackled by studying fundamentals and using available resources to develop an effective user interface. One notable difficulty encountered initially was adapting to the office environment. However, it's important to note that this challenge did not have any adverse impact on my work or the company's operations. These efforts enhanced the testing and development processes at Abeeway.

3.5 Gantt Chart

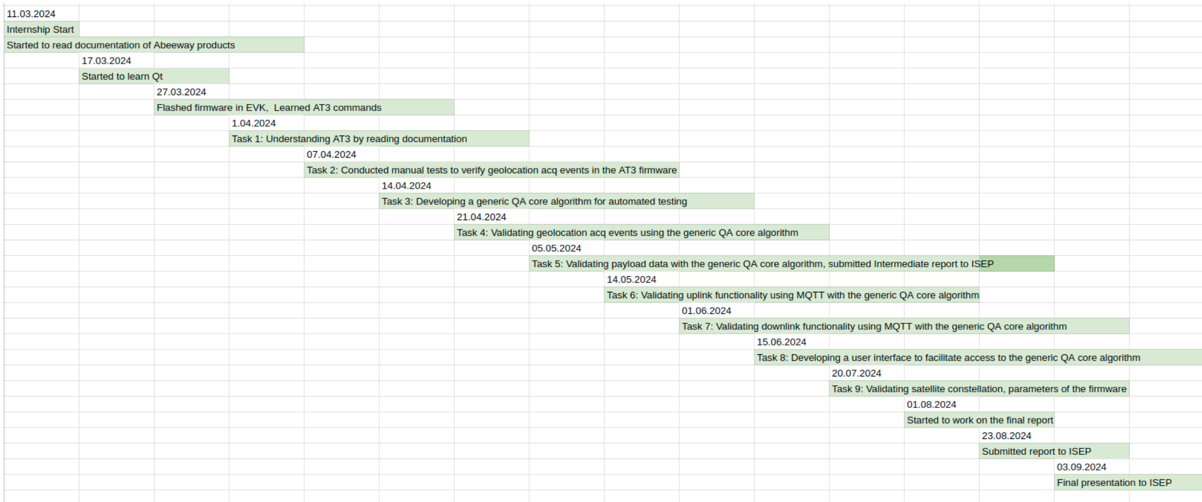


Figure 3.24: Gantt Chart

During my internship, I employed a Gantt chart to meticulously plan and monitor my tasks. This visual tool was instrumental in ensuring that all activities were completed on schedule and offered a clear view of the project's progress. The Gantt chart displayed a detailed timeline of my tasks, which proved essential for staying organized and managing deadlines effectively.

Using the Gantt chart, I was able to set specific deadlines, visualize the overall project timeline, and allocate my time and resources efficiently. This approach greatly contributed to the successful achievement of my internship goals.

3.6 Future Enhancements and Scalability

Abeeway is advancing its Asset Tracker 3 (AT3) firmware with the integration of LTE-M and NB-IoT technologies, utilizing modules from Sequans Communications. This upgrade, part of the Combo LPWAN Compact Tracker, enhances its capability to transmit location data using either LoRaWAN or LTE, depending on availability and network preference.

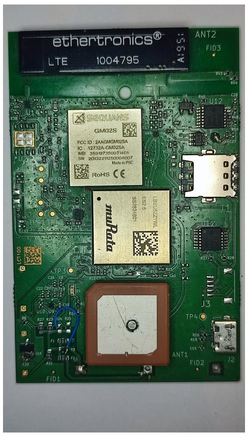


Figure 3.25: Abeeway Combo LPWAN Compact Tracker

The new Combo LPWAN Compact Tracker will feature a versatile multi-mode tracking system that supports both Cellular (LTE-M, NB-IoT) and LoRaWAN technologies. It integrates a range of embedded sensors, including accelerometers, multi-constellation GNSS receivers, low-power GPS, Wi-Fi sniffers, BLE, and LoRa TDoA geolocation technologies. This combination ensures precise tracking both indoors and outdoors, providing a robust solution for comprehensive geolocation needs.

Looking ahead, the generic QA core algorithm developed during the internship can be updated to incorporate testing for these new cellular functionalities. This enhancement will make the tool more scalable and adaptable, allowing it to efficiently evaluate the added LTE-M and NB-IoT features in the AT3 firmware. By integrating these future capabilities, the testing tool will support ongoing development and optimization, ensuring the firmware's performance across all supported technologies.

Chapter 4

Managerial Analysis

4.1 Corporate Social Responsibility (CSR) Analysis for Abeeway

4.1.1 Introduction

Overview of CSR:

Corporate Social Responsibility (CSR) refers to a company's commitment to operate in an ethical and sustainable manner, considering its impact on society and the environment. CSR initiatives often address issues such as environmental sustainability, workplace safety, and community engagement.

Company Background:

Abeeway, located in Biot, France, within the prestigious science and technology park of Sophia Antipolis, specializes in low-power geolocation solutions for the Internet of Things (IoT). The company's mission focuses on delivering advanced GPS tracking technologies for mobile assets, people, and animals.

4.1.2 CSR Analysis

Carbon Footprint Overview

Documentary Research:

Abeeway and Actility's carbon footprint for 2021 was estimated at 608 tCO2e, with significant contributions from material purchases (255.1 tCO2e from Abeeway) and service-related emissions (118.3 tCO2e from Actility). Employee commuting (37.2 tCO2e) and air travel (15.4 tCO2e) had a lower impact on the total emissions.

Interviews:

Patrick Beatini, Firmware manager at Abeeway: Highlighted the challenge of reducing emissions from material purchases, as these are integral to product quality. He emphasized the need for supplier collaboration to source more sustainable materials.

Observations:

The largest contributors to Abeeway's carbon footprint are material purchases, amounting to 255.1 tCO2e. Employee commuting and air travel also contribute to the carbon footprint, though with less impact.

Recommendations:

Material Sourcing from abeeway: Collaborate with suppliers to develop and use lower-carbon materials. This could be supported by introducing stricter sustainability criteria for suppliers.

Cloud Server Management from actility: Reassess the environmental impact of cloud operations and consider relocating to regions with a cleaner energy mix. Regularly audit server usage to identify energy-saving opportunities.

4.2 Analysis of Managerial Theme: Innovation Management at Abeeway

4.2.1 Introduction

Theme Overview:

Innovation management is critical for companies like Abeeway, which operate in the rapidly evolving field of IoT and geolocation technology. Effective innovation management involves fostering creativity, developing new products, and maintaining a competitive edge in the market. Abeeway, a key player in low-power geolocation solutions, continuously strives to innovate and enhance its product offerings to meet the needs of its diverse customer base.

4.2.2 Innovation Management Analysis

Strategy and Tools

Abeeway's innovation strategy focuses on integrating cutting-edge technologies and responding to market demands. Key elements include:

R&D Investment: Abeeway invests significantly in research and development to advance its geolocation technologies and integrate new features into its products.

Collaboration: The company collaborates with industry partners and research institutions to drive innovation and stay at the forefront of technological advancements.

Product Development: Abeeway employs agile development practices to quickly adapt to changes in technology and market requirements.

Documentary Research

Analysis is based on internal R&D reports, product development documentation, and industry research papers.

Interviews

Jean Pierre, Embedded engineer at Abeeway: Discussed Abeeway's innovation strategy, highlighting their focus on integrating new technologies and fostering collaboration with external partners. Jean emphasized the role of R&D in driving product advancements and maintaining market leadership.

Observations

Observations from internal reviews and meetings confirm the effectiveness of Abeeway's innovation management practices. The company's commitment to R&D and customer-driven product development is evident in their product offerings and market presence.

Recommendation

Expanding efforts to include emerging technologies such as artificial intelligence and machine learning could open new avenues for product development and enhance the company's competitive advantage in the geolocation market.

Chapter 5

Conclusion

5.1 Overview of Internship

During my internship at Abeeway, a leading company specializing in low-power geolocation solutions for the Internet of Things (IoT), I had the opportunity to work closely with the firmware development team. The company is based in Biot, France, within the prestigious science and technology park of Sophia Antipolis. Abeeway is renowned for its advanced GPS tracking solutions for mobile assets, people, and animals.

My primary responsibility was to develop an automated testing tool for the Asset Tracker 3 (AT3) firmware. This task involved creating a generic QA core algorithm to streamline the testing process. The AT3 firmware integrates a new geolocation module developed in collaboration with Murata, which combines multiple technologies (LoRa, BLE, GNSS, and Wi-Fi) into a single package. The goal was to ensure that this integrated module performed efficiently and reliably across various functionalities such as geolocation acquisition, payload data handling, and communication protocols (uplink and downlink).

I developed a **Generic QA Core Algorithm**, this algorithm was designed to send commands to the firmware, receive responses, and validate them using a JSON configuration file that outlined various test states and expected outcomes. To handle specific validation logic for different test scenarios, I implemented **callback functions**, ensuring precise and flexible testing.

I also integrated **MQTT protocols** to validate uplink and downlink functionalities, particularly for comparing results between the firmware and the server. Over 100 test cases were created to cover these areas comprehensively. The automated tool I created generated result and debug files, documenting test outcomes and helping to identify inefficiencies and bugs. Additionally, I developed a **user interface** to display these results, making it easier to analyze and interpret the data.

This hands-on experience was vital for understanding the practical applications of the geolocation module and its integration into the AT3 firmware.

5.2 Professional Growth

This internship at Abeeway was pivotal for my professional development, offering practical experience in a dynamic, real-world setting. I gained valuable insights into various aspects of software development and project management, which significantly contributed to my growth:

> **Technical Proficiency:** The internship allowed me to refine my skills in Python and Linux, particularly in the context of developing automated testing tool for the AT3 firmware. Working with MQTT and GUI development using PyQt expanded my technical expertise. Each validation scenario required a tailored approach, enhancing my problem-solving capabilities and deepening my technical knowledge.
>
> **Collaboration and Communication:** Collaborating with team members at Abeeway, based in Biot, honed my communication and teamwork skills. Regular interactions, including weekly meetings and updates, facilitated transparency and collective problem-solving. This experience highlighted the importance of clear communication and teamwork in achieving project goals.
>
> **Project Management:** Managing multiple facets of the testing tool development, including creating the QA core algorithm and coordinating test scenarios, demanded effective time management and prioritization. Utilizing project management tools, such as Gantt charts, helped track progress and adhere to deadlines, reinforcing my project management skills.
>
> **Adaptability and Problem-Solving:** The fast-paced environment at Abeeway required me to quickly adapt to new challenges and troubleshoot issues efficiently. This experience underscored the importance of flexibility and innovative problem-solving in a technology-driven setting.
>
> **Innovation and Continuous Improvement:** The focus on automating and enhancing the processes reinforced the value of continuous improvement. I developed a mindset geared towards identifying inefficiencies and devising effective solutions, aligning with the principles of innovation and iterative enhancement.
>
> **Application of ISEP Skills:** The skills acquired from my studies at ISEP (Institut Supérieur d'Électronique de Paris) were instrumental during this internship. My background in IOT and software development provided a solid foundation for understanding complex firmware and automation requirements. The theoretical knowledge and practical skills gained from ISEP were directly applicable to the technical challenges I faced, from developing the automated testing tool to analyzing and optimizing firmware performance.

Overall, this internship not only deepened my technical abilities but also enhanced my project management and collaborative skills. The experience has equipped me with valuable insights and practical expertise that will serve as a strong foundation for my future career in technology and engineering.

5.3 Conclusion

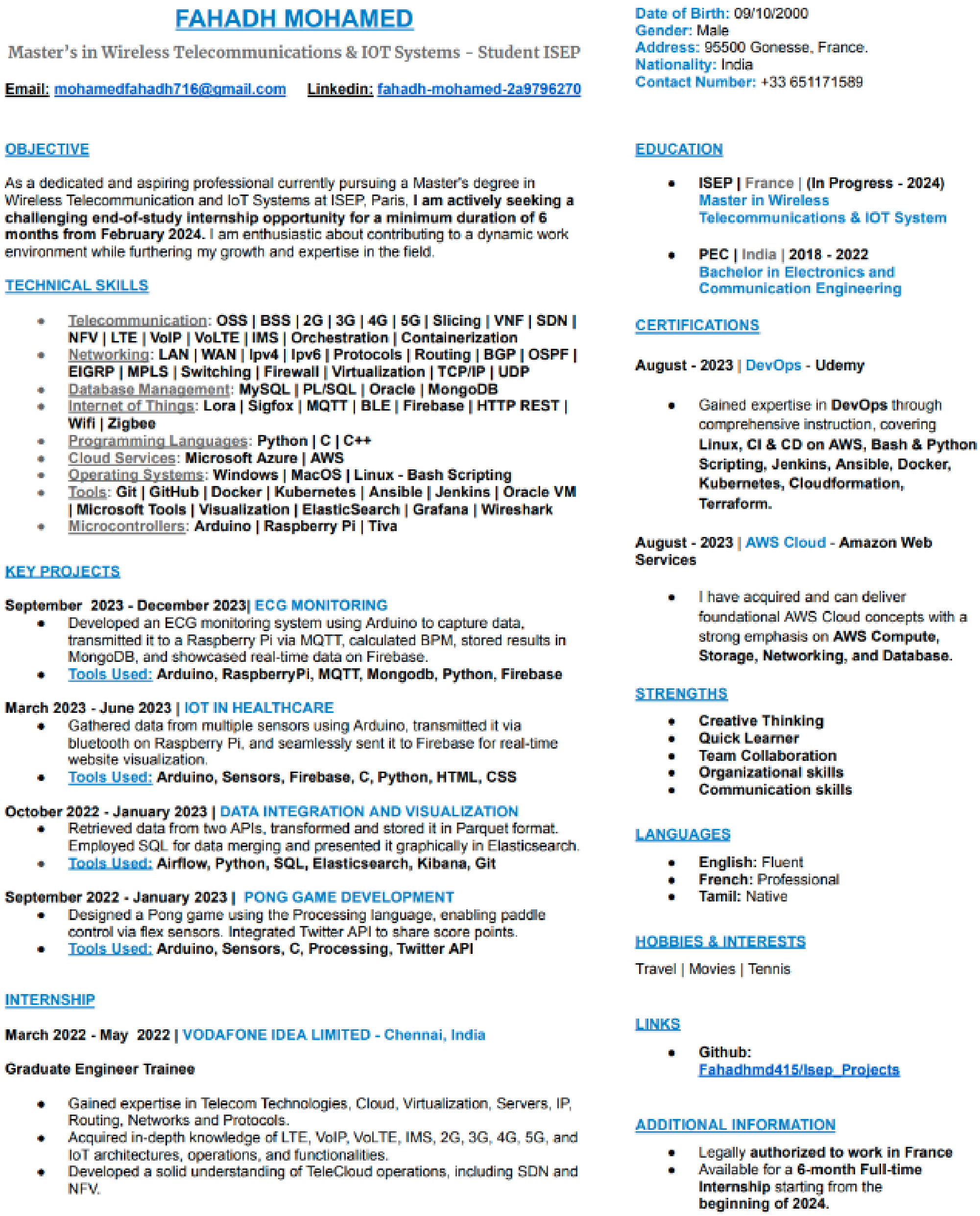
My internship at Abeeway provided a comprehensive and enriching experience in firmware automated testing. By developing a generic QA core algorithm for the AT3 firmware, I contributed to the enhancement of the company's testing processes and overall product quality.

The opportunity to work with advanced geolocation technologies and collaborate with industry professionals has been invaluable. The skills and knowledge acquired during this internship will undoubtedly contribute to my future career in technology and engineering, providing a strong foundation for continued professional growth and development.

Chapter 6

Appendices

6.1 CV



FAHADH MOHAMED

Master's in Wireless Telecommunications & IOT Systems – Student ISEP

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Date of Birth: 09/10/2000
Gender: Male
Address: 95500 Gonesse, France.
Nationality: India
Contact Number: +33 651171589

OBJECTIVE

As a dedicated and aspiring professional currently pursuing a Master's degree in Wireless Telecommunication and IoT Systems at ISEP, Paris, **I am actively seeking a challenging end-of-study internship opportunity for a minimum duration of 6 months from February 2024.** I am enthusiastic about contributing to a dynamic work environment while furthering my growth and expertise in the field.

TECHNICAL SKILLS

- Telecommunication: **OSS | BSS | 2G | 3G | 4G | 5G | Slicing | VNF | SDN | NFV | LTE | VoIP | VoLTE | IMS | Orchestration | Containerization**
- Networking: **LAN | WAN | Ipv4 | Ipv6 | Protocols | Routing | BGP | OSPF | EIGRP | MPLS | Switching | Firewall | Virtualization | TCP/IP | UDP**
- Database Management: **MySQL | PL/SQL | Oracle | MongoDB**
- Internet of Things: **Lora | Sigfox | MQTT | BLE | Firebase | HTTP REST | Wifi | Zigbee**
- Programming Languages: **Python | C | C++**
- Cloud Services: **Microsoft Azure | AWS**
- Operating Systems: **Windows | MacOS | Linux - Bash Scripting**
- Tools: **Git | GitHub | Docker | Kubernetes | Ansible | Jenkins | Oracle VM | Microsoft Tools | Visualization | ElasticSearch | Grafana | Wireshark**
- Microcontrollers: **Arduino | Raspberry Pi | Tiva**

KEY PROJECTS

September 2023 - December 2023| ECG MONITORING
- Developed an ECG monitoring system using Arduino to capture data, transmitted it to a Raspberry Pi via MQTT, calculated BPM, stored results in MongoDB, and showcased real-time data on Firebase.
- Tools Used: **Arduino, RaspberryPi, MQTT, Mongodb, Python, Firebase**

March 2023 - June 2023 | IOT IN HEALTHCARE
- Gathered data from multiple sensors using Arduino, transmitted it via bluetooth on Raspberry Pi, and seamlessly sent it to Firebase for real-time website visualization.
- Tools Used: **Arduino, Sensors, Firebase, C, Python, HTML, CSS**

October 2022 - January 2023 | DATA INTEGRATION AND VISUALIZATION
- Retrieved data from two APIs, transformed and stored it in Parquet format. Employed SQL for data merging and presented it graphically in Elasticsearch.
- Tools Used: **Airflow, Python, SQL, Elasticsearch, Kibana, Git**

September 2022 - January 2023 | PONG GAME DEVELOPMENT
- Designed a Pong game using the Processing language, enabling paddle control via flex sensors. Integrated Twitter API to share score points.
- Tools Used: **Arduino, Sensors, C, Processing, Twitter API**

INTERNSHIP

March 2022 - May 2022 | VODAFONE IDEA LIMITED - Chennai, India

Graduate Engineer Trainee

- Gained expertise in Telecom Technologies, Cloud, Virtualization, Servers, IP, Routing, Networks and Protocols.
- Acquired in-depth knowledge of LTE, VoIP, VoLTE, IMS, 2G, 3G, 4G, 5G, and IoT architectures, operations, and functionalities.
- Developed a solid understanding of TeleCloud operations, including SDN and NFV.

EDUCATION

- **ISEP |** France | **(In Progress - 2024)**
  Master in Wireless Telecommunications & IOT System
- **PEC |** India | **2018 - 2022**
  Bachelor in Electronics and Communication Engineering

CERTIFICATIONS

August - 2023 | DevOps - **Udemy**

- Gained expertise in **DevOps** through comprehensive instruction, covering **Linux, CI & CD on AWS, Bash & Python Scripting, Jenkins, Ansible, Docker, Kubernetes, Cloudformation, Terraform.**

August - 2023 | AWS Cloud - **Amazon Web Services**

- I have acquired and can deliver foundational AWS Cloud concepts with a strong emphasis on **AWS Compute, Storage, Networking, and Database.**

STRENGTHS

- **Creative Thinking**
- **Quick Learner**
- **Team Collaboration**
- **Organizational skills**
- **Communication skills**

LANGUAGES

- **English:** Fluent
- **French:** Professional
- **Tamil:** Native

HOBBIES & INTERESTS

Travel | Movies | Tennis

LINKS

- **Github:** Fahadhmd415/Isep_Projects

ADDITIONAL INFORMATION

- Legally **authorized to work in France**
- Available for a **6-month Full-time Internship** starting from the **beginning of 2024.**

Figure 6.1: CV

6.2 Job description

Internship Opportunity at Abeeway: Research and Development in Multi-Technology Geolocation

About Us: Abeeway is at the forefront of innovation in multi-technology geolocation solutions. As we continuously evolve our products, we are looking for a talented and motivated intern to join our Research and Development (R&D) team. This internship presents a unique opportunity to work with cutting-edge GPS chipsets and contribute to the development of low-power IoT trackers.

Internship Description: As an intern at Abeeway, you will be an integral part of our R&D team, collaborating closely with radio and system engineers and firmware experts.

Your main responsibilities will include: Learn about GNSS technologies, including Abeeway patented LPGPS techniques. Set up automatic testbench for GPS characterisation. Evaluate latest GNSS chipsets in term of accuracy and power consumption. Compare their performance in various conditions and scenarios (GPS signal strength, GPS states, multi-constellations, cold/warm start) Propose an implementation for our new trackers.

Internship Duration: 5 to 6 months

Location: Abeeway's office, located at 2000 Route des Lucioles | Sophia Antipolis | 06140 Biot | France

Requirements: To succeed in this internship, you should meet the following qualifications: A BAC+5 degree or master's degree in electronics / system engineering school. Understanding of GNSS and its operational principles. Data processing and analysis. Proficiency in programming languages, such as Python. Ability to use measurement equipment.

Benefits: This internship provides an exceptional learning opportunity, allowing you to work on state-of-the-art geolocation technologies and gain hands-on experience in the development of IoT product. You will be mentored by our experienced R&D team, and your contributions will directly impact the future of our products.

If you are passionate about IoT and geolocation technologies, eager to learn, and excited to make a real impact, we encourage you to apply. Please send your resume and a brief cover letter to contact@abeeway.com with the subject line Abeeway Internship Application.

Join us on the journey of innovation at Abeeway and be a part of shaping the future of geolocation solutions.

6.3 Cover letter

I am Fahadh Mohamed, a Master's student in Wireless Telecommunications and IoT Systems at ISEP, Paris. I'm reaching out to express my interest in the internship opportunity focused on GPS Chipset Characterization for IoT Applications at Abeeway.

With a strong background in IoT, I have hands-on experience with tools like Arduino, Raspberry Pi, and proficiency in networking protocols. My technical skills include Linux, C, C++, Python, Docker, SQL, InfluxDB, MongoDB, HTTP REST, MQTT, Node Red, Raspberry Pi, and IoT Gateway technologies.

I have successfully collaborated with international and French teams, emphasizing effective communication and teamwork. The outlined internship structure aligns perfectly with my academic background and practical experiences, especially in studying GPS technologies and proposing implementations for new tracker generations.

My expertise in understanding GNSS, data processing, Python programming, and designing tests makes me well-suited for this role. I am eager to contribute to the study and evaluation of the latest GPS chipsets, striving for high accuracy and low power consumption.

I am available to start the internship at your earliest convenience and committed to dedicating 6 months to the project. I look forward to the opportunity for an interview to discuss how my skills align with the goals of Abeeway.

Best regards,
Fahadh Mohamed Jaheer Hussan

6.4 Bibliography

Abeeway products
Geolocation module
Geolocation Evaluation Kit from thingpark
Thingpark architecture

Interview in managerial analysis

Patrick Beatini, Firmware Manager

Jean Pierre, Embedded Engineer