INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

2023 - 2024

PORTFOLIO FOR MS INNOVATIVE SMART SYSTEMS

INNOVATIVE SMART SYSTEMS

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1 General Information

1.1 Portfolio Overview

This document aims to highlight the expertise gained throughout the Master's program in Innovative Smart Systems at INSA Toulouse. It primarily focuses on the culmination of this education: the projects undertaken during this master's program, along with the various skills acquired and their connection to the professional project I intend to pursue. Throughout this academic year, all courses, practical learning experiences, and assignments have been dedicated to the development of numerous projects to enhance my knowledge and skills, preparing me for the relevant aspects of my professional project.

1.2 Presentation of MS Innovative Smart System

The coming years are poised to witness the expansive growth of the Internet of Things (IoT), marking a significant technological leap and often referred to as the fourth industrial revolution. Forecasts suggest that by 2024, the IoT will connect over 30 billion smart devices, illustrating its tremendous potential. However, this ambitious vision encounters multifaceted challenges spanning various domains.

The MS Innovative Smart Systems program aims to equip aspiring engineers with essential skills and innovative strategies to navigate these complexities effectively. It comprehensively prepares students for the challenges presented by the IoT's diverse layers.

The IoT comprises several fundamental layers:

- Perceptual Layer
- Network Layer
- Support Layer
- Application Layer

Each layer introduces unique challenges, delineated as follows:

- Designing intelligent devices (Training Unit: Smart Devices)
- Establishing device connectivity (Training Unit: Communication technologies for IoT)
- Managing data flow across network entities (Training Unit: Security for IoT)
- Providing services for seamless network interaction and efficient data utilization (Training Unit: Middleware and Services)

To adeptly tackle these challenges, the program encompasses a range of specialized training modules. Successfully navigating the intricacies of IoT networks necessitates a diverse skill set. Therefore, the program encourages interdisciplinary collaboration, welcoming students from varied backgrounds—electronics, telecommunications, informatics, and physics—to collectively address the complexities associated with deploying IoT networks.

1.3 Curriculum

1.3.1 Identification

Personal Information

- **Name, Surname**: Abdelmajid Anka Soubaai
- **Age**: 22
- **Email**: ankasoub@insa-toulouse.fr

1.3.2 CURRICULUM VITAE

You'll find my Curriculum Vitae below:

ABDELMAJID ANKA SOUBAAI

ENGINEERING STUDENT IN THE 5TH YEAR OF AUTOMATION AND ELECTRONICS SPECIALISING IN EMBEDDED SYSTEMS.

CONTACT INFORMATION

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+33755112251

Driving License B

Abdelmajid Anka Soubaai

SKILLS

Communication Protocol

- CAN, SPI, I2C, UART, TCP, UDP, ADC, GPIO

Methodology and Management

- V-Model, Agile, MagicDraw

Programming Languages

- C, Embedded C, C++, Java, Assembly, Python, Ada, UML/SysML

Software and Tools

- ***Electronics and Automation Software***
  - MATLAB/Simulink, LTspice, Labview,VHDL
- ***Computer Software***
  - Eclipse, QT Creator,Oracle , OpenStack, Dependecy Walker, Keil, Git,MCUExpresso, Pack Office

Embedded Systems

- FPGA, STM32, ARM, Arduino, Raspberry Pi, Pic16f84,NXP

Other Skills

- Cloud, Networks, Digital and Analog Electronics, Petri Nets, Power Electronics, MBSE

Languages

French	★★★★★	C1 Level
English	★★★★☆	B2 Level
Arabic	★★★★★	Native language

PROFESSIONAL EXPERIENCE

Hensoldt Nexeya | Toulouse | Internship | June 2023 - September 2023

INTERNSHIP: SOFTWARE DRIVER DEVELOPMENT FOR SIGNAL ACQUISITION TOOL

- API Usage / DLL / SDK Manipulation
- C and C++ Driver Coding / Analysis, Testing, Validation
- HMI Creation / User Guide Writing
- Driver Validation with Electronic Setups
- Tools Used: QT, Dependency Walker, Visual Studio Code, Oscilloscope, LaTeX, GitLab

Ménara Préfa | Marrakech | Internship | June 2021 - August 2021

INTERNSHIP - COMPUTER TECHNICIAN

- Enhancement of Unit Tests / Generating Test Plans / Requirements Writing.
- Low-level C Programming / Code Analysis and Validation.
- Utilizing GitLab, Cppcheck, JIRA.

UNIVERSITY PROJECTS

- Building and handling a **Database** using **SQL** and **SYSML**.
- **C** coding for **TCP/UDP** transmission.
- Designing and implementing an automatic timing system for swimmers using **Python** and **Arduino**.
- **Cloud** project involving task virtualization (**Kubernetes**, **Docker**).
- Sailboats project using **STM32**: handling Masks, Timers, ADC, PWM, Interrupts, GPIO, UART, SPI.
- Intelligent Parking project in **C++**: Managing available parking spots, Controlling parking barrier opening using **Arduino**.
- Water leak detection project using **ESP32** and coding in **C** and **C++**.

EDUCATION

MASTER'S IN NETWORK TELECOMMUNICATIONS AND CONNECTED OBJECTS

DOUBLE DEGREE AT ENSEEIHT | TOULOUSE | SEPTEMBER 2023 - PRESENT

MASTER'S IN EMBEDDED SYSTEMS, SPECIALIZING IN INNOVATIVE SMART SYSTEMS

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES | TOULOUSE | SEPTEMBER 2020 - PRESENT

EXTRACURRICULAR ACTIVITIES

- Project Management Leader at the INSA Toulouse **Robotics Club**.
- Participant in the **NXP CUP** competition (Coding an NXP microcontroller for an autonomous vehicle).
- **Member** of the swimming sports association.
- **Versatile employee** at Burger King Wilson and at the university restaurant at INSA.
- **Travel coordinator** for people with disabilities at Glob Tours Adapted."

1.3.3 Background

Prior to joining the Innovative Smart Systems program, I was pursuing a master's degree in Electronics and Automatic for Embedded Systems. This path provided me with a strong foundation in designing and controlling integrated electronic systems.

My decision to enroll in the Innovative Smart Systems program stemmed from my eagerness to tackle the challenges associated with creating smart devices. I firmly believe that these systems represent the future of technology, serving as a natural progression from embedded devices. The diverse range of courses offered in this master's program aligns well with my professional aspirations, providing a comprehensive foundation for the realization of my career objectives.

Throughout this program, I delved deeply into the complexities of designing smart devices. This experience served as a direct extension of my previous work during my Engineering studies in Electronics and Automatic. The projects I undertook then played a pivotal role in enhancing my understanding of the essentials required to develop innovative solutions in the realm of embedded and smart systems.

1.3.4 Training units within the Innovative Smart Systems orientation

Training Unit	**Description**	**Length (in hours)**
Smart Device	**Sensors Introduction:** • Grasp fundamental concepts related to sensors and data acquisition from the perspectives of physics, electronics, and metrology. • Create a nano-particle sensor using micro-electronics tools involving chemical synthesis, assembly, testing, and datasheet design.	11.25

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Training Unit	Description	Length (in hours)
	CAD, manufacturing and integration of nano-technology sensors (AIME): Create nano-particle sensors using micro-electronics tools involving CAD design, chemical synthesis, assembly, testing, and datasheet creation.	13.75
	Open Source Hardware: Design shields for gas sensors, develop software for gas sensors and their HMI, and integrate components into a smart device.	25
	Analog electronics Labs: Combine all the aforementioned components into a smart device.	2.75
Communication Protocols for IoT	**Wireless Sensor Networks:** • Explore the design, implementation, and deployment of Wireless Sensor and Actuator Networks. • Emphasize key metrics—cost, energy-efficiency, robustness, lifetime, and ease-of-deployment—crucial for these networks. • Adopt a bottom-up approach to delve into implementation constraints and wireless medium properties. • Enable trade-offs across network layers for optimized performance.	18.25

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Training Unit	Description	Length (in hours)
	5G Technologies: • Comprehend the primary development stages in mobile communications and their related technology advancements. • Grasp the implications of emerging mobile technologies. • Analyze and assess the most efficient wireless network technologies. • Propose optimal technological solutions for IoT networks. • Comprehend and excel in optimizing communication protocols for IoT within energy constraints. • Master the optimization of communication protocols addressing security concerns. • Familiarity with key processing techniques in digital communication and explaining the fundamental structure of digital RF transmitters.	7.5
	Communication Protocols for LP-WPAN: Gain insights into communication protocols for Low-Power Wide-Area Networks (LP-WPAN) in IoT environments.	7.5

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Training Unit	Description	Length (in hours)
	Emerging Networks (SDN, NGN): • Explore the limitations of traditional Internet design for new network usages, particularly in connecting diverse IoT devices and applications. • Introduce recent network paradigms to meet evolving communication needs. Provide foundational knowledge in configuring SDN equipment and developing network control applications.	10.5
	Embedded AI for IoT: Explore the integration of Artificial Intelligence (AI) within embedded systems for IoT applications.	15.75

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Training Unit	**Description**	**Length (in hours)**
Middleware and Service	**Service Architecture:** • Understand the process of defining a Service-Oriented Architecture (SOA). • Implement an SOA using web services. • Configure and implement an SOA utilizing SOAP technology. • Set up and implement an SOA leveraging REST principles. • Incorporate a process manager into an existing SOA.	31
	Software Engineering: • Define the various stages in software development. • Understand the diverse project management methodologies. • Implement one of these methodologies in a project.	2.5

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<table>
<tr><th>Training Unit</th><th>Description</th><th>Length (in hours)</th></tr>
<tr><td rowspan="2"></td><td>Middleware for Internet of Things:
Understand the primary standards pertinent to the Internet of Things.
Deploy an architecture adhering to an IoT standard and execute a sensor network.
Deploy and configure an IoT architecture utilizing OM2M.
Interact with the various resources within the architecture using REST services.
Integrate a new technology into the established architecture.</td><td>14.75</td></tr>
<tr><td>Cloud and Edge Computing:
Comprehend the concept of cloud/edge computing.
Utilize task virtualization.
Employ task containerization using Docker.
Implement Kubernetes for task management.
Utilize OpenStack for network management.</td><td>21.5</td></tr>
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Training Unit	**Description**	**Length (in hours)**
Security and Energy optimization for IoT	**Security for connected objects:** • Understand the core principles of security. • Ability to recognize security vulnerabilities within an IoT architecture. • Capability to evaluate the consequences of exploiting security vulnerabilities within an IoT architecture. • Proficiency in suggesting appropriate security measures and countermeasures.	34.5
	Energy for connected objects (recovery, transfert): Take into account energy constraints when designing an embedded device.	10.5
Innovative Project & English	**Innovative Project:** • Assess real-life issues for analysis • Propose technological solutions to identified problems • Develop and execute prototypes to address the problems	38.5

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Training Unit	Description	Length (in hours)
	English: • Deliver and discuss technical decisions made during the project • Generate an English report detailing the project's development	30

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Training Unit	Description	Length (in hours)
Innovation & Humanities	• Solve problems creatively • Develop the first stage of innovation • Understand production, validation, distribution, acceptability, and consequences of innovation to establish a business plan • Learn to work in interdisciplinary teams • Convincingly present and defend an idea • Express and exchange hypotheses • Suggest a strategy to solve the identified problem • Suggest a model • Choose, design, and/or justify an experimental prototype or protocol • Reflect on training methods and process • Be able to articulate training experiences, whether explicit or implicit • Be self-sufficient and responsible for one's education	67.5

2 Description of Contextual Experiences

2.1 Presentation of Contextualized Experiences Associated with the Master's in Innovative Smart Systems

In this section, I aim to offer a comprehensive overview of experiences that have been particularly relevant to my academic pursuits throughout this academic year and in previous years. The content primarily comprises diverse projects and internships that have significantly contributed to my learning and skill development in the field. These experiences will be presented in the table below, including the period during which I undertook each experience, its duration, and the role or function I held during that time.

Date (From - To)	**Duration**	**Context**	**Function**
17/10/2023 to 27/01/2024	3 Months	Project for Detecting Water Leaks	• The code implementation for managing components related to water leak detection using ESP32 includes the integration of the flow meter, API data transmission, lithium battery state monitoring, and the battery charging system. • Electronic assembly to connect all components • Presentation and debate to defend our point of view and choices

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Date (From - To)	Duration	Context	Function
30/10/2023 to 3/11/2023	1 Week	Internship at the Interuniversity Workshop of Micro-nano Electronics	Designing a Nanoparticle Gas Sensor
01/12/2023 to 20/01/2024	7 Weeks	Smart Gas Sensor Integration Project	Comprehend sensor fundamentals, craft datasheet designs, grasp microcontroller architecture, construct data acquisition systems, devise electronic circuits for signal conditioning, create protective shields, build software for gas sensor functionality, and integrate all elements into a smart device.
13/11/2023 to 22/12/2023	6 Weeks	Enhancing Aid Requests Through Microservice Architecture	Creating a platform where volunteers respond to requests, facilitating aid for isolated individuals, and transitioning the architecture into a microservice model for enhanced functionality.

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Date (From - To)	Duration	Context	Function
12/10/2023 to 24/11/2023	7 Weeks	Integrated IoT Application Development	• MQTT protocol implementation for IoT communication • Creating applications to control IoT devices using REST APIs and Node-RED • Configuring resources and access control policies • Implementing features to track sensor changes • Developing a dashboard to visualize IoT sensor data
02/10/2023 to 23/10/2023	4 Weeks	Advanced Exploration of Cloud, Edge Computing, and IoT Technologies in a Distributed Context	• Explored virtualization, cloud concepts, and edge computing • Delved into OpenStack for cloud management • Applied Kubernetes and Docker for containerized deployments • Contributed to service virtualization for scalability

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Date (From - To)	**Duration**	**Context**	**Function**
10/06/2023 to 12/09/2023	3 Months	Software driver development	• Development of software drivers tailored to specific hardware components • Designing, implementing, and testing drivers for compatibility and reliability. • Collaboration with hardware engineers to understand hardware specifications. • Translation of hardware specifications into functional software interfaces. • Designing and developing a Graphical User Interface (GUI) for user interaction. • Debugging, optimizing, and maintaining drivers for smooth operation. • Ensuring compatibility across diverse systems and platforms.

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Date (From - To)	**Duration**	**Context**	**Function**
06/12/2023 to 22/12/2023	3 Weeks	Wireless Sensor Networks for Enhanced Aircraft Safety and Maintenance	• Implement TDMA for aviation comms. • Develop MAC-level communication. • Collaborate based on expertise mix. • Integrate WSN for aircraft monitoring. • Enable real-time fault detection. • Focus on cost-effective solutions.

2.2 Experiences Breakdown

2.2.1 Water Leak Detection

To begin, let's highlight our accomplishments within this project. This section focuses on our most time-consuming project, where we meticulously steered the development from initiation to completion, handling every facet from design and specifications to execution.

Motivation : Confronting alarming statistics revealing a significant 20% water loss in France due to leaks, our project is propelled by the urgent need to revolutionize residential water conservation. With over 1.1 billion cubic meters lost in the past 13 years and adversely affecting the lives of 700,000 residents annually, immediate action is imperative.

Benefits : Our project aims to proactively detect water leaks in homes at their earliest stages, seeking to significantly reduce water wastage and consequent financial burdens. Prompt user alerts upon detection empower individuals to take immediate action, mitigating additional expenses incurred due to water network leaks. Our vision encompasses crafting a solution ensuring early detection, user-friendliness, accessibility, and cost-effectiveness for households. Offering an innovative and affordable product, we aspire to encourage widespread adoption and active participation in water conservation efforts. In essence, our project aims not only to detect leaks but also to reshape water management in residential properties, contributing to environmental sustainability and alleviating financial strains for homeowners. This pressing need motivates our team to develop a solution that will tangibly impact water resource conservation.

Team : This project demands a diverse array of skills, much like most IoT systems. Our team consists of four students from the Innovative Master's in Intelligent Systems program. This interdisciplinary master's program unites individuals from various academic backgrounds, aligning perfectly with the project's technical requisites. Development calls for expertise in computer science, electronics, and embedded systems. Hence, our team is divided into two groups: one focusing on database management, service handling, and user application development, rooted in a computer systems background, while the other concentrates on microcontrollers and programming various materials for water leak detection, including myself, from an automation and electronics background.

Environment and Context : This project stands as the culmination of our year. Its primary goal was to apply all the skills we've acquired, involving smart device deployment, microcontrollers, and refining communication, leadership, and teamwork abilities. Through research and discussions on energy consumption, range, security, and more, we gained a deeper insight into available technologies.

We worked on a personal project for an individual associated with Veolia. The objective was to develop a smart device capable of detecting water leaks within households by calculating the water flow rate at the entry point of each house.

Function : Given my expertise in embedded systems, I naturally gravitated towards the electronic and microcontroller programming facets of the device. My primary focus revolved around the module responsible for retrieving water flow data, a crucial component that communicated with the database developed by my teammates.

Furthermore, inspired by our coursework on **Energy for Connected Objects (Recovery, Transfer)**, we explored the innovative concept of integrating a hydraulic generator. The idea was to harness the energy during water circulation phases to recharge our microcontroller. This novel approach not only aligned with sustainability principles but also showcased our commitment to exploring unconventional power sources, enriching our project with diverse technological solutions.

Additionally, my role extended to configuring setups aimed at regulating voltage distribution among various components. This critical task aimed to ensure the stability, reliability, and optimal performance of the entire system. The knowledge gleaned from coursework discussions and practical applications profoundly influenced our decision-making process, guiding us towards effective and efficient solutions.

2.2.2 The design of the gas sensor at AIME

This one-week internship took place at AIME, a specialized laboratory focused on micro and nanoelectronic research and development. At AIME, we received comprehensive guidance, covering every step of creating a gas sensor, following various systematic protocols.

Motivation : Creating a gas sensor is driven by unparalleled motivation. Understanding the fundamental stakes concerning safety, health, and the environment sparks the desire to develop this device, aiming to ensure the safety of spaces we inhabit daily. Crafting such a sensor seeks to provide a proactive solution for detecting potentially hazardous gas leaks, thereby safeguarding individuals and the environments we inhabit. The quest for such a device is fueled by the aspiration to create a reliable, precise, and accessible tool, enhancing everyone's quality of life and contributing to the preservation of our world.

Benefits : Developing gas sensors offers crucial safety benefits by swiftly detecting leaks in various environments, enhancing environmental health by monitoring harmful gas levels, and enabling remote monitoring for efficient management in different industries and settings.

Team : In this project, we worked as a team, organized into three pairs. Despite our small group structure, we conducted experiments together, sharing tasks and collaborating closely. My partner and I coordinated our efforts, dividing responsibilities to make progress efficiently and cohesively. This approach allowed us to leverage our complementary skills and maintain a steady pace throughout the project.

Environment and Context : This particular project delves into the manufacturing process of a gas sensor, utilizing micro-electronics tools and cleanroom skills. These acquired skills extend beyond the gas sensor's production and could potentially be applied to manufacture other components, such as ASIC components, in similar controlled environments.

Function : The core objective was centered around producing a nano-particle gas sensor, initiated during the **Smart Devices** training module, laying the groundwork for crafting such sensors. This endeavor commenced with the preparation of wafers that housed gas sensor templates, a compilation including key elements like a poly-silicon block functioning as a heater, an aluminium strip acting as a temperature sensor, along with metallic combs, as illustrated in Figure 1. The subsequent stages comprised pivotal tasks such as photolithography, verifying development and resistivity, meticulous cell selection and cutting, mounting onto a package, preparing and depositing nano-particles, confirming the deposition, and electric sensor characterization under controlled environments. Furthermore, practical insights into cleanroom methodologies were acquired while fabricating photovoltaic cells from P-doped silicon wafers, broadening the scope of knowledge and expertise.

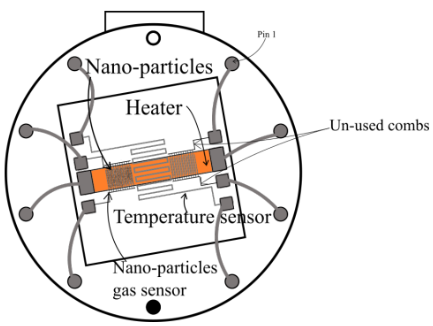

Figure 1: Nano-Particle gas sensor schematic

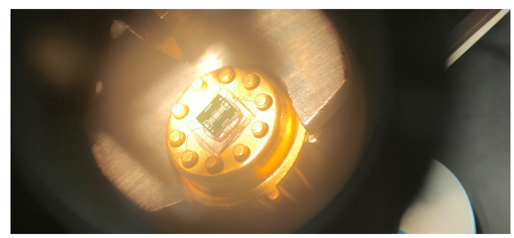

Figure 2: Gas sensor under construction

2.2.3 Smart Gas Sensor Integration

Within this project, we delved into an extensive exploration of sensor fundamentals, crafting datasheet designs, understanding microcontroller architecture, constructing data acquisition systems, devising electronic circuits for signal conditioning, creating protective shields, building software for gas sensor functionality, and integrating all these elements into a smart device.

Motivation: My motivation was to gain a comprehensive understanding of the underlying technologies and skills required to design an innovative gas detection device, combining both theoretical knowledge and practical application for real-world use.

Benefits: This immersion provided the opportunity to merge multidisciplinary knowledge to create a functional and intelligent gas detection device, enhancing practical understanding of gas sensors and smart systems.

Team : As a team, we functioned as a close-knit duo, having collaborated on previous projects, fostering a strong familiarity and rapport. This familiarity enabled us to efficiently divide tasks, optimizing our workflow and expediting progress towards our goals.

Environment and Context : This project falls within the broad scope of intelligent systems and the Internet of Things (IoT), where gas sensors play a crucial role. The objective is to delve into the functioning of gas sensors, from basics to the creation of sophisticated devices. These sensors have diverse applications, ranging from smart homes to industrial environments. The working framework encompasses an in-depth exploration of sensor fundamentals, datasheet designs, microcontroller architecture, and the construction of data acquisition systems. It also involves crafting electronic circuits for signal conditioning, designing protective shields, and developing dedicated software for the proper functioning of gas sensors.

The ultimate goal is to integrate all these components into an intelligent device capable of efficiently monitoring air quality while seamlessly integrating into connected environments and IoT networks. This project offers a unique opportunity to explore various technological aspects and contribute to creating innovative solutions for environmental monitoring.

Function : Within this project scope, my involvement encompassed a diverse array of functions essential for its success. I undertook tasks that revolved around comprehending the fundamental principles of sensors, crafting detailed datasheet designs, and acquiring a comprehensive understanding of microcontroller architecture. Constructing data acquisition systems was a pivotal aspect of my role, requiring meticulous planning and execution to ensure seamless data retrieval.

Additionally, I was deeply engaged in devising electronic circuits for signal conditioning, a crucial step in refining and processing sensor data accurately. Creating protective shields to safeguard the intricate electronic components further enhanced the durability and reliability of the gas sensor system. Moreover, I played a significant part in developing the software for gas sensor functionality, implementing complex algorithms and programming logic to enable precise sensing capabilities.

The integration of all these elements into a cohesive and efficient smart device was a key challenge and responsibility. Beyond these core functions, I took on the task of crafting an intuitive user interface (UI) using Node-RED. This graphical interface aimed to streamline user interactions, ensuring seamless and user-friendly access to sensor data and functionalities.

Collaborating with my pair, I configured a gateway for data transmission by LORA via The Things Network (TTN), ensuring secure and efficient data transfer from the sensors to a centralized hub. Soldering and PCB (Printed Circuit Board) printing were also integral aspects of my tasks. Soldering involved precise and meticulous work, ensuring the proper connection and assembly of electronic components. Furthermore, engaging in PCB printing was a key function, necessitating the design and fabrication of custom circuit boards to optimize the sensor's functionality and integration within the system. These hands-on tasks contributed significantly to the overall success and functionality of the gas sensor project, requiring a combination of technical precision and practical skills.

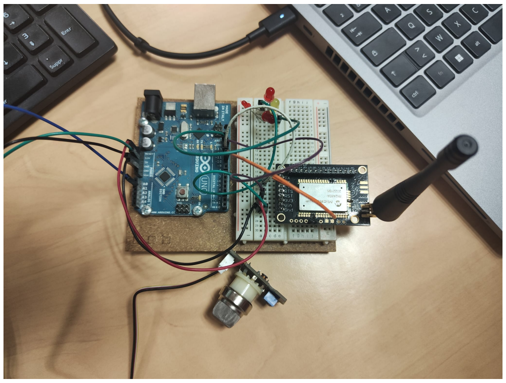

Figure 3: Gas Sensor Implementation with Arduino and RN2483 for Data Transmission

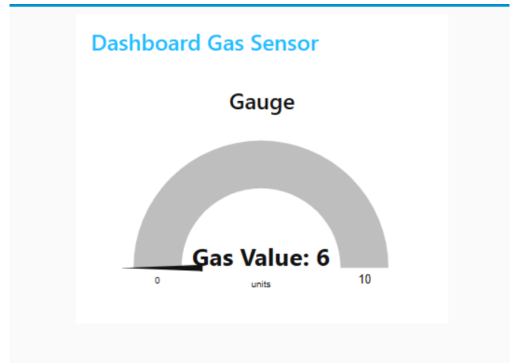

Figure 4: Node-RED Dashboard Displaying Gas Sensor Values

2.2.4 Enhancing Aid Requests Through Microservice Architecture

This project embodies the design and development of a comprehensive platform aiming to connect volunteers with isolated individuals, streamlining the process of aid requests and undergoing a pivotal architectural transition into a microservice mode. The endeavor encompasses multifaceted elements ranging from the creation of an interactive volunteer-response interface to the optimization of aid distribution protocols.

Motivation : My driving force behind this initiative lies in the urgency to establish a cohesive system that efficiently bridges the gap between volunteers and individuals facing isolation. The motivation stems from the need to revolutionize the aid-delivery process, ensuring swift and appropriate responses to requests while fostering a seamless communication channel between volunteers and those in need. Moreover, transitioning the platform's architecture into a microservice model aims to enhance its agility, scalability, and overall functionality, addressing the dynamic demands of aid distribution systems.

Benefits : The project presents a multifaceted approach aimed at revolutionizing aid distribution and connectivity within communities. At its core, the platform seeks to create a streamlined ecosystem where volunteers promptly respond to aid requests, ensuring isolated individuals receive timely assistance. One significant benefit lies in its ability to engage volunteers effectively, offering them an accessible interface to contribute meaningfully to their communities. By efficiently allocating aid, the platform minimizes delays, ensuring swift support for those in need. Additionally, the transition of the platform's architecture into a microservice model marks a pivotal enhancement, promising scalability, adaptability, and increased agility. This transformation empowers communities, fostering collaborative efforts and a sense of shared responsibility, ultimately nurturing a more connected and supportive community.

Team : Within this project, I collaborated in a close-knit duo with the same teammate from the previous project involving the **Smart Gas Sensor Integration**. Our prior experience facilitated a seamless partnership, leveraging our established workflow, mutual understanding, and efficient task delegation. This familiarity and shared expertise significantly contributed to optimizing our efforts and streamlining the project's progress, ensuring a cohesive and coordinated approach towards our shared objectives.

Environment and Context : This project arises in a context where the demand for assistance and support for isolated individuals is growing, necessitating an effective and swift solution to connect volunteers with those in need. The evolution of social needs and the increasing requests for aid have underscored the need for an agile platform capable of efficiently addressing humanitarian needs.

The project operates within the realm of managing aid requests, aiming to streamline and optimize how volunteers interact with isolated individuals seeking support. It's an environment where efficiency, responsiveness, and ease of access to aid services are crucial in meeting the immediate needs of individuals in distress.

The transition to a microservices architecture is driven by the need to enhance the existing structure to achieve greater agility, scalability, and flexibility. This aims to ensure better request management, improved resource allocation, and increased scalability to adapt to future shifts in social needs.

In essence, this project is situated within a dynamically evolving social context, requiring an innovative and technological approach to effectively address aid requests and enhance connectivity between volunteers and isolated individuals.

Functions : In this project, my responsibilities encompassed several critical functions central to the enhancement of aid requests and the evolution of the architecture into a microservice model. I delved into defining services using both SOAP and REST architectures, understanding their intricacies, and designing services accordingly. This involved crafting comprehensive service definitions, ensuring their compatibility, and enabling seamless communication between different components within the system.

Additionally, I played a pivotal role in implementing microservices using Spring Boot, a framework renowned for its efficiency in developing microservice-based applications. This involved translating architectural concepts into practical applications, leveraging Spring Boot's features to create modular and scalable microservices. Through this implementation, the goal was to enhance the system's agility, scalability, and resilience by breaking down monolithic structures into smaller, independent services. This transition not only optimized resource utilization but also facilitated easier maintenance and future expansion of the system.

Figure 5: Postman API Testing - Assessing Microservice Servers

Figure 6: Spring Boot - Utilized for Developing Our Microservices

2.2.5 Exploration of Integrated IoT Application Development

The core objectives of this proeject focused on integrating the MQTT protocol for IoT communication, building applications capable of managing IoT devices via REST APIs and Node-RED, establishing resources with access control policies, monitoring sensor changes, and formulating an intuitive dashboard for visualizing IoT sensor data.

Motivation: The driving force behind my commitment to this project stemmed from a profound aspiration to construct a resilient IoT application, proficient in managing diverse IoT devices and their functionalities. The motivation lay in reshaping IoT communication dynamics, fostering seamless integration among varied devices, and furnishing users with an instinctive interface to interact with these devices. Additionally, the vision of visualizing sensor data via a user-centric dashboard aimed to elevate the comprehensive oversight and management of IoT ecosystems.

Benefits: This holistic approach to IoT application development offered a multitude of advantages, primarily centered on refining IoT device management and control mechanisms. The integration of MQTT protocol and REST APIs facilitated swift, secure communication between IoT devices and applications, fostering heightened interoperability. The development of a dashboard empowered users with real-time insights into IoT sensor data, enabling informed decision-making and enhanced monitoring capabilities.

Team: Within this project, I collaborated closely with a team member with whome I've previously worked on projects centered around **Smart Gas Sensor Integration** and **microservice architecture**. Our shared experience significantly contributed to the partnership, streamlining workflows, enhancing communication, and optimizing task allocation. Our familiarity with each other's work styles and capabilities facilitated a more cohesive and efficient project execution.

Environment and Context: The IoT middleware project involved immersive hands-on exploration of fundamental IoT technologies, encompassing MQTT, oneM2M REST API, and rapid prototyping using Node-RED. This endeavor provided a comprehensive understanding of communication protocols, IoT architectures, and practical application development. Focusing on ESP8266 & MQTT, the project elucidated MQTT's pivotal role in IoT communication and the versatility of ESP8266 devices. Transitioning to oneM2M, the project underscored the establishment of Common Services Entities and Application Entities orchestration, highlighting the significance of standardized architectures in IoT ecosystems.

Functions: My contributions within this project spanned diverse functional domains, encapsulating pivotal tasks and functionalities that shaped the project's success. Key responsibilities included developing MQTT communication modules for efficient data exchange between IoT devices and the central server. Crafting REST APIs and implementing Node-RED flows enabled seamless control and monitoring of IoT devices, facilitating user-friendly interactions. Setting up access control policies to regulate resource access and managing sensor changes for real-time tracking were integral parts of ensuring system reliability. Additionally, my role in designing and implementing the dashboard for visualizing IoT sensor data empowered users with insightful analytics for informed decision-making. Moreover, my involvement extended to collaborative troubleshooting, debugging, and optimizing system performance, ensuring a robust and user-centric IoT application.

Figure 7: Node-RED Dashboard: Visualizing Data for Enhanced Insights

2.2.6 Advanced Exploration of Cloud, Edge Computing, and IoT Technologies

The primary focus of this project was an in-depth exploration of cloud, edge computing, and IoT technologies in a distributed context. I delved into virtualization, cloud concepts, and utilized OpenStack for cloud management. Additionally, I applied Kubernetes and Docker for containerized deployments and contributed to service virtualization for scalability.

Motivation : My motivation behind this project was to gain comprehensive insights into the intricate workings of cloud, edge computing, and IoT technologies. I aimed to leverage this understanding to revolutionize modern computing paradigms.

Benefits : This project provided invaluable knowledge in managing cloud infrastructure, containerized deployments, and the critical role of edge computing in modern IoT ecosystems. Hands-on application of tools like Kubernetes, Docker, and OpenStack offered practical experience crucial for implementing scalable and efficient distributed systems. Furthermore, my contributions to service virtualization promised enhanced scalability, meeting the dynamic requirements of distributed environments.

Team : During the course of this project, I closely collaborated with a team member with whom I had previously worked on projects focusing on **Smart Gas Sensor Integration** and **microservice architecture**. Our shared experience played a pivotal role in enhancing our partnership, streamlining workflows, and optimizing task allocation. The familiarity with each other's work styles and capabilities contributed significantly to a more cohesive and efficient project execution.

Environment and Context : The backdrop of our endeavor is set against the dynamic backdrop of distributed computing, a realm witnessing a growing demand for adept professionals in cloud, edge computing, and IoT technologies. Our goal with this project was to respond to the urgent requirement for skilled individuals who can adeptly navigate and leverage these technologies within distributed frameworks, aligning with the ever-evolving demands of contemporary computing paradigms. Additionally, this initiative extends beyond the scope of our prior networking courses, utilizing that foundation to delve into advanced concepts in cloud, edge computing, and IoT.

Functions: During the specified timeframe, I delved into task virtualization, particularly focusing on virtualizing the operations of a calculator, exemplifying the creation of virtualized environments tailored for specific applications. This exploration included an in-depth study and application of Docker for containerization, enabling the reliable and isolated execution of applications. Concurrently, I prioritized the utilization of Kubernetes to effectively orchestrate and manage these containers within a distributed setup. Additionally, I acquired substantial expertise in leveraging OpenStack for the creation of virtual machines (VMs) and network administration, fostering a comprehensive grasp of managing cloud infrastructure. These endeavors were dedicated to comprehending and practically implementing core technologies essential for modern distributed systems, particularly in the realms of cloud, edge computing, and IoT.

Figure 8: Managing Virtual Machines and Networks in Cloud Infrastructure

Figure 9: Container Orchestration with Kubernetes and Docker in a Distributed Environment

2.2.7 Software Driver Development

This project, undertaken during our fourth-year internship,spanning a duration of 3 months, it was primarily focused on the development and management of software drivers customized for a specific hardware component.

Motivation: Our primary motivation behind this project was to address the critical need for robust and efficient software drivers, ensuring seamless interaction between hardware components and software systems (signal acquisition) . This endeavor aimed to enhance system performance, reliability, and compatibility by creating drivers specifically designed to complement various hardware functionalities.

Benefits: The outcomes of our project included the creation of optimized software drivers that enhanced hardware performance, reliability, and compatibility. Additionally, the developed Graphical User Interface (GUI) facilitated user interaction, contributing to a more user-friendly experience with the hardware components.

Team: Despite being the sole contributor to this project, I navigated the entire development process from inception to completion. Being solely responsible allowed me to delve into the project comprehensively, working on all aspects from A to Z. This experience provided an in-depth understanding of the project's intricacies and honed my skills in independent project management.

Environment and Context: The project's primary aim was commercial in nature, with the company, Nexeya, where I completed my internship, seeking to demonstrate to UEIdaq, a hardware manufacturer, the capacity for signal acquisition from their hardware using Nexeya's proprietary software, Kallisté. This demonstration was aimed at showcasing the seamless integration and effectiveness of their hardware with Kallisté's software for signal acquisition.

Functions: During my tenure, I engaged in a comprehensive study and practical utilization of the Kallisté software's API, delving into its intricacies to understand its functionalities thoroughly. Additionally, I conducted a detailed examination and applied the UEIdaq's Cube API, exploring its capabilities for signal acquisition purposes. Notably, I actively contributed to the development of the software driver, writing code to establish the necessary connections between the software and hardware components, ensuring seamless communication and data transfer.

Furthermore, I extensively conducted testing and debugging procedures, meticulously analyzing the driver's performance, identifying issues, and refining the codebase for optimal functionality. In parallel, I undertook electronic circuit assembly, designing and constructing various electronic setups to facilitate comprehensive testing scenarios. These setups were instrumental in simulating real-world conditions, allowing for rigorous testing of the software's interaction with different hardware configurations. These multifaceted efforts were aimed at ensuring the reliability, adaptability, and robustness of the software drivers in diverse operational environments.

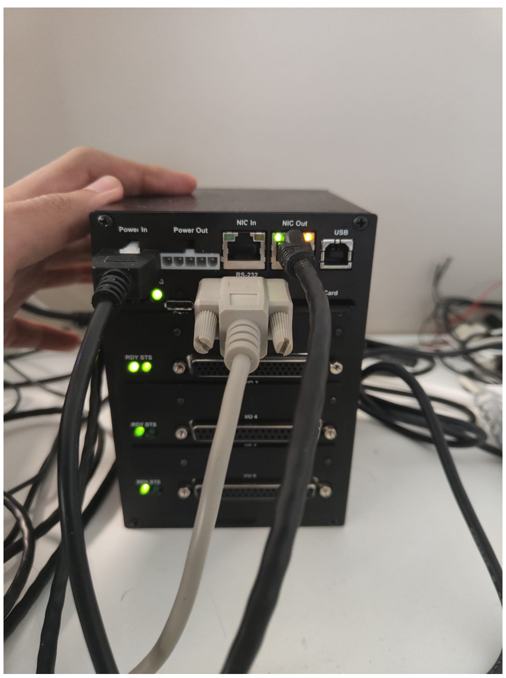

Figure 10: Utilized Hardware Configuration During My Internship

Figure 11: Company Logo: Representation of My Internship Experience

2.2.8 Wireless Sensor Networks for Enhanced Aircraft Safety and Maintenance

Motivation: In the context of aeronautics, our fundamental motivation lies in the pursuit of innovative solutions to enhance aircraft safety and maintenance. Integrating Machine-to-Machine (M2M) communications within Wireless Sensor Networks presents an opportunity for advanced structural monitoring. The primary goal is to reduce operational costs and enhance safety by promptly identifying and preventing aircraft structural defects.

Benefits: This in-depth exploration of PHY and MAC layers in the aerospace context promises several significant advantages. Successfully applying these layers ensures precise, real-time monitoring of critical aircraft systems, enabling proactive maintenance. Additionally, effective sensor communication will allow precise synchronization and reduced energy consumption, ensuring reliability and extended sensor lifespan.

Team: Our multidisciplinary team comprised 7 members from diverse specializations, including students from the Computer Networking option and experts in Embedded Systems. This diversity enriched our perspectives, enabling us to approach the project from various angles, combining networking skills with embedded systems expertise.

Environment and Context: Situated in the demanding and complex field of aeronautics, this project exists within an ever-evolving context where system safety and reliability are crucial. The successful implementation of M2M communications in this domain provides innovative tools for aircraft monitoring, addressing a critical need in modern aerospace industries.

Functions: Within the team, we divided tasks based on our skills and previous experiences. Some members, familiar with GNU Radio, naturally gravitated towards that aspect of the project, while others, including myself, focused on exploring and implementing the MAC-level communication protocol.

We chose to concentrate on implementing the Time Division Multiple Access (TDMA) protocol for several reasons. TDMA offers a predefined temporal framework to allocate specific time slots to each network node. This choice stems from the critical nature of communication in the aerospace domain, where synchronization and temporal management are crucial to ensure the reliability of transmitted data.

Additionally, we developed two code versions: one without an Interface Human-Machine (IHM) and another with an IHM. In the IHM, users can designate the number of peripherals within the aircraft, configure each peripheral (number of time slots, data transmission type, in our case, text files for testing), and add the peripherals one by one using the 'validate' button. Then, by clicking the 'start protocol' button, the data is transmitted.

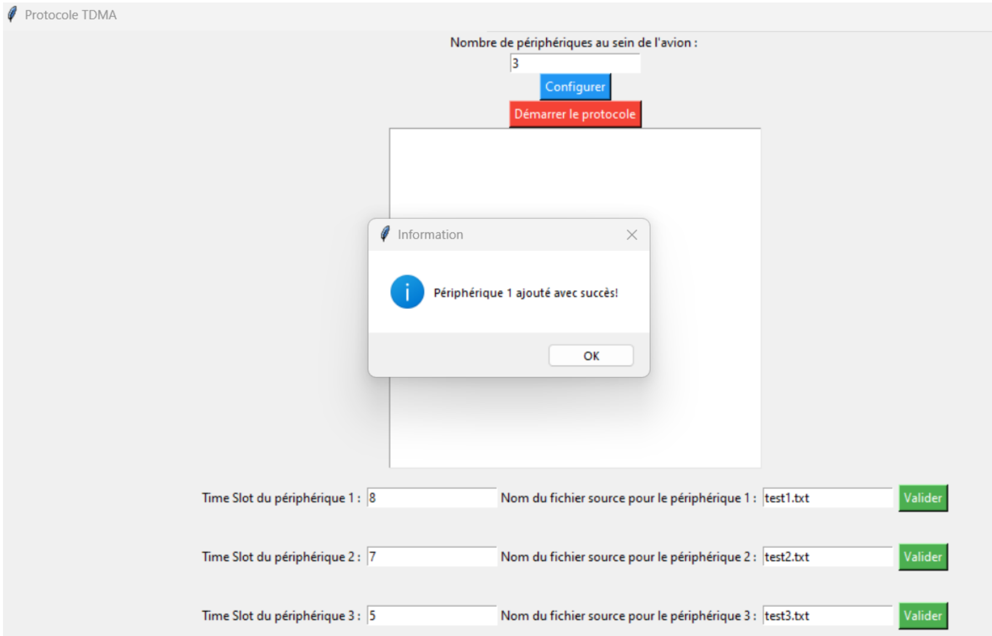

Figure 12: Adding a Peripheral in the User Interface

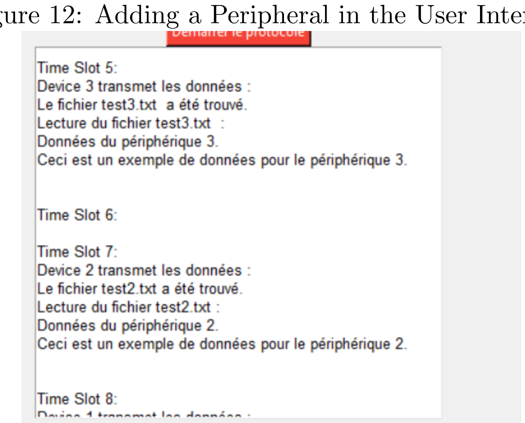

Figure 13: Protocol Transmission Overview

3 Conquering Technical Challenges Within Projects

Throughout my education at the INSA of Toulouse and during various projects, I've consistently faced situations that demanded problem-solving. These experiences have been instrumental in sharpening my skills and broadening my understanding of global science.

In the upcoming sections, I aim to delve into these specific situations, shedding light on the technical abilities I employed to overcome the challenges encountered. This exploration will encompass a comprehensive review of the courses undertaken during this academic year and the projects I've been involved in. Each course and project brought its unique set of challenges, offering invaluable opportunities for skill development.

3.1 Water Leak Detection

During the water leak detection project, I encountered several technical challenges. The context was the design and implementation of an intelligent device capable of detecting water leaks in households by calculating the water flow rate at the entry of each house. My role primarily focused on the development of electronic modules and microcontroller programming for data collection and transmission.

3.1.1 Problem 1: Energy Management

Designing a sustainable energy system to power the water leak detection device posed a significant challenge. The device required a reliable energy source to ensure continuous operation without relying solely on external power.

Problem Resolution

- **What:** I explored integrating a hydraulic generator to harness energy during water circulation phases.
- **How:** Leveraging knowledge from the **"Energy for Connected Objects (Recovery, Transfer)"** course, I developed a microcontroller-tailored energy recovery system.
- **Why:** This approach aimed to make the device self-sufficient and sustainable.

Skills and Knowledge Mobilized : These challenges prompted me to deepen my skills in energy optimization for connected devices and the integration of autonomous systems, as covered in the **"Energy for Connected Objects (Recovery, Transfer)"** course. I further developed these skills through specialized course, practical lab, and discussions with peers and the teacher.

Synthesis and Conclusion : These experiences underscored the critical role of meticulous planning when designing sustainable energy systems. Looking back, I appreciate the ingenuity required to tackle these technical obstacles.

3.1.2 Problem 2: Choosing Data Transmission Technology

Problem Faced : Selecting the most suitable technology for data transmission between the ESP32 and the API presented a significant challenge. We faced the decision between various technologies like Wi-Fi, Sigfox, and BLE (Bluetooth Low Energy)...

Problem Resolution

- **What:** After comprehensive analysis influenced by insights gained from the **"5G Technologies"** course, we determined that a WIFI connection would be most advantageous.
- **How:** Drawing on insights gained from the **"5G Technologies"** course, we harnessed the built-in Wi-Fi module of our ESP32 board to establish robust communication between the device and the API.
- **Why:** We chose Wi-Fi due to its widespread availability, ease of use, and efficiency in establishing a stable wireless connection. Opting for Wi-Fi allowed us to ensure reliable communication between our ESP32 device and the API while providing a practical and widely adopted solution for wireless data transmission.

Skills and Knowledge Mobilized : This challenge drew upon our learnings from the **"5G Technologies"** course, where insights into various communication protocols enabled a more informed decision-making process regarding data transmission technologies

Synthesis and Conclusion : This experience highlighted the importance of leveraging knowledge acquired from coursework, such as the **"5G Technologies"** course, to make informed technological choices. It underlines the significance of aligning theoretical knowledge with practical implementation for successful project outcomes.

3.1.3 Problem 3: Data Security

Problem Faced : Ensuring the security of transmitted data posed a significant challenge. Safeguarding the sensitive information collected by the device was critical for maintaining data confidentiality and integrity.

Problem Resolution

- **What:** Utilizing our knowledge in **Security for connected objects** course, we implemented robust security measures such as user authentication.

- **How:** We implemented an authentication mechanism to access water consumption data. Each user is assigned a unique identifier and password. In the event of unauthorized access attempts, the system rejects the connection, preventing any unauthorized access to water consumption information.

- **Why:** This step was pivotal in thwarting potential threats like data interception or unauthorized access.

  This strategic approach, guided by insights gained from the security course, fortified the security measures implemented to safeguard the transmitted data effectively.

Skills and Knowledge Applied: Tackling these challenges enhanced our practical understanding of **security for connected objects** course. We refined and applied these skills through hands-on lab exercises and case studies.

Synthesis and Conclusion : These experiences underscored the critical importance of making informed choices in communication technology and fortifying data security in IoT device development. In reflection, these challenges served as a platform to apply acquired skills and bolstered our proficiency in resolving intricate technical issues encountered in real-world projects.

3.2 Integration Journey: From Nanoparticle Sensor Design to Smart Gas Sensor System

Spanning across distinct yet interconnected timeframes, my engagement in both the one-week **Internship at the Interuniversity Workshop of Micro-nano Electronics** and the extended seven-week **Smart Gas Sensor Integration Project** underscored a continuous journey in refining expertise and innovation in gas sensor technology. These endeavors, while temporally separate, shared a thematic focus—exploring the intricate realm of gas sensors, their functionalities, and their integration into advanced detection systems.

The initial one-week internship focused on designing a Nanoparticle Gas Sensor, setting the stage for the subsequent seven-week project. This longer endeavor amplified the complexity, encompassing a broad spectrum from sensor fundamentals to crafting a fully integrated smart device. Despite their temporal distinction, both projects shared fundamental requisites and challenges. They demanded an in-depth understanding of sensor design, microcontroller architecture, data acquisition, electronic signal conditioning, software development, and the seamless integration of these elements into a cohesive and intelligent detection system.

In the forthcoming section, I will explore the challenges encountered in these two projects, elucidating the journey from foundational sensor design to the intricate amalgamation of technology.

Problem Resolution During this module, I didn't encounter significant challenges. In fact, I had already had the opportunity to experiment and master skills such as design, routing, drilling, and welding, thanks to my specialization in Automation and Electronics. This prior experience from various electronics labs prepared me well, ensuring a smooth process without encountering major obstacles during these projects.

Skills and Knowledge Mobilized : This section doesn't specifically apply since I didn't encounter major issues. However, in these two projects, we had to apply knowledge from the entire **smart devices** module, notably the courses on using Arduino. Additionally, our work involved using Node-RED, which we had previously covered in the **Middleware for Internet of Things** course.

Synthesis and Conclusion : I found this module very enjoyable and interesting. However, the only downside was the specific constraint of using LORA technology due to the availability of a LORA gateway at INSA. This limited the application of skills acquired in the **5G technologies** course.

3.3 Enhancing Aid Requests Through Microservice Architecture Project

The **"Enhancing Aid Requests Through Microservice Architecture"** project tackled the challenge of developing a platform to streamline aid requests, emphasizing scalability and data integrity. The primary challenge focused on creating a scalable platform to manage increased user volumes and evolving functionality, necessitating a shift towards microservice architecture. Addressing this challenge involved restructuring the platform's architecture into a microservice model, drawing insights from the **"Service Architecture"** course. This narrative delves into the strategies devised and insights gained while overcoming this fundamental obstacle, highlighting the convergence of theoretical knowledge with real-world implementation.

3.3.1 Problem 1: Platform Scalability

Problem Faced: Creating a platform for aid requests required scalability to handle increased user volumes and evolving functionality, demanding a transition to a microservice architecture.

Problem Resolution

- **What:** Exploring microservice architecture designs to enhance scalability and flexibility.

- **How:** Leveraging insights from the **"Service Architecture"** course, we restructured the platform's architecture into a microservice model.
- **Why:** This transformation aimed to improve responsiveness and adaptability to changes in user requests, ensuring the platform's future scalability.

The transition to a microservice architecture, influenced by our learnings from the **"Service Architecture"** course, facilitated improved scalability and adaptability for efficient aid request management.

Skills and Knowledge Mobilized: Addressing this challenge involved applying our understanding of microservice architecture from both the **"Service Architecture"** and **"Software Engineering"** courses. We further developed these skills through practical applications and by integrating insights from detailed tutorials available on Moodle.

Synthesis and Conclusion: This experience underscored the significance of structured architectural design, particularly microservices, in overcoming scalability challenges. It emphasized the value of applying theoretical concepts from coursework, such as the **"Service Architecture"** course, to real-world projects for optimized outcomes.

3.4 Exploration of Integrated IoT Application Development

In the pursuit of developing a comprehensive IoT application, the project encountered pivotal challenges, each demanding intricate solutions to ensure the system's robustness and reliability.

3.4.1 Problem 1: Integration of MQTT Technology and Implementation of REST APIs

Problem Faced: Integrating MQTT technology for IoT communication and using REST APIs to manage IoT devices posed significant challenges. The complexity lay in synchronizing these two technologies to ensure reliable and secure communication between devices and the central server.

Problem Resolution:

- **What:** Development of MQTT communication modules for efficient data exchange between IoT devices and the central server.
- **How:** Using REST APIs and implementation of Node-RED flows for seamless control and monitoring of IoT devices, enabling user-friendly interactions.

- **Why:** These steps were crucial to ensure reliable and secure communication between IoT devices and the central server, ensuring the system's smooth operation.

Skills and Knowledge Utilized: Addressing this challenge required a deep understanding of IoT communication protocols, architectures, and practical application development skills acquired from the **"Middleware for Internet of Things"** course.

Synthesis and Conclusion: This experience underscored the significance of synchronizing diverse IoT communication technologies for seamless device interaction. Leveraging insights from the **"Middleware for Internet of Things"** course, the development of MQTT communication modules and REST APIs facilitated robust and secure communication, ensuring the system's efficiency and reliability.

3.4.2 Challenge 2: User-Friendly Implementation with Node-RED

Problem Faced: Implementing a user-friendly mechanism for managing and interacting with the IoT system through Node-RED presented a critical challenge. Ensuring ease of use while maintaining robust functionality required thoughtful consideration.

Problem Resolution:

- **What:** Utilization of Node-RED to create a user-friendly interface for controlling and monitoring IoT devices.
- **How:** Applying knowledge gained from practical experiences and tutorials to design intuitive Node-RED flows.
- **Why:** This step aimed to enhance the accessibility of the IoT system, making it more user-friendly and facilitating efficient control and monitoring.

Skills and Knowledge Utilized: Addressing this challenge involved practical application of Node-RED, drawing from experiences and tutorials.

Synthesis and Conclusion: The incorporation of Node-RED for user interface development enhanced the accessibility and user-friendliness of the IoT system. This approach, influenced by practical experiences and tutorials, contributed to the seamless control and monitoring of devices, further emphasizing the importance of user-centric design in IoT applications.

3.5 Advanced Exploration of Cloud, Edge Computing, and IoT Technologies

In my pursuit of a comprehensive understanding of Cloud, Edge Computing, and IoT technologies within a distributed context, several pivotal challenges emerged, each demanding intricate solutions. Addressing these challenges involved applying the knowledge and skills acquired from various training units throughout the academic year.

3.5.1 Problem 1: Integration of Virtualization and Orchestration

Issue Faced: I faced a significant challenge in integrating virtualization and orchestration within a distributed context for efficient application management. Ensuring coherent interaction between these technologies to guarantee reliable and efficient deployments was complex.

Problem Resolution:

- **What:** I conducted in-depth experimentation with tools like Kubernetes and Docker for virtualization and orchestration.
- **How:** I leveraged skills acquired from the *Cloud and Edge Computing* course, encompassing understanding cloud/edge computing concepts, employing task virtualization, task containerization using Docker, and implementing Kubernetes for task management.
- **Why:** These steps were crucial to ensure effective and scalable application operations in a distributed environment, enabling agile workload management.

Skills and Knowledge Utilized: I applied my skills obtained from the **Cloud and Edge Computing** course, which encompassed understanding cloud/edge computing concepts, employing task virtualization, task containerization using Docker, implementing Kubernetes for task management, and utilizing OpenStack for network management to address these challenges.

Synthesis and Conclusion: This experience highlighted the significance of integrating various tools and methodologies in a distributed environment. The knowledge gained from the **Cloud and Edge Computing** courses proved instrumental in effectively managing virtualization and orchestration tools like Kubernetes and Docker.

3.5.2 Problem 2: Resource Optimization and Network Management

Issue Encountered: I faced a significant challenge in optimizing resources and effectively managing the network for Cloud and Edge Computing infrastructures in an IoT context. Ensuring optimal performance while maintaining efficient network resource management was complex.

Problem Resolution:

- **What:** I extensively used OpenStack for virtual machine management and network administration.
- **How:** I applied skills acquired from training units like **Middleware for Internet of Things** and **Cloud and Edge Computing**.
- **Why:** These measures were essential to ensure optimal resource utilization and efficient network management, fostering optimized performance for distributed applications.

Skills and Knowledge Utilized: I applied my skills in Cloud infrastructure management, network administration, and performance optimization gained from units like **Middleware for Internet of Things** and **Cloud and Edge Computing** to overcome these challenges.

Synthesis and Conclusion: This challenge emphasized the significance of adeptly managing Cloud infrastructure and network resources. Leveraging skills acquired from **Middleware for Internet of Things** and **Cloud and Edge Computing** units was pivotal in effectively handling OpenStack and ensuring optimized resource utilization within the project's context.

3.6 Software driver development

3.6.1 Problem :

In this project, I faced a unique challenge where my supervisor's expertise was more focused on commercial aspects rather than the technical intricacies I was dealing with. This situation meant I had to navigate the technical challenges independently without the direct support or guidance from my supervisor, who was primarily oriented towards commercial aspects. It placed me in a context where I had to handle and resolve issues on my own.

Skills and Knowledge Utilized : This timeframe provided an opportunity to apply and refine a range of software development skills, including driver design, implementation, and rigorous testing to ensure reliability and compatibility.

Collaborating closely with hardware engineers enhanced my comprehension of hardware specifications, facilitating the translation of these technical specifications into functional software interfaces. Moreover, the experience in designing and developing a Graphical User Interface (GUI) for user interaction significantly bolstered my expertise in user interface design and development. Furthermore, I drew parallels between this project and **the Middleware for Internet of Things** course, particularly in the segment where we utilized Node-RED, emphasizing a similar independent problem-solving approach.

Synthesis and Conclusion: This project offered a fulfilling experience in software development, providing an opportunity to delve into the intricacies of designing and implementing drivers while ensuring their compatibility across diverse systems and platforms. The absence of specific challenges allowed for a more comprehensive exploration and refinement of software development skills within this context.

3.7 Wireless Sensor Networks for Enhanced Aircraft Safety and Maintenance

3.7.1 Problem :

Encountering minimal challenges in this project was a significant advantage, allowing me to focus extensively on a field I'm passionate about: *Software Sevelopment*. The coursework in Wireless Sensor Networks presented fewer hurdles, providing a smooth path to explore this domain.

Skills and Knowledge Utilized : The coursework in Wireless Sensor Networks equipped me with a solid foundation in comprehending the nuances of **wireless Sensor networks**, emphasizing crucial metrics and enabling a bottom-up approach for implementation. Leveraging these skills, I could optimize performance across network layers and manage resources efficiently. I heavily drew upon these skills and knowledge throughout the project, enhancing its trajectory.

Synthesis and Conclusion: This project was particularly rewarding as it allowed me to immerse myself in an area I truly appreciate: *Software Development*. The experience reinforced my passion for this field within the context of wireless networks, aligning seamlessly with my professional interests and aspirations.

4 Comprehensive Skills and Knowledge Assessment

In this section, I aim to delve deeper into the insights gained from my involvement in the Innovative Smart Systems program during my tenure at INSA. I will reflect on the skills honed, the expertise acquired, and how these experiences have significantly contributed to shaping my professional trajectory. Moreover, I will outline the pivotal aspects that I believe will play a crucial role in guiding my future endeavors.

4.1 Module Summation and Course Insights

In this section I'm summarizing the knowledge gained from each module. While the experiences I previously shared were from my PTP and other projects I worked on, they don't fully encompass all that I engaged with or learned in each course.

4.1.1 Smart Device :

This module covered a broad spectrum of sensor technology fundamentals. It delved into the core concepts, spanning data acquisition from different viewpoints such as physics, electronics, and metrology. Practical application was emphasized through the creation of nano-particle sensors using microelectronics tool (cf Designing gas sensor project 2.2.2). The process involved diverse stages including chemical synthesis, assembly and meticulous testing.

Moreover, the module encompassed Computer-Aided Design (CAD), manufacturing procedures, and the integration of nano-technology sensors into larger systems. It also involved the development of shields for gas sensors, software programming for these sensors, and the creation of a Human-Machine Interface (HMI), with a focus on integration into smart devices(Cf Smart Gas Sensor Integration Project 2.2.3).

The practical application was integral, culminating in the Analog Electronics Labs where all these components were integrated into the development of a comprehensive smart device. Hands-on experience was obtained through various activities such as chemical synthesis, assembly, testing, and software development, providing valuable insight and skills essential for sensor technology and the creation of smart devices.(Cf Smart Gas Sensor Integration Project 2.2.3)

Overall, this module facilitated a comprehensive understanding and practical application of sensor technology, microelectronics, CAD, and software development, crucial for the creation and seamless integration of smart devices.

4.1.2 Communication Protocols for IoT

During the Communication Protocols for IoT module, I gained a multifaceted understanding of various critical areas. This encompassed Wireless Sensor Networks, delving into their lifecycle from design to deployment, emphasizing essential metrics like cost, energy efficiency, robustness, and ease-of-deployment. Additionally, we had the opportunity to put our knowledge into practice during a project focused on enhancing aircraft safety and maintenance(cf 2.2.8) . This project allowed us to deploy our skills in real-world scenarios, implementing TDMA for aviation communications, developing MAC-level communication, enabling real-time fault detection, and emphasizing cost-effective solutions.

In the domain of 5G Technologies, I gained insights into various mobile communication developmental stages, including 3G, 4G, 5G, Zigbee, LoRa, Sigfox, and more. This extensive study broadened my understanding of diverse communication networks. These acquired insights were instrumental in our project (Cf Water Leak Detection Project 2.2.1) , where we utilized this knowledge to make informed decisions regarding the selection of communication technologies suitable for our specific project requirements.

Additionally, exploring Emerging Networks acquainted me with the limitations of traditional Internet designs, providing foundational insights into Software-Defined Networking (SDN) and network control applications. It is worth noting that this module served as somewhat redundant for me since, as a student enrolled in a dual-degree program at ENSEEITH in collaboration with INSA, I had already taken this course at the beginning of the semester at ENSEEITH. However, this repetition proved beneficial, allowing me to revisit the concepts and anticipate the professor's expectations for the Practical Work sessions. Please be aware that on the day of the portfolio submission, we had not yet completed the practical session. Still, I will include the report from the session conducted at ENSEEITH, covering the same concepts presented in this course.

In the "Communication Protocols for LP-WPAN" course, I delved into the intricacies of communication protocols specifically designed for Low-Power Wide-Area Networks (LP-WPAN) within IoT environments. This module provided valuable insights into the specialized protocols tailored to meet the unique requirements of LP-WPAN, emphasizing their relevance and application in the context of the Internet of Things. The exploration covered various LP-WPAN communication standards, shedding light on their characteristics, functionalities, and practical implementations. This knowledge equipped me with a comprehensive understanding of the communication landscape, enabling me to navigate the challenges and opportunities presented by LP-WPAN in the realm of IoT.

The module broadened my knowledge in integrating Artificial Intelligence (AI) into embedded systems for IoT applications. It encompassed the study of various machine learning methods, including K-Nearest Neighbors (K-NN), which utilizes proximity-based classification or regression, and Support Vector Machine (SVM), an algorithm aiming to find a hyperplane for efficient data classification. Additionally, Convolutional Neural Networks (CNN), specialized in processing structured data like images, were explored. The labs were enriching; however, the three practical sessions were insufficient to fully cover the CNN and PCA parts, highlighting the complexity and depth of these topics.(Refer to the Annexes for a detailed view of these lab reports(5)).

4.1.3 Middleware and Service

Throughout the Middleware and Service Architecture module, I gained extensive knowledge in crucial areas. In particular, exploring Service-Oriented Architecture (SOA), I delved into defining and implementing SOA using web services, SOAP technology, and REST principles. This encompassed integrating process managers into established SOAs. Furthermore, the insights from this coursework found practical application in the project Enhancing Aid Requests Project(2.2.4) This initiative focused on building a platform for volunteers to respond to aid requests, thereby facilitating support for isolated individuals. The coursework knowledge was pivotal in transitioning the architecture into a microservice model to enhance overall functionality and service delivery.

The Software Engineering aspect provided a comprehensive understanding of various software development stages and project management methodologies, including Continuous Integration (CI) and Continuous Deployment (CD). This knowledge was put into practice in two distinct projects: the Water Leak Detection project (2.2.1) and a TP focusing on room management within INSA (See Annexes (5)). In both projects, we utilized Jira as a project management tool to organize our scrums, ensuring effective team coordination. Moreover, we had the opportunity to implement a CI/CD method using Jenkins for our Water Leak Detection project, enhancing our proficiency in software engineering principles and project management methodologies.

The Middleware for Internet of Things course significantly enriched my comprehension of IoT standards. It empowered me to deploy and configure IoT architectures using tools like OM2M, effectively interact with architecture resources through REST services, and seamlessly integrate novel technologies. These learnings were extensively applied and reinforced through our project Integrated IoT Application Development (2.2.5). This project offered a hands-on understanding by implementing the MQTT protocol for IoT communication, creating applications to manage IoT devices using REST APIs and Node-RED, configuring resources, establishing access control policies, tracking sensor changes, and developing a comprehensive dashboard to visualize the data collected from IoT sensors.

Furthermore, Cloud and Edge Computing provided an in-depth exploration of cloud/edge computing concepts, task virtualization, containerization using Docker, Kubernetes for task management, and OpenStack for network management. These modules collectively broadened my expertise in crucial areas such as service architecture, software engineering methodologies, IoT standards, and cloud/edge computing technologies. These learnings were practically applied in our project Advanced Exploration of Cloud, Edge Computing, and IoT Technologies in a Distributed Context (2.2.6). This project delved into virtualization, cloud concepts, and edge computing, extensively utilizing OpenStack for cloud management, deploying Kubernetes and Docker for containerized operations, and contributing to service virtualization to ensure scalability.

4.1.4 Security and Energy optimization for IoT

In this training unit, I gained extensive knowledge focusing on two critical aspects: security for connected objects and energy considerations within IoT devices. Regarding security, I developed a strong understanding of fundamental security principles, adeptness in identifying vulnerabilities within IoT architectures, and the capacity to assess the impact of exploiting these vulnerabilities. Moreover, I honed my proficiency in recommending appropriate security measures and countermeasures to mitigate potential risks. This module played a crucial role as we considered it for the water leak detection project(2.2.1), and we took it into account when working on the M2M lab (I have written a report on the security aspect, which you will find in the Annexes(5)).

In terms of energy optimization, the course emphasized the significance of considering energy limitations during the development of embedded devices. This theoretical knowledge was practically applied during the *Energy for connected object* lab sessions, encompassing the study of load characteristics, LED activation strategies, rectifier characterization, antenna selection, ambient electromagnetic energy harvesting, and radiative electromagnetic wireless power transfer. In our water leak project 2.2.1, we integrated a hydraulic generator, showcasing the application of recovery and transfer strategies. The lab sessions further enriched my understanding by providing hands-on experience in implementing various methodologies to effectively manage and optimize energy/power consumption within IoT devices.

4.1.5 Innovative Project & English

The 'Project for Detecting Water Leaks'(2.2.1), our main project of the year, focused on creating code to detect water leaks while implementing an electronic assembly to interconnect various components needed for this purpose. This ambitious project formed the core of the "Innovative Project & English" module, encompassing a series of complex technical steps. It involved a meticulous phase of developing leak detection strategies, coding their implementation, and assembling various electronic elements for their optimal functioning. (Here is details about this project (2.2.1).

In addition to this technical aspect, as the name suggests, this module also included a linguistic dimension. The English component highlighted the ability to present and discuss the decisions made during the project, demanding a well-argued defense of the choices. Moreover, particular emphasis was placed on communicating technical decisions and drafting a comprehensive report in English, detailing the project's development, thereby facilitating a clear and precise communication of the technical advancements achieved.

4.1.6 Innovation Humanities

As engineers, we are expected to have a solid technical background, but sometimes we overlook the importance of humanities classes. Ethics often gets associated with science despite having a contentious relationship at times. It seems crucial to take time to reflect on ethical questions. Considering what we bring to society and ensuring we align with our beliefs is imperative. When discussing humanities, it's crucial not to overlook problems that arise in team communication.

We took a Social Psychology course that helped us better understand how to interact and resolve these communication issues. Exploring topics such as wages and different company payment methods is important since it's knowledge we might not gain on our own, especially concerning motivation. This was incredibly beneficial for our main project as it reinstated motivation that we had lost due to encountered issues.

Similarly, the PPI provided us with general knowledge about job interview and salary, which was necessary. It was a module where the lecturer assisted us with our presentations.

4.2 Skill Matrix

In this section, in the 'Main Skill Acquisition Method' column, **'FI'** stands for Initial Training, **'EP'** for Peer Exchange, **'AF'** for Self-training, and **'PP'** for Professional Practice.
In the 'Self Evaluation' column, **'AP'** refers to Application Level, **'AN'** to Analysis Level, **'M'** to Mastery Level, and **'EX'** to Expertise Level.

- **'AP' - Application Level:** Follow-up of instructions or procedures.
- **'AN' - Analysis Level:** Improvement or optimization of solutions or proposals.
- **'M' - Mastery Level:** Designing programs or defining specifications.
- **'EX' - Expertise Level:** Defining directions or strategies.

4.2.1 Smart Device :

Skills	**Req. Level**	**Self Eval.**	**Main Skill Acquisition Method**
Understand basic notions of sensors, data acquisition: physics, electronics, and metrology aspects	4	4 (EX)	**FI:** AE Background
Be able to manufacture a nano-particles sensor using micro-electronics tools: chemical synthesis, assembly, testing	4	4 (EX)	**FI:** During ISS (2.2.2)
Be able to design the datasheet of the sensor manufactured	4	3 (M)	**FI:** During ISS (2.2.3)
Understand micro-controller architecture and use them	4	4 (EX)	**FI+AF+PP:** During ISS (2.2.3 + 2.2.1) + AE Background + Summer Internship

Be able to design data acquisition system (sensor, conditioner, micro-controller) with respect to the application	4	4 (EX)	**FI:** During ISS + AE Background (2.2.3)
Be able to design the electronic circuit of a sensor's signal conditioner (design + simulation)	4	4 (EX)	**FI:** AE Background
Be able to design a shield to accommodate the gas sensor	4	2 (AN)	**FI:** During ISS (2.2.3)
Be able to design the software to use the gas sensor and its HMI	4	4 (EX)	**FI + PP:** During ISS + Internship (2.2.3 + 2.2.5)
Be able to combine all of the above mentioned components into a smart device	4	4 (EX)	**FI:** During ISS + AE Background (2.2.3)

4.2.2 Communication Protocols for IoT

Skills	Req. Level	Self Eval.	Main Skill Acquisition Method
Understand the major development phases for mobile communications and development of the associated technology	4	4 (EX)	**FI + EP :** During ISS Project (2.2.1)
Understand the impact of new mobile technology	4	4 (EX)	**FI:** During ISS Courses
Be able to analyse and evaluate optimal wireless network technologies	4	3 (M)	**FI + EP:** During ISS + Hands-on Practical Work (2.2.8)
Be able to suggest optimal technological solutions for IoT networks	4	4 (EX)	**FI:** During ISS Project (2.2.1)
Understand and master optimization of communication protocols with respect to security concerns	4	3(M)	**FI:** During ISS Courses
Know the main processing techniques used for digital communication and know how to explain the basic structure of digital RF transmitter-receiver	4	3 (M)	**FI + EP:** Practical Labs in ISS (2.2.3)

Mastering the architecture of an energy management system, simple storage, energy recovery, know how to size the storage element according to the specifications	4	4 (EX)	**FI + EP:** During ISS (2.2.1)

4.2.3 Middleware and Service

Skills	**Req. Level**	**Self Eval.**	**Main Skill Acquisition Method**
Know how to define a Service Oriented Architecture	4	4 (EX)	**FI:** Tuto Courses + Practical Projects(2.2.4)
Deploy an SOA with web services	4	3 (M)	**FI + AF:** Tuto Courses + Practical Projects(2.2.4)
Deploy and configure an SOA using SOAP	4	4 (EX)	**FI + AF:** Tuto Courses + Practical Projects(2.2.4)
Deploy and configure an SOA using REST	4	4 (EX)	**FI + AF:** Tuto Courses + Practical Projects(2.2.4)
Integrate a process manager in an SOA	4	4 (EX)	**FI + AF:** Tuto Courses + Practical Projects(2.2.4)
Know how to situate the main standards for the Internet of Things	4	4 (EX)	**FI:** Courses + Practical Work (2.2.5)
Deploy an architecture compliant to an IoT standard and implement a sensor network	4	4 (EX)	**FI:** Courses + Practical Work (2.2.5)
Deploy and configure an IoT architecture using OM2M	4	3 (M)	**FI:** Courses + Practical Work (2.2.5)
Interact with the different resources of the architecture using REST services	4	3 (M)	**FI:** Tuto Courses + Practical Projects(2.2.5)
Integrate a new technology into the deployed architecture	4	4 (EX)	**FI:** Tuto Courses + Practical Projects(2.2.5)

Understand the concept of cloud computing	4	4 (EX)	**FI + AF:** Courses + Practical Work (2.2.6)
Deploy and adapt a cloud-based platform for IoT	4	4 (EX)	**FI + EP:** Courses + Practical Work (2.2.6)

4.2.4 Security and Energy optimization for IoT

Skills	Req. Level	Self Eval.	Main Skill Acquisition Method
Understand the fundamentals of security	4	4 (EX)	**FI:** During ISS Project (2.2.1)
Be able to identify security weaknesses in an IoT architecture	4	3 (M)	**FI + EP:** During ISS Project (2.2.1)
Be able to assess the impact of exploiting a security vulnerability in an IoT architecture	4	3 (M)	**FI:** During ISS Project (2.2.1)
Be able to propose adequate security counter-measures	4	4 (EX)	**FI:** During ISS Project (2.2.1)
Take into account energy constraints when designing an embedded device	4	3 (M)	**FI + EP:**During ISS Project (2.2.1)
Understand and master the optimization of communication protocols for IoT with respect to energy limitations	4	4 (EX)	**FI +EP:** During ISS Project (2.2.1)

4.2.5 Innovation Humanities

Skills	**Req. Level**	**Self Eval.**	**Main Skill Acquisition Method**
Solve a problem in a creative way	4	4 (EX)	ISS Project (2.2.1)
Develop the first stage of innovation	4	3 (M)	**FI + EP + AF:** ISS Project (2.2.1)
Understand production, validation, distribution, acceptability, and aftermath of innovation	4	4 (EX)	**FI + EP + AF:** ISS Project (2.2.1)
Structure and lead an innovative project	4	3 (M)	**AF:** ISS Project (2.2.1)
Learn teamwork	4	4 (EX)	**AF**
Multi-disciplinary students work as a team	4	4 (EX)	**AF**
Be convincing: present and defend an idea	4	4 (EX)	**AF**
Express and exchange hypotheses	4	4 (EX)	**AF**
Suggest a strategy to solve the problem identified	4	4 (EX)	**AF**
Suggest a model	4	4 (EX)	**AF**
Choose, design, and/or justify a protocol or an experimental prototype	4	3(M)	**AF + FI**
Self-evaluation with a portfolio	4	3(M)	**AF**

Reflect upon my training process and methods	4	3(M)	**AF**
Be able to put forward my training experiences, whether they be explicit or implicit	4	4 (EX)	**AF + FI**

4.2.6 Innovative Project & English

Skills	**Req. Level**	**Self Eval.**	**Main Skill Acquisition Method**
Analyze a real-life problem	4	4 (EX)	**AF + FI:** ISS Project (2.2.1
Suggest a technological solution to a problem	4	4 (EX)	**AF + FI:** ISS Project (2.2.1)
Implement a prototype to solve the problem	4	3 (M)	**AF + FI:** ISS Project (2.2.1
Present and debate (in English) the technical choice made	4	3 (M)	**AF + FI:** ISS Project (2.2.1 + 4.1.5)
Produce a report (in English) for the developed project	4	4 (EX)	**AF + FI:** ISS Project (2.2.1 + 4.1.5)

4.3 Self Evaluation of the year

Embarking on this academic journey, I discerned early on that certain modules would align seamlessly with my intrinsic interests, while others would present formidable challenges. As I reflect upon the culmination of this academic year, my initial assessments have largely proven accurate. However, the profound sense of personal and academic fulfillment that comes from immersing oneself wholeheartedly in the content of each course has been a revelation.

While I maintained my preferences and understood from the outset that becoming an expert in every field within the given timeframe was a lofty expectation, this realization did not deter my commitment to understanding the core concepts of each subject. It was evident that mastery in every topic was an unrealistic goal, but a comprehensive understanding of key concepts remained more than satisfactory.

Unexpectedly, a new dimension emerged during this academic odyssey – moments of occasional frustration stemming from the realization that becoming an expert in every subject was an unattainable feat. However, I view this revelation positively, recognizing that despite not delving into the depths of certain subjects, I managed to grasp their essence. While the desire to explore certain topics more profoundly persists, the constraints imposed by time and other commitments were duly acknowledged.

In contemplating the entire experience, I recognize significant personal and academic growth. I now feel adept at designing and implementing intelligent systems, navigating the complexities of advanced hardware and software integration. This process involves critical considerations such as energy consumption, security protocols, user-friendliness, system mobility, and the judicious selection of technologies tailored to the specifications of the system.

Despite the multifaceted challenges, one aspect that added a unique layer to this academic year was the simultaneous pursuit of work to finance my studies. Juggling assignments and responsibilities between academia and employment was undeniably demanding. Nevertheless, this challenging dynamic has offered a distinct perspective and reinforced my ability to manage competing priorities.

Moreover, the opportunity to engage in a collaborative project with businesses proved to be a pivotal experience. This endeavor not only broadened our understanding of the corporate landscape but also provided a tangible link between theoretical concepts and practical application. The challenges faced throughout the year have been instrumental in cultivating resilience, problem-solving skills, and the ability to adapt to unforeseen circumstances.

In essence, while the academic year posed its fair share of difficulties, it has been a year of substantial personal and academic development. I've gleaned invaluable insights and skills that extend beyond the confines of textbooks, enriching my overall educational journey.

4.4 Analyzing Insights for Portfolio Construction and their Relevance to My Professional Goals

Beyond the purely academic aspects, my experience at ISS has been profoundly shaped by the rich diversity present among fellow students. This diversity extends beyond just technical skills to encompass a wide array of cultural backgrounds. Engaging with this heterogeneous cohort has been an incredibly enriching experience. It has not only challenged me to abstract complex electronic concepts but has also honed my ability to communicate these ideas effectively across diverse audiences. The process of teaching and sharing knowledge within this diverse environment has been exceptionally rewarding, as it necessitates a deep understanding before imparting information effectively.

Moreover, the year-long endeavor of structuring this portfolio has provided me with a comprehensive overview of the extensive range of topics covered in the ISS program. This process has played a pivotal role in not only validating my acquired skills but also in crystallizing my understanding through meticulous written documentation. As I meticulously compose this final section, my objective is to synthesize the multitude of experiences, delineate the nuanced skills acquired, and reflect on the profound relevance of these experiences for my impending professional journey.

Furthermore, I am particularly excited about how the knowledge and skills gained through this training will significantly bolster my professional pursuits. With a keen interest in DevOps, I foresee the Software Engineering and Cloud courses as instrumental in equipping me with the necessary insights and proficiency to kickstart a successful career in this domain. These courses have not only provided me with a deep understanding but have also furnished me with practical tools and knowledge, positioning me with a robust foundation as I embark on my journey in DevOps. I am confident that the insights garnered from these courses will serve as a valuable asset, enabling me to navigate and contribute effectively to the dynamic field of DevOps.

5 Annexes

To streamline the size of my portfolio, I have compiled all the annexes in this Git repository. I hope you find it informative, the link to the GitHub repository is as follows: `https://github.com/Abdel211/Portfolio.git`