Portfolio

Innovative Smart System

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Abstract

This portfolio was prepared as part of the second year of a Master's program in Innovative Smart Systems (ISS) at INSA Toulouse. Its purpose is to provide a comprehensive overview of my academic year, detailing the skills and knowledge I gained, along with my reflections on each course taken during the program. Within this portfolio, you'll find summaries of each course, including insights on the topics covered and my personal assessments. Additionally, it includes reports from practical sessions (laboratory work) and project-based exercises that allowed me to apply theoretical concepts in real-world contexts.

Table of contents

Chapter 1 : Introduction

Dans le cadre de ma 5 ème Annéeà l'INSA Toulouse, j'ai eu l'occasion de me spécialisé dans le domaine de l'innovative smart system. Dans la première partie vous retrouverez des informations sur ma scolarité, ainsi que mon CV qui vous informerons un peu mieux sur qui je suis.

Chapter 2 : General Information

2.1 Presentation of MS Innovative Smart System

The **Internet of Things (IoT)** is expected to grow rapidly in the coming years. Often described as the fourth industrial revolution, IoT is a promising field, with over 20 billion smart devices projected to be connected by 2020. However, achieving this scale will involve overcoming several challenges at multiple levels.

The **Innovative Smart Systems Master's Program** aims to prepare young engineers to understand and tackle these challenges by developing innovative solutions. IoT systems consist of multiple layers, each with its own focus:

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

Each of these layers has specific challenges, addressed by different training units in the program:

- Designing smart devices: *Smart Devices Training Unit*
- Connecting devices: *Communication Training Unit*
- Processing data within the network: *Data Processing Training Unit*
- Providing services for network interaction and data access: *Middleware and Services Training Unit*

This master's program addresses these challenges through a variety of courses, bringing together students from diverse fields, including Electronics, Telecommunications, Computer Science, and Physics. By combining these skills, students can collaborate to solve the complex problems involved in developing IoT networks and systems.

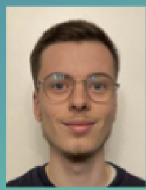
2.2 Curriculum

2.2.1 Student Profile

Personal information :
Surname: VASSEUR.
First name: Cyril.
email: vasseu@insa-toulouse.fr.

2.2.2 Curriculum Vitae

CYRIL VASSEUR



Profil

22 ans (1er Avril 2002)
Permis B
Véhiculé

Coordonnées

Adresse :
35 Avenue Jules Julien
31400 Toulouse
Téléphone :
06 46 12 29 23
Email :
vsr.cyril@gmail.com

Skills

Logiciel :
SEE Electrical, Unity PRO, Eagle, Altium, Mattlab, Microsoft Office, Keil, Visual Studio
Programmation :
C++, C, JAVA, Flutter, Assembleur, Python, Rust
OS :
Windows ,UNIX

Langues

Anglais B2
Japonais A2
Allemand A1

Qualités

Ambitieux
Energique
Curieux
Digne de confiance
Persévérant

Centres d'intérêt

Aéronautique
Aérospatial
Parachutisme sportif
Badminton
Modélisme

Formation

2022/ 2025
Formation Ingénieur Automatique et Electronique en alternance
INSA de Toulouse

2022
Formation à l'habilitation électrique d'un chargé de travaux (B2V)
Plastic Omnium

2020/2022
Diplôme Universitaire de Technologie en Génie Electrique et Informatique Industriel (DUT GEII)
Institut Universitaire de Béthune

Expériences professionnelles

4 Septembre 2023
Apprenti ingénieur logiciel navigation par satellite
Thales Alenia Space

septembre 2022
Bénévole du Fablab de l'INSA Toulouse

5 Septembre 2022 au 1er Septembre 2023
Développeur de banc de test batterie
Plastic Omnium

1er Avril au 31 Juillet 2022
Stage d'étude de 4 mois dans le cadre du DUT GEII au Japon
National Institute of Technology Sendai College

1er Octobre au 1 Avril 2022
Tutorats des élèves de premiére Année du DUT GEII

De Juillet 2020 à Septembre 2020
De Juillet 2021 à Septembre 2021
De Aout 2022 à Septembre 2022
Préparateur de commandes
Leclerc Drive

2.2.3 Background

Before entering INSA for my third year of higher education, I completed a two-year technical diploma (DUT) in Electrical Engineering and Industrial Computing at IUT of Béthune. I then pursued an engineering degree at INSA Toulouse, where I began a Master's in Automation and Electronics through an apprenticeship program. My first year was spent with Plastic Omnium, where I worked on developing a test bench for heavy vehicle batteries used in trains and trucks. For my second year, I moved to Thales Alenia Space, drawn by my interest in the space sector, where I became a software apprentice specializing in satellite navigation. After completing my Master's, I continued at Thales Alenia Space to pursue my second Master's in Innovative Smart Systems (ISS).

2.2.4 Training units

Below, you can find the overview of the various courses completed in the ISS program.

	AE	Evaluation method
Discover methods to validate and prioritize innovations and market targets	3	portfolio
Know the points to work to offer value and build a good business model	3	portfolio
Define if an idea is patentable and carry out a search of anteriority	3	portfolio
Define your financing tool according to your needs and adapt	3	portfolio
set goals in line with your means, discover and select digital and traditional commercial actions	3	portfolio
recuit, manage and organise a startup	3	portfolio
make a pitch	3	presentation

Figure 2.1: Business Startup Unit

Software Engineering	AE	Evaluation method
Define the different phases in software development	3	Project
know the different project management methods	3	Project
Apply one of these methods a project	3	Project
Processing Semantic Data	AE	Evaluation method
design and understand a model for an application	3	TP Report
Know how to infer new knowlegde from a knowledge base	3	TP Report
Be able to enrich data with semantic meta-data	3	TP Report
Data Processing and Analysis: Big Data	AE	Evaluation method
Know how to explore and represent data sets	3	TP Report
Master R	3	TP Report
Master complexity associated to statistical data processing and know the techniques to be used to minimise them	3	TP Report

Figure 2.2: Analysis and data processing, business applications Unit

Protocols and communication	AE	Evaluation method
Understand the major development phases for mobile communications and development of the associated technology	4	
Understand the impact of new mobile technology	4	
Be able to analyse and evaluate optimal wireless network technologies	4	
Be able to suggest optimal technological solutions for IoT networks	4	
Understand and master optimisation of communication protocols for IoT with respect to energy limitations	4	
Understand and master optimisation of communication protocols with respect to security concerns	4	
Know the main processing techniques used for digital communication and know how to explain the basic structure of digital	4	
Mastering the architecture of an energy management system, simple storage, energy recovery, know how to size the storage el	4	
Security for IoT networks	AE	Evaluation method
Understand the fundamentals of security	4	TP Report
Be able to identify security weaknesses in an IoT architecture	3	TP Report
Be able to assess the impact of exploiting a security vulnerability in an IoT architecture	3	TP Report
Be able to propose adequate security counter-measures	3	TP Report

Figure 2.3: Communication Unit

Manage an innovative project:	AE	Evaluation method
Solve a problem in a creative way	4	
Develop the first stage of innovation	4	
Understand production, validation, distribution, acceptability, and aftermath of innovation	4	
structure and lead an innovative project	4	
Learn teamwork	AE	Evaluation method
Multi-disciplinary students work as a team	4	
Be convincing: present and defend an idea	AE	Evaluation method
express and exchange hypotheses	4	
Suggest a strategy to solve the problem identified	4	
Suggest a model	4	
choose, design and / or justify a protocol or an experimental prototype	4	
self evaluation with portfolio	AE	Evaluation method
Reflect upon my training process and methods	4	report/WEB
Be able to put forward my training experiences, whether they be explicit or implicit	4	report/web
Be self-sufficient and responsible towards my education	4	report/WEB

Figure 2.4: Innovation and humanity Unit

	AE	Evaluation method
Analyse a real-life problem	4	report/presentation
Suggest a technological solution to a problem	4	report/presentation
Implement a prototype to solve the problem	4	prototype
Present and debate (in English) the technical choice made	4	presentation
Produce a report (in English) for the developed project	4	report

Figure 2.5: Innovative project Unit

<u>Service Oriented Architecture</u>	AE	Evaluation method
Know how to define a Service Oriented Architecture	4	Project
Deploy an SOA with web services	4	Project
Deploy and configure an SOA using SOAP	4	Project
Deploy and configure an SOA using REST	4	Project
Integrate a process manager in an SOA	4	Project
Middleware for the Internet of Things	AE	Evaluation method
Know how to situate the main standards for the Internet of Things	4	TP Report
Deploy an architecture compliant to an IoT standard and implement a sensor network	4	TP Report
deploy and configure and IoT architecture using OM2M	4	TP Report
Interact with the different resources of the architecture using REST services	4	TP Report
Integrate a new technology into the deployed architecture	4	TP Report
Adaptability: Cloud and Autonomic Computing	AE	Evaluation method
Understand the concept of cloud computing	3	TP Report
Use a IaaS-type cloud service	3	TP Report
Deploy and adapt a cloud-based platform for IoT	3	TP Report

Figure 2.6: Middleware and Service Unit

Skills	AE	Evaluation method
<u>Introduction to Sensors</u>		
Understand basic notions of sensors, data acquisition: physics, electronics and metrology point of view	4	Exercise of application by project group to be inserted in the portfolio
Be able to manufacture a nano-particles sensor using micro-electronics tools: chemical synthesis, assembly,	4	Cleanroom training
Be able to design the datasheet of the sensor manufactured	4	Datasheet inserted in portfolio
<u>Microcontrollers and Open Source Hardware</u>		
Understand microcontroller archictecture and how to use them	4	Portfolio
Be able to design data acquisition system (sensor, conditioner, microcontroller) with respect to the application	4	Portfolio
Be able to design the electronic circuit of a sensor's signal conditioner (design + simulation)	4	Portfolio
Be able to design a shield to accommodate the gas sensor	4	Portfolio
Be abe to design the sofware to use the gas sensor and its HMI	3	Portfolio
Be able to combine all of the above mentioned components into a smart device	4	Portfolio

Figure 2.7: Smart devices Unit

	AE	Evaluation method
Knowing the main issues in security for IoT	3	report/presentation
Understand the terminology of security	2	report/presentation
Being able to have a critical look at the design of a system from a security point of view	2	report/presentation
Being able to understand a scientific article that explains a weakness or a security solution and to explain it	2	report/presentation

Figure 2.8: Security Unit

2.2.5 apprenticeship

Descriptive

Chapter 3 : Communication

3.1 Energy For Connected Oject

3.1.1 Descriptive

As part of the Innovative Smart System specialization in the 5th year, the course titled Energy for Connected Objects focuses on energy solutions for connected objects (IoT), addressing innovative techniques such as ambient energy harvesting and wireless energy transfer. The objective of this course is to provide students with an in-depth understanding of modern methods for managing and generating energy for connected objects. These systems are crucial in a context where energy autonomy and sustainability are essential for the development of the Internet of Things.

The course is structured with a combination of lectures and practical work. The four theoretical sessions cover topics ranging from electricity generation and storage to ambient energy harvesting techniques (such as light, vibrations, and electromagnetic fields) and advanced wireless energy transfer methods (including near-field and far-field electromagnetic solutions). These concepts help to understand how to power connected objects wirelessly and without batteries, by exploiting available energy sources in the environment.

The two practical sessions allow students to apply these concepts by designing an emulator for connected objects and characterizing an electromagnetic energy harvesting system. Evaluation is based on a group lab report and an in-depth study of energy autonomy options for an innovative project. This study includes exploring battery-free power supply possibilities, paving the way for sustainable IoT projects. Additionally, the course provides a series of academic resources to further knowledge in energy harvesting and wireless transfer, which are essential for developing efficient and environmentally responsible IoT devices.

3.1.2 Technical

The technical dimension of this course focuses on two key areas: ambient energy harvesting and wireless energy transfer, with particular attention to practical aspects and technical challenges in designing energy-autonomous IoT systems.

Ambient Energy Harvesting This technique involves capturing energy from the environment and converting it into electricity to power connected objects. Ambient energy sources include:

- Light: primarily through photovoltaic cells that capture both solar and artificial light.
- Mechanical (kinetic): using electromagnetic, piezoelectric, or electrostatic transducers capable of converting vibrations or motion into electrical energy.
- Thermal: using thermal transducers like thermoelectric devices, which generate electricity from temperature gradients.
- Electromagnetic: using capacitive and inductive transducers to capture ambient electromagnetic fields.

This approach allows for continuous power, although it depends on the proximity of field sources. Each type of energy harvesting presents challenges related to availability, stability, and energy efficiency. Optimization techniques such as using hybrid transducers or transducer networks (series/parallel topologies) can improve the efficiency of energy collection for low-power IoT devices.

Wireless Energy Transfer This field covers methods that enable the transmission of energy without cables, focusing on powering connected objects via dedicated energy sources, which are often more reliable and predictable than ambient sources. The main wireless energy transfer techniques include:

- Optical (light): using lasers or infrared for long-distance transfers, requiring a direct line of sight.
- Acoustic: using ultrasound, especially for specific applications and short-range transfer.
- Electromagnetic: which is divided into near-field transfer (capacitive or inductive coupling, suitable for short distances with high efficiency) and far-field transfer (radio or microwave waves), enabling longer ranges but typically with lower efficiency.

To maximize the energy efficiency of these wireless systems, devices like rectennas (rectifying antennas) are used, converting RF waves into DC current. Optimal rectenna design involves selecting an appropriate frequency, using impedance matching circuits, and carefully configuring the rectifier to minimize losses. Signal modulation techniques, impedance management, and waveform optimization are essential to reduce energy dissipation and meet the power and autonomy requirements of connected objects.

This course provides a technical understanding of energy management solutions for autonomous IoT systems, covering the design of autonomous sensors, reducing energy consumption, and best practices to optimize the efficiency of energy harvesting and transfer devices. These skills are crucial in the development of sustainable IoT applications, ranging from smart homes to industrial sensor networks.

3.2 Analytical

Chapter 4 : Middleware and service

4.1 Cloud and Edge Computing

4.1.1 Descriptive

The Cloud and Edge Computing course, taught by Dr. Sami YANGUI, explores key concepts and technologies related to distributed computing, cloud computing, and edge computing. This course is essential for students specializing in Innovative Smart Systems, as it covers the fundamentals needed to understand how Internet of Things (IoT) systems interact with cloud and edge architectures, thus optimizing data processing and management.

Key concepts include:

Distributed Computing: This approach uses multiple interconnected components to work together in a single environment, with coordinated actions to achieve common goals. These systems help optimize communication and resource sharing within IoT applications.

Cloud Computing: This model relies on access to a vast pool of virtualized resources, available on demand, with a "pay-as-you-go" billing model. The cloud offers great flexibility for IoT infrastructure and applications, reducing operational costs.

Edge Computing: This technique brings data processing closer to the sources, reducing latency and enabling real-time processing. Edge computing is especially relevant for IoT applications requiring high responsiveness, such as predictive maintenance, fleet management, or autonomous navigation systems.

The course also covers virtualization and the role of hypervisors in enabling the simultaneous operation of multiple operating systems on a single physical infrastructure, which is crucial for resource management in cloud and edge environments.

4.1.2 Technical

Technically, the course delves into the architectures needed to set up cloud and edge systems suitable for the constraints of IoT applications. The concept of virtualization is central, particularly with the use of type-1 (bare-metal) and type-2 (hosted) hypervisors, which allow for flexible and efficient resource allocation. These hypervisors also ensure process isolation, reducing the risk of conflicts and optimizing security.

One key technical aspect of the course is cloud federation and the portability of applications between different environments. Through federation, multiple cloud services can collaborate to better manage load spikes. For example, in fleet management applications, a hybrid cloud infrastructure can dynamically distribute tasks between the centralized cloud and edge nodes to ensure continuous availability and low latency.

The practical work allows students to deepen their use of containers (such as with Docker) and cluster management via Kubernetes. As part of the lab project, students set up a hybrid cloud-edge architecture capable of handling the mobility and dynamic availability of edge nodes, simulating events like road accidents or construction sites. The goal is to maintain reliable service throughout a journey by replicating services across the network and migrating services between nodes when necessary.

Finally, the course covers deployment models, such as IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software as a Service), which offer varying levels of control and flexibility. Students learn to choose the appropriate model based on the specific needs of IoT applications, as well as how to design scalable and autonomous services to optimize costs and performance.

4.2 Analytical Part

Voici le contenu de la première section.

4.3 Annexes

CLOUD AND EDGE COMPUTING

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Brunetto Marie
Vasseur Cyril

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE