INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Innovative Smart System

Portfolio

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Part I
Introduction

1 Background

I am Romain Moulin a student at the French National Institute of Applied Science of Toulouse (INSA Toulouse). During my studies, I specialized in computer science and more precisely in the networking and telecommunication pathway. For my 5th and last year, I joined the Innovative Smart System (ISS) class which is opened to students from computer science, electronics or even physics backgrounds. It is focused on Internet of Things (IoT) as this field require specific skills from each three background. I decided to do this as is was in my opinion, a pathway that got some networking which is the field I want to work in and also because I like the idea of being mixed with other students, all having their own skills.

2 Presentation of the Portfolio

As an INSA student, we had the opportunity to follow many different courses on various topics. As this courses are often composed of labs and project, we found interesting to keep a track of all the work accomplished as well as the different skills learnt.

This document is the record of all the different project we did in the ISS program as well as some personal or professional project that are relevant regarding my professional perspectives. It is composed of a brief introduction and presentation of the portfolio. Then in the second part, I will describe and analyse the projects that I did. Finally, in a last part, I will take a step back on all my curriculum and give some feedbacks about the formation as well as my professional perspectives.

NB: This document is part of a github repository that will contain all the reports for the different projects as well as my CV.

Part II

Description and analysis of my projects

1 Table of the projects

Date	Duration	Context	Content
from 15/06/2023 to 22/09/2023	576 hours	Internship at TNO in the Netherlands	Trainee in the network department, Implementation of monitoring functions in a Software Defined Network (SDN)
from 02/10/2023 to 23/10/2023	21,5 hours	Cloud and Edge computing course	Learn and practice about virtualization techniques such as VMs and containers
from 06/10/2023 to 17/11/2023	7,5 hours	5G technologies course	Learn about 5g and more generally topic related to cellular networks
from 03/10/2023 to 12/01/2024	33,5 hours	Service Oriented Architecture course	Learn about legacy and actual architectures service oriented for software engineering
from 09/11/2023 to 20/12/2023	18,25 hours	Wireless Sensor Networks course	Learn about wireless sensor networks technologies
from 12/10/2023 to 24/11/2023	14,75 hours	Middleware for IoT course	Discover communication protocols for IoT
from 16/10/2023 to 26/01/2024	34,5 hours	Security for connected objects	Discussion about need and how to secure protocols for IoT
from 05/10/2023 to 01/02/2024	68,5 hours	Innovative Project	The guideline industrial project of our year
from 30/10/2023 to 03/11/2023	13,75 hours	Lab at AIME	Discover the creation of a sensor

from 20/11/2023 to 21/12/2023	39 hours	Microcontrollers Open-Source Hardware and Sensor Introduction courses	Introduction to microcontrollers programming and implementation of our sensor in a complex circuit
from 20/11/2023 to 12/01/2024	7,5 hours	Low Power Wireless Personal Area Network course	Definition of a TCP/IP protocol stack for a LP-WPAN network
from 08/01/2024 to 23/01/2024	10,5 hours	Energy for Connected Objects course	Introduction to the different methods to power Energy for Connected Objects
from 09/01/2024 to 19/01/2024	15,75 hours	Embedded IA for IoT course	Introduction to the concepts of AI applied to an IoT context
from 09/01/2024 to 31/01/2024	10.5 hours	Emerging Network course	Discovery of emerging network paradigms
from 05/10/2023 to 31/01/2024	6,75 hours	Portfolio course	Redaction of the document you are actually reading

Figure 1: Table with information about all my projects

2 Internship at TNO in the netherlands

2.1 Environment and context

The Netherlands Organisation of applied science research (TNO) is a Dutch research laboratory that has 24 sites in the Netherlands, 1 in Belgium and 1 in Japan. It is composed of 6 mains units :

- Mobility & Built Environment
- Energy & Material Transition
- **Defense, safety & security**
- Healthy living & work
- High Tech Industry
- ICT, Strategy Policy

I was part of the Defense, safety and security. I was assigned to the Softanet Project which objective is to develop the interaction between federal Software Defined Network (SDN) in order to establish end to end slicing allowing us to give guaranties (on the bandwidth, delay and jitter) to the end users.

I chose to do my 4th year summer internship at TNO because I was really interested in having an international working experience to see the differences with a french company. In my opinion, having this vision of the work place in two different countries is really useful for an engineer because it allows discover new way of thinking, working and dealing with problems and in our future work implementing the best from the two worlds to get a better work environment and an optimal efficiency.

2.2 My function

My role in the softanet project was to design and deploy monitoring functions inside a SDN. The challenge here is to know the state of our own network with how much resources are available. Firstly, it would allow an administrator to check that everything is working, to be warned when a link is down ... Secondly, as it is a SDN, we could automatically accept or refuse new connections to the network based on the state of the network.

2.3 Technical solutions

To implement this monitoring functions, I used prometheus which is a software that allows to "scrape" different targets to collect metrics from these targets. I used the snmp exporter as well as the sflow collector exporter and the node exporter that exposes more metrics from the devices for prometheus to scratch. These exporters are network oriented and allowed me to pull new metrics like the actual and max bandwidth of each link, if they are up and other information like the number of packet loss.

As we are in a SDN context, I also used the network controller, here OpenDayLigh (ODL) which is an open source network controller. By making request to the northbound API of the controller, I could get the topology of the network in a JSON file. By parsing the topology and mixing it with the metrics that I got from prometheus, I could construct a graph with the topology of the network and the state of each link. To do that, I used Grafana. It is a software that allows us to construct graphs based on metrics that we provide. It is a relevant solution in my case because it has a prometheus and JSON API plugin that allows me to import the appropriate data sources for my

graph. Finally, my last mission was to deploy all these monitoring functions dynamically through the use of scripting. To do that, I used Ansible which is a scripting software that, by connecting to targets through ssh can manage hosts. That way, I could install and configure automatically all the software needed on the different targets

2.4 Problems faced and solved

During my internship, I faced some problems. The first main challenge was that when I arrived I did not have any experience in monitoring networks. I knew some protocols that I studied in my 4th year communicating systems like SNMP (Simple Network Management Protocol) but this protocol is really limited. To solve this problem, I spent my first month looking online on all the different existing solution to monitor networks. I also had the opportunity to talk a lot to expert in the company that knew some software like prometheus or grafana or sflow so I could find a first track to begin my searches.

For the infrastructure of deployment, I had to use TNO private cloud with Openstack to deploy Virtual Machines (VMs) for implementing my topology. I did not had at that time any knowledge on how cloud worked so I had to learn how to use it efficiently.

2.5 Skills learned

From a technical point of view, I could learn a lot in network by doing my researches but mainly by talking to experts in networks that had a lot of experience in this domain. I learned a lot about monitoring and how to implement it. I also could learn and manipulate some SDN which is a concept that we see in 5ISS. I also could discover scripting deployment with ansible which is something that I really enjoyed doing.

From a personal point of view, this internship helped me to confirm my professional project. Indeed, I am now sure that I want to be a networking engineer as it is something I really enjoyed. I also could develop my English, I had the opportunity to discuss with people from all around the world working at the company which helped me to discover new cultures, way of thinking and way of working which is really enriching.

2.6 Analysis

As mentioned before this experience was very enriching and I could learn a lot in networking. However, for the drawbacks of this internship, I would have liked to be part of a group working on the same subject because it would have gave me the opportunity to interact more with other employees and to fully discover how to work in team in a company.

3 Cloud and Edge Computing

3.1 Context

The first course that I could follow in 5ISS was Cloud and Edge computing, taught by Sami Yangui. The objective of this course is to discover the virtualization techniques used in the industry and in Cloud service providers. I was very interested on this matter as networks are core components of Cloud infrastructures. In addition to that, the Cloud market strongly increased this past year making it one important solution to approach for future engineers. This course is divided in a theoretical and practical parts which is in my opinion the most efficient way to learn about the subject.

3.2 Technical aspects

During this course, we discovered the two main virtualization methods which are containers and virtual machines (VM). The objective for both methods is to provide multiple isolated environments sharing the same hardware. That way you can provide on demand environment to execute code and deploy project but you can also just provide computation power to end users. The way these two method differentiate is by how they are working and their level of isolation.

Containers run over the operating system (OS) of the host machine. They share the kernel with the host machine and make call to that kernel to use their environment. They have the advantages of being very light and easy to deploy as only a small overload is required to deploy a container. However, as they uses the same kernel as the host machine, the kernel of the container deployed should be the same as the one from the operating system of the host. That means that it is not theoretically possible to run a Linux container on a Windows host and vice versa (in practice it can be done through the use of some software like docker desktop on windows). Another disadvantage of containers is that it does not provide a fully isolated environement as the container uses the kernel of the host OS. They are mainly used by developers so that they can run and share code to other user while being sure that they can execute it and that there will not be a problem with the executing environment.

On the other hand VMs consists of installing an hypervisor. They are two types of hypervisor but we will focus here on type 1 as they are more efficient and it is what is used in Cloud infrastructures. Type 1 hypervisor are software that you implement on "bare metal" (directly on the hardware) and that allows to run multiple OS on the same machine. You can allocate parts of the resources of the host machine to the VM. They present different characteristics compared to containers. For the pros, they present a totally isolated environment, that way a compromised VM cannot act on another VM even if it is on the same hardware. It is also possible to install as many OS as you want (and as long as the physical host have resources) on the same hardware. These OS can be totally different, it is possible to deploy Windows and Linux VMs on the same machine. However, for the cons, it is much more heavier than the containers as every VM has its own OS which can be very heavy. This solution is mainly used by cloud provider to propose IaaS (Infrastructure as a Service) where you can pay to have a VM running in their datacenters.

3.3 Practical Work and Difficulties

During our labs we had the opportunity to use OpenStack which is an open source software that creates and manage different VMs. We had a subject where we needed to implement an infrastructure for a client with one calculator service with an entry point that could be used from the public internet and 4 VMs on a private network that would execute some simple actions like addition, multiplication subtraction and division. The main calculator service would have to make call to the other sub service to get the result. It was very interesting labs because in addition to discover Cloud infrastructure and OpenStack we could discover the micro-services architecture.

Some difficulties that we had was about the automatic deployment of the infrastructure with the openstack python client. Indeed, we did not have the documentation on how to use it so we had to look at it ourself and as it is a big documentation, find the relevant part to implement what we want.

The last lab of this course was dealing with Edge computing which is to get the calculation aspect as close as the end device as possible to reduce the delay in the calculation and that way have powerful real time services. It is particularly used in 5G with the concept of slicing where the applications that have the most constraint on delay and jitter have their own slice with calculation power near the devices.

3.4 Skill Matrix

- Understand the concept of cloud computing
- Use a IaaS-type cloud service
- Deploy and adapt a cloud-based platform for IoT with autonomic computing
- Convert a PaaS into an autonomic system

Regarding these skills, I think that they are relevant compared to the content of the course. I feel that I master every skill presented. The theoretical classes made us understand the concepts of cloud computing and for the practical classes we could manipulate Openstack which is a cloud service and we were able to deploy an autonomic system of microservices to implement a calculator. However, even if this course was really good and interesting I do not really feel that we aplied it to the field of IoT.

3.5 Analysis

As mentioned in the context, I was really exited to do this course as I find the subject very interesting and it was in my opinion a great introduction to virtualization and cloud computing. We had the opportunity to work with open source technology with openstack which is something that lacks at INSA and that we should be more sensitized. Indeed Opensource technologies is very important for engineers as it represent the dynamic of sharing knowledge. As INSA has a role in training the engineers of the XXI st century, it should push the usage of Opensource technologies.

However, a drawback of this course is the fact that we do not have any lecture on Kubernetes while it is a very important technology for the course. As we do not have any training and theoretical knowledge on this software, it is hard to follow and fully understand the last lab of the course

4 5G technologies

4.1 Context

The course of 5G technologies is taught by Etienne Sicard. The main objective of this course is to discover a lot of actual topics regarding cellular network. This course was taught using reverse pedagogy which mean that the content of the course was mainly composed of presentation done by students. As the industry of cellular network evolve at a fast pace, it was really interesting to discuss about such a recent and emerging topic. Indeed 5G is a big change in cellular network as it is the first generation to introduce software defined radio (SDR) and microservices. This totally changed the architecture of cellular networks.

4.2 Technical aspects

During this course we could discuss about many varied subject. I had the opportunity to do with Aude Jean-Baptiste another student in ISS a presentation on the 5G core architecture with all the different microservices. They offer much more flexibility as it would be easier for telecom companies to fit the needs of special zone. Indeed as everything in 5G is transitioned to software, they would be able to deploy other microservices to adapt to the charge of the network. For example, in urban zones, it would be possible to deploy a same service multiple time and use a load balancer to increase the capacity of the network.

Another thing that microservices and SDR brings is the ease of evolution. Indeed, switching to a hardwared infratstructure to a more softwared infrastructure is good for evolution as it is a lot cheaper and easier to update a software than to change hardware for future implementation. The idea behind 5G is that we could keep the same hardware infrastructure and deploy update of 5G with only software and even deploy new generations of cellular networks like 6G without needing to change anything.

Finally another thing that 5G brings and which is in my opinion the most important change is the concept of slicing. Before 5G every devices used the same network. However, we have a lot of different categories of devices which have all different needs. Indeed, IoT devices for example generally requires low bandwidth but energy efficiency and massive capacity as a lot of devices need to connect to the network which makes previous cellular network not very well suited for IoT devices. However in 5G technologies, the concept of slice introduces the division of a physical network in logical network which are suited for specific category of devices. We can distinguish 3 different slices. URLLC (Ultra Reliable Low Latency Communication is suited for critical devices that needs guaranties on liability and latency for example connected cars. eMBB (enhanced Mobile BroadBand) is the classical slice dedicated for smartphone users. Finally mMTC (massive Machine Type Communication) is dedicated for sensors and IoT devices.

In this course we also had some presentation about other subjects linked to 5G like satellites, the semiconductor industry or even V2X (Vehicle to Everything). I will not go in detail on these subjects for length reason and because they are only linked to 5G and are not part of the standard.

4.3 Skill Matrix

- Understand and master the new mobile networks technologies

For this course I think that I master the 5G architecture with its microservices. However, I feel that we did not spent enough time talking about 5g hardware and especially SDR (Software Defined Radio) so I cannot say that I master these aspects of 5G technologies.

4.4 Analysis

This course was really interesting as it was linked to actual subjects. However, I do not particularly appreciate courses in reverse pedagogy as I think that we are more focused on our own work which can makes the comprehension of other's presentation harder are we are focused on improving our presentation. I think that a better balance between lecture by the teacher and presentation would be better. In the end, I only have high level knowledge on subjects presented by other while if the teacher would have done lecture on it, we could have dive more deeply in these subjects.

I also thought that for a course called 5G technologies we did not focused enough on the 5G and 6G standards while they are the present and future of cellular network which would be really interesting to focus on especially as these standards diverge a lot from the previous generations of cellular networks.

5 Service Oriented Architecture

5.1 Context

Service Oriented architecture is a course taught by Nawal Guermouche. The objective of this course is to discover legacy and actual architectures for software engineering. The theoretical part of this course is done through a MOOC (Massive Open Online Course) composed of many videos on different topics. As a student coming from a computer science background it is very interesting to know the different standards architecture for software engineering as we are probably going to work in this field.

The practical part of this course is divided in two parts. The first one is an introduction to the three different architectures that we define in part 5.2.

The second part of the labs for this course is a project that goes further into the last and most recent type of software architecture.

5.2 Technical Aspect

The first architecture that we saw during this course is SOAP (Simple Object Access Protocol), a legacy architecture. This protocol allowed to have a simple interface between clients and a server. All the methods and interactions are stored in the WSDL (Web Service Description Level). With this document, a developer could then create an application using a web service by making soap requests to the web service to interact with it even if it use a different programming language.

The second architecture is REST (Representational state transfer). This architecture uses the web protocol HTTP to enable one or many interfaces depending on the need of the service. The REST architecture use 4 different HTTP requests for different uses:

- The POST request is used to create content for the service (for example a new user).
- The GET request is used to get information from the server to the client.
- The PUT request is used to modify content that already exists
- the DELETE request is used to delete content from the service

This architecture is way better than the SOAP one because as it uses HTTP which is a common protocol, it is really easy to use and does not need the consultation of a document to know all the services available. On the server end, unlike SOAP, many services can coexist on the same port as long as they use different URI.

The last and most recent Architecture is the microservices architecture. With this architecture, a service is divided in a lot of little microservices all independents from the others. That way it simplifies a lot the programming for developers as the feature they need to create are very small. To recreate a whole service, we need interactions between all the microservices. To do so we use REST interfaces. A user can make a request to an entry point which will then automatically make requests to other microservices. That way, the architecture is very scalable as it is easy to add or modify a feature with new microservices.

5.3 Skill Matrix

- Understand the related concepts and features of a Service Oriented Architecture
- Develop a distributed architecture using web services
- Deploy and configure an SOA using SOAP
- Deploy and configure an SOA using REST

- Design, develop, and deploy a microservice architecture

For the Service Oriented Architecture course, I think that the majority of skills aimed by the course are relevant except the one regarding SOAP. Indeed, I think that for student we focused on REST and microservices architecture as it is the actual and future software architecture while SOAP is a legacy architecture that is generally not implemented anymore. However, during this course, we approach all the different aspects of SOA and I think that I master every skill in this matrix with the exception of being able to deploy a SOAP architecture, which is in my opinion not very important.

5.4 Analysis

Overall this course is usefull as the REST and microservices architectures are really implemented in the industry and make programming easier. However, I do not think that studying legacy architectures like SOAP is useful as it does not exist anymore, is very heavy and that newer architectures does not take anything from SOAP.

For the theoretical part, I think that the MOOC format can be adequate for this course as we just have to explain the different architectures. However, I think that the MOOC that we followed was too blurry. Indeed, I found it hard to understand the concepts. Maybe a way to clarify these would be to illustrate more the points of the course through examples.

For the practical part of the course, I found the project interesting as it helped us to illustrate the concepts of the course. However, I found unfair that some groups did not have to do this project if their Innovative Project uses services oriented architectures. Indeed, as the Innovative project is the big project of the year, giving more hours dedicated to it depending on the subject is unfair.

In addition to that, for the project of the course, we did not have any course on Continuous Integration and Continuous Deployment (CI/CD) but it was mandatory to implement which made this part harder as we had to look for it ourself online. For the CD part, we did not have any platform to deploy our project which resulted in students having to create accounts on Microsoft Azure or AWS which should not be mandatory in my opinion.

6 Wireless Sensor Networks

6.1 Context

Wireless sensor networks (WSN) is a course taught by Daniela Dragomirescu. The objective is to discover the different solutions for WSN. The theoretical part of this course is divided in two parts. The first one is introduction to telecommunication and definition of the specific needs for WSN. The sencond part of the theoretical part is done in reverse pedagogy. Every group of students had to present an existing WSN technology from the physical layer to the MAC layer. With Aude Jean-Baptiste Onnig Brulez and Marco Ribeiro Badejo, we presented Zigbee which is a WPAN for WSN.

After the theoretical part we had another presentation to do on the different kinds of MAC layers for WSN that exist. This work was individual.

Finally, the last part of this class was a project. In this project, we had to define and implement a protocol for given specifications from the physical to the MAC layer. I did this project with Aude Jean-Baptiste, Emily Holmes, Onnig Brulez, Cyprien Heusse, Arthur Gautheron and Marco Ribeiro Badejo.

6.2 Technical Aspects

This course made me discover the different specifications for existing WSN protocols like Zigbee, Bluetooth ... These protocols have specific needs compared to classical networks. Indeed, WSN generally require low power consumption as the sensors can be placed somewhere it is not possible to charge it. To do this part, the most common solution is to disable the radio communication for some time. It is the inactive or sleeping time. Devices turn off their radio-communications component which is often the most power consuming.

For the second assignment, we had the opportunity to see all different kind of mac layers. There are three main kinds of MAC layer:

- Contention based : Send data when the medium is available (commonly CSMA/CA)
- Scheduled based : Every device get a time slot assigned in which they are the only one to transmit. That way, they have some guaranties on the bandwidth. (TDMA)
- Hybrid: Par of the superframe is Contention based and the other part is Scheduled based (Zigbee for example)

Finally, for our project, the requirements was a medical application for a elderly person with a falling sensor that sends data if the person fall and a gas sensor. During this project we splited the work between members of our group. With Arthur Gautheron and Cyrpien Heusse, we worked on the implementation of the MAC layer. We used python with a ZMQ library (similar to MQTT) for the communication with the physical layer. We developed two different programs, one for the gateway and one for the end devices.

6.3 Skill Matrix

- Be able to analyse and evaluate protocols dedicated to Wireless Sensor Networks / IoT
- Understand and master the optimisation of IoT communication protocols at MAC level

For this course, I think that through the project, I was able to master these skills. Indeed, this course is really focused on being able to analyses and criticize the different technical solutions for a WSN. In addition to that, with my background in networking, I already had a solid base on these concepts.

6.4 Analysis

In my opinion this course is interesting but suffer from a structural problem that I will define in the following paragraphs.

I think that it was more suited for students that does not come from the network background. Indeed, I feel like we already approached the majority of the subjects of this course during our 4th year. For example we saw CSMA/CA last year during the course of Slim Abdelatif on Wifi.

As mentioned in part 4.4 I do not appreciate the reverse pedagogy method as we are more focused on our own presentation rather than getting the information from every group.

I also think that this course is too long and has too much assignments. Indeed for only 1 ECTS, we had two presentations to prepare which took a long time in addition to a big project. I think that this course should be more focused on the project as we did not have enough time for implementing a fully working physical layer. In addition to that, I think that lab in autonomy is just a way to justify that we have enough time for the project without having to assign a teacher to the lab to help when students get stuck which happens a lot. In my opinion, the labs in autonomy should be removed for more sessions with teachers.

Following this point, I think that the second assignment is not really justified as it is just a summary of all the presentation from the first assignment. Moreover, I do not think it is relevant to ask all the student to prepare the exact same presentation on the same topic.

Finally, for the project, I think that it would be useful to have tracks on how to implement the protocol. Indeed, we only had a small presentation on GNU Radio for the physical layer which was not enough to understand how the software works and how to implement a working physical layer. As for the MAC layer we decided to use python and ZMQ because it found that there is a ZMQ block in Gnu Radio but we had to find this on our own and I think that to start a project we should have at least all the keys to do it.

7 Middleware for IoT

7.1 Context

Middleware for IoT is a course taught by Thierry Monteil. The objective is to discover different communication protocols for IoT allowing interactions between different applications. The theoretical part of this course was a MOOC introducing the concepts of the course and the practical part allowed us to use and illustrate the concept approached in the theoretical part.

As the IoT market is very large there is no standard solution for communication between IoT devices. That is the purpose of a middleware. It is a software that allows to interconnect two different applications.

7.2 Technical Aspects

During this course, we talked about the different communication protocols used for IoT. The first one is MQTT (Message Queing Telemetry Transport). MQTT is particularly used for IoT devices. With this protocol there are two kind of nodes, the publisher and the subscribers. Publishers publish data in a topic and subscriber get all the data published on a specific topic. It uses a broker which is a central server storing all the messages. As this concept is really easy to understand and to implement we can find similar protocols used in the industry. One of the example I can think about is Kafka which is a similar protocol with topics, publisher and subscriber designed for IoT real time communication. The difference with MQTT is that it stores the messages over time and use redundancy in different brokers to avoid single point of failure.

The other communication protocol that we saw during this course is OneM2M. It is a protocol developed by different standardisation organizations accros the world. It was designed to propose a standard for interoperability between IoT architectures. It is based on a REST architecture. A server has a hierarchical storing space composed of Application Entities (AE) which represent features available in which there are containers (CNT) which are category of data and Conntent Instance (CI) which is an instance of data published. A IoT device can publish or read an information from a container in an AE.

7.3 Skill Matrix

- Know how to situate the main standards for the Internet of Things
- Deploy an architecture compliant to an IoT standard and implement a sensor network
- Deploy and configure an IoT architecture using OM2M
- Interact with the different resources of the architecture using REST services
- Integrate a new technology into the deployed architecture

As I will mention in the Analysis part, the organization and content of this course really harden the comprehension of this course. With these problems, I do not think that I master any of the skills present in this matrix with the exception of the one about REST services as we saw that in the SOA course. I do not think that I fully understood the OM2M standard as it was poorly explained and illustrated in the course and labs. The only concept of this course that I feel mastering is the MQTT protocol as it is a very simple protocol and that I already saw during my 4th year internship.

7.4 Analysis

As for WSN, I think that the content of this course is really interesting as if answer an important problematic of IoT which is interoperability of IoT device. However, it also faces a lot of problems which leads to difficulties to get all the information from the course.

The first major problem of this course is the MOOC. Indeed, the content and the form of this course present huge problems. For the form, the course is taught by a synthetic voice. It is very dehumanizing and creates the impression for students that the teachers did not involved themselves enough in the course to record their own voice for the lectures. In addition to that, during some part of the lecture a significant part of the video (a third of certain videos) are unlistenable as the encoding of the synthetic voice bugged and prevents us from understanding the content of the course. As mentioned by the teacher, the course is up for about 6 years so this is really a shame that such huge bugs are still present.

For the content of the course, it feels like only a small part is dedicated to middleware and a too large part is dedicated to explaining other concepts that we already saw in other courses. For example, there are videos on SOAP and REST architectures which are the same than the one from SOA. For the content on middleware, we only talk about OneM2M which is supposed to be a important standard but I think that we do not have enough details on how it works. Indeed, after watching the course and to write the technical aspects of this part, I went to the official website of OneM2M and I saw a lot of concepts that I did not understand or some core features that were not approached during the lecture. To conclude, I think that for a better understanding of this course, this MOOC should be done again from scratch with the voice of the different teachers and with a new approach on the content.

A second problem regards the form and the content of the labs. Firstly, we had to install all the software for the labs (MQTT broker, Node-Red, OneM2M server ...) on our personal computers. In my opinion, this is not normal and all the labs of the university should be done (or at least feasible) on the computers of the university. The university should provide us all the resources to work and do the labs and project, which was not the case here. This led to related problems like the fact that we spent a major part of the labs in class to install/debug the software that we needed for the lab. This is time wasted that we did not use on understanding the notions of the course.

For the content of the labs, I think that there were not elaborate enough. Indeed, some part of the subject of the labs were too blurry and we had questions like "create an application using MQTT". I think that for a better understanding of the course, the subject of the labs should have more precise question and better defined.

Finally, I feel like that during the course we should have understand that OneM2M is a better and more complete solution for IoT middleware compared to MQTT which, after talking to other students, we did not really understand why. Indeed, for the labs, we developed an application to interconnect a sensor (a button) and an actuator (a led) and we had to develop the exact same application using OneM2M as if the purpose was to illustrate that it is a better solution. However, it only appeared as a more costly and harder solution that MQTT. A major part of the class did not understand the advantages of OneM2M over MQTT and in which case it would be more interesting to use OneM2M.

8 Security for Connected Objects

8.1 Context

A subject that is often left behind in IoT is security. Indeed, as the main objective of most IoT device is to be efficient while being low power, the security in those devices in often minimal perhaps non existing. As these devices are mainly wireless, they become a perfect targets for hackers. Hacking IoT device can lead to really negative consequences. For example if domestic devices are not secured enough, a hacker could use this vulnerabilities to gain a total access on the house.

In this context, we followed a course entitled Security for Connected Object taught by Eric Alata and Vincent Migliore. This course is an introduction to some software and hardware security targeted specifically for IoT needs. It is composed of theoretical class to explain the concepts behind a certain topic followed by a one or two labs per topic. That way we had the opportunity to see a wide range of topics regarding security.

8.2 Technical Aspects

During this course, we saw a lot of different concepts.

Firstly, we studied vulnerabilities in communication protocols and how to design one. For that we used the proverif with is an online tool that helps to detect vulnerabilities in communication protocols. To do so, you pass different conditions and mathematical expression describing your protocol.

Secondly, we saw the different mechanism for securing web pages. Indeed, a lot of IoT solutions uses web pages to display the data collected by sensors. We saw the danger of SQL injection that can be use retrieve data stored in the database which can be used to retrieve password for admin account. This can also be used to drop every data from the database. To prevent this types of attack, we can run code that parse the SQL request and detect special character that would permit such injections and use backslashes to prevent it. We also saw some attacks to steel the cookie from other legitimate users in order to gain privileges.

These security solutions were mainly software. During the course, we also studied the behaviour of microprocessors pipeline to be able to reverse engineer a microprocessor to understand its properties. We used some functionalities like the prefetching to get the size of a line of cache and the whole size of the cache.

At the end of this course, we also saw the basic concepts of cryptography. We could study some protocols like AES, symetrical and asymetrical cryptography. During the labs we saw the certification process with the generation of the public and private key in order to sign the certificates for servers so that client can be sure that the servers that they try to access are legitimate.

8.3 Skill Matrix

- Understand the fundamentals of security
- Be able to identify security weaknesses in an IoT architecture
- Be able to assess the impact of exploiting a security vulnerability in an IoT architecture
- Be able to propose adequate security counter-measures
- Be able to design secure communication protocols for IoT

This course really made me develop my skills on security. I was able to understand and master the fundamentals concepts of security with the theoretical class as well as the counter-measures and the design of a secure communication protocol. However, as this course is not really focused on the security for IoT networks, I do not think that I master the identification of security weaknesses in an IoT architecture and the impact of exploiting a security vulnerability in an IoT architecture even if I have a good understanding of these concepts.

8.4 Analysis

This course was very interesting. We had the opportunity to see a lot of different part composing the security of IoT devices and more generally web security.

I particularly enjoyed the fact that this course was meant to be an introduction to security and did not aim to makes us specialist about some security aspects. That way, we had the opportunity to discover more topics and develop a wider range of skills. The structure of the course with a lab associated with one or two theoretical class was really interesting in my opinion.

However, I think that this course does not focuses on the concept of security for the IoT field. Indeed, we know that the security in IoT devices is generally neglected in profit of the power efficiency but we did not approached any attacks regarding IoT devices and the concepts were mostly generic. The only part that could apply to IoT devices is on the security of communication protocols but it was still very generic.

9 Innovative Project

9.1 Context

During this year in ISS, we have the opportunity to work all over the semester on an innovative project. We work in groups of 4 or 5 students on a project chosen among several subjects, with some proposed by industrial companies. I worked with Aude Jean-Baptiste, Emily Holmes and Cyprien Heusse on a project proposed by Continental. The project is entitled Advanced Cyclist Assistance System (ACAS). The main objective is to increase cyclist safety as more and more people die on the road.

To do so, we have to both detect a danger for the cyclist and to warn the cyclist of the incoming danger.

For the detection part, it uses a camera placed on the back of the bike, connected to a jetson board which is an embedded system that analyzes the images taken by the camera. A pre-trained IA is responsible to detect the danger. This step of detection has been done by Continental. On our side we are responsible to create the warning system.

For the warning system, we needed to alert the cyclists without perturbing them on the road. To do so, we firstly developed an android application that connects to the jetson board through Wifi in order to get notifications in case of a danger. When it happens, the application display the video in real time of the rear view of the bike with the detected danger circled. That way, the cyclists can see the identified danger without needing to turn themselves. Another system designed to alert the cyclists is a vest that has integrated haptic and bluetooth modules in order for the jetson board to send orders to vibrate to the vest to alert the cyclists.

As some part of this project are confidential, the report is not available on the github repository.

9.2 Technical Aspects

During this project we had the opportunity do develop a lot of different technical skills. As students coming from a computer science and more precisely a network background, I had the opportunity to use my knowledge in networking. Indeed, in order to work efficiently on the jetson, we wanted to use SSH to work with our own machines. To do so, we configured a DHCP server on the jetson that would automatically give us an IP address when we would connect our pc through ethernet.

In addition to that, for this project, we had to chose the communication protocols between the jetson and the phone as well as between the jetson and the vest. With my knowledge and considering the requirements for the project (bandwidth to send video, QoS ...) we decided to use Wifi for the communication between the jetson and the phone and Bluetooth between the jetson and the vest.

Finally, I was responsible to create the android application following a design that Cyprien and Emily did. As I never developed an application neither I ever used native React, which is a Javascript framework, this was very challenging. I had to learn a lot about the the Javascript language and how to integrate video streaming into an application.

9.3 Skill Matrix

- Analyse a real-life problem
- Suggest a technological solution to a problem
- Implement a prototype to solve the problem

- Present and debate (in English) the technical choice made
- Produce a report (in English) for the developed project

For this project, the skills aimed are really well defined. Indeed, as this project was proposed by a company it is a real-life problem that we have to face and analyses. The variety of background and by extension skills in our team ease and make interesting the suggestion and implementation of a whole technical solution for our problem. And finally, as the report and the defense of the project are done in English, this project help us to develop our presentation, debating and writing skills in English. To conclude, I think that through this project I was able to master all the skills present in the matrix.

9.4 Analysis

This project was really enriching and helped us develop a broad variety of new skills.

The first thing that I really appreciated during this project is the fact that we mixed between students from computer science and electronics backgrounds. That way we, could discover how to work in group, how to split tasks and time scheduled when everyone has different skills. This really felt like a more concrete project than anyone that we previously had at INSA.

I also really appreciated the help from Continental. Indeed, it really felt like they were invested in the project as they stayed available and responded to our needs and problems very quickly. They also understood the fact that this is a project done by students with very limited time over the semester and did not expect a fully working, ready to sell product at the end of the project unlike another company that proposed a subject. They only expected a proof of concept with a demonstration at the end which we delivered as well as the next steps that has to be worked on.

10 Lab at AIME

10.1 Context

As ISS is focus on IoT, we use a lot of different sensors. Indeed, to make a smart device and able to take decisions, it first need to analyse its environment. We often uses the final product without realizing how do we make and how much does a single sensor cost. During a week at the AIME (Atelier Interuniversitaire de Micro-nano Électronique), we had the opportunity to create a gas sensor from a simple half made wafer.

10.2 Technical Aspects

This course was mainly focused on chemistry and physics. As it is not my main skills and it is not something that I want to do professionally, I will not develop a lot this course.

As mentioned in the context, this labs were only an introduction to the creation of sensors. We created in parallel, the chemical solution containing nanoparticles that will detect the gas and the wafer on which we applied the chemical solution. After this step, we did a dielectrophoresis to place the nanoparticles on the wafer. A dielectrophoresus is a physical manipulation that consists of applying a electrical field on the wafer while placing the nanoparticles on it in order to stick them between the interdigitated comb. That way, when a gas is detected, the resistance of the sensor drop because the electrical field goes through the nanoparticles instead of the resistance.

10.3 Skill Matrix

- Be able to manufacture a nano-particles sensor using micro-electronics tools: chemical synthesis, assembly, testing

As I do not come from a physical or chemist background. I cannot say that I master the conception and manufacturing of a nano-particle sensor but I can say that through this course I was able to have a better understanding of the different concepts.

10.4 Analysis

This course was really interesting as it helped us realize all the process that hides behind the creation of sensors. The instructions were really clear and beginner friendly which made these labs a good introduction to the world of physics and chemistry. The teachers were pedagogue and helped us to understand every processes of the synthesis and creation of the wafer.

However, this course suffered from coordination problem between the ISS teachers and the ones from the physical department which resulted on these labs being placed during the holidays which hardened the understanding of the concepts.

11 Microcontrollers Open Source Hardware (MOSH) and Sensor Introduction

11.1 Context

After the week of labs at AIME to create a gas sensor, we had another course with the physical department on how to implement it in a bigger circuit with microcontrollers to collect and analysis its data. The objective of these courses were to create a datasheet for our sensor and to implement it with a microcontroller to create an application using a LoRa network able to display the results collected by the sensor.

11.2 Technical Aspects

As I come from a network and computer science background I will focus on the high level of this course (creation of the application and microcontroller programming) and not treat the hardware part (creation of a PCB and circuit for the integration of the gas sensor).

To begin our project, we first tried to connect an arduino to the Lora network. To do so, we used a RN2483 chip made by Microship which is a module that is able to communicate on a Lora network. As this chip only has tiny connectors, we needed to weld the component to a board that would have bigger connectors for the communication with the arduino.

After this step, we were able to connect our arduino to the INSA's Lora network. For this, we used The Things Network library for arduino. For this, we had used the otaa authentication method. We got the device ID using the library and the application ID and key on the chirpstack website.

With the established connection, we had to send data to the gateway in order to retrieve it and display it on a dashboard. As a first implementation of this application we connected an already made gas sensor which is the MQ-3B gas sensor to our arduino.

After that we changed our arduino code to read the value from the gas sensor and send it to our LoRa network. As the max value we can get from the sensor is 1024, we encoded the information on 2 bytes before sending it.

As the data is received by the LoRa network, we could visualize it on the chirpstack web page. However, it is not fited for a real usage of our gas sensor. A user of gas sensor would like to see the state of the sensor in real time in a dashboard. To do so, we decided to use node-red and MQTT.

MQTT is a communication protocol particularly used for IoT devices. With this protocol there are two kind of nodes, the publisher and the subscribers. Publishers publish data in a topic and subscriber get all the data published on a specific topic. This protocol is supported by chirpstack which automatically upload the data it receives in a MQTT topic.

Node-red is a web-browser flow editor that helps to easily connect flows. It provides visual coding with blocks for the ease of conception. It also implements dashboard library to display the data is user friendly dahsboards. We used a MQTT subscribe block to get the data from chirpstack that we pipe into a javascript function that decodes the data (it is encoded in base64 by chirpstack). Finally we send the decoded data to a dashboard block to visualize the data.

To test our sensor, we putted hydroalcoholic gel near it to see if we could see it on our dashboard. This experience was a succes and we were able to see through the dashboard the increase of the gas rate near the sensor.

During this course, we had also a small introduction on Open Source and free licenses explaining the difference between both and giving us some example of licenses like the creative commons licenses.

11.3 Skill Matrix

- Understand microcontroller archictecture and how to use them
- Be able to design data acquisition system (sensor, conditioner, microcontroller) with respect to the application
- Be able to design a shield to accommodate the gas sensor
- Be abe to design the sofware to use the gas sensor and its HMI
- Be able to combine all of the above mentioned components into a smart device
- Understand basic notions of sensors, data acquisition: physics, electronics and metrology point of view
- Be able to design the datasheet of the sensor manufactured
- Be able to design the electronic circuit of a sensor's signal conditioner (design + simulation)

As I do not come from a electronics or physics background, I do not have solid bases in the design of an electronic circuit or embedded programming. However this course was a good introduction to these concepts and it helped me understand these concepts. However, I cannot say that I master the skills mentioned in the matrix but I developed basic knowledge and a general point of view on how the design part of an electronic circuit is done in the industry.

11.4 Analysis

This course was really interesting as it used a lot of diverse skills from different background but everything was accessible for everybody. This really push forwards the skills of every students and favors the collaboration between group of student which come from different background. That way, I liked the fact that we had the opportunity to keep working with the sensor that we made during the lab at AIME, creating a PCB and a electrical circuit for it which is something that I never did before.

However, one drawback of this course is that all the labs were condensed into two weeks which represent a lot of hours on the same subject in a very short time. I think we would have better understood the concepts of this course if the labs were a little bit more spread in time.

I also really enjoyed the part of the course on licenses which is something that we never approached during our scholarship at INSA. We had the opportunity to understand what stands behind the term Open Source and what is a difference with a free license.

12 Low Power Wireless Personal Area Network (LP-WPAN)

12.1 Context

Low Power Wireless Personal Area Network (LP-WPAN) is taught by Slim Abdelatif. It is a very short course composed only of lectures. The objective of this course is to discover a specific TCP/IP protocol stack for LP-WPAN. With the training of ISS centered on IoT, it is very interesting to see an example of implementation a sensor network protocol stack.

12.2 Technical Aspects

As this course is very short, we did not have a lot of time to see a wide range of different technical skills. In addition to that a first part of this course was dedicated to explain basic concepts about network and telecommunication like the concept of a scrambled network (interference).

During this course, we saw an example of TCP/IP protocol stack for LP-WPAN. This stack used the 802.15.4 norm which is a norm for MAC and physical layer. It is notably used in protocols like Zigbee. Over this layer we use IPv6 with a intermediate layer to reduce the size of a packet which is 6LoWPAN.

12.3 Skill Matrix

We were not provided the skill matrix for this course, so I would try to analyses the skills that I could developed. This course was in my opinion an extension of the WSN course in the way that the same subjects are approached but using a different point of view. This course gave us a good example of a TCP/IP stack for a LP-WPAN. One of the main skill was to understand the benefits and cons of using standards protocol based on IP. Another important skill that we developed during this course was understanding how to integrate IPv6 in a low power use case with 6LOWPAN. Through the theoretical classes that we had during this course and with my networking background, I think that I was able to master the different skills that were aimed by this course.

12.4 Analysis

This course was really interesting as it explains different technical choices for protocols in a LP-WPAN context. However this course was really short and most of the lectures were dedicated to explaining network and telecommunication concepts that we, as students from networking background, already saw. In the end, this course was more targeted for student from computer science, electronics and physics background.

During this course, there was a lot of overlaps with the WSN course. Indeed, the teacher presented the IEEE 802.15.4 norm which is a norm that we already presented with Zigbee in the first assignment for WSN. I think it is unfortunate to have redundant information on a course that is so short.

However, during this course I really appreciated the fact that the teacher explained his own visions on how to implement a wireless solution for LP wireless protocols. Indeed, during the WSN course, the teacher defended the fact that it is better for LP protocols to design ourselves a protocol that specificaly fit our needs. During the LP-WPAN class the teacher said that even if he knew the other positions from the other teachers at INSA, he thought that it was easier to use an already existing stack based on IP for integration purposes.

Without taking position on who is wright and who is wrong, I found really interesting to have diverging opinions ton the same topic from the teacher as I makes us think by ourselves on the

argument and not taking what a teacher says as absolute truth. It made us develop our critical mind which is really important for engineers.

13 Energy for Connected Objects

13.1 Context

Energy for Connected Object is a course taught by Gaël Loubet. This course is an introduction to how to power an embedded devices. During this course we saw the 3 different methods on how to power a device as well as all the different kind of energy that we can harvest in an embedded system. It was composed of few theoretical classes followed by two labs on turning on a LED through wireless transferred power.

13.2 Technical Aspects

During this course we saw the different methods to power an embedded system as well as the different energy sources available to harvest or to use for wireless power transfer.

There are three different method to power an embedded system. The first and easiest one is to power directly the device. To do so we put a battery in the embedded system from which the device can take power when it needs it. The major pro for this method is the ease of implementation and decide on the dimensions. Indeed, putting a battery is very easy and it allows to plan precisely the interval of transmission and the lifetime of the device as long as we can define the consumption of the embedded device. The major cons is that we need to charge or change the battery of the device regularly which can be difficult in some cases (device in the concrete for example).

We can also use this method without needing a battery by using wireless power transfer which is named direct consumption. This remove the cons of the lifetime of the device but create another one which is that we need an external energy source that power the device. As the yield of that kind of system is rarely 1, then overall we lose some energy.With this method we do not store any exceeding energy.

The second method is to only use energy harvesting to power the system by storing the collected energy until it reaches enough energy to power the device. It can harvest the energy present in the environment but also the energy from a wireless power transfer source. The pros and cons of this method are the opposite of the first one. Indeed, this method can lead to a longer lifetime for the devices but is harder to define the interval of transmission and it can also be harder to implement than simply putting a battery.

The last method is a mix of both methods which is to directly power the device. With that method, we power the device directly by harvesting the ambient energy or by using a wireless power transfer source but we store the exceeding energy in order to use it when there is not enough energy to directly power the device. To illustrate this methods we can take the example of a device powered by solar power during the day and that uses the stored exceeding energy during the night.

There are a lot of different energy in the environment that we can use to power a device. We can use electromagnetic fields, mechanical energy (wind turbines for example), solar energy, thermal energy (using the difference of temperature). To power a device we can also use primary and secondary batteries.

13.3 Skill Matrix

- Know how to harvest/transfer, store and manage power for connected objects, and how to increase the power efficiency
- Be able to optimize the power consumption of connected objects
- Be able to design and implement an energy autonomous and battery-free connected object

Through this course, I could understand all the concepts of choosing and optimizing the power management for an IoT device. As we saw all different kinds of powering methods and energy sources, I think that I master the skill of knowing how to harvest/transfer, store and manage power for connected objects. As I do not have a strong background in electronics or physics, I do no think that I master the optimization of power consumption and design of a battery free connected object but I definitively understood the basic concepts.

13.4 Analysis

When I started this course I did not really enjoyed it as it was something that has nothing to do with my professional goal to become a network engineer. However, in the end, I really appreciated this course and could learn a lot from it. Indeed, this course was really well defined to only be an introduction to the concepts of powering an embedded device. Only few physics or electronic background was required and it was very enjoyable to follow. Through this good organization I could really get the knowledge and skills that the teacher wanted to taught through this course.

However, for the negative part, I think that the labs were a bit chaotic as nothing seemed to be working as intended. Overall, we could see the point of the lab and get through the manipulations but I think that it suffers from technical problems with the PCB done at INSA. As it is only the first year that these PCB were made, it is perfectly understandable that it has some problems.

14 Embedded AI for IoT

14.1 Context

Embedded IA for IoT is a course taught my Philippe Leleux. In this course we approached the fundamental concepts of AI in an IoT context. We saw the theoretical concepts during the lecture then we applied and analysed an implementation of AI for an IoT application. The specification of this little project was to detect the fall of elderly person for a retirement home. The objective was to design and give the guidelines on how to create and train an AI for embedded bracelet. You can find the results of our work with Aude Jean-Baptiste in the form of a python notebook.

14.2 Technical Aspects

As it is the major part of AI that we studied, we will focus on Machine learning with Neural Network (NN) Before applying an AI o an IoT context, we first need to understand the concept of AI. To work properly, an AI need to be trained, to do so, there are three different kind of training. Here we only will focus on supervised training which is the only type of training that we saw in details. To do this kind of training, you provide to the NN some data associated with the expected outputs. That way, the NN can train by changing its weights. By doing that on a large number of example we train the AI. After that we can provide new example without label and the AI return a value that it guesses based on its weight and the input.

As an AI can be really heavy, it is hard to implement it directly on an embedded device that has limited computation power. To be able to port the AI to the embedded device, we need to reduce its size. To do so we apply what is called pruning. It consists of deleting the weights in the NN that are not really relevant on the choice of the output (small weights compared to others on the same perceptron). That way, we can easily delete 80% of the weights without degrading much the accuracy of the AI. In some case it can even increase the accuracy as it prevent overfitting (the AI was too trained and does not guess correctly the results).

In the end, to optimize the implementation of the AI on the device, we can transform it in a tensorflow lite model that will use an interpreter to run the AI. By pruning our mode and using an optimized interpreter for our hardware we can put an AI on an embedded system with limited resources.

14.3 Skill Matrix

We were not provided the skill matrix for this course, so I would try to analyses the skills that I could developed. As a student from computer science background, we already saw the basic concepts of IA, however, here these concepts are adapted and applied for an IoT context. The theoretical and especially the practical classes of this course helped me mastered the concepts of AI for an IoT context with pruning and adapting the AI to an embedded system with an optimized interpreter. With the labs of this course, we also could develop the conception of an AI based on the specifications of a particular problem.

14.4 Analysis

This course was really interesting and was I my opinion pertinent for our class. Indeed, a lot of IoT application use AI when they do not seem compatible. AI often consumes a lot of resources while embedded device only have limited resources.

I also appreciated that this course made us question about the relevance of implementing an AI. Is it necessary? and if yes what kind of model? What kind of training? How do we optimize

it? This kind of reflection is interesting has AI become really popular and we start to see some implemented everywhere even if it not particularly necessary.

15 Emerging Networks

15.1 Context

Emerging networks is a course taught by Slim Abdelatif. It is a short course of only few hours about new paradigms for networks. We discover this paradigms during the theoretical class and have the opportunity to manipulate Software Defined Network (SDN) during practical courses.

Unfortunately, as all the labs are placed after the deadline of the portfolio report, I will not be able to talk about it in this part which shorten a lot the content of this part.

15.2 Technical Aspects

In this course, we studied the new network paradigms. The first one that we studied in detail is SDN. In this paradigm we remove all intelligence from the network devices (switches and routers) and centralize it in a single point which is the network controller. The objective behind this decision is for a network administrator to be able to take decisions and pilot the network by interacting with the network controller using classical programming. It also allows to handle packet more precisely and implementing behaviour of the network on demand and not being dependant of the functionalities proposed by the device manufacturer.

The other paradigm that we saw is the Locator/Identifier Separation Protocol (LISP) protocol it consists of attributing two IP address to a device. One used for the localisation and the other to identify uniquely the device. This allows mobility of node as only one address change and not the other. That way, to contact another node, we use the identifier node that never change, after that a protocol similar to DNS is ran to find the localisation address to reach the node.

However this is only possible if the edge router of the network is compatible with the LISP protocol as it is this one that will execute the translation.

15.3 Skill Matrix

- Understand and master the fundamentals of emerging network paradigms applied to IoT

As a student coming from a networking background, I already had solid bases on the concepts that were approached in this course. Indeed, we saw the SDN paradigm during my 4th year internship at TNO as well as the Master REOC that I will talk about in the section of this part. As for LISP, we already saw similar concepts during the 4th year course of IPv6 that can handle the mobility of nodes. So I easily mastered the fundamental concept that were approached during this course.

15.4 Analysis

As a student coming from a networking background I really appreciate this course because it deals with what I think is the future of networking. Indeed, I think that the flexibility that offers SDN will allow network administrator to implement the functionalities that they want. In a general way, I think that every field tend to softwarization due to its flexibility. To illustrate this point I can take the example of the 5G standard that has SDR (Software Defined Radio) as well as microservices for its core architecture.

However, in the case of ISS, I do not really see the point of approaching these subjects as SDN is more suited for core networks and not really for IoT networks. This is a point that the teacher talked about multiple times during the lecture. LISP can be interesting for IoT as device in this context can be mobile.

16 Portfolio

16.1 Context

During our last year at INSA we had to write a Portfolio, gathering all the projects, skills that we developed during this year as well as an analysis of these different experience. As this document is part of the project and reports that we have to do during this year, it seems normal that it has its own part in the portfolio in order for me to present the skills that it made me learn as well as the critics that I have regarding this document.

16.2 Technical Aspects

Through the redaction of this document, I had the opportunity to reinforce communication skills that I already developed with other personal and academical experiences. As you probably noticed, this document is wrote in English. This is at the same time the main difficulty, as we are not native English speaker, and a great opportunity to develop our mastery of the language. Indeed, I had the opportunity, notably with my internship this summer in an English speaking company, to write reports in English but this portfolio is by far the longest document I had to write in another language than French.

As many other courses during this year, this document helped me to develop other soft skills like for example my writing skills. Indeed, for this kind of long document and spread across time, it is important to be able to summarize our thoughts to only deliver relevant information and to avoid going in too many directions.

16.3 Skill Matrix

- Reflect on my training process and methods
- Be able to put forward my training experiences, whether explicit or implicit
- Be self-sufficient and responsible for my training

As I will mention in the analysis part of this course, I really do not see the point of this course and I have the same feeling for the skills present in the skill matrix. Indeed, I think that some of these skills are too vague. As this course is done 100% in autonomy, I do not think that it develop any skill except our writing, presentation and English skills. We also develop our ability to summarize as we need to talk about at least everything we did during this semester. The only skill present in the matrix that I find relevant and that I mastered is the reflection on my training process and methods. The two other skills are too vague especially being self-sufficient and responsible for my training.

16.4 Analysis

In my opinion, this course suffers from a lot of contradiction and does not answer to any need for student. Indeed, this course is presented as a way to summarize all our projects of the year, to illustrate the fact that we have various skills and, in the end help, for recruitment processes as it can be send to recruiters. However, for the argument of helping with recruitment processes, firstly, we cannot finish it before the end of the semester because we did not finish every courses but at that time a huge majority of the class would already have an internship. Secondly, even if we did have finish this document in time, after talking to other students in the class, everyone agreed with the fact that we would not send this document to a recruiter because: it is way too long and that nobody would ever read it. This is due to the fact that we are forced to discuss about topics that we do not want to talk about. Indeed, we have to talk about every course of this year even the ones

that do not have anything to do with our professional project.

The other argument for this course is that it illustrate the fact that we have various skills which is true. However the problem is that this document is way too long and takes too much time and energy to finish. It is very frustrating for students to spend the major part of their year writing a document that only you, the teachers, would ever read. It is without exaggerating, the project that took most of my personal time, that I would have preferred spending on other technical projects. As only teachers from INSA read this document it feels like its only purpose is to do some feedback about the year which is what I chose to do when writing this document.

To conclude on this course, I think that at the very least, it should be changed to be shorten by a lot but from a personal point of view I think that it should totally be removed from the curriculum.

17 Master REOC

17.1 Context

In parallel of my last semester at INSA, I decided to do a Master of Network and Telecommunication in partnership between INSA and ENSEEIHT. For this Master, we had additional courses on the Thursdays afternoon either at INSA or at ENSEEIHT. It was composed of theoretical courses as well as practical course with a small project on the INSA's side. At the end there also was an exam summering all the courses that we attended.

17.2 Technical Aspects

During this master we had a lot of different courses on various subjects. In this part, I decided to focus on a course that I found really interesting. This course was taught at INSA by Samir Medjiah and dealt with SDN (Software Defined Network) and MANO (Management and Orchestration).

SDN is a technology that allows developers to create applications to manage the network. To do so, we centralize the intelligence of the network in one single point which is the network controller. That way, all the network devices like switches and routers receive instructions on how to handle packets. This technology allows a lot of flexibility. For example during a lab on SDN, we developed an application to redirect the trafic from a server to another server in a totally transparent way for the client. To do so, we modify the destination address of the packet from the client to redirect to another server. To do it in a totally transparent way for the end user, we also have to change the source address of the answer from the server to the address of the server that the client wanted to contact originally. That way, the client thought it was interacting with one server when in reality, the answer came from another server. The flexibility offered by SDN make it a very powerful tool for network administrators.

The other concept that we saw during this course is MANO. It is a standardized protocol to deploy and orchestrate network functions. A network function is a function that is originally done by a dedicated hardware component like a firewall for example, that was transform into a software that can run on different generic machine. MANO is really useful because it allows to deploy and destroy network functions dynamically and automatically depending on the state and the need of the network. For example, if a network use a firewall at the entrance on the network but this firewall start to receive more traffic that it can handles, then with MANO we can deploy another firewall and a load balancer to divide the load of the network between the two firewalls.

These two technical solutions become very powerful and interesting when deployed together. To illustrate this point we will take an example. Let's imagine a network with a videoconferencing between two client on opposite edge of the network. If the resources available in the network decrease, then it would degrade the quality of the communication. To avoid that, we can develop an application that will detect the lack of resources on the network and deploy with MANO and encoding on one edge and a decoding function on datacenters on the other edge of the network. To use this functions, we can reroute the traffic with the SDN Controller to force the traffic to go through this two function in a transparent way for the users of the communication. That way, we reduce the resources needed on the network for the communication and avoid the degradation of the quality, all that without the need of a human intervention.

17.3 Analysis

As a student coming from a network background (4IR-SC) I found this master really interesting as it dealt with topics of networking that we did not saw like MANO, SDN or avionics networks. I

had the opportunity to learn a lot of different skills on various subjects. Unfortunately, due to difficulties to match time schedule between INSA and ENSEEIHT students, we missed a some course on subjects that seemed interesting like the modelization of a LoRa Network or the P4 protocol.

During the different course, I also noticed a difference of approach between the courses taught at INSA and the ones taught at ENSEEIHT. Indeed, I got the impression that the courses at INSA were more applied where the ones from ENSEEIHT were more theoretical and oriented on research. Indeed, a lot of teachers at ENSEEIHT gave us scientific papers that they wrote while at INSA we focused on some general concepts like virtualization, SDN and MANO with a small project to illustrate the courses. Because of that, I enjoyed more the course given at INSA as I prefer to approach the different notion through applied exercises and projects.

Part III
Conclusion

1 Summary of my year in ISS

This last year in ISS was very disappointing for me. Indeed, I do not feel like I learnt a lot of new concepts during the year or at least concepts related to my professional perspectives of being a network engineer. Indeed, as all the courses needs to be accessible for everyone, we already saw most of the content of the courses related to computer science or networking. As for other courses, I learnt few things on electronics, physics and chemistry but even there, not as much as I would have imagined.

As I already illustrated it in my analysis of the different courses, I think that this pathway suffers a lot from organizational problems that make some courses redundant or not pleasant to follow.

As a positive thing that I get from this year, I could meet a lot of different students from different background that I really appreciated discussing with and discovering their fields of expertise. I also think that with all the different subject that we saw, we have a much more broader view of every things that comes with the creation of sensors and the concept of IoT in general.

Another positive point about ISS is that it gave me the opportunity to do an additional master specialized in Networking and Telecommunications which is something that is very valuable for my CV and helped me develop my knowledge regarding networks.

To conclude, I think that if I had to do again my choice of pathway for my 5th year, I would not have chose ISS and would have go in SDBD with the minor SDCI (networking). That class seems more suited for me as I would have studied much more networking which is really important for me as I want to work in that field.