



Study and development of a mesh network of environmental sensors

Reflectie

Bachelor in Elektronica-ICT
keuzerichting Internet of Things

Lian Aarts

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Campus Geel, Kleinhoefstraat 4, BE-2440 Geel

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1 INTRODUCTION

The Université de Bordeaux is the largest university campus in Europe and welcomes 56 000 students every day. Thanks to the Erasmus program I had the opportunity to travel to Bordeaux and do my internship at the informatics department of the Université de Bordeaux.

This project aims to study, implement and deploy a network of environmental sensors (e.g. temperature, humidity) covering all the rooms of the *Department Informatique* building. The final purpose of the project is to be able to perform statistics on these environmental data but also to send some alerts in case of an anomaly (e.g. rapid drop in temperature).

Because of the size of the building, it is impossible to set up a centralized solution as is the case for most home automation systems. Moreover, the Wi-Fi infrastructure provided by the university cannot be used due to security reasons. Therefore, we are interested in the implementation of an autonomous mesh network.

The proposed approach will be to deploy each sensor with an ESP32 that can manage such a mesh network. For the data collection, visualization, and alert systems, we propose to set up a small Linux server running on top of an intelligent home software like Home Assistant.

The project consists of the following stages:

- A global study of both hardware & software.
- Demonstration of a mesh network of ESP32s.
- Study and choice of an environmental sensor.
- Study, installation, and configuration of a smart home server.
- Integration of the smart home server into the mesh network.

I will be working alongside my classmate Jeroen Weber who also came to Bordeaux. All the realizations in this document are made by me unless specified otherwise.

The Erasmus program doesn't only provide great educational programs but also the ability to discover new cultures and experiences. Bordeaux is the perfect city to interact with other local and international students. Communicating in other languages, adapting to a different working environment, or meeting new people are all important experiences I had.

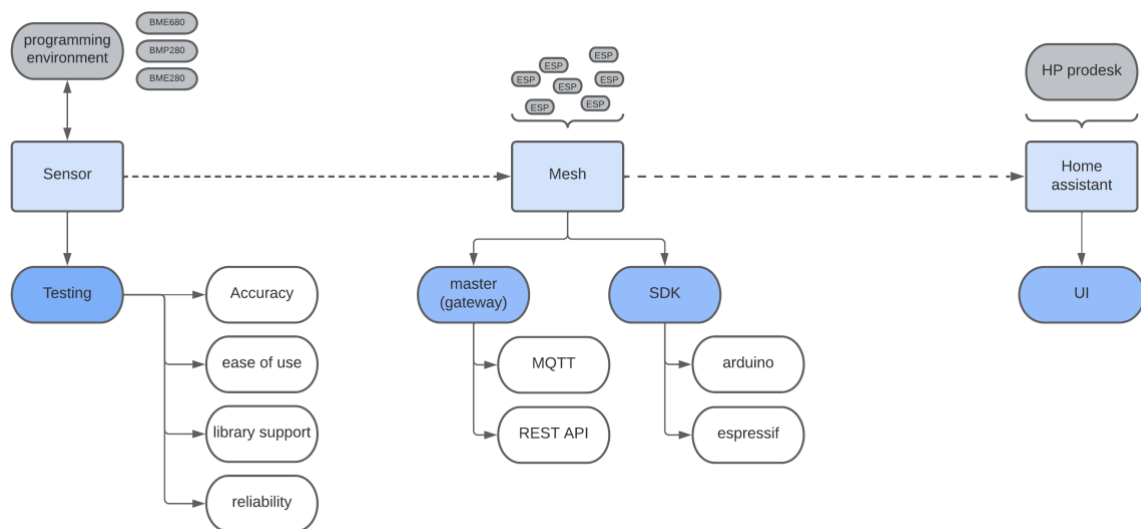
Vincent Autefage was our mentor during our internship. He is teaching at the Université de Bordeaux one day a week while also working at a private company. He is experienced in leading a research and development department.

2 REALIZATION

During the COVID-19 pandemic, air quality became very relevant. Based on the air quality we can decide when it is a good time to ventilate a room. With a pending law that would require all educational institutes to install air quality sensors in every classroom, our project was formed. With the deployment of the mesh network the university would be able to conform to this law in a costly manner. All the sensor data is visualized and available to anyone who needs this information.

The mesh network needs to be scalable so it can be used in case of future expansions. Documentation of the project would allow other students or interns to expand this even further. Even students with little to no knowledge of electronics need to be able to set up everything by only using our documentation.

The project was divided into three main parts. Every part needed to be researched and developed. Both hardware and software considerations had to be made. A sensor had to be selected. The mesh network had to be set up with the ESP32s and Home Assistant had to be installed on the desktop computer.



2.1 Sensor

For the monitoring of the environment, we needed a way to capture data. Three sensors were ordered by our internship coordinator. It was important we could make an educated decision. We connected all the sensors to the ESP32 and started reading the data through the I²C bus. We collected data over an extended period, so we had a representative comparison. A research document was made where we defend our decision.

2.2 Mesh

After Jeroen was struggling with the code of the mesh network I decided to take a different approach. The root node needs to be selected very carefully because we need a good connection to the Home Assistant server. My algorithm for selecting a root node appeared to be working well enough for our application. The research and development of the sensor node was the most time-consuming and critical part of the project. We expanded and improved on this code throughout our internship. I was fully responsible for both the software and hardware of the mesh network.

It was important that the nodes can be set up easily. When the node is powered on for the first time the node can be configured through an access point created by the ESP. This configuration will be saved in the EEPROM so it is not lost after a power cycle.

The code is fully [documented using Doxygen](#). Doxygen translates comments written in a specific format into a webpage that describes every class or function.

2.3 Home Assistant

Home Assistant would allow us to collect the data and visualize everything. Home Assistant can be installed in a few different ways. We used a basic install but soon realized we needed more control over the operating system. We decided to install Home Assistant on a regular operating system instead of using the Home Assistant OS. The installation of Home Assistant was not as straightforward as we thought. The installation we used is not recommended because of that. The WiFi card of the computer is used as an access point so the root node of the mesh network can send information to Home Assistant.

2.4 PCB and enclosure

We wanted to get as close to a finished product as possible. We decided to design a PCB. The PCB is fully SMD soldered and includes a UART adapter, battery management system (BMS), and IO for the operation of the node.



The enclosure is designed in Fusion 360. I based the measurements on the drawing of the PCB. It was 3D-printed. The assembly is fully toolless. The holes in the case allow for adequate airflow so we can ensure accurate measurements.



2.5 Result

When we combine these three elements it is possible to easily deploy a network of sensors without needing existing infrastructure. Home Assistant can be used to monitor the classrooms of the building. With the additions Jeroen made we can send notifications and manage the root network from Home Assistant.

Our large-scale experiment proved that we could use this network in practice. Because this project was classified as research and development this will not be deployed in this state. There is more testing and finishing needed to be able to industrialize this project.

2.6 My experience

The project was very educational and interesting. We were allowed to work with a lot of freedom. We could choose the technologies ourselves as long as we had good reasoning. We got challenged with a lot of good questions in our meetings. The large focus on security was also challenging. We had a weekly meeting where we discussed all our progress and set goals for the following week. We used an internal project & task management system. The agile methods of working allowed us to quickly change the functionality of certain parts.

This was my first experience with a lot of the technologies like mesh or Doxygen. This was also the first time designing a full SMD PCB. Debugging the PCB was very tedious and difficult but also very learn full.

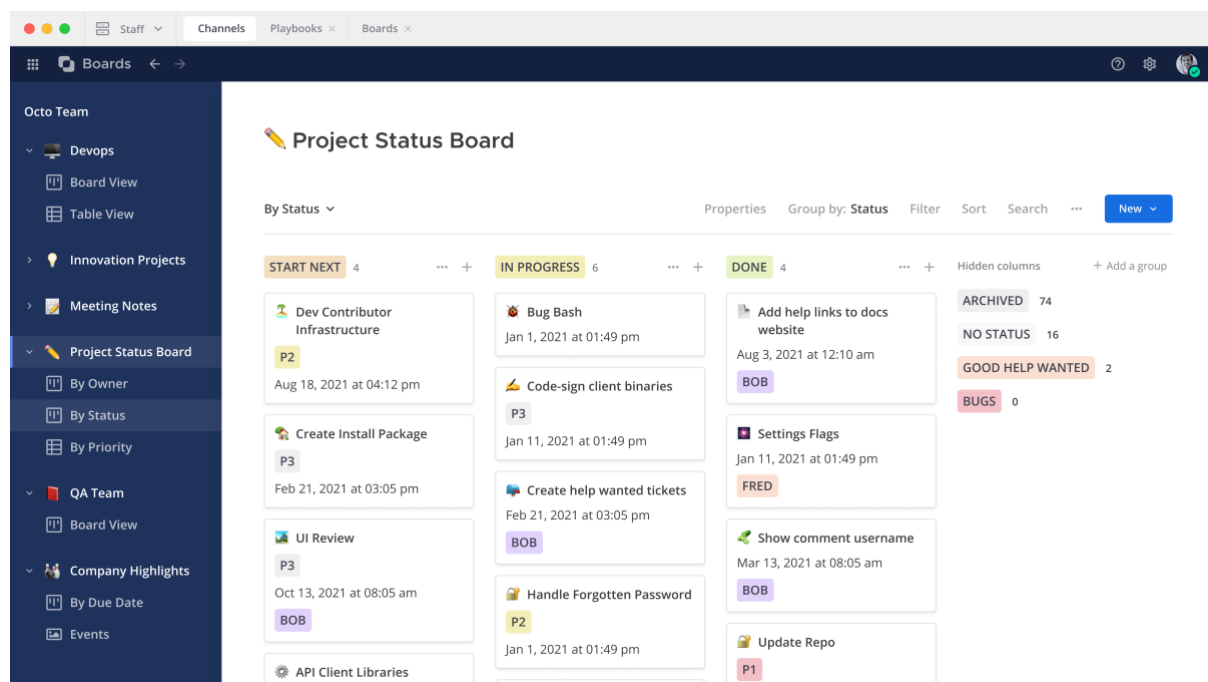
3 PERSONAL REFLECTION

The international experience certainly added a significant portion to the experience. The communication was better than expected. There were little to no misunderstandings between us and our mentor. During our meetings, we used English to make sure everyone understood everything. Our informal and personal conversations were often conducted in French.

The cooperation between Jeroen and myself was also essential. We worked on different parts of the project that eventually had to work in harmony. Setting clear guidelines and standards was very helpful. Getting a second perspective on some problems was also very insightful.

Because of a cyber-attack in the school on the 9th of May, we have not been able to access our task management system or our repository. We had no internet access in our Vlan so we have been unable to update Home Assistant. The internal communication tool that we have been using was also not accessible. We finished our internship in this state. We have managed to work around almost all our problems by using alternative tools.

Changing our goals and functionality was something that I learned very quickly. After our meetings, there were always some new points to research and improve. Setting priorities was also very important, we did not always have time to tackle every task. Our project board helped us finish a task quickly and efficiently.



Bordeaux is a great place to discover new experiences and cultures. The French way of life did take some getting used to. Everyone was very hospitable and helpful.