VRIJE
UNIVERSITEIT
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BACHELOR'S THESIS

mid-term report

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ENGINEERING SCIENCES

Chapter 1

About this project

This project is part of a bachelor-thesis in engineering sciences [ELO-ICT]. The main purpose of this thesis is to map the sound intensity or sound pollution from different areas into an application.

The numerous nodes will capture sound. Then because we are using LoRa we can't send too much data it is important that the processing is done by the nodes. Finally the nodes will send what they calculated to the gateway which in turn will send it to the cloud.

From the cloud the data can be pulled and displayed in a visual manner onto the application.

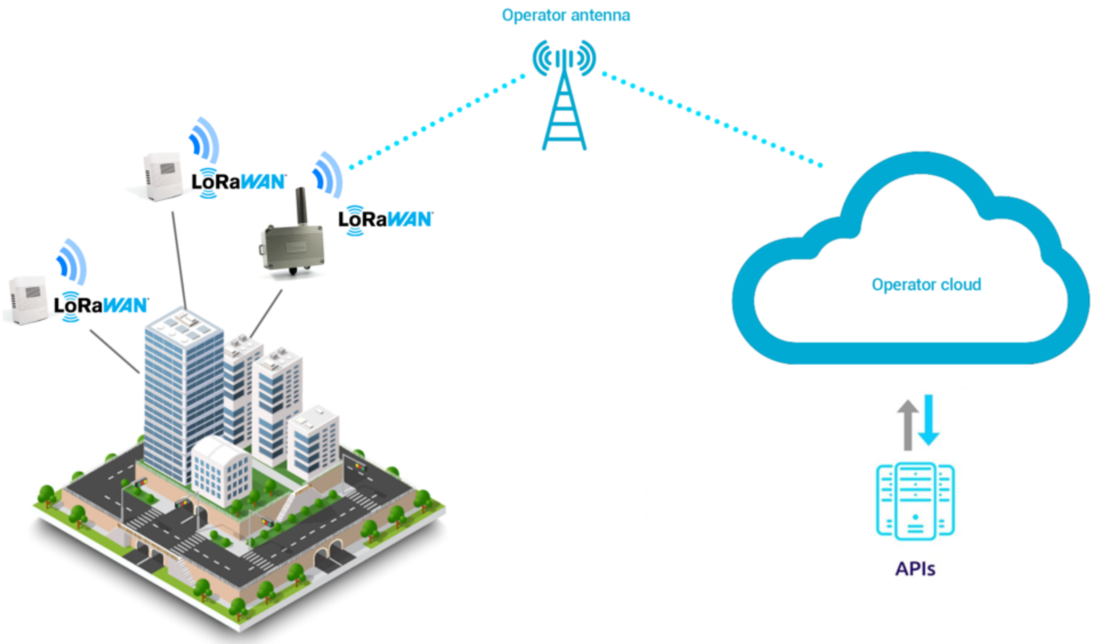

Figure 1.1: Visual representation of our project

Different kinds of technologies will be used in this project.

- KiCad to design our embedded-systems [Nodes]
- LoRa and IP for data transmission
- MicroPython to program the embedded-systems
- a Linux VM as our network- and application server

Current state of the project

2.1 Planning

2.1.1 What have we done ?

The first semester of the academic year 2021 was meant to research and become comfortable with new tools according to our planning. We had to research how to implement such an IoT Network and how sound must be captured.

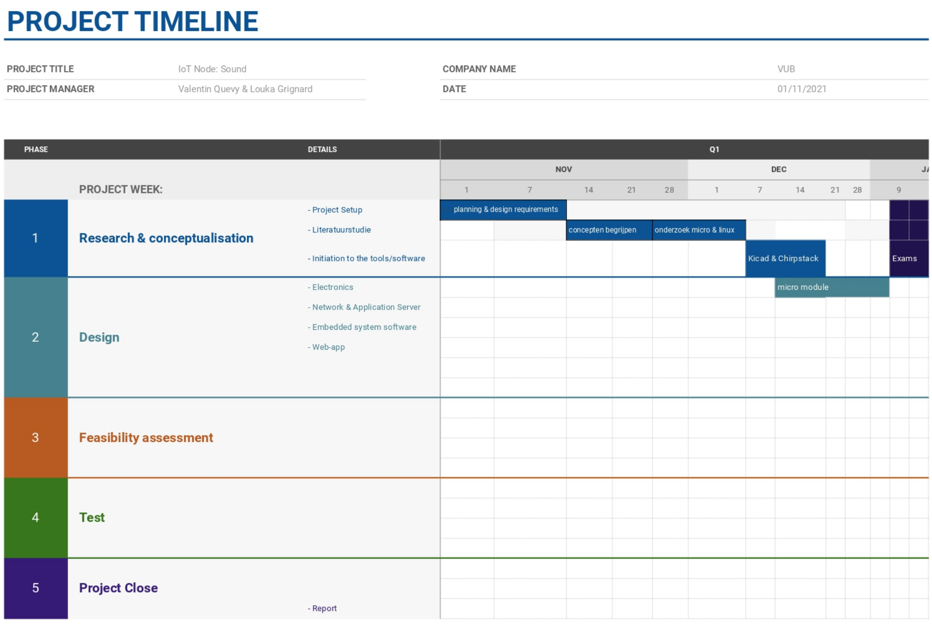

Figure 2.1: Project timeline

During the research we discovered new tools like Kicad & Chirpstack and learned using them. For the hardware part we designed our micro-module, we still have to purchase the micro and print the pcb.

For the server part we had to learn more about the LoRa communication technology before implementing a gateway. The next step would be to try sending information via our gateway to the Network server.

2.1.2 What are the next steps ?

We followed the planning for the most part in terms of research. We still have to print our pcb of our micro-module before testing & calibrating it with a wave-generator. For the server part we received the needed material mid-december. We will have to test our gate-way & server connection with chirp stack in order to implement nodes in the network.

In order to finish this project during the first sitting we will have a big workload during the second semester. The minimum for finishing this project would be to have at least one node communicating the sound measurements to our gateaway and displaying it on a web-site. We estimate a rate of succes of 65% for finishing this project on time.

The next steps we will take are mentioned in the planning : design, feasibility assesment, test and project close.

During february-march we are going to create the Network server with chirpstack on a Virtual Machine running Linux with Ubuntu as distribution. The micro-module will be printed and tested with our pycom microcontroller board. Then we will program our microcontroller to calculate the Fast Fourrier Transform of the signal and send it via LoRa to our gateaway.

The next deadlines are:

- micro module printed & tested - mid February
- setup chirpstack server network - mid February
- gateaway connection to server network - end February
- python script for sound measurement - mid March
- node implementation in the network - end March
- node shield (battery, antenna, micro) - end March
- website draft - begin April

If we spend enough time and collect the needed material on time we will be able to meet the deadlines. We still have to purchase the MEMS-micro.

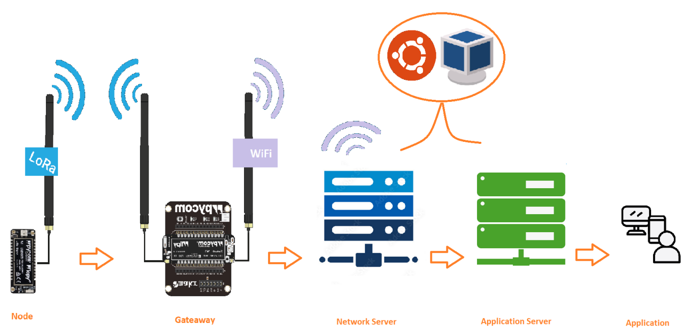

Figure 2.2: Network

Chapter 3

Documentation

We have made a literature study containing all the research we have done. Below you will find a summary of our most important finds for our project.

3.1 Literature Study

3.1.1 What is LoRa

LoRa is a wireless technology that offers long-range, low-power, and secure small packet data transmission for IoT applications. LoRa is based on chirp spread spectrum modulation, which has low power characteristics and can be used for long-range communications. These are some important specifications to know:

- standard: LoRaWAN R1.0
- frequency band: 868MHz (Europe)
- data rate: 0.3–50 Kb/s
- transmission range: <30 km
- energy consumption: very low (mA)

3.1.2 Project material requirements

3.1.2.1 Node

Every node will contain a LoPy4. This module is responisble for all the calculations and the LoRa communication.

All LoPy4 will have an antenna connected to them with the connecter that is part of the board.

We will also have to design a LoPy4 shield to be able to connect our microphone pcb to receive the data. this shield will also contain a fuse and maybe some LEDs to be able to easily see what is going on.

The microphone will be on its own PCB with a JST connector to the LoPy4 shield.

Lastly the node will contain a battery to power everything.

3.1.2.2 Gateway

Our gateway will exist out of a PyGate shield with a GPY development board and an antenna.

3.1.3 Hardware

3.1.3.1 Development board

For our development board we have chosen the LoPy4. There are several reasons it is better then the competition. Below you find a comparison with the raspberry pi pico.

Table 3.1: Comparision development boards

	LoPy4	Raspberry pi pico
Price	40€	5€
current active	± 100mA	± 100mA
current sleep	1µA	1mA
clockspeed	160MHz	133MHz
flash memory	4MB	2MB
RAM	8MB RAM	256kb sRAM

As you can see the LoPy4 is even or better in all aspects. This is logical if you look at the price. We can justify this price by looking at 1 aspect in particular: current sleep. The LoPy4 uses 1000 times less current while asleep then the raspberry pi pico. Since the goal of our project is to enable the node every couple of minutes to take a measurement, process it and send it the current used while asleep will have a big impact on the time 1 battery can sustain a node.

3.1.3.2 Gateway

As a gateway we have chosen for PyGate by pycom. For this we could also look at different gateways from different companies but seeing as this is from the same company as our development board we will use this gateway. Products from the same manufacturer will often work better together. The Pygate is a low-cost 8-channel LoRaWAN gateway that comes in the shape of a shield.

3.1.3.3 Microphone

One of the most important components in our project is the microphone. There are 2 things to look at. First we have to chose the type of microphone we will be using. We can choose between ECM en MEM microphones.

MEM's has several advantages over ECM.

- newer technology
- smaller
- cheaper
- relativly low output impedance
- digital versions are good in electrically noisy environments and high vibration environments
- can be reflow soldered
- wider operating temperature range
- less sensitive to tempature change

All of these facts combined made us choose to go with a MEM's microphone. But this isn't the end. MEM's come in both analog and digital.

Analog has:

– lesser pins
– smaller package

But digital has:

– digital MEMS support multiple power modes.
– easier to interface with
– more resistant to noise because it only has 2 states
– can be further from the system because it can handle a lot more noise

We decided to go with digital. It might be more expensive but it is much easier to work with and wont need any other components to convert the analog data so it might even come out cheaper in the end.

With all of this in mind we went to digiKey to find a microphone. The first thing we checked where the filters. these included multiple things we didn't understand so we started researching these terms. The most important terms are:

– **noise floor:** " The noise floor makes it harder or easier for wireless protocols to detect a signal. It's kind of like the ambient noise at a party making it difficult to hear the person next to you. If the noise around your conversation is too loud (or high) then you won't be able to make out the words (signal) that your friend is saying to you. However, if the noise around is suddenly quieter and the noise level much lower, then you can make out your friend's words much easier even if they are speaking at the same volume." From this we can conclude a low noise floor is better.
– **dynamic range:** "For a sound or a signal, its dynamic range is the difference between the loudest and quietest portions." the human ear has a dynamic range of 90dB. it goes from 30dB to 120dB. Since we will be mapping noise in cities its important to have to same range as the human ear.
– **frequency range:** Just like the dynamic range there is a frequency range the human ear can hear. its goes from 20Hz to 20 000Hz. For the same reasons as dynamic range we want to find a microphone with that range.

We applied the following filters:

– MEMS(silicon and Piëzo)
– frequency range must be between 20Hz and 20kHz
– omnidirectional mic(pics up sound from all sides)
– digital

After applying these filters 10 microphones remained from which only 2 were still in a decent stock. The first microphone cost 1,21€ and used PDM to communicate. The second microphone cost 2,27€ and used I2S.

We decided to go with the second one since we already worked with I2S. From some research we knew PDM needed a decimater to lower the sample rate before being able to process it so just like analog vs digital we choose to pay a higher price for 1 component then spread the cost over multiple cheaper components which could end up being more expensive and is also more difficult to design. We ended up with the DMM-4026-B-I2S-R.

3.2 CAD schematic and PCB

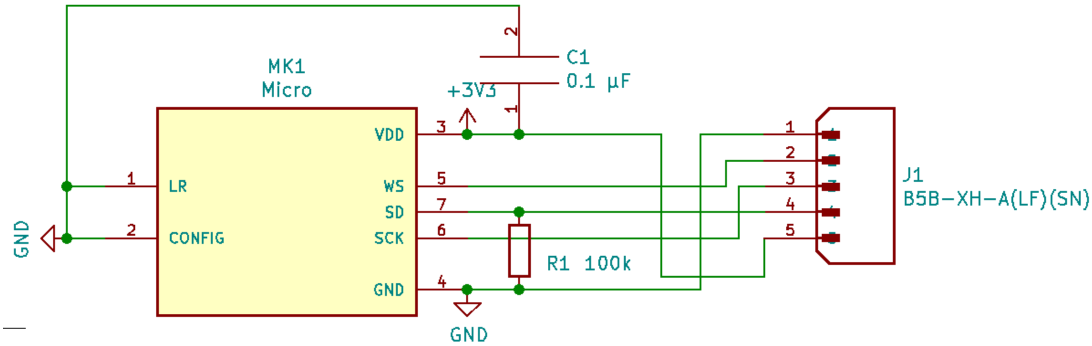

Figure 3.1: microphone PCB schematic

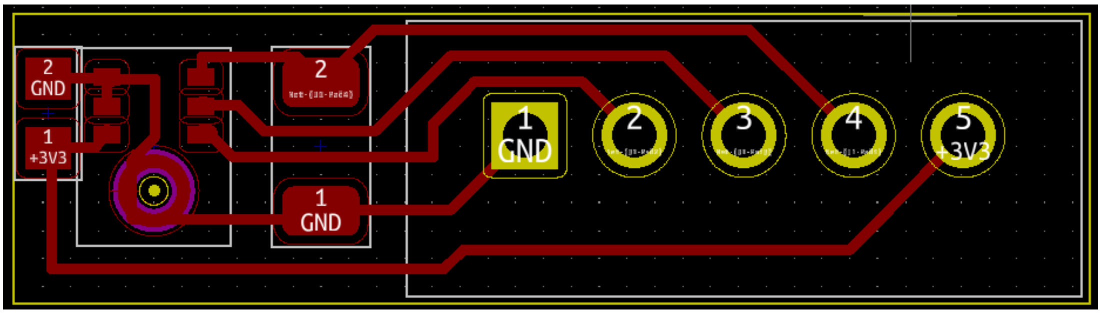

Figure 3.2: microphone PCB 2D model

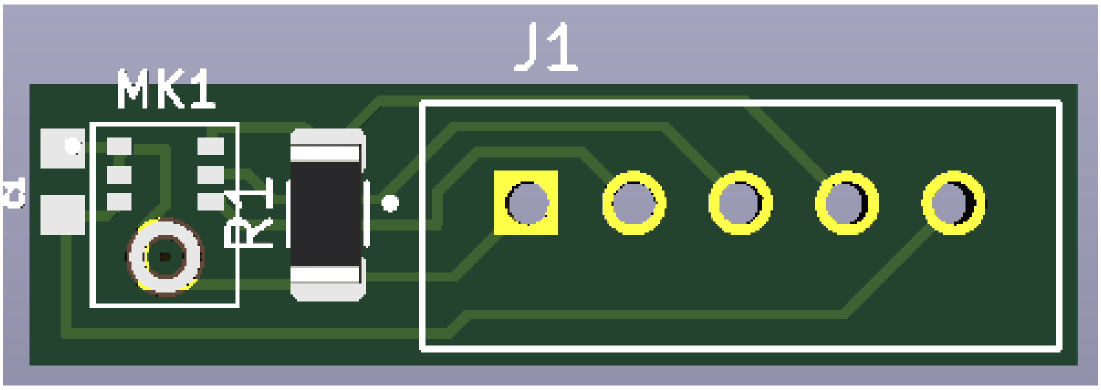

Figure 3.3: microphone PCB 3D model

3.3 To do

When we finished the report we send it to our promoter to ask for feedback. He asked us if the LoPy4 support the I2S communication protocol the microphone uses. At first we thought it did because that is what they advertise on their site but when we looked at the data sheet there was nothing to be found about I2S. This made us question what we should believe. After having looked at the pin out of the LoPy4 we couldn't find a way to work with I2S.

This is a big problem because it means we have to restart a part of the project. We will either need to find a converter from I2S to something the LoPy4 understands or we could also change to an analog mic. Changing to analog means we will have to do further research what extra components analog signals need. Since this will be quiet some work we decided to leave it for the start of the next semester since exams will be starting soon.

To do:

- be sure the LoPy4 doesn't understand I2S
- Find I2S converter to something the LoPy4 understands
- see what extra components an analog mic needs
- find what communication protocol analog mic needs
- compare prices and how big the PCB will get
- use the facts to decide on what new direction we will go in

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