Project Planning Report

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17 March 2023

Contents

1 Aims and Objectives

The aim of this project is to develop an Internet of Things (IoT) system to regularly monitor the health of the Griffith footbridge through three dimensional vibration analysis. The high level system of this project comprises of three sensor nodes placed across the length of the footbridge that transmit packets over the LoRaWAN protocol. These packets are received by a gateway placed at the end of the bridge and are uploaded to The Things Network (TNN) cloud for data processing. Arduino MKR 1300 and 1310 boards will be used as the carrier boards for these sensor nodes. Figure 1 shows the high level hardware diagram for this IoT system.

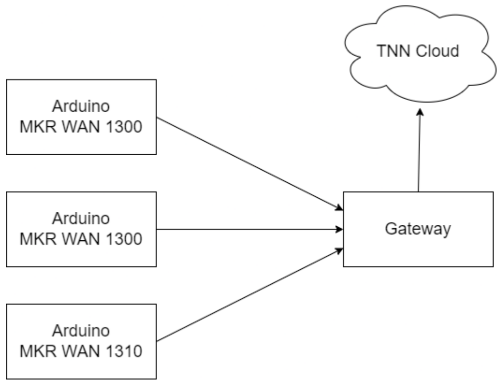

Figure 1: High Level Hardware Diagram

Each sensor node will include an accelerometer to detect, log and transmit movement in three dimensions (x, y and z axis). This data is sent to the on-board processor of the Arduino carrier board where it is logged. The average movement on each axis as averaged and sent via data packet over LoRaWAN via a dipole antenna every hour. The carrier board itself is powered with a simple solar panel / battery setup. The pro gateway is listening for packets on the LoRa network via a mono-pole antenna. These packets are then sent to the on board Raspberry Pi 3 model B+ processor. The processor transmits these packets to the TNN cloud. This more detailed system can be seen in figure 2.

Figure 3 displays the higher level software diagram for the transceiver and receiver. One of the major aims of the project will be to further explore this software design which is heavily dependent on the functional requirements of the system. The functional requirements of the system will dictate the packet size and transmission frequency. Additionally, different types of windowing techniques for the Fast Fourier Transform will be explored to remove noise from accelerometer analog inputs.

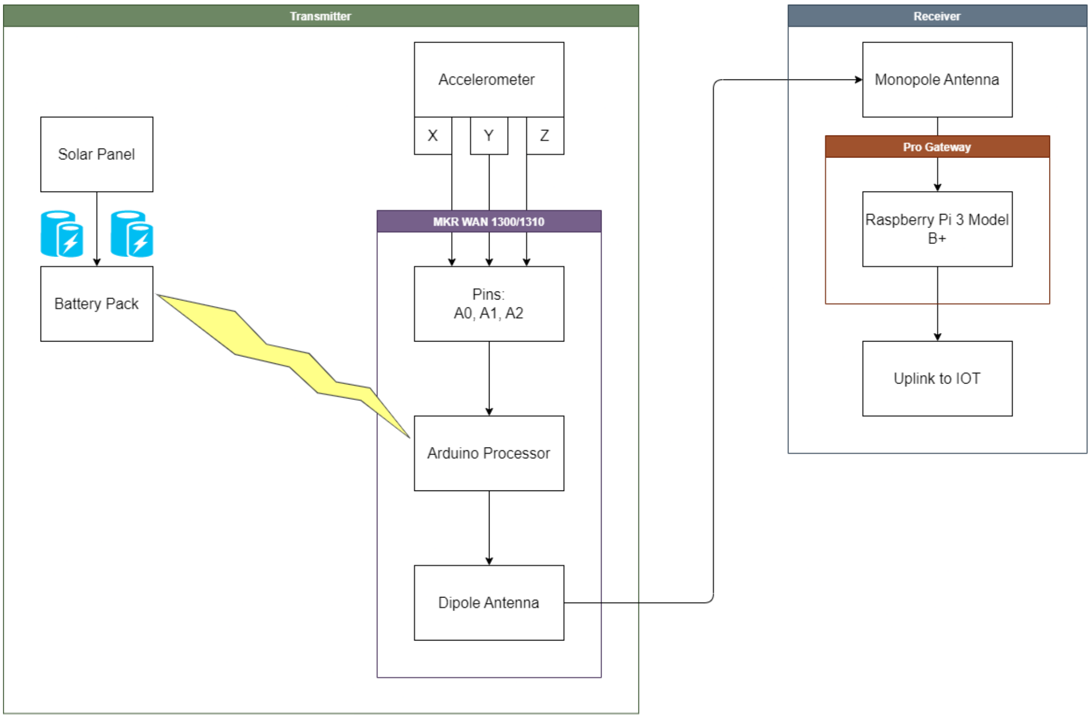

Figure 2: Detailed High Level Hardware Diagram

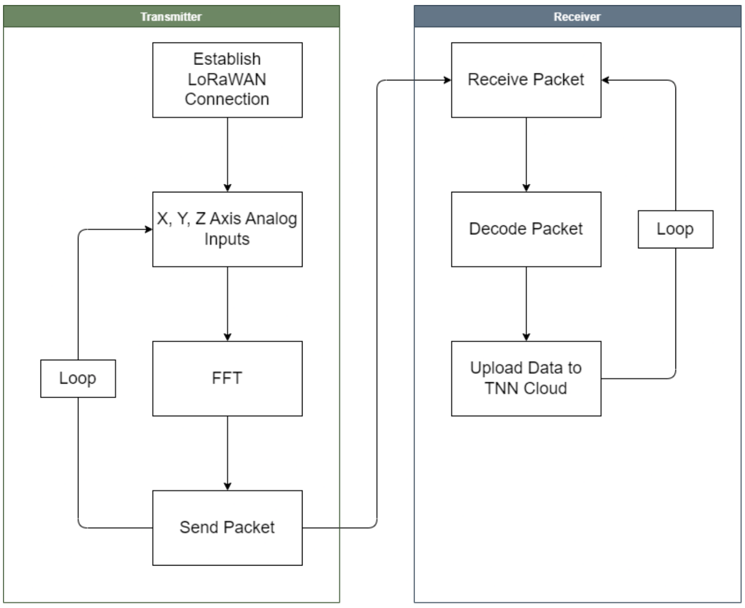

Figure 3: High Level Software Diagram

1.1 Funtional and Non-Functional Requirements

The funcional and non-functional requirements in table 1 form the basis of the measurable objectives that need to be met. Meeting these defined objectives will satisfy the aims of this project.

Requirement	**Status**	**Description**	**Verification Method**
[FR-1] The transmitter and receiver shall communicate at a frequency of 925MHz	Draft	The frequency band for LoRaWAN in Australia is 915-930MHz so the IoT network must operate within this range	This requirement can be verified through integration testing and observing packet transmition via test application
[FR-2] The gateway shall receive packets from a distance of up to approximately 600m	Draft	LoRa communication is advertised to operate within multiple kilometers but the system will only need to operate approximately up to 600m	The range of the system can be verified through integration testing by noting the distance at which packet loss occurs
[FR-3] The receiver shall receive packets and distinguish between at least three sensor nodes	Draft	The IoT system requires at least three sensor nodes to be placed along the bridge. It is therefore required that each transmitted packet contains an identifier	The identification of transmitted packets can be identified trough integration testing and observing packet transmission via a test application
[FR-4] The sensor nodes shall be powered by solar energy such that the nodes can transmit 24/7	Draft	The nodes need to transmit packets every hour 24/7 and hence require a solar battery system capable of supporting always-on low powered devices	The current draw from the sensor nodes can be measured and the appropriate power supply can be calculated. Otherwise field testing will be required to examine how long the sensor nodes can operate for

[FR-5] Each sensor node shall include an accelerometer to record analog input on the x, y and z axis	Draft	The accelerometers will measure the bridge's vibration. This data will be converted into digital data using Fourier transform techniques and encoded into packets	The accelerometers will be tested in the mechanical engineering lab with a vibrating beam setup
[NFR-1] The sensor nodes shall be resistant to overheating and rain	Draft	The sensor nodes will be exposed on the bridge and will therefore have to survive hot temperatures and rainfall	The enclosure will be designed with weather proofing in mind and will undergo laboratory environmental testing
[NFR-2] The sensor nodes shall contain temperature and humidity sensors and transmit this data	Draft	Temperature and humidity data will be useful to spot any discrepancies in the data due to external environment and will be useful to field test the thermal resistance of the device enclosure. The data from these sensors will be included in the transmitted packets along with the vibration data	The operational capabilities of these sensors can be examined in a lab. The functional capabilities of these sensors will need to be tested in the field

Table 1: Functional and Non-Functional Requirements

2 Expected Project Outcomes

This project involves multiple outcomes that are confined within the scope of the project. The first outcome to meet is a proof of concept that satisfies the high level hardware and software diagrams. This will initially be completed with one sensor node and will achieve the objective of creating a functional IoT system in a closed loop environment. The next outcome to meet is introducing three sensor nodes into the system and writing the software to distinguish between each node's packets. To complete the closed loop testing the nodes will be placed on a test beam set up in the mechanical engineering labs that simulates vibration. Once the closed loop testing has been completed, the permanent implementation of the device will commence. This involves a solar-battery system sufficient of powering the low-powered devices at all times. Theoretical calculations and quantitative testing will be conducted to determine the power drain characteristics of these sensor nodes. Finally, an enclosure will be modeled and printed to house the electronics and power systems and will be used to mount the devices to the bridge. These enclosures also serve the purpose of weather-proofing the sensor nodes. The final outcome is to have a functional IoT system over the length of the Griffith footbridge that is capable of transmitting packets 24/7 to a gateway that will be placed up to 600m away.

3 Methodology And Project Schedule

3.1 Project Methodology

This project is fundamentally a design project and so the design will heavily depend on the system functional and non-functional requirements as defined in table 1. These requirements will be verified through experimental analysis using both the mechanical and electrical engineering laboratories, and the Griffith footbridge. The experimental verification methods include integration testing, environmental testing and field testing. The testing methods required to validate each requirement is also defined in table 1. Additional to these requirements, closed loop testing will provide experimental analysis to verify that the accelerometers, temperature sensors, ADC conversion, packet transmission and retrieval meet the design requirements of the system. Testing will also be conducted on the designed enclosure to ensure the system is sufficiently weather proofed against heat and rain.

3.2 Tasks and Schedule

Figure 4 displays the rough timeline for the completion of this project. This timeline also includes professional practice deadlines.

3.3 Resources

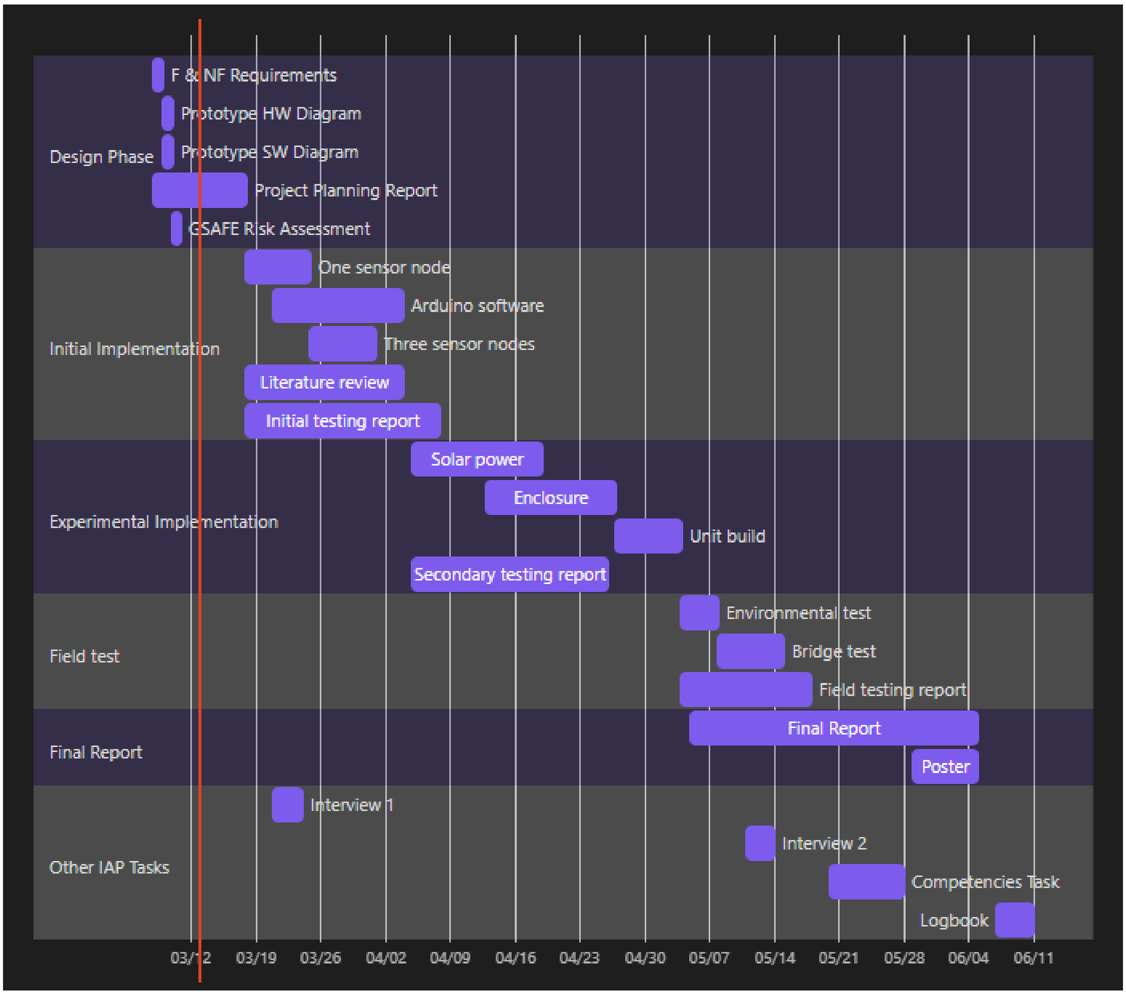

Figure 4: Project Timeline Gantt Chart

4 Risk Assessment

4.1 Risk Assessment Risk Matrix

	Consequences				
Likelihood	**Catastrophic (Cat)**	**Major (Maj)**	**Moderate (Mod)**	**Minor (Min)**	**Insignificant (Ins)**
Almost Certain (AC)	**Very High (VH)**	**Very High (VH)**	**High (H)**	**Medium (M)**	**Very Low (VL)**
Likely (L)	**Very High (VH)**	**High (H)**	**Medium (M)**	**Low (L)**	**Very Low (VL)**
Possible (P)	**High (H)**	**High (H)**	**Medium (M)**	**Low (L)**	**Very Low (VL)**
Unlikely (U)	**Medium (M)**	**Medium (M)**	**Low (L)**	**Very Low (VL)**	**Very Low (VL)**
Rare (R)	**Low (L)**	**Low (L)**	**Low (L)**	**Very Low (VL)**	**Very Low (VL)**

Table 2: Risk Assessment Matrix

Risk Level	What should I do?
Extreme	Eliminate from activities
High	Eliminate from activities
Medium	Specific monitoring or procedures required, management responsibility must be specified
Low	Manage through routine procedures. Unlikely to need specific application of resources

Table 3: Risk Level Management

4.2 Identified Risks

In table 4, (C) are consequences, (L) is likelihood and (LvL) is the level of risk.

What could cause harm?	What could go wrong?	C	L	LvL	What controls are required?
Actively handling sensitive electronics	Risk of destroying components with ESD	Ins	R	VL	Wear ESD wristband when handling sensitive electronics.
Soldering electronic connections	Burns and inhalation of solder fumes	I	R	VL	Safety glasses and gloves. Extractor fans / ventilation.
Placing equipment on a tall footbridge over a busy highway	Dropping equipment onto the traffic below and causing an accident	M	U	VL	Bridge has protective railing. Design a lightweight system and gain supervisor approval before field implementation.
Vibrating beam experiment	Crushing or physical injury	I	R	VL	Wear enclosed footwear. Ensure surroundings are clear. Keep distance whilst experiment is running.

Table 4: Identified Risks

5 Ethics Issues Related to the Project

6 References