

**Deakin University**

Aquaponics Manager

Project Proposal

Project Sponsor

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Project Team

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# Document Revision History

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Date** | **Version** | **Editor** | **Reason** | **Supervisor Signature** | **Client Signature** |
| 28/08/2021 | 1.1 | Louis da Silva | Provide project “Motivation / Project Description”, “Context” and “Value Proposition” |  |  |
| 29/8/2021 | 1.2 | John f | Added core ideas and target deliverables. |  |  |
| 29/8/2021 | 1.3 | Daniel Brett | Modified the Sprint 1 and Sprint 2 Goals and Deliverables. |  |  |
| 29/8/2021 | 1.5 | Yiannis D | Provided Limitations and Constraints |  |  |
| 30/08/2021 | 1.6 | Daniel Brett | Created Appendix A Documents Schema for database and identified documents to be kept within collection for the database. |  |  |
| 31/08/2021 | 1.7 | Louis da Silva | Provide “Roadmap”. |  |  |
| 31/08/2021 | 1.8 | Louis da Silva | Added proposed keys to documents in Appendix A |  |  |
| 31/08/2021 | 1.9 | John F | Revised proposed keys to documents and added grow beds to fish tank in Appendix A |  |  |
| 31/08/2021 | 2.0 | John F | Added Appendix B  MQTT Channels |  |  |
| 01/09/2021 | 2.1 | Louis da Silva | Added Appendix C –  System architecture and MQTT channel diagrams |  |  |

# Motivation / Problem Description

The aim of this project is to create a remote management system for an aquaponics farm (see schematic in figure 1) using ‘IoT’ devices and technologies.

Diagram

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Figure 1 Basic Aquaponics Farm Setup

The motivation for doing this is to further enhance what is already a more efficient version of aquaculture and hydroponics. The plants filter out and use the fish waste, whilst creating their own by-products that provide nutrients to the fish. A healthy and efficient aquaponics setup:

* Maximises fish produce
* Maximises crop growth
* Conserves water
* Reduces the required external resources as:
  + The fish provide fertiliser for the plants
  + The plants provide minerals for the fish and filter their water

The net effect of these factors is saving water, saving money, and supplying food, which can be consumed or sold for profit (thus generating income). This makes a healthy aquaponics farm a very valuable asset. Ultimately the people who could most benefit from this are those in impoverished nations where food resources are scarce (initial setup costs could be overcome with the help of sponsors/charities/NGO’s etc.). Of course, the project would not just be limited to this setting, as systems can also be used and scaled for anyone from a hobby farmer to a full commercial operation.

# Context

As explained, there are great benefits to a healthy aquaponics farm, but there are many factors involved in achieving this. This project aims to ease the process, by providing automated / remote monitoring and control, to provide key insights that help inform decisions as well reduce labour. A regular setup requires frequent monitoring and control of:

* Temperature
* Water pH levels
* Lighting: Natural and Artificial
* Dissolved Oxygen content of water
* Water Salinity
* Water Level

In addition to these key factors we propose to try and further reduce ongoing cost, by including a solar system with a battery and provide automated control of switching between:

* Charging the battery
* Powering the system using solar (direct or from that stored in battery)
* Powering the system using mains power

An extension of all of these features is to have the system monitor weather by way of interaction with an API, to make most efficient use of power dependent upon predicted sunlight availability, as well controlling ventilation and lighting levels within the aquaponics system dependent upon rain / sunshine.

# Value Proposition

This solution would provide benefits:

* Commercially:
  + Power Savings
  + Water Savings
  + Increased fish output
  + Increased crop output
* Socially
  + The same factors that are of commercial benefit apply in assisting in job and resource creation in impoverished regions.
* Technological
  + The project builds on existing ‘Internet of Things’ (IoT) technologies and possibly provides new areas of research and development within this field.
* Operational
  + Reduced labour requirements and upskilling of those in the fields of agriculture, hydroponics, aquaculture and aquaponics.

# Core Idea/User Stories/Requirements

**The core Idea**

This project will be to create a highly automated and efficient system capable of providing advanced aquaculture and aquaponics outcomes to allow a greener self-sufficient lifestyle.

**The User**

Will be of intermediate knowledge of the systems used not requiring full automation of the system but more prompts for when it goes outside of limits.

This user will want a minimal impact system that focus on efficiency first and the least use of adding nutrients to the system and maximising the use of renewable resources.

**Requirements**

* Automated monitoring of system levels
  + Ph
  + temperature
  + water
* Maximised solar use
* System error notification
* Visualisation of various system metrics
* growth
* power use
* Nutrient levels

# Target Deliverables

The following goals have been identified as dependencies that need to be addressed early in the life cycle of the project:

1. Hydroponics system
   1. Monitor soil moisture levels
   2. Temperature
   3. Light levels
2. Aquaculture system
   1. Monitor water Ph
   2. Temperature
   3. Water Level
3. Pump
   1. On/off
   2. Flow rate and water volume
   3. Physical system errors
4. Power system
   1. Monitor power source levels
   2. Monitor battery charge
   3. Automatic switching
5. User interface
   1. System manual controls
   2. Monitor and predict growing conditions
   3. Provide visual data for various metrics
   4. Provide physical system status

# Roadmap

## Execution Strategy

* Meet with the client and present this document for initial presentation and agreement upon project expectations.
* Incrementally,
  + Build and demonstrate features and functionalities for the client, in weekly ‘sprints’ as detailed below. Weekly meetings will allow the client to observe and give input to the project progress, informing subsequent sprint goals.
* Test features as they progress.
* Document features once demonstrated to and agreed upon by the client.

## Planning Stage

**Goals**

* Deliver a proposal document (this document) covering project expectations, scope and planning.
* Have a meeting with the client to discuss project goals and expectations.
* Agree upon final goals and deliverables for sprint 1.
* Assign tasks within the team for sprint 1.
* Begin planning framework / architecture of system.

**Target deliverables**

* Clear goals for sprint 1 as agreed to with client.
* Project proposal document (this document) that has been agreed upon by all team members and client.
* Client communication and delivery expectations agreed to by all parties (weekly meetings with client on a Monday at 6pm).

## Sprint 1

**Goals**

* Have the following infrastructure complete:
  + Server
  + MongoDB
  + Database APIs
  + Sensors communicating via messaging APIs
* Have a basic front-end working.
* Collaborate with Kevin to create an output data schema.
* Prepare a suitable environment within a docker container to encapsulate and execute the transformation process.

**Target deliverables**

* A docker container encapsulating the transformation engine
* An invocation script that accepts the input folder, output folder and invocation parameters
* A deployment document that describes how to install and use the solution

## Sprint 2

**Goals** (can be amended based on how Sprint 2 goes)

The goal of Sprint 2 is to build upon the Increment in Sprint 2, namely by adding:

* Error logging
* Input/Output Validation
* Transformation logic

**Target deliverables** (can be amended based on how Sprint 2 goes)

* A docker container encapsulating the transformation engine
* An invocation script that accepts the input folder, output folder and invocation parameters
* A deployment document that describes how to install and use the solution
* List of errors and associated meaning
* Sample dataset to validate the transformation engine reported results

## Sprint 3

**Goals**

* This will be informed by the outcome of sprint 2.

**Final deliverables** (can be amended based on how Sprint 2 goes)

* This will be informed by the outcome of sprint 2.

## Sprint 4

**Goals**

* This will be informed by the outcome of sprint 3.

**Final deliverables** (can be amended based on how Sprint 3 goes)

* This will be informed by the outcome of sprint 3.

# Limitations, Constraints and Considerations

The limitations, constraints and considerations of the project are as follows:

* Feeding the fish
* Cleaning the tanks otherwise clogging will occur which then will lead to water channelling, inefficient biofiltration and inefficient nutrient delivery to plants
* Maintaining adequate water conditions: temperature/carbon dioxide/pH
* Initial start-up can be very expensive for average folks
* Checking for dead fish

Challenges:

* Plants dying
  + Insufficient water and oxygen
  + pH levels
  + Regular check of the plants for bugs/pests
  + Water must have enough minerals – regular check of iron levels
* Algae growth: Algae can be a problem if they get out of hand. So, measures must be taken.
  + Shading: Without light, algae do not grow
  + Mechanical Filtration: filters, screens, vortex
* Management System Limitations/Constraints
* System design failure
* Lack of technology knowledge in users
* Lack of senior support
* Lack of education in the installation of the system
* Software – Incorrect data formats
* Information overload
* Hardware – Wrong sensor data, sensors not working, activation errors

# Appendix A – Database Schema

Note: ‘am’ below is just short for ‘Aquaponics Manager’, if anyone has a more creative idea for the name we can change it.

|  |  |  |
| --- | --- | --- |
| **Grow Beds** | | **Comments** |
| \_id | String | The mongo id |
| name | String | Name of the rgow Bed |
| moistureActual | Number | A percentage number between 0 and 100, the actual moisture level in the grow bed |
| moistureNeed | Number | A percentage number between 0 and 100, the desired moisture level to maintain the grow bed at |
| crop | String Array | e.g. [ tomato, corn, silverbeet ] |
| planted | date | The date the grow bed was planted |
| harvest | date | This is an expected harvest date |
| valveID | String | The valve to open or close to let water in from the pump |
| temp | Number | Air temp of growbed |
| light | Number | The light intensity in the growbed |

|  |  |  |
| --- | --- | --- |
| **Fish Tank** | | **Comments** |
| \_id | String | The mongo ID |
| name | String | The fish tank Name |
| level | Number | The water level |
| stock | String Array | [ trout, bass, salmon ] … no idea what species can or should be mixed, maybe only one species in a tank in which case it could just be a string not an Array? |
| pump | String | The ID of the pump operating from the tank |
| pH | Number | The alkalinity of the tank |
| temp | Number | Water temp of fish tank |
| growbeds | Mongo\_doc | List of growbeds serviced by this tank |

|  |  |  |
| --- | --- | --- |
| **Water Pump** | | **Comments** |
| \_id | String | The mongo ID |
| name | String | Pump name |
| state | Boolean | On / Off |
| fishTank | String | The fish tank id the pump is operating from – Cross references to pumpID in the Fish Tank document |
| valves | Mongo\_doc | The valves controlling flow from the pump [ v1, v2, … ] |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **Valve** | | **Comments** |
| \_id | String | The mongo ID |
| name | String | AM system ID |
| growBed | String | The grow bed the valve controls water supply to |
| pump | String | The ID of the pump supplying water to valve |
| flow | Boolean | A flowmeter downstream of the valve to check when valve is open water is flowing – could be used for capturing and reporting errors? Or could this be avoided by using logic that looks at pump on -> valve open -> growBed moisture not increasing |

# Appendix B – MQTT Channels Hierarchy

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MQTT Channel Hierarchy** | | | | |
| **Root** | **Depth 1** | **Depth 2** | **Depth 3** | **Depth 4** |
| **aquamanager/** |  |  |  |  |
|  | **fishtank{\_id}/** |  |  |  |
|  |  | **ph** |  |  |
|  |  | **temperature** |  |  |
|  |  | **waterlevel** |  |  |
|  |  | **growbed{\_id}/** |  |  |
|  |  |  | **moisture** |  |
|  |  |  | **temperature** |  |
|  |  |  | **light** |  |
|  |  |  | **valve{\_id}/** |  |
|  |  |  |  | **flowrate** |
|  |  |  |  | **State** |
|  |  | **pump{\_id}/** |  |  |
|  |  |  | **State** |  |

# Appendix C – System architecture and MQTT communication schematics

Diagram

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Figure 2 - Object Relationships

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Figure 3 - Fish Tank Sensors to MQTT channels

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Figure 4 - Grow Bed Sensor to MQTT Channel

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Figure 5 - Pump to MQTT channel

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Description automatically generated

Figure 6 - Valve to MQTT channel