AquaEco:
A Smart Aquarium

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Problem :

- There is a need for automated solutions with everyday machines and everyday activities.
- Pet product market is rapidly increasing and there is a lack of available aquarium monitoring solutions.
- There is a lack of knowledge for first time aquarium owners, increasing the mortality rate of the fish.
- With so many individual aquarium products available, it is hard for first time buyers to know what products they actually need.

Goals and objectives

- Learning team dynamics and collaboration experience
- Managing responsibility and and task assignment with optimal skill utilization
- Brainstorming, Thinking critically, and solving practical problems in a real application environment
- Developing proper documentation techniques
- Researching relevant information to successfully make informed design decisions
- Following a well developed plan to its logical conclusion in a practical manner
- To ultimately design and implement a project that gives practical engineering experience

Requirements and specifications

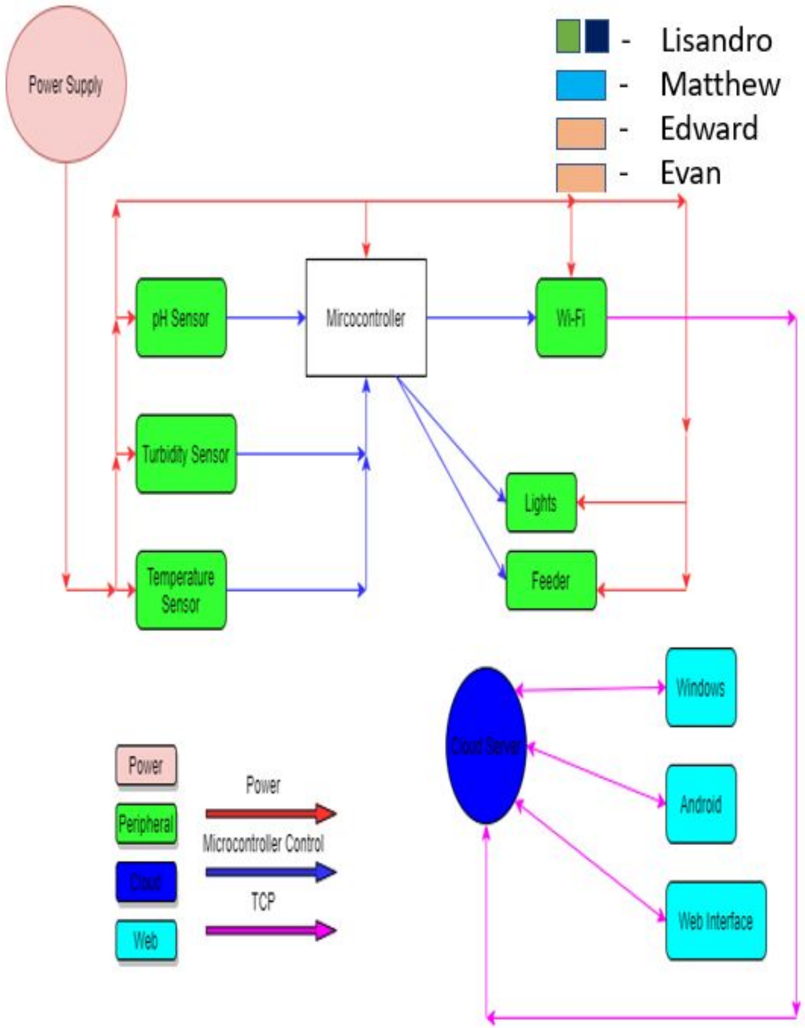
Type of requirement	Description
Marketing 1	A compact system that can be easily stored and carried is necessary.
Marketing 2	The system will have components that meet the needs of a consumer for aquarium maintenance.
Marketing 3	Fish feeder will provide the necessary amount of food at the correct intervals.
Marketing 4	System interacts using WIFI to deliver results at any given time and place.
Marketing 5	Thresholds set in app will deliver fast notifications to users.
Marketing 6	Fast and responsive application for users to interact.
Marketing 7	The app and tank should be easy to set up for the average consumer
Marketing 8	Accurate sensors and data

Overview of PCB and WiFi Module

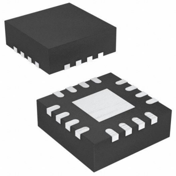
- The Atmega328P will control sensor readings and communicate with the ESP-01 chip using UART
- ESP-01 chip will manage updating data in the remote database and receiving updated instructions to send over UART to the PCB

Hardware Main Diagram

- Each of the different sensors retrieves data from the aquariums environment and transmits that data back to the microcontroller
- The microcontroller receives data via the cloud server which is used to control the lights and feeder
- The wifi based cloud server receives data from the user application
- Sensor data is also transmitted to the user application through the server
- The power supply is set to input 5 volts and 2 amps. Fortunately the majority of components have an operating voltage of 5 volts and a low operating current.
- A voltage regulator circuit is developed to supply power to the ESP8266

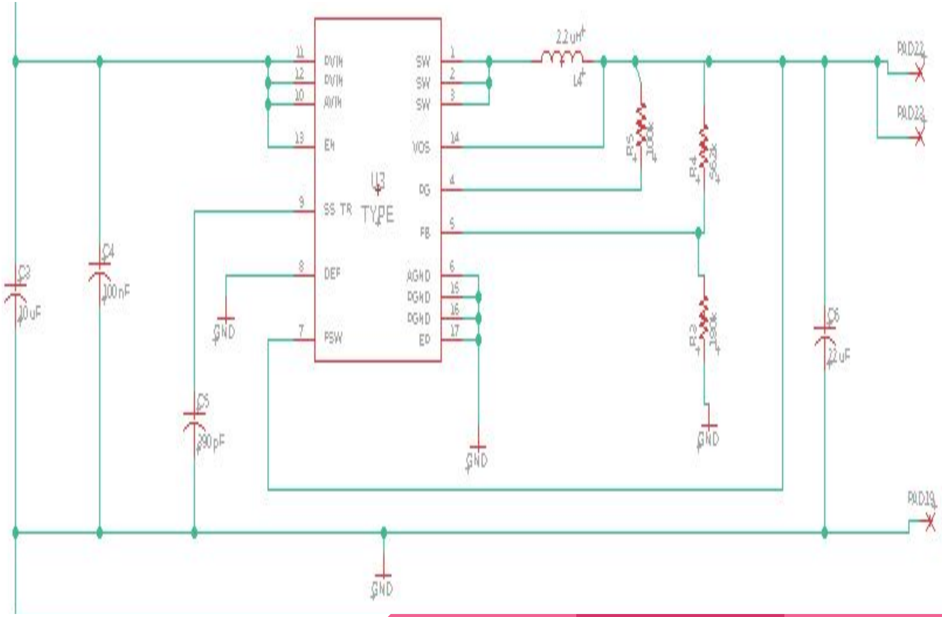


Power Needs: Voltage regulator



Component:	Operating voltage:
Gravity: Analog pH Sensor	5 Volts
DS18B20	3-5 Volts
Gravity: Analog Turbidity Sensor	5 Volts
Servo 9g	5 Volts
Atmega328p-pu	3.3 - 5 Volts
ESP8266	3.3 Volts
WSB2811 LED	5 Volt

A voltage regulator which drops 5 volts to 3.3 volts is created to provhttps://www.google.com/url?sa=i&u



Hardware Design: Sensor considerations

Part	**Justification**
Sensors	
pH	• Cheap and easy implementation • Small changes in pH number can mean a drastic difference in pH level
Ammonia, Nitrite, and Nitrate	• Can be controlled through filtering, water changes, and reducing pH • No electronic and constantly submersible implementation
Temperature	• Too much heat can increase ammonia production • Waterproof implementation available
Turbidity	• Turbidity signals excessive bacterial or algae growth • Low-cost, electronic, and waterproof

Hardware design: pH Sensor selection

pH Sensors		
Liquid Pho-14	● Built-in analog sensor and board ● Can interface with the PCB	● Low-quality parts ● Little user reviews; indeterminable reliability
Gravity: Analog pH Sensor	● < 1 min. reading time ● Measures within ±0.1 pH ● Operates well in standard aquarium conditions	● Cost ● Requires need of sensor analog conversion board

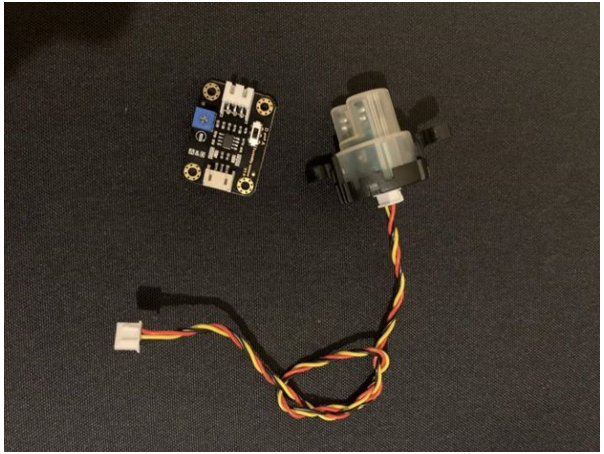
Hardware design: Temperature sensor selection

Part	**Advantages**	**Disadvantages**
Temperature sensor		
Vktech	• Proper voltage • Inexpensive • Accuracy	• Lacks documentation
DS18B20	• Accurate • Included interface • Has proper documentation and support	• Higher upfront cost

Hardware design: Turbidity sensor selection

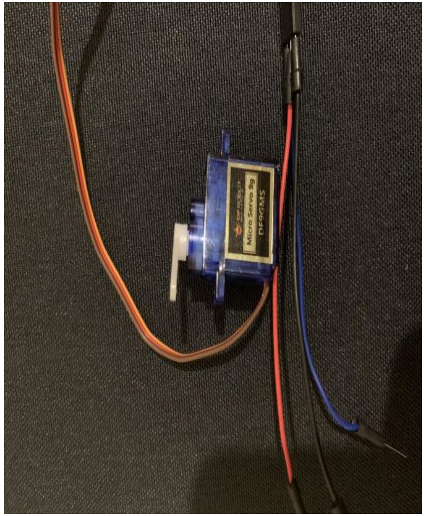
Gravity: Analog Turbidity Sensor

Advantages	Disadvantages
• Response Time: <500ms • Analog output: 0-4.5V • Voltage can be easily converted to NTU NTU = -1120.4*square(volt)+5742.3*volt-4353.8	• Not very accurate • Digital output option only allows for a high or low response • Top of sensor not waterproof



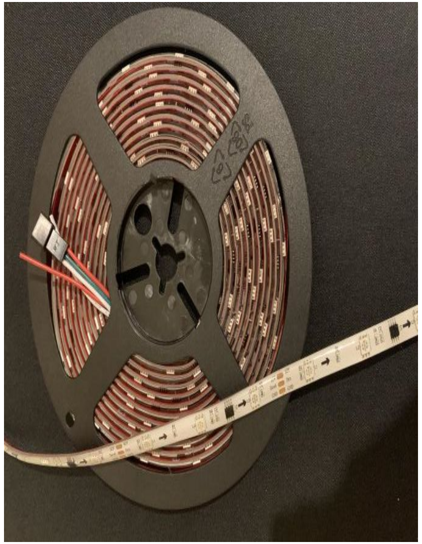
Hardware design: Motor selection - Servo 9g

Part	**Advantages**	**Disadvantages**
Fish Feeder Motor		
Servo 9g	• Common • Inexpensive • Compact	• Slow • Less torque
5v Stepper motor	• Energy-inefficient • Very fast • Directly pluggable.	• Higher cost • Point of failure with larger usage
7 Stepper Motor	• Very strong torque • Can drive large objects	• Most expensive • More power draw

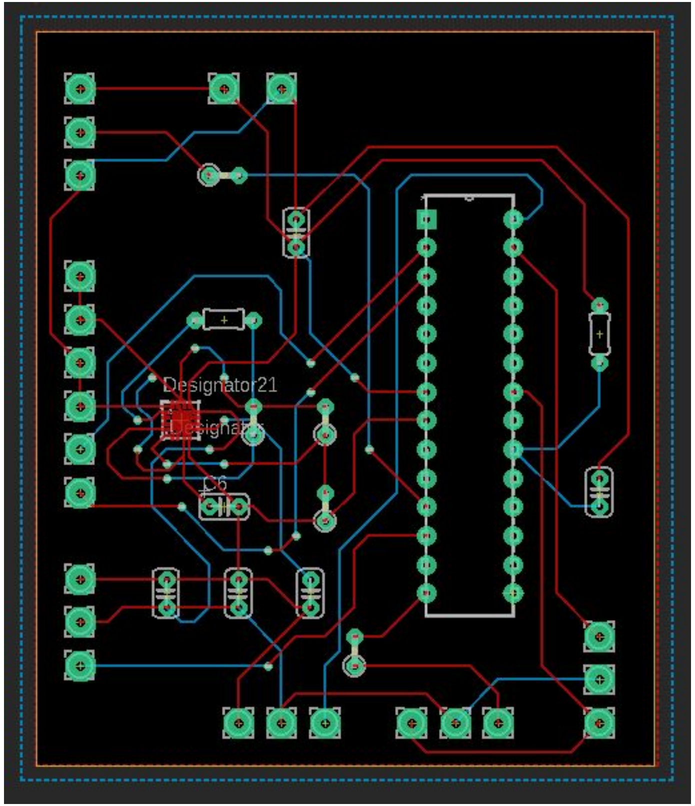


Hardware design: Hardware selection - Lighting

Part	**Advantages**	**Disadvantages**
Lighting		
Incandescent	• Common • Inexpensive	• Produces a lot of unnecessary heat • Energy inefficient
Fluorescent	• Energy-inefficient • Produces little heat • Longer lifespan	• Higher upfront cost with bulbs
LED	• Compact • Energy-efficient • Very long-lasting	• Higher upfront cost with bulbs



Hardware design: PCB implementation



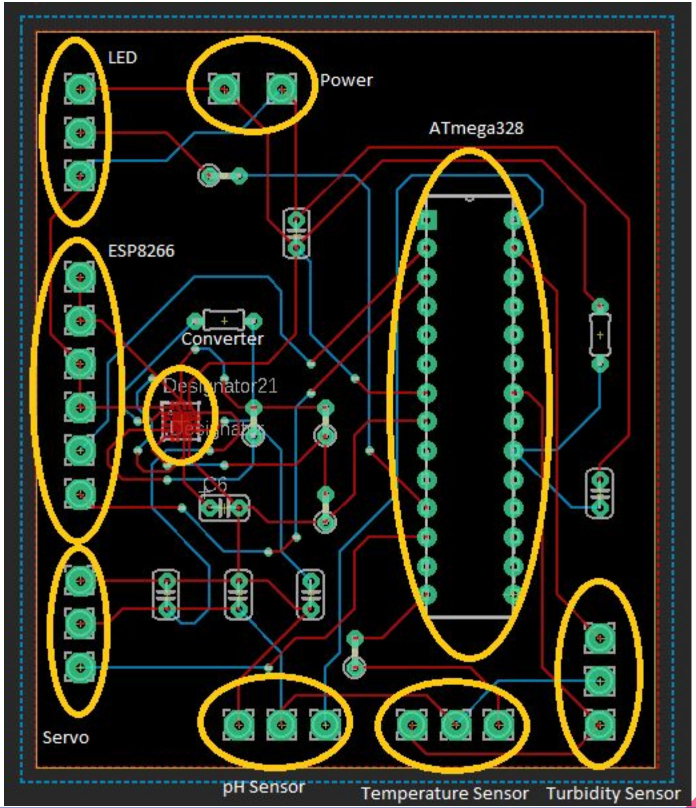
Hardware design: PCB implementation

- Minimalized components mounted onto the PCB:
    - Reduces soldering components directly on the board during prototyping
    - Allows flexibility of parts to better fit a variety of tanks
- Through holes for connection:
    - Minimal components on the PCB allows space for through holes
    - Durable for prototyping
- Possibility of surface mount connections as additions or replacements, if needed.
- 5 V to 3.3 V converter included to provide the needed voltage for the WiFi module

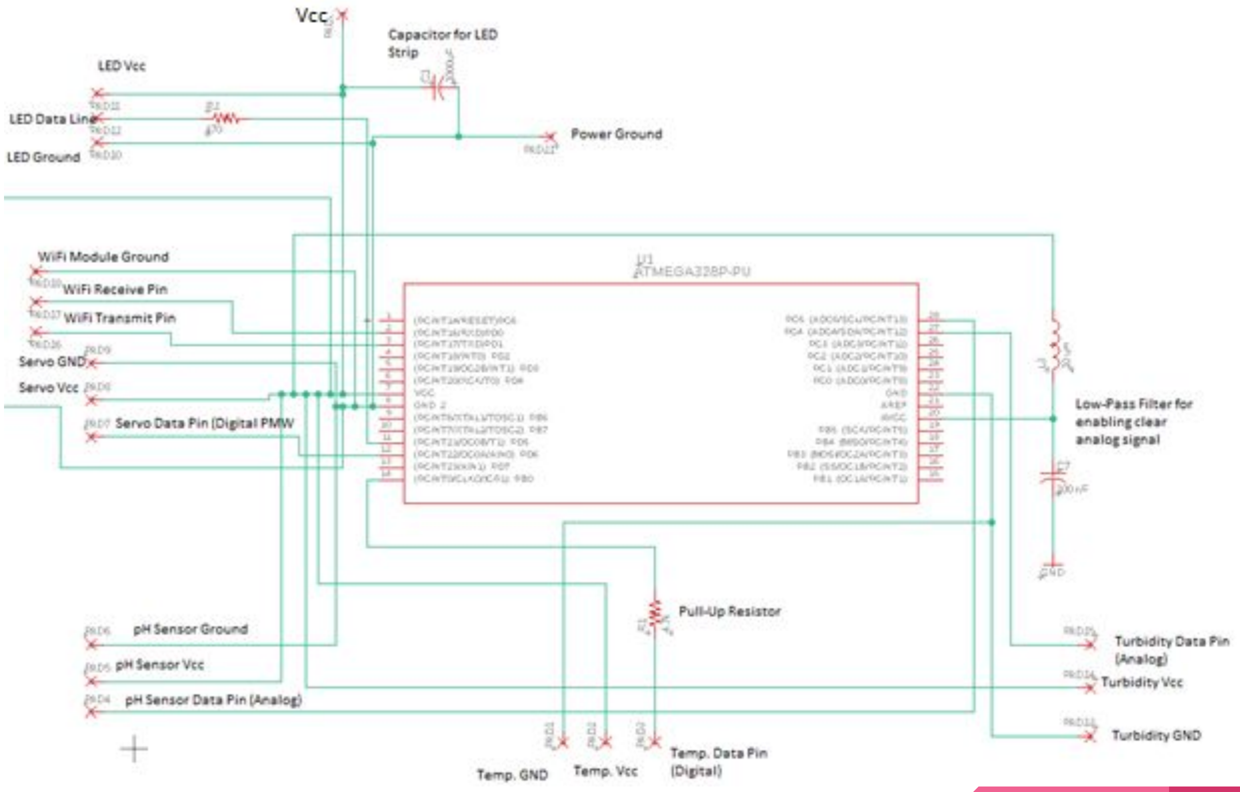
Hardware design: PCB implementation

- Through holes spaced and sectioned to provide sufficient connections for devices
- Each sensor requires a ground connection and 5 V supply
    - pH sensor data line connected to analog
    - Temperature sensor data line connected in series with a resistor to digital
    - Turbidity sensor data line connected to analog
- ATmega328 is connected to the ground, RXD, and TXD pins of the MCU, and connected to the 3.3 V converter for VCC and CH_PD
- Servo data line connected to a PWM pin of the ATmega328
- LED strip VCC is connected directly to the power supply with a capacitor, and data line is connected with a resistor in series to a PWM pin

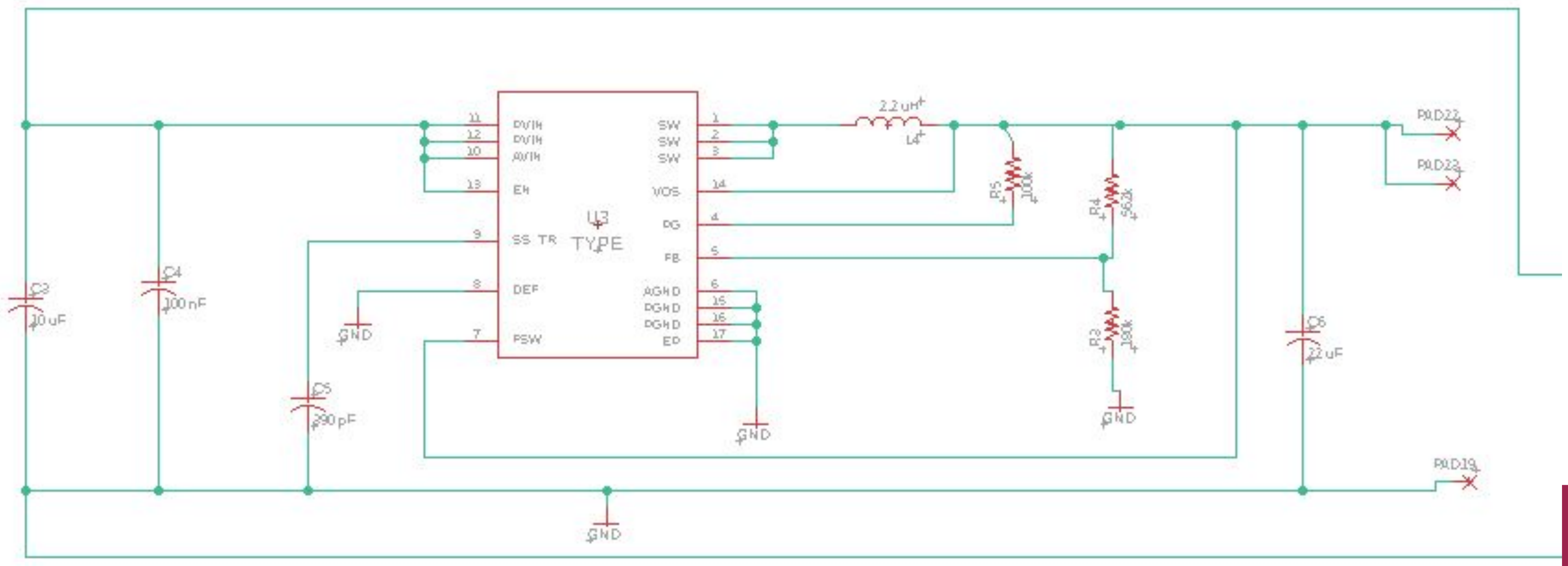
Hardware design: PCB implementation



Hardware design: PCB Schematic



Hardware design: PCB Schematic



Hardware Design: Challenges

- Acquisition of needed components
- Ensuring that all equipment and parts are functioning as anticipated
- Developing a PCB and potentially adjusting the design
- Cutting unnecessary actions and minimizing expenditures
- Testing the design for robustness and reliability

Phone application vs Web application

Phone applications offer tight integration with the operating system.

Access to notifications and widgets.

vs

Increased phone performance.

Applications can be used offline.

Faster development tools and helpful UI building tools.

Selection of Android operating system

Android studio has been recently updated with new features and enhanced speedy building of application and works on windows.

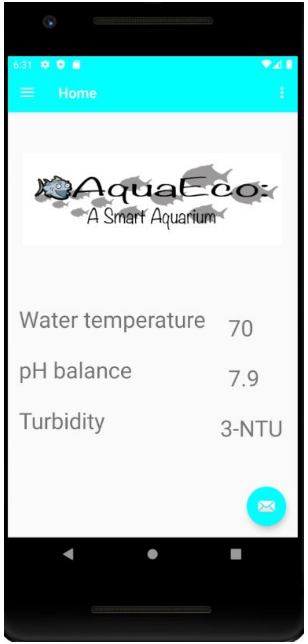
Open source and free.

Built on java with years of documentation and bug helping.

Strong built in emulation tools and debugging.

Android has more than 50 percent market share.

Features of application



Access to pH, temperature and turbidity readings .

Access to information for many different types of fish.

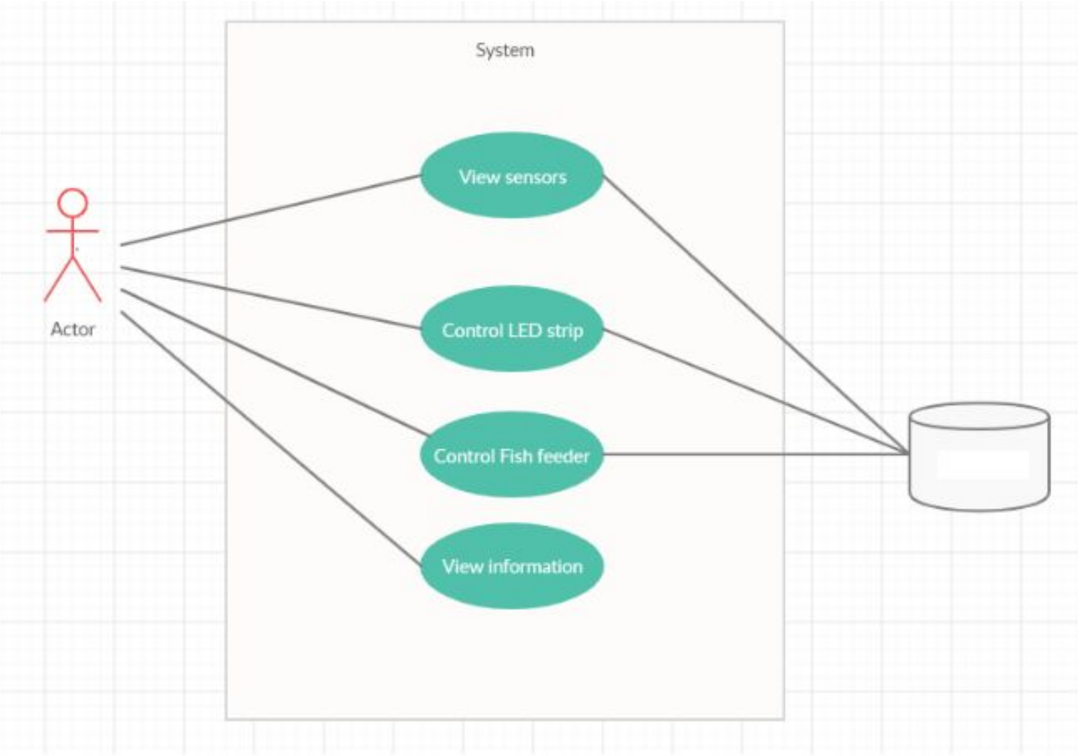
Control when the lighting turns on and off.

Control the fish feeder and allow feedings to happen at certain times.

Weekly assessments of sensor readings to indicate a healthy fish environment.

Notifications for upcoming feeding or sensor readings.

Use case diagram



The user will use the app and its features that will then communicate to a server the information requested or needed to send.

Android application Communication

Communication will occur between the android application and a web server.

This will be done in the form of GET/POST requests to the server.

There will be two types of information being sent to and from the server.

Information relating to retrieval of sensor data.

Information relating to push data relating to led and motor.

Extra Information Presented in Application

The app will serve to provide the end user with information relating to their current system.

An in built wiki will help with first time users with information about fish and how to set up the aquarium.

An an inbuilt aquarium builder helper will tell the user if temperatures are too high for the fish they input and will give compatibility between the different species.

Developing android application

Successes:

Strong extensive external libraries facilitates faster coding time.

Easy to use XML based ui builder.

OpenGL compatibility for graphics.

Strong debugging tools incorporated into emulation and physical hardware with android usb debugging.

Developing android application

Challenges:

Android studio Ui interface has a large learning curve.

Communication between android app and the esp chip in different network required the use of a seperate server.

Confusing file structure for beginners.

Software Design Selections

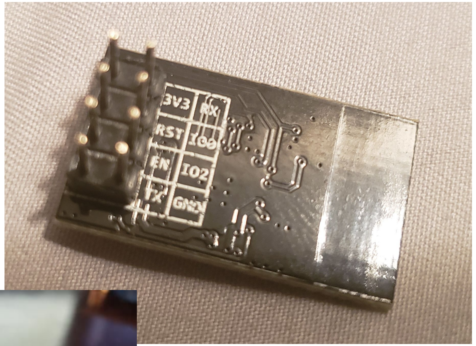
- We chose to use the ESP-01 chip for our WiFi needs because it has a low cost, bearing the ESP8266 microcontroller
- It also has plenty of support from online hobbyist forums and with that comes a lot of reference information
- We can flash it with custom firmware using the arduino IDE
- Our MCU for the PCB is the Atmega328P, which can also be programmed with the Arduino IDE.

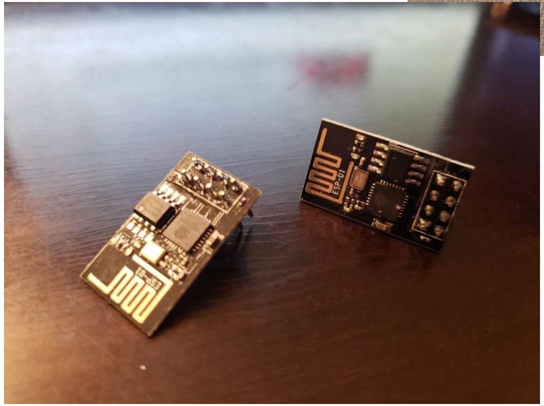
Sensor Communication

- Sensors will be all connected to the PCB
- Most are analog
- ADCs will be used to read values from the sensors
- Sensors are connected using I2C
- Our PCB will handle reading the sensor values on an ongoing basis, and will also control LEDs and the feeder at specified times
- These readings will be sent via UART to the ESP-01 chip

WiFi Communications for ESP8266

- Uses the ESP8266 ESP-01 microchip for WiFi capabilities
- Has existing firmware for simple AT commands
- We will overwrite this with custom firmware for our needs using Arduino IDE
- Has built in antenna and communicates with PCB by serial connection



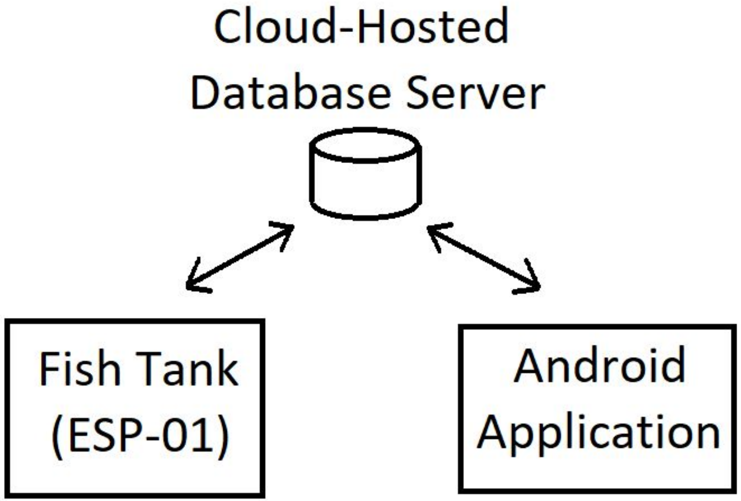


Software design challenges for Hardware Aspect

- Reading sensor data properly
- Controlling LEDs and feeder servo to perform tasks at the appropriate times
- Communicating data between Atmega and ESP
- Originally planned for direct communication, but that won't work remotely
- Problem of public and private IP addresses, struggle to transfer information between devices on different networks without heavy user setup
- Therefore, we must find a different way (middleman database)
- Obtaining public IP address for use as database key
- Updating database with sensor readings, and checking for new times for lights and food over the internet

Communications Structure

- ESP8266 module will communicate with the cloud hosted database server to update sensor data
- Android app will communicate with cloud database to obtain sensor readings and post updated lights and feeding times
- No direct communication between tank and app



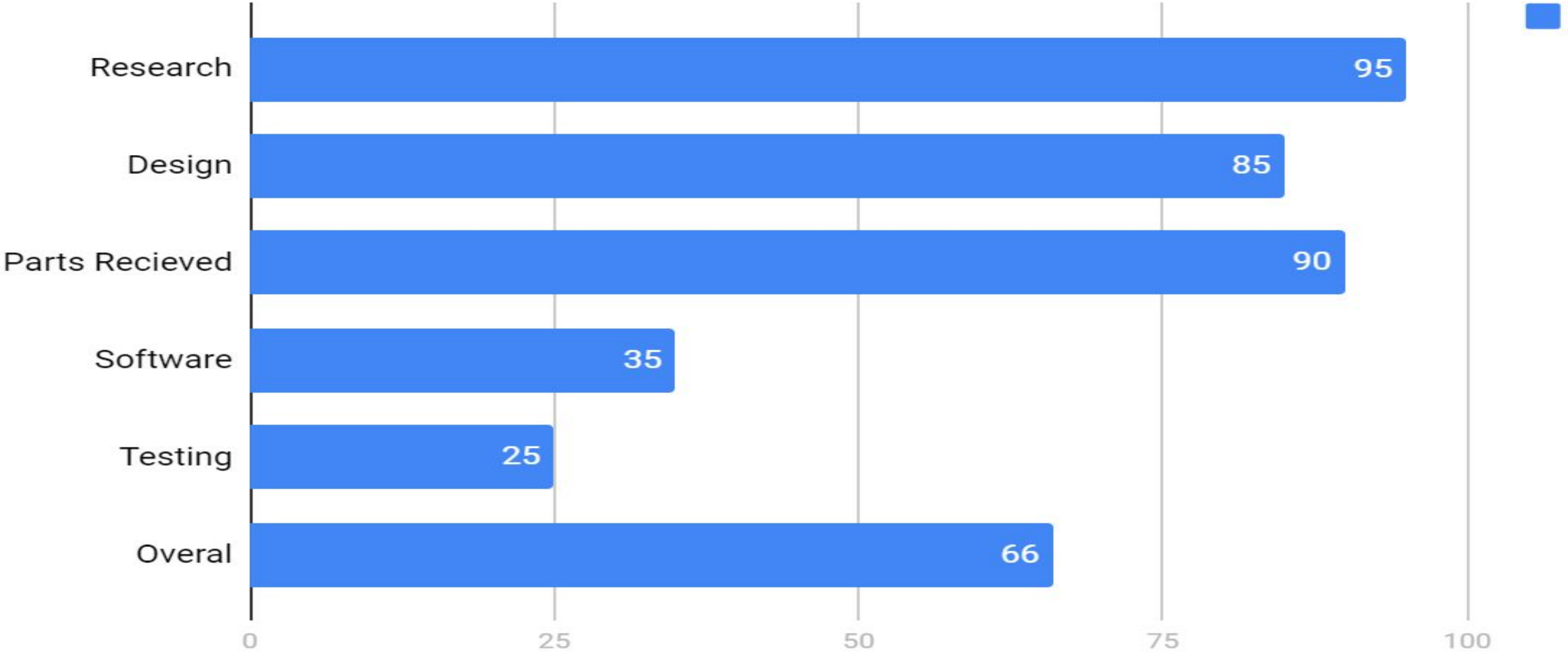
Budget

Device to Purchase	Predicted Cost	Current Expenditure
5 Gallon Fish Tank	$20.00	TBD
Analog pH Tester	$56.90	$56.90
Turbidity Tester (2)	$19.60	$19.60
Temperature Reader (2)	$7.98	$13.80
Fish Feeder Servo and Casing	$15.00	Servo: $3.50
PCB and Components	$120.00	2 PCBs: $85.36 Voltage Converter: $10.22 ATmega328: $5.50 ESP8266: $7.50 Total: **$108.58**
Enclosure	$20.00	TBD
LED Strip	$15.88	$15.88

Work distribution

- Eddie Richards:
  - Create PCB board which supplies power to all sensors
  - Assemble electrical components onto PCB
  - Create system housing
- Evan Kurnia:
  - Create PCB board which supplies power to all sensors
  - Assemble electrical components onto PCB
  - Supply different communication devices with power
- Matthew Klein:
  - Microcontroller programming, including interfacing with the various sensors and controlling the functions of the tank
  - The tank’s side of communications with the app
- Lisandro Osorio:
  - Ui design and API interface for the application
  - Microcontroller interface to application
  - Designing a way for data from microcontroller to reach the application wireless, without needing bluetooth connection for improved distances

Overall Progress



Remaining tasks and plans

PCB assembly

Flash ATMEGA with developed code

Tweak/transfer created ad hoc WiFi server on to system

Finish application development

Testing: PCB, WiFi connectivity, application functionality, sensor readings