KelpNet

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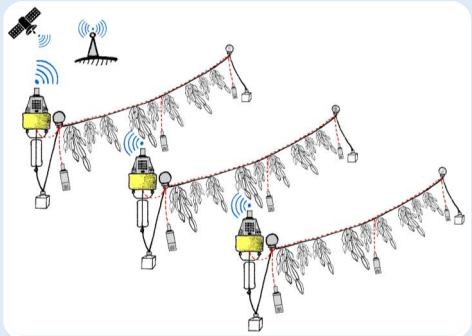
INTRODUCTION AND CONCEPT

The global seaweed market is worth multiple billions of dollars and is growing fast as countries are investing in sustainable and environmentally friendly growing techniques. Seaweed farming is one of the solutions being researched and invested in to aid in the fight against global food scarcity and climate change.

Concept Art



DESIGN OVERVIEW

KelpNet aims to provide an affordable hardware/software solution for interfacing commercial water quality sensors and connecting them to the internet using IoT (Internet of Things) protocol. To reduce the system costs KelpNet will provide a scalable and customizable solution that is specifically designed for Kelp farming so that the customers receive a purpose-built solution tailored to their requirements.

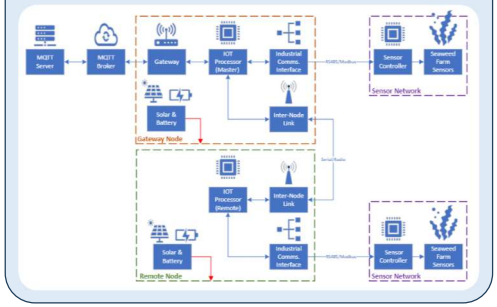
System Components

IoT:
- MQTT Broker
- Visualization and analysis server

Gateway Node:
- Embedded Linux Environment
- RS-485 serial interface
- Modbus and MQTT Protocols
- Cellular/Satellite internet connectivity
- Solar/Battery unit
- Low powered radio (local comms)

Remote Node:
- Same as Gateway but without internet connectivity

System Block Diagram

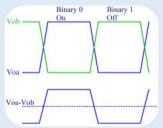


TECHNOLOGY AND METHODS

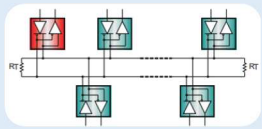
KelpNet was designed using common industrial/commercial protocols and electrical standards to be compatible with industry standards and commercially available hardware/software such as water quality sensors and Amazon Web Services (AWS) for their IoT services.

Serial Communication – RS-485

Features of RS-485:
- An electrical standard in the physical layer of the OSI model
- Multiple devices on the same bus (Multidrop)
- Data rates up to 10Mbit/s
- Up to 1,200 m transmission distance (lower speeds)
- Full-duplex capable
- Differential pair signal – Noise cancellation



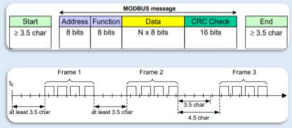
RS-485 Electrical Signal [1]



RS-485 Bus Architecture [1]

Modbus

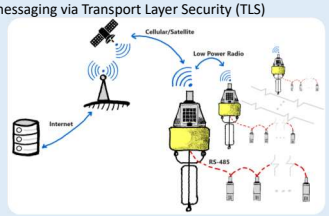
Features of Modbus:
- Client/Server data communications protocol in the application layer of the OSI model
- Openly published and royalty-free
- Developed for industrial applications
- Can use serial communication (RTU) or Ethernet (TCP)
- Asynchronous serial communication



Modbus messaging structure [3]

Internet of Things (IoT)

Utilizing an IoT design, based on Message Queue Transport Protocol (MQTT), brings scalability for monitoring one farm to monitoring thousands with a simple publisher and subscriber model. Additional benefits include:
- Lightweight messaging for data constrained connections
- One-to-one, one-to-many, many-to-one functionality
- Secure messaging via Transport Layer Security (TLS)



Water Quality Monitoring

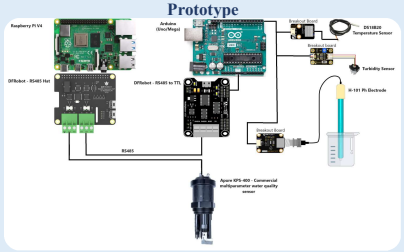
KelpNet is built to interface with available scientific-grade water quality sensors communicating via the Modbus protocol. Seaweed crop yield is determined by several water quality factors such as:
- Temperature
- pH
- Turbidity (clarity)
- Salinity
- Nitrate Concentration
- Photosynthetically active radiation (PAR)

KPS-400 multiparameter water quality sensor [2]

PROTOTYPE DESIGN

The prototype was designed using available development boards and prototyping sensors to satisfy the design specifications within the time constraints of the project. The software development was driven by the library accessibility of the hardware components and the fastest route to a functional prototype.

Prototype



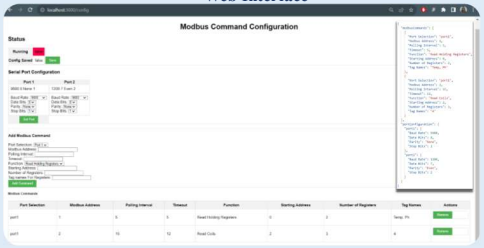
Hardware Components:

Gateway:
- Raspberry Pi V4
- DFRobot RS-485 hat

Sensor Controller:
- DFRobot RS-485 multiplexer
- Arduino UNO or Mega
- DS18B20 Temperature Sensor
- DFRobot – Gravity – Turbidity sensor
- H-101 Ph Electrode

Commercial Water Quality Sensor (Optional):
- Apure KPS-400 multiparameter sensor

Web Interface



Software Components:

Gateway:
- Web GUI – Configuration interface (Nodejs with Express and EJS-Embedded JavaScript Templating)
- Automation and Control Application (Python)

Sensor Controller:
- Modbus and Sensor integration application (C/C++)

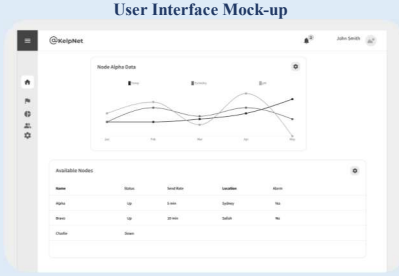
User Interface
- Web-based dashboard receiving real time updates

CONCLUSIONS AND FUTURE WORK

Seaweed agriculture is a growing market that facilitates the potential for ocean restoration as well as contributing renewable food and agriculture-based products. However, due to the tight profit margins farms often rely on manual solutions to gathering water quality data rather than investing in the current high-cost solutions for remote monitoring. KelpNet offers a low-cost solution for remote water quality monitoring directed specifically towards seaweed farming as an effort to help increase farm yields through continuous and real time water quality monitoring.

While an initial prototype was produced, future implementations could include:
- Efficient solar charging utilizing maximum power point tracking (MPPT)
- Custom PCB for gateway
- Integration of satellite or cellular communications
- Trend analysis using machine learning to ensure optimal harvesting time

User Interface Mock-up



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Sugar Kelp farm in Alaska [5]