# Energy-Efficient Remote Water Monitoring Framework: Power Challenges in Real-World


Seyed Alireza Rahimi Azghadi[1], Kamyab Aghajamali[2], Ian Church[3], Francis Palma[4], Hung Cao[1]

[1]Analytics Everywhere Lab, University of New Brunswick, Canada
[2]Offsite Construction Research Center (OCRC), University of New Brunswick, Canada
[3]Ocean Mapping Group, University of New Brunswick, Canada
[4]SE+AI Research Lab, University of New Brunswick, Canada



## Abstract

With increasing urbanization, industrialization, and climate change, monitoring water bodies is crucial for detecting pollutants, managing resources, and preventing hazards. Continuous water assessment ensures the safety and sustainability of these resources. This paper presents a real-time remote water monitoring framework addressing the key challenge of power consumption. Our system consists of three parts: an end device for data collection, a shore-based gateway connecting to the cloud, and a cloud platform for data storage and analysis. We deployed a prototype, discussed challenges, and studied power-efficient end device architectures and use cases with low-cost sensors.


## Proposed Method & Implementation

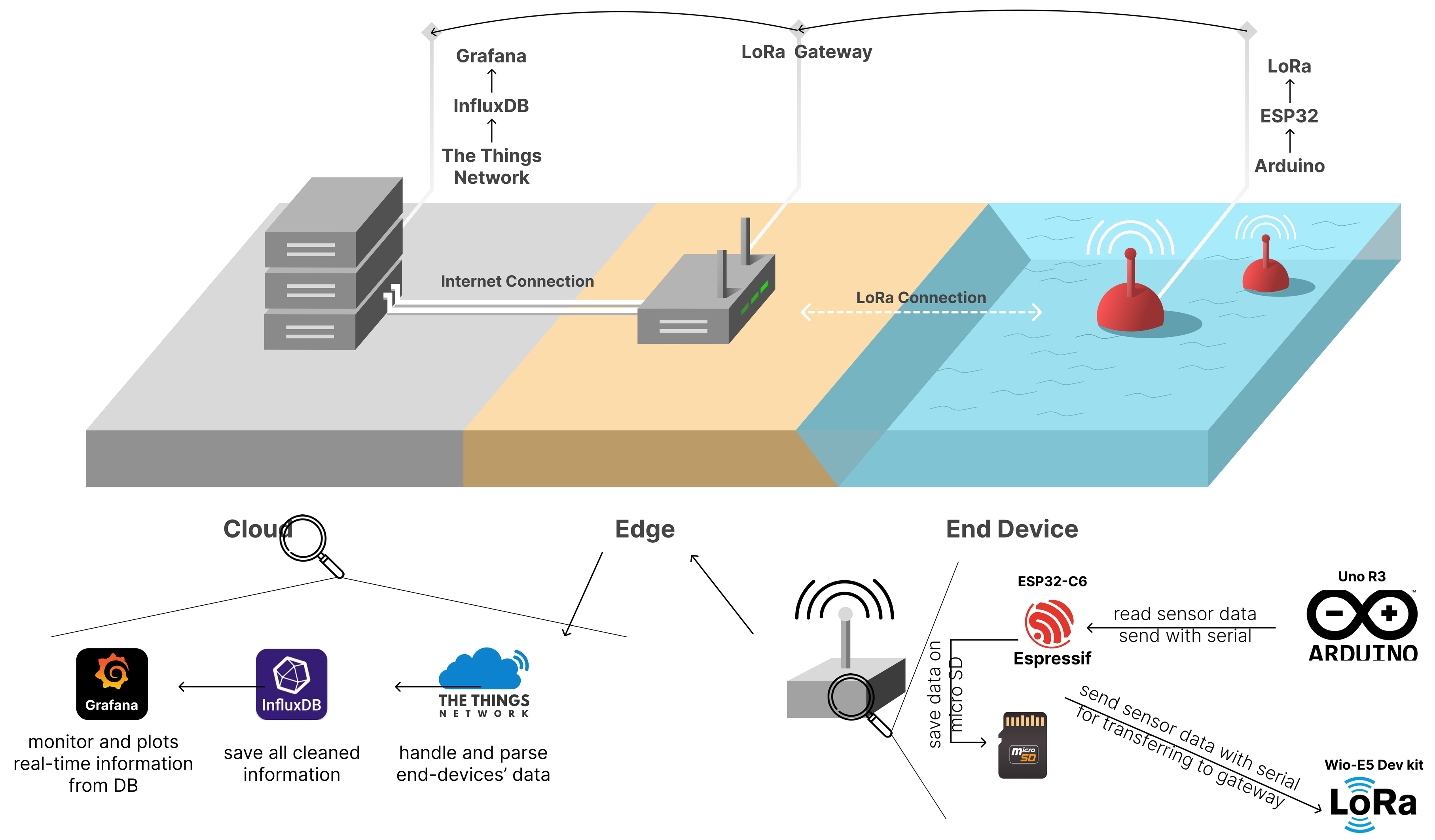


Figure 1. Our framework architecture, illustrating different elements of the system and their connections

**Framework Overview:** Our framework, designed to be low-cost, energy-efficient, and scalable for water quality monitoring, was tested in real-world scenarios. It consists of three key components: an end device, a LoRa gateway, and a cloud server.

### End Device

- **Design:** Energy-efficient, battery-powered, using LoRa for long-range, low-power communication.
- **Controller:** ESP32 microcontroller with deep sleep mode, drawing 10 $\mu A$ for extended battery life.
- **Data Collection:** Sensors connected to an Arduino in a separate module for flexible deployment.

### Gateway

- **LoRa Gateway**: Installed near water bodies to establish communication between end devices and the cloud. It has a range of up to 10 km with an appropriate antenna.
- **Hardware**: We used the SenseCAP M2 Multi-Platform LoRaWAN Indoor Gateway, connected to the internet for data forwarding to the cloud.

### Cloud Server

- **Data Management**: The Things Network (TTN) manages and authorizes the data from the gateways.
- **Database**: Data is stored in an InfluxDB instance, optimized for time-series data.
- **Monitoring**: Grafana is used for real-time monitoring with customizable dashboards and alerts.

**Configurations:** We developed and tested different configurations for our end device architecture to find an optimal setting that reduces energy consumption, illustrated in Figure 2.

- **Configuration A**: ESP32C6 controller with a current draw of 93.078 mA.
- **Configuration B**: ESP32 and Arduino modules in deep-sleep mode, reducing current to 64.80 mA (43% improvement).
- **Configuration C**: ESP32 in deep-sleep, Arduino and LoRa modules off when inactive, lowering current to 7.82 mA (728% improvement).

## Experiments

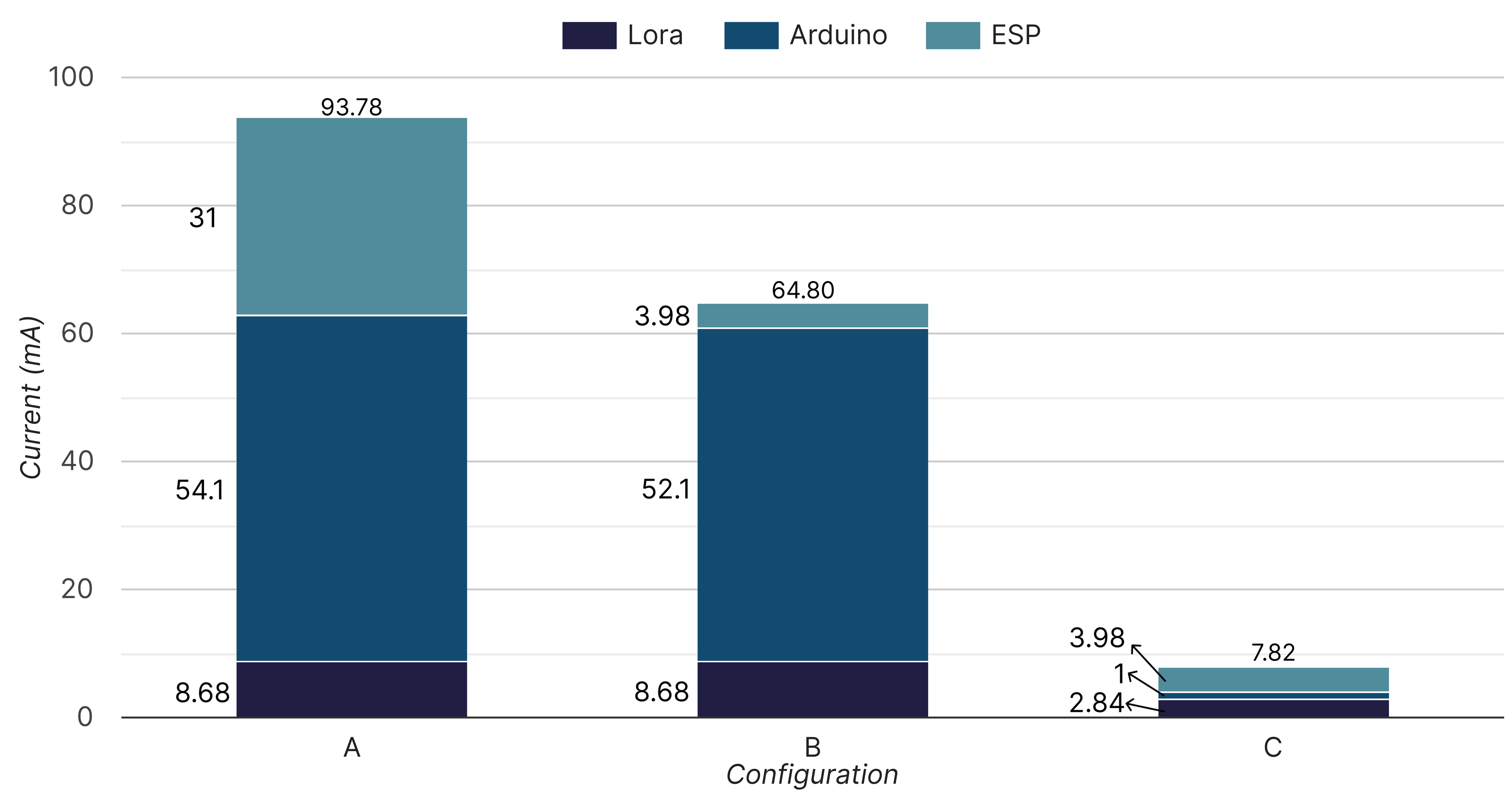


Figure 2. Long-Range IoT Water Monitoring Prototype and Deployment

**Lessons Learned:** During our Grand Lake, New Brunswick test, we faced several challenges.

- **Buoy anchoring**: Wind and tides caused the buoy to drift, making secure anchoring critical.
- **Watercraft interference**: Passing jet skis and boats posed risks, with curious individuals potentially tampering with the system.
- **Floating structure**: A reliable, waterproof floating structure is crucial for protecting the system's sensitive components.

## Use Cases of Water-Monitoring Framework

In this paper, we proposed a general water-monitoring framework to achieve various goals. Below are examples of use cases that require remote, long-term water monitoring systems.

- **Flood Monitoring:**
  - Our prototype can be installed upstream in rivers to monitor water levels, providing real-time data to warn decision-makers before a flood occurs.
  - Early warnings can help reduce potential damage to agriculture and protect lives in flood-prone areas.
- **Green Blue Algae Detection**
  - The prototype can detect blue-green algae (cyanobacteria), which are harmful to humans and animals.
  - low-cost turbidity sensors can be integrated to monitor cyanobacteria, enabling early detection of harmful algal blooms.
  - This provides a cost-effective solution for environmental monitoring.
- **Water Pollution Management**
  - Our system can be used to detect water pollution, such as sewage and contaminants in rivers.
  - Sensors for heavy metals and pH levels can be integrated to identify pollution and enable timely response, ensuring cleaner waterways.

## Conclusion and Future works

We designed and implemented a remote water monitoring framework to build and test a prototype capable of long-distance data collection and extended operation. Our prototype was tested at Grand Lake, NB, Canada, where we identified real-world deployment challenges. We also conducted a detailed analysis of power consumption and tested various architectures to ensure the system could operate for up to a year with a high sampling rate. Additionally, we explored potential applications of our system. Future work will focus on evaluating long-term performance, testing scalability, and collecting datasets from diverse locations to capture multiple marine cycles.

This work was supported by Ocean Frontier Institute Seed Fund and New Brunswick Innovation Foundation (NBIFEP2024-003).

alireza.rahimi@unb.ca