A Low-Cost IoT System for Water Quality Monitoring in Developing Countries

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***Abstract*—Continuous monitoring can allow early warning of abnormal behavior in water quality parameters for different uses. In developing countries where monitoring capacity is limited or absent, supporting water quality verification is essential. This work proposes a low-cost, real-time telemetry system based on Internet of Things (IoT) technologies to monitor water quality parameters. This work proposed an architecture for a wireless IoT system with a microcontroller, water sensors, Wi-Fi transceiver and a web application that allows monitoring from the internet. We implemented an early use case in water monitoring for aquaculture in El Salvador.**

***Index Terms*—IoT, Water Quality, Smart Cities, Sensor, Aquaculture**

I. Introduction

Water is vital for life on Earth. It is essential for biological processes. Statistics on global consumption reflect that 65% of water is used for irrigation, followed by the industrial sector with 25%, and domestic, commercial and other urban services consumption requires 10% [1]. In El Salvador, the State Secretary of Agriculture is responsible for ensuring the water quality used within the country. Access to good quality water is a human right. Therefore, supporting water quality verification is essential in developing countries with little or no monitoring capacity [2] [3]. In this local scenario, it is necessary to implement real-time data collection and analysis systems on water quality. Continuous monitoring can allow early warning of anomalous behavior in water parameters for different uses [4] [5]. This work proposes a low-cost, real-time telemetry system based on IoT technologies to monitor water quality parameters. An IoT node station equipped with sensors can take water parameter readings and send this data to an IoT platform for storage and web visualization. The proposed architecture for a wireless IoT system is based on a microcontroller, water sensors, Wi-Fi, and a web application that allows monitoring from the internet. We present a functional prototype of the IoT node and platform as a preliminary result of this work. Also, an early implementation of a use case in water monitoring for aquaculture is included.

II. A Low-cost IoT System for Water Quality Monitoring in Developing Countries

We present a low-cost IoT architecture and methodology for designing and implementing an IoT water quality monitoring system. The system consists of IoT nodes and a data platform for storing and visualizing water quality data. The IoT node monitors water parameters such as temperature, acidity (pH), and dissolved oxygen (DO). The IoT system must accurately measure water parameters, be easy to implement, and be cost-effective. The system must include wireless Wi-Fi connectivity, water quality sensors, and a cloud-based platform to store and analyze data to achieve these goals.

A. Purpose and Requirements Specification

The system provides comprehensive and automated water parameter monitoring in a pond, river or reservoir. Specifically, it monitors the temperature, pH and DO. Besides, it reports the results in real-time via a Wi-Fi link to a web dashboard. *System behavior:* An electronic station with sensors to measure parameters of water, composed of a programmable digital controller to take periodic readings from the sensors and a Wi-Fi radio transceiver to send the collected data to a web platform for online monitoring in real-time. The control software for the IoT station is coded in the C++ programming language and stored in the flash memory of the digital controller within the station. IoT platforms are used with applications that store, visualize, and analyze data generated by sensor stations. The control software for the IoT station is coded in the C++ programming language and stored in the flash memory of the digital controller within the station. IoT platforms are used with applications that store, visualize, and analyze data generated by sensor stations. The IoT station firmware starts a repetitive cycle upon booting. It configures IoT node hardware, reads the water parameters sensors, formats the data, and sends it to an IoT platform. This process is repeated periodically, see Algorithm 1. As an IoT platform, we use a low-cost and open-research ready-to-use service from Thinger [6].

B. Functional Specification

The functional architecture diagram for the IoT System is illustrated in Fig.1. *Hardware integration* of the IoT Node: we selected low-cost components, easy to integrate and with proven functionality, the ATmega328 microcontroller is used as CPU together a ESP8266 Wi-Fi transceiver with an external antenna. The sensors used are PH, DO and Temp probes with analog output interface. We use a Signal conditioning module

Algorithm 1: IoT Node Station Process Specification

Result: Periodically t read water parameters sensors then send it to IoT platform via Wi-Fi link

setup microcontroller hardware ; `// uC Board`
setup transceiver hardware ; `// Wi-Fi module`
setup I2C hardware ; `// sensors module`
connect to Wi-Fi network;
while *True* **do**
    read water parameters sensors output;
    format JSON payload with sensor & time data ;
    make a HTTP POST into web storage server;
    turn microcontroler deep sleep for t ;
    try again without delay t ; `// retry POST`

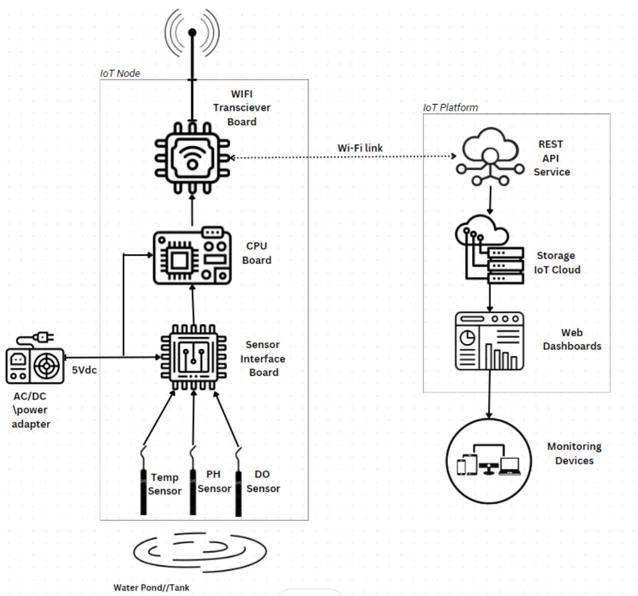

Fig. 1. Overview diagram of the system architecture.

to adapt analog output from sensors to I2C microcontroller inputs.

III. Water Quality Monitoring, a Study Case in El Salvador

We set up an early field test for the designed IoT system. One IoT node was deployed in a pond from *El Eden Tilapia Fish Farm* in Acajutla City, El Salvador. see Fig. 2. The test took one month, collecting data on three variables (Temp, DO, pH) and reporting to the IoT platform. The users can access an online dashboard to monitor the latest data collected and a historical record of that data, see Fig. 3. System performance during field-testing has been satisfactory so far. The Wi-Fi link has been stable and without data loss. The power supply on the farm was quite stable and interruptible.

IV. Conclusions

In this poster, we propose a low-cost architecture for an IoT system to monitor water quality parameters. The proposed architecture can be an efficient and low-cost alternative in developing countries with limited or no water monitoring capacity. We present an early implementation with promising results. We installed the IoT system in an aquaculture farm in El Salvador. For future work, we plan to incorporate more sensors for different types of water parameters. We will also consider using long-distance transmission links such as LoraWan, LTE, or NB-Iot to facilitate data collection and transmission. A solar energy harvest system is also planned to power the IoT Node. Additionally, we plan to perform more long-term field tests for the IoT system to collect enough data to analyze or forecast water quality or fish health.

Fig. 2. Filed test for the IoT System prototype.

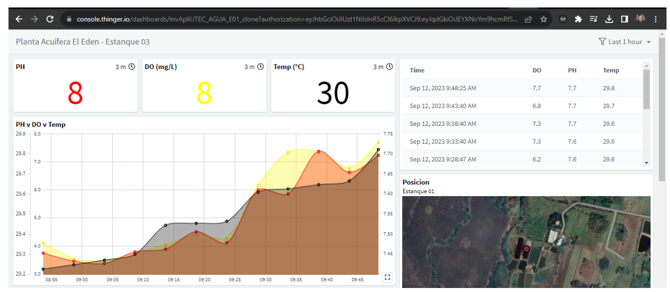

Fig. 3. Online data dashboard for the field test.

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