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準リアルタイム水質観測のための フリーオープンソースプラットフォームの開発

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Development Free and Open Source Platform for Near Real-Time Acquisition of Water Quality Parameters

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1. Introduction

Access to Open Source software and low-cost sensors have opened new opportunities for the design of real-time monitoring systems in several application needs. Water quality monitoring is crucial for effective environmental management. Therefore, it is necessary to design near real time water quality monitoring system for unattended data acquisition (Jiang *et al.*, 2020).

Geo-IoT platform with Android device for in-situ water quality measuring has been developed and tested in the previous study (Bandara *et al.*, 2020). The attempt of this study is to design an Open Source platform that is extendable and customizable for water quality monitoring. Therefore, in this study we provide an integrated solution for collection of water quality parameters for both human assisted in-situ measurements and continuous unattended monitoring.

We describe the framework of Open Source software tools that were implemented to collect, process, and visualize the data received by sensor devices in near real-time. The current platform was tested for monitoring four physio-chemical water quality parameters namely, pH, Oxidation Reduction Potential (ORP), Electrical Conductivity (EC) and Temperature.

The presented architecture can be exploited for various monitoring scenarios for both surface water and groundwater monitoring to identify trends of key parameters and provide alerts when recorded data values are beyond normal threshold situations.

2. Material and Methods

The sensor device comprises of a Raspberry Pi Zero W single-board computer (www.raspberrypi.org/products/raspberry-pi-zero-w), Atlas Scientific pH, ORP, EC, Temperature sensors and Tentacle T3 extension board (atlas-scientific.com). The data are logged locally on SD-card. Real-time data transmission is enabled using CANDY Pi Lite+ communication board (candyline.com/portfolio/candy-pi-lite-lte-m) and IIJmio IoT SIM (www.iijmio.jp/mit). Sensor device leverages above mentioned components to develop data logging system. Connectivity between each of the peripheral and single-board computer is illustrated in Figure 1.

In the continuous unattended monitoring scenario, the sensor device sends data directly to the ThingsBoard (thingsboard.io) platform over the internet. In the human assisted water quality monitoring scenario, the sensor device connects to Android phone via Bluetooth. Open Data Kit (ODK, getodk.org) is as an interface for field data collection. ODKSensor app is newly developed to integrate data from water quality sensors with ODKCollect data collection form.

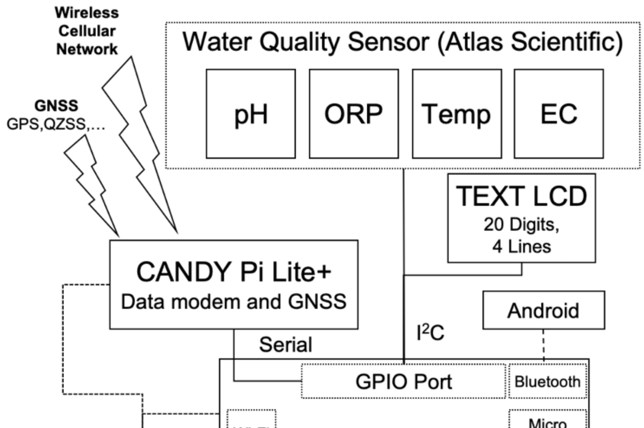

Figure 1: Details of data logging system

3. System Design and Workflow

Overall system design consists of assembling sensor devices with single board computer, implementing wireless transmission, software integration and development. The functions of system can be broadly be divided as client and server components. The client side for unattended continuous data acquisition consists of main sensor device and communication module. The client side for human assisted data collection includes the same sensor device without CANDY Pi Lite communication board. Android device is connected to sensors via inbuilt Bluetooth module in Raspberry Pi Zero W single-board computer for data transmission. ODKSensor app is integrating sensor values into ODKCollect form fields.

At the Server side, the ThingsBoard Open Source IoT platform is deployed for device management, data collection, processing and visualization. The data collection via Android mobile is supported using ODK-Central Server.

A middleware solution was deployed to facilitate communication and interoperability between ThingsBoard and ODK-Central. The middleware provides as a hidden translation layer for seamless data visualization on the Thingsboard dashboard.

PostgreSQL (www.postgresql.org) is used as a backend database for both ThingsBoard and ODK-Central. Integration of server side components is shown in Figure 2.

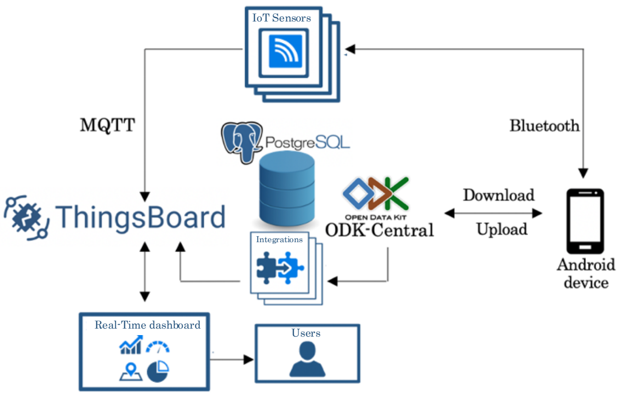

Figure 2: Software integration and system architecture

Current sensor device is configured to collect data in at predefined intervals for continuous monitoring scenario. The timestamp from the sensor device and recorded sensor readings are uploaded to the server using MQTT (mqtt.org) messaging protocol for IoT. Data stored in the PostgreSQL database is instantaneously displayed on ThingsBoard dashboard.

In the human assisted data collection scenario, the data is gathered using ODKCollect mobile application. First, the fields for sensor data is defined in the XLS form (xlsform.org). The developed XLS form is uploaded to ODK-Central server. Subsequently, the data collector can download XLS form to an Android phone. The ODKSensor app connects to sensor device via Bluetooth and populates the ODKCollect form with the sensor readings. Data from mobile phone can be uploaded to the server individually or as a collection of data points once the internet is available. The middleware application is triggered when ODK-Central receives data form Android device and data is automatically displayed on ThingsBoard dashboard.

4. Results

Numerous experiments were carried out to monitor the system's behaviors and functions. The system kept in continuous operation for 48 hours. Data received from the sensor device can be visualized on a customizable web-based dashboard. Figure 3 depicts the screenshot of the Thingsboard dashboard.

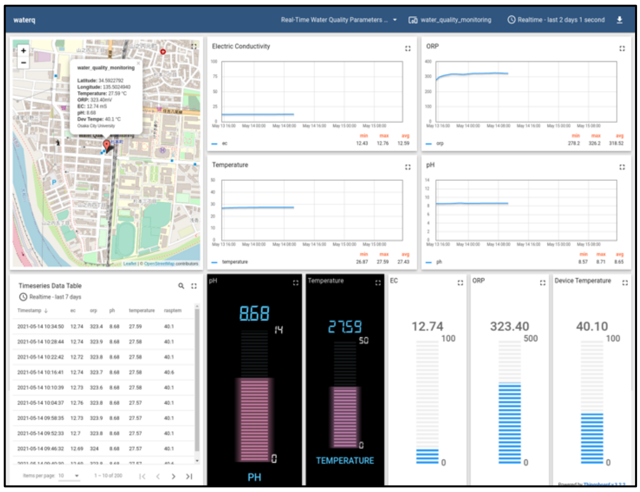

Figure 3: Data visualization on ThingsBoard dashboard

Users can visualize present data or set the dashboard to visualize past data with a given hour or date. Information that supports the interpretation of water quality data is visualized as time series line charts, digital gauges and tables with timestamps in the panel. The spatial location of data collection is shown on the map with background OpenStreetMap layer.

5. Conclusion

Survey of available water quality monitoring solutions reveals that existing platforms are either designed for field data collection or to support unattended continuous monitoring. Few systems permit multi-purpose uses (Skarga-Bandurova *et al.,* 2020). However, these systems are not capable of fulfilling the requirements of complete client-server platforms to support data management needs. The system developed in this research provides a comprehensive, generic, and multi-purpose solution for remote data collection needs. Moreover, the system can be easily customized for a variety of real-time environmental monitoring.

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