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A Portable Low-Cost COTS-based Water Quality Monitoring System

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Abstract- This paper introduces a low-cost, portable water quality monitoring system for a study, user, and water distribution systems as well. This system consists of a main controller mounted on a Commercial Off - the-Shelf (COTS) single-board computer and fitted with an LCD touch screen for viewing data information; a central measurement unit is attached to a multi-parameter sensor array to collect data from the environment and a connectivity unit that links the sensor interface to the Internet. Portable water monitoring system dimensions are 38 cm x 12.8 cm x 8 cm, with a weight of 658gr. We measured from the experiment that the delay in data processing is 1 second and communication delay is only 2 seconds with internet connection of 3.1Mbps. Water pollution is one of ecological globalization's greatest threats. Thanks to waterborne diseases, water pollution impacts human health. Necessary steps must be taken to prevent water pollution. First step is to estimate water parameters such as pH, turbidity, conductivity, etc., as the variations in these parameters ' values point to pollutant presence. In the current scenario, water parameters are detected through the chemical test laboratory test, where the test equipment is stationary and samples are provided for test equipment. Thus, it is a tedious and time-consuming manual system.

Keywords- COTS, Portable low cost, water monitoring system, LCD,

INTRODUCTION

People need clean drinking water in their daily lives as is a critical resource, and water is also important for health. The real-time operation of drinking water utilities poses many challenges due to limited water resources, growing population, high-cost maintenance, infrastructure degradation functionality, regulatory complexity, and water supply threat from accidental or deliberate contamination. Comparing existing laboratory-based methods, online water monitoring systems are too slow to develop operational response in order to support operations at water utilities and do not provide a level of real-time public health protection. For the water monitoring system to support human health, real-time monitoring device with portability feature, ubiquity, accurate detection to some instances of contamination is important. It is no longer considered efficient to manually take water samples at different times for water quality control at different locations, followed by laboratory analytical techniques to characterize water quality.

By using chemical and biological agent, the current methods of analysis also have several disadvantages:

- Labor intensive and relatively expensive (labor, organizational and equipment)
- Inadequate coverage (small sampling sites)
- Lack of real-time water quality information to allow important public health decisions (long-term discrepancies between sampling and pollution detection)
- Lack of portability (no portable device) integrated with Big Data architecture.

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This paper suggests the concept of tracking the quality of water supplied to customers, utilizing low cost, low power and compact sensors focused on Commercial off the-shelf (COTS). The main contribution of this paper is the prototype of a low-cost machine that can be used at the site or position of customers to continuously track qualitative water parameters, portability platform that can to travel or mobility, modularity framework that offer multi-flexibility to the user and integration with Big Data architecture via Web. The contributions to the low-cost system in particular are the design and development of low-cost portable networked embedded systems combined with water quality monitoring sensors, the development of modularity system to enhance functionality, integration with big data architecture. In particular, the contributions regarding the low-cost system is the design and development of low-cost portable networked embedded systems combine with water quality monitoring sensors, the development of modularity system to increase functionality, integration with big data architecture.

SYSTEM DESIGN

Fig. 1 Display the overall system design and comprises of the following three subsystems: a central measuring unit (ARM MCU-based board)[1], [2] that gathers water quality measurements from sensors, applies a water quality monitoring algorithm and transmits results to other devices, a control unit (ARM SBC-based board) stores measuring data from the central measuring unit in a CSV format, Provides a 5V DC battery display and powered by a power bank, a communication unit consists of a CDMA modem connected to an Internet device and sends data to a cloud server.

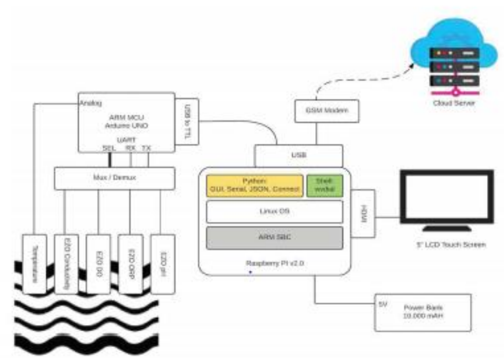

Fig.1: System Architecture

1. Central Measurement Unit:

The main measurement device[3], [4] is interfaced with the pH, ORP, Dissolved Oxygen, Conductivity, and Temperature multipara meter sensor array. The sensors we used are the ENV-SDS package and the Mux / Demux system for accessing multiple sensors is the Multi Circuit UART. All devices come from Atlas Scientific. From the Mux / Demux device connected to the Arduino UNO ARM MCU computer and from the Arduino UNO analog port linked temperature sensor. This Arduino UNO gathered sensor data and then transmitted the data to the Control Unit. Using USB-to-TTL, Arduino UNO connected to the Control Unit. Arduino UNO read sensor data (CSV) with the order: ORP, pH, Conductivity, DO and Temperature.

2. Control Unit:

The control unit[5], [6] for this computer is the main processing chip. Raspberry PI ARM Single-Board Computer (SBC) version 2.0 was used by the control unit. The Raspberry PI is powered by a power bank of 5V DC 10,000 mAh. The control unit is attached to the Raspberry PI with a 5 "LCD touch screen connected via HDMI port, as well as a 40 pin board. We used Smartfren CE682 modem connected via USB port for communication. Raspbian OS with version 3.18 is the software environment we used in the device. We built Python scripting language and BASH shell for application development. We used Python library function to develop GUI application, Serial communication to read Arduino UNO data, JSON modification, and operating system command

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as well. We built our own Python-based application to read sensor data, send data to Big Data server, save data in local storage using CSV format, special LCD touch screen GUI to help users use the device as user-friendly as possible, and connect easily to the Internet using CDMA modem as seen.

3. Communication Unit:

The communication unit[7], [8] is a communication device that can send any data to the cloud server from water quality sensors. The device of the communication unit is CDMA Modem; the type we used is Smartfren CE682 connected to the USB port and capable of connecting to the Internet with a throughput of around 3.1 Mbps. To activate the modem, we used the wvdial command from the shell.

IMPLEMENTATION

In this segment we discuss the hardware and software engineering implementation as well as the findings of the conducted experiment.

1. Implementation:

Fig. 2 displays the installation of a COTS[9], [10]-based portable water quality monitoring system. The portable monitoring system for water quality consists of three parts or structures: a) part of the battery, b) main part, and c) modular part. We put 10,000 mAh power bank inside the battery case part, mainly consists of RaspberryPI as the main controller unit and LCD touch screen, and modular components such as water quality sensors are attached to the outside of the main part. With this design we hope that with different sensors or other communication devices we can change the module part in the future.

Fig.2: Portable Water Quality Monitoring System

The algorithm of the application:-

```
Python import Tkinter, serial, thread, subprocess,
time, os, request
function GETSENSOR
    result = read.serial          ▷ Read data from serial;
    orp = result[0]
    ph = result[1]
    con = result[2]
    do = result[3]
    temp = result[4]
end function
function MODEMCONNECT
    system(wvdial smart)          ▷ Connecting modem;
end function
function DATAPROCESS
    getsensor()
    gettime();
    save CSV
end function
function SEND
    getsensor()
    request dweetIO()             ▷ Upload to DweetIO;
    save CSV
end function
loop
    root=tk.Tk()
    prepare label
    if Button = connect then
        modemConnect()
    end if
    if Button = data then
        dataProc()
    end if
    if Button = Send then
        send()
    end if
end loop
```

The configuration of the sys-temp testing of portable water quality can be seen in Fig. 3. The measurement of the water portable monitoring system is 38 cm x 12.8 cm x 8 cm and the weight is 658gr. On Fig 4 you can see the dimension for each component. 4. The LCD touch screen was used by the portable water monitoring system, and the system's GUI uses a large button model to help the user control the

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device. Fig. 5 Shows about the portable water monitoring system user interface.

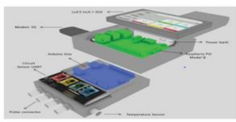

Fig.3: Structure of PWQMS

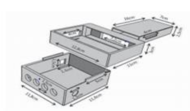

Fig.4: Dimension of PWQMS

Compared to the similar device on the market, the cost of portable water monitoring system components is quite low. Table I displays the expense definition. Total deployment expense is about IDR 13, 758, 000.

No	Part	Item	Qty	Price (IDR)
1.	Main	Raspberry PI 2 Model B	1	Rp. 600.000,-
		LCD Touch Screen	1	Rp. 690.000,-
		SD Card 8GB	1	Rp. 58.000,-
2.	Modular	ENV-SDS Kit	1	Rp. 10.600.000,-
		Mux/Demux	1	Rp. 316.000,-
		USB-to-TTL	1	Rp. 45.000,-
		Rainbow cable	1	Rp. 15.000,-
		Modem	1	Rp. 99.000,-
		Arduino	1	Rp. 180.000,-
		USB Hub cable	1	Rp. 30.000,-
3.	Battery	10.000 mAh Powerbank	1	Rp. 125.000,-
4.	Case	3D Print Prototype	1	Rp. 1.000.000,-
Total				Rp. 13.758.000,-

Table.1: The Cost of Portable Water Monitoring System

Experimental

Fig. 6 displays an experimental river-side portable water monitoring system[11], [12]. For experimental purposes, we have not compared the results of our sensors with other systems, as there are many papers that have already discussed the results and the accuracy of Atlas Scientific Sensor is 99%. We tested battery performance; the power bank is 10,000 mAh in this case. We did the experiment by running the system to gather data by booting every 1 second until the battery went out. The portable water monitoring system was able to run up to 270 minutes with that power and was able to collect data up to 1616 levels.

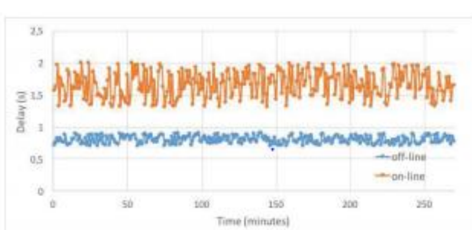

Fig.6: Experiment

CONCLUSION

We developed a portable water monitoring system consisting of a main controller unit with Raspberry PI equipped with an LCD touch screen, a modular unit with an Atlas Scientific sensor kit, as well as a 3 G modem for sending data to the cloud server and powered by Power Bank 10,000 mAh. Portable water monitoring system measurements are 38 cm x 12.8 cm x 8 cm, with a weight of 658gr. The device supports modularity, which implies that with different functions we may alter the modular component. It was possible to collect data from sensors every 1 second from the new, portable water monitoring system. And also by utilizing CDMA modem communication, the latency contact is about 2 seconds. With this pause, we can still change the data quickly. Powered by a battery of 10,000 mAh, this device can run for up to 4 1/2 hours (270 minutes).

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