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Real Time Monitoring of Water Quality in IoT Environment through Android Application

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Abstract

Access to clean water is Human Rights. However, insufficient protection of water sources, non-existent water quality monitoring system or use of water quality monitoring system with considerable delays, as well as inadequate treatment of water puts the community at risk of different infectious diseases. To ensure the quality of drinking water, real-time monitoring of the supply water is necessary. This paper presents a Real-time Water Quality Monitoring System based on Internet of Things (IoT) where the water supplier and consumers can directly monitor the quality of the water through android, and web-based application and the administrator, as well as the end-user, can get an alert if there is any problem in the quality of the water to take necessary action. The IoT setup connected with several online sensors which measure the physical and chemical parameters of water such as Temperature, Conductivity, pH, Oxidation Reduction Potential (ORP), Dissolve Oxygen (DO) and Turbidity. The measured parameters can push to the cloud layer of the IoT through the edge controllers. By sending a request an end-user and administrator can check the quality of the water through web-based as well as android based Applications with the help of cloud for real-time monitoring. An automatic alert comes to the water supplier through android application when the sensor value deviates from its normal drinkable range of water as Mentioned by Bureau of Indian Standards (BIS). Index Terms—Internet of Things, Cloud Computing, Edge Controller, cloud server, Android, Water Quality Parameters.

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I. INTRODUCTION

Access to safe drinking water is crucial for human health. Every 3 in 10 people lack to manage access to drinking water [1]. Globally, around 2 billion people use drinking water source contaminated with feces, and by 2025 half of the world's population will be living in water-stressed areas [2]. The voluntary introduction of contaminants in drinking water can lead to malicious acts and the reason behind human death [3]. For that reason, real-time monitoring of the water quality is required to ensure proper water quality supply as well as to take early action in case of any water contamination [4-7]. Real-time detection of water contamination is a complex task [8], due to a wide variety of contaminants in water like biological and chemical. The traditional approach of water quality involves the manual water sample collected from different locations, followed by laboratory analytical techniques to detect the quality of the water. Such approaches take longer time and not efficient, where real-time response is required [9-13]. Therefore, there is a demand for continuous online water quality monitoring to check the quality of water. There are a few papers where the system performs real-time water quality monitoring. However, some systems are manual handheld devices, and some other systems are IoT based real-time system only to measure the parameters of water [14].

A step forward this paper focuses on automated real-time IoT based water quality monitoring system which can give pre-emergency alert to the water supplier and end-user through web and android application when the smart sensor deviates its value from the normal drinkable range as mentioned by Bureau of Indian Standards (BIS) [15]. Moreover, there is a web and android application where the end-user and supplier can check there daily, weekly and monthly water quality of individual biological and chemical parameters value of water given by smart sensor attached with the system. Also, through the android application, the end-user and supplier can check the live data of the water quality parameters. In this paper, raspberry PI3 is used as an edge device (controller). The controller fetches the sensor data connected with the system and sends it to the cloud. The sensor data can be viewed on the cloud using ThingsBoard IoT platform. Additionally, the IoT module also provides Wi-Fi for viewing the data on android application and web application.

The rest of this paper is organized as follows: Section II represents the overall system architecture of the proposed method. Section III shows the experimental setup and results from the analysis. Section IV shows the conclusion and future scope of the proposed system.

II. PROPOSED SYSTEM ARCHITECTURE

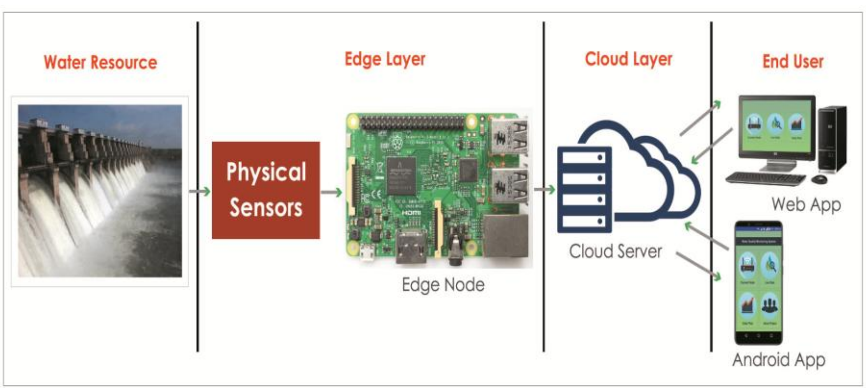

Figure 1. Architecture for IoT Water Quality Monitoring System with pre alert in emergency

The proposed system architecture divided into four parts: the source layer, edge layer, Cloud layer, and the end-user as shown in Figure 1. The source part here is the water resources who need to test in real-time. The edge layer holds the smart sensors to sense the biological and chemical parameters of the water as well as an edge node as a controller which fetches the sensor values and push into the cloud. As an edge node/controller, pi3 is used. The third layer is the cloud layer, which always stores and processes the sensor data accessed from the edge node. The last layer is the end-user layer, where the end-user can check the quality of the water by sending a request to the cloud through android or web-based application. The end-user can get an automatic alert from the cloud if the smart sensor data deviates from the normal range and behaves abnormally.

III. Experimental Setup and Results

2.1 Experimental Setup

To perform the experiment, direct tank water preserved in a reservoir is taken as an input source. To measure the water quality parameters turbidity, ORP, DO, Temperature, and Conductivity sensors are used in the edge layer. The edge node is a Raspberry Pi3 with Raspbian operating system, kernel version 4.14 (CPU configuration 1GHz and 1GB RAM) onboard connectivity with wireless LAN and Bluetooth. The cloud layer contains a Virtual Machine (VM) which is working in the windows environment with the specification of 4 cores 4GB of RAM and windows 10 Operating system. The cloud layer receives the data from the edge in JavaScript Object Notation (JSON) through REpresentational State Transfer (REST) Application Program Interface (API). Python program is running at the edge as to push the data to the cloud. Cloud system runs with ThingsBoard IoT platform to store the data in it. The end-user communicate with the cloud through JSON request and response.

To make the system real-time and to monitor the water 24X7 a self-navigated solar-powered buoy having slots to install multiple sensors in bay access to water sample has been placed inside a small reservoirs at the author's institute which is represented in Figure 2.

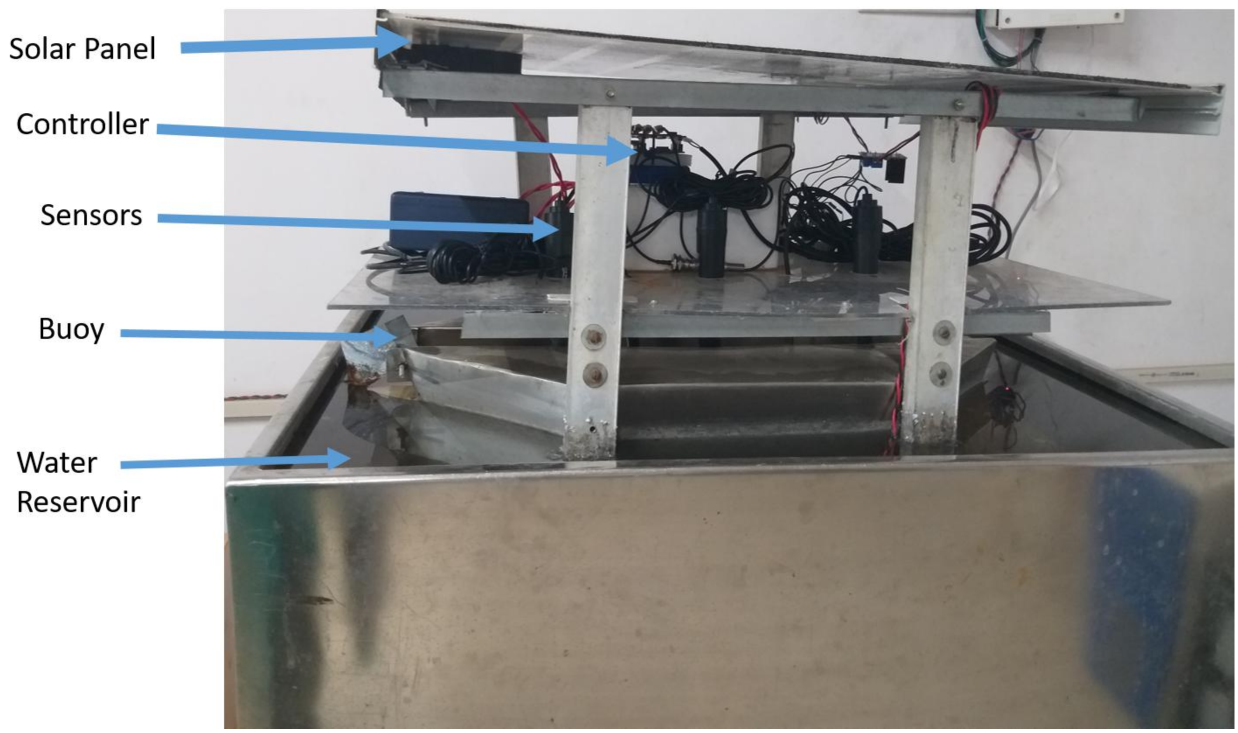

Figure 2. Buoy with Complete IoT setup

The smart sensors have been placed in the assigned slot of the buoy. Here the controller (Pi3) act as an edge node helps to fetch the sensor data in every fifteen minutes and push it to the cloud. The cloud sends an emergency alert to the end-user automatically at the point of

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requirement. Or view the sensors data where there is a request from the user.

2.2. Result and Discussion

The water quality monitoring is essential for several applications such as monitoring of drinking water distribution, pond, and ecosystem, contamination Detection in drinking water. In this paper, the proposed system can monitor the water quality parameters through the web application and android application. ThingsBoard IoT platform is used as a cloud server in the proposed system. The data are pushed into the ThingsBoard from edge node through Http post request. For the end-user, the real-time data are showcases through the dashboard. These parameters can view in the android application by fetching the stored content from the cloud with the help of JSON request and response. Internet connectivity is necessary to access the data from the cloud through android applications. Figure 3 shows the latest water parameters stored in the cloud server with the latest entry information like last update time, sensor names, and values.

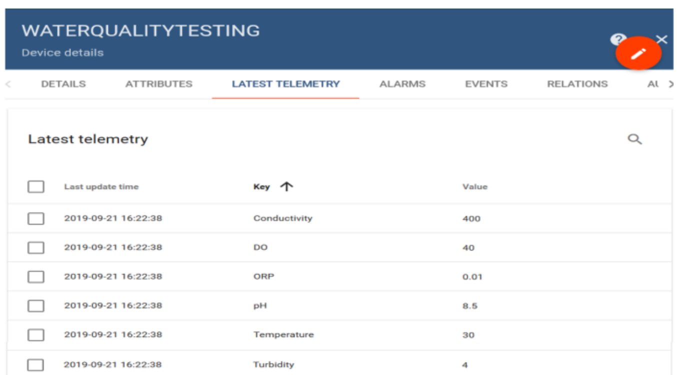

Figure 3. Data storage view of the cloud server

The real-time values of the sensors are visualized to the end-user through the dashboard; the representation is shown in Figure 4.

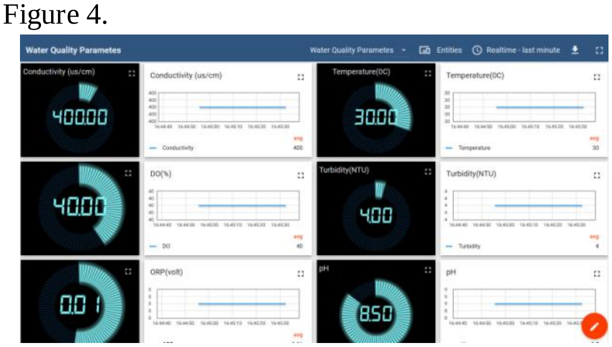

Figure 4. Data Visualization to the end-user through Web

Figure 4 represents the real-time user view. Here the user can check the real-time sensor value with a smooth interface. The digital gauge shows the recent real-time data, and the graph shows the real-time historical value of each parameter. The edge device pushes the data to the cloud in every 15 minutes, so the dashboard data is changed in every 15 minutes. However, any time can be fixed to push the data into the cloud from edge according to the requirement. Instead of the web application, the end-user can check the real-time data through an android application, the main page of the application is shown in Figure 5.

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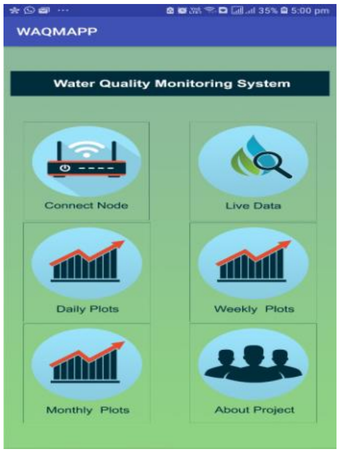
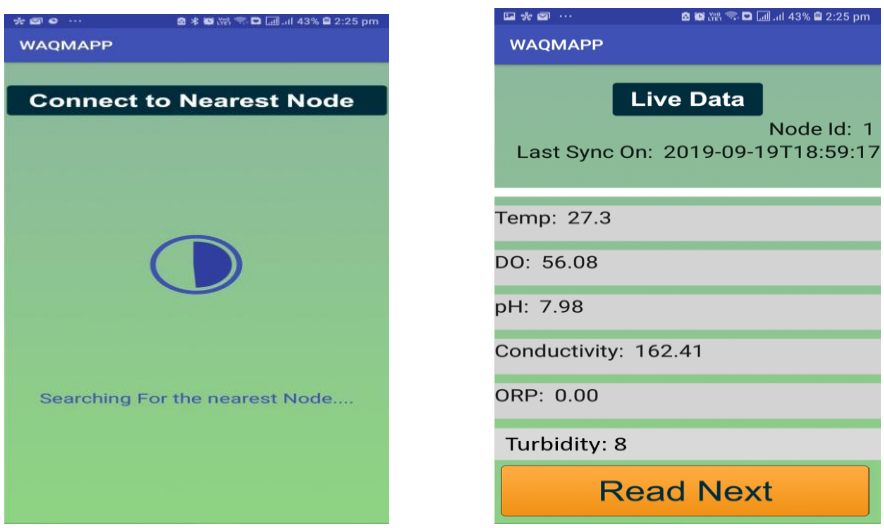


Figure 5. Main page after Login to the application

Here in Figure 5, there are five main modules such as Connected Node, Live Data, Daily Plots, Weekly Plots, and Monthly Plots. If the connected module is selected, it searches for the nearest edge device, as shown in Figure 6. (a). If the nearest node found, the connection is established through Bluetooth (Bluetooth automatically turn on for search through the android app) then fetch the data directly. It displays the live data of that particular node to the end-user once the connection got established, which is shown in Figure 6. (b). If there is no nearest device, it displays a message "no nearest node found" after complete scan for the nearest device.



(a) (b)

Figure 6. (a) Searching for nearest edge device (b) Recent data of all water parameters

A user can check the recent entry of the cloud directly through the "Live Data" module. Here the end-users can check the live water quality parameters of any particular node selected by the user, as shown in Figure 6 (b).

In Figure 6 (b), the "Read Next" value is to access the recent data from the cloud each time whenever required. Through the android application, the end-user can also check the daily, weekly, monthly individual water quality parameters values by selecting the date. The daily graph plot is shown in Figure 7.

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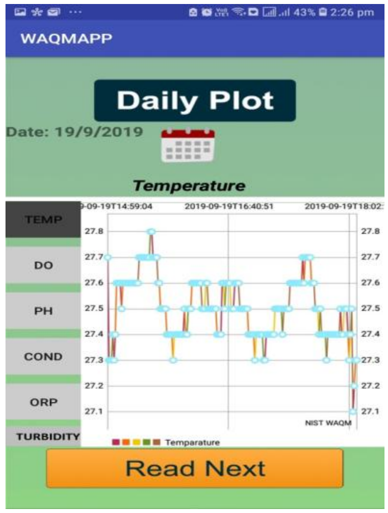
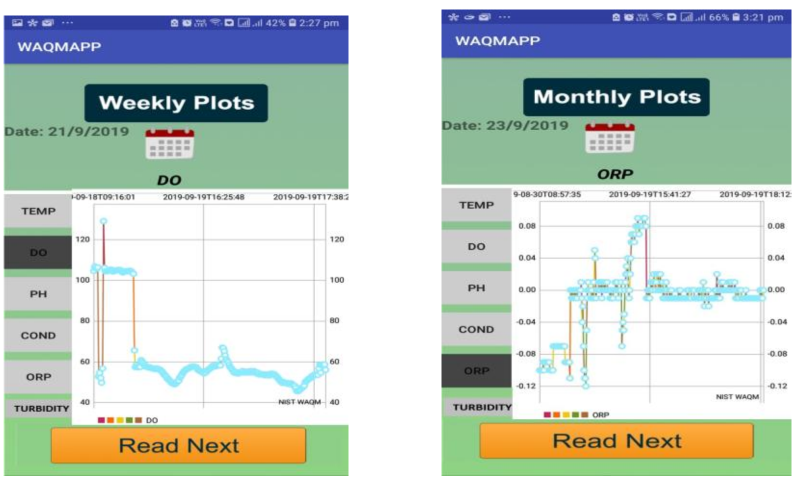


Figure 7. Water Temperature pattern for a particular day

From the above Figure 7, the user can check the water temperature pattern of the daily consumed water. Similarly, the user can monitor all other parameters' daily quality patterns. Here, the selected parameter is highlighted in dark grey color. In the same way, the user can monitor the weekly and monthly consumed water quality pattern of individual parameters by selecting the corresponding modules represented in Figure 8 (a) and Figure 8 (b).



(a) (b)

Figure 8. (a) Water DO pattern of a week selected by the user (b) Water ORP pattern of a monthly selected by the user

In the above Figure 8 (a) and (b), DO pattern is shown for the weekly plot, and ORP pattern is represented in the monthly plot. The weekly graph shows the last 7 days data from the selected date. Similarly, in monthly data, the applications show the last 30 days data from the selected date.

If the water quality parameter is not in the drinkable range, the android application gives an alert to the user or supplier whoever installed the application in his/her mobile through a notification and creates alarm from the cloud. The parameter relation establishment in the cloud to send an alarm and notification is shown in Figure 9 and Figure 10.

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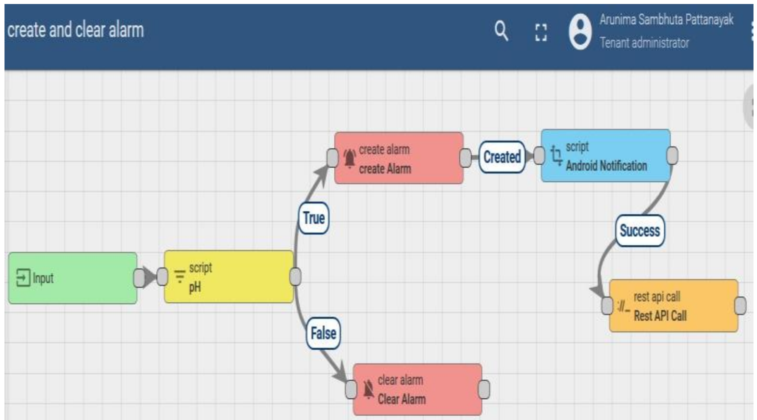

Figure 9. Alarm Creation and Notification to the android app during the critical pH value of water

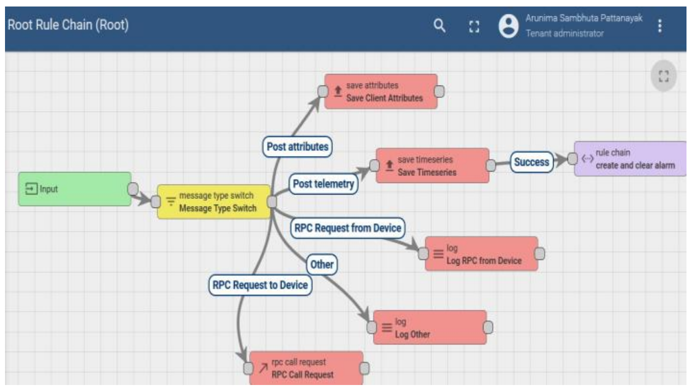

Figure 10. Created Notification rule chain added to default root rule chain

Figure 11 is created to generate the alarm and give notification to the user through the android application if the pH values deviate from the drinkable range. The created rule chain of Figure 11 is added to the default root rule chain of Figure 12 for functioning the defined function inside it. This notification is for the user to get alert about the water quality immediately. The system also sends an auto-generated mail to the administrator to check the quality of the water.

The proposed system is completely automated and run throughout the day with a power back up through solar power and battery.

IV.CONCLUSION

This paper presents a complete setup of the real-time water quality monitoring system with IoT. The proposed system contains few sensors to measure water quality parameters, Raspberry PI3 with inbuilt WiFi and Bluetooth connectivity as an edge device (controller) and ThingsBoard IoT platform as the cloud. The system gives an emergency alert through an android application in critical condition. The data visualization of the system is performed through a dashboard and also through WIFI to android device. This implementation is suitable for monitoring water quality in real-time. It can be installed in the pond of several locations and in the water distribution network to collect water quality data for analysis purpose in future.

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