IoT Based Water Usage Monitoring Application
(IoT Based Water Waste Awareness Application)

Abstract

Nowadays, minimizing the effects of drought and water shortages is one of the major challenges for many countries around the world. Even though our need for fresh water sources is always increasing because of population and industry growth, the supply of water remains constant. To help to preserve water, a real-time water waste awareness application has been developed. It focuses on monitoring the usage of water, proposing an effective way of controlling the wastage of water at home or industries by switching the color of the wireless light bulb. A water sensor is placed at the partition of the pipeline from where the water gets diverted to various part of a block, and the wireless light bulbs can be placed anywhere you want. The concept of IoT is to track and send the real-time water usage data to Cloud server when the sensor senses the flow of water from each pipe. The user can easily see water usage through the web or mobile application with an internet connection. Then based on the usage data the light bulb should change the lighting colour. The changing light colour will reflect the water usage for that day, which will make the residents aware and more responsible for their usages.

Keywords – IoT, Water management, Real-time, Wireless, Sensor, Alert, Limiting use.

Introduction

There's nothing more essential to life on Earth than water. Yet, from Cape Town to Flint, Michigan, and from rural, sub-Saharan Africa to Asia's teeming megacities, there's a global water crisis. Drinking water remains inaccessible to 1.1 million people globally. Safe and readily available drinking water is important for public health. Improved water supply, sanitation and better management of water resources can boost countries' economic growth and can contribute greatly to poverty reduction.[1]. Water conservation requires forethought and effort, but every little bit helps. We can all make changes in our lifestyles to reduce our water usage.

Traditional water meters are used to calculate the amount of water usage at home for billing purpose. Water waste awareness application can be used to help user being aware of the usage of water in daily life. Hence it is necessary to modify the traditional water meters for the users to continuously monitor their water usage. With this thought, this project focuses on monitoring the usage of the water by particulate house block and sending the data to Cloud through the Internet of Things (IoT) space. The users can see a real-time dashboard which displays current water usage through the web or mobile application with an internet connection. Meanwhile, the wireless light bulb will switch the lighting color, as the user will be reminded whether he reached the limitation of usage. People will start using water carefully and will probably stop overusing water.

This paper will start with a detailed explanation of the approach. It is followed the application architecture and the implementation. The paper then highlights its results and its conclusion.

Related works

An IoT based water management for measuring the water usage based on usage of house pipe connected through multiple water sensor is proposed in [2]. This application is using Arduino and water flow sensor to track the water usage and send the data to Cloud and through Cloud sent to a mobile application as well. However, the paper did not include notification system to warn the users regarding their water usage, and it didn’t mention how past data are managed such as clean-up schedule of data.

Paper [3] discusses the development of the water monitoring system for various purposes by using Arduino. Automated water usage monitoring system proposes an effective way of controlling the wastage of water at home/Industries by means of Wireless sensor nodes and LabVIEW software. Sensor nodes are placed at every water outlet sensing the flow of water, the server collects the data through Wi-Fi/LAN to process and track usage and wastage of water at every outlet. When water is used at excess it is indicated and an alert mail is sent to the user. The user can continuously keep a track of the water usage or wastage through a mobile or laptop with an internet connection. However, Sajith and V.Nithya’s approach didn’t include any methods of storing data locally. When the network is disconnected, their data will be lost.

A household water supply monitoring and billing system are proposed in paper [4]. Arduino was utilized in this project along with double relay for automation of the switching feature and water level sensors and water flow sensors was used to detect the level and the amount of water used respectively. The feature of this project is automatic switching of the DC water motor based on the level of water present in the reservoir along with the display of the amount of water used in each block by using LCD Alphanumeric display. They used the motor to turn the taps automatically such as full water levels or halt warning for further water pumping. But they failed to mentioned any specific alert system to notify the user to manage water usage.

The author of paper [5] presents an IPv6 network connected IoT design for real-time water flow metering and quality monitoring. their prototype implementation uses CoAP for monitoring and control approach which supports internet-based data collection. At the same time, they measure the quality of water distributed to every household by deploying pH and ORP sensors. In order to visualize all of the data, they create a web application to show a detailed diagram and calculate the monthly bill. This approach has the same issue in Paper [3], their data would be lost if Internet access has been interrupted.

Based on pervious work done by other researchers, I decided to set up the Raspberry Pi, water flow sensors to wirelessly collect water usage data while storing the data locally at the same time. The data will be pushed into Power BI Streaming Real Time Dashboards and users are able to check the real time consumption of the water at home. Meanwhile, based on the usage data, a Philips IoT light bulb would change the lighting color, which reflects the water usage of the day. This approach should increase the awareness of the water consumption of the household.

Methodology

I. Experimentation (Components Used):

1. Water flow sensor

Water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. This pulse reading by flow is calibrated in L/hr by a simple formula. The flow range of this sensor is 1-30L/MIN and water pressure is less than or equal to 1.75MPa. The water flow sensor is shown in Figure 1.

Figure 1: Water flow sensor

When water flows through the rotor, the rotor rolls. Its speed changes with different rate of flow. Installing the sensor on the water pipe to measures the water usage and process by Raspberry Pi. To the water flow sensor, there are three wires, red wire that is for 5V VCC, black color wire for GND, and usually yellow color for the signal/pulse line. For clear understanding refer to Figure 2.

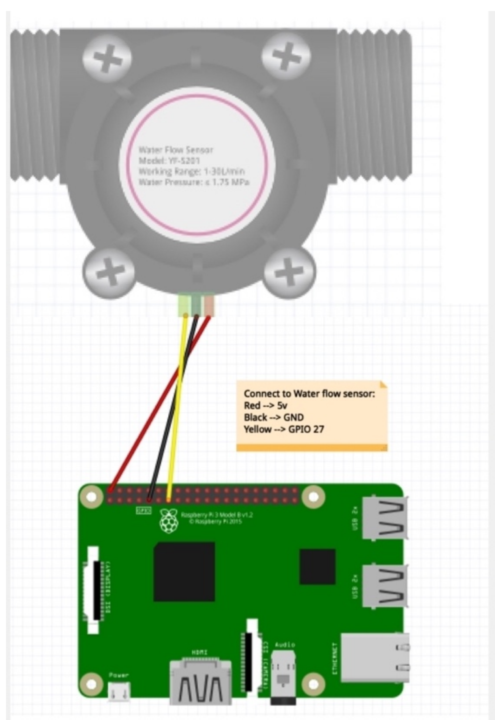


Figure 2. Pin configuration for water flow sensor

2. Raspberry Pi 3 Model B

Raspberry Pi 3 Model B is a series of small single-board computers with a 1.2 GHz 64-bit quad core processor, onboard Wi-Fi, Bluetooth and USB boot capabilities [6]. Internet of Things converging with cloud computing offers a novel technique for better management of data coming from different sensors, collected and transmitted by low power, low-cost ARM-based minicomputer Raspberry Pi [7]. This is used to connect and complete the main circuitry of the monitoring system. The Raspberry Pi 3 Model B is shown in Figure 3.

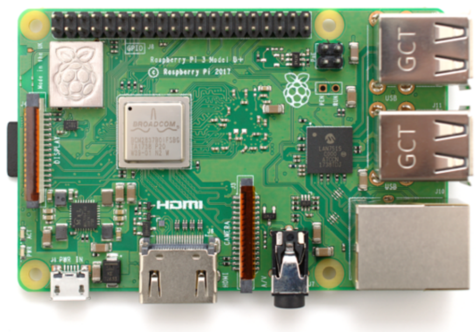


Figure 3. Raspberry Pi 3 Model B

3. Philips Hue Smart Bridge

Philips Hue Bridge is based on ZigBee, a low-power and reliable technology to control lights. This hub is the main controller to enables the user to control all of Philips Hue products. The Philips Hue Smart Bridge is shown in Figure 4.

Figure 4. Philips Hue Smart Bridge

4. Philips Hue Ambiance White and Colour Extension Bulb A19 E26

This light bulb produces high-quality white and coloured light with 16 million colours and tuneable white light. Tune, dim and control Hue with connecting Philips Hue bridge. The Philips Hue Ambiance White and Color Extension Bulb is shown in Figure 5.

Figure 5. Philips Hue Ambiance White and Color Extension Bulb

5. LCD Display

A 16x2 LCD display which is used for data representation current water usage. The 16x2 LCD display is shown in Figure 6 and Pin configuration for the LCD display is shown in Figure 7.

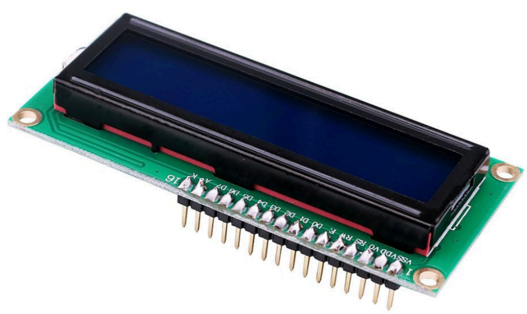


Figure 6. 16x2 LCD display

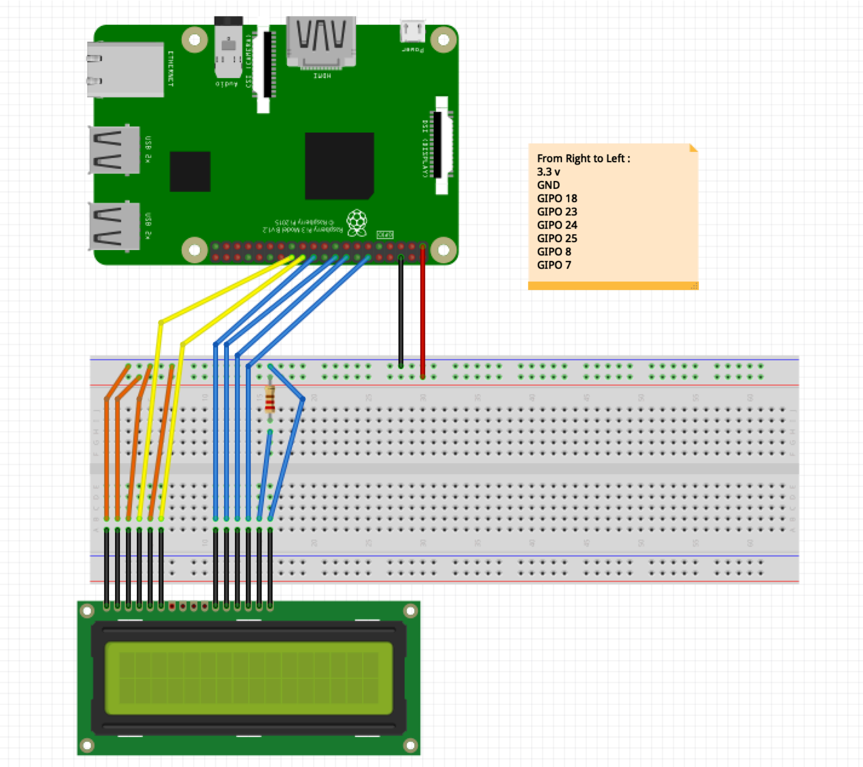


Figure 7. Pin configuration for LCD display

MISCELLANEOUS COMPONENTS

1. Breadboard
2. Jumper Cable
3. LED's red + green Ø 5mm
4. Resistors (2 * 220 Ω, 10K Ω)
5. Male to Male, Male to Female, Female to Female Jumper wire

II. Application Architecture

In this section, we look at the hardware prototype of the application for monitoring water usage and this application lies in alerting the user of excess usage of water at every outlet, also providing the user a way to monitor the water usage time to time. It is a logical block diagram for the sensor set up and how they perform periodical tasks for wireless communication.

Figure 8 shows interfaced with all of the transmission units such as water flow sensor, LCD display, Philips hue bridge, and light bulb. A flow sensor is to estimate the total volume of water flowing through the main supply outlet pipeline and the LCD screen displays the current usage at the same time. The Raspberry Pi will send the command to Philips Hue Bridge which allows the light bulb to switch the color when the usage is over permissible limits. Then Philips Hue Bridge is used for controlling the light bulb through Internet cable.

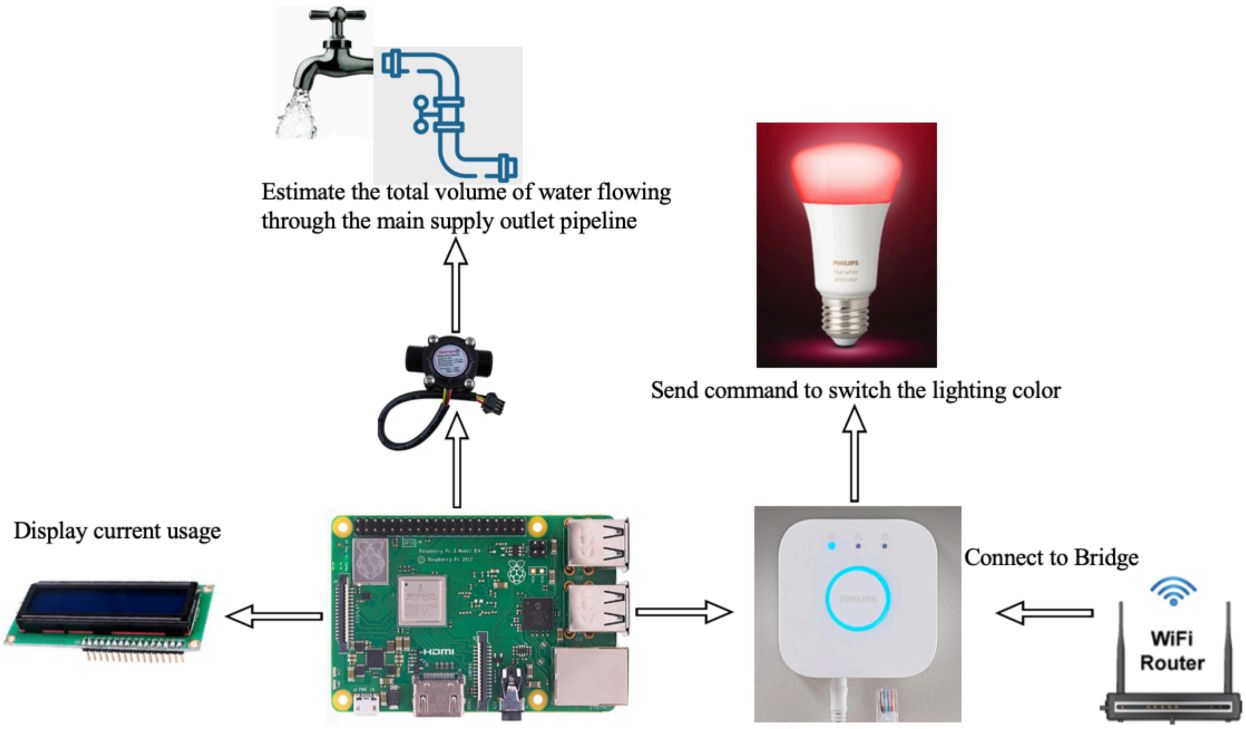


Figure 8. Logical block diagram of Water Waste Awareness Application sensing modules

III. Receiving and Data processing Unit

As the water flows through the sensor is taken from the digital pin of Raspberry Pi is displayed on the serial window of Raspberry Pi, and the data are sent to the Power BI server. Figure 9 shows measuring the data and push all the data into Power BI server. Raspberry Pi is taken, stored, analyzed, viewed and actioned using API for IoT (Internet of things).

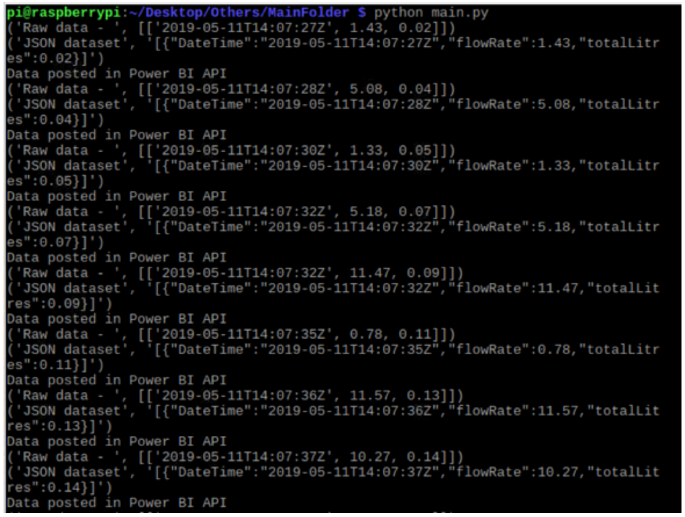


Figure 9. Measuring the data and push into server.

The concept of the IOT (Internet of Things) is that every object that you might think of is somehow accessed and connected to other devices on the internet. Figure 10 shows that Power BI has real-time data visualization capability. In other words, we push streaming dataset to Power BI and Power BI updates dashboards in real time. With the help of IOT, it is possible to collect and analyze data automatically. Raspberry Pi convert sensor data to JSON format and pushes data to Power BI over an endpoint. This endpoint is defined as Push URL by Power BI. So, Power BI stores the dataset in the server and allows us to connect and track IoT sensors values in web or mobile, especially to visualize sensor data in real-time via mobile devices. However, all of the processes have to be support through the Internet, if the network is disconnected, there is no way to push the data into the server. So, we store the data in the local micro SD card when the connection is disconnected in order to keep the missing data properly.

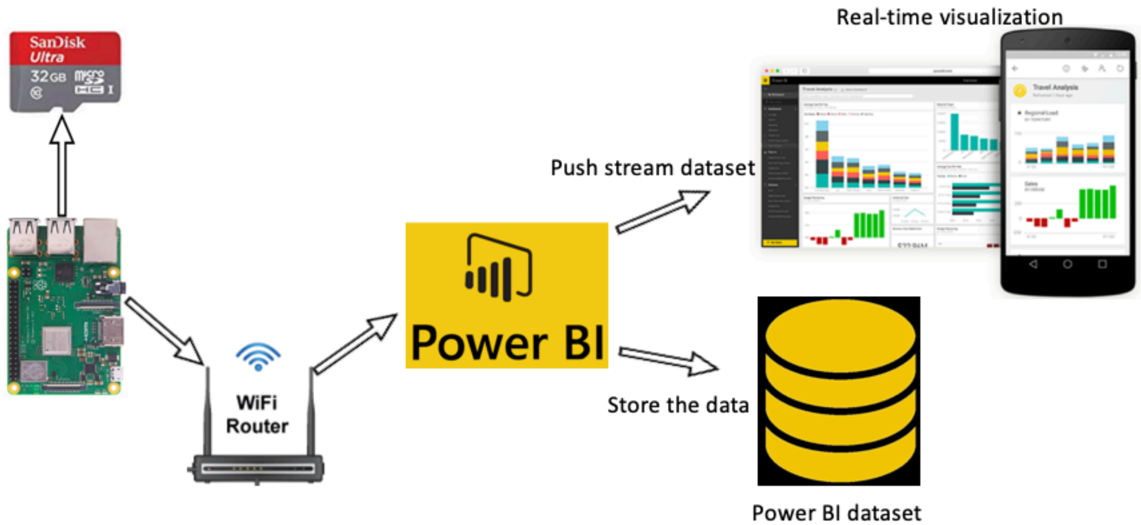
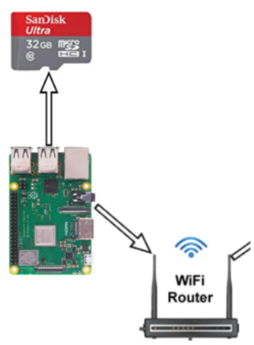


Figure 10. Logical block diagram of Water Waste Awareness Application Data Processing unit.

IV. Pseudocode



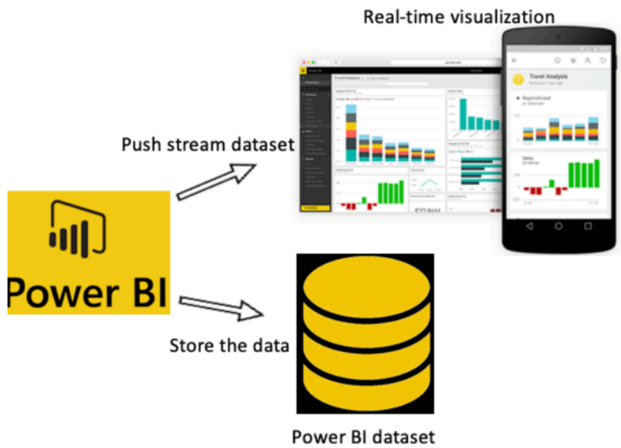
IF network is disconnect **THEN**

    Stored the data locally

ELSE (network is connected) **THEN**

    Push data into PowerBI dataset and stored them locally at the same time

END IF



WHILE network is connected

Push data into PowerBI dataset and visualize the data in the real-time dashboard

IF usage >= XX Liters **THEN**

Switching lighting color to red

ELSE

Keeping lighting color as white

END IF

END WHILE

Result

Power BI is an integral part of water waste awareness application which acts as a cloud-based and analytics service that provides a full overview of your most critical data. Power BI simplifies data evaluation and sharing with scalable dashboards, interactive reports, embedded visuals and more.[8]

In this paper [2], the water flow readings through arduino is collected by thingSpeak and visualized in graphical form. The data collection is real time data collection from arduino. Figure 11 is the data reading of 3 flow sensor on ThingSpeak. And as shown in figure 12, it also shows the screen shot for mobile application GUI after opening the application, which shows the reading of use of water by the houses and also the reading of the water in main supply tank.

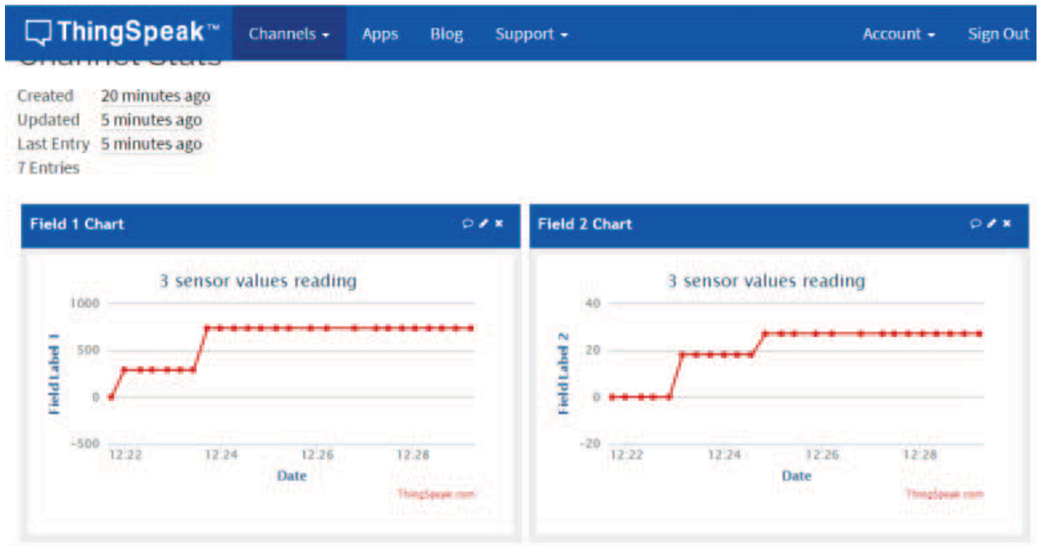


Figure 11. Data reading of 3 flow sensor on cloud (ThingSpeak) [2]

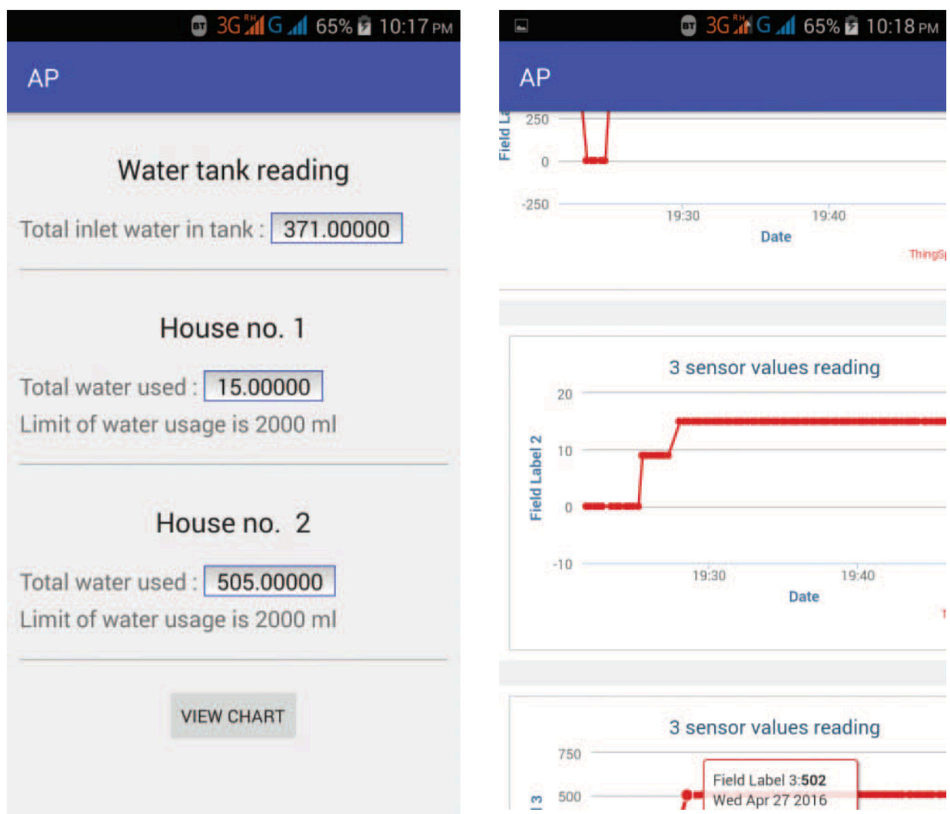


Figure 12. Screen display after clicking on view chart in Mobile Application [2]

Figure 13. Graphical representation of real time dashboard

However, using Power BI REST APIs to create and send data to push datasets and to and streaming datasets which is easier because Power BI has own mobile version. It is unnecessary to build a mobile application to show a real-time dashboard. Meanwhile, the user are easy to customize the GUI for their dashboard whether it's a web-application or a mobile app. With a streaming dataset, data is also pushed into the Power BI service, but Power BI only stores the data into a temporary cache, which quickly expires.[9] Figure 13 shows a real-time dashboard and the temporary cache is only used to display visuals which have some transient sense of history.

DateTime	flowRate	totalLiters
03/05/19 12:53:42 PM	20.99	1.00
03/05/19 12:53:43 PM	25.17	1.02
03/05/19 12:53:44 PM	30.54	1.04
03/05/19 12:53:45 PM	30.82	1.06
03/05/19 12:53:50 PM	28.37	1.07
03/05/19 12:53:51 PM	27.49	1.09
03/05/19 12:53:52 PM	19.24	1.11
03/05/19 12:53:53 PM	43.05	2.28
03/05/19 12:53:54 PM	35.28	1.16
03/05/19 12:53:55 PM	29.19	1.18
03/05/19 12:53:56 PM	23.01	1.20
03/05/19 12:53:57 PM	27.87	1.22
03/05/19 12:53:58 PM	17.44	1.24
03/05/19 12:55:31 PM	1.03	0.02
03/05/19 12:55:32 PM	33.62	0.04
03/05/19 12:55:33 PM	32.58	0.05
03/05/19 12:55:34 PM	63.75	0.16
03/05/19 12:55:35 PM	30.36	0.11
03/05/19 12:55:36 PM	22.64	0.13
03/05/19 12:55:37 PM	12.96	0.14
03/05/19 12:55:38 PM	5.51	0.16
03/05/19 12:55:44 PM	26.06	0.38
03/05/19 12:55:45 PM	25.37	0.21
03/05/19 12:55:46 PM	23.29	0.23
03/05/19 12:55:47 PM	38.06	0.52
03/05/19 12:55:48 PM	20.92	0.29
03/05/19 12:55:49 PM	14.03	0.30
03/05/19 12:55:50 PM	49.23	0.66
03/05/19 12:55:51 PM	18.69	0.36
03/05/19 12:55:52 PM	22.01	0.38
03/05/19 12:55:53 PM	30.65	0.39
03/05/19 12:55:54 PM	37.32	0.84
03/05/19 12:55:55 PM	23.69	0.45
03/05/19 12:55:56 PM	28.32	0.47
03/05/19 12:55:57 PM	25.78	0.48
Total	32,361.87	87,854.61

Figure 14. Dataset in Power BI server

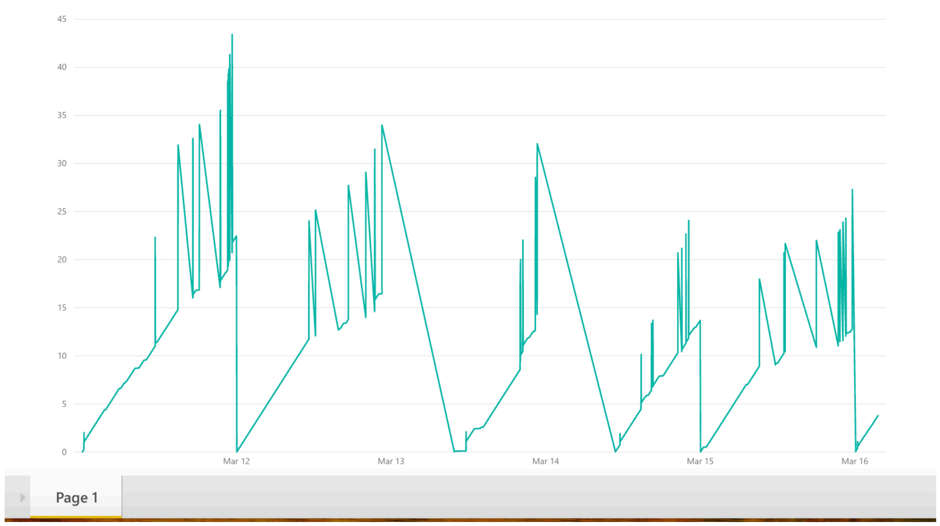


Figure 15. A Line Diagram from A Weekly Report

With a push dataset, data is pushed into the Power BI service. When the dataset is created, the Power BI service automatically creates a new database in the service to store the data which are shown in Figure 14. Since there is an underlying database that continues to store the data as it comes in, reports can be created with the data. Figure 15 describes a part of the diagram from a weekly report and a weekly report's visuals are just like any other report visuals, which means you can use all of Power BI's report building features to create visuals, including custom visuals, data alerts, pinned dashboard tiles, and more.

Figure. 16. Alert and warning system display at server[3]

The author of paper [3] presents their system starts the process by checking the status of the tap. If the tap continuously uses water greater than the specified value then the warning signal is activated. The system will turn off the tap and alert the user through mail. At the same time, the alert signal from server which is shown in Figure 16 will flash the indicating LED to notify the user which water outlet is open.

However, if the user ignore to open the server or mail, they will never know the water usage is greater than the specified value. In our project, switching the lighting color in the house is more intuitive to be seen by users and it will make the residents aware and more responsible for their usages. As water flows, the water usage is sent to Power BI server and through cloud sent to Power BI application, the application will be updated for the user to know how much of water they have utilized. However, the responsibility of Philips Hue bridge is to send commands through Wi-Fi to switch the lighting color. when the user is over a threshold, it will change the color of the bulb from white to red in order to remind the user which is shown in Figure 17.

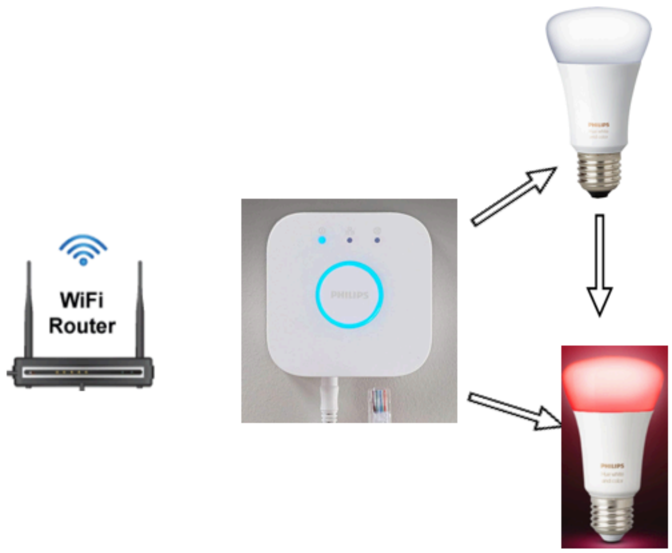


Figure 17. Logical block diagram of Philips Hue system

Conclusion

The paper demonstrates the successful implementation of an Internet-based approach to monitoring water usage on a real-time basis. This setup allows us to accurately measure the water usage. An analysis of the user's water usage through various outlets in a house was provided in order to educate residents on cutting down the wasteful usage. Future improvement can include prepaid billing system and extra alert feature such as sending the alert email and alert text message. Additional feature could be pushing the missing data into the server when the connection is restored. The widespread use of Power BI in the future will make this system very useful and necessary because Microsoft is improving more feature for this tool. This idea also can be further extended to other areas likes gas, oil, electricity as well as air monitoring system.

Reference

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