IoT Water Consumption Monitoring & Alert System

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***Abstract*—The water consumption monitoring and alert system via Internet of Things (IoT) Ubidots Cloud is a one of the platform to monitor amount of water usage in domestic household per day, per week and per year in the real-time on mobile phone or laptop. The Ubidots Dashboard provide interface to display the water consumption level data and also can be illustrated using graph. The graph shown water consumption per day in household, when the water start flowing through the sensor, that sensor start measuring the volume of water and send data to Ubidots IoT platform. Using Ubidots Event, when the data reach the specified limit of water consumption specified, an alert on the excessive usage of water is send to the home user through telegram or email on the phone.**

Keywords – *Water consumption monitoring and alert system; Internet of Things; Ubidots*; *Message Queuing Telemetry Transport.*

I. INTRODUCTION

Throughout the years, the world is facing water crisis that leads to water shortage due to the climate change, population increase, improvement in living standard and also increasing of industrial demand [1]. The amount of water consumption suggested by World Health Organisation (WHO) is 165 liters per capita per day, however average of water consumption in Malaysia is higher than the recommended amount which is 210 liters per capita per day [2]. As the country grows, water consumption among public community will also grows too. Water wastage can be avoided if consumer use water prudently. Hence, one of the solutions is to limit unnecessary usage of water in their daily chores. The daily water consumption can be monitored and triggered a notification alert to house owner if they utilized water excessively. The public should be educated to consume certain amount of water daily depending of their family size and their locality. Furthermore, by controlling their daily usage of water can also reduce the water bill.

The water company can also utilize the system to automate polling the meter reading for monthly billing of water consumption in their client houses. This help to prevent late and inaccurate manual billing due to human error. Furthermore, the water consumption between the main piping to domestic houses piping can also be monitor to enhance the water utility company maintenance capability in detecting water leakage that occur between water utility provider main piping and consumer piping. Hence, obtaining information of daily water consumption is vital in order to control and analyze water supply and usage. At present, water utility management is monitored manually by the Malaysian water companies. The company will monitor any of the water infrastructure by schedule or through complain from consumer. Thus, the maintenance and repairing process takes a longer time. Besides, it is necessary to provide an automatic system for monitoring the consumer daily water usage since the current manual meter reading sometimes is not accurate due to systematic error such as equipment and observation error. Apart from that, the monthly water billing also takes time to be generated and it is not suitable for the purpose of water consumption estimation.

One of the characteristics of a smart city is managing the city assets by using urban informatics and technology which includes management of water supply network. This will shift Malaysia towards becoming a developed and modern country such as Japan and South Korea. An efficient water supply network will be achieved through integration of smart devices and equipment for monitoring and measuring water. In this process, consumer and water company provider collaborated where client is in charge of their conduct while provider monitor and maintain the network [3]. At consumer side, the devices provide daily consumption report with forecasts of the projected savings for the current month base on changes in consumption habits [4]. As a provider, they utilized the system to provide automatic monthly billing to prevent late and inaccurate billing. It also enhances the company maintenance capability through pressure and leakage management.

This paper presents the development of water consumption monitoring and alert system (WCMAS) has been proposed to collect real-time water consumption data in consumer daily usage. By using IoT system, the water usage level will be sent to the IoT Cloud infrastructure and display on IoT dashboard. The collected water consumption data is also analyzed by using Ubidots and an alert is sent for any excessive water usage into home owner smartphone. The smartphone is listed in Ubidots Event via internet connection. The remainder of the paper is organized as follows. Section II describes water consumption monitoring and alert system development and design approach in term of hardware and software component. Section III discussed the development result of the water consumption monitoring and alert system. Finally, section IV draws our conclusions and point out the ideas for future extension of this work.

II. System Development

The system development is based on IoT to monitor water consumption level and water leakage detected by water meter sensor node and send to Ubidots IoT Cloud, the data can be read back from Ubidots's dashboard and to give early notification to the owner about the excessive usage or any water leakage. Refer to the block diagram in Figure 1 below, the developed system consist of a 1) water node that implemented using an Intel Edison board connected with water flow sensor; 2) Wi-Fi router that interconnected the sensor node to Ubidots IoT Cloud platform and 3) Ubidots Cloud platform that consist secured IoT devices organization, Ubidots Dashboard to display and visualize the water consumption level data using realtime graph and Ubidots Event to notify home owner via telegram/sms on smartphone via an alert on excessive water consumptions that were over the specified water usage threshold limit.

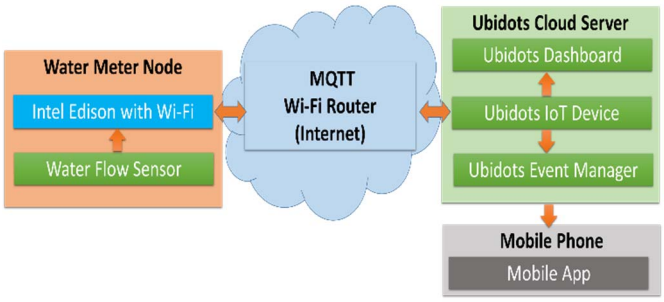


Figure 1: Block Diagram of Water Consumption Monitoring and Alert System

This paper presents the overall operation of water consumption monitoring through to the internet. Before start running the microcontroller, it must be make some appropriate coding and calculation about the flowrate of the water to achieve the objective [5]. This section very important because during collecting the water consumption in the day, suitable calculation to relate with the calibration factor of the sensor.

A. Mathematical model for calibration of water flow

Before going through the mathematical model for calibration of water flow, preferably to look the structure and how the water flow sensor work. A water flow sensor shown in the Figure 2 need minimal working voltage DC 4.5V with maximum working current 15mA (DC 5V). The supply need in range 5V~24V. Furthermore, flow rate range can be work at 1~60 L/min and can support load capacity ≤ 10mA (DC 5V). It also can be operate in opperating temperature ≤ 80°C and can support lliquid temperature ≤ 120°C [6].

Fig. 2. Water Flow sensor

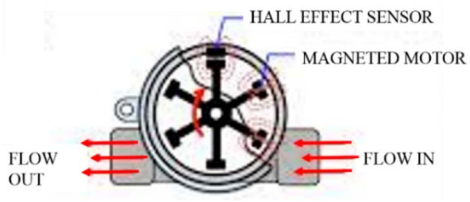


Fig. 3. Circuit Diagram and Process Flow

As shown at the Figure 3, its show how this water flow is operate. Water flow sensor consists of a plastic valve body via mini turbine, that mini turbine consist a water rotor, and a hall-effect sensor. When water is flowing through the rotor, the rotor rolls. Speed changes with different flow rates [7]. Hall-effect sensor outputs the cor

responding pulse signal. This sensor will be place to the valve point beside the water meter or at the main pipe valve of water flow [8]. By the referring process flow show in the Figure 3 can came out some mathematical equation by using Bernoulli's concept [9]. Flow rate one method to measure the volume of liquid that move in a certain amount of time.

The flow rate formula is:

$$Q = Av \quad (1)$$

where Q = liquid flow rate (m^3/s or L/s)

A = area of the pipe or channel (m^2)

v = velocity of the liquid (m/s)

The flow rate can be converted to liters per second using : $1 m^3/s = 1000$ L/s. Actually, flow rate related on the area of the pipe or channel that the liquid through moving it, and the velocity of the liquid. For example when liquid trough the water flow, that water flow look like a cylinder that, that area formula is

$$A = nr^2 \quad (2)$$

where: n = velocity of the water (m/s)

r = radius of the pipe. (m)

But in rectangle, the area is

$$A = wh \quad (3)$$

where w = width (m)

h = height (m)

The flow rate can be measured in meter cubed per second (m^3/s), or in liters per second (L/s). Usually, liters relate for measured of liquid volume with 1 $m^3/s = 1000$ L/s [9].

B. Hardware Implementation

The water flow sensor is connected to Intel Edison microcontroller as shown in Figure 4 below. An Intel Edison we can assume as a smallest computer offered by Intel as to improve system for easy to wearable devices [8]. From that theoretical Intel Edison are very reliable to use because there it does not using the wide area to implement that to the water

meter. The Intel® Edison development platform is designed for a range of inventors, entrepreneurs, and consumer product designers to rapidly prototype and produce "Internet of Things" (IoT) and wearable computing products [8]. It dimension are 35.5 X 25.0 X 3.9 mm, with full of component on both side. The board's Edison major component is a 22nm Intel that include a dual-core, dual-threaded Intel Atom CPU running at 500MHz and one Intel Quark microcontroller running at 100MHz.

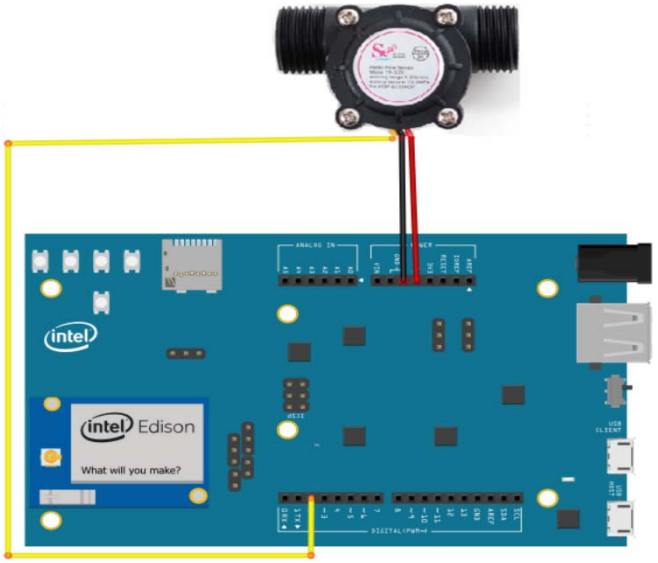


Fig. 4. Intel Edison with Arduino Breakout Board and water flow sensor

After upload and compile that program, it can be start with flow the water through the sensor and collect the data. The data send to the IoT platform by MQTT. MQTT stands for message queuing telemetry transport [8] lightweight messaging protocol mainly IoT connectivity protocol, working on default TCP/IP port 1883 [10]. MQTT specializes in low-bandwidth, high-latency environments; it is an ideal protocol for machine-to-machine (M2M) communication. Basically there are three components in MQTT publisher, subscriber and broker. Here, whenever the user wants to check or go through any data it sends the request to broker and upon receiving the request it [10]. MQTT are use because it is also possible to implement into the research field of remotely robot control, or knowledge-exchange of the machine over the cloud platform [10]. Therefore, IoT was connect with MQTT by using the protocol connectivity and send data to the Ubidots IoT platform. Ubidots is also can interface many devices that can interact with the users by sending notification to the message, telegram, email and etc by set the limit on the variable in the Ubidots.[11].

C. *Software Implementation*

From the mathematical model above, the program is written in Arduino IDE that can compile and upload the program into Intel Edison microcontroller. Figure 5 shown the flowchart of water monitoring and alert system. Firstly when the power suppply on the board, water flow through to the sensor water flow. After water flow through the sensor, the system start to measure the water flow in term of flow rate, flow liter and total liter data and send to IoT platform and analyse the data. When the data reach the limit, it will be send an alert notification to consumer through the media medium like telegram and email. If does not reach the limit that process will be rotate from measuring data until reach the limit.

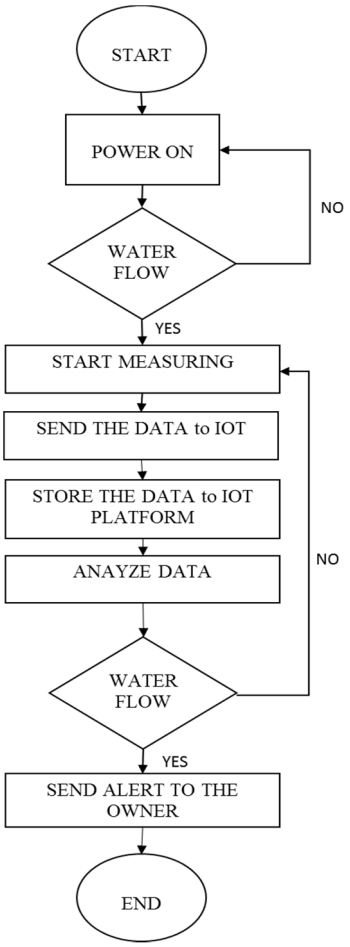


Fig. 5. Flow Chart WCMAS

D. *The developed prototype of WCMAS*

The prototype was created by using an aquarium motor pump to make it cycle the water through water flow sensor that to Intel Edison as shown in Figure 6.

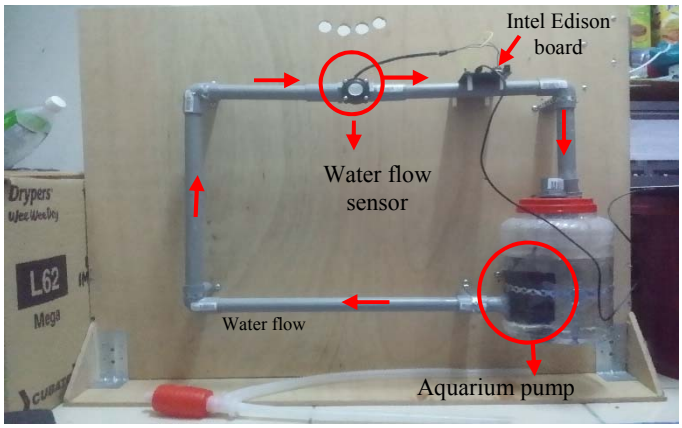


Fig. 6. Prototype of WCMAS project

III. RESULT AND DISCUSSION

A. Displaying Water Consumption on Dashboard

In this section all the result and data obtained from the experiment or demonstration is been described. The water consumption level data is display on water_flow device in Ubidots Dashboard in Figure 7.

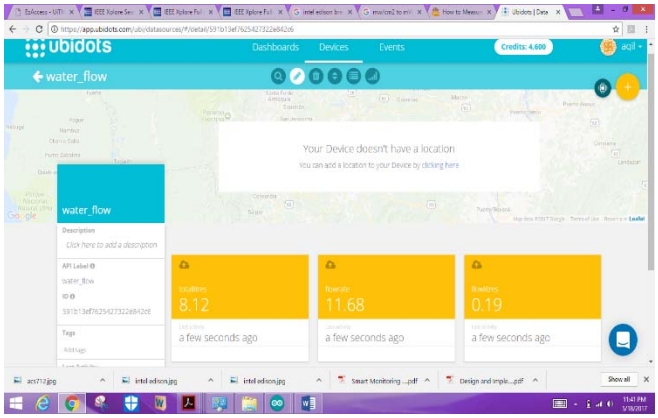


Fig. 7. Water_flow data of totallitres, flowrate and flowlitres on Ubidots

Figure 8 shown uploading water consumption data from the sensor meter node and displaying the water flow device on the Ubidots IoT Cloud of totallitres, flowrate and flowlitres is similar and fast loading to Ubidots server.

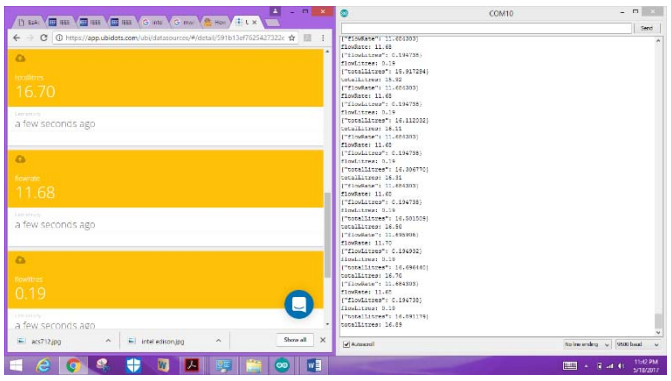


Fig. 8. Serial Monitor on Arduino IDE value on Edison(right) similiar with water_flow value on Ubidots Platform(left)

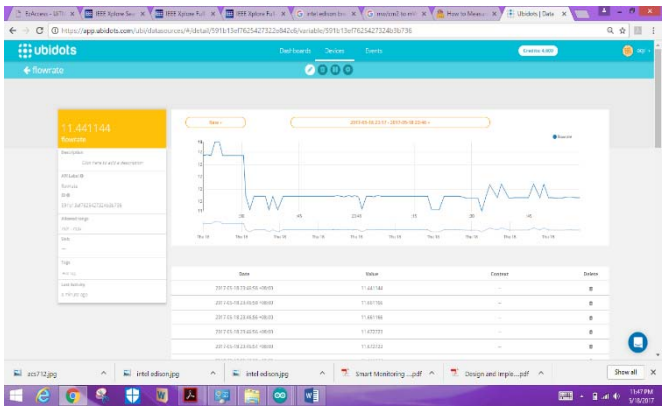


Fig. 9. Graph of data collected for flowrate on Ubidots

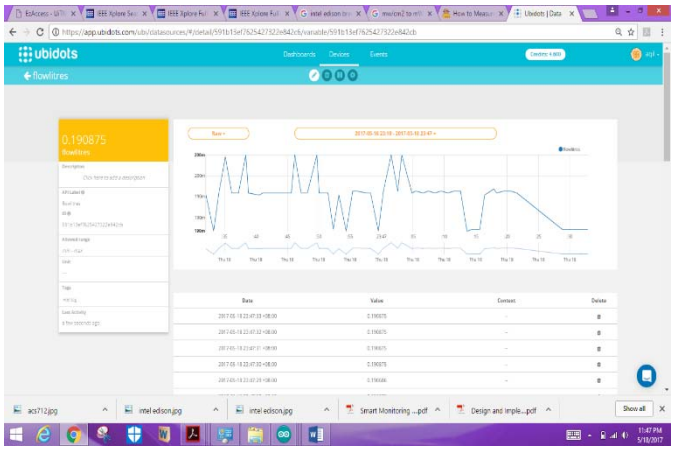


Fig. 10. Graph of data collected for flowlitres on Ubidots

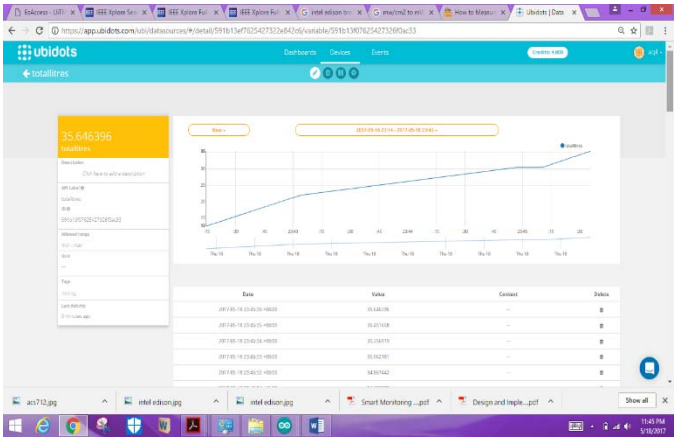
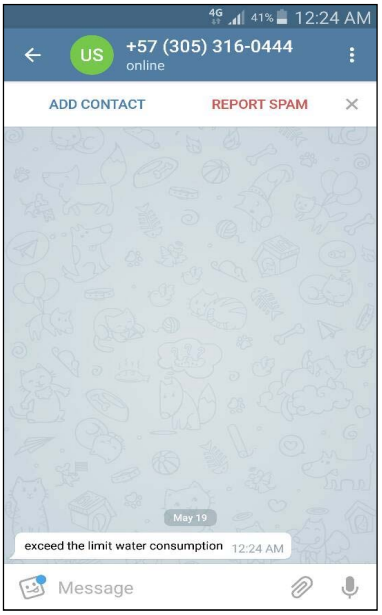


Fig. 11. Graph of data collected for totalitres on Ubidots

Figure 9, 10 and 11 shown the real-time graph on the Ubidots IoT Cloud of uploaded water consumption data in term of flowrate, flowlitres and totallitres for water_flow device in 3 days. The totallitres is the overall water consumption data throughout the water flowcycle of the WCMAS prototyped. An alert is send when the water consumption data of the totallitres is more than 400 L/m^3.

B. Ubidots Event Notification

Ubidots Event notify home owner via telegram, sms on smartphone and email on laptop when the water consumption data of totallitres is over than the specified water usage threshold limit. The medium to notify the owner is using a telegram message as shown in Figure 12 and using an email as in Figure 13. Users can easily monitor the water consumption of their house, even when they are outside. This system has been very useful to people as an early management of household water consumption. This system works smoothly from data collection until the visualization of water consumption level data. The water flow sensor able to detect the water flowing into piping and deduced the water consumption using the mathematical model. The Ubidots Cloud is simple yet powerful technology because it can send alert message via many mediums such as telegram, sms as well as email and Webhook.



Fig, 12. Get notifiction via Telegram from Ubidots

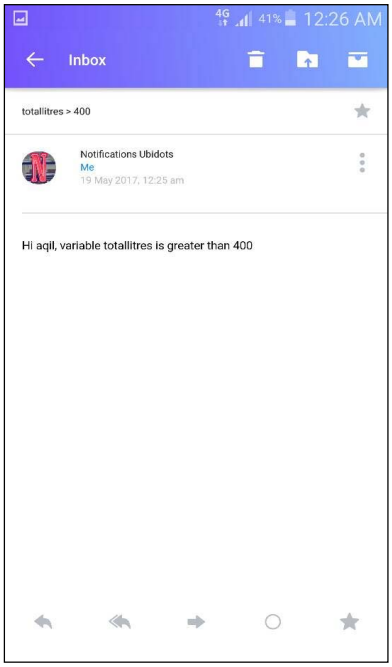


Fig.13. Notification via email from Ubidots

IV. CONCLUSION

An encouragement result obtained on the water consumption and alert system for notification to homeowner using Ubidots IoT Cloud Services. In this venture, an Internet of Things (IoT) framework proposed to monitor the water consumption at home. The prototyped of WCMAS is successfully implement using a water flow sensor is connected to Intel Edison board that acts as an internet gateway for transferring water usage data to Ubidots platform. The water consumption monitoring via IoT and alert system on Ubidots is a one of the platform to monitor the water usage in household per day, per week and per month. A notification through SMS, Telegram and email is send to homeowner as an alert on excessive daily usage of water at home.

Real-time data of the system allowed consumer to control the water consume in order to prevent water wastage especially in a high dense housing area. These precautions can alert and educate the homeowner about the any excessive water usage at their home. Furthermore, users can estimate water consumption in order to limit unnecessary daily water usage, thus saving the water consumption in cities.

In future work, an automated and smart water metering system for management household water consumption data at each house and also between main piping distribution centre and housing area data can be implement using Ubidots IoT. Any abnormality due to water distribution problem can be studied using machine learning on all real time data collected to determine as water leakage due to underground water piping leakage between distribution center and housing area burst or due to stealing of water by people and then alert the utility company personnel through SMS or email.

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