Internet of Things (IoT) and Water Crisis

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***Abstract*— In the coming years, technology will impact the water crisis experience in many ways. Internet of Things (IoT) continues to confirm its important position in the context of Information and Communication Technologies and the development of society. The purpose of this proposing SMART2L is to find out the potential of IoT to be a part of the effort to curb the problem of water crisis and manage water resources efficiently. Further, efforts are necessary for releasing the full potential of IoT systems and technologies. Therefore, this paper presents a study about IoT that stands to change dramatically the way it impacts on the water crisis in Malaysia. On the other hand, IoT also brings tremendous challenges to water management in Malaysia. Hence, this paper also presents the perspective on the challenges of SMART2L in delivering its service to provide the assistance in solving water crisis especially in managing water resources.**

Keywords—SMART2L, IoT, communication, water crisis, water, resources, Arduino,

I. Introduction

Water is one of the necessities of life. Every government in every country, especially in Malaysia, is emphasizing avoiding water wastage [1]. It will greatly reduce the water wastages if it will be implemented in especially government offices and departments, private industries, institutions and even in homes [1]. On the verge of managing water and meet the current technology, pipe breaks and also the unaccounted for water are leveraging its importance to be emphasized [1]. Thus, for the past two decades, water monitoring have included real-time control and supervision.

However, technology and needs have grown. It needs something that includes sensing, data, inform and act (Fig. 1). For instance, SMART2L uses several sensors available to monitor water parameters. These sensors are placed in the water and pipes to be tested which can be either stored in water or running water. Sensors convert the physical parameter into equivalent measurable electrical quantity, which is given as input to controllers. The main function of the controller is to read the data from the sensor, optionally process it, and send the same to the application by using appropriate communication technology. In this case, SMART2L uses Wi-Fi to send data to the application (SMART2L Apps/Firebase server).

Fig. 1: The flow of movement from insights (sense with sensors, gathering and analyzing data) to an action (informed through notifications for users to act as a response) plan.

The application includes the data management functions, data analysis and alert system based on the monitored parameters. In this proposed system, SMART2L will store data in Firebase that send by the controller (Arduino Yun). Then, data will be used for storage and analysis. By placing this system in a smart building, we will be able to collect and analyze the water usage patterns of the users while notifications will be sent to users and their response (saving the water) act as an action. For example, SMART2L will send out notification or alert if leakage present within the distribution pipe and when water in the main tank is below the threshold.

In the era of advancement technologies following the centerpiece conversation at recently held World Economic Forum on ASEAN in Kuala Lumpur on Internet of Things, IoT and Industry 4.0, new tools or systems are emerging to help individuals to support water conservation through monitoring. For that IoT is a blessing as a solution. Access with the SMART2L system is expected to help people or companies to track daily usage and find the opportunities to conserve water for future prospects especially during the off-seasons in Malaysia. So, with IoT, it enables the smarter way to utilize water crisis like water ration in Malaysia.

II. Water Crisis In Malaysia

A. The Problem

The country is facing towards water crisis due to the high demand, unmatched water supply, and lack of management and population growth. The crisis will be prolonged if there is no proper management. Globally, over half of the population will be facing water crisis by 2030 when all the demand exceeded the water supply said General Ban Ki-Moon, United Nations Secretary [2].

According to our Deputy Prime Minister, Datuk Seri Dr. Zahid Hamidi, water experts, and industry players must keep abreast with the latest knowledge and technology on water management to ensure sustainable water development

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resources [2]. The water crisis is crucial because in the effort to manage water was a dynamic issue, adding that technology could simulate a bad situation caused by poor water management and work on finding a solution to the matter [2].

Additionally, water crisis had been identified by the industries, governments, academia and also civil society as the top three global risks with the highest concern [2]. The biggest challenges will be the sustainable development of water in the future which can be felt over the environment, social and economics. More from Datuk Seri Dr. Zahid, we must focus on the education on sustainable water development, ensuring that the public was taught on the value and the importance of water, also the shared responsibility in protecting and conserving water resources so that all the efforts will not end in vain [2].

Above all, water crisis gives impact greatly to all major areas. More specifically, the threat of a water crisis affecting the people directly is when there is not enough water for use and consumption, water scarcity [3]. The recent water crisis in Johor, Selangor, Federal Territory of Kuala Lumpur (FTKL) and Putrajaya [3, 4] could provide an important lesson on the need to promote smart water management.

B. Benefits of Smart Water Management

Water utilities in Malaysia are still marching at a greatly deliberate speed when it comes to deal with smart water management. Not anything like gas and electricity, most are in synchronized with the adopted cutting-edge technology. As an IoT solution, SMART2L can play its part in the current developing industry like the new housing development, in supporting the government's policy on focusing the latest knowledge and technology on water management to ensure sustainable water development resources [4].

Mutual real-time data is a smarter pronouncement [4]. Data collected can be promptly turned into valued data for any reasonable decision making in the entire areas of the company, improving the whole part of the utility's data sharing technique that is normal for daily tasks. Eventually, operators, planners, and managers can obtain continuous, pertinent and precise updates anytime from everywhere despite the need to wait for offline reports or data.

In addition, real-time data control even makes sense further than the normal control room [4]. For example, the SMART2L operational system utilizes the real-time data in assisting the utilities to predict any effects within the system network, thus restricting the times to respond to any events, or comprehend the effects that a repair has on the whole system network, wherein return, reducing the effect on the user's side.

Yet, another beneficial feature of smart water management data is the capability to uphold an up to date data in the utility, so when operators are deployed to do some tasks, they have the latest data on their devices, facilitating them in fixing the problem rather quickly, accurately, and precisely [4]. For instance, in Fig. 2 below shows that SMART2L has its own mobile application to monitor the whole system including the flow rate of water, pump status, water level, leakage status and also the volume of water that has been distributed.

Fig. 2: SMART2L Apps, mobile application monitoring for the whole system.

The information gathered from the real-time monitoring will be benefited department of water resources and also the public. The main idea of a real-time IOT-based water resources information system is to convey inclusive and precise figures. The system is established through five major and essential parameters (as seen in Fig. 2). So, when each time the utility gathers, treats and distributes water and when each time a pump starts, a tank is filled, and a tap is opened, all the data is produced and disseminated. These valuable data can be used to study the pattern of the water usage for forecasting and decision-making.

C. Malaysia's Accomplishment in Water Management

Malaysia portrays water as a paradox that demonstrates itself in both situations, floods, and droughts. In to some extent of actions to manage water resources in Malaysia, both futile conditions will have to take account [5]. Nevertheless, the issues on water crisis are non-stop or completely solved here. In a proper explanation in regards to the upfront, issues are to point out the concealed water management problems, especially leakage [5]. The cases of unsuccessfully managing pipeline leakages are part of the many studies demonstrating or take into account the concern of managing the pipeline leakage in Malaysia [5].

On the other hand, this brings about the issue of increments in the Non-Revenue Water (NRW) [5]. This is to anticipate all on how SMART2L can curb the impacts and effects of NRW. On the water supply services, environment and financial of Malaysia. NRW is presently being one of the concerns intensely conversed globally. The cost of water in Malaysia is very insignificant and do not cover the actual costs. The huge amount of unforeseen water loss calls for the government to fund the water board companies with major funding every year.

In Malaysia, NRW rate was recorded at a national average of 36.6 percent of the total water produced in 2013 [6]. NRW rate in Malaysia's state are various, amongst thirteen states in Malaysia, NRW rates were ranging from only 18.2 percent to as high as more than 60 percent. Penang State is the only Malaysian state that has NRW rate below than 20 percent [6]. In the early 2000s, Malaysia suffered impending difficulty regards to water supply [6]. Conferring to Suruhanjaya

Perkhidmatan Air Negara (SPAN), Malaysia's average NRW was 36% which was about 36.4% of water lost from the liters of piped water produced per year [6]. As reported by Chow in The New Straits Times in April 2017, Perlis has been recorded to have the highest NRW percentage (the treated proportion of treated water that is lost before it reaches consumers) at 60.7%, followed by Kedah, Kelantan, and Pahang. Thus, NRW has shown a tremendous increment in such states [7].

Conferring to the Minister of Energy, Green Technology and Water, Datuk Seri Dr. Maximus, all the three states recorded to have almost near to 50% NRW [7]. On the latest statistics for NRW, Datuk Seri Dr. Maximus told that the government will need to spend RM531 million for the NRW program for a total of six states (Sabah, Sarawak, Perlis, Pahang, Kedah, and Kelantan) [7]. Even so, governments had set a reduction target of 25% NRW by 2020 [7]. On the other hand, Malacca, Penang, and Johor reported being the lowest [7].

There are several aspects to be reflected when we are to detect water loss. The main factor contributing to such issue can be the unforeseen leakages which are the major contribution (70%) of the water crisis in Malaysia [7]. Unforeseen leakages can be either leaking pipes, valves or tapping saddles. In different aspects of factor caused the rising of NRW can be as difficult as to identify faulty domestic household meters, water theft and lack of management skills of the water company [7]. The causes of NRW are literally can be from leakages from worn-out pipes, water theft or inaccurately recording the water meters usage [7]. Besides that, another aspect can be from the malfunction or overflow liquid tanks or reservoirs which can serve to cause the NRW to increase. Since, industrial or home tank system play an imperative role in an industrial application such as in beverage processing, pharmaceutical.

These suggest the implementation of Internet of Things (IoT) to address water crisis. In the verge of creating better insights to both the demand and supply, IoT is one of the greatest idea this day to assist government and utilities to work hand-in-hand in the effort to improve the water ecosystem governance. With the popularity of Internet of things, this problem could be solved. Introducing the SMART2L system allows users to monitor leakage status in real-time in return will help to reduce the effect on to the NRW percentage.

III. Water Crisis and Internet of Things (IoT)

Widely discussed in today's world, the potential tool to assist in understanding, tackling and learn this problem of the water crisis is the Internet of Things (IoT). It is the era of embedding sensors and connected wirelessly into devices. It is the trend where devices start to communicate with each other, Machine-2-Machine (M-2-M). These are plus point to all the governments, industries and people to better define their priorities for water supply, demand, and governance.

An example like the traditional way to detect the leak from a zone of distribution pipes, operators need to manually turn on/off the valve in order to pinpoint broken pipe's exact location. Following that, operators also need to take account of the flow rate reading, manually, for them to determine pipe leakage size. Nonetheless, the advancement of the Internet of Things in these work field can be abridged.

Thus, by implementing an IoT-based system, for instance, the SMART2L system (Fig. 3), only one operator/user needed to monitor the real-time system and be alert with the notifications. Sensors will calculate the readings every one second and send the data to the server followed by the apps. The added advantage with the SMART2L system is that e-mail notifications are made available to notify the users to be alerted of two major conditions if flowrate becomes slower than normal (presence of leakage) and also when there is a difference with the water threshold. So the operator can take a fast-action alongside with the best decision-making to prevent water from loss.

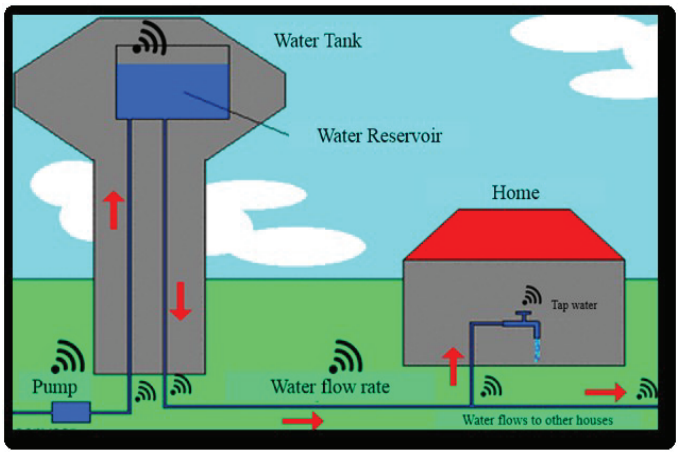

Fig. 3: One example of a SMART2L system implementation for new housing development for water utility system

In the case where there is drought season is possible, with the implementation of the SMART2L system, the operator can keep monitoring the water level and usage of the water in order to save the water from being overused in drought season. Most prominently, every data recorded can be used for forecasting the water usage pattern in drought season. The long-term drought forecasting is very complex thus far, we really need those data to study how to manage water smartly.

Fig. 4 below depicts the block diagram for five parameters to be measured water level, pump status, water output, leakage status and flow rate in real-time. These are connected to the Arduino Yun. This module is used to access the sensor data. The data will be processed and uploaded to the Firebase via the Wi-F. Users or operators like the utility department can view the recorded data graphically using their credentials. Alerts (email and SMS) are sent in return as an action to the notifications.

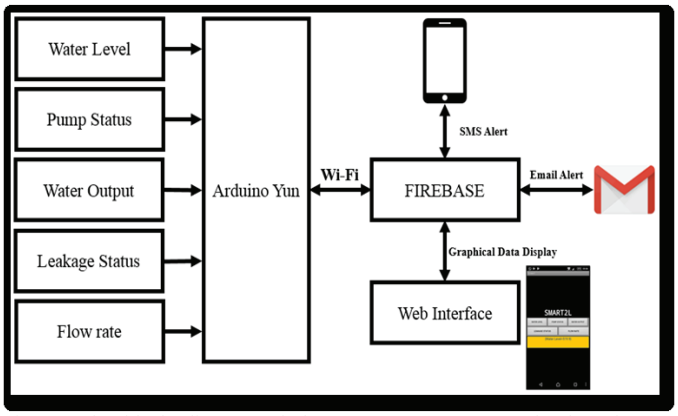

Fig. 4: The block diagram of the SMART2L system. The key features monitored are water level, pump status, water output, leakage status and flow rate.

IV. How It Works?

SMART2L system integrates the usage of Arduino Yun. A reserve tank, batteries (power supply), water tank and water pump are used to set up the water pump system. The reserve tank is connected to the main tank via a water pump. The water pump is used to pump water from reserve to the main tank and is controlled by the main tank's water threshold, which turns on/off the water pump. This is the most common method of threshold level control for the main tank which simply to start the water pump at its low level and permits it to run until the water is filled up. Below are the cases that have the potential to occur at the two conditions. Fig. 5 depicts the flowchart for this system.

A. Presence of Leaks

The liquid sensor will first sense any leakage present either at the valve or the distribution of PVC pipes. If there is a presence of leakage, the Arduino Yun will send an e-mail to notify the users. The decrease in the water below the threshold level will cause Arduino Yun to send an e-mail too. This will cause the pump to automatically pump water and liquid will start to flow from the reservoir to the main tank till it is full. Beforehand, users need to install the SMART2L apps on their smartphone to ensure the users able to monitor SMART2L system through mobile apps as Arduino Yun sends the system data to Firebase. Users will be able to directly attend to the specific site of leakage within the system. This, on the other hand, will save cost, time and effort in searching for leaks within the system. The SMART2L system overall will be programmed to check continuously the level of water within the system.

B. The absence of Leaks; Low Threshold

On the other hand, in the absence of leakage, the SMART2L system continuously still sense the liquid threshold through eTape sensor. Any changes, Arduino Yun will send notification through e-mail. Simultaneously, the shape sensor monitors the threshold level as a step taken to prevent the liquid from overflowing. Real-time data will continuously be updated to Firebase.

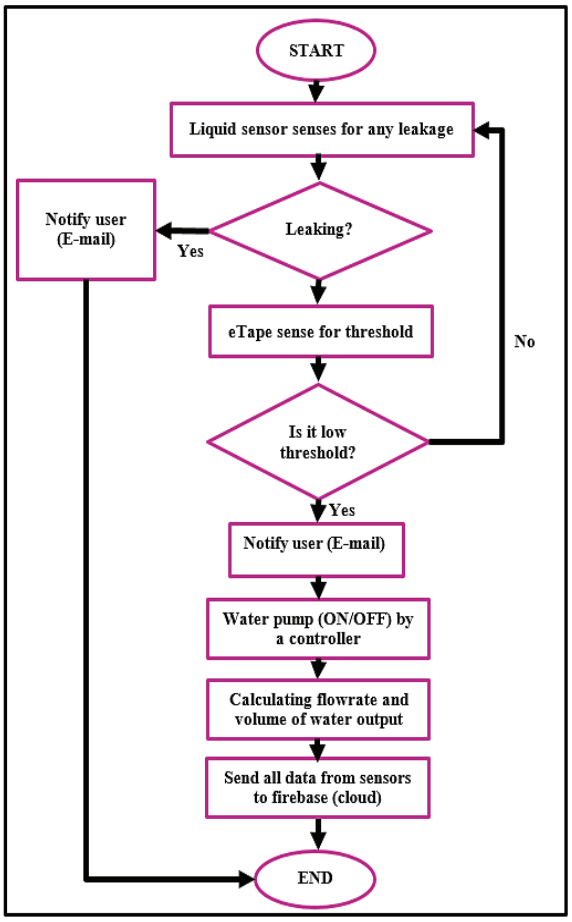

Fig. 5: Flowchart of SMART2L system

V. Result and Discussion

Monitoring sensor networks comprise several valves, pumps, and tanks, an important part in managing water resources. SMART2L system uses Firebase (Fig. 6), a cloud services provider, also can be integrated and to be used along within many applications and greatly recommended. Usually, Firebase is used for app's backend maintenance of its data storage, user's authentication, and static hosting.

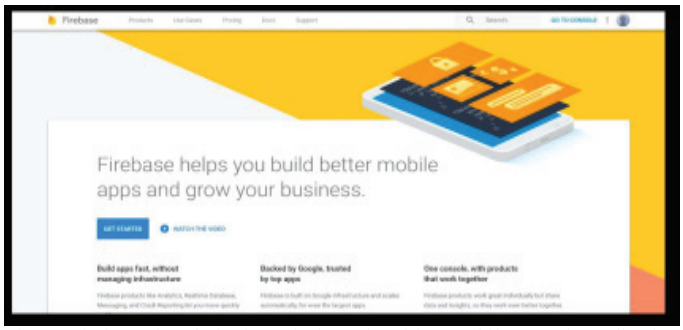

Fig. 6: Firebase, in whole, is a platform for either mobile or web application with infrastructure and tools which allows any developers to build great quality applications.

The information of the SMART2L system that is gathered in Firebase to view overall data. The data will be constantly

updated in the real-time following any changes happen within the system. Firebase is used together to store the analytics info gathered from all the available sensors in the SMART2L system. The information in Firebase is stored in JSON format. Every updated, added or deleted information can be observed in real-time and colors flashing in the cloud database based on Fig. 8 signifying such actions are being done.

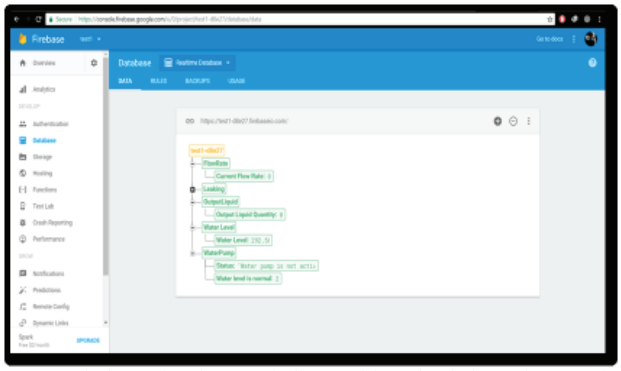

Figure 8: Flashes of colors to indicate either the information are being updated, added or deleted in real-time. All the parameters can be monitored here and also via the SMART2L apps.

Apart from that, the users will also receive an email notification on alerting the users about the water threshold as well as if any leakage present, Fig. 9.

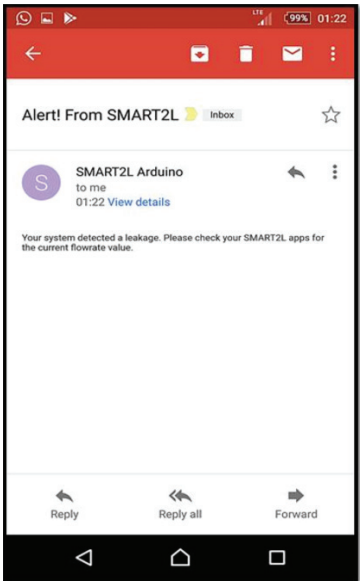

Fig. 9: Email notification of leakage to alert the users to check on the SMART2L monitoring system.

On top of that, as future work for this system, we are proposing to integrate a new platform, FAVORIOT, besides monitoring water on apps in a smartphone in the idea for the usage of utility companies and industries. This system is being integrated with FAVORIOT as shown in Fig. 10 below. It is intended to show that our system visualizes sensor data using a simple and intuitive data representation.

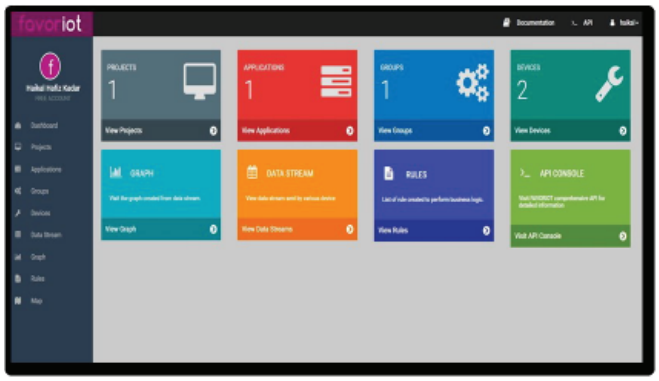

Fig. 10: FAVORIOT, dashboard.

In making sure that water is being monitored efficiently, water with the SMART2L monitoring system and FAVORIOT is monitored in real-time. FAVORIOT provides real-time aggregated data streams to applications and also access to historical data for data aggregation. Data management within the SMART2L system is efficiently being controlled by FAVORIOT as seen in Fig. 11 – 13.

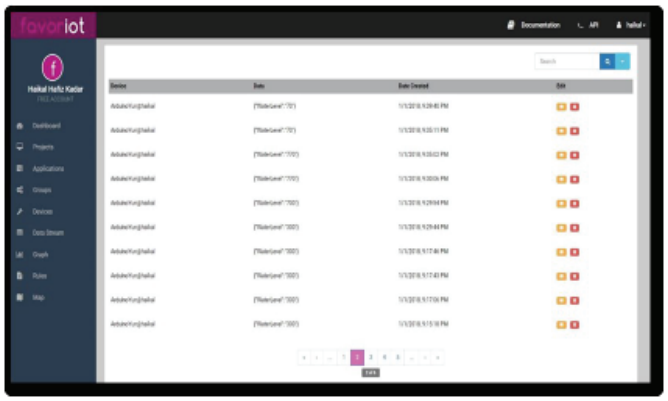

Figure 11: In this project, the design of IoT-based monitoring system is being implemented at which the system is able to monitor both water level and leakages in real time.

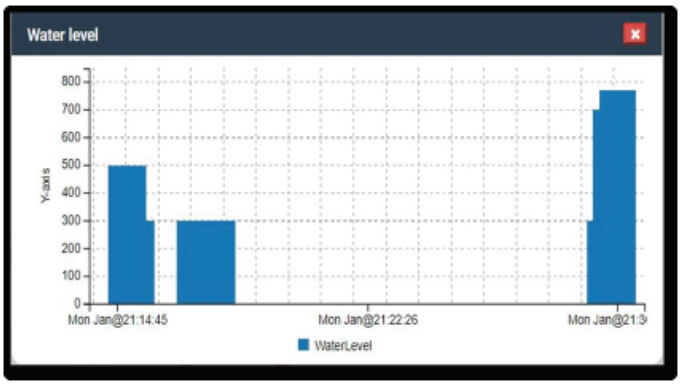

Figure 12: Sample of one of the system parameter, Water Level. The graph display of the parameter being measured in real-time where operators can use the data to make any comparisons, data engagement, and for data forecasting.

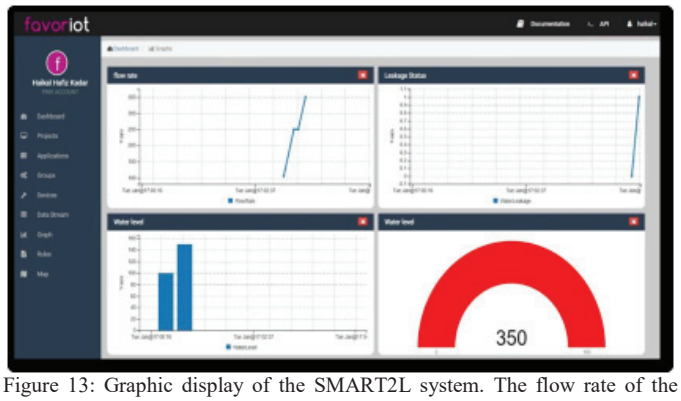

Figure 13: Graphic display of the SMART2L system. The flow rate of the water is shown using a line graph same goes for the leakage status.

Through FAVORIOT, users will also receive an email notification on alerting the users about the water level as well as if any leakage present, Fig. 9

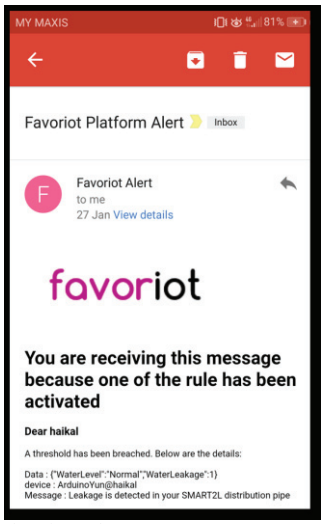

Fig. 14: Alert from the FAVORIOT on water threshold.

VI. Conclusion

Beyond everything, this study concludes that dealing and supervised NRW rate at its lowest possible rate be duty-bound to be a crucial undertaking for any water authorities in Malaysia to make sure the sustainability of water in municipalities. A state cannot announce itself to be sustainable when there is still stipulation from the people living in the city regards to the need of water because they still have to face the water supply problem that caused by high NRW rate. Basically, investing in the current cutting-edge technology like the Internet of Things (IoT) really gives great impact in curbing the issues related to the water crisis and water management. The existing systems employ additional period to gather data and focus less on the insights of the data. Most of the existing systems require the manual collection of data. Analytics obtained from the SMART2L monitoring system (IoT-based system) can make a transformation for this by engaging the real-time data in front to facilitate the analyst focuses more on analysis and actions in short period with low cost.

The SMART2L monitoring system, an IoT-based system able to deliver a better solution in monitoring the water resources which equipped with proper sensors. A faulty pipe can leak anywhere within seconds. Without proper flow sensor monitoring on sites, a basic break like this could be resulted in losing substantial amounts of water and can take weeks to be made conscious of the matter. Thus, the SMART2L system can immediately send alerts of leaks or breaks, which can then either automatically be turned off, or addressed to circumvent any catastrophic water loss.

This real-time visibility and remote access have been so beneficial to the district, that SMART2L system has can now become mandatory especially for all new construction projects. With the help of the SMART2L system, the monitoring of water level and leakage are able to reduce their water consumption, saving the significant water during one of the worst drought seasons. Beside that this project can be implemented in a real situation and can hold a market value especially in a residential unit or in industries. This is because it is about time for the residential and also the industry to make a change to appreciate the benefits of IoT since they still reliably engaged to the float technology which marginally inefficient and lacking precisions.

References

[1] S. M. Shahabudin. Water Malaysia 2015. (2), 3-22. Retrieved 18 May, 2018 from http://www.mwa.org.my/pdf/wm-issue28_final.pdf. 2015.

[2] H. Harun, Water Crisis is real, Zahid wants industry players to use tech, innovation to better manage water resources. Kuala Lumpur: The New Straits Times. Retrieved 12th December 2017, from https://www.nst.com.my/news/nation/2017/08/267665/water-crisis-real-zahid-wants-industry-players-use-tech-innovation-better. 2017.

[3] Bernama. Selangor to face critical water shortage from 2017-2019, MB says. Kuala Lumpur: The Malay Mail Online. Retrieved on: 15th December, 2017, from http://www.themalaymailonline.com/malaysia/article/selangor-to-face-critical-water-shortage-from-2017-2019-mb-says#cLWo9DCQErWtmc6k.97. 2016.

[4] F. F. Zulzaha. Suggestions for residents and Syabas on ways to counter water shortage. Kuala Lumpur: starproperty.my. Retrieved on:15th December, 2017, from http://www.starproperty.my/index.php/articles/property/news/suggestions-for-residents-and-syabas-on-ways-to-counter-water-shortage/. 2013.

[5] J. M. Choong. Industries Fear Nation's Worst Water Crisis. Petaling Jaya: The Malay Mail Online. Retrieved 12th December, 2017, from http://www.themalaymailonline.com/malaysia/article/industries-fear-nations-worst-water-crisis#gEaVpvUHgpwBMJji.99. 2016.

[6] Lai C.H., Phang W.L., and Chan N.W. (2013). A Study of Non-Revenue Water Management in Penang as an Example of Good Water Governance. Retrieved on: 3rd January, 2018.

[7] M. D. Chow. M'sia Targets 'Non-Revenue Water' Reduction of 25 Percent by 2020: Water Ministry. Kuala Lumpur: The New Straits Times Online. Retrieved 12th December, 2017, from https://www.nst.com.my/news/nation/2017/04/233817/msia-targets-non-revenue-water-reduction-25-2020-water-ministry. 2017.