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Dripless: A smart household water monitoring system

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Abstract- *Egypt is facing a water scarcity challenge in the upcoming years, making rationalizing household water consumption an issue of national priority. Dripless is a residential wireless water monitoring and control system that offers leak detection and prevention. It uses a smartphone dashboard to provide users with the ability to monitor and control their household water remotely. This paper introduces the dripless system, features, components, and challenges.*

Index Terms – *IOT, Water Saving, Water consumption monitoring, Smart Cities.*

I. INTRODUCTION.

Water is considered our most valuable natural resource It is considered one of the fundamental resources for human and economic development. Ensuring sustainable access to safe drinking water was one of the Millennium Development Goals (MDG) established by the United Nation in the year 2000 [1]. Recent statistics According to FDA, "The Food and Agriculture Organization of the United Nations" estimate that around 184 billion dollars are globally spent every year for supply of clean water, in addition to 14 billion dollars for water pumping energy costs [2]. Nevertheless, water scarcity remains a global threat that faces more than 1.8 Billion people worldwide.

Egypt is recently facing such threats with the growing population and the increasing water demands for economic development plans [3]. Increasing water efficiency and saving water resources have become a national priority. In order to achieve such goal, residential usage stands out as an important factor. Table 1. Shows some official statistics [3,4] about the incline in average domestic water usage patterns over the past two decades.

The presented statistics indicate a high rate of the per capita residential water usage in Egypt as compared to international standards. This is mainly contributed to low water awareness as many users underestimate the amount of lost water during simple daily activities like taking a shower or flushing the toilet. A problem which is increased by socio-demographic factors such as education and income levels.

Table 1. Progress of Annual domestic water demand in Egypt

	1993-1997	1998-2002	2008-2012
Total water withdrawal (billion m ³ /year)	58.871	68.3	78
Municipal water withdrawal (billion m ³ /year)	3.7291	5.3	9
Municipal water withdrawal as percentage of total withdrawal (%)	6.3341	7.76	11.54
Total water withdrawal per capita (m ³ /capita/year)	909.1K	963.2K	910.6K
Produced municipal wastewater (billion m ³ /year)	3.6	3.76	7.078
Collected municipal wastewater (10 ⁹ m ³ /year)			6.479
Treated municipal wastewater (10 ⁹ m ³ /year)	0.7	1.9	4.013
Not treated municipal wastewater (10 ⁹ m ³ /year)	2.91		3.065
Number of municipal wastewater treatment facilities	67	121	372
Treated municipal wastewater discharged (secondary water) (10 ⁹ m ³ /year)	0.45	0.6	3.011

Another important factor for residential water loss is the aging infrastructure and poor maintenance of household water lines. A factor that result in many leaks and break events. Which in turn can result in extra economical losses due to water damage.

The Dripless system presented in this paper is a system that aim to offer a solution to save our limited water resources. It is a smart water system that help the customer to save water by monitoring his usage and remotely controlling it. This can aid customer to rationalize his water consumption and build a long-term behavioral change [5]. Instantaneous measurements of the water flow and pipe pressure is collected transmitted to the consumers through a mobile

application to let him know how much water is consumed. The system also analyzes the usage consumption pattern and issue a leakage alert to the user if an abnormal behavior is detected [6]. This paper is organized as follows: in the next section we will introduce the Dripless system architecture and the main features of the system. Section III introduces the conducted market research and competitor analysis. Section IV introduces some of the planned future features of the system.

II. DRIPLESS SYSTEM DESCRIPTION.

The Dripless system consists of a wireless measurement node, webserver and a mobile application. The measurement node is installed on the main water inlet to the house and configured via a server application to enable wireless connectivity via Wi-Fi and cellular GSM.

As shown in Figure 1, the Dripless device consists of a water flow meter to measure water flow, pressure sensor to measure the water pipe pressure, Solenoid valve for shutting water, and a hydroelectric generator that is used to recharge batteries. It also contains a microcontroller (AVR) and wifi wireless module and GSM module for the communication layer.

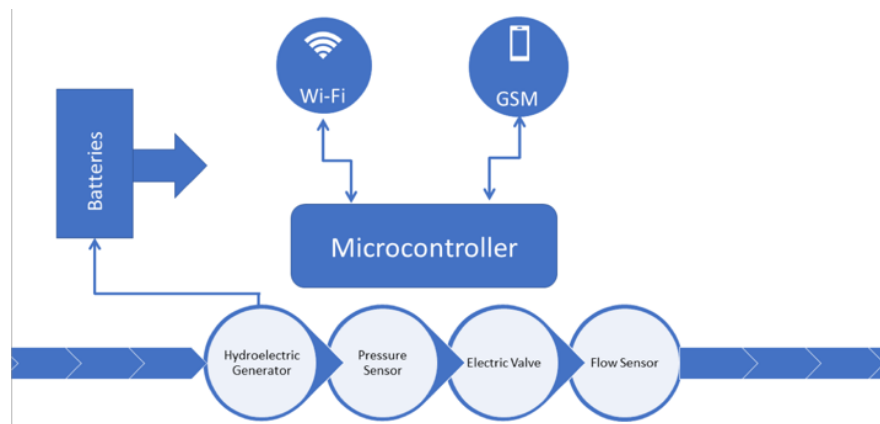


Figure 1. The Dripless Node architecture

Dripless main features can be summarized as follows:

- **Consumption data statistic:**

It is difficult to track water usage when you only get a monthly bill, specially that administrative process causes significant delay in receiving your monthly bill. Through real-time water monitoring, the customer can track his water usage on mobile application and web dashboard. The system offers daily, weekly, and monthly consumption patterns. Figure 2 shows some screenshots from the Dripless mobile applications showing for Real-time tracking and usage statistics.



Figure 2. Dripless Mobile screenshot for tracking water consumption

- **Water leakage prevention:**

The main feature of the Dripless system is its ability to detect abnormal usage patterns and issue a leakage alert directly to the user via mobile services. It also features a remote valve shut-off from the mobile app. Figure 3 shows the mobile applications screenshots for such features.

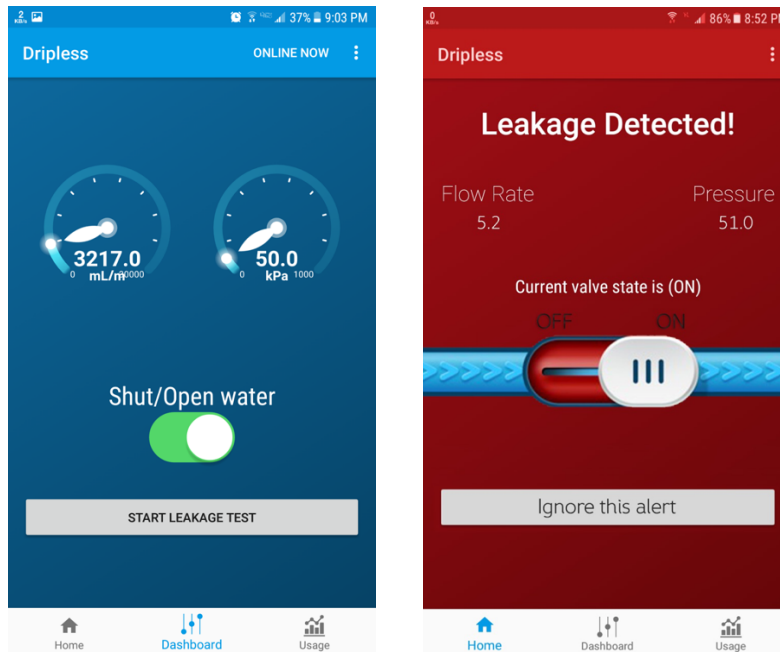


Figure 3. The Dripless Mobile application screenshots for water leakage detection and alerts

- **Personalized water saving tips:**

Through analyzing daily usage patterns, Dripless can send personalized water saving tips about how to reduce your consumption.

- **Water-saving goals and social competition:**

It helps the user to set a goal of his next month consumption and let him know if he is going forward towards his target, it can also organize social competitions where users receive points for every liter, they and compete with local competitors.

- **Water pump protection:**

Monitoring water pump behavior and track generated pressure to detect any fault of water pump operation or pressure tank.

Figure 4 shows the first installed prototype of our Dripless hardware node. Our market surveys revealed that security, power management, and the size of the device really matters to the customers. Dripless uses secured connections with trusted servers, it also limits the direct communication with wireless network during first-time configuration only, then it can be reconfigured through the server.

In order to avoid connecting a power adapter next to the main water source, Dripless was designed to be power-sufficient, as it charges its rechargeable battery using water flow, then it reuses the charge of batteries to power itself when there is no water flow. The sensing and transmission scheduling were optimized to reduce power consumption during the non-operation time through a power saving mode.

Finally, in order to reduce the overall length of the device, we used the hydrogenator as a flow meter in addition to its role in power management. Our calibration results showed that we achieved the same performance with 25% reduction in the device length.

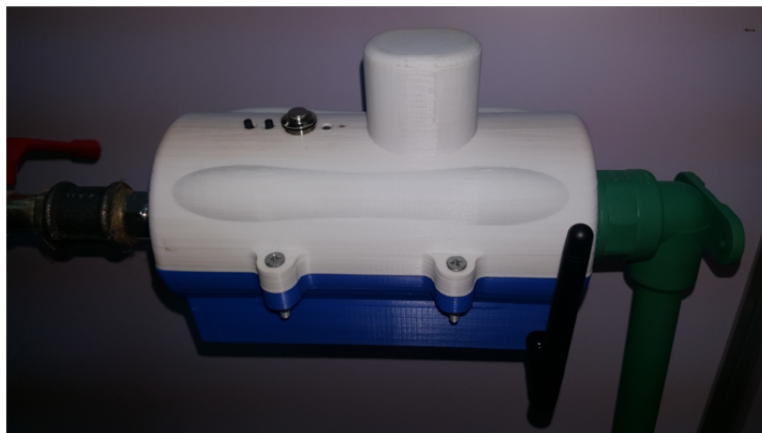


Figure 4. The Dripless Node Prototype

III. MARKET AND BUSINESS RESEARCH.

In this section, we present some preliminary market research results through market survey and competitor analysis.

A. Market survey results.

In order to fully understand the customer needs for such system, we conducted a simple market research survey. We asked future customers what they want in this product, or whether they like it and find it helpful or not. We requested their feedback suggestions to make it better and more trustworthy. The size of the surveyed sample was 90 future customers of different backgrounds.

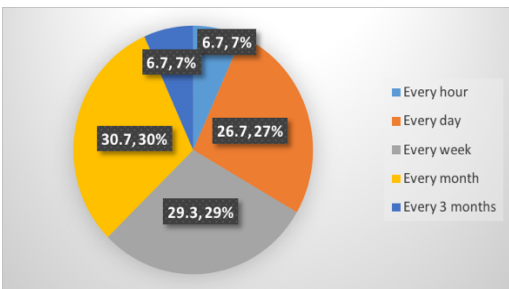
The questions of the marker research survey were as follows:

1. Do you want to know about water consumption in your house? (Yes/No)
2. When do you want to be informed about your consumption? (five Choices ranging from every hour -to- every 3 months)
3. Do you want to know about water Pressure in your house? (Yes/No)
4. Do you want to know if there is a water leakage in your house? (Yes/No)
5. How do you want to be informed if water leakage is detected? (Mobile App notification/ SMS)
6. What is the perfect behavior when observing leaking? (Notification by App/ Notification by SMS/ Close the valve)
7. What is the maximum period which you will be satisfied if leakage is detected within it? (five choices ranging from 1 hour to 1 month)
8. If your device needs maintenance or battery replacement every 6 months, how will you be satisfied in scale of 1 to 10?
9. Which option do you prefer? (Small Device that needs external power source /larger device with self-sufficient battery)
10. Do you have fixed Wi-Fi Internet connection in your home? (Yes/No)

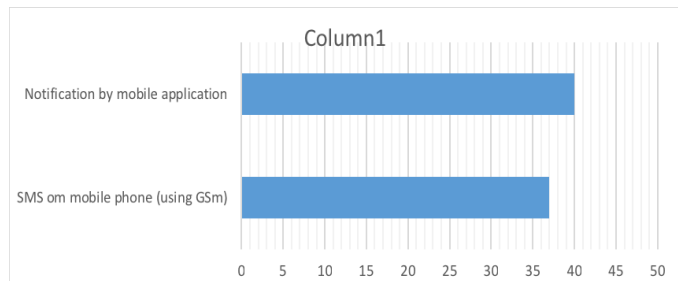
Some of the obtained responses are shown in Figure 4. According to the responses of Question2, the requested periodic rate of consumption monitoring varies among the sample as shown in Figure 4(a). With around 30% of the sample satisfied with monthly notification, and similar numbers for weekly and daily more periodic notifications. Very few customers are interested in

hourly updates of the consumption. A fact that can be utilized in our system to save the power of the device by sending the collected data once a day.

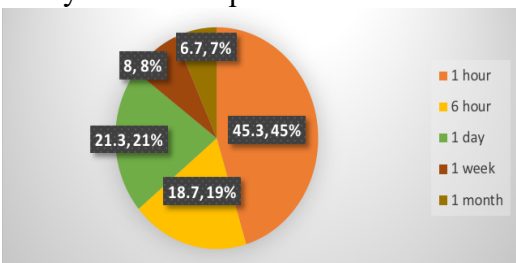
It was clear from response analysis that leakage detection is the most important feature request for the users. With 98% of the survey sample agreeing to the feature (Question 4), as compared to 88% interest in water consumption and 85% interest in water pressure. Moreover, around half of the surveyed sample request a detection of the leakage within one hour as shown in Figure 4 (c). Surprisingly, the selected method of notification was leaning towards SMS mobile messages as compared with mobile app Figure 4 (b).



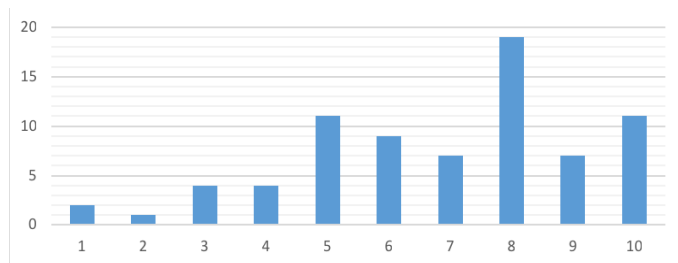
(a) Response for Question 2. “When do you want to be informed about your consumption?”



(b) Responses for Question 5. “How do you want to be informed if water leakage is detected?”



(c) Response to Question 7. “What is the maximum period which you will be satisfied if leakage is detected within it?”



(d) Response to Question 8. “If your device needs maintenance or battery replacement every 6 months, how will you be satisfied in scale of 1 to 10?”

Figure 5. Some of the market survey results

In terms of the device construction. Most of the users were satisfied with a 6-month battery lifetime if the device is battery operated Figure 4 (d). More than half the sample (55%) were

leaning towards a smaller device form and 92% of the surveyed sample have Wi-Fi internet access in their homes.

B. Competitor analysis.

We have reviewed some of the similar IoT systems in the market that offer similar service or features to our device. Figure 5 shows images of four similar devices, and Table (2) offers feature comparison of these devices.



(a) D-Link DCH-S160 [7]



(b) Driblet [8]



(c) WATERHERO WATER MONITROING SYSTEM [9]



(d) FLO All-in-one security system for your home water [10]

Figure 6. Different competitor devices available in the international market

The DCH-S160 device by D-Link [7] is a Wi-Fi water sensor that detects leakage, by installing it in the basement, then it detects water on the sensor cable, at which point the alarm sounds and a notification delivers to the smartphone. This device has an ease of installation but miss to a lot of features as it just a water sensor. It cannot measure consumption of water or help you to

reduce your consumption or even detect any fault or your water pump. In addition, it lacks a GSM module to communicate with user using SMS. Price of the device in USA is around \$100.

Driblet [8] is a small device that can be attached to any residential water pipe, where it captures data on how much water a household uses, as well as the water's temperature and pressure. A Wi-Fi module sends all the data to the user's smartphone and presents the user's water consumption in digestible graphs. The Driblet app also allows users to set water-saving goals and tracks their progress. Because it's powered by water pressure, Driblet never needs to be recharged – just installed once.

The WATERHERO alarm system [9] makes use of a homeowner's existing Wi-Fi network to collect water usage information in the Cloud, down to a per-second level. Simple profile information provided by the user allows Water Hero to start looking for unusual water flows that may indicate a leak. When it detects abnormal water usage, a homeowner receives a warning message via a text message. Unless the homeowner instructs otherwise, Water Hero will activate a motorized valve to shut off the water, protecting your home. It requires a cut into the main pipe by a professional plumber.

The Flo water security and management system [10] is a Wi-Fi connected device installed on the main water supply line. The system uses an iOS or Android app that controls conservation, monitoring and security settings. By continually monitoring the home's water flow, pressure and temperature, Flo detects abnormalities to help to avoid problems like bursting pipes. Flo has water pressure sensors which use machine learning to proactively detect leaks. The system can automatically shut off the water supply in response to a pipe burst, flooding or other irregularities. To conserve water, it senses water pressure, flow rate and temperature and learns homeowner usage patterns. You can check current water usage, compare to historical data and set conservation goals in the Flo app.

It is worth noting that none of the reviewed devices were available in the Egyptian market, this can be contributed to the fact that the selling prices for the devices that offers similar functionality was very high for the Market in Egypt.

Table 2. Comparison of the main features and price value for the different competitor devices

Product	Dripless	D-Link [7]	Driblet [8]	Water Hero [9]	Flo [10]
Ease of installation	Moderate - Cut right into the pipe where water enters the home	Easy – Sensor on floor	Hard - Plug into all water pipes	Moderate - Cut right into the pipe where water enters the home	Moderate - Cut right into the pipe where water enters the home
Water Consumption and Statistics	✓	✗	✓	✓	✓
Consumption Goals and Advises	✓	✗	✓	✗	✓
Mobile Application	✓	✓	✓	✗	✓
Web Dashboard	✓	✗	✗	✓	✗
Connectivity	Wi-Fi & GSM	Wi-Fi	Wi-Fi	Ethernet	Wi-Fi
Leakage Detection	✓	✓	✗	✓	✓
Detection Method	Artificial Intelligence	Detecting Water on Floor	-	Detecting exceeded water flow	Detecting exceeded water flow
On-Leakage Action	shut-off Water & Buzzer	Siren	✗	shut-off Water	shut-off Water
Water Pump Monitor	✓	✗	✗	✗	✗
Power Source	Self-Operated	AC Outlet	Self-Operated	AC Outlet	AC Outlet
Price in	< \$100	\$107 + Shipping from USA	Not Released	\$600 + Shipping from USA	\$400 + Shipping from USA

CONCLUSION.

In this paper, we presented Dripless an IoT residential wireless water monitoring and control system that offers leak detection and prevention. It uses a smartphone dashboard to provide users with the ability to monitor and control their household water remotely. This paper introduced the dripless system features, and components. It also provided a preliminary market survey and competitor analysis of the potential market for such system.

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