Smart Water Distribution Using IoT

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Abstract: ***The water may be supplied either continuously for all the 24 hours of the day or maybe supplied only for peak periods during the morning and evening. In an intermittent supply system, water is generally stored by consumers in tanks, drums, utensils, etc. For non-supply periods. They throw this water even if unutilized as soon as the fresh supply is restored. This increases the wastage and losses considerably. In intermittent water supply, water quality becomes an issue because of biological, chemical contamination, backflow, etc. in the other hand continuous water supply is way better than intermittent water supply as water quality cannot be compromised. But continuous water supply is challenging to achieve. As continuous water supply is further affected by low tariffs and cost recovery, poor metering, and high rates of NRW. There are high chances in some cities that water will not be available in sufficient amounts. This paper explains how smart water distribution can achieve continuous water supply and equal distribution of water. This can be further useful for cost recovery using the IoT platform.***

Keywords: Water, IoT

1. Introduction

Millions of people in low- and middle-income countries receive water through intermittent water supply for drinking and domestic purposes. The complex biological, physical, and chemical mechanisms can degrade water quality during water transmission from a source to consumer taps. Currently, international agencies and governments promote conversion to continuous water supply or improving supply continuity, which while a desirable challenge for resources. This paper explains how continuous water supply can be applied using IoT even if an insufficient (limited) water source is available. Which will be further useful for cost recovery.

2. Problem Statement

Millions of people in low- and middle-income countries receive water through intermittent water supply for drinking and domestic purposes. In intermittent water, supply water gets contaminated most of the time because of the following reasons. Intrusion, backflow, biofilms, loose deposits, and microbial growth. Biofilms formed in stagnant water were found to have more bacterial cells and detach more rapidly when exposed to change in shear stress than biofilms that had developed in flowing water, when flow restarts in an intermittent water supply, pipe charged up may cause flushing effects because pressure increases rapidly.

People have a general tendency to keep the taps open during non-supply to keep the tap open during the non-supply hours, so that they may come to know of it as soon as the supply is restored. Many a time water goes on flowing unattended even if the supply is restored thus resulting in wastage of water. In intermittent water supply, people at higher elevations may not able to store a sufficient amount of water as they may get lower pressure. When the water supply is for a very short time some people use pumps at the tap to get more water in less timethant results some people may not get water at their tap. Due to a lack of awareness or uneducated people don't save water they waste water unnecessarily as the cost of water is very low, and some people do not pay water taxes regularly. To overcome such problems smart water distribution can be very useful.

3. Literature Review

Smart water consumption measurement system for houses using IoT and Cloud Computing

Henry Fuents and David Mauricio (2020) conducted a study, where an intelligent measurement system is implemented to detect possible leaks and live consumption measurement of water using IoT and Cloud Computing.

IoT Architecture

Henry Fuentes and David Mauricio mentioned the technological solutions for the measurements of water consumption are supported by an IoT Architecture design of the layer of the system that will allow communication between smart devices. In a research article by Horseburgh et al.(2017), an open-source IoT architecture, which includes local processing and low-cost hardware is proposed to measure and record the water consumption. Similarly, a low-cost IoT architecture is presented by Zafar et al. (2018), which in addition to its simplicity allows real-time monitoring of the temperature and humidity environment.

Wireless Technology

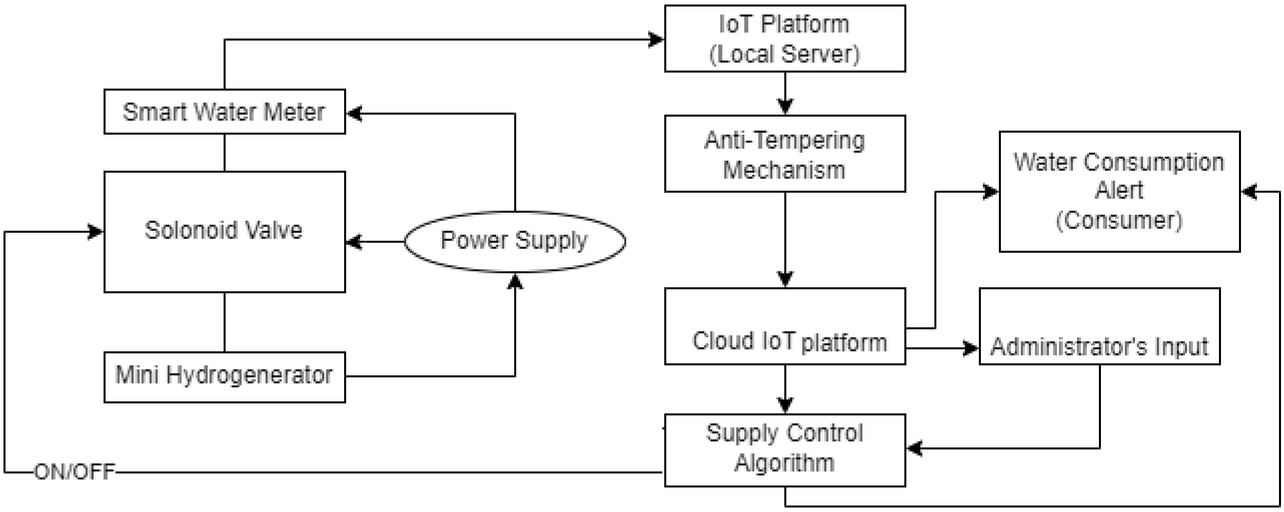
Technological solutions based on IoT require wireless communication technologies, through which the devices can send and receive the data effectively (Henry Fuents and David Mauricio 2020, Marais et al 2016). A water monitoring system is built by Chen and Han (2018) in a city based on the "Bristol Is Open" platform; likewise, Wi-Fi is used due to its long-range (up to 100m) and a transmission packaged of up to 7 Gbps.

Smart Water Consumption Measurement System:

The smart measurement system is based on the development of architecture for IoT that covers 5 important aspects. First is the capture of water consumption, which for security must have a data encryption mechanism (Zha et al 2018). Then the local preprocessing of the consumption received. The third is the physical security of electronic devices. Then the storage and the visualization of water consumption were obtained. Finally the analysis of consumption through the leak detection algorithm. (Henry Fuents and David Mauricio 2020).

4. Smart Water Distribution System (Components and Working):

The working of the smart water distribution system is as follows.



Mini Generator:

Through this component, electricity gets into a generator, which is further used for the solenoid valve's smart water meter and operations.

House Data Collection:

Each time t1 captures water consumption through this component, which is sent to the local server (Edge Gateway) for storage and processing. The consumption is obtained through a sensor of water pulses where approximately for every 367 pulses they are equivalent to the pass of 1L of water. Then the Node MCU ESP8266 module (Handson Technology.n.d.) is responsible for transforming these pulses into digital values with JSON format, which are sent to the gateway via Wi-Fi and using a lightweight protocol called MQTT. (Henry Fuents and David Mauricio 2020)

Edge Gateway

This component receives the data obtained from the "House Data Collection" component, which are stored and processed to be subsequently sent in a single frame the accumulated in time t2 to the "Cloud" component. This local server is mounted on a small, low-cost computer with a Wi-Fi connection called "Rasp-berry pi". On the other hand, the processing is done using the "Node-Red" software, which through a flowchart interface adds logic that allows the transformation and storage of the data in the NoSQL database called couch DB, which contains the process that is executed every time t2, and which is responsible for obtaining the accumulated consumption within that period and sending it to the "Cloud" component for later storage and analysis. (Henry Fuents and David Mauricio2020)

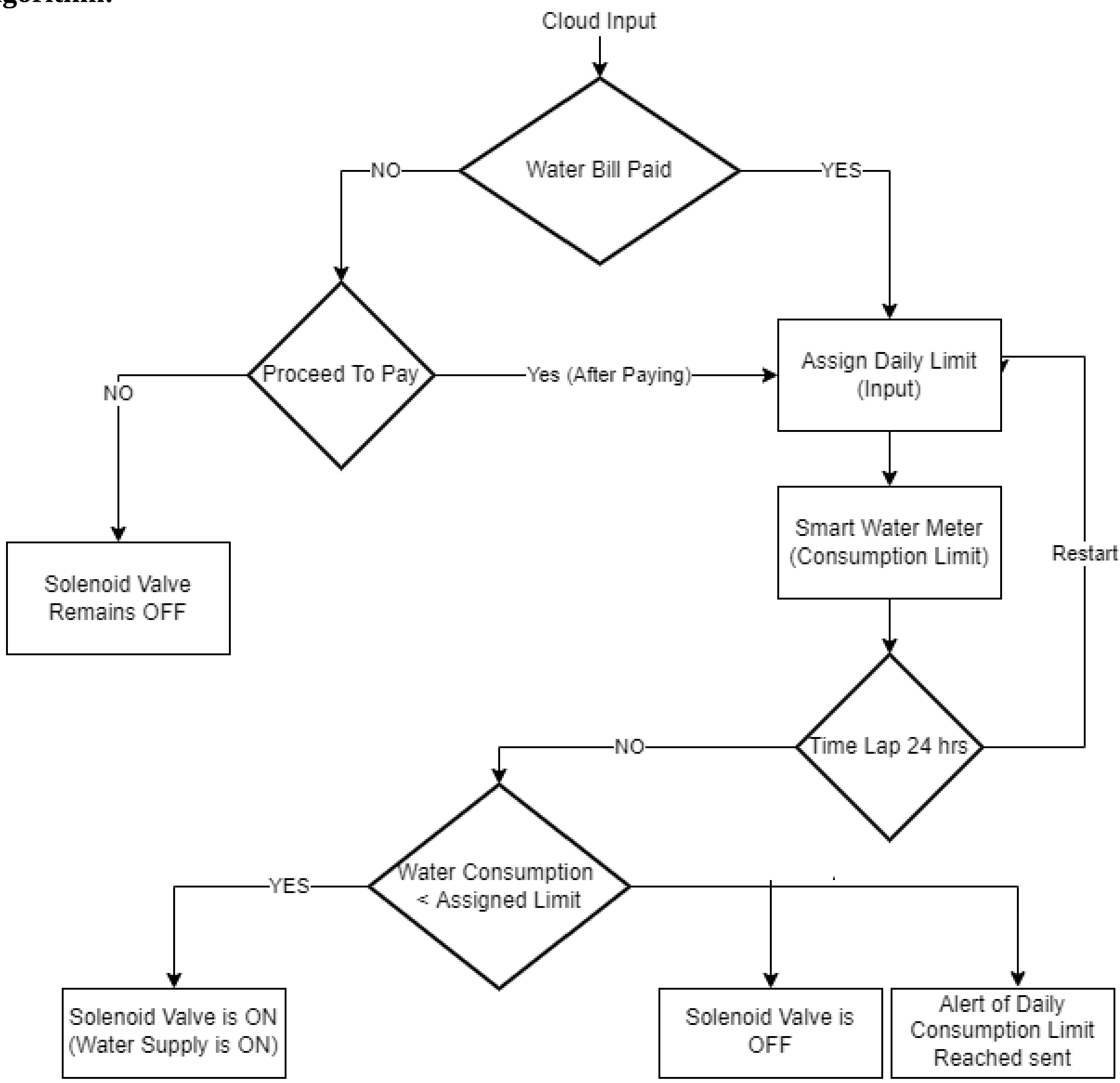
Anti-Tempering Mechanism:

This component is used to ensure that, in case of any physical manipulation of the "Raspberry pi" device, an alert is issued to the user and administrator to guarantee its proper functioning. This can be achieved through a vibration sensor such as SW-420 which also calibrates the sensitivity level. This component was not implemented in the prototype; however, Abreu et al (2018) consider physical protection as a requirement of almost every IoT device that is physically accessible by anyone. (Henry Fuents and David Mauricio2020)

Cloud:

This component receives the data obtained from the "Edge Gateway" component and the user's location through the cell phone's GPS which is sent every time t3, so that can be stored, analyzed, and displayed in the cloud platform. The analysis is performed on the IBM streamflow analysis platform which allows analyzing and acting in real-time on massive amounts of data that may come from different sources and that are constantly sent. In addition, in this component "Cloud" there is a web portal, which is deployed in the Azure cloud. So that users can see in real-time.

5. Algorithm:



After processing of data; the cloud sends it to the server where data is analyzed that is consumed by every user. The daily consumption limit is assigned for DMAs, Sub-DMAs, or every individual household by the server.

The first condition of the water distribution algorithm is "whether the water bill is paid or not" if the water bill is paid daily limit for the consumer is getting assigned. If the water bill is not paid there is the condition "proceed to pay" if a consumer pays the bill daily consumption limit gets assigned. If not solenoid valve remains off. After assigning the daily limit algorithm take input from the smart water meter for live consumption. After the smart meter, there is a time lap condition of 24 hours. When the water supply completes 24 hours it restarts again. When 24 hours is not completed there is the condition "Live water consumption < Assigned limit" if this condition is true solenoid valve remains on otherwise solenoid valve gets stopped and an alert to the consumer is sent that their daily consumption limit is reached.

6. Result

Details of consumption. May 2022

User No. 0000021

Water bill status: ☑

Location DMA1, BUILDING2, HOUSE NO:1

Date	Assigned Limit(L)	Water Consumed	Supply Status.
01/05/2022	1000	870	Did not stopped
02/05/2022	1000	900	Did not stopped
03/05/2022	1000	991	Did not stopped
04/05/2022	1200	1120	Did not stopped
05/05/2022	1200	950	Did not stopped
06/05/2022	1000	650	Did not stopped
07/05/2022	900	900	Stopped at 2300 hrs
08/05/2022*	1000	656*	Supply is on

7. Conclusion

This system is designed for an equal amount of water distribution. This is helpful to achieve a continuous water supply system. A smart water distribution system is very useful for cost recovery as users get water only when they have paid their previous water bills. Wastage of water is reduced as people have their daily consumption limit. For excessive water, people have to pay the bills first. People who are at higher elevations also get an equal amount of water. People do not need to store water. To continue consumption everyone has to pay water bills on time hence NRW is reduced. Water quality is improved. In some cases water may not be available in a sufficient amount at this time also water is equally distributed. People can analyze and manage their water consumption as they have access to their live consumption. People do not need to keep their taps on as they have a continuous water supply hence wastage of water gets reduced.

References

[1] Smart water consumption measurement system for houses using IoT and cloud computing Henry Fuentes · David Mauricio 2020
[2] https://link.springer.com/article/10.1007/s10661-020-08535-4#Sec6
[3] Intermittent Water Supply: Prevalence, Practice, and Microbial Water Quality Emily Kumpel†,‡ and Kara L. Nelson*,† 2016
[4] https://pubs.acs.org/doi/full/10.1021/acs.est.5b03973

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