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Enhanced Leak Detection in Water Distribution System Using IoT

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***Abstract*—** Water leakages in underground distribution of water through pipelines are the major issue faced by all. The inspections made by Human resources to find leakage are difficult in the real time. In this project, we propose a leak detection system to continuously monitor the underground water pipelines to make the man work easier. This system detects the leak as soon as any damages made to the pipelines due to several factors such as the pipe's age, improper installation, and natural disasters. Here the water management staff is informed about the leakages through message. The staff will be able to determine the leak of water and its precise location of the leakage. The system is made up of basic components: sensors, GSM module, Raspberry-pi. Mobile phone's message and the mail is the alert transmitter of the system to the user and higher authorities in case of water leaks. This project helps the water department workers to identify the underground water leakage in an effective way and reduces the wastage of water which is unnoticed by humans.

***Keywords*—**Global System for Mobile Communication(GSM), Hall Effect Sensor, Raspberry-pi, Leakage Detection

I. INTRODUCTION

Water is the most important natural resource in the human's life. Human needs water in almost all daily activities such as washing, cleaning, taking bath, agricultural and industrial purpose. However, the amount of clean water is decreasing where as the number of people in the world are always increasing. Water is a precious thing required everywhere, but because of its excess use the time says to use it carefully so that the next generation people will face minimum problem. Our world and community is facing excessive water usage either for domestic or commercial purposes and it is a serious issue, which affects the sustainability of our environment. Water shortages or scarcity may be caused by the current climate changes, as altered weather-patterns (including droughts or floods), increased pollution, and increased human demand and overuse of water. As water is one of the scarce natural resources, it is important to properly use and manage our usage in different sectors. If we keep on wasting water continuously it can be very dangerous problem in future. There are various ways through which water gets wasted. Whenever there is a leakage in any area we couldn't get it in initial stage, when it becomes a huge problem it causes large wastage of water. So, it is better to take action immediately as soon as leakage takes place. The main goal of the project is to curtail the water scarcity problem by diagnosing the leakage in water distribution networks and update it to the connected authorities for the further action.

The workflow of the project is as follows:[2] presents the brief overview of the existing literature on this topic.[3] describes the process of identifying the flow rate of water in a pipe, methodology to detect the leak in the pipelines, intimation of leak through mail and alert message to the higher authorities and the water man respectively.[4] includes the evaluation metrics, results and summary of the proposed system's effectiveness.[5] describes the interpretation of the project and gives a proper conclusion for the project.

II. RELATED WORK

A design for automatic water supplying system in farmland using raspberry Pi 3,Ardunio microcontrollers, WiFi module, GSM shield and water flow sensors .The system will help utilizing water resource wisely and reducing the human effort in maintaining crops which will consequently decrease damage from human errors [1].The automatic water level controller is a smart system as all processes occur automatically with continuous updates by controller, to the user, via GSM technique i.e. SMS Notification [2].The quality of water is measured using pH sensor and Turbidity sensor. The water level is measured by ultra sonic sensors. Pressure of water is detected by using Force Sensitive Resistor (FSR) of water leakage [3].In their finding, they investigate the design of water level sensor device that is able to detect and control the level of water in a certain water tank. The proposed model is to forecast and monitor the consumption of water basically consists of flow meter, microcontroller, micro computer and infra structure. The flow meter measures the flow rate of water and generates a

pulse signal accordingly [4].Their system shows the leakage detection, data storage and communication of the water distribution system by using intelligent sensors like flow meter [5].The early modeling approach are being referred as a traditional methods for leak detection. Model-based approach is extended with the concepts of machine learning for improving leak detection. Solution is based on the clustering algorithm on the data from smart meters [6].The early modeling approach are being referred as a traditional methods for leak detection. Model-based approach is extended with the concepts of machine learning for improving leak detection. Solution is based on the clustering algorithm on the data from smart meters [7].The device is designed to take into account the feasibility of the technology and user needs. The features of this device allow the leak detector to perform remote operation by listening to the recorded suspicious leak sound. This will enable them to make more accurate judgment by comparing the normal sound produced by the Pipeline [8].Main objective to implement their project is to design and develop a low cost reliable and efficient technique to make proper water distribution by continuous monitoring and also controlling it from a central server so that we can solve water related problems [9].An implementation of a system to monitor water tank levels is presented. The system is called: Interface for Monitoring water tanks and consists of the following modules: 1) a set of electronic components consisting of one ultrasonic sensor installed in the water tank, bound to an Arduino Microcontroller Board connected to 2) the application service installed in a Server Machine to receive and manage the measurements of the water tank levels, to advise 3) the Mobile Interfaces using any smart phone or any mobile device based on SMS [10].The main sensor node consists of several in-Pipe electrochemical and optical sensors and emphasis is given on low cost, lightweight implementation, and reliable long time operation.

Moreover, contamination event detection algorithms have been developed and validated to enable these sensor nodes to make decisions and trigger alarms when anomalies are detected [11].In this paper, they presented a study on the use of Thermo graphy IR camera for detecting and locating leaks of water mains. The study encompassed field investigation and testing as well as modeling development. The leaks detected using IR camera was compared to those detected using acoustic- based leak finder method.

III. METHODOLOGY

The model consists of multiple branches, in which valve gets opened from the main area, water in the tank gets started to flow in the main branch of the pipe. A branch consists of two water flow sensors, to calculate the initial rate and the final rate (i.e) before splitting into branches. Once the rate is calculated it is sent to raspberry pi for programming, once it is done then with help of GSM a message is sent to the higher authorities.

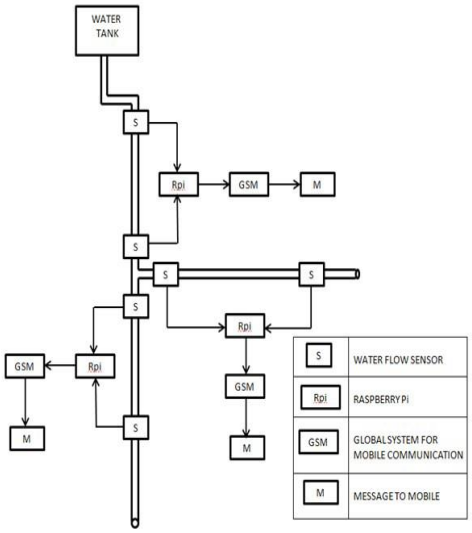

Figure 1 Proposed System Block Diagram

The **Figure 1** shows the overall block diagram of the proposed system. It consists of four terms such as sensor (water flow), Rpi-raspberry pi, GSM-Global System Monitoring, Msg- Message. The sensors in the working model of the water distribution systems are placed in a distance of one meter between the sensors. In the real time model, the distance can be extended to 1.5kilometers to 3kilometers.

Water flow Sensor and Modules:

Water flow through each branch in the pipe is identified by the water flow sensor. The sensor is connected to the water pipeline. Water flow sensor consists of a plastic valve body, a rotor and a hall-effect sensor, the rotor in the sensor rolls. The speed of the rotor changes with different rate of flow in the pipeline. The hall-effect sensor is used to measure the speed of the rotor.

Figure 2 Water Flow Sensor

The **Figure 2** describes water flow sensor consists of a plastic valve from which water can pass. A water rotor along with a halleffect sensor is present, it sense and measure the water flow.

Flow Rate Detection

By counting the pulses from the output of the sensors we can easily calculate water flow. The water flow sensor has the hall-effect sensor which uses the calibration factor to identify the flow rate. For calculating flow rate of water, use formula

Q=n/c, Where,

Q=flow rate,

n=number of wheel rotations,

c=calibration factor (7.5)

The hall-effect sensor output the corresponding pulse signal, which indicates the flow rate of the water through it.

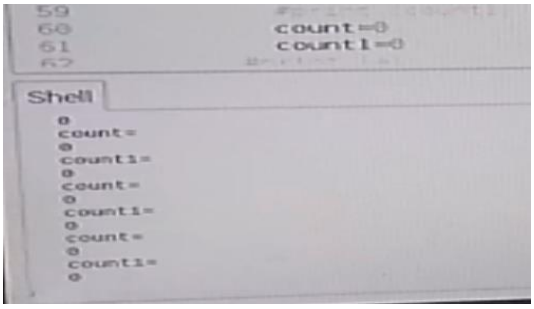

Figure 3 Sensor Rate

Leak Identification

Water flow sensor used in the project is of working range of 0.3 to 6 litres per min and water pressure of <=0.8 MPa. As mentioned in the flow rate detection, when the water flows through the sensor in the specified direction it results the rate of flow in liters per minute. In the block diagram figure 4, we have the initial and the other sensors in all the branches. As the pressure of the water increases the wheel inside the sensor starts rotating. The flow rate is identified from the pluses as mentioned above. The frequency of the flow rate is calculated using the formula:

Frequency = 7.5*flow rate →**Eq.1**

Eq.1 Describes the frequency of flow rate to be calculated. The threshold value to detect leak is fixed from the initial flow rate of the branch. The threshold value is compared with the other sensor values to detect leaks. If there is any decrease in the value there occur the leak in that branch and position of that sensor.

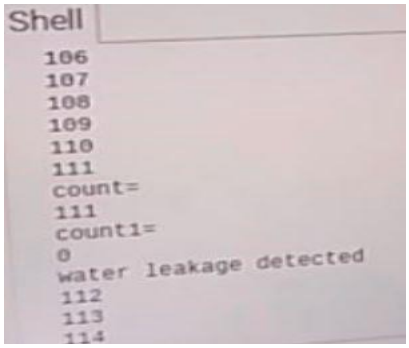

Figure 4 Difference in count rate of sensor

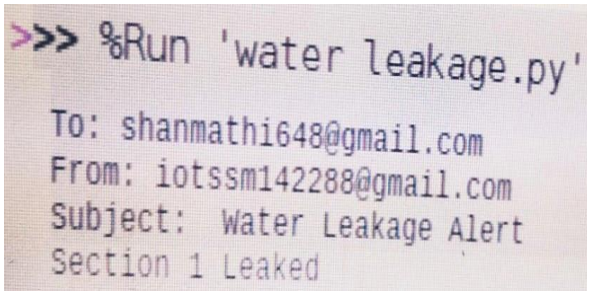

Figure 5 Leak Intimation

Figure 3 describes the user (water man) with to address, from address and it consists of subject that water leakage alert and which branch is leaked.

Mail Transfer Using SMTP:

The detected leak is mailed to the higher authorities through mail. When a leak is identified, the mail is sent to higher authorities with the branch number. By informing to higher officials, they can easily monitor the damaged pipelines. Simple Mail Transfer Protocol is used for the purpose of transferring the mail to the higher authorities. SMTP provides a set of codes that simplify the communication of email messages between email servers (the network computer that handles email coming to you and going out). It's a kind of shorthand that allows a server to break up different parts of a message into categories the other server can understand. SMTP can't be used to retrieve and store emails. SMTP is simple and reliable, but not very secure.

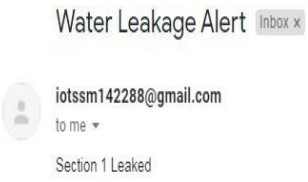

Figure 6 Alert mail with branch

Figure 3 describes the alert message through mail service to higher authorities. It identifies the leak and indicates which section (branch) is leaked.

Message Service using GSM:

GSM-Global System for Mobile Communication is a digital cellular technology used for transmitting mobile voice and data services. GSM is the most widely accepted standard in telecommunications and it is implemented globally. GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time-slots. GSM operates on the mobile communication bands 900 MHz and 1800 MHz in most parts of the world. GSM makes use of narrowband Time Division Multiple Access (TDMA) technique for transmitting signals. GSM was developed using digital technology. It has an ability to carry 64 kbps to 120 Mbps of data rates. GSM

provides basic to advanced voice and data services including roaming service. Roaming is the ability to use your GSM phone number in another GSM network. The leakage detected in the water distribution network is intimated to the water man of the leakage branch .The intimation is done using the GSM module to message the leak alert to the user. The Raspberry Pi indicates about the leakage through GSM module and its precise branch of leak. The GSM module sends the alert message to the specified water man of that branch and its location of leak.

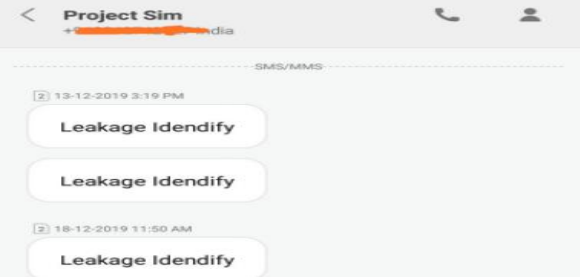

Figure 7 Message Intimation

Figure 4 shows the message intimation sent to the concerned person.

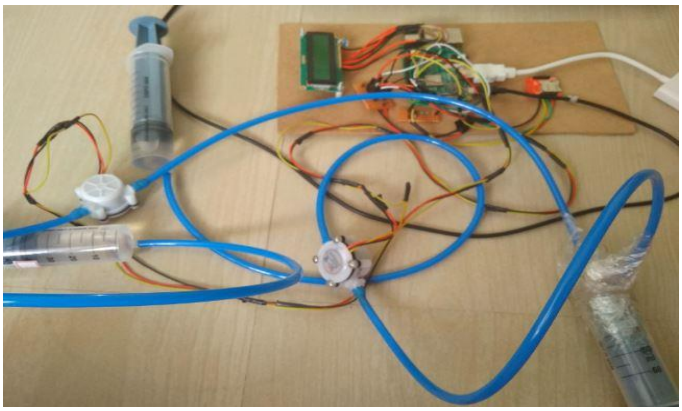

Figure 8 System Architecture

Figure 5 shows the complete architecture of our system in which it consists of sensors which is connected to the pipelines (i.e) inlet, outlet and leakage, HDMI cable connected to the monitor and circuit connections are made to get the corresponding output.

IV. RESULTS AND DISCUSSION

The sensor used in the present system for the leakage detection in water distribution system has the drawbacks as mentioned in the Table 1. The water flow sensor used in the present system has high accuracy of detection. The flow rate will be correct even though in less flow in it. The sensor will not affected by natural changes like temperature change, dust etc.

Table 1 Sensor Classification Chart

Sensors	**Drawbacks**
Pressure Sensor	Oscillating values cannot be determined
IR sensor	Affected by hard objects like dust etc
Sound Sensors	No accuracy ,high memory space
Flow meter	Difficult in the time of less flow
Ultrasonic sensors	Variations due to different temperature
Force-Sensitive Resister R	Low accuracy

The sensors used in the previous IOT project have many drawbacks in the accuracy of values which is most important in identifying leaks. The water flow sensor has high accuracy in the flow rate detection and cost effective for implementing in very large water distribution networks.

In our experiment, the difference in the flow rate of water and its result of detection is discussed. This project discuss about the implementation of IOT in water distribution system on the basis of designed IOT architecture, results in identifying leakage of water in underground pipelines. In the present working model of our project the plastic pipes are used for water flow. In future, while constructing in the real time model we may use polyvinyl chloride (PVC), copper, steel, chlorinated polyvinyl chloride (CPVC) etc can be used. The message to the water man about the leakage through GSM helps to recover it as soon as possible. The higher authorities are also intimated about the leak through mail to be known about the condition of the pipelines and the recovery process.

The results from the water flow sensor are converted to the frequency of the flow rate by using the above mentioned formula. The table below provides the comparison and helps in identifying the leakage.

Table 2 Flow Rate and Frequency Calculation

BRANCH	SENSORS	FLOW RATE (L/min)	FLOW FREQUENCY (Hz)
Main branch	Initial sensor	2.6	19.5
	Other sensor	2.6	19.5
1st branch	Initial sensor	1.5	11.25
	Other sensor	1.3	9.75
2nd branch	Initial sensor	1.1	8.25
	Other sensor	1.1	8.25

The Table 2 shows the results in flow frequencies of all the sensors in all branches. The variation in the frequency shows the leakage in that specific branch. In the resulted values the main branch and the second branch has no leaks. The first

branch has difference in the flow frequencies and hence there occurs leak in that branch and also in those branches.

V. CONCLUSION AND FUTURE SCOPE

The sensors are classified based on their drawbacks and it is identified that water flow sensor has high accuracy and it is a cost effective. The flow rate is converted to flow frequency using the above mentioned formula. The variation in frequency shows the leakage in the branch. Implementing this system with multiple sensors for sub branches which will able to identify the leak in all branches with a correct rate and sending it to the user man via SMS.

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