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COLLEGE OF SCIENCE AND TECHNOLOGY

African Center of Excellence in Internet of Things

IOT BASED SMART WATER LEAKAGE DETECTION SYSTEM

Dissertation Submitted in partial fulfilment of the requirements for the award of

MASTER'S DEGREE IN INTERNET OF THINGS- WIRELESS INTELLIGENT SENSOR NETWORKING

Submitted by:

UWIZEYE Marie Grace

Reference Number: 220014347

December 2021

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Thesis Title:

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Case Study: University of Rwanda, College of Science and Technology,

MUHABURA Block Building

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Supervised by:

Dr. GAURAV Bajpai

Dr. KABANDANA Innocent

December 2021

DECLARATION

I, **UWIZEYE Marie Grace** hereby declare that the project work **"IOT BASED SMART WATER LEAKAGE DETECTION SYSTEM"** is the record of my work and has never been presented or submitted for any academic award authentic in any University or Institution as a whole or in part except where specifically acknowledged. The contents of this project may be made available for academic purposes in the College of Science and Technology/African Center of Excellence Library.

Student Name:

UWIZEYE Marie Grace

Ref: 220014347

Signature:

Date:

BONAFIDE CERTIFICATE

This is to certify that the Project work entitled **"IoT Based Smart Water Leakage Detection System"** is a record of the original work done in partial fulfillment of the requirements for the degree of Master of Science in the Internet of Things-Wireless Sensor Intelligent Networking at the African Center of Excellence in IoT (ACEIoT)-College of Science and Technology (CST) in University of Rwanda (UR).

Supervisors,

Dr. GAURAV Bajpai **Dr. KABANDANA Innocent**

Signature: **Signature:**

Date: **Date: 17/01/2022**

Head of Masters and Training ACEIoT,

Dr. James RWIGEMA

Signature:

Date:

DEDICATION

This project is dedicated to The Almighty God who always cares for me, my supervisors who worked with me all the time and gave me more advice to achieve my target, my family members that introduced me to the joy of reading, enabling such a study to take place today and classmates and all my friends that contributed directly or indirectly to completion of this study,

I dedicate this work to you all.

ACKNOWLEDGMENTS

It gives me a great sense of pleasure to present this report of master's degree in Internet of Things at the African Center of Excellence in the Internet of Things, a project undertaken during my final year.

I owe a special debt of gratitude to my supervisors **Dr. GAURAV Bajpai** and **Dr. KABANDANA Innocent** their constant help, support, and more advice, I consider the honor to work with them, without this guidance and persistent help this project would not have been possible.

I would like to express my deepest appreciation to Ag. Director **Dr. DAMIEN HANYURWIMFURA** and our Head of master's Program **Dr. James RWIGEMA** for their full support and assistant during the development of this project.

This also is my great opportunity to acknowledge the contribution of all members of ACEIoT for their kind assistance and cooperation during the development of this project.

May the almighty God bless you!

ABSTRACT

Water is an important resource in life. Every creature's life depends on water availability, is used for various purposes in daily routine. This system has been developed to detect a leakage of pipe to be maintained directly in a short time. So, it is important to have real-time control of water leakage to avoid any issues. This will be achieved by introducing a system that will detect leakage in water distribution pipes. It consists of water flow sensors placed on the pipe to sense the rate of water, microcontroller Arduino Nano to control hardware modules, power supply, Global System for Mobile communication (GSM) for sending messages to the mobile phone of authorities also it allows transmission of email notifications. This project aims to implement a water leakage detection system for plastic water supply pipelines using the internet of things (IoT) in the College of Science and Technology/MUHABURA Block Building for keeping the availability of water in the toilettes used by students and staff as it is a building with many rooms.

Keywords: *IoT, Water Leakage Detection, GSM, and Water flow sensor.*

LIST OF ACRONYMS

UR: University of Rwanda

ACEIoT: African Center of Excellence in the Internet of Things

CST: College of Science and Technology

Ag: Acting

IoT: Internet of Things

Ref: Reference

GSM: Global System for Mobile Communication

WASAC: Water and Sanitation Corporation

SMS: Simple Message System/ Short Message

USA: United State of America

RURA: Rwanda Utilities Regulatory Authority

GUI: Graphical User Interface

API: Application Programming Interface

RF: Radio Frequency

DC: Direct Current

USB: Universal Serial Bus

MWF: Modified Waterfall Model

LED: Light Emitting Diode

GPS: Global Positioning System

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Chapter 1

1.1 Introduction and Background

Currently, IoT remote monitoring with detection techniques is being used for tracking, collecting, analyzing data from remote areas. If the leakage happens in undergrounded and non-grounded pipelines will be detected and reported to Water and Sanitation Corporation (WASAC) with other registered authorities established by WASAC then put the maintenance in action. The location of the leakage water pipe that is the big challenge will be known by getting SMS and email. This system will reduce non-revenue water here in Rwanda. The recent report indicates that non-revenue water reaches 12-35% of the drinking water supply in the USA, 6-24% in Europe, and 4.7-24% in Korea[1], in Rwanda, RURA Statistics as of March 2020 indicates that Rwanda is losing 40% of water supplied in different areas before it reaches the customers. Real losses through overflows at storage tanks, burst leaks in distribution pipelines caused by bad connections, pipe corrosion, physical damages[2]. It is necessary to detect burst leaks in buried water pipes to reduce water production costs as well as to protect public safety[3].

Leak detection methods are classified into two groups: external and internal. The external group includes methods that failure (leakage) is found using signals collected outside pipelines[4]. Visual inspection, thermographic methods are the best examples. Internal methods are based on signals collected inside pipes. This category includes methods based on wave propagation phenomena or volume balance[5][6]. Changes in steady-state operating conditions of fluid transportation systems excite a guided wave. The guided wave has several modes that can propagate with different velocities along with pipeline systems. Wave propagation in such systems is complicated, leading to phenomena that can be affected by many factors, including geometric properties of the system, pipeline network configuration, or the existence of hydraulic fitting[7]. In addition, medium flow characteristics also influence wave propagation. It is well known that wave propagation velocity depends on frequency, temperature, pressure, medium density, pipe material[8].This system will be useful here in Rwanda where such a level of leakage is likely to happen.

The Water and Sanitation Corporation is the entity set up to manage the water and sanitation services in Rwanda because of the Government of Rwanda (GoR) decision to unbundle the

national utility former EWSA (Energy Water and Sanitation Authority). The reform is intended to deliver water with sanitation utility sufficiently focused to deliver new infrastructure, efficient, effective service delivery, building a strong people capability, and meeting key national milestones. It is expected to reverse status that includes improving viability, autonomy, establishing a sustainable and customer-centric utility to deliver an important mandate that touches people of all walks of life

1.2 Motivation

The lack of water in life is a great problem found that many times it is caused by leaking pipes in water distribution network[7]. To find the leak point requires much effort where it requires digging a long distance by finding the point of water leakage sometimes that point is missed while it is in another area, so this becomes the motivation of working on this project.

1.3 Problem Statement

Water leakage is one of the main causes of non-revenue water also causes a huge impact on clean drinking water access as leakage happens, water mixes with soil[9]. Moreover, it decreases revenues from billed water, operational costs increased. In some regions like mountains, forests, buildings, finding the location of a leaking pipe is more difficult. Water leakage in pipes leads to the wastage of water, floods, land sliding, and house fall[10]. Water Leakage on service connections up to the customer's meter is one of the types of water leakage that is usually more difficult to detect then results in the greatest volume of physical losses. However, this fault should be detected to be repaired in real-time. In Rwanda, several initiatives to strengthen non-revenue water control strategies have been taken, in Kigali and up-country.

Today, in Rwanda it is difficult to find leakage in water pipes. It requires many efforts to find the leakage point where it is done manually also there is no communication technique used for getting information about leakage. In response to this problem, this research proposed an IoT water leakage monitoring system as a project to minimize those problems where multiple sensors attached to the water pipeline will continuously report pipe flow measurement as well as send automatic alerts if there is any leakage along the water pipelines. This allows the water supply company to identify the location of leakage then prioritize a quick repair in real-time.

1.4 Objectives

1.4.1General objectives

The general objective is to design and implement an automatic water leak detection system based on a wireless sensor network with real-time notification which leads to rapid maintenance, high water revenue, water availability, environment safety, time management, and cost-saving.

1.4.2 Specific objectives

1. Review on existing solutions
2. To design a circuit for collecting water leakage information from sensors
3. Prototyping a designed system
4. To implement a microcontroller for controls hardware modules
5. Analyzing the solution by comparing it to the existing ones to show the innovation in the system

1.5 Study Scope

In conducting this project, the prototyping takes place in MUHABURA block building, College of Science and Technology, the University of Rwanda by using water flow sensors to detect a leak point in pipe, the in-flow and out-flow rate of water will be measured, when the rate measured by the sensor is less than to that was measured by the previous one in, in that case, there is a leakage. Water flow sensor sends signal pulses to Arduino Nano to be processed, the output obtained from Arduino is sent to the GSM then GSM sends the message of information produced to the mobile phone and to the Cloud to be accessed on email, Thingspeak server is used for storing data on the cloud, so Data collected sent to the cloud to be analyzed, WASAC gets notifications about leakage location. Also, Buzzer is used to produce loud sounds to inform the surrounded society that there is a problem of water leakage.

1.6 Significance of the Study

The deployment of a smart water leakage detection system based on IoT, will contribute, provide high revenue from billed water, minimize the cost of maintenance, it will significantly reduce the

manual work, will reduce the shortage of water supply, and ensure the availability of reliable service. With the deployment of IoT smart water leakage detection systems, water management becomes easier to be done efficiently.

1.7 Expected Outcome

IoT Based Smart Water Leakage Detection System is important and powerful. The outcomes expected after designing and implementing this system are getting SMS and email about the leakage that happened to be maintained directly for avoiding water wasting, the income from billed water will increase because not much water will be lost as the action of maintenance done directly also the negative impacts caused by the leakage will be reduced.

1.8 Proposed System requirements

1.8.1 Functional requirements

The IoT Smart Water Leakage Detection System must meet the following requirements:

- Detect the leakage by using a Water flow sensor
- Real-time notification of leaking pipe
- Send SMS and email to the registered authorities

1.8.2 Non-functional requirements

Software requirements are:

1. Operating System: Windows
2. Programming language: C-Programming
3. Thingspeak server for storing data
4. Arduino Nano

Hardware requirements are:

1. MINI USB Arduino Nano Board V3.0 ATmega328P
2. SIM800L V2.0 5V Wireless GSM GPRS MODULE Quad-Band
3. Water Flow Sensor

4. LEDs
5. Pipe
6. Buzzer

1.9 Thesis Contribution

The IoT Based Smart Water Leakage Detection System is an internet of things solution to handle many problems appearing in the water distribution networks where the pipe can be leaked, and the people don't know its location until many dangerous problems happen in that area. This system comes as a solution to notify in real-time the location of the leaking pipeline and the maintenance done quickly. This will facilitate monitoring different water distribution networks in a short time.

1.10Organization of the Project

This research is composed of five chapters

Chapter 1: General Introduction

This is the introductory chapter. It describes the background of the study, problem statement, objectives of the study, study scope, study significance, and the organization of the study.

Chapter 2: Literature review:

This chapter describes the related works done by other researchers towards smart water leakage detection system

Chapter 3: Research Methodology:

This chapter clearly shows the researcher proposed methodology with all corners covered.

Chapter 4: System Design and Analysis:

This chapter shows the prototype, corresponding data dashboard, and how sensors are installed

Chapter 5: Results and Analysis:

This chapter shows the results of the prototype.

Chapter 6: Conclusion and Recommendation:

This chapter gives the conclusion of the study and recommendations for future researchers.

1.11Summary of Chapter 1

This system is an important system to detect and monitor leakage in real-time. among all the other systems used, it possesses a great advantage of notifying to both ways, one is on the mobile phone wherever you are the message comes, another way is on the email where the notification comes in the inbox on email.

In this chapter, the project has given an introduction with background, motivation of the project, problem statement, objectives, study scope, the significance of the study, expected outcomes, system requirement, thesis contribution, and organization of the project.

Chapter 2 Literature Review

2.1 Introduction

Water leak detection is an expression more commonly used for larger, integrated systems installed in modern buildings or other critical assets where early notification of a potentially damaging leak proves beneficial[11]. Water leak detection has become a necessity in data centers, trading floors, banks, and homes. The existing water supply systems that incorporate high-range acoustic and pressure detection devices are way costlier to be implemented in developing countries[12]. Some irrigation leak detection systems use heating coils to detect the flow rate difference which has a drawback of detecting the fast change over in the system due to the uniform response of the temperature sensor.

This single parameter does not help in stopping leakage in the system. In this project, a water flow sensor-based system integrated with a microcontroller to detect the leak due to breakage has been discussed. This system is designed to prevent the further leakage of water flowing in the pipeline.

2.2 IoT Based Smart Water Leakage Detection System

2.2.1 Internet of Things definition

Firstly, the Internet of Things describes the network of physical objects or things that are embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems in short or long distances over the internet[13].

2.2.2 Common Causes of leaky pipes

1. **Broken seals**

In some distribution networks, the pipes used are not metal. When appliances are installed and rubber sealant placed around any connection or area like dishwasher door to keep everything watertight, as the age of the appliance the sealing can degrade and break over time.

Figure 1: Broken seal

2. **High water pressure**

When water pressure is excessively high, it could cause pipes to leak and burst. Also, even the pressure in pipes is distributed unevenly, it puts unnecessary force on the rest of the pipes and causes leaks[14].

Figure 2: High water pressure

3. **Corrosion**

As plumbing systems pass more ages, rust and another form of corrosion can attack the pipe directly causes a hole for water to escape. When the pipe is used for a long time must be upgraded.

4. **Underground movements**

The growth of tree roots, earthquakes, and flooding can move the pipes, when the ground moves the pipes can twist and bend than crack, the underground leaks happen[15].

5. **Intruding tree roots**

Tree roots can mix with water lines and cause moisture near the pipe then create the sinkhole.

Figure 3: Intruding tree roots

6. **Fixture cracks**

This typically occurs due to physical impact such as someone tripping and catching on the faucet. It can also occur out of sight due to repeated items being forced into the cupboard.

2.2.3 Proposed System

This system constructs with the microcontroller that has an integrated processor, RAM, and program memory which are used to interact with things connected to the chip, step down regulator which is the device to decrease the primary voltage of 12V to the secondary voltage of 4.2V accepted by GSM, water flow sensors that send the signal pulses to the microcontroller and send output to the GSM for sending notifications to WASAC and other registered operators. The data sent to the cloud will be stored on the thingspeak server.

At the same time, the buzzer will produce the sound signal to the entire surroundings, the LEDs also have been used to identify if there is a leakage or not, Green Led indicates that there is no leakage and the Red Led for indicating that there is a leakage.

2.3 Related works

To propose a good quality system, different existing systems done by researchers have been reviewed; they have been considered, compared with the current situation in Rwanda. IoT-based

smart water leakage detection system is developed, to inform WASAC about the locality of a leakage point in the pipeline using distributed flow sensors.

S/No	Authors/Year	Title	Description/Results	Gap/Weakness
1.	S. Rashid, S. Qaisar, H. Saeed, and E. Felemban (2014)	A Method for Distributed Pipeline Burst and Leakage Detection in Wireless Sensor Networks Using Transform Analysis[16]	-Analysis of pressure in the pipeline -This technique uses information carried in the transient pressure signal. -For communication, The system utilizes the Zigbee module.	-Information cannot precise the real leakage position. -Zigbee module cannot operate long-range.
2.	R. Hanson (2017)	Water Leak Detection System[17]	-The alert message is sent to the water user in the case of a problem in the water pipe.	-The maintenance action is not done by the user -the real-time maintenance is done here -There is a lack of water for the user fora long time.
3.	S. M. Rabeek, H. Beibei, and K. T. C. Chai (2019)	Design of wireless IoT sensor node & platform for water pipelineleak detection[18]	- water leaks can be detected by acoustic sensors such as Hydrophone. - Captured acoustic signatures are sent to the central server through the Wi-Fi network for post-processing and leak detection. -Hydrophone data is sent to the server and the GUI program can plot the position of the sensor node using Google map API.	In time the Wi-Fi network is crashed, it is better to use GSM also, to avoid lack of Informa.
4.	The on-the	The on-theonline monitoring system of water leakage detection in pipe networks with artificial intelligence[19]	- The data is taken from the pressure data when a leak was happening, either at the junction/intersection point or in a pipeline. - Detection of the leakage magnitude and location by Simulation - Arduino UNO microcontroller is used.	- The change of pressure can be caused by different issues. -The simulation only is not enough for leakage location detection
5.	M. Thilagaraj, S. Akkara, M. Aakil Habibullah, T. Manikandan, M.	Water leakage detection and management system using	-An alert system is the first part of this project to enable customers to use excess Water	-To find the reallocation of the leak take time.

	Rajmohan, and P. Yuvaraj (2020)	IoT[20]	-The second aspect is the estimation of the flow patterns and the regulation of the pipeline leak	
6.	A. M. Sadeghioon, N. Metje, D. N. Chapman, and C. J. Anthony (2014)	SmartPipes: Smart wireless sensor networks for leak detection in water pipelines[21][22]	-It uses Radio Frequency (RF) technology - In buried pipeline monitoring, sensor nodes are deployed in soil - The Micro Controller Unit (MCU) is responsible for gathering measurements from the sensors	- The RF transmission range in the soil is significantly lower than in air, therefore communication between nodes is much more limited.
7.	J. Navarajan, B. Aswin kumar, S. Venkatesh, T. Jayachandran	Detection of Water Pollution and Water Management Using Smart Sensors with IoT	The proposed system consists Several devices having respective sensors and the collected data from all devices are gathered at the core controller raspberry pi via Zigbee protocol IEE802.15.4 [23].	The weakness is about short-range issues that cannot be applicable for long-range.
8.	Ali M. Sadeghioon, Nicole Metje, David N. Chapman, and Carl J. Anthony	Smart Pipes: Smart Wireless Sensor Networks for Leak Detection in Water Pipelines	The RF transmission range in the soil is significantly lower than in air, therefore communication between nodes is much more limited. This imposes limitations on routing protocols [21][24].	The underground environment imposes major limitations on sensor nodes, such as poor Retransmission and lack of maintainability. Digging trenches to repair or replace nodes is extremely costly; therefore, sensor nodes should have a long operational life without any maintenance.

Table 1: Comparison table of related works

2.4 Current status of the project

The current system is able for detecting the leakage in the pipe by using water flow sensor and GSM to notify the location of the leaking pipe. The surrounded environment is also being able to hear the sound produced by the buzzer to indicate that there is a problem of leakage.

Chapter 3: Research Methodology

3.1 Introduction

Project methodology contains different approaches and techniques used for collecting data, the software development model, is also covers all about the system tools and techniques to use to be implemented[25]. In this project, the methodology is used for analyzing the data to identify water leakage. Every system development, collection of data, and defining the requirements needed by

the system is very important. Many methods can be used such as interviews, observations, referring to the related works, and internet search[26].

3.2 Data collection methods

Data collection methods are the techniques that were used to collect data in this project, Observations, interviews, and internet search were used.

3.2.1 Observations

In this project, the data have been collected by observations in different regions by seeing how people try to find the leaking pipe in their region.

3.2.2 Internet search

Internet search was also used with comparing to the related works done previously, by searching how the problem of water leakage in different pipeline distribution networks was solved. Different websites have been visited.

3.3 Software development model

During the development of this system, the model called the “Modified Waterfall Model” was adopted.

The MWF model is a derivative of the traditional waterfall model but with some minor variations relative to iterations between certain stages. The whole process of software development is divided into separate phases which are cascaded to each other[27]. Those are:

- System Requirements
- Software Requirements
- Analysis
- System Design
- Implementation to code
- Testing the System
- System Deployment and Maintenance

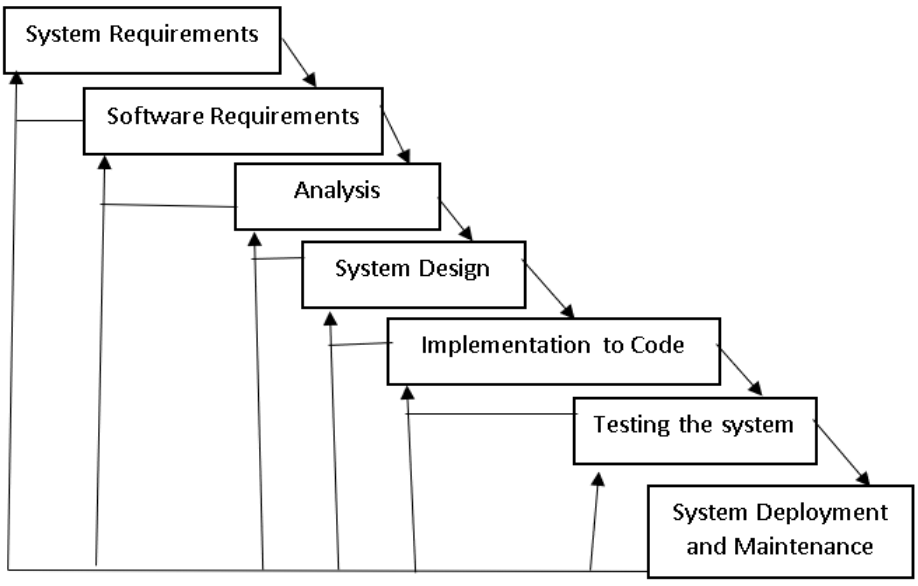


Figure 4: Modified Waterfall Model

Requirements in this phase, data have been collected by observation, internet search then information obtained were analyzed to help system design by designing how the system will work. The next step is implementation code where coding is the main objective. It is concerned with coding and testing sub-components of the system referring to the system design from the system requirements of previous phases to make this system. In the Testing system, the system was tested for confirmation with the system requirements by seeing that the results obtained are those the system aimed, the project has started with a unit test first, where every single activity was tested and then tested all activities as a single unit. The final step is the system deployment and maintenance where the system must be deployed to different locations to detect the leakage once the leakage in the pipe happens must be maintained directly.

Chapter 4: System Design and Analysis

4.1 Introduction

This chapter describes the proposed system architecture where the solution of the problem stated found. Initially, the water flow sensor is installed on the pipe for flow measurement to calculate the volume of water that has passed through[28][29]. Normally the volume entered in the first sensor must be equal to the volume acquired by the following sensor, if there is a difference, this indicates that there is a leakage happened between those sensors. Directly the notification is sent by SMS and email to WASAC and others that are registered.

4.2 Block diagram of the system

The Block diagram of the system shows the way components are connected to complete the task of detecting the leakage. Water flow measures the volume of water entering the pipe and sends signal pulses to the Arduino Nano for further processing, the result obtained is sent to the GSM that will notify the cloud and the mobile phone. The Buzzer produces the sound, Green Led light shows that there is no leakage and Red Led light for leakage. The power supply used is Battery for powering the system.

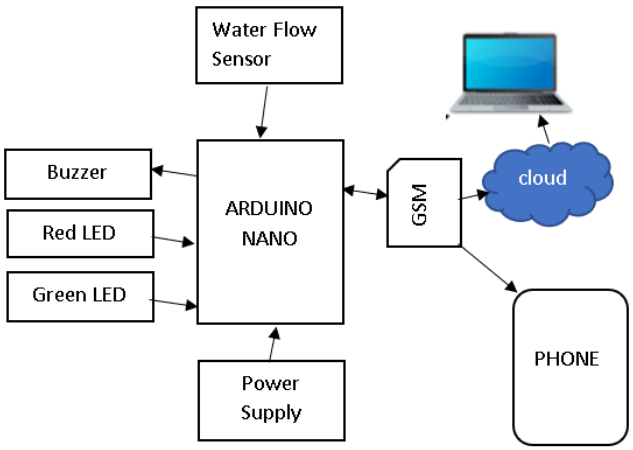


Figure 5:Block diagram of the system

4.3Use case diagram

The use case diagram of IoT-based Smart Water Leakage Detection is composing the functions of WASAC and another authorized person to complete the task as well as the technician.

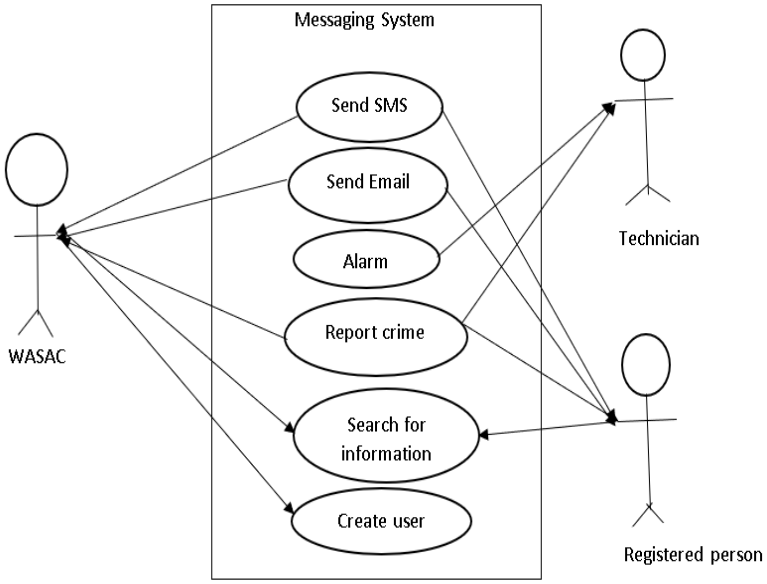


Figure 6: Use case diagram of the system

4.4System-level sequence diagram

The system-level sequence diagram determines all actions of each actor in the system.

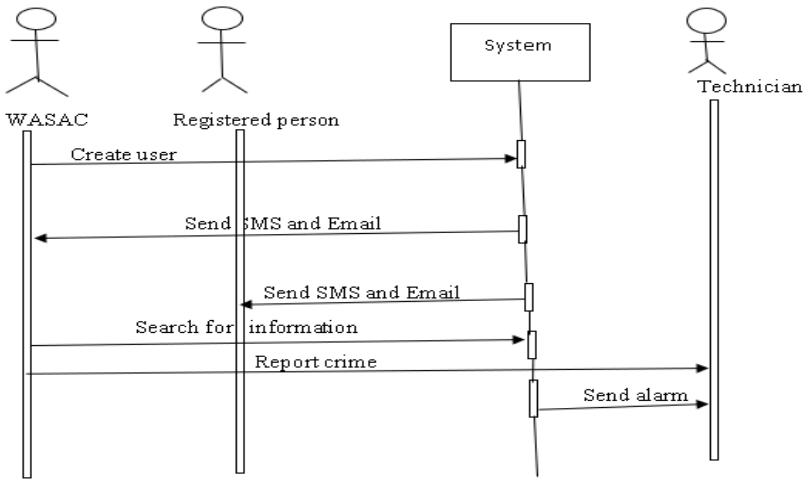


Figure 7: Sequence diagram of the system

4.5 The flow chart of the proposed system

This is the flow chart of the proposed system to explain how activities are done in the system, the process of actions to complete the task of detecting leakage in the waterline.

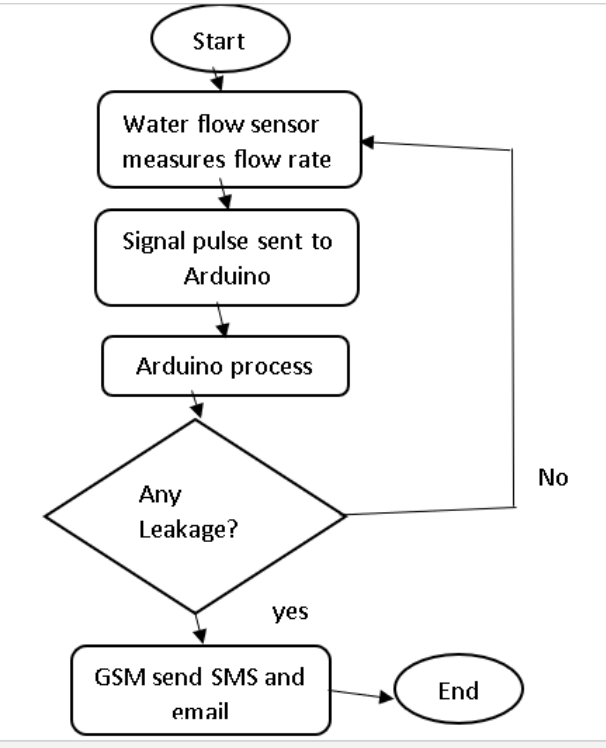


Figure 8: Flow chart of the system

4.6 Tools and components used

Components	Functions	Specifications
	**Flow sensor** The flow sensor is used for flow measurements to find the leakage in a pipe. Accurate flow measurement is an essential step both in the terms of qualitative and economic points of view. This sensor sits in line with the waterline and contains a pinwheel sensor to measure how much water has moved through it. There is an integrated magnetic Hall-Effect sensor that outputs an electrical pulse with every revolution[26].	- Minimum rated working voltage: DC 4.5 5V-24V - Maximum working current:15 mA（DC 5V） - Working voltage range: DC 5～18 V - Load capacity: ≤10 mA（DC 5V） - Operating humidity range:35%～90%RH (no frost) - Flow Range:1-30L/min

		- water pressure ≤ 1.75MPa - Allow compression: Water pressure 1.20Mpa - Storage Temperature: -25〜+ 80℃
	**GSM** GSM is an international standard for mobile telephones. It is an acronym that stands for Global System for Mobile Communications. It is also sometimes referred to as 3G, as it is a second-generation cellular network. GSM supports outgoing and incoming voice calls, Simple Message Systems (SMS or text messaging), and data communication[28].	- Supply voltage range 3.4 ~ 4.4V and - Current of 1A or more (the current is very important) - It features Bluetooth, FM, and Embedded AT (AT commands) - Quad-band 850/900/1800/1900MHz - Operation temperature: -40~85 degrees Celsius
	**MINI USB Arduino Nano V3.0 ATmega328P BRD53** The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x). It has more or less the same functionality as the Arduino Duemilanove but in a different package. It lacks only a DC power jack and works with a Mini-USB cable instead of a standard one[30].	- Microcontroller: ATmega328P - Operating Voltage (logic level): 5V - Input Voltage (recommended) 7V-12V - Digital I/O Pins 14 (of which 6 provide PWM output) - Flash memory 32 KB (ATmega328) of which 2KB is used by the bootloader - 8analog input ports - 6PWM Ports: D3, D5, D6, D9, D10, D11

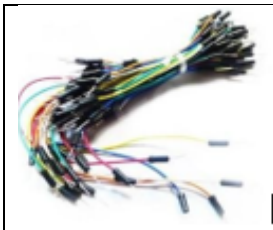
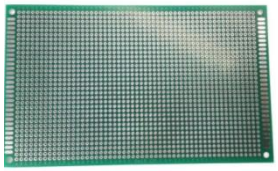
	**Male to Female Jumper Wires 20cm (Pack of 20) PRO54** Jumper wires are used in the circuit to connect items on the breadboard and Arduino's pins.	These are 20 cm long jumper wires terminated as male to female. Use these to jumper from any male or female header on any board. Multiple jumpers can be connected next to one another on a 2.54 mm header. Comes in one pack of 20 jumpers.
	**PCB Double Side Board BRD25** is used to construct an electronic circuit and wiring items to the microcontroller board.	- Size: 9X15CM - Thickness: approx. 1.6 mm - Hole pitch: approx. 2.54 mm - Hole diameter: approx. 1.0 mm - color: Green
	**Buzzer** Is used in the projects for Audio Signaling	Uses 5V for loud noise
 	**LEADS** **Green Led** is a 3mm LED with Green as its emitting color used to indicate that there is no leakage. **Red Led** is a 3mm LED with RED as its emitting color used to indicate that there is a leakage[23].	- LED 3mm green Color green Light Super Bright COM22 - LED 3MM RED COLOR RED LIGHT Super Bright COM22

Table 2: Components of the system

Cloud-Based Server

The Thingspeaks Cloud server stores any data generated by the sensors installed in the pipeline network[31].

This cloud service allows the email warning to be sent to the WASAC about various circumstances.

Chapter 5: System Results and Analysis

5.1 Introduction

This chapter shows the results obtained in solving the problem of detecting the leakage and in real-time by receiving the notifications of SMS and Email. The water flow sensors are installed on the pipe to communicate with the Microcontroller about the water volume that passes through[28], to indicate the leakage here the van was used by avoiding cutting a pipe in the testing process.

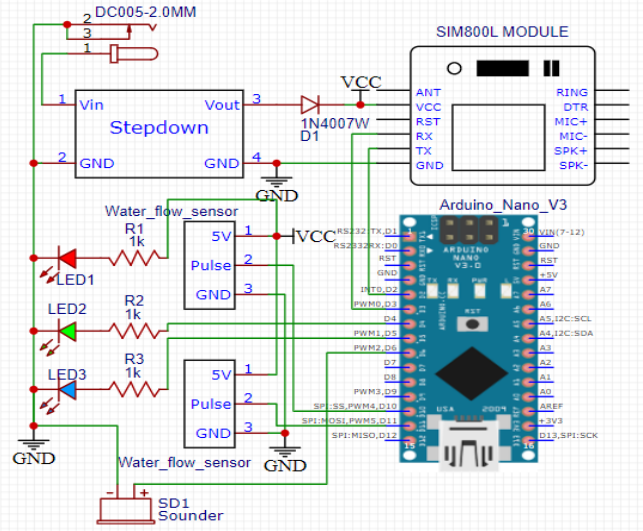


Figure 9: System circuit diagram

This circuit diagram of the system shows how the electronic devices used are connected one to another to communicate and complete the task of detecting leakage.

Alert; water leakage
of 2.28L from
MUHABURA line

Figure 10: SMS sent by GSM

Figure 10 shows the message obtained on the phone sent by GSM to notify that there is a waste of 2.28 liters of water caused by the leakage that happened in the water line located in Muhabura-line.

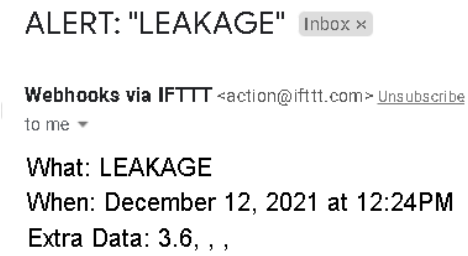


Figure 11: Email notification

This email notification is obtained in the inbox of registered authorities to alert them that the leakage of water appears at any point in the water distribution network.

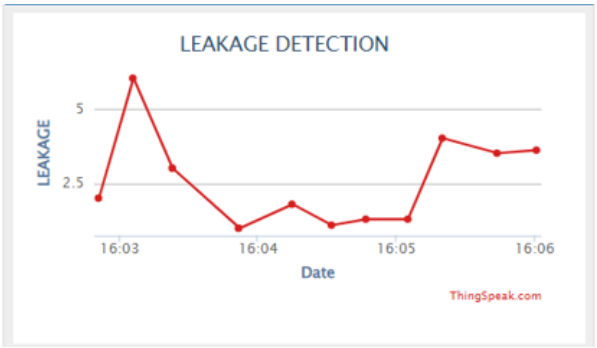


Figure 12: Graph from thingspeak

Figure 12 indicates the graph of data stored on the thing speak, the system checks every minute if there is a leakage and what it gets must be sent to the thing speak server for further analysis.

Figure 13: Prototype of the system

This figure shows the prototype of the whole system. The flow sensors are installed on the pipe for water volume measurement, the microcontroller is placed above the van and the van was used to indicate the leakage point in the testing process.

Chapter6: Conclusion and Recommendation

6.1 Conclusion

The implementation of the Smart Water Leakage Detection System with leakage identification is done successfully. A Water Leakage Detection System is thus designed by using Arduino Nano along with Water Flow Sensor and GSM. When the leakage happens, the message is sent to WASAC, the location of the leakage could be found out for quick maintenance.

A wide future scope guarantees that an enhancement to this system finds great importance in a real-time system. The system can further be improved by using actuators to be closed while the leakage happened, using GPS, and to test if drinking water is cleaned.

6.2 Recommendation

Based on the findings and discussions, technology has evolved around the world and water is the most useful thing everywhere, Water Leakage Detection System is implemented to solve the problem of wasting water. WASAC and other authorities who are responsible for water management are recommended to use this system.

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