IoT-Based Leak Detection System (Group #23)

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Concept of Operations

REVISION – Draft
25 January 2018

Concept of Operations
for
IoT-Based Water Leak Detection System

Team #23

Approved by:

Project Leader	Date
Prof. Kalafatis	Date
T/A	Date

Change Record

Rev.	Date	Originator	Approvals	Description
-	02/05/2025	The Leakage Team		Draft Release
1	02/20/2025	The Leakage Team		Corrections for submission, along with FSR, ICD and Validation Plan

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1. Executive Summary

Preventing water leaks in pipes is critical for avoiding serious infrastructure damage. Rather than addressing leaks after they escalate, our goal or aim is to provide an IoT-Based detection system that integrates an advanced sensor that alerts users immediately when a leak is detected. By continuously monitoring changes in water flow rate inside pipes, the system can detect irregularities or abnormal activity that could indicate potential leaks. Under normal conditions, water is expected to either flow at a constant rate or remain still. This means that any unexpected fluctuations will trigger the built-in sensor, which will instantly send a notification to the user through a linked mobile app. The app not only sends instantaneous alerts. but also allows the user to track the historical data of the flow rate for better controlled maintenance. This system is crucial for preventing leaks in pipes of small or large infrastructures, essentially minimizing long term damage and expensive repairs.

2. Introduction

2.1. Background

Water leakage is an issue that affects residential, commercial and industrial buildings, leading to expensive repairs and even structural damage. Conventional leak detections such as pressure monitoring systems are often reactive instead of proactive. These conventional methods typically include some basic moisture detectors that trigger alarms when water is sensed. Many of these systems cannot differentiate between normal fluctuations in water use and potential leaks. This can lead to false alarms or missed detections.

The water leak detection system aims to enhance conventional leak detection systems by integrating IoT-Enabled sensors which will enable the system to wireless transmit real-time data to an app notifying the user when a leak is detected. This app will also allow users to see the historical data of the flow rate. Unlike traditional systems this enhanced system will enable more proactive behavior. With the historical data being easily accessible, controlled maintenance will be much easier. These enhanced systems will also help to minimize damage and improve system efficiency.

2.2. Overview

Our system will be used to monitor water flow to check if there is a leak in any of the pipes and notify the user of the leak. Using a cistern as the source, we will have one pipe leading into two different taps to simulate multiple taps being used at once. Turning on a tap will allow for simulation of the leak. There will be one sensor in each tap to detect where the leak is. We will detect the leak using water flow sensors to send data out through small pulses. A PCB will count the pulses and output a constant voltage to communicate the data to the microcontroller. The microcontroller will read the sensor data, calculate the flow rate, and transmit the data to the app via wifi. When a leak is detected, the app will instantly notify the user. The app will also contain historical data of the flow rate.

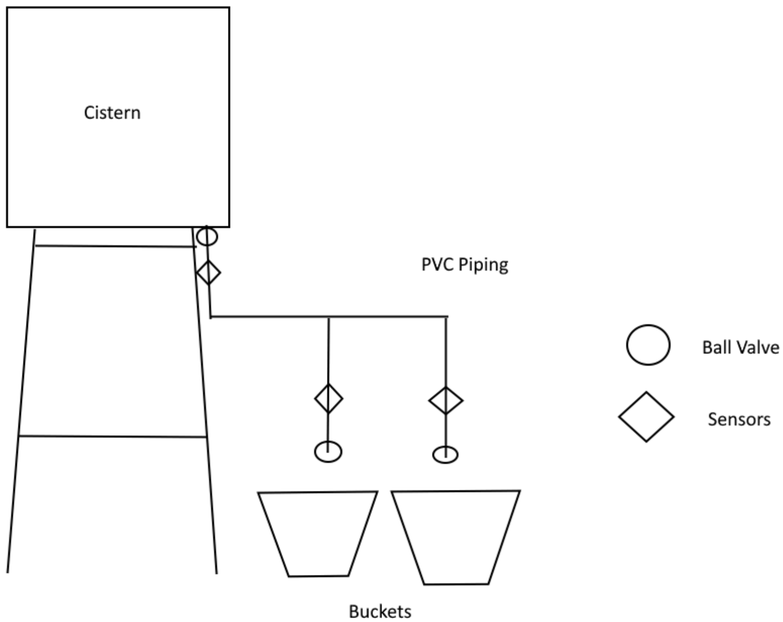

Figure 1. A basic description of the prototype that will be used to demonstrate our system.

2.3. Referenced Documents and Standards

- IEEE Wi-Fi communication standards: 802.11
- International Plumbing Code (IPC)
- General Data Protection Regulation(GDPR)
- Devices For Detection, Monitoring Or Control of Plumbing Systems(IAPMO Z1349-2021)

3. Operating Concept

3.1. Scope

The IoT-based leak detection system is designed to detect leaks in pipes and report them to the owners through a phone app they would have installed. The leak detection system is specifically designed for houses left during holidays or long periods of absence, during which there is no one to see the water damage a leak would cause. This ensures that there is no flow in the pipes as the appliances aren't being used, so any other flow is assumed to be a leak. As several sensors are around the house, the system can also localise and point out where the leak occurs to the owner. The system can also be scaled up to be used to aid plumbers in detecting leaks across a whole house if enough sensors are installed to localise the leak.

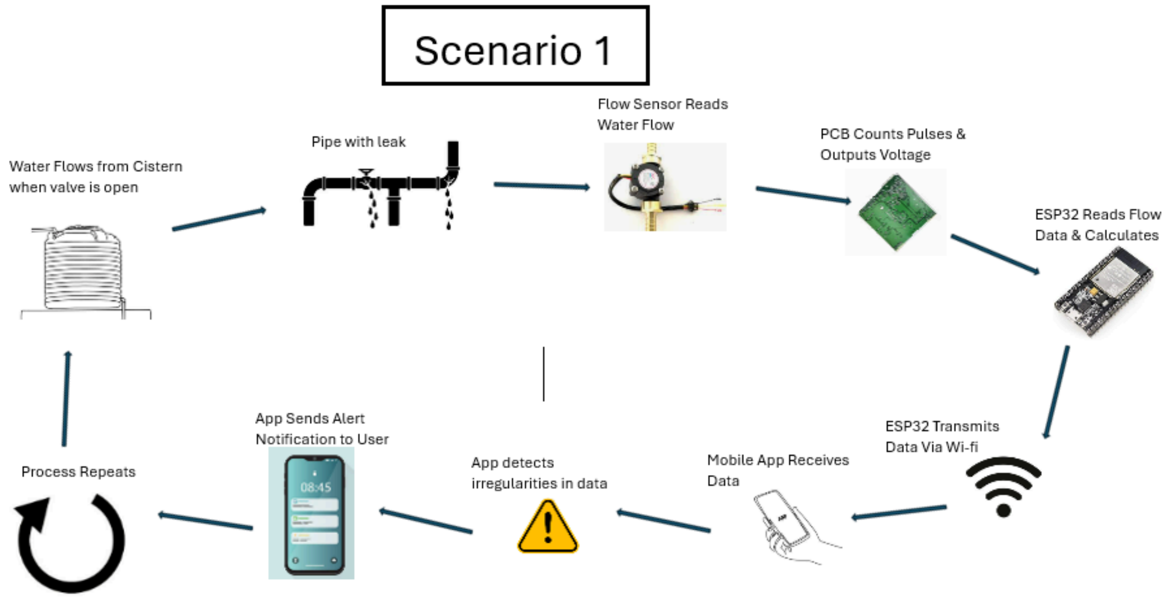

Figure 2. Flow Chart for a complete system with a simulated leakage

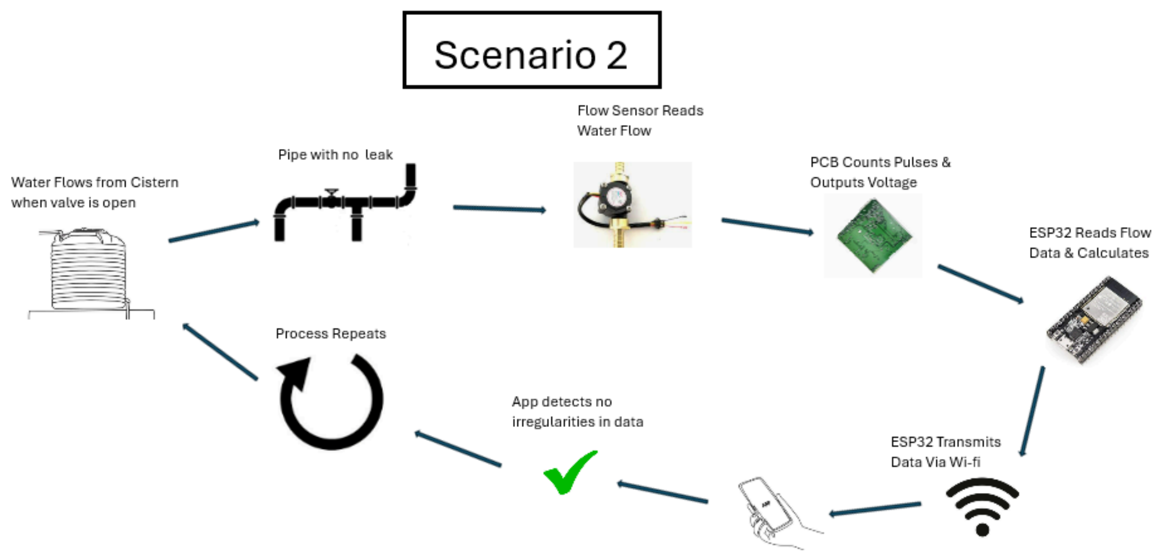

Figure 3. Flow Chart for complete system with no leakage

3.2. Operational Description and Constraints

The IoT-Based Water Detection System is intended to be used for homes, buildings, or any infrastructure that uses water pipes. It allows the user who could be a property owner, technician, plumber, or even an agricultural worker to monitor and detect potential water leaks in pipes. Sensors will be installed within the pipes to monitor flow rate. A microcontroller will gather the data and send it to an app via wifi. And lastly, the app will alert the user whenever there is a leak. The user will therefore have enough time to prevent the leak from getting worse and causing any damage to the property.

Constraints for this operational description:

- The pipes have to 3/4ths of an inch
- The sensor has to be installed inside of the pipe
- The app will work only if its connected to the same wifi as the microcontroller attached to the sensor
- The sensor cannot work or should be operated when appliances are being used

3.3. System Description

Subsystem 1 - Flow measurement gate

The gate used to measure the amount of water flowing through a specific point in the water network. This system will need to be easily integrated into existing water architecture, ideally being as non-intrusive as possible. This system will report the quantitative flow of water and battery remaining to the wireless component.

Subsystem 2 - Prototype piping

The pipe system (as shown in Figure 1) will be used to demonstrate the modes of operation, the extent of flow measurements, and how the rest of the subsystems will be integrated into a plumbing system. While not actively part of the leak detection system in and of itself, the prototype will act as a demonstration of the system's viability.

Subsystem 3 - Microcontroller

The microcontroller will be used to collect real-time data from the flow measurement gate. It will process this data and use it to calculate the flow rate and send the data to the application through Wi-Fi. This microcontroller will also be used to see the battery life of the flow measurement gate.

Subsystem 4 - App

The mobile app serves as the monitoring system and user interface. It receives live flow rate data via WIFI from an ESP32 microcontroller. The app processes the data to detect any irregularities such as a drop in the rate to indicate a leak. Any leaks will instantaneously be notified to the user through a notification. The app will show any records for the flow rate whenever the sensor was on.

3.4. Modes of Operations

System - Off

The system is off and does not send notifications to the app despite flow. This mode of operation is designed for when the domicile and plumbing system is in use to avoid throwing false positives to the user’s phone.

System - On
The system is on and will notify the app if it detects flow. This mode of operation is designed for when the domicile is left, and the plumbing system is turned off. This is the system's main use as a detection system.

System - Maintenance
The system collects flow data and displays it. While not the original intention, the system can be used to facilitate plumbing maintenance by viewing it over a device and noticing any outlier values. The mode of operation is more designed for installation teams, maintenance teams, and plumbers rather than average users.

3.5. Users

Our leak detection system will be marketed towards working singles to middle-class families in areas prone to erratic weather conditions and business owners in the plumbing business, especially sudden cold snaps, such as Texas. The relative cheapness of the system will appeal to middle-class families who can nonetheless afford to travel and will need a system to detect any leaks in their homes. The same cheapness will appeal to working-class singles who may not afford expensive repairs after a leak worsens but also are working during the day and do not have anyone to notice a leak back home, making our system a nice alternative.

Installation requires extra skill in construction due to the need to work with piping. However, an installation support crew can fix such an issue.

On the other hand, use would require a basic understanding of phone apps and the ability to replace batteries in the sensors, and it is unlikely to cause any issues in the long term.

3.6. Support

Support would be provided through an installation crew that would put the system on the plumbing system and leave an instruction manual. The instruction manual would direct the users to where to download the app for the system, how to change the batteries on the system if one of the sensors runs out of juice, an FAQ on common issues and how to fix them, and also offer a tech support number to contact support in case the system malfunctions or requires removal or replacement. The same tech support number would also be shown in the app installed for the system.

4. Scenario(s)

4.1. Passive water leak detection

The system can be used for a home or office building's water system when the building is not in use, such as during the winter holidays, when leaks are a frequent occurrence, but no residents or workers are available or willing to check for leaks. The IOT-nature of the system allows for our user to be notified of changes in the water system while away, granted they have an internet connection available.

4.2. Active water flow measurement

Despite not being the original intended purpose for our system, it can be used to simply measure the water-use of different appliances, or it can be used to troubleshoot problems regarding water delivery to various parts of the water network. Multiple devices could be used in conjunction with one-another to create a scalable network of water measurements to pinpoint discrepancies and not only discover the presence of a water leak, but the relative location of it as well.

5. Analysis

5.1. Summary of Proposed Improvements

The IoT-based leak-detection system provides several advantages to its users:

- When mounted, the system is extremely cheap to run. It relies on batteries for power and uses cheap and simple sensors. This also means that the system can be left to run for long periods of absence from the home without worrying about energy requirements.
- The above advantage also means that even with a blackout, the system does not lose power and will return online as soon as the power is restored to the local internet modem.
- When mounted, the system is unobtrusive, and the sensors on the pipes are ergonomic and do not require further maintenance.
- Leaks are reported at the speed of the internet and are sent directly to the user's phone, ensuring that any actions to manage the leaks can be taken quickly.
- The system does not require the user to take any additional devices, relying on an app, which means that the user can be sure of a lack of leaks just by bringing their phone with them.
- The above advantage also means that if the user has forgotten to turn on the system before leaving the house, they do not need to return home and can instead activate it with a single click on their phone screen.

5.2. Disadvantages and Limitations

There are, however, several disadvantages and limitations to this format of leak-detection system:

- The system presumes that the user is leaving for an extended period of time (for example, holidays over winter), and will not be present for the whole time and not using the water, meaning there is no flow. As the system does not discern valid water use (washing machines, sinks, etc.) and leaks, it is not usable when the plumbing where it is installed is in use.
- Due to budget constraints, to install the sensors, the piping must be disassembled, cut into to place the sensor and then replaced. While clamp-on sensors are more expensive, they are easily removable and movable along the plumbing system. On the other hand, while cheaper to run, the IoT-based sensors are hard to move, replace or even remove, as this would require a new section of pipe to replace the old cut-into piping.
- A failure of one sensor requires more invasive procedures and more expenses to replace due to the aforementioned issue of the sensors being cut into the plumbing rather than being clamp-on.
- As the system is IoT-based, it assumes a stable internet connection on the part of the house where the system is installed and on the part of the user. If the user loses access to the internet or the house's modem is damaged by the leak, the system becomes inoperable.
- The system itself only detects leaks, it does not stop them, meaning the user will have to come into contact with some third party to stop the leak.
- While the consumption of battery power is very small, it is still there and the sensors will require battery replacements to keep functioning.

5.3. Alternatives

Leak detection can be achieved in other ways:

- Having a person come to check on the state of one's house during weather that puts the pipes at risk.
- Setting up a baby camera to look into the house over an app.
- Investing in a similar system that uses clamp-on sensors instead.
- Investing in a similar system that relies on mobile networks rather than Wi-Fi.
- Investing in pipes rated for the weather that causes them to burst.

5.4. Impact

The impact that our project has on the individual, society and the environment includes:

- Preventing more expensive water damage, thus protecting the individual from extra expenditure and damage to their private property.
- Preventing water waste caused by leaks helps avoid the crises of personal water waste and thus protects the environment.
- Creating further reliance on the internet for data transfer which puts society at greater risk, as a hijacked system may cause panic or confusion for users. Such data transfers by the web also create a greater risk of personal leak information being stolen, be it for resale or for use by water companies, endangering the individual's privacy.

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INTERFACE CONTROL DOCUMENT

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INTERFACE CONTROL DOCUMENT
FOR
IoT-Based Leak Detection System

PREPARED BY:

Author Date

APPROVED BY:

Project Leader Date

John Lusher II, P.E. Date

T/A Date

Change Record

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-	2/20/2025	IoT-Based Leak Detection System		Draft Release

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1. Overview

The document will provide details on how the sensors, microcontroller, and app will all interface in a standard home water pipe system. An explanation of the inputs from the sensor and how it is passed to the microcontroller will be provided. Next, a description of how the microcontroller communicates to the application is given. Lastly the details of the application's notification system and data will be provided.

2. References and Definitions

Provide any references (i.e., standards documents) and definitions. Examples are shown below.

2.1. References

MIL-STD-810F
Environmental Engineering Considerations and Laboratories Tests
1 Jan 2000
Change Notice 2
30 Aug 2002

American National Standard for VME64 (ANSI/VITA 1-1994 (R2002))
4 Apr 1995

American National Standard for VME64 Extensions (ANSI/VITA 1.1-1997)
7 Oct 1998

2.2. Definitions

OS	Operating System
PCB	Printed Circuit Board
PVC	Polyvinyl Chloride
DC	Direct Current
RAM	Random-Access Memory
MB	Mega Bytes(1,000,000 Hz)
GB	Giga Bytes(1,000,000,000 Hz)

3. Physical Interface

3.1. Weight

The system’s weight should not exceed 2 kilograms in total, when not accounting for the prototype testing system, that being the set of PVC pipes and cisterns used to show the system’s working capabilities. The prototype testing system should weigh about 10 kilograms empty.

3.2. Dimensions

3.2.1. Dimension of measurement system

The measurement system (Water meter, PCB, wireless component) will not exceed a 3”x3”x3” area.

3.2.2 Dimension of Prototype Testing System

The dimensions of the prototype testing system include a 34’’ by 12’’ by 19’’ water cistern and 16’’ by ¾’’ by 16’’ PVC piping system connected to the water cistern for testing.

3.3. Mounting Locations

The measurement system is mounted directly on the piping being checked for leakages through the use of metal straps and a hole in the piping.

4. Thermal Interface

The microcontroller will not need a heatsink as it will not be performing complex computations. It will also not be in environmental conditions that should require it to have a heatsink to prevent overheating and poor efficiency.

5. Electrical Interface

Provide details on the electrical interface. Examples are:

5.1. Primary Input Power

Input power will be 5v DC supported by an array of AA or AAA batteries.

5.2. Signal Interfaces

Output of Water meter - Pulses delivered every turn of the water wheel. Input to the PCB to be translated to flow rate.

Output of PCB - Measurement of water flowing through the water meter. Input to the wireless system to be delivered to the user.

5.3. User Control Interface

The user control interface is a mobile app that displays and provides analysis of the flow rate data collected from the system and provides alerts for when a possible leak is detected. The user can also access historical data on the app to perform user calculated conclusions on whether there is an issue with the flow rate or system.

6. Communications / Device Interface Protocols

Provide details on the protocols for communication. Examples are:

6.1. Wireless Communications (WiFi)

The ESP32 contains built-in Wi-Fi that uses IEEE 802.11g, IEEE 802.11b, and 802.11n standards. It will be used to send data to a mobile application that will make the necessary calculations and notify the user of any alerts.

6.2. User Device

The User will interact with the system through a mobile app that is downloadable on any android device with the following specifications: OS version 8.0 or higher, 2GB RAM or higher, Quad-core processing unit, 100 MB available to download app, screen resolution of 720p (HD, 1280x720), and Wi-Fi enabled (for ESP32 data reception). Having higher specifications can allow for optimal performance.

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Functional System Requirements

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25 January 2018

Functional System Requirements

for

IoT-Based Leak Detection System

Prepared by:

Author	Date

Approved by:

Project Leader	Date
John Lusher, P.E.	Date
T/A	Date

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1. Introduction

1.1. Purpose and Scope

This specification defines the technical requirements for the development items and support subsystems delivered to the client for the project. Figure 1 shows a representative integration of the project in the proposed CONOPS. The verification requirements for the project are contained in a separate Verification and Validation Plan.

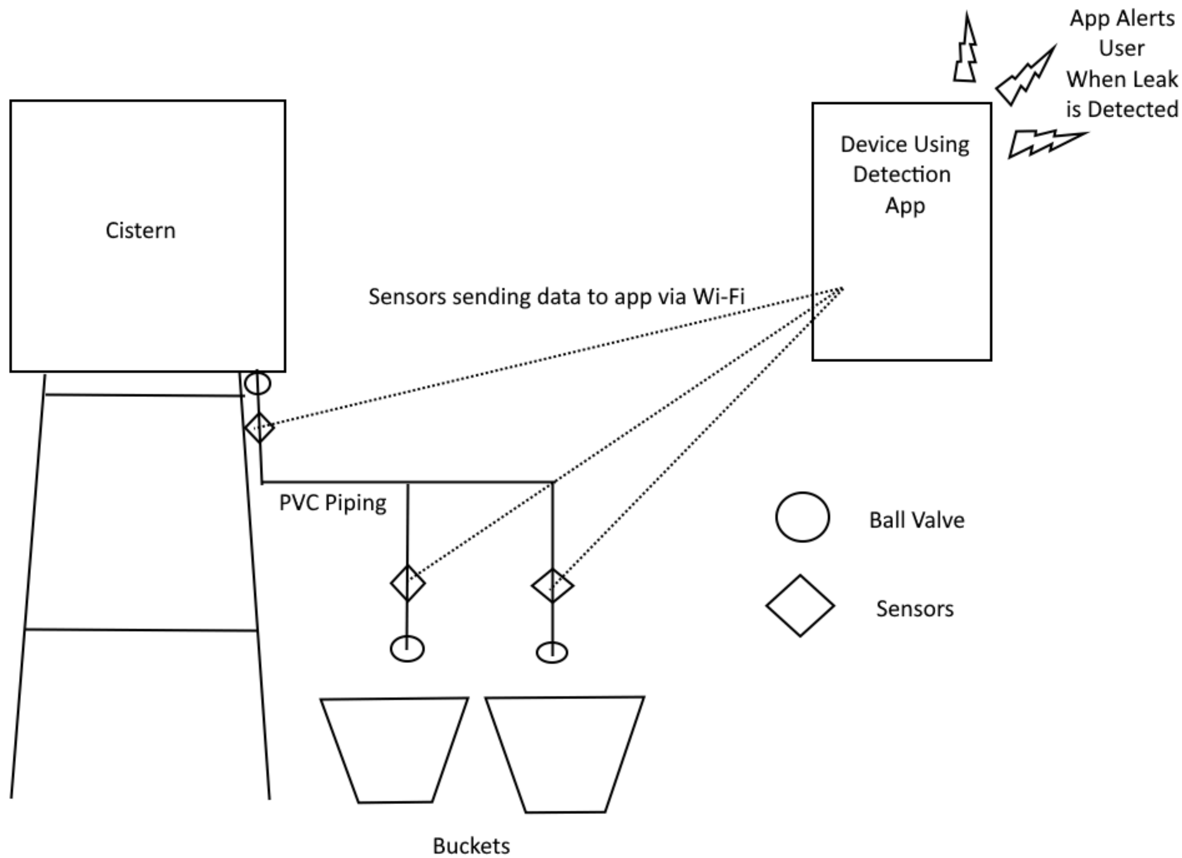

Figure 1. Our Project's Conceptual Overview

The following definitions differentiate between requirements and other statements.

Shall:	This is the only verb used for the binding requirements.
Should/May:	These verbs are used for stating non-mandatory goals.
Will:	This verb is used for stating facts or declaration of purpose.

1.2. Responsibility and Change Authority

Acting team leader is Igor Ovsyannikov, who is responsible for distributing the responsibilities within the project. The project can be changed with the approval of the sponsor, Niloofar Borzooei, and the approval of the acting team leader. If the acting team leader is indisposed or not in the state to sufficiently support the project, the project team is free to choose its acting leader via vote.

2. Applicable and Reference Documents

2.1. Applicable Documents

The following documents, of the exact issue and revision shown, form a part of this specification to the extent specified herein:

Document Number	Revision/Release Date	Document Title
IEEE 802.11	02/09/2011	Wireless Network Managment

2.2. Reference Documents

The following documents are reference documents utilized in the development of this specification. These documents do not form a part of this specification and are not controlled by their reference herein.

Document Number	Revision/Release Date	Document Title

2.3. Order of Precedence

In the event of a conflict between the text of this specification and an applicable document cited herein, the text of this specification takes precedence without any exceptions.

All specifications, standards, exhibits, drawings or other documents that are invoked as “applicable” in this specification are incorporated as cited. All documents that are referred to within an applicable report are considered to be for guidance and information only, except ICDs that have their relevant documents considered to be incorporated as cited.

3. Requirements

This section defines the minimum requirements that the development item(s) must meet. The requirements and constraints that apply to performance, design, interoperability, reliability, etc., of the system, are covered.

3.1. System Definition

Provide a brief overview of the project, and then describe some of the main sub-systems of your proposed solution.

The IoT-Based Leak Detection System provides a solution for detecting leaks in pipes. By reading pulses from the water flowing in the pipes, the subsystems work together to convert the pulses into flow rate data which can then be monitored and analyzed for detecting a leak. And in the case that there is a leak, the user can be notified.

The Entire IoT-Based Leak Detection System comprises four main sub-systems that work together to detect leaks and monitor pipe conditions. Sub-System 1 is the physical design consisting of the cistern, valves, and pipes. The cistern is used for holding the water which will then be released into pipes through opening the valve attached to the cistern. Sub-System 1 is how we will simulate the flow of water through pipes under normal conditions and when there is a leak. Sub-system 2 is the part that collects data from a sensor . The sensor is a flow meter that will be installed inside the pipe to sense pulses of the water going through and a PCB will collect that pulse data and send it to the next sub-system through a direct wired connection. Sub-System 3 is the microcontroller (ESP32) which receives the pulse data and converts it into comprehensible flow rate data. The ESP32 will have a built-in Wi-Fi component that will send the data to the final sub-system. Additionally, Sub-System 2 and 3 will both be powered by AAA batteries. Lastly, Sub-System 4 is the android compatible mobile app which will receive the data through its connection with the ESP32 via Wi-Fi. The app will provide access to historical flow rate data for personal monitoring and will also provide alerts whenever the data shows that there might be a leak.

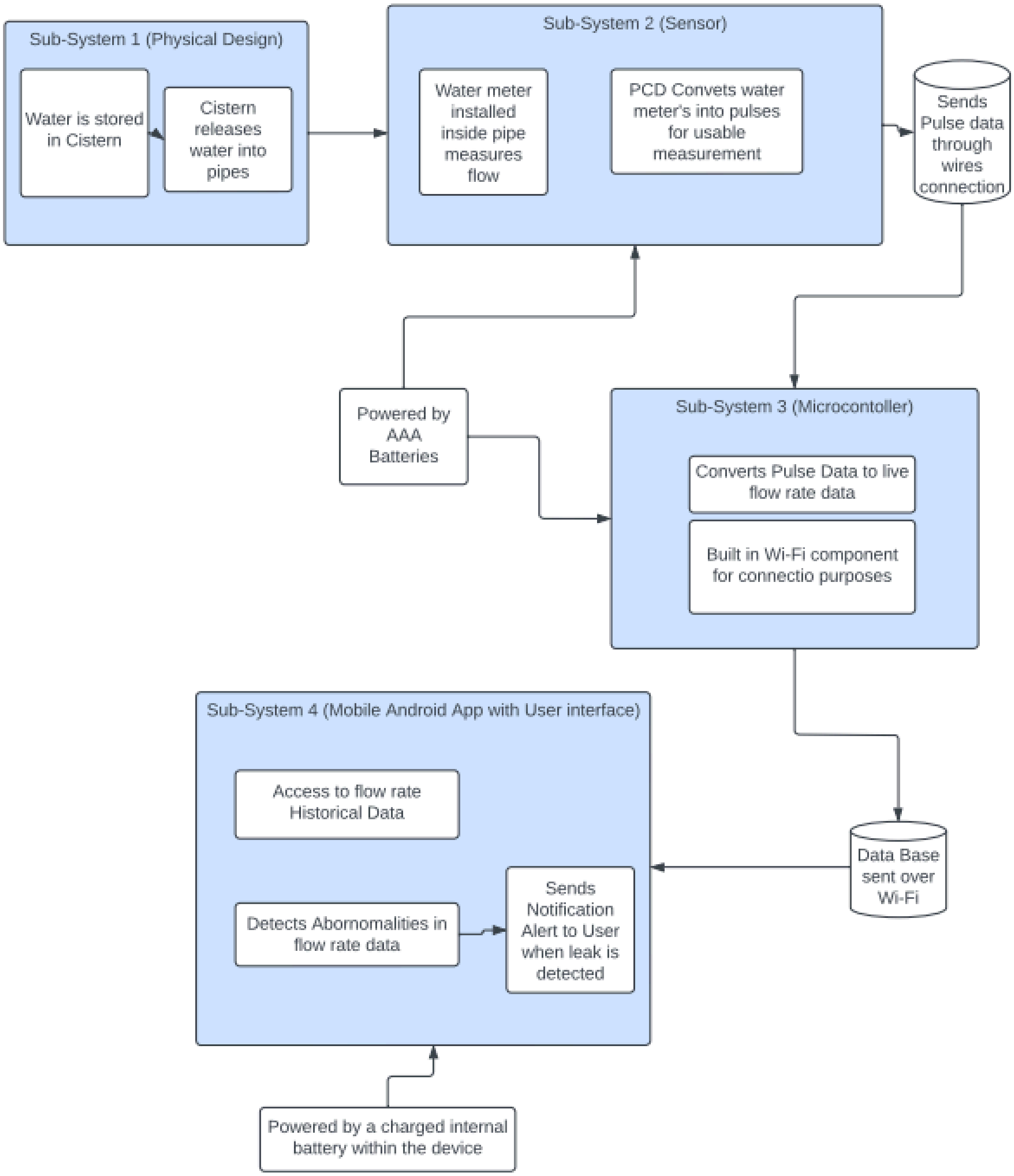

Figure 1. Block Diagram of the 4 Subsystems and their relations.

3.2. Characteristics

3.2.1. Functional / Performance Requirements

3.2.1.1. Sensor sensitivity

The measuring component (water meter/PCB board) should be capable of measuring within a lower limit of 1 L/M. The upper limit is not entirely crucial, as leak detection, in general, is our main goal, and a large leak will be detected regardless of our device's upper limit.

3.2.2. Physical Characteristics

These are the physical characteristics of our system.

3.2.2.1. Mass

The mass of the system without the prototype piping system is about 2 kilograms.

Rationale: This is a requirement due to the fact that the system should be able to be fit on many different systems without causing issues due to weight.

3.2.2.2. Water Cistern Volume

The water cistern volume should be around 50 gallons or around 190 litres.

Rationale: This is a requirement in testing our system due to the need to put a certain amount of water pressure into the pipes as to simulate an actual plumbing pipe.

3.2.2.3. Mounting

The sensors should be mounted by cutting into the piping in question and fitting the sensor into the hole, and then securing the sensor with a metal strip.

Rationale: The sensors do not have any other method to connect to the piping as to prevent the expenses of the project from ballooning and keep it accessible to the average consumer, cheaper sensors were chosen.

3.2.3. Electrical Characteristics

3.2.3.1. Inputs

The system shall take inputs from the accompanying app.

Rationale: Due to the nature of the project being IoT-based, implementing an input system within the accompanying app minimises the amount of work needed to be done to access the sensors and serves the consumer's convenience.

3.2.3.1.1 Power Consumption

The system should be supported by a simple combination of commercially available batteries (AA, AAA), and remain operational for at least 6 months without a need for battery replacement. The decision to use batteries rather than the home's power supply is for safety reasons concerning our system working with water, as well as the system itself remaining operational during loss of household power.

3.2.3.1.2 Input Voltage Level

The input voltage level for the measurement system is 5v- which will be achieved using the requirements listed in 3.2.3.1.1.

3.2.3.1.3 External Commands

The IoT-Based Water Leakage Detection System System shall document all external commands in the appropriate ICD.

Rationale: The ICD will capture all interface details from the low level electrical to the high-level packet format.

3.2.3.2. Outputs

3.2.3.2.1 Data Output

The IoT-Based Leakage Detection System shall provide a interactable mobile application to monitor data logging and receive emergency notifications for leaks.

Rationale: The IoT-Based Water Detection System alerts and information will be available to the user through a mobile based application.

3.2.3.2.2 Diagnostic Output

The IoT-Based Leakage Detection System shall include a diagnostic interface for data monitoring in the accompanying app.

Rationale: Provides the ability to diagnose the time at which a leakage occurred.

3.2.3.3. Wiring

The system will be wired using clean solders between jumper wires and devices. The wiring will be pathed starting from the battery pack, powering the Vcc and Ground wires on the water meter. The pulse or "data" wire will be soldered to a PCB which will then have a single data output measuring the water flow wired to our wireless component.

3.2.4. Environmental Requirements

The system will be able to function in slightly damp environments and in small and enclosed spaces.

Rationale: This is a requirement due to the placement of pipes in buildings, as some may be positioned in damp or enclosed spaces, meaning that the sensors should also be able to follow that requirement.

3.2.4.1. Thermal

The system will be able to function in a range slightly below freezing to warm (around -5 C to 50 C).

Rationale: As the sensor does not use parts that are temperature sensitive, the main issue becomes ice, which may damage the wheel in the sensors. As the system has to work after cold snaps, the system has to be tested for such an occurrence.

3.2.4.2. Humidity

As mentioned above, the system will be able to function in the humidity of the average household walls.

3.2.5. Failure Propagation

Failure propagation is highly unlikely as each of the sensors is independent, meaning that a failure of one sensor should not affect the rest of the system, beyond faulty detection at the one spot where that failing sensor has been placed.

3.2.5.1. Failure Detection, Isolation, and Recovery (FDIR)

The IoT-Based Water Leakage detection system shall have a failure detection to ensure reliability throughout the four subsystems: prototype design, sensor setup, microcontroller, and mobile app. Failure detection will involve analysing expected vs. actual behaviour, such as detecting no flow from the cistern, random spikes in the flow variation, or sensor malfunctions by using real-time data analysis. Isolation will be achieved through cross-checking the sensor data, start-up data, app connection problems, and debug messages from the ESP32. Recovery plans will include automatic reconnection for Wi-Fi issues, rebooting or recalibrating the sensor, restarting the ESP32 for incorrect flow calculations, and in-app troubleshooting. The FDIR principles will ensure that the system accurately detects leaks, has on time alerts, and recovery from failures.

3.2.5.1.1 Built In Test (BIT)

The measurement system will have a low cost, separate output (apart from zero) to communicate “no flow” to the wireless component. This is to avoid a situation in which the measurement system loses power, yet the network component still believes the measurement system is active and reporting zero flow.

3.2.5.1.1.1 BIT False Alarms

The BIT shall have a false alarm rate of less than 5 percent.

Rationale: This requirement will limit the number of false notification alerts sent to the user to check.

3.2.5.1.1.2 BIT Log

The BIT shall save the results of each test to a log that shall be stored in the mobile application.

Rationale: Allows the user to look at the historical data of the flow rate at a given time and notice abnormal trends in their pipes.

3.2.5.1.2 Isolation and Recovery

The IoT based Water Detection System should provide for fault isolation and recovery by enabling subsystems to be reset or disabled based upon the result of the BIT.

Rationale: During cases in which the data is not coming out as expected the System will need to undergo a full reset in ESP32 and in the mobile app.

4. Support Requirements

The system will come with an instruction manual on the installation of the sensors and a link to download the app required for working with the sensors. It will also include a phone number so if the customer does not have the tools or the know-how to use them; they may call an installation support team. The manual will also provide a phone to a support team in case the app or the sensors malfunction, the team then may redirect the customer to contact the support team and buy a new sensor if one has to be replaced. The system will come with metal strips to connect the sensors to the pipes, or if the customer has called the support team for installation, the support team will be provided with the same metal strips.

Appendix A: Acronyms and Abbreviations

IoT	Internet of Things
BIT	Built-In Test
CCA	Circuit Card Assembly
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EO/IR	Electro-optical Infrared
FOR	Field of Regard
FOV	Field of View
GPS	Global Positioning System
GUI	Graphical User Interface
Hz	Hertz
ICD	Interface Control Document
kHz	Kilohertz (1,000 Hz)
LCD	Liquid Crystal Display
LED	Light-emitting Diode
mA	Milliamp
MHz	Megahertz (1,000,000 Hz)
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
mW	Milliwatt
PCB	Printed Circuit Board
RMS	Root Mean Square
TBD	To Be Determined
TTL	Transistor-Transistor Logic
USB	Universal Serial Bus
VME	VERSA-Module Europe

Igor Ovsyannikov
ECEN-403-902

02/20/25

Progress Report As Of 02/20/2025

Date Checked	01/14/2025	01/21/2025	01/28/2025	02/04/2025	02/11/2025	02/18/2025	02/25/2025	03/04/2025	03/11/2025	03/18/2025	03/25/2025	04/01/2025	04/08/2025	04/15/2025	04/22/2025	04/29/2025	05/06/2025
1 - Sensor Hardware																	
FPGA Acquisition																	
FPGA Connection																	
FPGA Configuration																	
PCB Connection																	
PCB Configuration																	
Fluid Testing																	
PVC Connection																	
2 - Wireless Integration																	
ESP32 Acquisition																	
Test Data Acquisition																	
Sending Test Data to App																	
Implementing With Sensor Data																	
3 - Software Development																	
UI Design and Fronted Implementation																	
Data Communication																	
Data Analysis and Leak Detection Logic																	
Notification System																	
Optimization and Testing																	
4 - Prototype Flow System																	
Material Acquisition																	
Converting Materials to Parts																	
Connecting Parts																	
Connecting Hardware to Parts																	
Leakage Testing																	

Legend:

	Not Started
	In Progress
	Completed
	Behind Schedule

Igor Ovsyannikov
ECEN-403-902

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Validation Plan

Paragraph	Test Name	Success Criteria	Methodology	Status	Responsible Engineer(s)
3.2.1.1	Sensor Sensetivity	The system can detect a flow down to 1L/M	Flow test: The flow is decreased and sensor reaction is observed for the cut-off point.	UNTESTED	Igor, Tanner
3.2.2.1	Mass	The system weighs, altogether, 2 kilogram	Weight test: The system is weighted to make sure it does not exceed the maximum weight.	UNTESTED	Igor
3.2.2.2	Water Cistern Volume	The system can withstand a full water cistern worth of pressure.	Endurance test: The prototype cistern is filled completely, and the system is left to stand without further disturbance for 24 hours to ensure that it can maintain function after pressure is applied to it.	UNTESTED	Igor
3.2.2.3	Mounting	The system's mounting can maintain its connections with metal strips while water is running and while water is still.	Endurance test: The prototype cistern is filled completely, and the system is left to stand without further disturbance for 24 hours to ensure that the mounting holds after pressure is applied to it, the flow is then opened to see if the mounting can equally withstand flowing water.	UNTESTED	Igor
3.2.3.1	Inputs	The system responds to inputs from the accompanying app	Signal test: The app is used to activate the system and the output is checked to see if the system has activated.	UNTESTED	Rushil, Luke
3.2.3.1.1	Power Consumption	The system should be able to maintain function on commercially available batteries for around 6 months.	Endurance test: The system is left on for 24 hours and the amount of power spent by the batteries is extrapolated to 6 months.	UNTESTED	Igor, Tanner
3.2.3.1.2	Input Voltage Level	The system should run on 5V input	Voltage test: The voltage of the input is measured to ensure that it follows the requirements	UNTESTED	Tanner
3.2.3.1.3	External Commands	The external commands can be input and are logged	Signal test: The app is used to activate the system and the output is checked to see if the system has activated. Logs are then checked to ensure that the input was logged.	UNTESTED	Rushil, Luke
3.2.3.2.1	Data Output	The system can output data to the application, logs and notifications	Signal test: The app is used to activate the system and the output is checked to see if the system has activated. The app is checked to ensure it outputs notifications and logs.	UNTESTED	Rushil, Luke
3.2.3.2.2	Diagnostic Output	The system's diagnostic interface can be accessed and outputs the correct data.	Signal test: The app is used to activate the system and the output is checked to see if the system has activated. The diagnostic interface is checked to be showing the expected data.	UNTESTED	Rushil, Luke
3.2.3.3	Wiring	The wiring in the system is functional and transfers data succesfully	Flow test: The flow is increased and the output of the sensors is recorded to ensure the output is correct.	UNTESTED	Tanner
3.2.4.1	Thermal	The system can run between -5C and 50C without failing.	Temperature test: A part of the pipe with a sensor is frozen and then warmed. The system is then activated to see if it is functional after the change in temperature.	UNTESTED	Igor
3.2.4.2	Humidity	The system can run with humid pipes for 6 months without failure.	Endurance test: The prototype cistern is filled and left undisturbed for 24 hours. The sensors are then checked for if the sensors are still functional after being subject to the pipes' humidity.	UNTESTED	Igor, Tanner
3.2.5.1.1	BIT	The system can detect a misfiring of the sensors during the use of BIT	BIT test: The BIT is run and its response is correct.	UNTESTED	The Leakage Team
3.2.5.1.1.1	BIT False Alarms	The system does not misfire more than 5%	BIT test: The BIT is run and reports less than 5% failures.	UNTESTED	The Leakage Team
3.2.5.1.1.2	BIT Log	The system logs BIT tests and displays them reliably and accurately	BIT test: The BIT is run and its response can be accessed reliably and is correct.	UNTESTED	The Leakage Team
3.2.5.1.2	Isolation and Recovery	The system can be disabled and reset, even if the sensor in question is malfunctioning	Signal test: The system responds to commands to shut down.	UNTESTED	Rushil, Luke