UNIVERSITY OF MALAWI

SCHOOL OF NATURAL AND APPLIED SCIENCE
COMPUTING DEPARTMENT

SMART PREPAID WATER METER (SPWM)

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1. INTRODUCTION AND OVERVIEW

Welcome to the world of smart prepaid water meters! The smart prepaid water meter project aims to modernise and optimise the water meter management process. The current water meter systems have challenges and limitations which includes the inability to monitor and track water usage, recharging water units as well as controlling which involves opening and closing the meter remotely and in real time. With the introduction of the smart prepaid water meters, these limitations are overcome, providing users with a hassle-free and transparent remote experience. The Smart Prepaid Water Meter provides a convenient and reliable solution for tracking and managing your water usage remotely. With its advanced features and user-friendly interface, you can gain better insights into your water consumption patterns and make informed decisions to conserve water and reduce wastage.

By implementing a smart prepaid water meter, you gain access to a range of benefits. Firstly, the meter allows for accurate and real-time monitoring of your water consumption. This empowers you to understand your usage patterns, identify potential leaks or wastage, and make informed decisions to conserve water and reduce your utility bills.

Additionally, the smart prepaid water meter system provides you with access to various value-added features and services. These include usage alerts. These alerts notify you when your consumption reaches a predetermined threshold, helping you manage your usage more effectively.

2. BUSINESS CASE

2.1. EXECUTIVE SUMMARY:

The implementation of smart prepaid water meters presents a compelling business opportunity for water utility companies and municipalities. This business case outlines the benefits associated with adopting smart prepaid water meters as a solution for modernising water management processes and enhancing customer satisfaction.

2.2. BACKGROUND AND PROBLEM STATEMENT:

A Smart Prepaid Water Meter (SPWM) is an IOT project that gives users an opportunity to connect with their meter online. The purpose of this project is to allow prepaid meter users to access their meter information anywhere online instead of being close to the meter in order to check water consumption and load water units.

Prepaid water meter users often face challenges with the prepaid water meter systems

- Prepaid meter customers have to be around the meter in order to communicate with the meter using the Customer Interface Unit (CIU).
    - Checking how much they have used.
    - Checking how much water they have left.
    - Recharging water, loading water units.
- Sometimes the customer interface unit fails to communicate with the meter making the customers travel all the way to nearest Water Board stations in order to get the assistance.
- Customers often receive inaccurate readings from the meter, which makes it difficult for them to understand their water usage.

These limitations result in customer as well as water board inconveniences.

2.3. OBJECTIVES

The primary objectives of implementing smart prepaid water meters are:

- Remote monitoring of water flow, consumption, and remaining water balance.
- Opening and closing the meter remotely.
- Adding water to the meter. (some sort of recharging the water to be used)
- Most importantly allowing access to the meter to be done remotely through an application, a functionality which is not present in the current prepaid water meters.

2.4. SOLUTION OVERVIEW:

- We want customers to interact with the meter remotely.
- This includes checking their water balance, checking their consumption and loading water to the meter anywhere as long as they have an internet connection.
- Closing and opening the water meter remotely
- **These to be done through mobile app**

2.5. BENEFITS:

5.1. CUSTOMER SATISFACTION:

- Empowerment of customers through real-time monitoring of water consumption.
- Accurate billing, leading to trust and reduced customer disputes.
- Enhanced control over water expenses, resulting in greater customer satisfaction.
- Remote interaction with the meter.

5.2. OPERATIONAL EFFICIENCY:

- Automated real time meter readings eliminate the need for manual meter reading, reducing labour costs and errors.
- Remote interaction with the meter reduces inconvenience.

2.6. IMPLEMENTATION PLAN:

- Prioritise installation in areas with higher water consumption or revenue losses.
- Conduct pilot projects to evaluate system performance and customer feedback before full-scale deployment.

2.7. RISK AND MITIGATION STRATEGIES:

2.7.1. POTENTIAL RISK

- Resistance from customers in using the system.
- Integration challenges with the existing system.
- Cybersecurity concerns.

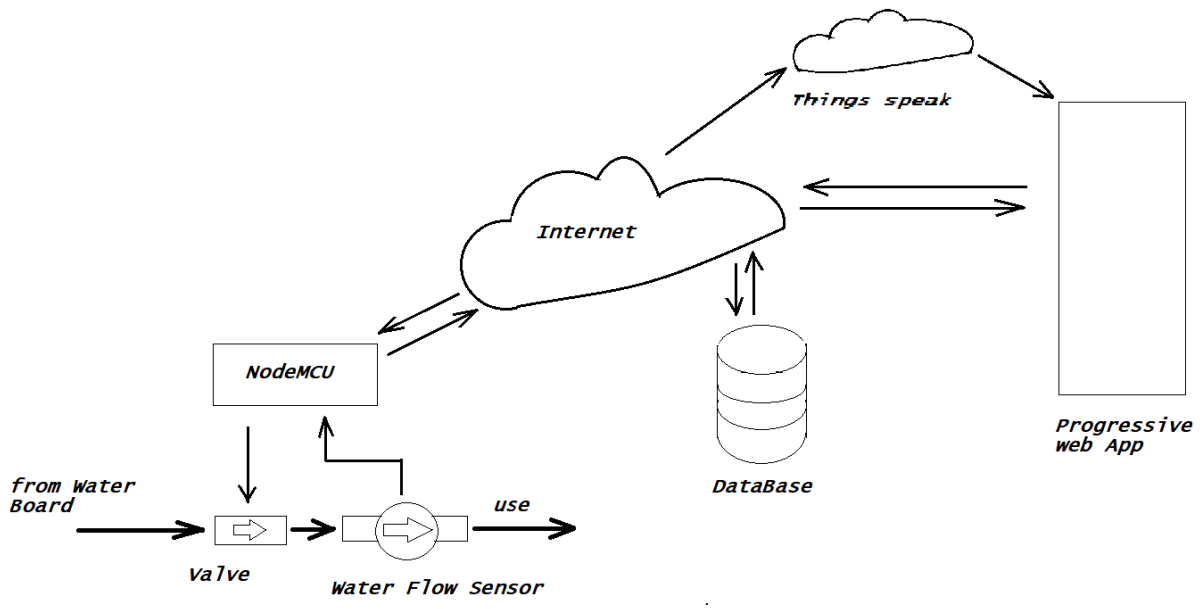
2.7.2. MITIGATION STRATEGIES

- Comprehensive customer education.
- Robust system testing
- Implementing strict, precise and exacting cybersecurity measures.

2.8. CONCLUSION:

Implementing smart prepaid water meters offers a transformative solution for prepaid water meter customers, improving them with satisfaction, and enhancing operational efficiency. With the financial benefits outweighing the initial investment, this business case supports the adoption of smart prepaid water meters as a strategic initiative for sustainable growth and improved service delivery.

3. PROJECT ARCHITECTURE/ BLUEPRINT



3.1. VALVE:

responsible for stopping and allowing the flow of water in the pipes. It closes the meter if it receives a signal to be off and opens if the signal is on and by default when the water units are less than one it automatically closes and it can only be open when water units are recharged.

3.2. WATER FLOW SENSOR

Responsible for producing readings like flow rate and volume of water.

3.3. NODEMCU

This is an open-source firmware and development board based on the ESP8266 Wi-Fi module. It is designed to simplify IoT(Internet of Things) development by providing a platform for building Wi-Fi enabled projects with ease. In this project the NodeMcu was reading values from the water flow sensor and sending the data to thingspeak and the database via the internet. It was also controlling the valve by giving it a signal to be on or off.

3.4. DATABASE

This is where the reading and the valve signal will be kept from the meter and the mobile application will be fetching the details from the database. We are using firebase to store real time data from the nodeMcu via the internet.

3.5. THINGSPEAK

An IoT analytics platform service that allows aggregation, visualisation, and analyse live data streams in the cloud. This platform is helping with graphs of flow rate and the remaining volume.

3.6. PROGRESSIVE WEB APP

We are calling our app SPWM (Smart prepaid Water Meter). This is displaying everything required for monitoring on the dashboard: The graphs from thingspeak, remaining water, amount of litres bought, flow rate and water used. It has the recharge section where a token is entered, a control section used to control the opening and closing of the valve. And the notifications sections for notifications of remaining water, recharge and if there is no water.

4. USER GUIDE FOR THE SMART PREPAID WATER METER

This user guide provides you with comprehensive information and instructions on how to effectively use and manage your smart prepaid water meter system. This innovative technology brings convenience, accuracy, and control to your water consumption, revolutionising the way you monitor and pay for your water usage remotely. This user guide will walk you through the installation process, system components, user interface and meter usage of the smart prepaid water meter. We aim to provide clear instructions and explanations to ensure you have a seamless and enjoyable experience with your smart prepaid water meter system.

Get ready to embrace the future of water management and take control of your water usage like never before. Let's dive in and explore the exciting features and functionality of your smart prepaid water meter!

4.1. SYSTEM COMPONENTS

The smart prepaid water meter system consists of mainly two components that work together to monitor and manage your water usage. Familiarise yourself with the following components:

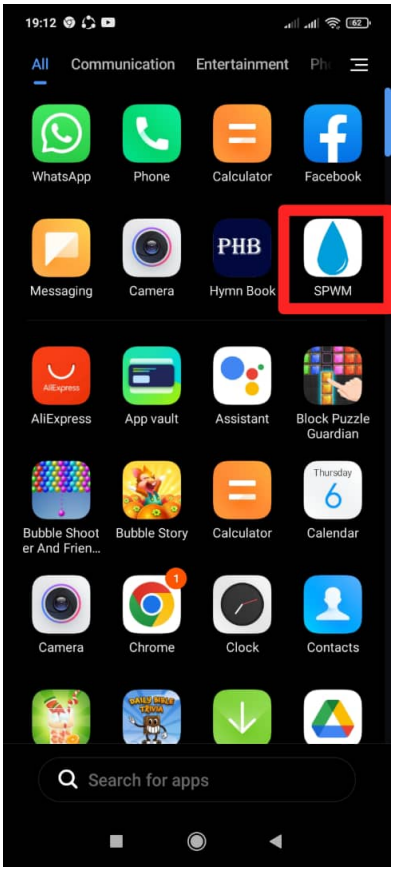
4.1.1. WATER METER

- The water meter is the primary device that measures the amount of water consumed
- It is installed in the water supply line and accurately records the volume of water passing through it.
- The meter uses a water flow sensor, solenoid valve and a relay to read the water flow, close and open the meter.
- The meter is equipped with wireless communication capabilities using a wireless module called ESP8266, to do the computation and transmit data to the mobile application (SPWM).
- To power up the meter there are pre installed rechargeable batteries and a powerbank to be charged using a solar power source.
- The meter has a display unit on it which shows the flow rate and total consumed volume.
- The display unit is equipped with a bright LCD screen that provides relevant information about your water usage.

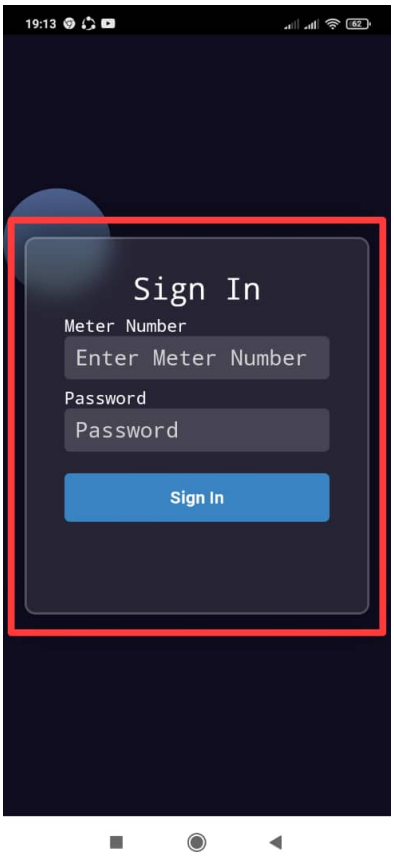
4.1.2. MOBILE APPLICATION (SPWM)

- The SPWM acts as the control center for your smart prepaid water meter system.
- It receives data from the water meter and provides real-time information about your water consumption i.e. water flow rate, total consumed water volume, remaining water as well as your last loaded unit.
- The display unit typically features a screen to display usage details, buttons for navigation, and indicator lights.

4.2. INSTALLATION AND SETUP



The installation is done by the water board (service providers) technicians. You just need to navigate to https://swps.netlify.app/ and install the application.



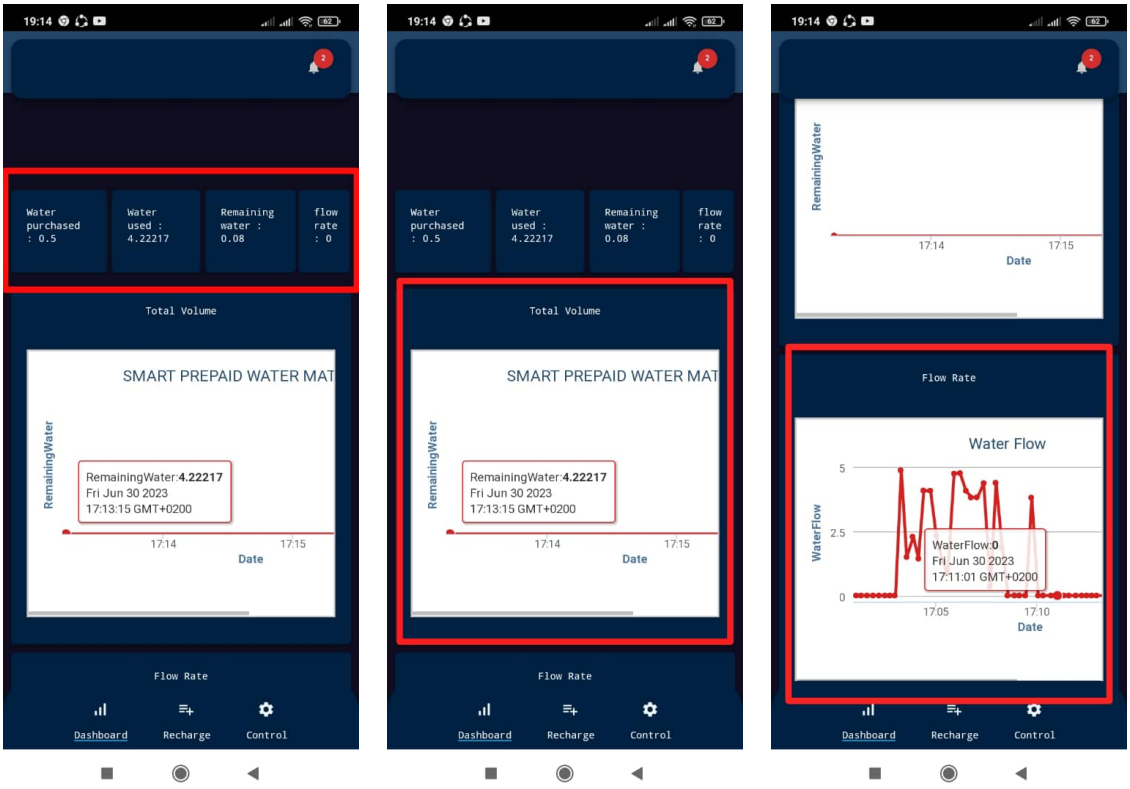
Login with the meter number and for a desired password for the first time. Then take note of the password every time you will be using that password and the meter number as your credentials to log in to the mobile application for you to interact with your meter including checking the remaining water, checking the water flow rate, opening and closing the meter as well as loading water units. Lastly you need to verify the installation. On the mobile application navigate to the control section try to open and close the valve if the meter opens and closes then everything is set.

4.3. USER INTERFACE

The user interface of the smart prepaid water meter is the mobile application called SPWM. The mobile application provides an interactive interface for the users allowing them to monitor the water usage, water flow, close and open the meter and load water units in real time and remotely. Familiarising yourself with the user interface (mobile application) will allow you to effectively manage your smart prepaid water meter. Here is an overview of the elements of the mobile application:

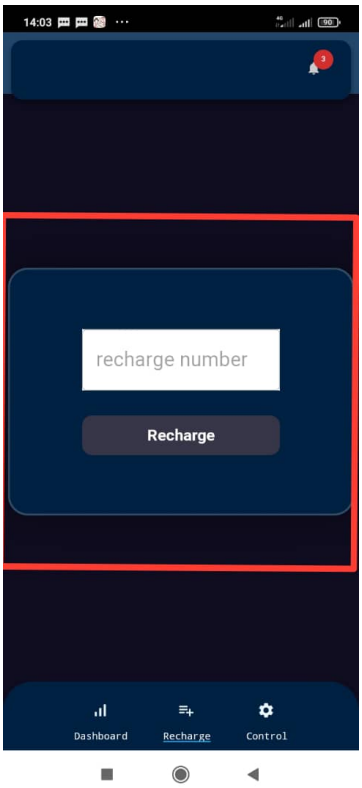
1. DASHBOARD

On top of this section there are four areas which display some information about the meter in real time. Starting with purchased water. This area displays the amount of units in litters you have loaded recently. Followed with consumed water which is the total volume of water that has been used.



The next area is the remaining water. This is where you will be able to see the balance of water you have to use. Lastly there is the flow rate area. This is where the current flow rate of water passing through the meter is shown. After these four areas there are graphs. The first graph shows the total consumption of water. The second graph shows the flow rate of water passing through the meter. Note that all the values displayed here are in litters and minutes. i.e . flow rate is measured in litres per minute.

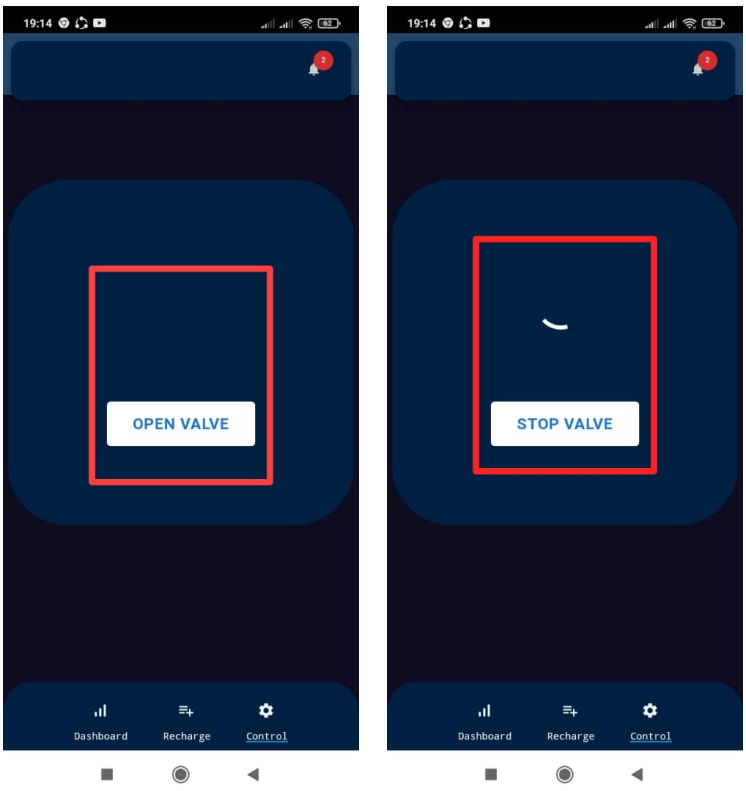
2. RECHARGE



This section is where you will be recharging water units. The section provide an area where you will be typing in the token given to you when you have bought water units.

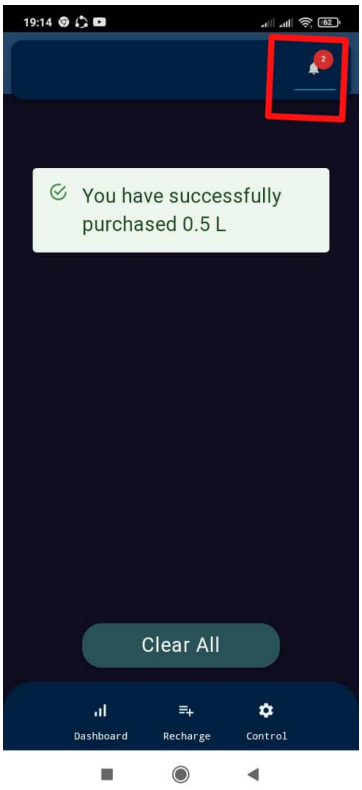
3. CONTROL

This section is where you will be able to open and close the meter. When the section is showing OPEN VALVE that means your meter is closed and for you to open you have to click where there is OPEN VALVE.
When the meter is open, in the section it will be showing STOP VALVE. For you to close it you have to click on this.



Note that these operations will only be possible when the remaining water is greater than 1. In other words you water units in your meter. Otherwise yes you will be able to close and open but this will yield nothing to the water meter.

4. NOTIFICATION



To navigate to this section, click on the notification icon on the top far right of the mobile application. In this section you will be able to see notifications of recharges you have made, whenever remaining water is getting to zero.

4.4. METER USAGE

The smart prepaid water meter displays real-time water consumption data on its interface. The display will show the amount of water consumed, water remaining as well as flow rate in litres. This data provides insights into your usage patterns and helps you monitor your water consumption. By regularly checking the meter, you can identify any sudden increases in usage or detect potential leaks. Sometimes the reading on the interface may be taking time to reflect what is on the actual meter because of network issues and some delays.
If the meter is not working properly, please contact the service providers (Water Board)

5. REFLECTIONS

Reflecting on this project, we have accomplished our objectives successfully while also encountering some challenges and gaining valuable lessons along the way. Our primary goals were to enable remote monitoring of water flow, consumption, and remaining water, as well as the ability to remotely open and close the meter, and recharge water credits. Importantly, we aimed to achieve these functionalities through a dedicated mobile application, which was not available in the existing prepaid water meter system.

All the project objectives were successful. We were able to do all the objectives and controlled using our progressive web application which we installed in our mobile phones. To analyse water flow and remaining water, we utilised an IoT analytics platform called ThingSpeak. This cloud-based service enabled us to aggregate, visualize, and analyse live data streams, with the consumed water data coming from our water flow sensor.

We used Firebase as our database This choice was made because we were dealing with real-time data, and Firebase provides support for such requirements. All the relevant information was stored in Firebase, and our application retrieved the necessary data. . Opening and closing of the valve was represented by a binary indicator (0 and 1) which was stored in the database. a value of 1 would mean open and a value of 0 closed. We were recharging our water credit using tokens that we defined. In this project we generated tokens that represented 0.5 litres, 1 litre, 2.5 litres and 3 litres.

We had faced a lot of challenges during this project. Firstly, we faced material shortages due to our decision to switch from a pump to a valve. This made us spend more money on buying more materials that would work with the valve like a relay.

The second challenge was when our node mcu malfunctioned, requiring us to acquire a new one. This unexpected setback caused delays in our project timeline and required additional investment to replace the faulty component.

Furthermore, we encountered difficulties related to incorrect calibration calculations. Our initial representation of the measured volume as litres turned out to be inaccurate. It became clear that the readings obtained from the meter did not reflect the true volume accurately. As a result, we realised that the data we were collecting was unreliable and did not align with the objectives of the project.

Another significant challenge we faced was ensuring a secure and stable internet connection for real-time monitoring and control. Additionally, we focused on enhancing the user experience by designing an application that is as user friendly as possible.

Furthermore, we encountered a challenge related to notifications. We wanted our application to give notifications when certain thresholds are reached. However, we

encountered an issue where some values were skipped, and notifications were not being triggered as intended.

We learnt a lot during this project. We have learnt team collaboration and communication. Without this we wouldn’t have achieved what we did. We also learnt to value other people’s opinions and inputs on a project especially if they are stakeholders, this improved how we worked on our project and adjusted where need be.

Additionally, we also learnt the importance of building upon existing systems and implementing improvements. While we successfully developed our own solution, we acknowledge that working on an existing system would have provided a stronger foundation and potentially led to more accurate results.

For future enhancements, we recommend the utilisation of GSM technology to enable notifications through text messages.for areas with poor network connectivity

This project aligns well with the current digital era we live in. In today's world, where everything is becoming digital, We understand the significance of adapting to these changes and have developed a solution that allows people to monitor and control their prepaid meters using a mobile app.