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AN AUTOMATED WATER CONSUMPTION MANAGEMENT SYSTEM WITH WATER LEAK DETECTION USING MOBILE APPLICATION

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Abstract
The importance of water sustainability has long been recognized across the globe and it is considered as one of the most important commodities that is very essential in all of humanity's basic functions. In the Philippines or like most in the other nations, in order to control the water supply, most of them relies on reading the water-metering system manually. Wherein this kind of processes is very time consuming and locating where the possible leakage is hard to identify. Due to these reasons, the proponent of this study comes up with an idea to create a solution with these problems. One of the objectives is to develop An Automated Water Consumption Management System with Water Leak Detection Using Mobile Application wherein it can monitor the rate of water-flow in real time basis; can calculate the amount of water consumes; and notify the end user if water leakage exists. These capabilities help the end-user to prevent the high consumption of water due to water leakage and unnecessary use of water. In addition, this study focuses also on controlling the said device (waterflow sensor) manually when a particular leakage exists, and the special features added to the application is that it can send an alert or notification message to the end-user. In terms of design of the project development, the proponents rely on the use of Agile Methodology in order to identify and solve the common problems that will exist on the phase of developing this study.

1.0INTRODUCTION

The significance of water sustainability has long been recognized. It is considered as one of the most important commodities on the globe. This aspect is vital to all of humanity's basic functions. Water is unfortunately lost both domestically and internationally due to a variety of reasons. According to the Metropolitan Waterworks and Sewerage System (MWSS), about 39% of water supply from Maynilad and 11% from Manila Water is lost to system depletion or non-revenue water due to busted water pipes and leaks.

To control water use and supply, the Philippines, like most other nations, relies heavily on analogue and manually read water-metering systems. Such readings are time consuming, and when leak occurs, it is difficult to locate the source of the leak. Locally, there is a strong need for increased water quality, especially for communities aiming to develop smart cities with smart grid networks as a backbone. This necessitates the implementation of a suitable technology for a low-cost, highly scalable approach for tracking water usage in near real time.

Furthermore, the existing water network architectures in the Philippines are built on massive, consolidated networks with minimal management options. These technologies

have many significant disadvantages, including poor operation performance due to a disparity of water availability and demand, high disposal costs, and low treatment efficiency in both supply and wastewater due to fixed treatment methods. Leaks and pipe bursts are also frequent faults in municipal water delivery networks; when a large burst occurs in the main pipeline, the water distribution mechanism will be totally shut down.

A modern water management scheme that allows for real-time management is needed to address the current water management dilemma. The aim of this study is to incorporate a mobile-based water management application with a water leakage detector to help users collect real-time data for real-time analysis. The application can provide the user with real-time water usage data since it tracks consumption as a whole and produces a number of visual graphs of the gathered data that are displayed to the consumer in a readable manner. The paper's complexity prevents it from focusing on the ongoing implementation of analogue water meters for better precision or considering how raw data can be applied to the new billing service scheme.

The general objective of the study is to develop An Automated Water Consumption Management System with Water Leak Detection using mobile application that will contribute on the proper consumption of water of every business. Specifically, this study aims to design and develop a system that can monitor the rate of water flow in real-time basis, this application can also calculate the amount of water consumes and notify the end-user if water leakage exists.

2.0 METHOD

A context diagram is a data flow diagram that only shows the top level known as level 0. It shows one process node that represents the functions of a complete system in regard to how it interacts with external entities.

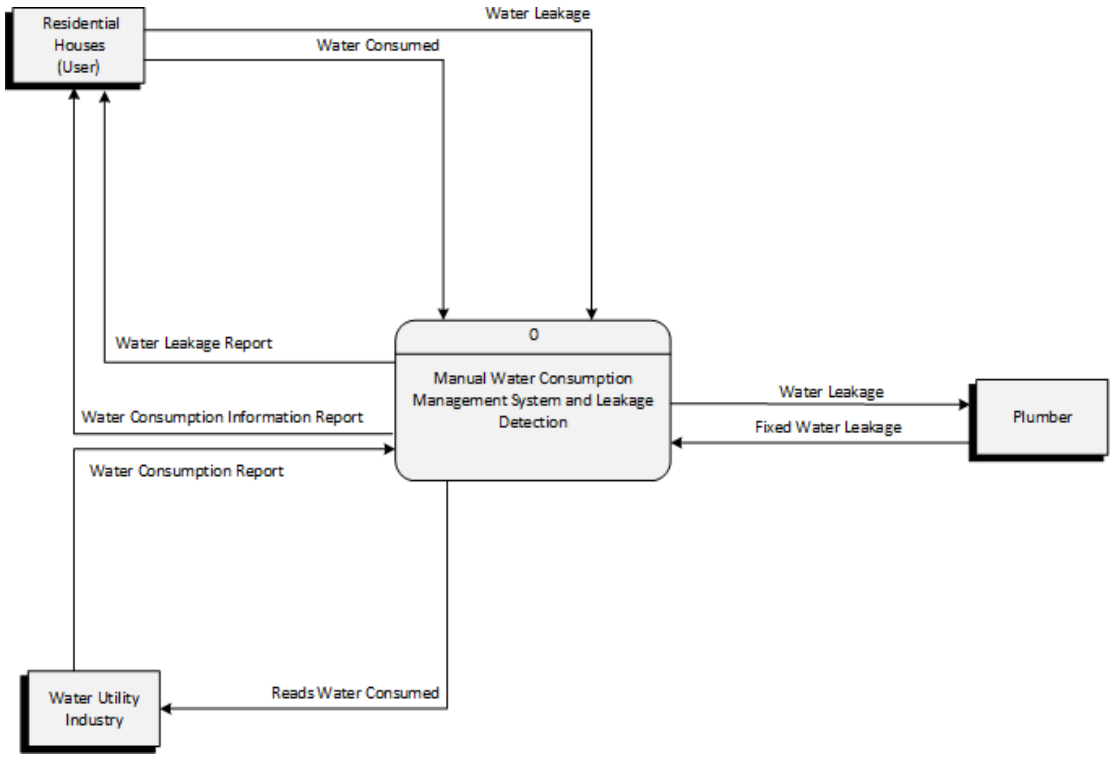

Figure 1. Level 0 Context Diagram of the Existing System

The figure above shows the processes of important data throughout the existing system of the study. Also, this diagram shows the process of the different entities such as user, which is dedicated to residential houses, plumber – the one who fixed the water

pipelines if problem occurs and lastly, water utility industry like Manila Water, Nawasa and Maynilad. As the user consumes water, all the data will be processed by the water industry utility. A leakage will only be realized by the owner when the amount of consumption is not appropriate with the normal consumption happened within a specific time. The one who takes action on fixing this particular problem is the plumber who is knowledgeable with this. The main role of water utility industry is to manage and to record all the water consumption done by the user.

A data flow diagram (DFD) shows the flow of data through an information system, modelling its process aspects.

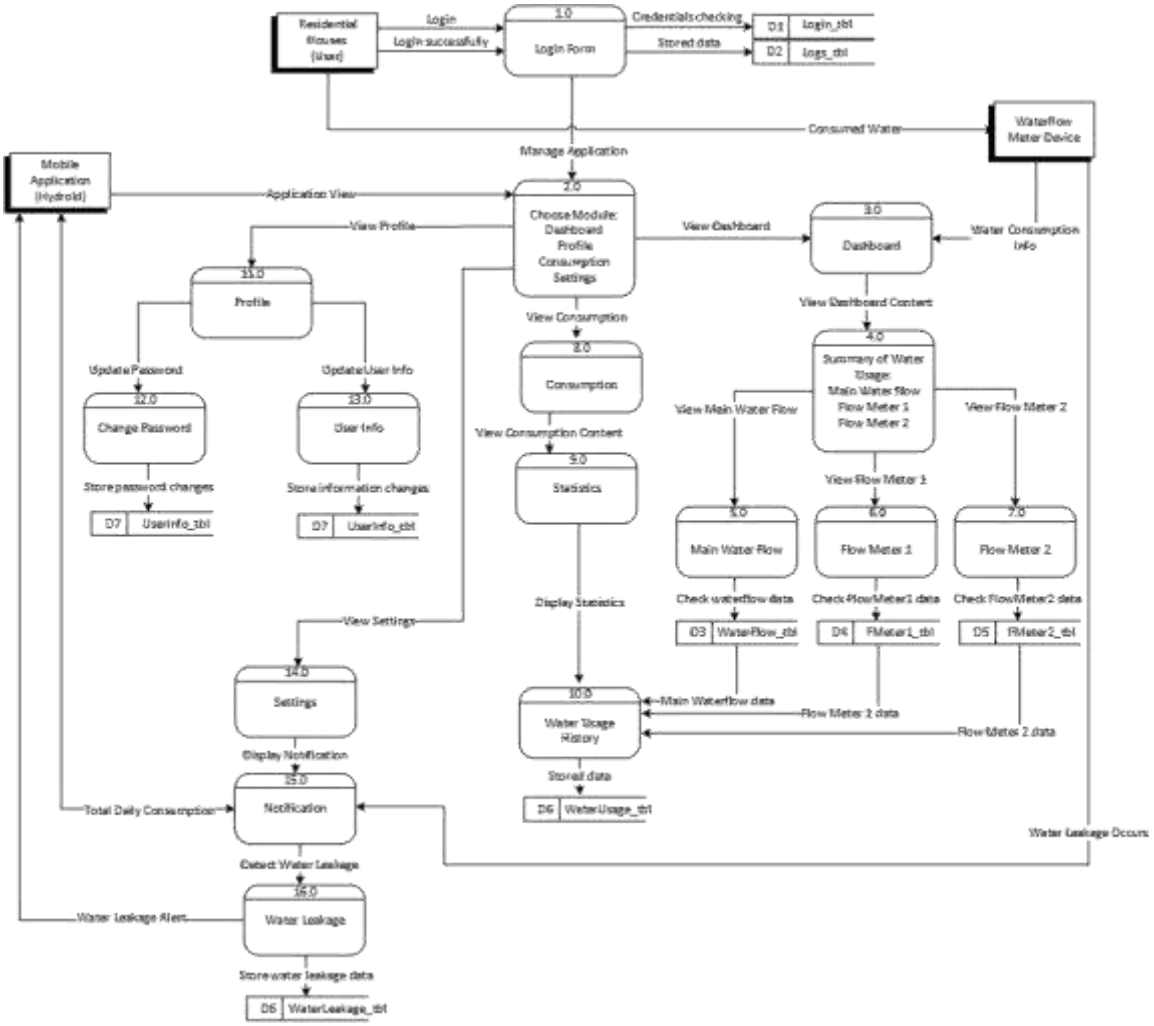

Figure 2. Data Flow Diagram of the Proposed System

Based on the figure above, it represents the detailed and informative flow of data of the proposed system wherein it composed of entities, different process, data stores and data flow. To further understand on how data flows. It will be explained clearly and defined the different kind of terms that is not familiar with the user. Based on the process 1.0 – login form, this is a place where the user put all the credentials or information to access the contents of the mobile application. Process 2.0 focuses on the contents of application where user can freely choose the data and access information from it. Process 3.0 shows the Dashboard where user can see it as the summary of mobile app contents. Which this process contains of subprocess which composed of process 5.0 up to process 6.0. These processes primarily concerned on how the waterflow meter device sends data to the application. Once data is being collected, it will store on a data storage. Next is process 8.0 that pertains on the consumption module, this process has statistics wherein

it is used to see all the history of water usage from the process of waterflow meter device. Another module is particularly assigned on the process 11.0 that contains the profile module where users can see all the data or information being inputted in the system like name, address, contact number, and the like. Also, change of password is also included since it gives a security purpose on how the user will use the application. And once all of data is being inputted, it will store on a real-time storage called firebase. Lastly, the process 14.0 indicates the settings module where it handled the notification alert. This notification alert is only applicable if there is a leakage occurs within the water systems of a residential house. To produce an alert, a second device will be beneficial wherein it detects the noise of the water that came from the pressure of the leakage or moisture of the water that came from the leak of water pipes. As all the information is being processed, all the data will be displayed on the user with mobile application.

In addition to this, according to (Lynch, 2021), data flow diagram is the detailed information of context diagram wherein it maps out the flow and process of information happened within the system. Data flow diagram composed of four components which is helpful in mapping out the flow of data in developing a system.

These components consists of; external entity – an outside system that sends and receives data; process – this is use to change the process of data and the main role of it is to produce an output after processing a data; data store – are files or repositories that hold the information, one example of this are database or tables that represents as the storage of all data of the system; and lasty data flow – which known as the route of the data that takes between external entities, processes and data stores. Furthermore, data flow diagram can range into simple and even an in-depth process that dig progressively deeper into how data should be handled.

One of the main reasons of using data flow diagram is to create a picture or to analyze how a certain data flows on the system and what benefits and what changes it can give from the existing system of the company.

2.1 System Development

System Development covered the comprehensive techniques used in constructing the proposed study. Moreover, different components of the chosen methodology are being defined to understand the detailed processes of the study. In developing the proponents' proposed study, different components and methods involves in identifying and solving the research problem. One of the methods and/or components used by the proponents of this study is the System Development Life Cycle wherein this methodology has different kinds. Primarily the proponents of this study use the Agile Model as part of the of the methodology used in conducting the study. Conforming to (Biltawi et al., 2017), Agile methodologies is an iterative, lightweight, and lean software design and development methodology that was being introduced in the late 1990s. This methodology was being used to be highly compatible to the rapid development of the WWW (World Wide Web). Moreover, this kind of method is based on iterative enhancement where it focuses on the ability to continuously adapt and make improvements to the way how work should manage based on each iteration process. Also, agile methodology creates values and principles that would be beneficial in deciding and planning on the things that may encounter during the process of conducting the study.

The figure above shows the research methodology used by the proponents in developing the study. This method is known as Agile Model which composed of six different phases including requirements, design, development, testing, deployment, and review. This phase is very important in developing the systematic process of project development. The Agile System Development Life Cycle is a development process iteration in which the customer is able to see the result and gauge whether the client is satisfied with it or not. The advantage of this SDLC is that the development of the project is closely monitored by the client and developed in accordance with the clients' needs. Its disadvantage is that project development costs and its resources are difficult to estimate.

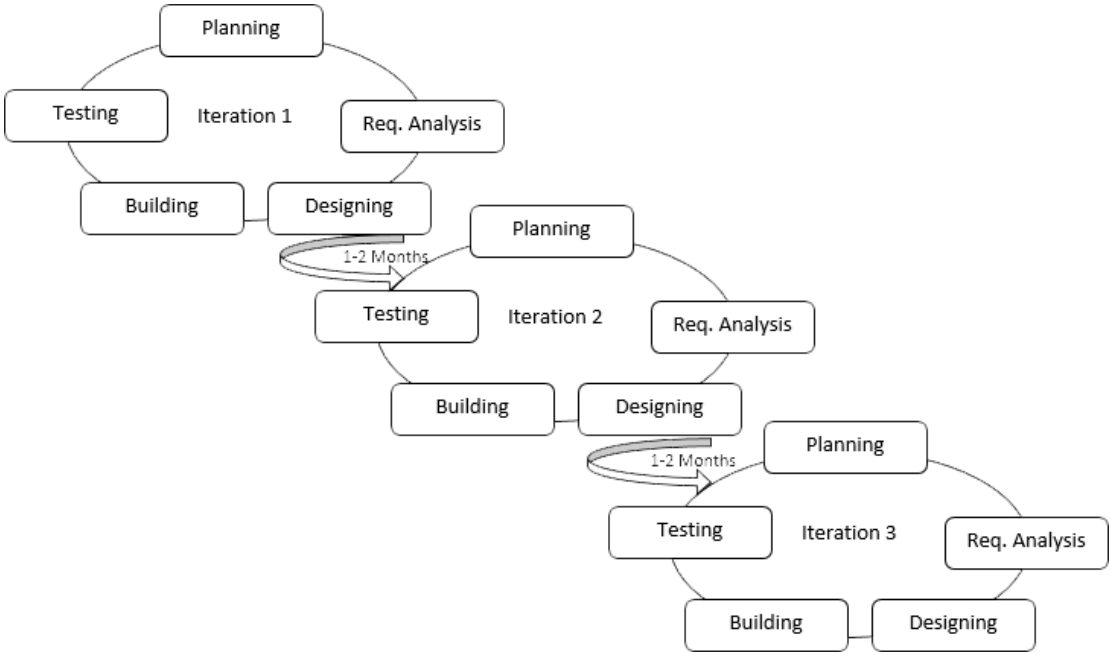

Figure 3. Agile System Development Life Cycle (Otsetskyi, 2017)

2.2 Hardware and Software Requirements

The Hardware and Software Requirements in this portion of the paper is divided into two parts, the hardware and software requirement in the development of the application and the hardware and software requirement in the execution of the mobile application. The hardware requirement in the development of the device prototype requires Arduino IDE application and in terms of software requirement, it requires the Android Studio Application. Android Studio requires a computer with the processor of x86_64 CPU Architecture; 2nd generation Intel Core or newer version, AMD CPU with support for a Windows Hypervisor, 8GB RAM or more, 8GB of available disk space minimum (IDE + Android SDK + Android Emulator), and 1280 x 800 minimum screen resolution. These are the minimum hardware requirements, and have been identified to run the application. Any specification higher may be used for the better output of the system. As for the hardware and software requirements for mobile devices such as smarthpnes, first, it must be running on Android OS which is the current Operating System known as Android Oreo. Android Phone with 4GB RAM is required. The device must be Quad Core (4 x 2.2 GHz, Quad Core, Cortex A73 + 1.7 GHz, Quad Core, Cortex A53).

2.3 Evaluation Procedure

The proponents created a survey questionnaire in accordance to the ISO 25010 standards. This standard is used in software evaluation and analyzes eight main parts of a system, namely: functional suitability, performance efficiency, compatibility, usability reliability, usability, security, maintainability, and portability of the system. The system is evaluated through the Likert scale of 1 – 5. 5 is the highest which considered as (Strongly Agree) and 1 being the lowest (Strongly Disagree). The sample size is asked to check on the statements that best describes their experience with both the current system and the proposed system.

3.0 RESULTS AND DISCUSSIONS

3.1 Description of the System

According to the World Health Organization (2019), 1 out of 10 people in the Philippines, does not have any access on improved water resources. Variety of reasons why most of the people faced these problems is due to the; insufficiency of water distribution especially in rural communities, expensive infrastructure of water systems, lack of knowledge with regards of consuming the water wisely and lastly, the effect of climate change to the weather such as El Niño.

Due to these reasons, the proponents come up with the idea of creating "An Automated Water Consumption Management System with Water Leak Detection using Mobile Application". Whereas the system is intended only for commercial type of property such as businesses who owns water station or any water resources. The system divides into two parts, where it consists of hardware and a software device; the hardware device is made up of Arduino together with the other essential requirement such as a water flow sensor, Nodemcu ESP8266, and a sound sensor. Technically the main purpose of the water flow sensor is to measure the number of water flows within the water system of a particular area and the proponents come up with using the Nodemcu ESP8266 as a way to connect the device with any internet connection. The sound sensor is used specifically for detecting any water leakage that may occur within the water systems of a business.

The software device primarily lies on the use of the mobile application to monitor all the different events that happened within the water systems. In developing the software device, different software applications have been used such as Android Studio that acts as an integrated development environment (IDE) and a way to create the interface of mobile application. Android Studio requires a Java or Kotlin Programming Language to create a powerful mobile application. The requirements of the proposed system remain on the use of android phone with a minimum requirement of Android Oreo as part of the Operating System (OS) and above hardware specifications of the phone is at least 4GB Random-Access Memory (RAM).

Primarily, the proponents of this study collected data from different places where the primary respondents include business owner of water stations or any water resources, including also the staffs and other employees of the company. An Automated Water Consumption Management System with Water Leak Detection using Mobile Application provides a way of monitoring and maintaining the situation of any water resources using an application to monitor it. The system/application can also detect any leakage exists and sends a notification message that act as an alert to catch the attention of the user/business owners. The proposed system/application can also schedule the time when to monitor the leakage and the time of sending a notification to the user. Also, the proposed system comes up with an additional functionality, whereas it can calculate the amount of water consumed into Philippine peso. The main purpose of calculating the

consumed water is to serve as a basis for monthly billing payments from water resource industry like Maynilad, Nawasa or Manila Water.

3.2 System Capabilities and Limitation

The proposed system has the following capabilities: The proposed system is used online. The proposed system can monitor the amount of consumption done by a user during a real time basis. The proposed system can calculate and convert the amount of consumption into peso. The proposed system can detect leakage. The proposed system can send a notification alert when leakage exists.

The proposed system has the following limitations: The proposed system cannot be used offline. The proposed system cannot remotely control the hardware devices such as the waterflow sensor and sound sensor. The proposed system can only be accessed by android devices. The proposed system can be only used by commercial type of houses such as business owners (an example of this business type is a water refilling station.)

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the study conducted, the proponents concluded that the proposed study "An Automated Water Consumption Management System with Water Leak Detection using Mobile Application" was successfully developed such that the system was successfully developed with the use of the Android Studio – an Integrated Development Environment used to create a mobile application, Firebase – a real-time database to store real-time information, Arduino IDE – to setup the software requirements of the prototype device. The system is able to make a system that introduces the modern way of monitoring and managing the water consumption consumed by the business and its owners. The system also allows the business to prevent high consumption of water due to water leakage. The proposed system minimizes the time consumed in terms of manually monitoring the water situation. The proposed systems reduce the over-calculated water bill since the system can calculate the amount of water consumed. The proposed system reduces the risks of water leakage since the system can send a notification alert if there's any leakage exists.

The proponents have made the following recommendations to improve the proposed system entitled "An Automated Water Consumption Management System with Water Leak Detection using Mobile Application". First recommendation is concerned with the prototype model whereas the researchers recommend changing the Arduino into Raspberry Pi due to the reasons that it is more superior than Arduino when it comes to performance, speed, and onboard features. The second recommendation concerned with the schedule time of application wherein the researchers recommend to create a time management or a scheduled time in terms of checking the consumption and detecting the possible leakage. The main purpose of scheduled time is to have an ease of access and inform the end-users when is the time to monitor and to check the situation of water systems within the business. The third recommendation concerns with the administrator page whereas the researchers recommend to create an administrator page of this application whereas additional configurations is possible to setup like multi-tasking of application, and ensures that the systems/application is running effectively.

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Appendix F

Grammarian Certificate

OUR LADY OF FATIMA UNIVERSITY
COLLEGE OF COMPUTER STUDIES
ANTIPOLO CITY

64

Grammarian Certificate

This is to certify that I, Dr. Benjamin L. Pagco has been tasked to be the grammarian to the following BSIT 4th year students of Our Lady of Fatima University (OLFU) Antipolo Campus. Namely Daisy M. Balerite, Lordino G. Dela Rosa, Riczhie Kylla M. Morfe, Jaymark B. Saga, whose capstone project titled " ***An Automated Water Consumption Management System with Water Leak Detection using Mobile Application***" for Aqua Koi Water Refilling Station that has been undergone with revision and now on the final stage of the project. As part of my main task, I have thoroughly checked their work and was able to make the necessary correction for it to be submitted as a final requirement to pass the subject.

Issued this 6th day of January, 2022

Signed by:

Dr. Benjamin L. Pagco
Editor

Conformed:

Ms. Alneslyn C. Bucud, MIT (c)
Technical Adviser

 AN AUTOMATED WATER CONSUMPTION MANAGEMENT SYSTEM WITH WATER LEAK DETECTION USING MOBILE APPLICATION