Algerian People's Democratic Republic

Ministry of Higher Education and Scientific Research

Mohamed Khider University - BISKRA

Faculty of Exact Sciences, Science of Nature and Life

Computer Science Department

Master dissertation

Option

Software Engineering and Distributed Systems

Theme

Water Quantity Monitoring Based On IoT

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Abstract

The aim of this dissertation is to optimize the performance of water services at home to management the quantity of the water distributed to family members. Measuring and managing water are one of the most common problems in the home. Currently, the normal method is to manually check the reservoir and distinguish the amount of water. For this purpose, we propose an automatic system for monitoring water quantity for management of water based on IoT (Internet Of Things). This system provides a real time monitoring of water quantity, and it is distinguished by the advantages of time minimization, perfection and intelligent management of the services in the home.

Keywords: IoT, Automatic Monitoring, Management Of Water Resources.

الملخص :

الهدف من هذه المذكرة هو تحسين أداء خدمات المياه في المنزل من خلال إدارة كمية المياه الموزعة على أفراد الأسرة. يعد قياس كمية المياه المنزلية وإدارتها من أكثر المشاكل شيوعًا. حاليا، تعتمد الطريقة التقليدية على فحص الخزان يدويا وتحديد كمية المياه بداخله. لذا، نقترح نظامًا آليًا لمراقبة كمية المياه و إدارتها باستخدام تقنية إنترنت الأشياء. يوفر هذا النظام مراقبة فورية لكمية المياه ويتميز بمزايا تقليل الوقت، حسن الاستغلال، والإدارة الذكية للخدمات في المنزل.

الكلمات المفتاحية: إنترنت الأشياء، مراقبة آلية، تسيير الموارد المائية

Acknowledgements

I would first like to thank my dissertation superviser water quantity monitoring, Telli Abdelmoutia of the Computer Science faculty at Mohamed Khider University-BISKRA. The door to Prof.Telli office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this paper to be my own work, but steered me in the right direction whenever he thought I needed it.

I would also like to thank my friends for their support. Last but not the least, I would like to thank my family: my parents and to my brothers and sisters for supporting me spiritually throughout writing this thesis and my life in general.

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General Introduction

"Don't let the noise of others'
opinions drown out your own inner voice"
Steve Jobs

Background and Motivations

ONE of the problems at home is monitoring and managing the amount of water. Thus its too important to find the solution for water monitoring and control system. IoT is a solution. In recent days, development in computing and electronics technologies have triggered Internet of Things technology. Internet of Things can be describe as the network of electronics devices communicating among them by the help of a controller. The most common method to monitoring water quantity is check the reservoir and distinguish the amount of water. It is seen that there are many academic studies about the use of IoT technology in smart houses.

In this dissertation, IoT technology is used in smart houses to monitoring water quantity in real time. Using the standard internet protocol, this technology can transfer wirelessly the data obtained by digitizing the data of the object or the domain of the adapter that it is adapting to the server.

Problematic and Contributions

The traditional method of water quantity monitoring faces many problems. Our contribution is how to use of IoT technologies to develop a real-time system for water quantity monitoring.

Dissertation Organization

Our dissertation consists, in addition to the general introduction and the general conclusion, four chapters. The two first chapters are state of the art, while the other last chapters are the contributions and implementation on water quantity monitoring. The dissertation is organized as follows:

We present in the **Chapter 1** an introduction to water quantity monitoring that describes important definitions of water quantity.

Chapter 2 presents in the first part the Internet of Things and how it includes in the concept of home automatization while the second part is about water quantity monitoring

In **Chapter 3**, the evaluation and conception of the proposed system are presented

The implementation, tests and results of our system has been presented in **Chapter 4**.

Chapter 1

Water Quantity Features

"And We have made from water every
living thing Will they not then believe"
Allah

1.1 Introduction

THE quantity of water delivered and used for households is an important aspect of domestic water supplies. Domestic water supplies are one of the fundamental requirements for human life. Without water, life cannot be sustained beyond a few days. Many uses of water occur largely at the household (for instance drinking, eating and hand-washing). Others may occur away from the home (laundry and in some cases bathing). This therefore needs to be borne in mind when ensuring that adequate quantities of domestic supply are available for these purposes and in interpreting and applying minimum values.

In this chapter, we study the water quantity features, such as definition, characteristics and standards norms. Then, we present a general observation about water quantity.

1.2 Definitions

Water quantity is the timing and total water production yield of water from a watershed, and is measured by total yield and peak flow over a specified period of time [1]. However, WHO defines household water as being 'water used for all usual domestic purposes including consumption, bathing and food preparation [2].

Domestic water use is water used for indoor and outdoor household purposes all the things you do at home: drinking, preparing food, bathing, washing clothes and dishes, brushing your teeth, watering the garden. Domestic water use refers to the amount of water that is "self-supplied", or water withdrawn directly by users, such as from a well at a person's home [3].

1.3 Published Reference Values

2.6 litres of water per day is lost through respiratory loss, insensible perspiration, urination and defecation. In addition, a significant quantity of water is lost through sensible perspiration if hard work is performed. These figures led them to suggest that a daily minimum of water required in tropical climates would be around theree litres per person, although the volume of water loss suggests that this should be at the upper end of this scale. But under extreme conditions of hard work at high temperatures in the sun this figure could rise to as much as 25 litres per day. However, they also point out that the proportion of the fluid intake achieved via food would be expected to vary significantly and could provide 100% of the fluid requirement in some rare cases [4].

	Normal conditions	High average temp	Moderate activity
Adults	1.0-2.4	2.8-3.4	3.7
Adult male	2	-	-
Adult female	1.4	-	-
Child (10 years)	1.0	-	-

Table 1.1: Daily fluid intake reference values in litres per capita.

Based on US National Research Council guidelines in relation to hydration needs resulting from average energy expenditure and environmental exposure in the USA, the average male should consume a minimum 2.9 litres per day and the average female 2.2 litres. Approximately one-third of this fluid was considered likely to be derived from food [5].

1.4 Water Supplies And Their Productive

What is meant by 'productive use of water at the household level'? The reason for this rather cumbersome phrase is the need to encapsulate a set of activities that typically fall between a number of sectors or sub-sectors. Household water supplies are most often thought of as coming under the remit of the domestic water supply and sanitation (WATSAN) sub-sector, with its exclusive focus on water supplies for drinking, washing, cooking, and sanitation (so-called basic needs). Water for agricultural production is assumed to be provided by the irrigation sector, but this in turn seldom focuses on smaller scale or domestic uses at the household scale [6].

We use the concept of 'productive use' to refer to water used for small-scale, often informal activities whose primary purpose is improved nutrition and/or income generation. And we use the term 'household level' to indicate both the relatively small-scale of the activities (and quantities of water) involved, and the primary social unit at which the use of this water takes place. Enabling productive use means providing a quantity of water over and above that needed for purely basic needs. A major outcome of the Johannesburg symposium in January 2003 "Poverty and Water: Productive Uses of Water at the Household Level" [7] was agreement among a wide range of professionals that a quantity of water sufficient for both domestic and (at least some) productive use will typically be between 50 and 150 litres per capita per day (lpcd) not far from what is typically supplied by northern and urban water supply utilities [2].

1.5 Water Quantities Required For Cooking

Defining the requirements for water for cooking is difficult, as this depends on the diet and the role of water in food preparation. However, most cultures have a staple foodstuff, which is usually some form of carbohydrate rich vegetable or cereal. A minimum requirement for water supplies would therefore also include sufficient water to be able to prepare an adequate quantity of the staple food for the average family to provide nutritional benefit. It is difficult to be precise about volumes required to prepare staples as this depends on the staple itself.

An example can be provided for rice, which probably represents the most widely used staple food worldwide. Recommendations for nutrition usually deal with the intake of nutrients rather than specific food stuffs. Most food pyramids give a suggest an intake for cereals of 6 to 11 servings per day, or 600 – 1100 grams per day.

More water may be required to ensure that other foodstuffs can be cooked, although defining minimum quantities is difficult as this depends on the nature of the food being prepared. For instance, on average 10 litres per capita per day is required for food preparation [8], in East Africa only 4.2 litres per capita per day were used for both drinking and cooking for households with a piped connection and even less (3.8 litres per capita per day) for households without a connection. Taking into account drinking needs, this suggests that between 1.5 and 2 litres per capita per day is used for cooking.

If the quantity of water required for cooking rice is taken as representing the needs for staple preparation and assuming further water is required for preparation of other food, the evidence suggests that in most cases approximately 2 litres per capita per day should be available from domestic supplies to support food preparation.

1.6 Water Quantity Requirements For Hygiene

The need for domestic water supplies for basic health protection exceeds the minimum required for consumption (drinking and cooking). Additional volumes are required for maintaining food and personal hygiene through hand and food washing, bathing and laundry. Poor hygiene may in part be caused by a lack of sufficient quantity of domestic water supply [9]. The diseases linked to poor hygiene include diarrhoeal and other diseases transmitted through the faecal-oral route; skin and eye diseases, in particular trachoma and diseases related to infestations, for instance louse and tick-borne typhus [2, 9].

The relative influence of consumption of contaminated water, poor hygiene and lack of sanitation on diarrhoeal disease in particular has been the topic of significant discussion. This has mirrored a broader debate within the health sector worldwide regarding the need for quantifiable evidence in reducing health burdens. The desire for evidence-based health interventions is driven by the need to maximise benefits from limited resources (a critical factor both for governments and their populations). It is also driven by the desire to ensure that populations benefit from the interventions that deliver the greatest improvement in their health [2].

1.7 Other Uses Of Water

Many others uses of water in our life. Let's cite someone's:

1.7.1 Household Productive Uses of Domestic Water

This section deals with the productive uses of domestic water at a household level, which includes brewing, small-scale food production and household construction in low-income areas. We do not consider community-level enterprises that use water resources in income generating activities, such as irrigation systems (beyond simple use of water by a household for gardening), industry, larger commercial entities, energy production and transport. However, as noted in the introduction, in terms of overall use of water sources the economic use of water typically greatly exceeds that used for domestic supply, but may compromise the ability of the resource to meet basic needs (either through over-consumption or through uses leading to quality deterioration). The health sector oversight of water supply, has traditionally not considered productive uses of water as important to control.

However, it is increasingly recognised that productive uses of water have particular value for low-income households and communities and have health and well-being benefits [10]. Direct health benefits are derived for example from improved nutrition and food security from gardens crops that have been watered. Indirect health benefits arise from improvements in household wealth from productive activity. In urban areas, this often is essential for low-income communities to meet nutritional requirements and may offer additional income from small-scale sales.

In families living in 'ultra-poverty' water could form anywhere between 1.5 and 10% of the total production costs in household enterprises. The removal of a water supply, or deterioration in the quality of service, through decreased quantity or availability or increased intermittence or cost may lead to further poverty among poor households using this water for small-scale economic activities such as food production. The quality of water used for productive processes needs to be suitable for domestic supply where it is used for processing food for retail or in some circumstances irrigation for its production [2].

1.7.2 Water Amenity Uses

Amenity uses are not typically considered in relation to health aspects of water quantity. Amenity uses include lawn-watering and car washing, although in some cases the latter would be more correctly categorised as productive uses of water as it may be used to provide an income. There are some benefits of purely amenity uses of water in terms of quality of life. However, particularly for the most vulnerable, amenity use of water is likely to be limited [2].

The principal concern in relation to amenity uses of domestic water supplies is to reduce the consumption of water for these purposes when this may place a significant demand on the water supply such that universal basic access is compromised. This is a problem noted in many developed countries where increasing efforts are being made to educate users on the problems of use of water for such purposes and in some cases restrictions applied and enforced to conserve water resources. Such approaches may include the use of variable tariff rates that penalise excess use, although in this case care must be taken to ensure that there would be no financial penalty for ensuring water for basic needs, including laundry. Over-use of scarce water supplies for amenity uses is also found in developing countries, particularly in urban areas where the patterns of use among the wealthy may directly impact on the availability of water to the poor [11].

Therefore, controlling amenity use of domestic water supplies should be driven to ensure that basic needs are met throughout the population in an equitable manner. It is important that such controls consider not only meeting the basic needs for current populations, but also takes into account future population growth. Furthermore, as many developing countries are either already experiencing or facing water scarcity and water stress, the need to control consumption of water to conserve resources is also critical [8].

1.8 The Sphere Standards

Attempts have been made in the past to define minimum water quantities required in emergencies. In 2004, a cluster of relief agencies developed the document entitled Sphere Humanitarian Charter and Minimum Standards in Disaster Response which set standards for the minimum level of services people affected by an emergency should receive. For water supply, it states that all people should "have safe and equitable access to sufficient quantity of water for drinking, cooking and personal and domestic hygiene" and that public water points should be "sufficiently close to households to enable use of the minimum water requirement". Most major relief agencies and their donors have accepted the Sphere Standards as the foundation for acceptable relief services. Sphere also describes indicators which relate to the delivery of the standards, including water quantity standards. Indicators are suggestions of what might be a reasonable interpretation of the standards.

People use water for a wide variety of activities. Some of these are more important than others. Having a few litres of water to drink each day, for example, is more important than having water for personal hygiene or laundry, but people will still want and need to wash for the prevention of skin diseases and meeting other physiological needs. Other uses of water have health and other benefits but decrease in urgency as Figure 1.1 demonstrates [12].

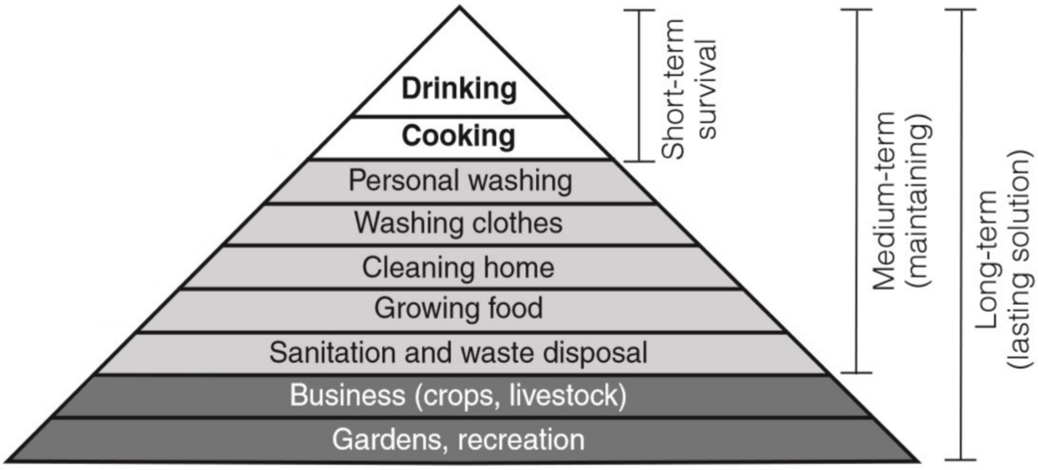

Figure 1.1: Hierarchy of water requirements.

1.9 Basic Survival Water Needs

People do not always have predictable needs. In some cultures, the need to wash sanitary towels or to wash hands and feet before prayer may be perceived to be more important than other water uses. Talk to people to understand their priorities.

Women and men may have different priorities. Women may be concerned about basic household water requirements, whilst men may have concerns about livestock. In the assessment, waste spillage and leaks also need to be taken into consideration. The Sphere Standards suggest a basic survival-level water requirement to use as a starting point for calculating demand (See Table 1.2). However, research indicates that 20 litres per capita per day is the minimum quantity of safe water required to realise minimum essential levels for health and hygiene. Therefore, efforts should be made to incrementally secure this amount for each individual [12].

Using	Quantity	Depends
Survival needs: water intake (drinking and food)	2.5–3 litres per day	Depends on the climate and individual physiology
Basic hygiene practices	2–6 litres per day	Depends on social and cultural norms
Basic cooking needs	3–6 litres per day	Depends on food type and social and cultural norms
Total basic water needs	7.5–15 litres per day	

Table 1.2: Basic Water Needs By Day For One Person.

1.10 Water For Non-Domestic Use

Water is essential for many other services provided in emergencies, especially health care. Affected communities may also want to use water for religious activities and agriculture. Users, not providers, decide how they will use a scarce supply of water. If people consider their livestock to be more important than doing the laundry, then they will distribute the available water accordingly. Ensure that there is enough water to meet people's priority needs with enough left over to meet the priorities related to effectively managing the emergency [2].

1.11 Conclusion

Our water resources, irregularly distributed in space and time, are under pressure due to major population change and increased demand. Access to reliable data on the availability, quality and quantity of water, and its variability, form the necessary foundation for sound management of water resources. The different options for augmentation expand the boundaries of the water resource in a conventional sense, helping to match demand and supply. All components of the hydrological cycle, and the influence of human activities on it, need to be understood and quantified to efficiently and sustainably develop and protect our water resources.

The next chapter focuses about a new technology based on IoT to monitoring water quantity in house.

Chapter 2

IoT and Water Quantity Monitoring

"What a computer is to me is the most remarkable tool that we have ever come up with. It's the equivalent of a bicycle for our minds."
"I think the things you regret most in life are the things you didn't do."
Steve Jobs.

2.1 Introduction

THE fast development of the Internet of Things (IoT) technology in recent years has supported connections of numerous smart things along with sensors and established seamless data exchange between them. So it leads to a stringy requirement for data analysis and data storage platform such as cloud computing and fog computing [13]. IoT aims at creating smart environments in which individuals as well as whole societies will be able to live in a smarter and more comfortable way.

This chapter presents in the first part the Internet of Things technology and how it includes in the concept of home automatization. While, the second part is comparaison between existing water quantity monitoring systeme (the related works) and our proposed system.

2.2 Internet of Things Technology (IoT)

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [14].

An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally [15].

Figure 2.1: Internet of Thing Devices.

2.3 Application Areas for IoT

IoT applications promise to bring immense value into our lives. With newer wireless networks, superior sensors and revolutionary computing capabilities. Because There is an increasing interest in new use cases such as smart manufacturing, augmented reality and a multitude of IoT applications, Let's check them out:

2.3.1 Smart City

The Smart city is another powerful application of IoT which is generating curiosity among world's population. Automated transportation, smart surveillance, smarter water distribution system, smarter energy management systems, urban security and environmental monitoring are few of the examples of internet of things applications for smart cities [16].

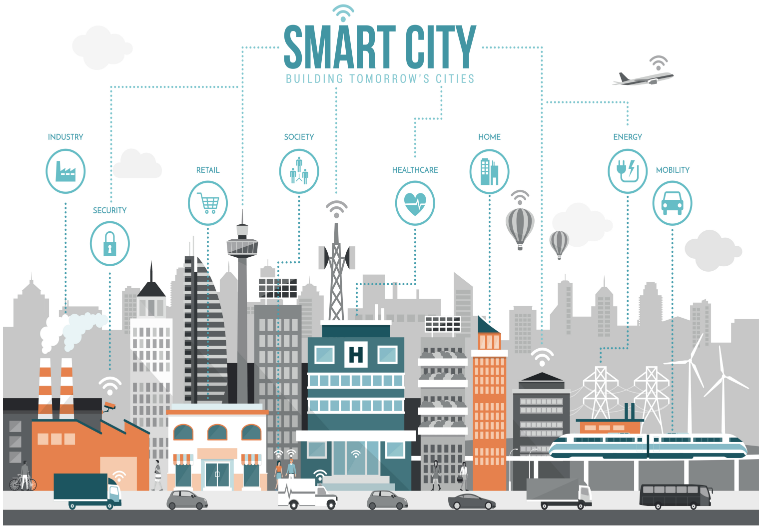

Figure 2.2: Smart City.

2.3.2 Smart Home

A smart home is a convenient home setup where appliances and devices can be automatically controlled remotely from any internet-connected place in the world using a mobile or other networked device. A smart home has its devices interconnected through the internet, and the user can control functions such as security access to the home, temperature, lighting, and home theater. Related terms include "home automation" and "smart building" [17].

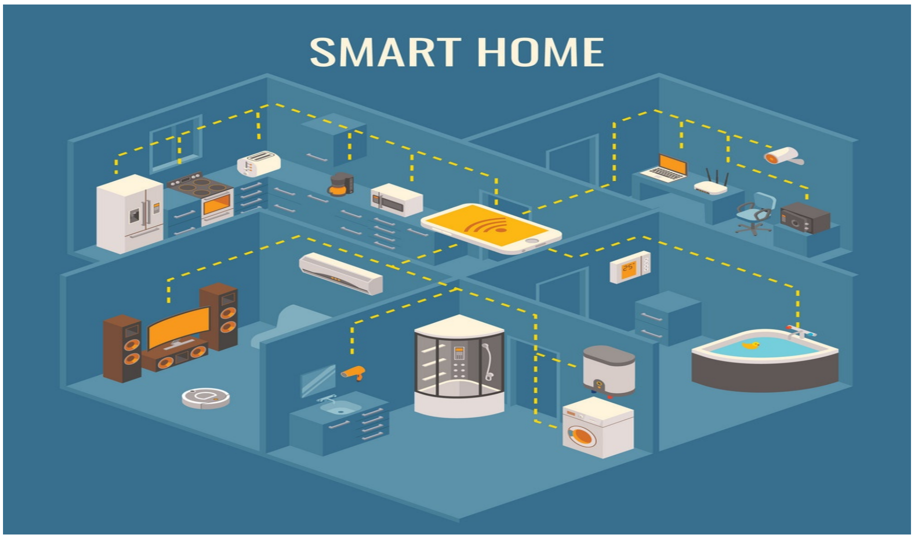

Figure 2.3: Smart Home.

2.3.3 Wearable

Wearable technology is a category of electronic devices that can be worn as accessories, embedded in clothing, implanted in the user's body, or even tattooed on the skin. The devices are hands-free gadgets with practical uses, powered by microprocessors and enhanced with the ability to send and receive data via the Internet [18].

Figure 2.4: Wearable Examples.

2.4 IoT Based Smart Home System

IoT based smart home (IoT SH) refers to a system where all the devices in the house are connected and synchronized. The system that collects information about the user provides an estimate of its behavior and habits. For this reason, the IoT SH system can be characterized as a measurable analytical ecosystem of sensors and actuators designed to automate and control living areas [19].

The IoT based smart home system relies on open platforms that use an intelligent sensor network to provide information about the state of the house. These sensors perform tasks such as power generation andmeasurement, heating/ ventilation/ airconditioning (HVAC) , lighting , security system control [20].

In the coming period, IoT SH applications are likely to become a 'social laboratory' where the behavior and preference patterns of users are transformed into data and examined by various social engineering techniques in order to increase sustainability and economic efficiency [21].

2.4.1 Smart House Advantages

Smart homes offer several advantages over conventional homes [22]:

- **Monitoring**: We should be able to monitor in real time or historical, from any remote location, the house status. A smart house should provide live data and statistics about most of the systems integrated like energy consumption, water consumption, temperature and humidity monitoring, heating system status, security access alerts, proximity scanning and people presence counting.

- **Convenience**: Convenience is one of the biggest reasons that people build and purchase smart homes. These homes give users remote access to systems including heating and cooling systems, intercoms, music and multimedia devices throughout the home. Integrated hard drives allow homeowners to watch video or listen to audio in any room; video intercoms make it easy to communicate with others in the home or visitors at the door. All of these smart home technologies streamline common tasks.

- **Security**: Smart homes include advanced security systems with cameras, motion sensors and a link to the local police station or a private security company. Smart homes may also use key cards or fingerprint identification in place of conventional locks, making it harder for someone to break in.

- **Accessibility**: For elderly or disabled residents, a smart home may feature accessibility technologies. Voice-command systems can do things like control lights, lock doors, operate a telephone or use a computer. Home automation allows an individual to set a schedule for automatic tasks like watering the lawn, removing the need to perform these labor-intensive tasks on a regular basis.

- **Efficiency**: Smart homes offer enhanced energy-efficiency. Lights can shut off automatically when no one is in a room, and the thermostat can be set to let the indoor temperature drop during the day before returning it to a more comfortable level just before residents arrive in the evening. All of these automated tasks, along with modern, energy-efficient appliances, combine to save on electricity, water and natural gas, thereby reducing the strain on natural resources.

- **Resale**: When it comes time to sell a smart home, sellers will have an abundance of effective selling points. Whichever advantage of a smart home appeals to a given buyer, the seller can explain the system and discuss how it makes life easier. Homes with automated systems have the potential to sell for much more than comparable homes with conventional technologies. Automating a home can be a worthwhile investment in increasing its market value and attracting possible buyers in the future.

2.5 Existing Water Quantity Monitoring (Related Works)

There are various studies of water quantity monitoring system such discussed in [23], [24] and [25]. The author in [23] proposed that an IoT based water monitoring system that measures water level in real-time. The modelis based on idea that the water level can be very important parameter when it comes to the flood occurrences especially in disaster prone areas. A water level sensor is used to detect the desired parameter, and if the water level reaches the parameter, the signal will be feed in real time to social network like Twitter.

In the [24] the author proposed that in recent times, tremendous growth of Internet of Things applications is seen in smart homes. The large variety of various IoT applications generally leads to interoperability requirements that need to be fulfilled. Current IoT project is achieved using physical platforms that lack intelligence on decision making. A architecture that implement Event-Condition-Action (ECA) method is proposed to solve the management of heterogeneous IoTs in smart homes. The proactive architecture, developed with a core repository stores persistent data of IoTs schema, proved to be an ideal solution in solving interoperability in smart homes.

However, In [25] the author shown how to monitor the water level of water systems such as water tanks, rivers, ground water table, and bore wells remotely. They also shown that how to control the working of pump automatically and remotely. It can be used to remotely monitor the flood affected areas wirelessly and information can be sent to mobile wirelessly. This system is designed to monitor the level of water with the help of water level sensors.

In our proposal, we have developed a system for real monitoring water quantity using IoT technology. This system monitoring the water quantity in the home tank with a sensor, then sends the information to the phone.

2.6 Conclusion

Currently, Internet of Things (IoT) is being used in different areas of research for monitoring, collecting and analysing data from different locations. Water is a very precious commodity for all human beings as water utilities face a lot of new challenges in real-time operation, these challenges originate because of limited water resources, and growing population, ageing infrastructure etc. Therefore, there is a need for better methodologies to monitor the water quantity in order to ensure the safe supply of drinking water at home and it needs to be monitored in real-time.

In the next chapter, we intend to present the design and development our system for real monitoring water quantity using the IoT environment.

Chapter 3

Proposed Water Quantity Monitoring System

"The way to get started is to quit talking and begin doing."
Walt Disney.
"In order to succeed, we must first believe that we can."
Nikos Kazantzakis.

3.1 Introduction

THE traditional method of water quantity monitoring is not efficient and accurate for calculate quantity of water and give a good results. Evidently, with development of IoT technologies other solutions appear easier and simpler. For this aim, we propose a system that performs water quantity monitoring and regulated water supply operation. We use a sensor (ultrasonic sensor) to calculate the level quantity of water in the reservoir. Then, we study the quantity of water obtained in comparison with daily activity and the number of person at home, after that we display the result to the consumer by an application mobile.

This chapter represents our contribution which contains a system architecture, description of needed tools and the sequences diagrams of all transactions registrations.

3.2 General Conception

Automatic water quantity monitoring system is the process of detecting the level of water in the reservoir, is done without human intervention and is repetitive. This system performs a number of actions called tasks or operations. This section explains the complete block conceptuelle of the proposed system. Also, it presents the detail explanation of each and every block.

3.2.1 System Architecture

The overall block conceptuelle of the proposed system is as shown in Figure 3.1. This proposed diagram consiste a sensor of measurement (ultrasonic sensor) for read a level of water, as well as software and services. The data collected from device are gathered and sent to the Raspberry Pi 3 model B. Then the Raspberry calculate the quantity of water and sent it to application mobile for display and adapted it with profile.

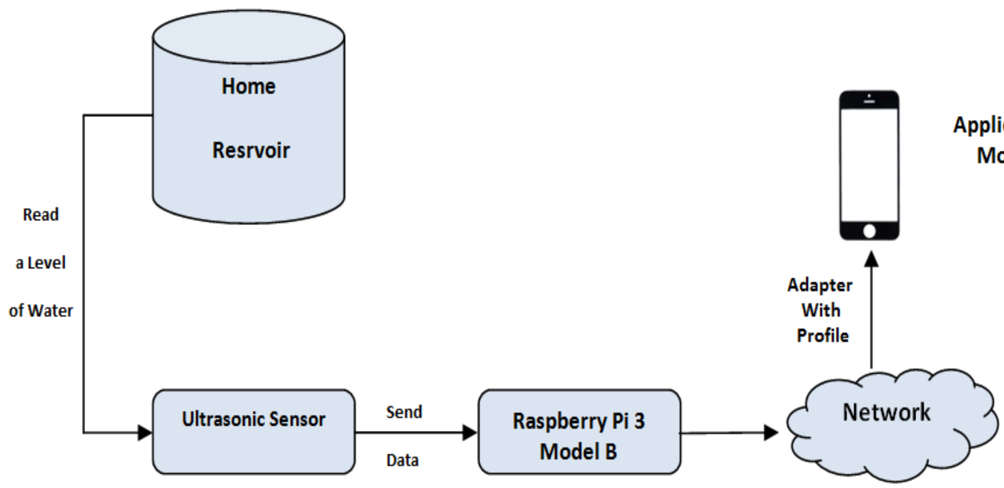

Figure 3.1: System Architecture Of Proposed System.

3.2.2 System Operations

The operation of the water quantity management at the level of the reservoir are managed automatically by our system so as to monitoring and management the quantity of water in reservoir.

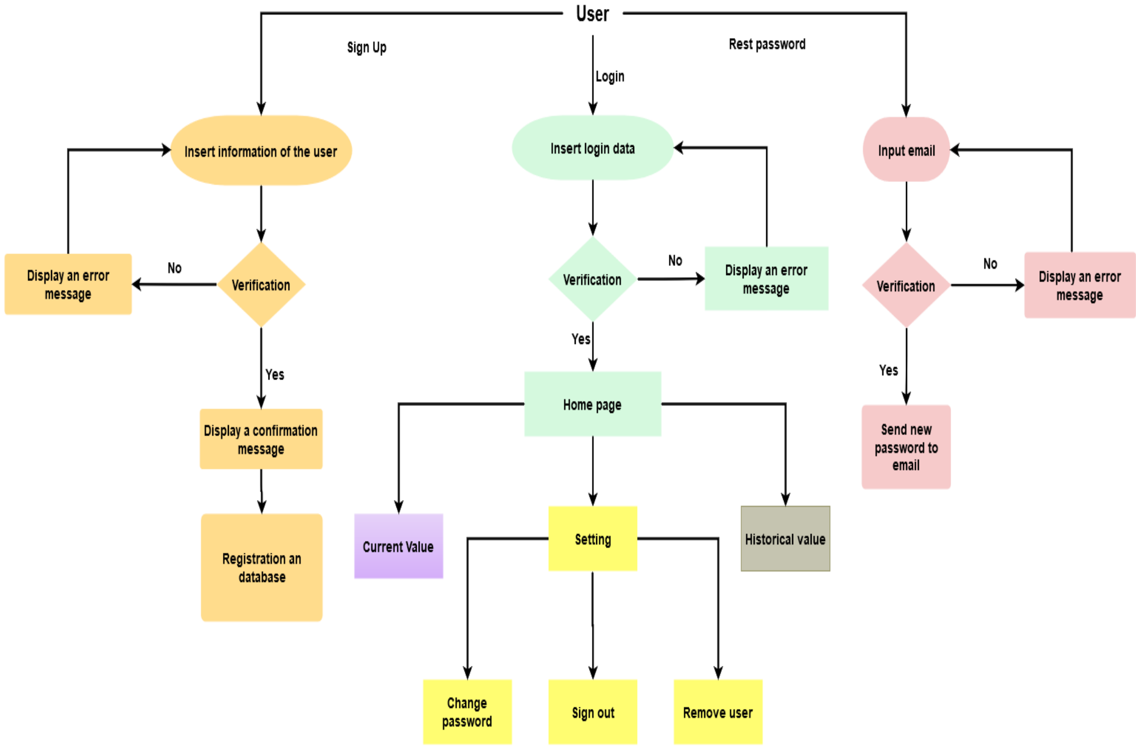

Figure 3.2: Organizational Chart Of System.

1. **Reading sensor data:** We will use specific sensor to measure quantity (See Chapter 4). This sensor are connected to Raspberry which can read the distance between the sensor and the water.

2. **Traitement:** We will calculate the volume of water existing in the reservoir, by the total volume of reservoir and the distance calculated by the sensor.

3. **Sending sensor data to web server:** In this part, we will host a server on Raspberry, where represents the client side which sends sensor data to server.

4. **Display current data:** We use the mobile application to receive data from web server and display water quantity current.

3.3 Detailed Conception

A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved. A use case diagram can identify the different types of users of a system and the different use cases and will often be accompanied by other types of diagrams as well. The use cases are represented by either circles or ellipses. In this section we will describe user interaction with mobile application (See Figure 3.3).

3.3.1 Scenarios Description

- In the beginning, the user is able to access each of registration, log in or reset password. When the user is already have an account, he can:
- Consults water quantity parameters values (current values or historic values).
- Makes changes in his personal account (change the number of people, define the use of water, change password, reset password, remove user and sign out).

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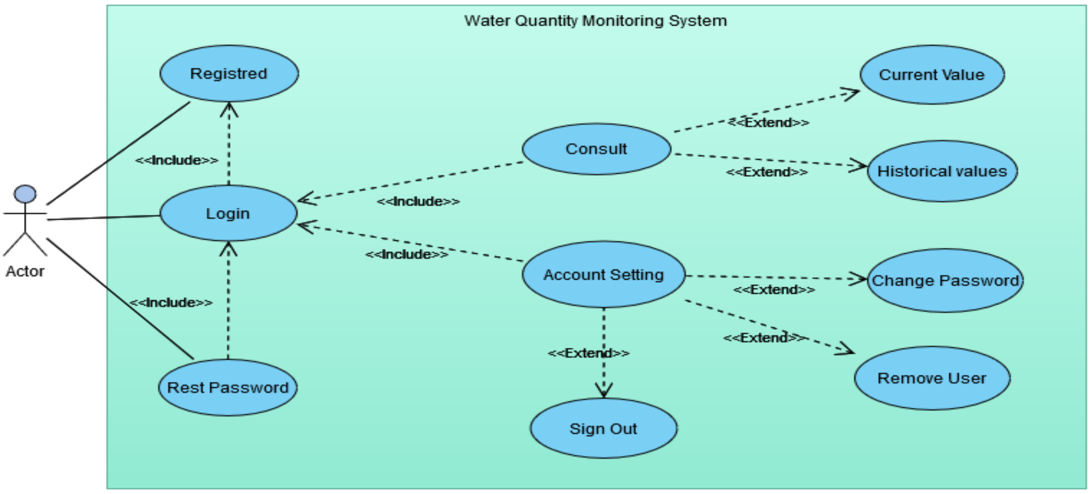

Figure 3.3: Use Case Diagram.

From use case diagram we can see different operations that user can obtain. But, by sequence diagram, we will detail in some of these operations:

3.3.2 Registration Sequence Diagram

- Registration process starts when the user has not an account.
- He types his information in registration user interface.
- Then, mobile application will check the format of these informations (email format and password length).
- Finally, it send them to Database to create a new account.

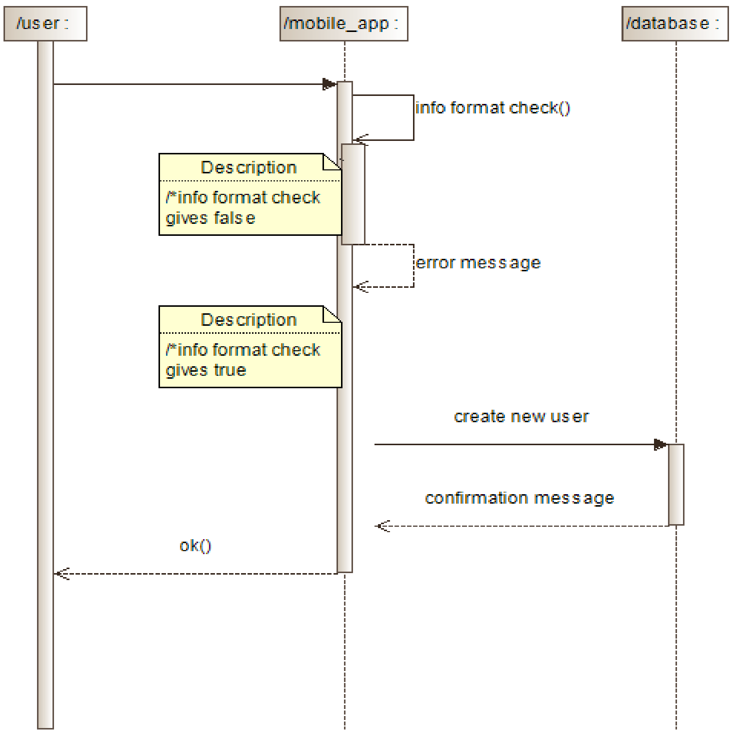

Figure 3.4: Registration Sequence Diagram.

3.3.3 Sequence Diagram of Displaying Data

- Display data process starts when the user has an account.
- The user requests the quantity of water from the raspberry.
- Then, the raspberry send the request to the sensor.
- The sensor measures the distance between it and the water and sends the value to the raspberry.
- Finally, The raspberry calculate the quantity of water and send it to the user via the web page.

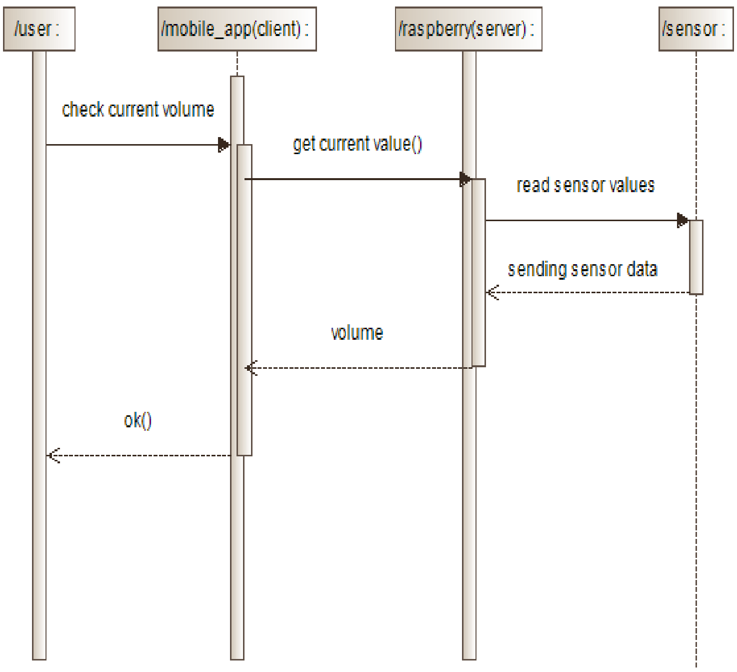

Figure 3.5: Displaying Data Sequence Diagram.

3.4 Conclusion

This chapter focused about proposed monitoring system of monitoring water quantity using corresponding sensors. This system can monitor water quantity, and does not require people on duty. Hence, the water quantity monitoring will be more accurate, convenient and very fast. Our system has good flexibility by contacting the corresponding sensor and changing the data between the raspberry Pi and the application mobile.

The implementation and testing of our system will be displayed in the last chapter.

Chapter 4

Implementation and Results

"Pessimists, we're told, look at a glass containing 50% air and 50% water and see it as half empty. Optimists, in contrast, see it as half full. Engineers, of course, understand the glass is twice as big as it needs to be."
Bob Lewis

4.1 Introduction

IN this chapter, the focus is on experimentations studiens and evaluation of system. The implementation of our system makes it possible to evaluate the results obtained. This evaluations is performed using a set of tests. The tests make it possible to estimate the quantity of water obtained.

The rest of this chapter is includes a description hardware and software needs. In addition, the defferents mobile applications interfaces relased. In addition, it presents the different interfaces of mobile applications realized.

4.2 Implementation

4.2.1 Hardware Description

All the experiments are performed on a Hp 255 laptop with 1.4GHz AMD E1-6015 APU (R2) processor and 4GB 1600 MHz DDR3 RAM. However, the material used for the realization our system are following:

4.2.1.1 Raspberry Pi3 Model B

The Raspberry Pi3 Model B[1] is a wonderful platform that can be used to build automation systems. Clearly, the Raspberry Pi3 model B board is perfect when being used as a "hub" for automation systems, connecting to other open-source hardware parts like sensors. Raspberry Pi3 Model B is a small sized single board computer which is capable of doing the entire job that an average desktop computer does like Spreadsheets, Word processing, Internet, Programming, Games etc.

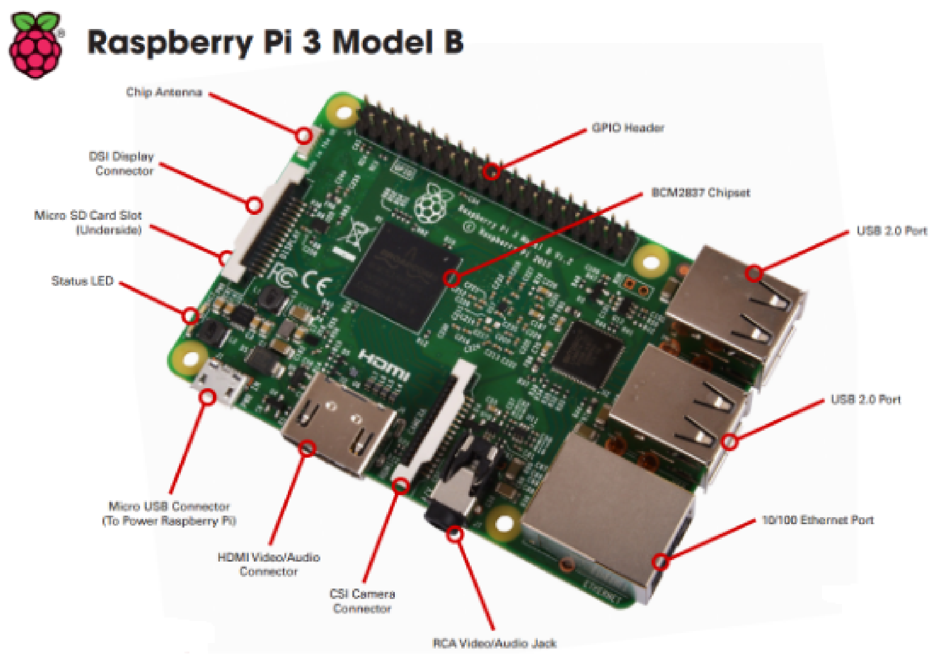

Figure 4.1: Raspberry Pi Model B.

[1] https://www.raspberrypi.org/

Specification: Raspberry Pi3 Model B Built on the latest Broadcom 2837 ARM v8 64 bit processor. The new generation Raspberry Pi3 Model B is faster and more powerful than its predecessors. With built-in wireless and Bluetooth connectivity, it becomes the ideal IoT ready solution. It consists of 1.2 GHz QUAD Core Broadcom, 1 GB RAM, 4x USB 2 ports, 40 pin extended GPIO, HDMI and RCA video output. It does not have any internal memory other than the ROM. It has an SD card slot which is capable of reading up to 32 GB. The GPIO pins of the raspberry Pi3 Model B are programmed using Python programming language. The I/O devices like sensors are givento GPIO pins whenever needed.

Software installation: Raspberry Pi3 Model B runs on Linux kernel based operating systems. It boots and runs from the SD card. Beginners should start with the NOOBS (New Out Of Box Software) operating system installation manager, which gives the user a choice of operating system from the standard distributions. SD cards with NOOBS pre-installed should be available from any of our global distributors and resellers. Alternatively, you can download NOOBS. Raspbian is the recommended operating system for normal use on a Raspberry Pi.

Accessories: There are a wide variety of accessories for the Raspberry Pi which we need them in our project (See Figure 4.2).

Figure 4.2: Raspberry Accessories.

4.2.1.2 Ultrasonic Sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target).

In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver. The formula for this calculation is D = ½ T x C (where D is the distance, T is the time, and C is the speed of sound 343 meters/second). For example, if a scientist set up an ultrasonic sensor aimed at a box and it took 0.025 seconds for the sound to bounce back, the distance between the ultrasonic sensor and the box would be: D = 0.5 x 0.025 x 343

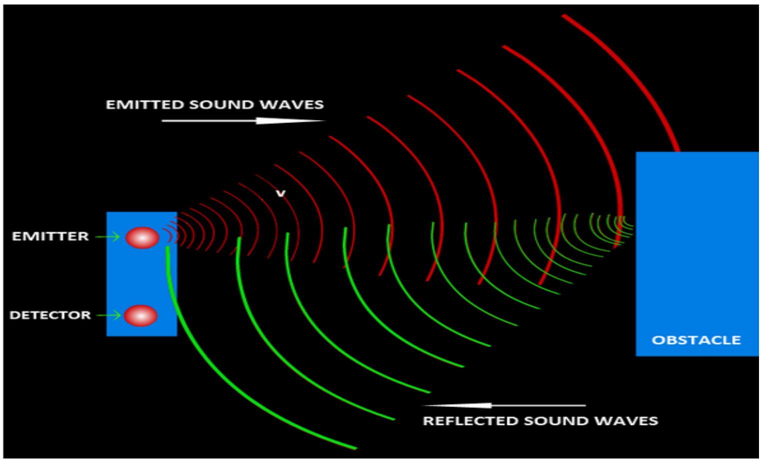

Figure 4.3: Ultrasonic sensor.

Really, Ultrasonic sensors are used primarily as proximity sensors. They can be found in automobile self-parking technology and anti-collision safety systems. Ultrasonic sensors are also used in robotic obstacle detection systems, as well as manufacturing technology. In comparison to infrared (IR) sensors in proximity sensing applications, ultrasonic sensors are not as susceptible to interference of smoke, gas, and other airborne particles (though the physical components are still affected by variables such as heat).

Ultrasonic sensors are also used as level sensors to detect, monitor, and regulate liquid levels in closed containers (such as vats in chemical factories). Most notably, ultrasonic technology has enabled the medical industry to produce images of internal organs, identify tumors[26].

4.2.2 Hardware Complementary

Below is the list of items complementary we will need to get through our project:

- **General Purpose Input/Output (GPIO:** one powerful feature of the Raspberry Pi3 Model B is the row of GPIO pins along the edge of the board (See Figure 4.4.

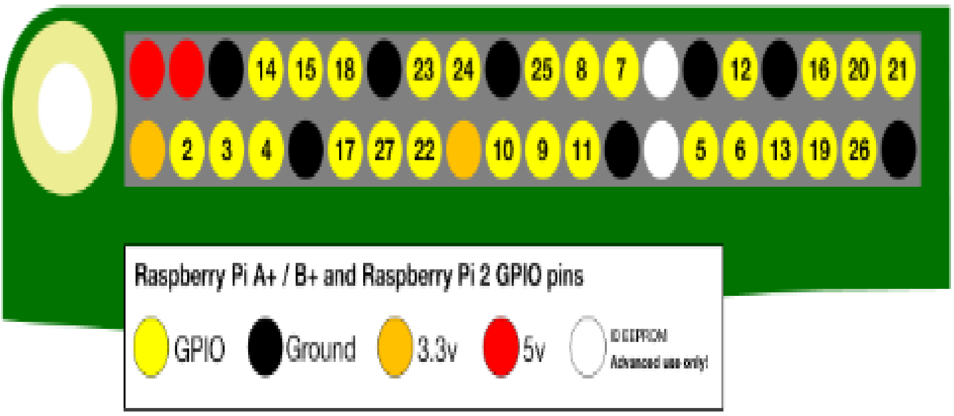

Figure 4.4: GPIO pins.

The voltages of GPIO is: two 5V pins and two 3V3 pins are present on the board, as well as a number of ground pins (0V), which are unconfigurable. The remaining pins are all general purpose 3V3 pins, meaning outputs are set to 3V3 and inputs are 3V3-tolerant.

The outputs of GPIO pin designated as an output pin can be set to high (3V3) or low (0V). However, its inputs designated as an input pin can be read as high (3V3) or low (0V). The program can be written on the pins to interact in amazing ways with the real world. Inputs don't have to come from a physical switch; it could be from a sensor or a signal from another computer or device.

For example,the output can do anything, from turning on an LED to sending a signal or data to another device. If the Raspberry Pi3B is on a network, you can control devices that are attached to it from anywhere and those devices can send data back. Connectivity and control of physical devices over the internet is a powerful and exciting thing, and the Raspberry Pi3 model B is ideal for this [27].

- **Power Supply:** the Raspberry needs a power source in order for it to operate and can be powered in a variety of ways. We can connect the board directly to your computer via a USB cable. If we want our project to be mobile, we using a 9V battery pack (See Figure 4.5).

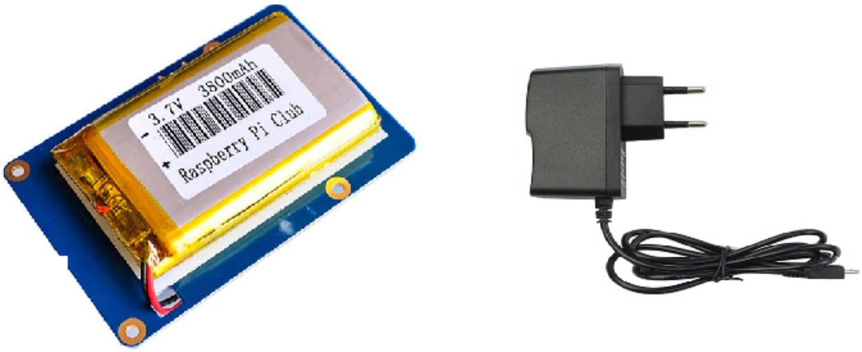

Figure 4.5: Raspberry Pi 3 Power Supply.

- **Breadboard:** very important item when working with Raspberry is a solderless breadboard (See Figure 4.6). This device allows you to prototype your Arduino project without having to permanently solder the circuit together. Using a breadboard allows you to create temporary prototypes and experiment with different circuit designs. Inside the holes (tie points) of the plastic housing, are metal clips which are connected to each other by strips of conductive material

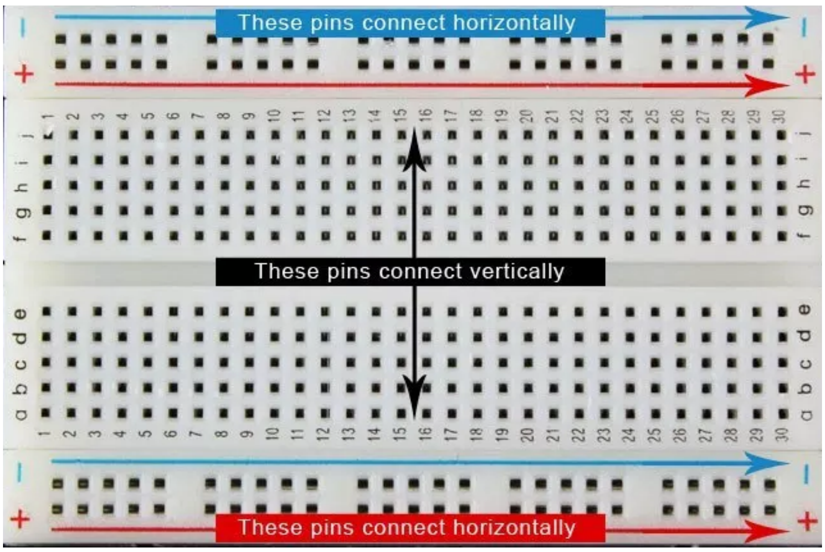

Figure 4.6: Breadboard.

- **Jumper Wires:** practically, the breadboard is not powered on its own and needs power brought to it from the Rasbpeery board using jumper wires (See Figur 4.7). These wires are also used to form the circuit by connecting resistors, switches, sensors, and other components together.

Figure 4.7: Jumper Wires.

- **Resistors Circuit:** we use the resistors as electronic components which have a specific, never-changing electrical resistance in order to protect the circuit and sensors. In our dissertation we use two resistors 1k and 2k.

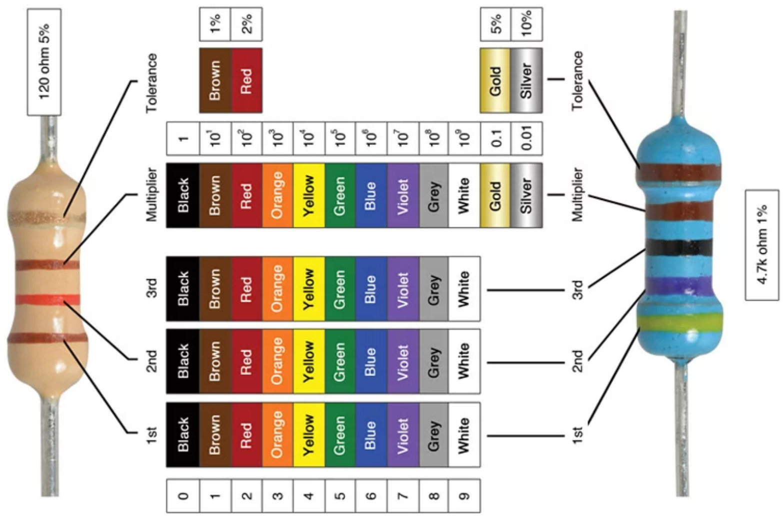

Figure 4.8: Resistors Circuit.

4.2.3 Software Description

During the implementation of our project, we need two different kind of software. First, we have utilized certain open source programming languages. Secondly, we developed some applications by software IDE.

4.2.3.1 Programing Language

- **Python[2]:** is a high-level programming language designed to be easy to read and simple to implement [28]. Raspberry Pi3 Model B and the Web server code are written in Python languge.
- **SQLite[3]:** SQLite is a relational database management system contained in a C programming library. SQLite database files are commonly used as containers to transfer rich content between systems and as a long-term archival format for data [29].
- **HTML[4]:** Stands for "Hypertext Markup Language". HTML is the language used to create webpages. "Hypertext" refers to the hyperlinks that an HTML page may contain. "Markup language" refers to the way tags are used to define the page layout and elements within the page [30]. The web server is implemented using HTML and SQLite.
- **Java[5]:** Java is a high-level programming language developed by Sun Microsystems. It was originally designed for developing programs for set-top boxes and handheld devices, but later became a popular choice for creating web applications [31]. The mobile application requires both Java and XML laguages.
- **XML[6]:** Stands for "Extensible Markup Language". XML is used to define documents with a standard format that can be read by any XML-compatible application [32]. We use the XML language to describe items that may be accessed when a Web page loads. It allows as to create a database of information without having an actual database.

[2]https://www.python.org/
[3]https://www.sqlite.org/index.html
[4]https://www.w3.org/html/
[5]https://www.java.com/fr/download/
[6]https://www.w3.org/XML/

4.2.3.2 Softwares IDE

- **Pycharm[7]:** The PyCharm development platform is easy-to-use and helps you quickly create embedded programs that work. The PyCharm editor and debugger are integrated in a single application that provides a seamless embedded project development environment. We used it for the implementation of our web server for different reasons such as it make facilities, source code editing, program debugging, and complete simulation in one powerful environment.

Figure 4.9: Logo of PyCharm.

- **Eclipse[8]:** Eclipse is the integrated development environment (IDE) for Android application development. It is based on the Java integrated development environment for software, and incorporates its code editing and developer tools [33]. We used this IDE softwer to develop our part of mobile application.

Figure 4.10: Logo of Eclipse for Android Developers.

[7] `https://www.jetbrains.com/pycharm/`

[8] `https://www.eclipse.org/downloads/packages/release/neon/m6/eclipse-android-developers`

4.2.4 Web Server Processes

4.2.4.1 Displaying Real Data

We will introduce some Gauges to present actual quantity value on a better way by using JustGage on our html/css files that allows us to generate and animate nice and clean gauges. If sensors does not give values no-sensor.html page will be displayed.

Figure 4.11: No Sensor Web Page.

However, if not current.html page will be displayed.

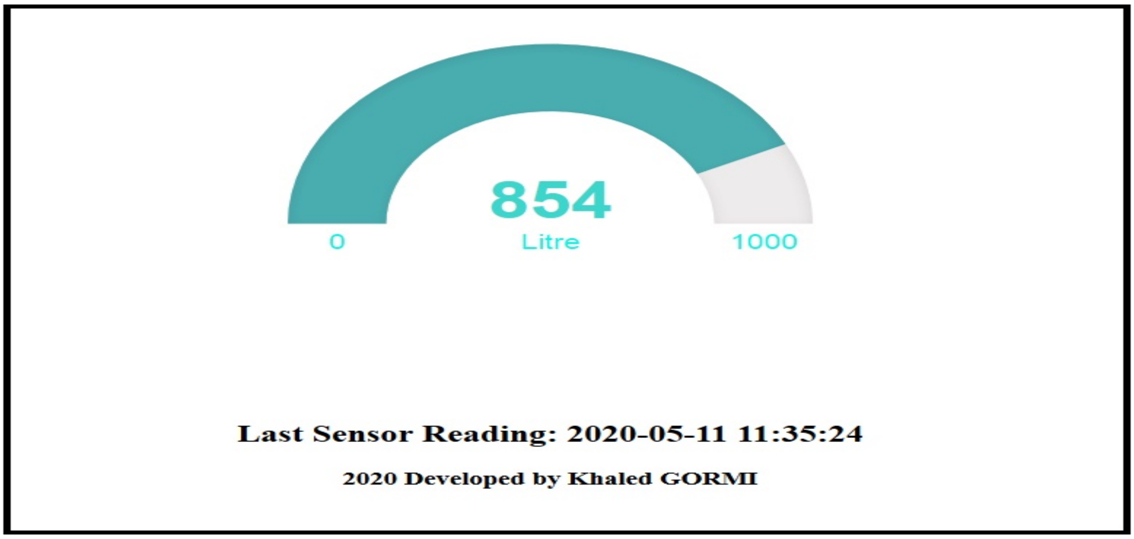

Figure 4.12: Current Sensor Values Web Page.

For more comprehension, we use colors where each color distinguishes a condition. For example orange when you can do all activities and rest less than 15% of water, Green when you can do all activities comfortably, Red you can do all that and rest 0%, Yellow you can do without some activities.

4.2.4.2 Displaying Historical Data

In order to log ultrasonic sensors measured data on the database, we created one table (a database can contain several tables). Our table named “quantity” it have 3 columns, where we will log our collected data: time(date and hour), quantity value and an identifier for table.

We have build our graphics based on historical data, sending as a input parameter the period that we want to analyse it to be retrieved from our database.

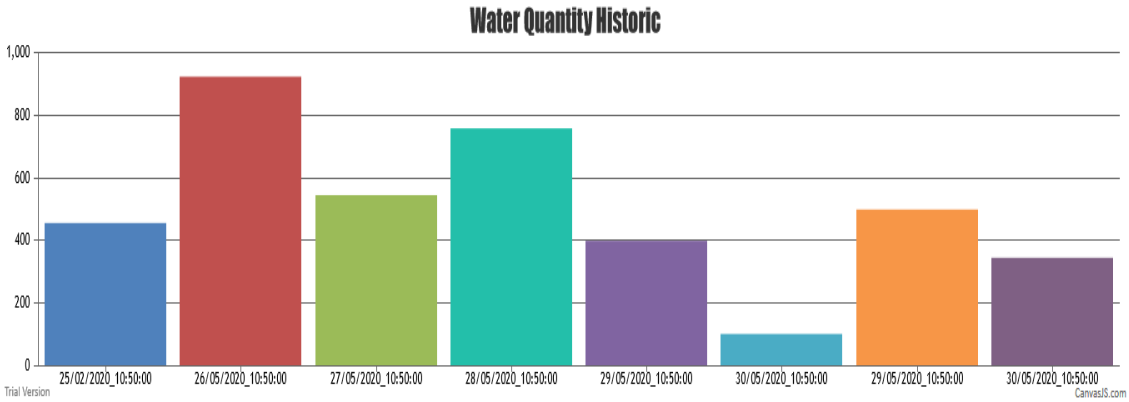

Figure 4.13: Historical Sensor Values Web Page.

4.2.5 Mobile Application Interfaces

4.2.5.1 Login Interface

The user login to application using an email and a password. An interface login offers the ability to user, view status and check personal.

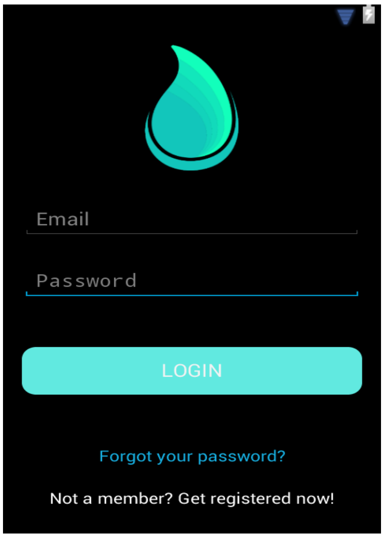

Figure 4.14: Login Interface.

4.2.5.2 Registration Interface

We're looking for the key information you'll need to sign in to account and access the other benefits of interface account.

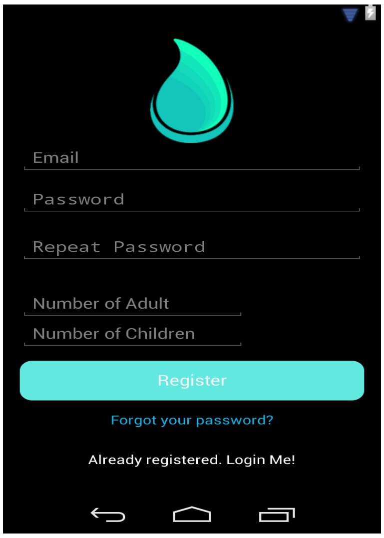

Figure 4.15: Registration Interface.

4.2.5.3 Reset Password Interface

In case of forgot password, the user is able to reset his password by receiving mail to get new password.

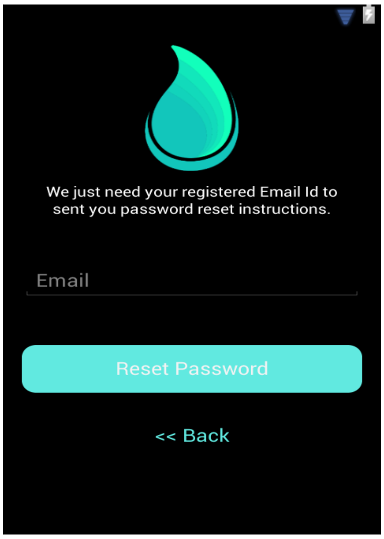

Figure 4.16: Reset Password Interface.

4.2.5.4 Account Setting Interface

In this interface, we have all account operations of changing password, remove user, and sign out.

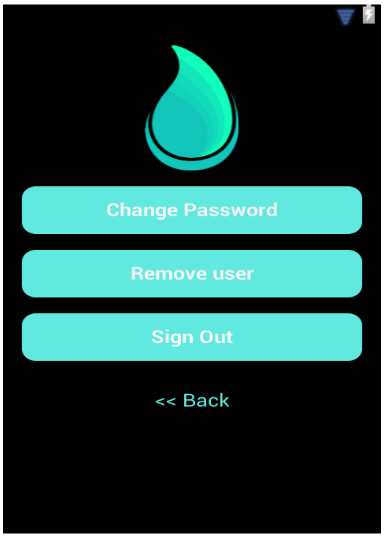

Figure 4.17: Account Setting Interface.

4.2.5.5 Daily Profile Interface

In this interface, we have a daily activity, and number of person.

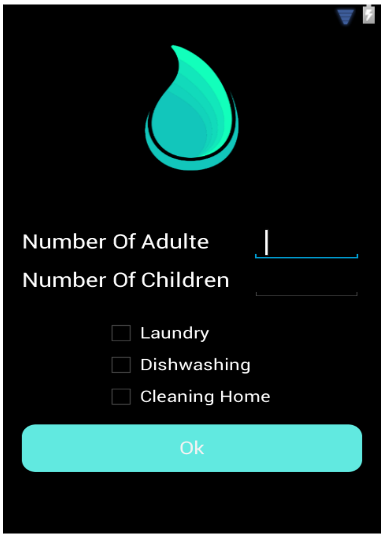

Figure 4.18: Daily Profile Interface.

4.2.5.6 Home Interface

This interface is the main one, it contains three fields, two of them are to displaying current and historical data, and one for account setting.

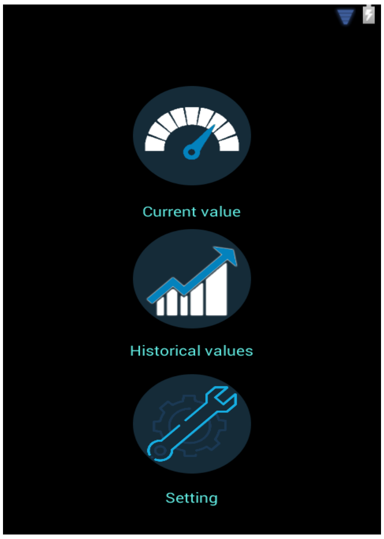

Figure 4.19: Home Interface.

4.3 Results and Discussions

4.3.1 Work Environment

As shown in the past Chapter 3, our project environment contains both of raspberry, sensor, computer and other accessories. We make connection between

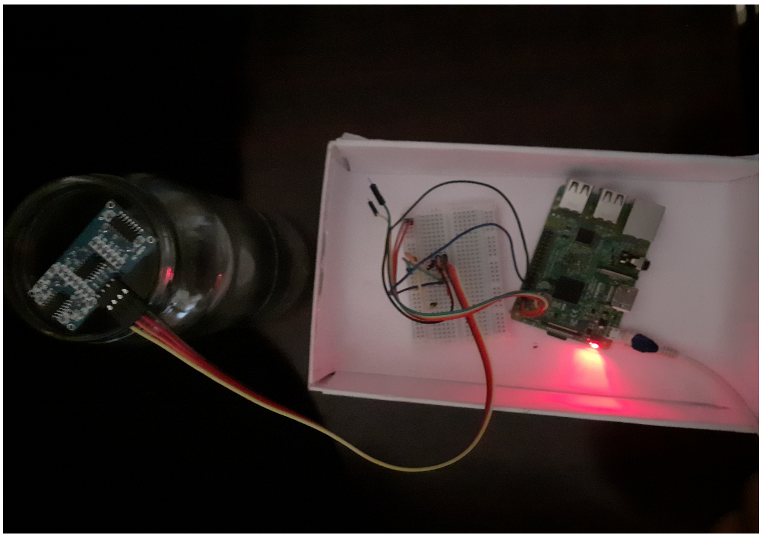

Figure 4.20: Work Environment.

Raspberry and computer using MobaXterm which is install on windows to access Raspberry Desktop.

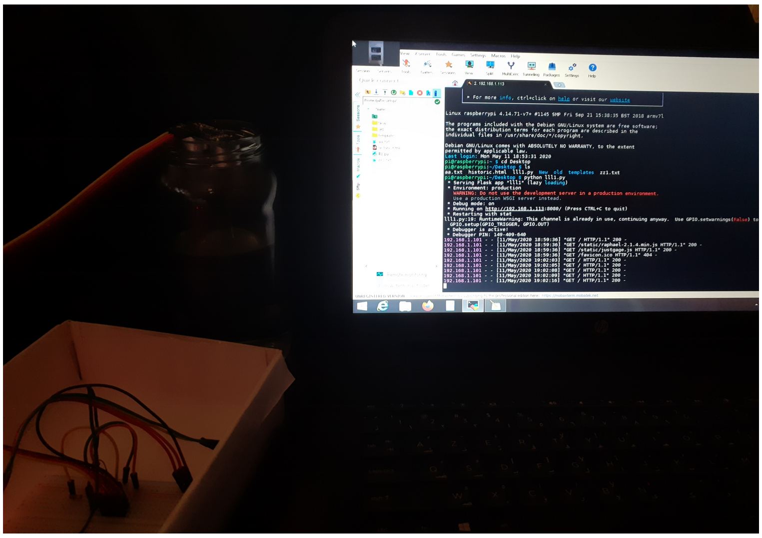

Figure 4.21: Read Sensor Data Using MobaXterm.

4.3.2 Calculate the volume

We tested our system and checked that it worked well, as we filled the reservoir and calculated the volume and the results were good.

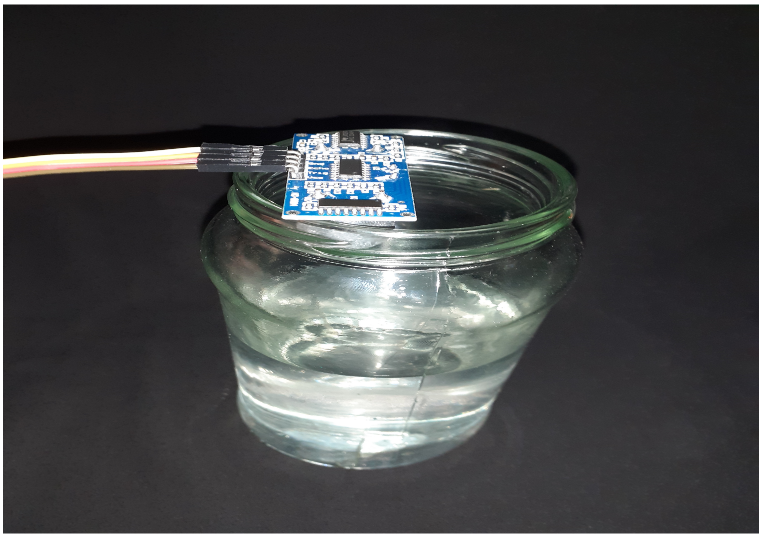

Figure 4.22: Volume Calculat.

The next figure display the current measured value of water quantity.

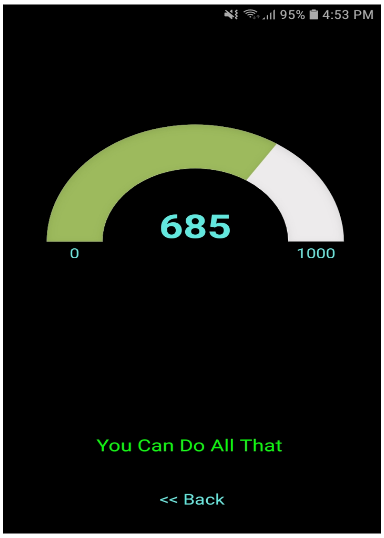

Figure 4.23: Display Current Volume.

4.4 Conclusion

This project aims to develop a system to monitoring and management the water quantity in home based on IoT . The developed system was successfully calcul and management. Hence, it updating in web page quantity of water, then it notify user if amount of a water sufficient for use or not.

This chapter presened real time monitoring system of water quantity in an loT environment. For this aim, we based in the concept of smart home and we use a sensor for measuring quantity of water which are citted in the pervious chapter. In short, the ultrasonic simply measures the amount of light coming from the light sender to the light receiver and calculates the distance.

Overall. The system developed offers fast and easy monitoring of water quantity.

General Conclusion

"When you are stuck in a traffic jam with a Porsche, all you do is burn more gas in idle. Scalability is about building wider roads, not about building faster cars."
Steve Swartz
"If people never did silly things, nothing intelligent would ever get done."
Ludwig Wittgenstein

WATER is one of the essential parts of life. And currently water is very prized for all the humans. One of the daily problems is the inability to calculate the amount and management of water in the home reservoir. So its too important to find the solution for water quantity monitoring and management. For this probleme of water quantity monitoring, we thought the design of a simple monitoring system capable of monitoring and management a water. The objective of this water quantity monitoring system using internet of things is to monitoring the water quantity and show it to users. We are going to implement this project at home water reservoir for that we are using an Raspberry board for measure value water. Then, we use a mobile application to have display the current quantity of water. Finally the user get a notification about water quantity. Overall, the system developed offers fast and easy monitoring of water quantity.

As prospects for our work, we propose to improve it by future work in order to obtain more efficient result. These future works are as follows:

- Add GSM network connection option.
- Use more sensors (flow sensor, temperature sensor).
- Build a soft and simple tool from this project.

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