International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol. 9, Issue.11, November 2021 E-ISSN: 2347-2693

Development of an IoT-Based Smart Home Water Leak Detection System

A. Q Mohabuth[1*], T. Pal[2], M. Sobrun[3]

[1]Department of Software and Information Systems, University of Mauritius, Reduit, Mauritius
[2,3]SD Worx (Mauritius) Limited, Nex Tower, Ebene, Mauritius

[*]*Corresponding Author: a.mohabuth@uom.ac.mu, Tel.: +230-4037642*

DOI: https://doi.org/10.26438/ijcse/v9i11.15 | Available online at: www.ijcseonline.org

Received: 03/Nov/2021, Accepted: 13/Nov/2021, Published: 30/Nov/2021

***Abstract*—** Water is a precious commodity and should not be wasted. It has always been a challenging issue worldwide to prevent wastage of potable water. Inspecting the entire water pipeline system of a house each time to find a leak or issue can be time consuming and costly if water is being wasted for a long period of time. People like to complete their daily household chores without any delay and find it frustrating when their work is halted because of unavailability of water arising from damages in their home water piping system. It is always a headache when there is leakage in the pipe systems at home. People may be away from their home, at work or on vacations. Pipe bursting goes unnoticed and resulted in consequent damages. Smart system can surely be helpful in preventing those unwanted surprises. This paper presents an implementation of a smart home water protection system that proves to be beneficial in saving up water, money and time. The smart system notifies the user about damages in home water pipeline systems while simultaneously taking measures to prevent further losses. Warning messages are issued to people thus keeping them informed about the problematic state of their water pipeline system. Alternatively, the smart system can take actions automatically to temporarily remediate the problem or allow the house owner to do otherwise. The system provides the user with a simple yet intuitive interface where information about the condition of the water pipeline system is in a conclusive way.

***Keywords*—** leakage, pipeline, pump, smart technology, water-flow

I. INTRODUCTION

Campaigns are being carried out in many countries around the world to sensitize people about the importance of water and actions are being taken to preserve it. Apart from drinking, almost all our daily chores require the use of water. Water obviously run when opening taps and this is being taken up for granted. Not until that there is draught and there is enforcement of restriction to the water supply that people realise the importance of savings up water. It is a commodity that not every individual unfortunately has access to. Pipeline system runs into home that facilitates the distribution of water to the entire house and leakage is certainly a risk. It is important to keep the home water pipeline system monitored to prevent water loss where possible. Detection of leakage has always been a challenging issue for plumbers who managed to get through by using their experience. Nowadays, technologies can be used to bring improvement to water pipeline systems. IoT can be a means to achieve the desired system. Computing devices such as microcontrollers, sensors amongst others work together in a holistic manner to make a system smart. In simple words, IoT has the ability to orient normal systems towards the Internet where different components can interact with each other over a network with the aim to mitigate the interaction between humans or between human and computer to solve problems quicker. Therefore, detecting and reporting of irregular behaviours can be done more efficiently, saving up water and time. Usually, a leak in a person's home water pipeline system is detected only after a significant amount of water has been lost or after complete breakdown of the water pipe. Many factors can cause a water pipe to break such as prolonged water leakages, pipes becoming old amongst others. Furthermore, the higher the water pressure, the more water is wasted and the higher the risk of causing damage to other parts of the water pipeline system. Leaks and other similar damages in a home water distribution system often occur in places which are difficult to have access to or where people are unable to notice them. People must go around their house and carefully examine each water pipe one by one to find the root of the problem. Moreover, the service provider at time cuts water supply region-wise for an interval of time as a preventive measure to preserve water, especially during dry seasons. During that time, a person might forget to close the tap after using it. The person may be away when the water supply is resumed and water keep running which resulted in heavy bills. The proposed system eventually present solutions to these problems by creating an IOT system which incorporates Cloud technology that monitors a home water pipeline system and notifies an individual about leakages in water pipes. The system also take actions on behalf of the user in case of delayed response to the problem while giving the latter the possibility to decline any automatic action.

II. RELATED WORK

IoT is among the most successful and constructive wireless communication models [1]. IoT technologies can monitor various objects and environmental situations such as smart water meter, organisms, moisture, and chemical contents [2]. In water management, a lot of IoT sensors are available to monitor specific values for water quality, water-Flow rate, pressure, and temperature. Due to a decrease in the price and size of these small devices along with its cleverness in different situations keep increasing, this has made IoT applications more feasible. The implementation of IoT in water management can help in saving millions of gallons of water in residential areas and also can ascertain when, where, and how much water is needed in many different fields such as for irrigation purposes and help in making users more aware of the usage of water and help reducing wastage alongside. IoT based smart system that includes watering features can be remotely operated using smart devices such as tablets, phone and PCs [3]. Arduino which is an open-source electronic prototyping platform enables users to create interactive electronic objects and particularly found to be useful in developing water protection system. Arduino is comprised of two parts: the Arduino circuit board and the IDE for issuing commands to the board via a USB cable, which are the respective hardware and software parts [4]. The use of Arduino board with appropriate sensor connection is effective for monitoring environmental conditions which may include temperature, pressure, water and humidity [5]. In fact, sensors may be connected to the Arduino circuit board to detect leak. An acoustic sensor may send an acoustic sound pulse in the direction of a target, which is reflected back to the sensor and the nearer the sensor is to the targeted water leak, the stronger the signal received by the sensor [6]. Furthermore, hydrophones, which are acoustic sensors, are used for the detection of underwater sound signals and may also be used for locating leakages through water leak noises [7]. In addition, to interface with mobile devices, the General Radio Packet Service (GPRS) module can be used to transmit sensor data from the microcontroller to a Cloud-based server wirelessly and uses the radio waves of the mobile network to provide easy Internet access [8]. The module can be set up to connect to the Internet by means of a power supply and SIM card along with AT commands to configure the network since it has an inbuilt TCP/IP protocol. The GPRS module can be used to send commands to a microcontroller in the form of SMS to open or close the smart valves considering the severity of problem encountered [9]. This is a good option to provide control over the smart water system while being offline since the system can also send an SMS to the owner using GSM acting like an alarm to notify any issue in the pipelines. A water detection system was proposed that comprises of three options to choose from which are: Water leak detection rope, water leak cable and spot sensor. The detection cable or rope has up to 225 meters spot coverage ability and is placed in areas prone to leakages while the spot sensor which is used for detecting dripping water, is best positioned directly below the leaking equipment. A web interface is provided to keep track of multiple leaks simultaneously through diagnostics displayed using sensor graphing, that is, graphical representation of data collected by sensors. However, the control need to rely on a heavy centralized infrastructure in the cloud which is costly. More recently, a system to proactively monitor home water pipeline systems was developed [10]. The technology uses temperature, water flow and pressure sensors to monitor and detect leaks with emphasis on pressure sensing. Processing of data is then done on cloud and these sensors are combined with a smart water valve which is configured with algorithms to make all the components work in harmony for water leak detection. The system's equipment is compatible with pipes having diameters of 0.75 inch to 1.5 inches. A standard power supply is used to support the system and it has a 24/7 operation ability. The smart valve used can be remotely opened or shut off from any part of the world provided that the user is connected to the Internet and can also be automatically controlled by the system if needs be. The technology however is still under evaluation, though it is found to be promising some users reported its complexity in terms of the setting infrastructure. The proposed system rather looked at the features of usability and comes with an application which can be easily installed on an android smartphone allowing the user to control the valves, view the home's real-time water usage statistics, alert the user about anomalies or contact a plumber in case of leak catastrophes and since water usage patterns are also learned, the system also promote efficient consumption of water at home.

III. METHODOLOGY

To implement the proposed system, NodeMCU is the chosen microcontroller on which connect all the sensors will be connected. It has Wi-Fi built-in and is found to be much more powerful than Arduino Uno at nearly the same price. Arduino IDE which supports a wide range of microcontrollers. Is considered as it has a high compatibility rate when dealing with NodeMCU. Android Studio has been chosen over Xamarin as it has a much more robust community support and produces rich and high quality applications. The system is developed using a sequential process as it involves interaction of both software and hardware components. The system is designed to monitor the Water-pipeline of the house on a 24/7 basis and notify the user when needed. User friendliness and ease of use are taken into account in the design process. The system should be able to adapt to various water-flow conditions such as when the water-flow become high or low. It should also be operable on an offline basis where the user can control the system via SMS messages. This resulted in the following architecture as detailed in Figure 1.

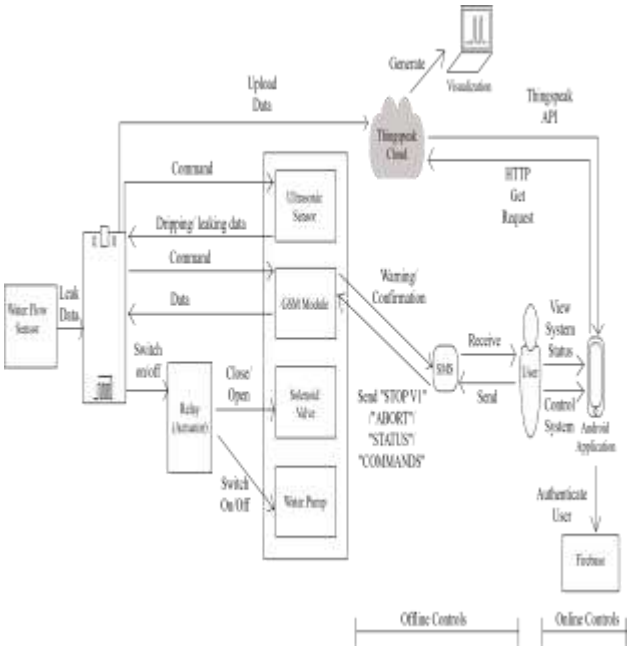

Figure 1. System architecture

A pipeline circuit model is designed based on the architecture. A non-returning valve is used to restrict water from flowing backward and taps are used to simulate the leaks along with appropriate fittings. Furthermore, an ultrasonic sensor is used to detect for small leaks in the system such as dripping issues even if the water-flow sensors cannot detect it. Both the pump and the ultrasonic sensor will be fixed inside the water tank. Figure 2 shows the circuit design.

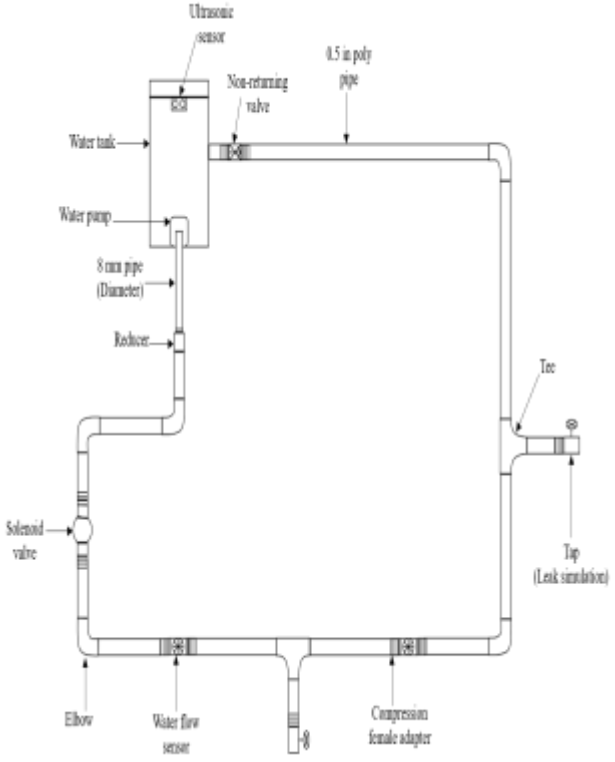

Figure 2. Pipeline circuit model

IV. RESULTS AND DISCUSSION

ThingSpeak is considered to interface with the cloud environment since it is well integrated with hardware devices like Arduino and is recognized as the only open data platform designed precisely for IoT in the cloud [11]. The API simplifies the visualization of data collected by means of spline charts, improving the visual appeal and ease of examination of data in comparison to other open source APIs. Furthermore, ThingSpeak uses a web application and server called Phusion Passenger Enterprise which allows the API to support powerful programming languages like Python, Ruby and Node.js, normally used to implement good functionalities [12]. ThingSpeak offers private channels to upload data as well as public channels enabling users to examine projects from other people with the main benefit being the free hosting provided for the data channels. This resulted in the design of the following android architecture as shown in Figure 3.

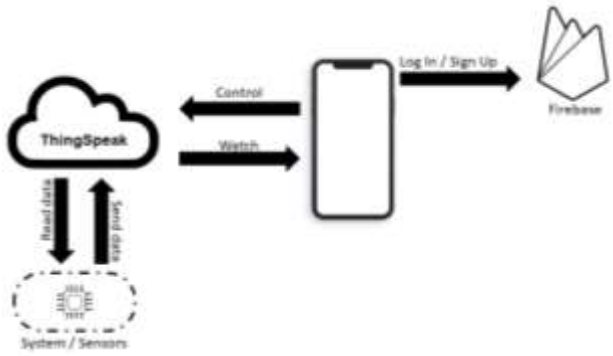

Figure 3. Android Architecture

IV. RESULTS AND DISCUSSION

The Arduino IDE is installed and a link to download the drivers and tools to program nodeMCU had to be placed in the preferences tab in Arduino-IDE and a package was installed from the board-manager prompt afterwards. The GSM module was set up by using a library named "SIM908IDE100" which had to be downloaded and placed in the Arduino-IDE's library folder. ThingSpeak was set up by creating an account and three new channels are set up namely sensors, pump and solenoid valve 1. Each channel has fields on which the data will be sent. After creating the channels and fields, the Read and Write API-Keys provided by ThingSpeak are used to program the nodeMCU to use Wi-Fi and update the channels. The GMS module is connected to the nodeMCU as shown in Figure 4. D7 and D8 pins allows the exchange of data between the NodeMCU and the module through the UART1 serial communication. The Module is programmed to initiate communication with the nodeMCU on serial baud rate 2400 because it cannot process fast enough to cope with higher baud rates. The GSM module is then used to send SMS notifications to the user whenever there is a leak or automatic action taken and to receive SMS to control the system using specific commands as listed in Table 1.

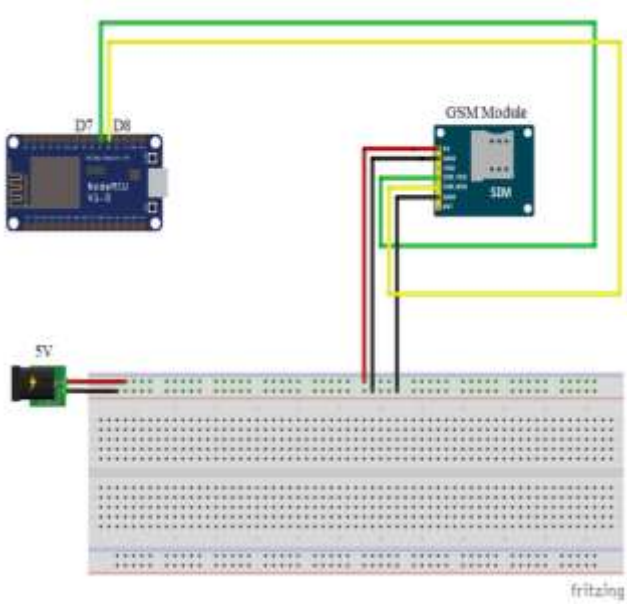

Figure 4. GSM connection to NodeMCU

Table 1. Instructions

Items	Description
STOP V1	Stops water system.
STATUS	Provides real-time readings of the sensors.
COMMANDS	Provides list of commands.
ABORT	Returns system to initial state.

The 5V power source is used to power up two water-flow sensors and the signal cables from each water-flow sensors are connected to the nodeMCU. The wire connection sends the readings to the nodeMCU as INPUT using pinMode function. The readings of the sensors are computed to get the water-flow rate of each one. The flow rates are then compared to determine if there is water leakage.

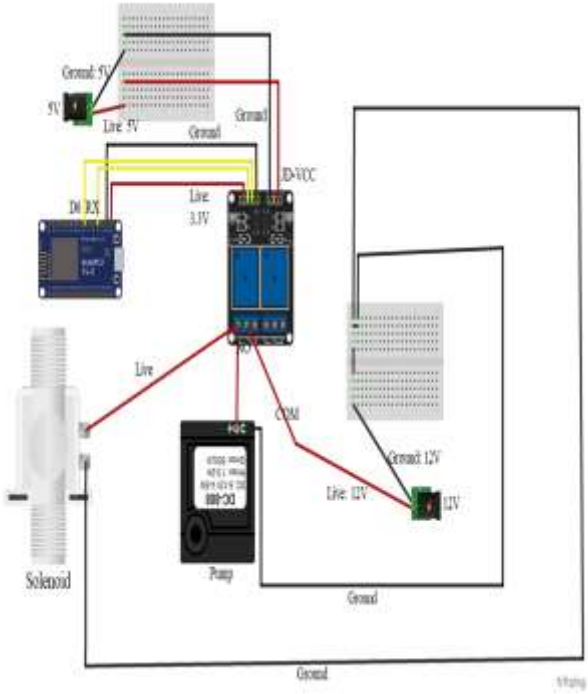

Figure 5. Pump connection to nodeMCU

Pump is then connected to the nodeMCU as shown in Figure 5. A relay is used to control the pump accordingly when the user wants to turn on or off the system. The pump's live wire is connected to the Normally Open (NO) port of the relay and the ground wire to the 12V power source's ground. To power up the relay, pins are connected to the 5V power source cables. The solenoid-valve1 is attached to the Normally Open (NO) port of the relay. The 12V live wire from the power source is connected to the relay's COM port where when the relay is set to HIGH with the signal cable, the solenoid turns on and allows the water to flow in the pipeline. When the pump is turned off, the solenoid has to turn off as well, as both components should work together. The system is thus assembled, and the automatic action is programmed. If the system has sent a notification and the user does not take an action, the system will automatically take the action and inform the user what action has been executed. This is achieved by using the Millis function of the microcontroller and the system will only take action if the user does not reply after a certain amount of time. The android interface is implemented after installing Android Studio, the necessary libraries and SDK-tools. The implemented watch interface is illustrated in Figure 6.

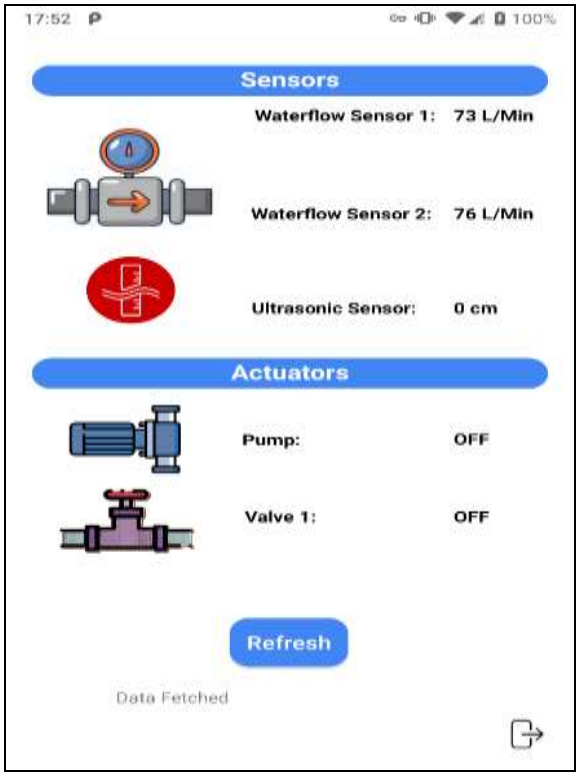

Figure 6. Implemented watch interface

After testing the different hardware components interface, the system is put to test by running the water flow. Expected results match the actual result obtained on android phone. Tap placed between water flow sensors is opened to simulate leak. Leak detected and system notifies user via SMS appropriately. Tap placed between water flow sensors is then closed, no leak detected and no notification is sent.

V. CONCLUSION AND FUTURE SCOPE

The proposed system has been developed with the purpose of reducing domestic water wastage in households and allow the user to take preventive measures in order to avoid possible future pipe damages and water losses. The result obtained is seen to be promising since the system is capable of monitoring the water flow rate and notifies users when a leak is detected in the water pipelines. The system allows the user to view real-time sensors and actuators information, presented in a simple format. It enables users to control the system via SMS commands or the android application. Whenever there is a leak detected by the waterflow sensors or by the ultrasonic ones, an SMS command is issued. The sms commands received by the GSM module are able to change the state of the actuators of the system. Besides, automatic intervention is enabled if no action is taken within 5 min, provided that an SMS has been issued to the user as a warning. However, the system is limited as it cannot accommodate any more sensors other that those already present since only one microcontroller was used. To enhance the system further, provision can be made for recognition of water usage patterns by using other technologies in combination with IoT.

REFERENCES

[1] S. Pirbhulal, H. Zhang, E. Alahi , M. Ghayvat, C. Zhang, W. Wu, "*A novel secure IoT-based smart home automation system using a wireless sensor network*", Sensors, Vol.**17,** Issue.**1**, pp.**69**, **2017**.

[2] V. Radhakrishnan, W. Wu "*IoT technology for Smart water system*", In the Proceedings of the 2018 IEEE 16th International Conference on Smart City; IEEE 4th International Conference on Data Science and Systems (HPCC/SmartCity/DSS), pp.**1491-1496, 2018**.

[3] S. Raut, S. Motade, "*IOT Based Smart Irrigation System using Cisco Packet Tracer*", International Journal of Computer Sciences and Engineering, Vol. **9**, Issue **2**, pp. **12-16**, **2021.**

[4] Y. Badamasi, "*The working principle of an Arduino*", In the Proceedings of the 2014 IEEE 11th international conference on electronics, computer and computation (ICECCO), pp. **1-4, 2014**.

[5] P. Sindhu, G. Leena Giri, "Real Time IoT Application of Urban Garden Design", International Journal of Computer Sciences and Engineering, Vol. 8, Issue **9**, pp. **12-16**, **2020.**

[6] L. Boaz, S. Kaijage, R. Sinde, "*Wireless sensor node for gas pipeline leak detection and location*", International Journal of Computer Applications, Vol. **100**, Issue **18**, pp**. 29-33**, **2014**.

[7] Y. Khulief, A. Khalifa, R. Mansour, M. Habib, "*Acoustic detection of leaks in water pipelines using measurements inside pipe*". Journal of Pipeline Systems Engineering and Practice, **Vol**. 3, **Issue** 2, pp.**47-54. 2012**.

[8] P. Gopalakrishnan, S. Abhishek, R. Ranjith, R. Venkatesh, V. Suriya, "*Smart pipeline water leakage detection system*", International Journal of Applied Engineering Research, **Vol**. 12, **Issue** 16, pp.**5559-5564**, **2017**.

[9] M. Daadoo, Y. Daraghmi, "*Smart Water Leakage Detection Using Wireless Sensor Networks (SWLD)*", International Journal of Networks and Communications, Vol. **7**, Issue **1**, pp**. 1-16**, **2017**.

[10] S. Thenmozhi, K. Sumathi, B. Asokan, R. Priyanka, R. Maheswar, P. Jayarajan, "*IoT Based Smart Water Leak Detection System for a Sustainable Future*", In the Proceedings of the 2021 IEEE 6th International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), pp. **359-362, 2021**.

[11] M. Maureira, D. Oldenhof, L. Teernstra, "*ThingSpeak–an API and Web Service for the Internet of Things*", World Wide |Web, pp. **1-8**, **2011**.

[12] S. Pasha, "*ThingSpeak based sensing and monitoring system for IoT with Matlab Analysis*", International Journal of New Technology and Research (IJNTR), Vol. **2**, Issue **6**, pp**. 19-23**. **2016**

Authors Profile

Dr A Q Mohabuth pursed Bachelor of Technology, Master of Science and completed his PhD in 2017. He is currently working as Senior Lecturer in Department of Software & Information Systems, University of Mauritius, Mauritius. He was formelly Poject Coordinator on full-time basis for the Work-based learning programme at the Univeristy of Mauritius for ten years. He has published more than 10 research papers in international journals and conferences and it's also available online. His main research work focuses on Green Computing, IoT Smart technologies, Project Management and E-Assessment. He has 25 years of teaching experience and 10 years of Research Experience.

Mr Tridev Pal pursed Bachelor of Science in Software Engineering from the University of Mauritius, Mauritius in year 2019. He is currently working in the IT Industry as Software Developer at the SD Worx (Mauritius) Limited He is involved in many IT projects that focuses on Cloud Security, Cloud Services, Big Data Analytics, DevOps, and IoT among others.

Mr Moksesh Sobrun pursued Bachelor of Science in Software Engineering from the University of Mauritius, Mauritius in year 2019. He is currently working in the IT Industry as a Software Developer at SD Worx (Mauritius) Limited and is a Microsoft Certified Professional (MCP). He is involved in many IT projects that focus on Payroll/ HR systems and business development using cloud technologies, DevOps automation and web development frameworks among other smart technologies.

