

Smart Water Meter: An IoT-based Solution for Efficient Water Management

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Abstract—This article presents a Smart Water Metering and Billing system that provides accurate and automated water usage monitoring and billing. The suggested system tracks water consumption in real-time and sends the information to a central server using IoT technology. The server uses an algorithm to calculate the water usage based on the received data and generates a bill accordingly. The system also provides consumers with a user-friendly API server to monitor their water consumption. The suggested method does away with the necessity for manual meter reading and enables prompt and precise invoicing, improving water conservation and facilitating effective management. The results of the proposed system's implementation demonstrate its effectiveness in accurately measuring water consumption and generating bills, thereby addressing the challenges of traditional water metering systems.

Index Terms— IoT, Smart water-monitoring system, Radio sensor network, Smart City, Flow rate.

I. INTRODUCTION

Water scarcity is a growing concern across various regions globally, and efficient water management is becoming increasingly important. We propose a Smart Water Meter (SWM) system that utilizes the Internet of Things (IoT) technology to enable efficient water management. The SWM system is designed to continuously monitor and record water consumption data in real-time, and to transmit the data to a central server for analysis and processing.

Access to clean and safe water is essential for sustaining life, and managing water resources effectively is critical for ensuring equitable distribution and efficient utilization. One of the primary challenges of water management is accurately measuring water usage and billing consumers accordingly. Traditional water metering systems often rely on manual meter reading, which can be time-consuming, error-prone, and expensive.

Moreover, manual meter reading can lead to delayed billing and inaccurate consumption data, hindering effective water management. This study suggests a smart water metering and billing system that makes use of Internet of Things (IoT) technology to enable precise and automatic water consumption monitoring and invoicing in order to address these difficulties. The suggested system makes use of sensors to track water use in real-time, and the information is sent to a central computer for automatic billing computation.

The system also provides consumers with a user-friendly API server to monitor their water consumption. The proposed system's implementation demonstrates its effectiveness in accurately measuring water consumption and generating bills, leading to improved water conservation and efficient management. The paper presents the

detailed design and implementation of the proposed system and evaluates its performance, demonstrating its potential as a viable solution to enhance water resource management through intelligent systems.

A smart water meter device, a data transfer module, and a central server make up the SWM system. The smart water meter device is installed at the customer's premises to measure the water consumption, and the data communication module is used to transmit the data to the central server via a wireless network. The central server is in charge of storing and analysing the data, and generating reports for the customers and water service providers.

II. LITERATURE REVIEW

Here's the Literature Review of papers we have taken as reference.

M. J. Mudumbe and A. M. Abu-Mahfouz et al. [1] For managing sustainable water resources, the conventional manual water meter reading approach is uncomfortable, time-consuming, and unsuccessful. For effective and trustworthy monitoring that allows the utilities industry and customers to know water usage levels in clever water meters that operate instantly are required. Smart water metering systems warn consumers of unusual water use and work to cut down on use. The water management system described in this research uses a wireless sensor network (WSN) as its foundation. With the help of Pandora FMS and a web-based system, the system is tracked and visualized. R. AL-Madhrabi et al. [2] Water usage monitoring and reduction have become major issues due to growing urbanization and population. The IoT has made it possible to build smart systems as well as apps that are water-efficient. This study develops and evaluates a data collection method for Internet of Things-based smart meters using the Arduino Uno, Wi-Fi-ESP8266, and water flow sensors. The used method, EDCDWM, minimizes packet transmissions, resulting in energy savings for both absolute change and relative changes across all nodes of around 60% and 93%, respectively. Analyses and simulations are performed using MATLAB R2019b. A. Amir, R. Fauzi, and Y. Arifin et al. [3] This essay outlines the creation of a smart water meter that measures water use using flow meters as a sensor. Contrary to conventional mechanical water meters used for invoicing, the suggested smart meter enables users to choose and manage the quantity of water needed. Once the necessary level of water has been attained, the system may also shut off the main valve. With a maximum discrepancy of 0.03 liters, the smart meter was tested and compared to manual readings. This smart water metering technology can help smart cities manage clean water more effectively.

Goulas, A. et al. [4] The public's impressions of smart water meters, which profile abnormalities and "events" in home water consumption using machine learning and IoT, were examined in an online poll conducted in the UK, according to this article. The study found that over half of the respondents would favor having such a meter installed. Lower ages, being a guy, having water meters that were already in place, and having other smart devices were all predictive variables. Demands for data privacy control, cheaper water prices, and free installation were all factors that affected the likelihood of choosing this specific water meter. In order to better understand the potential benefits of such technology, the study focuses on the practical challenges of using real-time environmental data for urban water administration and makes the suggestion of tracking public opinion and conducting urban experiments. Adams, M.N. and Jokonya, O. et al. [5] Using a thorough literature analysis and the Technology, Organization, and Environment (TOE) Framework, the study explores the variables impacting the adoption of smart water meters at universities. Following technology aspects as the most important adoption variables, environmental elements were also identified using quantitative content analysis. The least significant organizational elements were. The study advances knowledge of the elements driving smart water meter uptake in academic settings and recommends more empirically-based studies in the field. S nderlund, A.L. et al. [6] In order to ensure water security, this article examines the use of smart meters in demand management. Smart meters provide utilities a mechanism to calculate end-user demand and send real-time usage feedback. On the efficiency of feedback technologies in encouraging water-saving behaviours, there is, however, scant research. In order to address the mounting challenges to water security, the study analyses this data and emphasizes the necessity for adaptable measures.

D. Anandhavalli, K.S. Sangeetha, V. Priya Dharshini and B. Lukshana Fathima et al. [7] The article suggests utilizing smart water meters as a remedy for problems with water conservation in flats. Water use is tracked using a smart meter gadget that feeds data to the cloud. In comparison to utilizing a single meter for several residences, this method offers more precise measurement and invoicing of water usage. The suggested remedy can aid in reducing water waste and encouraging conservation efforts. Tiwari, R. and Nayak, S. et al. [8] Pricing and Challenges: This essay examines the state of drinking water in urban India, stressing problems such a lack of cost recovery, cheap pricing, and a significant degree of water-related responsibility. It indicates that setting water prices based on cost and instituting consumption-based tariffs might promote effective use and deter

waste. To satisfy the demands of an expanding urban population, the water sector must overcome substantial obstacles, and the provision of piped water supply remains an unmet aim in many states. G Hauber-Davidson, E Idris et al. [9] This document gives a general introduction of smart water meters, including its definition, features, and technology. Through case studies and examples, it explains the significance of smart water meters in gathering useful use data and emphasizes their advantages. The purpose of this document is to dispel misconceptions and explain the technologies behind smart water meters.

Cherukutota, N. and Jadhav, S. et al. [10] This study suggests a water metering system that is Internet of Things-based and employs ultrasonic flow monitoring. By giving data on water consumption, the system seeks to decrease water wastage and enhance water management. The MediaTek Cloud Sandbox cloud platform and the Link It ONE development board are both used in the suggested architectural framework to facilitate communication between the water meter and the cloud. Users may access, analyses, and share data using the cloud-based system's affordable, anytime, anywhere accessibility. The device has prospective uses in both household and commercial settings. Suresh, M., Muthukumar, U. and Chandapillai, J. et al. [11] The automated water meter reading method proposed in this research makes usage of IoT devices at a reasonable cost and a smartphone app, enabling meter readers and customers to update consumption data to the utility's web for billing and payment using their cell phones. This strategy differs from current commercial approaches and potentially lower utility costs associated with managing meter reading and invoicing for water delivery in major cities. March, H. et al. [12] The development of smart water metering in Spain, with a focus on the city of Alicante, is the major subject of this article. Smart metering programs for end users have become an essential strategy for water utilities to have an in-depth understanding of urban water usage. The paper addresses the benefits, drawbacks, potential applications, and problems of this technology in order to help create more sustainable urban water cycles. Statistics and interviews are used to chronicle and explain the experience of the city of Alicante, a pioneer in the widely used deployment of remote reading of water meters at the residential level and for significant metropolitan users. The purpose of the research is to offer insights into how smart meters are being used in various geographic areas.

Ray, A. and Goswami, S. et al. [13] This study suggests a smart water meter system that employs machine learning algorithms with IoT and cloud computing to distinguish between regular and excessive water consumption in industrial, home, and other sectors. The system seeks to promote sustainable water management and meet the rising demand for resources for clean water. Hydraulic data monitoring in real time and automated control will enable the detection of events like water leaks and excessive use, allowing for the taking of effective measures. To effectively manage water resources and save water for future generations, the suggested method may be deployed on a big scale and used by Indian citizens and people all over the world. Rajurkar, C., Prabakaran, S.R. and Muthulakshmi, S. et al. [14] The research focuses on tracking water use in a residential building near a pipeline partition. This project intends to monitor water consumption for various reasons since only 0.08% of the water on Earth is used by humans. Although resources are few, water is necessary for daily living. To encourage efficiency and conservation, the initiative will assess data on water use. Freshwater is a finite resource, and our effort seeks to guarantee that the water resources that are at our disposal are used properly. Data analysis on water use may support sustainability and efficient use of water resources. Gaikwad, V. et al. [15] A suggested IoT-based system would correctly track water consumption in particular homes and issue alerts if usage restrictions were exceeded. Micro-controllers employ ultrasonic sensors to measure the amount of water consumed, and then convey that information to clients through text message using a GSM module. In smart cities, if the technique is widely used, it might dramatically minimize water shortages and waste.

III. METHODOLOGY STRATEGY

This article presents a solution that combines an ESP8266 (Wi-Fi Module) with Arduino code and a water flow sensor to achieve effective water utilization. The proposed method involves using Arduino software to measure the water flow rate, show the findings on a using a serial monitor, users may capture data and transfer it to the cloud for viewing.

- A. Sensing: The smart water meter uses sensors to measure water consumption, typically using flow sensor (YF-S201).
- B. Data Analysis: The collected data is then analyzed by the smart meter to identify patterns, trends, and anomalies in water usage and prepare graphs according to data.
- C. Wireless connectivity: The meter uses wireless connectivity to send data to a central server, using ESP8266.

- D. User Interface: The smart water meter provides a user interface, typically through a mobile application or web portal, for users to access real-time data on their water consumption and billing information.
- E. Automatic Billing: The smart water meter can automatically generate bills based on consumption data and send them to customers, eliminating the need for manual meter reading and billing.

Overall, the methodological strategy of smart water meters focuses on leveraging technology, data analytics, wireless connectivity and consumer engagement to optimize water management, improve efficiency, reduce water loss, and promote sustainable water use practices.

IV. HARDWARE USED

A. Arduino Uno

For the purpose of implementation and testing, the Arduino Uno board is employed to generate and upload the code onto the flow sensor and Wi-Fi module.

B. Flow Sensor (YF-S201)

Water flow sensor is used to monitor how much water is travelling between different sites. This sensor is made up of a hall effect sensor, a water rotor, and a stainless- steel valve body. Its purpose is to precisely gauge the water flow during the transfer operation.

C. ESP8266 (Wi-Fi Module)

ESP8266 can be used to connect the smart water meter to a Wi-Fi network, enabling remote monitoring and control of the water meter readings. Its range is 2.4GHz.

D. How a Water Flow Sensor Works

As water enters the rotor, the resulting pressure initiates the rotational movement of the rotor, whose speed adjusts according to the flow rate. The hall-effect sensor then generates the corresponding pulse signal.

The water flow sensor utilizes the Hall Effect principle by incorporating a small rotor, resembling a fan or propeller, within the water's pathway. As the water exerts pressure on the rotor, it starts to rotate. The rotor is equipped with a Hall Effect sensor, which comprises a coil carrying electric current and a magnet attached to the rotor's shaft. Consequently, the rotor's spinning causes a voltage to be produced or pulse. For every minute, this flow meter generates approximately 4.5 pulses corresponding to each Liter of water passing through it. By employing a simple conversion formula, the flow rate in Liters per hour (L/hr) can be calculated.

Water flow rate is $Q = V \cdot A$,

Which stands for,

Q = total water flow through the pipe,

V = averaging the flow's speed,

A = the pipe's cross-sectional area

Pulsation Rate (Hz) = $4.5Q$,

Flow Speed (Liters/minute) = (Pulse frequency x 60 sec) / $4.5Q$

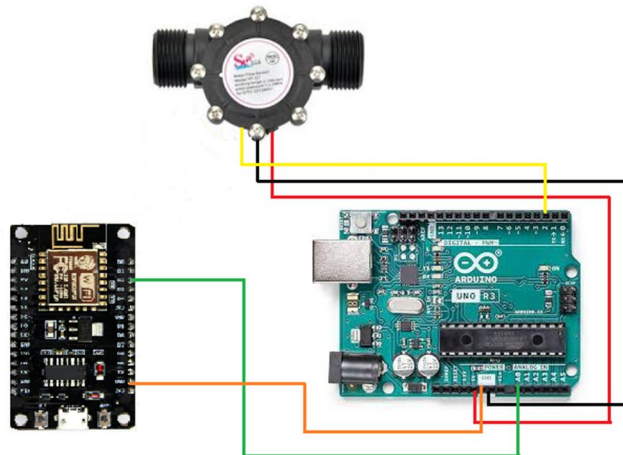


Figure 1: System Integration Diagram

E. Inter-connections of all Hardware's

Connecting an Arduino UNO, ESP8266 with a YF-S201, can be done using the actions that follow:

1. VCC pin of flow sensor to 5V pin of Arduino UNO.
2. GND pin of flow sensor to GND pin of Arduino UNO.
3. Signal pin of flow sensor to D2 pin of Arduino UNO.
4. GPIO4 pin of ESP8266 to A0 pin of Arduino UNO.
5. GND pin of ESP8266 to GND pin of Arduino UNO.

V. OBSERVATION

The smart water metre is a tool used to precisely measure and track water use, and providing valuable insights for homeowners, businesses, and municipalities. Observations for a smart water meter may include:

A. Accurate Measurements

A smart water meter can provide precise readings of water consumption, allowing for accurate billing and identification of leaks or other issues.

B. Real Time Monitoring

With a smart water meter, users can monitor their water usage in real-time, providing the opportunity to adjust consumption and potentially save money on utility bills.

C. Leak Detection

Smart water meters can identify unusual usage patterns that may indicate a leak or other issue, alerting users to potential problems and allowing for prompt repairs.

D. Water Conservation

By providing real-time feedback on water usage, smart water meters can encourage conservation efforts and help users identify ways to reduce water consumption.

E. Remote Management

Smart water meters can be managed remotely, allowing utilities to monitor usage patterns and identify areas where water conservation efforts are needed.

F. Data Analysis

Smart water meters capture data that may be analysed to find trends and patterns, giving utilities and customers alike useful information.

Overall, smart water meters provide a range of benefits, including accurate measurements, real-time monitoring, leak detection, water conservation, remote management, and data analysis.

VI. RESULT

In result, we are including the snapshots of website and database.

- a. This picture shows the GUI of Mobile API server, which enables to connect with the water meter through Wi-Fi.
- b. It shows the graph of water usage.
- c. It is the snapshot of readings taken from the real-time database.
- d. The bill receipt of water usage is also presented.

VII. CONCLUSION

In summary, installing a smart water meter system has a lot of advantages for both water utilities and customers. Smart water meters can give precise and timely data on water consumption through the use of wireless communication and cloud computing technology, resulting in more effective resource management and pricing. Additionally, individuals can make changes to their water usage patterns and spot any leaks using this data, which will reduce costs and conserve water.

The choice of hardware, communication protocols, and data analysis methods are only a few of the many variables that must be carefully taken into account during the creation and advancement of an intelligent water

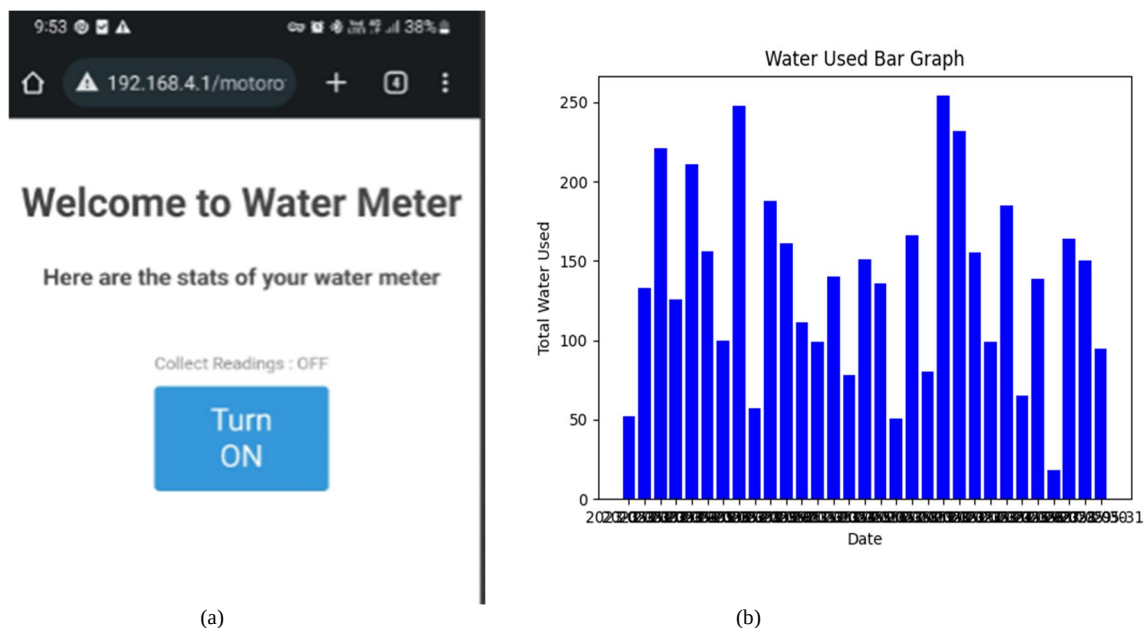


Figure 2: (a) GUI of Mobile API Server, (b) Graphical Representation of Water Usage



Figure 3: (c) Realtime Database,

(d) Bill Receipt of Water Usage

meter system. Additionally, the system must guarantee data security and privacy to safeguard customer information.

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