International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 05 May 2024
Page No: 1283 - 1288
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0177

Smart Water Dispensing: Enhancing Convenience Through App-Controlled Vending Machines

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Abstract
The demand for water vending machines has surged in India, particularly in urban Sectors like Airports, Metro station, malls, offices, Railway stations, Universities and other public sectors, where access to safe drinking water is a pressing concern. However, existing machines predominantly rely on digital and cash payments, posing challenges for individuals without smartphones or ready cash. To address this gap, we propose integrating a phone call facility into water vending machines, allowing users to make purchases via a simple phone call. Coupled with an integrated mobile application accessible nationwide, this system promotes inclusivity and convenience. By leveraging technology, we can ensure that clean water remains accessible to all, regardless of their digital capabilities or financial constraints, aligning with the principles of Digital India. Our goal is to address the challenge faced by individuals without access to cash or mobile phones. Through our in-machine phone call services, users can facilitate payments for others, promoting financial inclusivity. Additionally, our solution enables individuals worldwide to make payments seamlessly through a dedicated application.

Keywords: *Arduino IoT cloud services; Relay; Solenoid valve; UNO R4; Water flow sensor.*

1. Introduction

In India, the proliferation of water vending machines has been a notable response to the escalating demand for safe drinking water, particularly in densely populated urban areas. These machines have become fixtures in various public settings, ranging from business parks to transportation hubs, offering a convenient solution for accessing clean water on the go. However, while these machines represent a significant advancement, they primarily cater to users with access to digital payment methods or cash on hand.[1] This poses a challenge for individuals who lack smartphones or sufficient funds for immediate payment. In light of India's ongoing digital transformation and the government's push for a "Digital India," it is imperative to ensure that essential services like water vending machines are inclusive and accessible to all segments of society.[2] This entails addressing the barriers faced by individuals who may not have smartphones or ready access to digital payment methods. To bridge this accessibility gap, we propose the integration of a phone call facility into water vending machines. This innovative feature enables users to initiate purchases through a simple phone call, bypassing the need for digital transactions or physical currency. Complementing this feature is an integrated mobile application accessible nationwide, facilitating seamless transactions and enhancing user experience. In this paper, we explore the rationale behind integrating phone call capabilities into water vending machines, highlighting the benefits in terms of inclusivity, convenience, and hygiene. By leveraging

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technology and innovation, we aim to ensure that clean drinking water remains accessible to all, aligning with the broader vision of Digital India and promoting social equity in access to essential services. Through this initiative, we seek to contribute to the ongoing discourse on leveraging technology for social good and fostering inclusive growth in India's rapidly evolving digital landscape.

2. Literature Summary

Innovations in water vending machines have been evolving rapidly in recent years, driven by advancements in technology and a growing focus on sustainability and convenience. Here are some innovations and trends in water vending machines that have emerged in the past few years:

App-Controlled Interfaces: One of the significant advancements is the integration of mobile applications with water vending machines. Users can now control and monitor the vending process, including payment, selection of water type (e.g., purified, mineral, alkaline), and even receive alerts when the machine needs maintenance or refilling [3].

Contactless Payment Options: (R-9) With the rise of digital wallets and contactless payment methods, many water vending machines now offer NFC (Near Field Communication) or RFID (Radio Frequency Identification) payment options. This not only enhances convenience but also promotes a touchless experience, which is particularly important in the context of health and hygiene [4].

Customization and Personalization: (R-10,11) Some water vending machines allow users to customize their water preferences, such as choosing the temperature (cold, room temperature, hot for teas or soups), adding flavors or supplements (e.g., vitamins, electrolytes), and adjusting the carbonation level for sparkling water [5].

Sustainable Features: Many newer water vending machines incorporate eco-friendly features such as energy-efficient components, water-saving mechanisms, and the use of recyclable materials in their construction. Some machines also have sensors to detect bottle types and dispense the appropriate amount of water, reducing waste [6].

Water Quality Monitoring: (R-12) Advanced water vending machines are equipped with sensors and monitoring systems to ensure water quality and safety. These systems may include real-time monitoring of pH levels, TDS (Total Dissolved Solids) measurement, UV sterilization for purification, and periodic water quality testing.

Data Analytics and Remote Management: Manufacturers and operators can now leverage data analytics and remote management capabilities in smart water vending machines. This allows for better inventory management, predictive maintenance, and insights into consumer preferences and usage patterns [7].

Multi-Purpose Functionality: Some water vending machines are designed with multi-purpose functionality, serving not only as water dispensers but also offering additional features such as ice dispensing, hot beverage dispensing (coffee, tea), and even snack vending options [8].

Integration with IoT (Internet of Things): (R 1,2,7) IoT integration enables water vending machines to communicate with other devices and systems, facilitating automated processes such as inventory restocking, machine diagnostics, and customer support [10].

User Experience Enhancements: Manufacturers are focusing on improving the overall user experience by incorporating intuitive interfaces, interactive displays, multilingual support, and accessibility features for users with disabilities.

Hygiene and Sanitization: In response to health concerns, especially during pandemics, modern water vending machines are equipped with enhanced hygiene features such as self-cleaning mechanisms, UV-C sterilization for touch surfaces, and contactless dispensing options [9].

These innovations collectively aim to enhance convenience, promote sustainability, ensure water quality and safety, and provide a seamless user experience in the context of smart water dispensing through vending machines, our goal is to address the challenge faced by individuals

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without access to cash or mobile phones. Through our in-machine phone call services, users can facilitate payments for others, promoting financial inclusivity. Additionally, our solution enables individuals worldwide to make payments seamlessly through a dedicated application.

3. Methodology

The development of a water vending machine involves a systematic approach integrating various components to ensure functionality, reliability, and user-friendliness. The methodology encompasses the selection and integration of hardware components, programming of microcontrollers, and development of the mobile application for seamless operation. This section outlines the step-by-step methodology for designing and implementing a water vending machine.

Component Selection: The first step in the methodology involves identifying and selecting the necessary hardware components. This includes a water sensor to detect water levels in the tank, a solenoid valve for controlling water flow, a water tank to store the water, pipes for conveying water, wires for electrical connections, an Arduino Uno board for microcontroller functionality, a relay for switching high-power loads, and an Arduino IoT module for app integration.

Electronics Component and Sensors Used in Our Project Are: Water flow sensor, solenoid valve, relay, power adapter for solenoid because its only works on 12v dc, UNO R4 because it has inbuilt WIFI support, Water tank, connecting pipes, Wires And for app integration we are using Arduino IOT cloud services and taking their API for APP making [11].

System Design: Once the components are selected, the next step is to design the system architecture. This involves determining the layout of the water vending machine, including the placement of components such as the water tank, solenoid valve, and Arduino board. The design should optimize space utilization while ensuring ease of maintenance and accessibility [12].

Hardware Integration: With the system design in place, the hardware integration phase begins. This involves physically assembling the water vending machine by connecting the components according to the system architecture. The water sensor is installed in the tank to monitor water levels, while the solenoid valve is connected to control the flow of water. The Arduino Uno board serves as the central control unit, interfacing with the various components through digital and analog pins. Wires are used to establish electrical connections between components, ensuring proper functionality.

Programming: Once the hardware is integrated, the next step is to program the microcontroller (Arduino Uno) to control the operation of the water vending machine. This involves writing code to read data from the water sensor, activate the solenoid valve based on user input, and communicate with the Arduino IoT module for app integration. The programming logic should include error handling mechanisms to ensure safe and reliable operation of the vending machine.

Mobile Application Development: Concurrently with hardware integration and programming, the mobile application development phase commences. This involves designing and developing a user-friendly mobile application that allows users to interact with the water vending machine remotely. The application should enable users to initiate water dispensing, monitor water levels, and make payments securely using digital payment methods such as UPI or mobile wallets. Integration with the Arduino IoT module facilitates real-time communication between the vending machine and the mobile application, ensuring seamless operation.

Testing and Validation: Once the hardware integration, programming, and mobile application development are complete, rigorous testing and validation are conducted to ensure the functionality and reliability of the water vending machine. This includes testing the responsiveness of the mobile application, verifying the accuracy of water level sensing, evaluating the performance of the solenoid valve, and assessing the overall user experience. Any issues or discrepancies

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identified during testing are addressed through iterative refinement of the system.

Deployment and Evaluation: Upon successful testing and validation, the water vending machine is deployed for operational use in real-world settings, such as business parks, transportation hubs, or educational institutions. Continuous monitoring and evaluation are conducted to assess the machine's performance, user satisfaction, and adherence to regulatory standards. Feedback from users and stakeholders is collected to identify areas for improvement and inform future iterations of the vending machine.

4. Results and Tables

Table 1 This Table Includes Transactions for 500ML in 1 Rupee

Building Name	Total Transactions (500ml)	Total Revenue (INR)form 500ml
Building M And N	200	200
Building B	150	150
Building Q	250	250
Building S	180	180

Table 2 This Table Includes Transactions for 1 L in 2 Rupees

Building Name	Total Transactions (1 Liter)	Total Revenue (INR)form 1 Liter
Building M And N	150	300
Building B	100	200
Building Q	200	400
Building S	150	300

Table 3 This Table Provides a Comprehensive Overview of Transactions and Revenue Generated from Both 1-Liter and 500-Milliliter Purchases, as Well as Transactions Facilitated by Users Using Other Individuals' Phones Through Phone Calls

Building Nmae	Total Revenue (INR)	Transactions Via phone call
Building M and N	400	10% (35 Transactions)
Building B	275	5% (16 Transactions)
Building Q	525	8% (34 Transactions)
Building S	390	7% (25 Transactions)

Here Is Basic Block Diagram of Machine and Application Screenshot in Figure 1 &2.

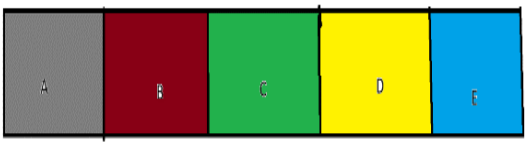

Figure 1 Block Diagram

Block 1 contains the water tank, where water is stored. In Block 2, we find the solenoid valve, connected to the tank via a pipe. The solenoid valve is an electronically operated device that remains closed when not powered. When power is supplied to the solenoid valve, it opens, allowing water to pass through. Moving on to Block 3, we have the relay, a component used to control power on/off based on Arduino Uno coding. Block 4 houses the water flow sensor, which measures the flow of water through a pipe. Finally, Block 5 is the Arduino Uno, where all coding is centralized. The Arduino Uno is connected to all sensors and, based on user behavior on the app, triggers the dispensing of water through the tap. The basic coding implemented in this setup offers water at the rate of 500ml for 1 rupee and 1 liter for 2 rupees is show in Table 1&2,3.

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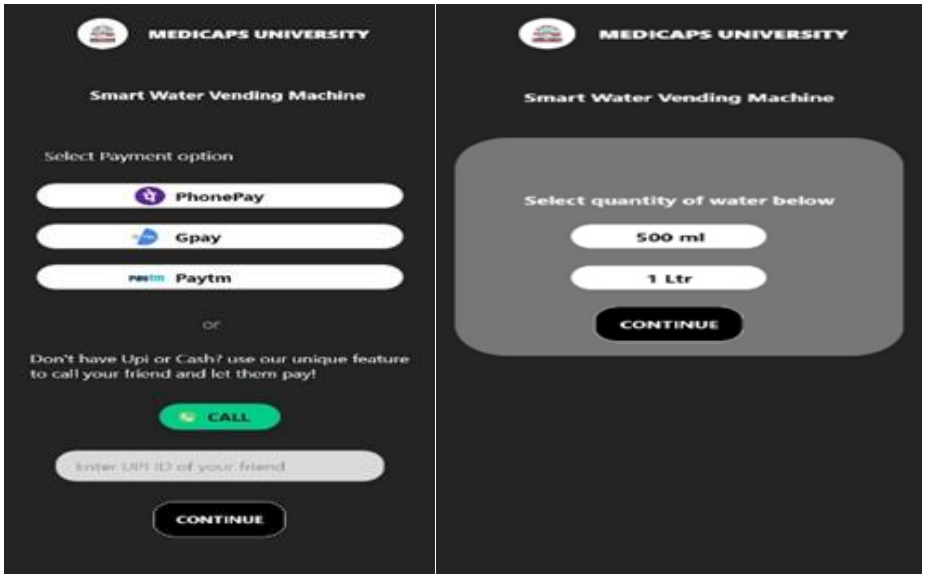

Figure 2 Application Screenshot

Conclusion

The results of our study underscore the effectiveness of app-controlled water vending machines in enhancing convenience and accessibility for users in India. By offering flexible pricing options and integrating innovative features such as the phone call facility, these vending machines cater to a diverse range of user needs and preferences. The success of the pricing options in encouraging cost-effective water consumption and the positive reception of the phone call feature demonstrate the potential of technology to address barriers to access and promote inclusivity in essential services.

Acknowledgements

We extend our sincere appreciation to our esteemed mentor, Dr. Juned A Siddiqui, whose guidance and support paved the way for the successful completion of our project titled "Smart Water Dispensing: Enhancing Convenience through App-Controlled Vending Machines" Additionally, we express our gratitude to Mrs. Varsha Khule for his invaluable insights and expertise, which significantly enhanced our project. Furthermore, we acknowledge the invaluable assistance provided by various online resources that aided us in comprehensively understanding and articulating our project. Last but not least, we would like to express our heartfelt thanks to our parents and friends whose encouragement and contributions enriched the project immensely.

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