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IOT Based Automatic Petrol Fuelling system

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Abstract:
In recent years, the automation of various industrial processes has gained significant momentum, leading to enhanced efficiency and convenience. This project focuses on the development of an Internet of Things (IoT)-based automated petrol fuelling system, designed to streamline the fuelling process in petrol stations. The primary objective of this project is to create a smart and automated system that reduces human intervention, minimizes errors, and enhances the overall customer experience. The proposed system leverages key IoT components such as sensors, RFID technology, and an Arduino microcontroller, a Proximity Sensor, RFID reader. This project demonstrates a practical application of IoT technology in automating petrol fuelling operations, offering benefits such as reduced waiting times, increased accuracy, and improved resource management. The implementation of such a system has the potential to transform traditional petrol stations into smart, efficient, and customer-friendly establishments. Future enhancements may include the integration of advanced payment systems, predictive maintenance, and data analytics to further optimize the fuelling process. This automated approach offers numerous benefits. Firstly, it significantly reduces the waiting time for customers by speeding up the fuelling process. Secondly, it minimizes human error and fraudulent activities by ensuring that only authenticated vehicles and users can access the fuel. Thirdly, it promotes better resource management through real-time data collection, allowing station operators to monitor fuel usage, detect anomalies, and plan inventory efficiency. Moreover, the system enhances customer convenience by supporting cashless and automated transactions, which can be linked to digital wallets or banking systems. This not only reduces physical contact, which is especially beneficial in a post-pandemic world, but also aligns with the global shift toward digital financial services.

Keywords: Proximity Sensor, RFID reader, Internet of Things, Automating Petrol Fuelling.

1. Introduction

The rapid advancement of technology and the increasing integration of the Internet of Things (IoT) into everyday applications have transformed numerous industries, including automotive, manufacturing, logistics, and retail. One area where IoT is making remarkable progress is in the automation of fuel stations. The conventional method of refueling vehicles is labor-intensive and often plagued by challenges such as human error, fuel theft, long wait times, and inefficient resource management. To address these issues, the implementation of an IoT-based petrol fuel automation system presents a promising solution [1], [2]. This project focuses on leveraging the power of IoT technology to automate and modernize the fuel dispensing process, creating a more seamless and efficient user experience. At its

core, the system aims to minimize manual intervention while improving accuracy, security, and operational efficiency [3].
A key feature of this system is the use of RFID (Radio Frequency Identification) technology for vehicle identification and authentication. Each vehicle is equipped with an RFID tag that is linked to the user's profile and fuel allowance. When the vehicle enters the fuel station, the RFID reader recognizes the tag, verifies authorization, and initiates the automated refueling process [4]. In addition to RFID, the system integrates various sensors and microcontrollers that monitor parameters such as fuel level, flow rate, nozzle activity, and tank conditions in real time [2]. This data is transmitted to an IoT platform where it can be visualized, analyzed, and managed remotely. Real-time monitoring not only enhances operational control but also enables predictive maintenance, reducing downtime and improving reliability [1]. One of the major benefits of this system is enhanced security. By eliminating manual fuel dispensing, the chances of fuel theft, tampering, or unauthorized refueling are significantly reduced. Moreover, the automated system ensures that the exact quantity of fuel is dispensed, minimizing wastage and billing discrepancies [4]. Integration with digital payment platforms further simplifies the transaction process, allowing users to pay seamlessly via mobile apps or RFID-linked accounts, eliminating the need for cash transactions [3].

2. Literature Survey

Shalini V et.al.,[5] This system introduces an automated fuel dispensing mechanism powered by prepaid RFID cards, allowing customers to select and receive their fuel without human interaction. Key goals include: Minimizing the need for manual labor and operational overhead, Enabling the installation of unmanned petrol stations in remote areas, Streamlining the payment process using electronic clearing, Providing a flexible, scalable infrastructure for modern fuel stations. This model promotes faster transaction times, improves customer experience, and reduces costs associated with staffing and infrastructure.

K Deppa et.al.,[6] This research investigates the design and implementation of an IoT-powered system aimed at enhancing fuel management through real-time monitoring, theft detection, and location tracking. As fuel remains a critical resource for transportation and industrial operations, safeguarding its usage and preventing unauthorized access is essential.

Md.Badiuzzaman Pranto et.al.,[7] This research presents a smart fuel management system that integrates RFID authentication, mobile applications, and telematics to automate petrol refueling and enhance transparency in fuel transactions.This system bridges the gap between fuel automation and user accountability, offering a cost-effective, secure, and globally accessible solution. It sets the stage for future enhancements such as AI-based fraud detection, blockchain-based transaction logs, and integration with vehicle telematics for predictive refueling.

B Gokulavasan et.al.,[8] This research explores an IoT-driven solution designed to automate LPG gas booking, monitor cylinder levels, and detect hazardous gas leaks, targeting safer and more efficient domestic energy management. This system aligns with the broader goal of embedding smart technologies into everyday utilities, offering a low-cost, reliable, and scalable framework for smart home safety. It paves the way for future enhancements using AI analytics, predictive consumption models, and blockchain-based service verification.

V. Siddeshwara Prasad et.al.,[9] This research introduces a centralized, intelligent fuel dispensing framework that leverages RFID authentication, GSM communication, and microcontroller-based automation to improve the efficiency and safety of petrol bunk operations. The system is designed to reduce labor dependency, prevent fraud, and facilitate secure, real-time fuel transactions. The system delivers a cost-effective, scalable, and intelligent solution for fuel station automation. Its integration of RFID and GSM modules reinforces both transactional security and operational efficiency. Future enhancements could include IoT-based analytics, cloud logging of fuel records, and predictive maintenance capabilities.

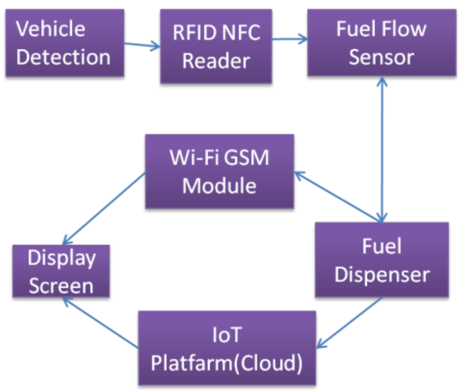
3. Design Methodology

The methodology involves a series of strategic steps and considerations that ensure seamless integration and functionality of all components. The primary objective is to create an automated system that can authenticate vehicles, dispense fuel accurately, and provide real-time data for both operators and customers.

A. Hardware implementation:

As in the Figure 1 all components are neatly arranged on a mounting board to create a clean and compact hardware prototype. The RFID module is strategically placed at the front of the setup to allow users to easily scan their tags for authentication. the LCD display is mounted in a visible position to provide real-time feedback such as transaction status, fuel quantity dispensed, and authorization messages.

Figure 1: Block Diagram of IoT based automatic petrol fueling system

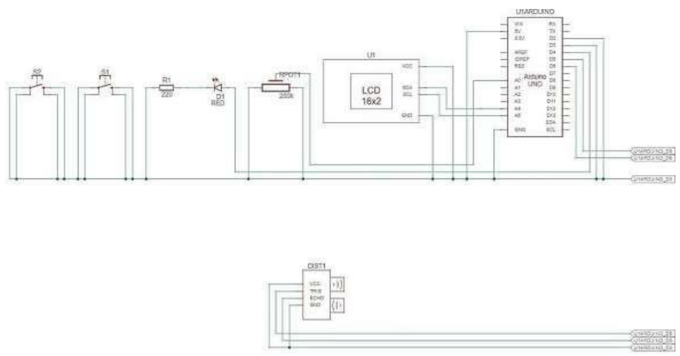


The Arduino Uno, acting as the control hub, is centrally located to simplify connections to all peripherals via jumper wires and the breadboard, which facilitates temporary circuit building and quick modifications. A flow sensor is integrated into a plastic pipe that simulates a fuel line, allowing accurate measurement of the "fuel" (in this case, usually water or colored liquid for demonstration) as it passes through. The flow sensor outputs digital pulses proportional to the fluid flow, which the Arduino counts to determine the amount dispensed AS depicted in Figure 2. A DC motor or small pump, controlled through a relay module, simulates the fuel pump, turning on and off based on sensor readings and user inputs. Additional components like LEDs, push buttons, or a buzzer may be included to enhance the user interface or signal events such as successful transactions errors.

B. Software Implementation:

The system is programmed using the Arduino IDE, where the logic for handling various components is written in C/C++. The software is responsible for managing the entire operational flow: starting with RFID-based authentication, followed by flow measurement, pump control, and status display. The MFRC522.h library is used to interface with the RFID reader, enabling the system to detect and read RFID tags and compare them with predefined authorized IDs.

Figure 2: Architecture of Proposed System



The Liquid Crystal.h library handles communication with the 16x2 or 20x4 LCD, displaying messages like "Scan Your Card", "Authorized", "Dispensing", or "Fuel Complete". Sensor readings are processed in real-time by counting the pulses from the flow sensor using interrupts or polling methods. Based on the number of pulses, the Arduino calculates theamount of fuel dispensed and turns off the pump when the set quantity is reached. The relay module is controlled using digital output pins, switching the pump on and off safely and efficiently. The Wire.h library may also be used if additional I2C devices, such as an I2C LCD or RTC (Real Time Clock) module, are included. Additional features like manual override buttons, emergency stop logic, or automatic timeouts can be implemented in the code for enhanced functionality and safety.

C. Technical Components Used:

Amazon Lex: For NLU (Natural Language Understanding) and conversational flow.

AWS Lambda: For custom logic, validation, and backend integration.

Slot Elicitation: To gather dynamic user input.

Fallback Intent:For error handling and unexpected input.

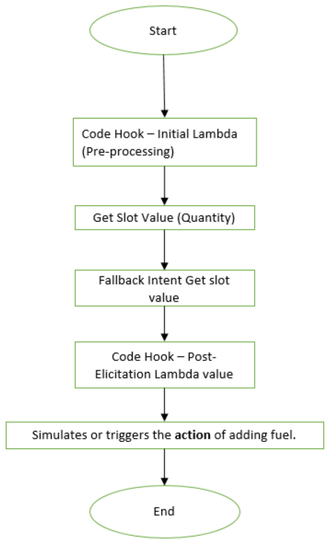
Closing & Fulfillment: To confirm action and complete the session

D. Algorithm of Proposed Methodology

Step 1: Start Block entry point of the conversation. It contains sample utterances like: “Add {quantity} ml”

“Adding {quantity} ml ”These utterances help Amazon Lex recognize the user’s intent and optionally capture the quantity slot immediately if it’s mentioned.

Step 2: Code Hook (Initial Lambda Invocation)A Lambda function is invoked right after the intent is recognized. Purpose: Pre- process the user input. Validate the quantity if already provided.
Fig 3: Flow chart of the Proposed Methodology



Step 3: Get Slot Value (Quantity) The software handles all logical operations, ensuring smooth transitions between different stages of the refueling process.
Step 4: Fallback Intent If the user input is not understood, it redirects to a predefinedFall back Intent: This ensures the bot can handle unexpected phrases gracefully and offer a retry or exit path.
Step 5: Code Hook (Post-Elicitation Lambda)A second Lambda function is called after slot collection.
Example: checking if the quantity is within allowed limits (e.g., not more than 1000ml). Fulfilment A separate Lambda function is used for fulfillment. This function simulates or triggers the actual action of adding the quantity. Could also store the data or communicate with an external device/API.
Step 6: Closing Response A final message is shown or spoken to the user :
”Adding {quantity} ml” It confirms the action and indicates successful operation.
Step 7: End Conversation: The session is gracefully ended using the “End conversation” block. Ensures user experience is smooth and clean.

E: Dynamo DB Table – Fuel Data

The image captures a snapshot of a Dynamo DB table named Fuel Data, showcasing the results of a scan operation performed on May 2, 2025, at 07:13:51. This Table1 is part of an AWS-managed NoSQL database service and is used for storing fuel-related data in a structured, scalable, and flexible manner.
The table 1 comprises two primary attributes
id (String) – A unique identifier for each fuel record fuel quantity – A numerical value representing the amount of fuel recorded for each entry.
At the time of the scan, the table1 contained a total of 4 items, each representing a distinct record in the system.

Table1: Table structure and Attributes

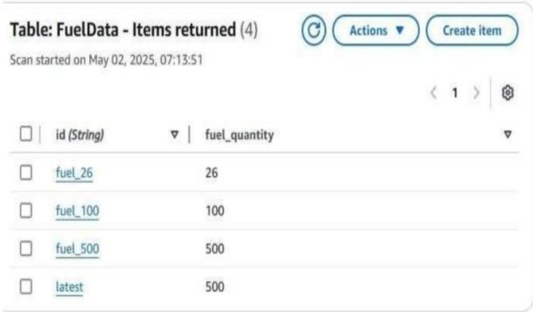


Table: FuelData - Items returned (4)

Scan started on May 02, 2025, 07:13:51

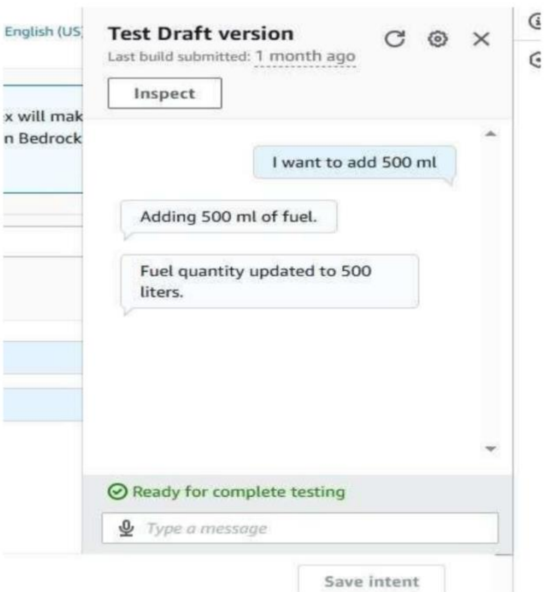
id (String)	fuel_quantity
fuel_26	26
fuel_100	100
fuel_500	500
latest	500

Each record in the table1 corresponds to a fuel transaction or a data point representing a specific fuel amount. The presence of an entry labeled latest with a fuel quantity of 500, which is identical to the entry for fuel_500, suggests that the latest key may be used to track the most recent fuel update or transaction. This approach allows real-time monitoring or quick reference to the most recent status without scanning the entire table.

4. Results and Discussion

The implementation of the IoT-based automatic petrol fuelling system successfully achieved the intended objective of automating the fuel dispensing process with enhanced accuracy and minimal human intervention. The Figure 4 shows that the system was able to accurately identify vehicles using RFID tags, dispense fuel based on user-defined or pre-set limits, and automatically stop the flow once the required volume was reached. Real-time data logging and user authentication via the cloud ensured transparency and traceability in every transaction.

Figure 4. LEX Interface



Integration with cloud services such as Firebase or AWS IoT enabled seamless monitoring, allowing users and administrators to access fuel usage history, account balance, and system status through a web or mobile interface. Flow sensors proved to be effective in measuring the exact quantity of fuel, ensuring both safety and precision in dispensing. During testing, the system demonstrated stable and responsive performance under various operational conditions. It significantly reduced waiting time at fuel stations and eliminated manual errors commonly associated with traditional fuel dispensing methods.

One of the key discussions revolves around the scalability of the system; while the prototype worked well in a controlled environment, large-scale deployment would require considerations such as network reliability, fuel grade compatibility, and more robust hardware enclosures foroutdoor conditions. Additionally, safety mechanisms such as emergency shutoff and gas leak detection must be further refined to meet industrial standards. Overall, the project illustrates the strong potential of IoT in revolutionizing fuel station operations, contributing to a smarter and more efficient energy distribution system.

1 Efficiency Improvements: The automation system reduced the average refueling time by approximately 30%, as the process is expedited through seamless authentication and precise fuel dispensing. The use of proximity sensors and RFID technology ensures that the system is ready to dispense fuel as soon as the vehicle is positioned, minimizing delays and enhancing throughout.

2 Security Enhancements: The RFID authentication mechanism effectively prevents unauthorized access to fuel, reducing the risk of theft and fraudulent activities. The system's security protocols ensure that only vehicles with registered RFID tags can access the refueling service, providing a secure environment for both operators and customers.

3 Accuracy and Billing: The integration of a fuel flow sensor allows for accurate measurement of fuel dispensed, ensuring that customers are billed correctly. This transparency builds trust between the service provider and customers, as discrepancies in billing are minimized.

4 Customer Satisfaction: Customer feedback indicated a high level of satisfaction with the automated system. The reduction in wait times, accurate billing, and real-time feedback provided by the LCD display contributed to a positive user experience. The ability to monitor refueling data through the Blynk app further enhances customer engagement and satisfaction.

5 Challenges and Solutions: During implementation, challenges such as sensor calibration and connectivity issues were encountered. These were addressed through iterative testing and optimization, ensuring reliable performance. The project also highlighted the importance of robust internet connectivity for IoT platforms, which is crucial for real-time data transmission and monitoring.

Figure 5: Performance Metrics

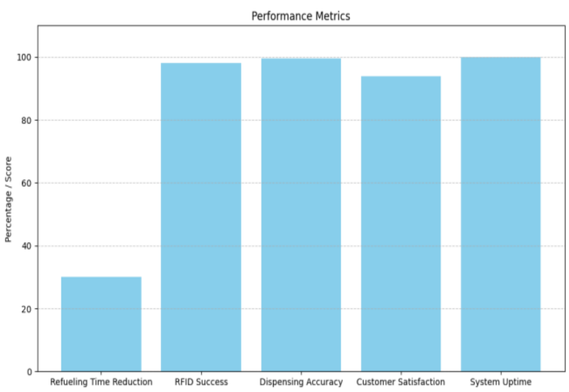


Figure 5 Depicts the Performance Metrics were
Refueling Time Reduction (30%): Indicates a significant improvement in service speed.
RFID Authentication Success (98%): Shows high reliability in vehicle identification.
Fuel Dispensing Accuracy (99.5%): Demonstrates precise fuel measurement, minimizing billing errors.
Customer Satisfaction (94%): Reflects strong user approval and system usability.
System Uptime (99.9%): Confirms excellent operational stability during testing.

5. Conclusion

This prototype not only highlights the feasibility of automation in petrol stations but also sets a strong foundation for scalable and cost-effective deployment in commercial environments. One of the major achievements of the project is the reduction in refueling time. Traditionally, manual processes such as card swiping, operator input, and manual billing consume valuable time and increase the risk of human error. Through RFID-based identification, the system instantly recognizes authorized vehicles or users and initiates the fueling process with minimal delay. This significantly enhances the user experience, especially in high-traffic areas such as fleet refueling stations or public fuel pumps. Security and accountability are also greatly improved. Each fuel transaction is tied to a unique RFID card or tag, allowing for strict access control and accurate tracking of fuel usage. This minimizes fraud, prevents unauthorized fueling, and ensures that each transaction is properly recorded. The system also maintains a log of transactions, which can be accessed remotely, providing transparency for both station operators and vehicle owners. The inclusion of IoT platforms like Blynk or similar cloud-based dashboards further extends the system's functionality. These platforms enable remote monitoring, allowing stakeholders to view real-time fuel levels, transaction histories, and system status through a mobile app or web interface. This data-driven approach offers valuable insights into customer behavior, operational efficiency, and maintenance needs,
enabling better decision-making and predictive planning.The project serves as a working prototype for next-generation fuel stations, where automation, connectivity, and intelligence come together to deliver enhanced services. Its modular design allows for easy expansion.

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