IOT BASED RFID FUEL MACHINE

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ABSTRACT

The proposed project introduces an IoT-enabled RFID fuel dispensing system designed to automate and secure the fueling process. Each vehicle is equipped with a unique RFID tag linked to the owner's account. When the vehicle arrives at the fuel station, the RFID reader authenticates the tag, and the IoT module communicates with a cloud server to verify account details, fuel balance, and transaction history. Once validated, the system allows fuel dispensing and records the transaction in real time. This approach eliminates manual intervention, reduces fuel theft, ensures cashless transactions, and provides centralized monitoring of fuel usage. By integrating RFID technology with IoT, the system enhances efficiency, transparency, and accountability in fuel management, making it highly suitable for smart cities and modern transportation networks.

KEYWORDS: *RFID (Radio Frequency Identification) IoT (Internet of Things) Smart Fuel Dispensing*

INTRODUCTION

Fuel management has always been a critical aspect of transportation and logistics. Traditional fuel dispensing systems often rely on manual intervention, cash-based transactions, and limited monitoring, which can lead to inefficiencies, fraud, and fuel theft. With the rapid advancement of digital technologies, there is a growing need for smarter, automated, and secure solutions to manage fuel distribution.

The integration of **Radio Frequency Identification (RFID)** with the **Internet of Things (IoT)** provides a modern approach to fuel dispensing. In this system, each vehicle is assigned a unique RFID tag linked to the owner's account. When the vehicle arrives at the fuel station, the RFID reader authenticates the tag, and the IoT module communicates with a cloud server to verify account details, fuel balance, and transaction history. Once validated, the fuel is dispensed automatically, and the transaction is recorded in real time.

This project leverages **IoT connectivity** for centralized monitoring, **RFID technology** for secure identification, and **cloud computing** for data storage and analytics. The system ensures transparency, reduces human error, and enables cashless transactions. Moreover, it allows fuel station operators and fleet managers to track consumption patterns, generate reports, and prevent unauthorized usage.

By combining automation, security, and real-time monitoring, the IoT-based RFID fuel machine represents a significant step toward smart infrastructure in transportation. It aligns with the vision of **smart cities**, where efficiency, accountability, and sustainability are key priorities

Beyond individual vehicle owners, this system has significant implications for **fleet management**. Companies operating large numbers of vehicles often struggle with monitoring fuel consumption and preventing misuse. By integrating RFID tags with IoT-based monitoring, managers can track each vehicle's fueling activity in real time, generate detailed reports, and analyze consumption trends. This not only reduces operational

costs but also improves accountability among drivers and staff. Furthermore, the centralized database ensures that all transactions are securely stored and easily retrievable for audits or performance evaluations

LITERATURE SURVEY

Recent advancements in smart fuel management systems have been largely driven by the integration of Internet of Things (IoT) technologies and Radio Frequency Identification (RFID). Chandana *et al.* [1] proposed an intelligent fuel dispensing system that combines RFID authentication with IoT-based monitoring to enable secure and automated fuel transactions. Their approach demonstrates how vehicle identification and fuel dispensing can be streamlined while ensuring transparency through cloud-based systems.

Ramya *et al.* [2] developed an IoT-based automatic petrol fuelling system aimed at reducing human intervention in fuel stations. Their system utilizes embedded controllers to automate the dispensing process, improving efficiency and minimizing manual errors. However, the study mainly focuses on basic automation without incorporating advanced analytical capabilities.

Sable *et al.* [3] presented an RFID-based automated fuel system emphasizing secure user authentication and controlled fuel distribution. The system restricts access to authorized users, enhancing security. Despite its effectiveness, the system faces challenges in handling multiple authentication requests simultaneously and maintaining data accuracy under heavy usage conditions.

Borkar and Patil [4] designed and analyzed a smart IoT-based fuel dispensing system with improved system architecture and performance. Their work focuses on achieving reliable communication between hardware components and cloud platforms, enabling real-time monitoring and scalability for practical applications.

Amulya *et al.* [5] introduced a smart e-fuel station using the ESP32 microcontroller integrated with IoT technology. The system enables real-time monitoring of fuel consumption through connected platforms. However, the implementation introduces complexity and raises concerns regarding data security and system management.

Khandbahale *et al.* [6] proposed an IoT-based automatic fuel pump system using RFID technology to enhance automation and user convenience. The system improves transaction speed and reduces dependency on manual operations. Nevertheless, it lacks advanced features such as predictive analytics and intelligent decision-making.

PROPOSED SYSTEM

The proposed IoT-based RFID fuel machine leverages the ESP32 microcontroller as the central processing unit, chosen for its built-in Wi-Fi and Bluetooth capabilities, which make it ideal for IoT applications. Each vehicle is equipped with a unique RFID tag linked to the owner's account. When the vehicle arrives at the fuel station, the RFID reader scans the tag and authenticates the user.

The ESP32 then communicates with the cloud server to verify account details, fuel balance, and transaction history. Once authentication is successful, the ESP32 activates the fuel pump, and the transaction is recorded in real time. This ensures secure, automated, and transparent fuel dispensing.

Unlike conventional systems that rely on external modules for connectivity, the ESP32 provides integrated wireless communication, reducing hardware complexity and cost.

It manages the RFID reader, controls the fuel pump, and establishes seamless communication with the cloud. The cloud server stores all transaction logs, user accounts, and fuel consumption records, which can be accessed through web or mobile applications. This architecture not only ensures automation but also enables centralized monitoring, allowing administrators to track fuel usage, detect anomalies, and generate detailed reports.

The system is designed with scalability in mind. For example, it can be extended to fleet management applications, where multiple vehicles are monitored under a single account. Managers can analyze consumption patterns, optimize operations, and prevent unauthorized usage. Furthermore, the proposed system supports cashless transactions, reducing dependency on physical currency and enabling digital payments.

IMPLEMENTATION

The implementation of the IoT-based RFID fuel machine begins with the integration of an **ESP32 microcontroller**, chosen for its built-in Wi-Fi and Bluetooth capabilities. The ESP32 acts as the central processing unit, interfacing with the RFID reader, fuel pump, and cloud server. Each vehicle is assigned a unique RFID tag, which is scanned by the RFID reader when the vehicle arrives at the fuel station. The ESP32 processes this input and initiates communication with the cloud server to authenticate the user and verify account details. Once validation is complete, the ESP32 sends control signals to activate the fuel pump, thereby dispensing fuel securely and automatically.

The system is supported by a **cloud-based database**, which stores user accounts, transaction logs, and fuel consumption records. The ESP32 communicates with the cloud using its Wi-Fi module, ensuring real-time synchronization of data. A web or mobile application is developed to provide users with access to their fueling history, balance, and consumption patterns. Administrators can also monitor multiple vehicles, detect anomalies, and generate reports through the same interface. This ensures transparency and accountability in fuel management.

To enhance usability, the system incorporates **cashless transaction support** by linking RFID tags to digital payment accounts. This eliminates the need for physical currency and reduces transaction time. The ESP32 ensures secure communication by using encrypted protocols, thereby protecting user data from unauthorized access. The modular design of the system allows scalability, making it suitable for both individual vehicle owners and fleet management applications.

Finally, the hardware setup includes the RFID reader, ESP32 microcontroller, relay circuits for pump control, and a power supply unit. The software implementation involves programming the ESP32 using Arduino IDE or MicroPython, integrating cloud APIs for data storage, and developing a user-friendly interface for monitoring. The combined hardware and software implementation ensures that the system operates efficiently, securely, and reliably in real-world conditions.

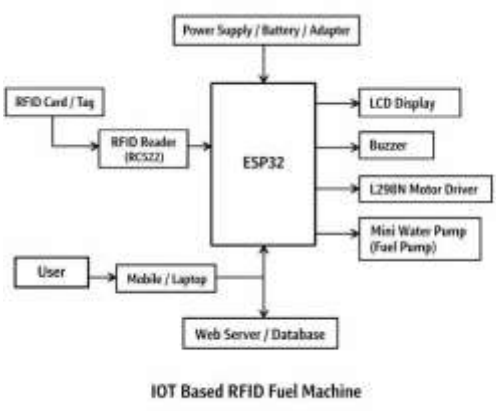

Fig: 1: Block Diagram

The system starts with a User presenting an RFID Card/Tag to the RC522 RFID Reader, which sends the data to the ESP32 microcontroller. The ESP32, powered by a Battery/Adapter, verifies the card and controls the L298N Motor Driver to activate the Mini Water Pump for fuel dispensing. It also updates the LCD Display, triggers a Buzzer for feedback, and logs the transaction to a Web Server/Database, accessible via Mobile/Laptop

HARDWARE IMPLEMENTATION

The hardware implementation of the IoT-based RFID fuel machine begins with powering the system using a battery or adapter connected to the ESP32 microcontroller. The RFID Reader (RC522) is interfaced with the ESP32 through SPI communication, allowing it to read RFID cards or tags presented by the user. Once a valid card is detected, the ESP32 processes the data and sends control signals to the L298N motor driver module. The motor driver then powers the mini water pump, which acts as the fuel pump, dispensing liquid through a plastic pipe or tube. Alongside this, the ESP32 drives an LCD display to show transaction details and activates a buzzer for audio feedback. Using its built-in Wi-Fi, the ESP32 logs transaction data to a web server or database, which can be accessed remotely via a mobile or laptop. Jumper wires are used to establish all necessary connections between modules, ensuring smooth communication and operation of the system.

SOFTWARE IMPLEMENTATION

The software implementation of the IoT-based RFID fuel machine using ESP32 and RC522 focuses on authentication, pump control, and IoT data logging through a web server interface. The ESP32 is programmed in the Arduino IDE or PlatformIO with libraries for RFID (MFRC522), Wi-Fi, and HTTP/MQTT communication. When a user presents an RFID card, the RC522 reader captures the card ID and sends it to the ESP32. The ESP32 checks the ID against a database stored on the web server. If the card is valid, the ESP32 activates the L298N motor driver, which powers the mini water pump to dispense fuel. At the same time, the ESP32 triggers a buzzer for feedback and sends transaction details—such as card ID, time, and fuel dispensed—to the web server via Wi-Fi. The web server acts as the main display interface, allowing users and administrators to monitor logs, manage authentication, and track usage remotely through a mobile or laptop browser. This software design ensures secure authentication, real-time IoT connectivity, and a user-friendly web-based monitoring system

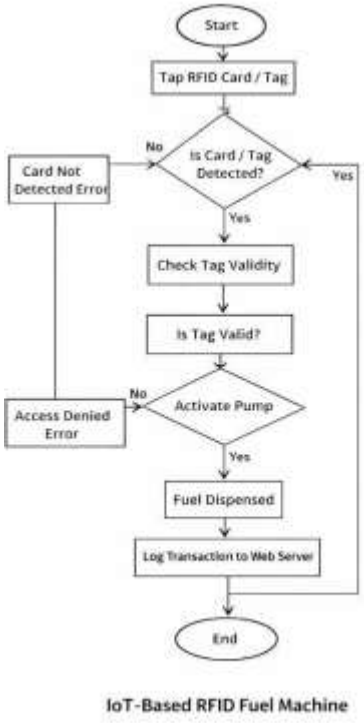

Fig :- Flow chart

CONCLUSION

The IoT-Based RFID Fuel Machine offers a smart, secure, and automated solution for fuel dispensing using RFID authentication and ESP32 microcontroller. By integrating components like the RC522 RFID reader, L298N motor driver, and a mini water pump, the system ensures precise control and efficient operation. The use of a web server for real-time monitoring and transaction logging enhances transparency and remote accessibility. This project not only demonstrates the power of IoT in automating physical systems but also provides a scalable framework for smart fuel management in various sectors.

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