NEXUS ELITE VEHICLE WASH

Project Reference No.: *49S_BE_3611*

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Keywords

MQTT Communication, Automatic Number Plate Recognition (ANPR), Flask Web Application, Smart City Infrastructure, Hybrid Slot Booking System

Introduction:

1. With the rapid increase in urban vehicle population, conventional vehicle washing systems often result in long waiting times, inefficient resource usage, and traffic congestion near service stations. The lack of structured access control and real-time monitoring limits their suitability for modern Smart City environments. To address this, the project proposes an IoT-enabled smart vehicle wash system integrating a web-based platform with embedded hardware for efficient and organized operation. Users can pre-book wash slots online or access the facility through an RFID-based walk-in system, ensuring flexibility and convenience.
2. A Flask-based web application handles user interaction, booking, and monitoring, while an ESP32 microcontroller controls hardware components such as sensors, relays, and gate mechanisms. Communication between the backend and hardware is achieved using the MQTT protocol for real-time operation. The system also incorporates camera-based Number Plate Recognition (ANPR) for secure vehicle authentication. All operational data, including bookings and wash activity, are stored in a database for monitoring and analysis. The proposed system aims to reduce congestion, optimize resource utilization, and enhance user experience, supporting Smart City initiatives through efficient and automated service management.

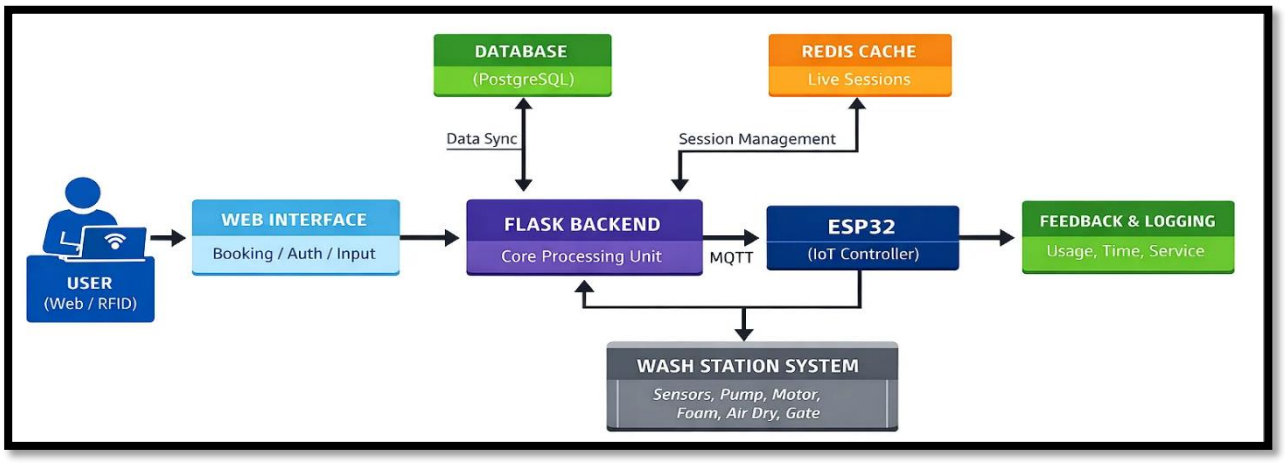


Figure 1: Overview of Proposed Nexus Elite Vehicle Wash System

Objectives:

1. Web-Based Hybrid Slot Booking System
2. Automatic Number Plate Recognition (ANPR) Based Entry
3. RFID-Based Access Authentication
4. Real-Time Monitoring and Feedback
5. Reduced Waiting Duration for Users
6. Real Time Database logging
7. Significant Contribution to Smart city initiative

Methodology:

The proposed system is designed and implemented using an integrated IoT-based architecture that combines a Flask web-based platform with embedded hardware to enable an efficient and automated vehicle washing process.

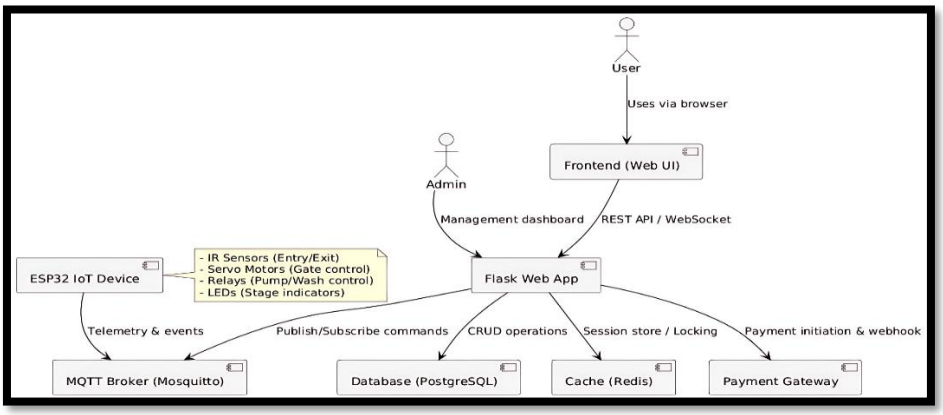


Figure 2: Overall Architecture of the Proposed & Implemented System

The Overall architecture of the system is shown in Figure 2. It comprises a Flask-based web application acting as the central controller for user interaction, booking, and monitoring. The backend communicates with an MQTT broker for real-time data exchange with the ESP32 microcontroller, which controls sensors, relays, servo motors, and indicators. A database stores user and operational data, while an integrated payment gateway enables secure transactions.

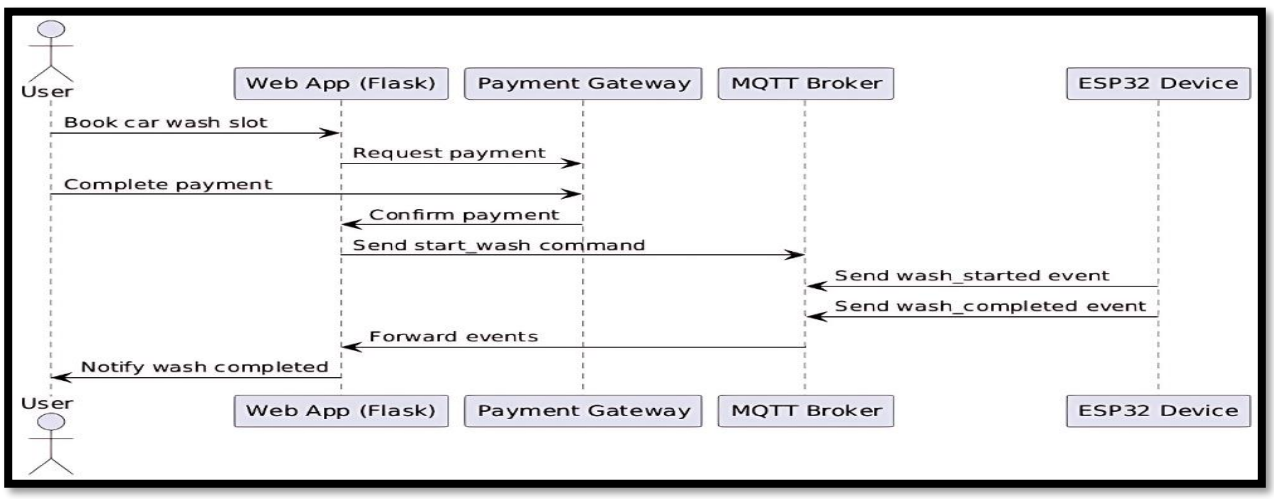
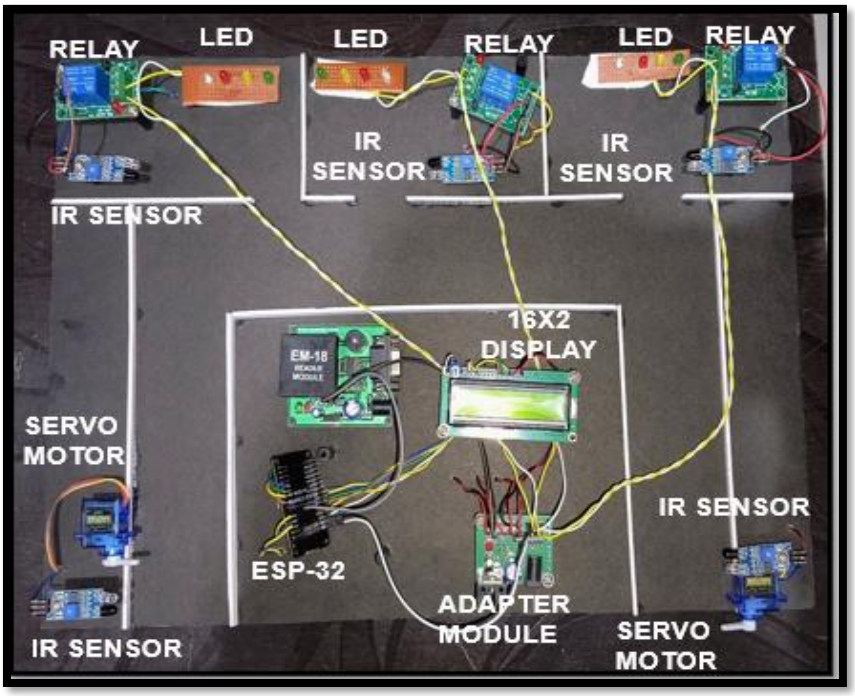


Figure 3: Operational Workflow of the Project

The operational workflow of the system is illustrated in Figure 2. The user initiates the process through web booking or RFID access, followed by payment processing and authentication using RFID or ANPR. Once verified, the Flask backend sends a command to the ESP32 via MQTT to start the washing process. The ESP32 controls pumps, relays, and gate mechanisms, while real-time updates are sent to the backend. Upon completion, the system logs the data and notifies the user, ensuring a seamless automated workflow.

Result and Conclusions:



The Implemented system successfully demonstrates a fully functional IoT-enabled smart vehicle wash solution integrating a web-based platform with embedded hardware. The implementation of hybrid access (online booking and RFID), along with ANPR-based authentication, ensures secure and flexible user interaction. Real-time communication between the Flask backend and ESP32 using MQTT enables efficient control and monitoring of the washing process.

The system effectively achieves reduction in waiting time, improved wash bay utilization, and optimized resource usage, aligning with Smart City objectives. The developed prototype validates the feasibility of deploying a scalable, cost-effective, and user-friendly solution for modern urban vehicle service management.

Project Outcome & Industry Relevance:

The proposed project demonstrates a fully functional IoT-based smart vehicle wash system integrating web technologies with embedded hardware. It enables structured access control through online booking and RFID-based entry, reducing waiting time and improved operational efficiency. Real-time communication between the backend and hardware ensures automated and synchronized operation, while ANPR-based authentication enhances security and reliability. The system successfully achieves efficient wash bay

utilization, seamless user interaction, and real-time monitoring, validating its effectiveness as a practical and deployable solution for modern urban service management.

Working Model vs. Simulation/Study:
The project involves the development of a fully functional working model integrating both hardware and software components. The system is implemented using an ESP32 microcontroller, sensors, relays, and gate mechanisms, along with a Flask-based web application for user interaction and control. Real-time communication is established using the MQTT protocol, enabling seamless coordination between the backend and hardware.

The developed prototype operates in real-time and has been successfully tested under practical conditions, demonstrating its feasibility as a deployable solution. This confirms that the project is not a simulation or theoretical study, but a complete working system.

Project Outcomes & Learnings:

1. Developed a fully functional IoT-based smart vehicle wash system integrating web, backend, and hardware components.
2. Achieved automated access control and real-time operation using RFID, ANPR, and MQTT communication.
3. Gained experience in integrating software with embedded hardware for real-time applications.
4. Improved skills in system design, debugging, and practical problem-solving

Future Scope:

The future scope of this project includes:

1. Integration of AI-based demand prediction for dynamic slot allocation**.**
2. Development of a mobile application for enhanced accessibility and user experience.
3. Integration with digital payment UPI-based transactions.
4. Expansion to multi-location deployment and centralized monitoring.