

Smart Vehicle Service Management System with Automated Parking Allocation Using Full-Stack Web Technologies

Ms. Surabhi KS¹, Vignesh Kumar R²

¹Professor, Department of Computer Applications, Nehru College of Management, Coimbatore, Tamil Nadu, India.

ksurabhi454@gmail.com

²Student of II MCA, Department of Computer Applications, Nehru College of Management, Coimbatore, Tamil Nadu, India.

vkvignesh46@gmail.com

ABSTRACT

The rapid expansion of the automobile industry has significantly increased the operational complexity of vehicle service centers. Service centers are required to manage multiple activities simultaneously, including customer handling, service scheduling, technician coordination, spare parts inventory control, billing operations, and parking space management. Traditional service center management approaches often rely on manual documentation and fragmented digital tools, which lead to inefficient workflow execution, data inconsistency, delayed service delivery, and poor resource utilization.

This research presents the design and implementation of a Smart Vehicle Service Management System integrated with an Automated Parking Slot Allocation mechanism to improve service center efficiency and operational transparency. The proposed system provides a centralized digital platform for managing customer records, vehicle service history, technician assignments, real-time inventory updates, automated billing generation, and intelligent parking slot distribution. By leveraging full-stack web technologies, the system ensures scalability, security, and real-time accessibility. The automated parking module dynamically monitors slot availability and allocates parking resources to incoming vehicles, thereby reducing congestion and improving spatial utilization. The implementation of this integrated solution demonstrates enhanced workflow automation, reduced service processing time, and improved customer satisfaction.

KEYWORDS — vehicle service automation, smart parking management, full stack web systems, resource optimization, service center digitalization

INTRODUCTION

Modern automobile service centers operate in highly dynamic environments characterized by fluctuating service demand, limited physical resources, and the necessity for rapid service execution. With the continuous growth in vehicle ownership, service centers face increasing pressure to maintain service quality while ensuring operational efficiency.

Traditional management practices involve manual data entry, paper-based service tracking, and unstructured parking management. These methods create challenges such as delayed technician assignment, inefficient inventory monitoring, inaccurate billing calculations, and parking congestion within service premises. The lack of integration between digital service records and physical infrastructure management further intensifies operational bottlenecks.

Digital transformation through intelligent management systems has emerged as a critical requirement for improving service center productivity. A comprehensive system that integrates workflow automation with parking space optimization can significantly enhance operational performance.

The proposed Smart Vehicle Service Management System aims to address these challenges by providing a unified web-based platform capable of managing both administrative and physical resources efficiently.

PROBLEM STATEMENT

Service centers frequently encounter issues that affect overall productivity and customer experience. These challenges include:

- Fragmented customer and vehicle data management
- Inefficient technician workload distribution
- Lack of real-time visibility into spare parts inventory

- Congested parking areas due to absence of automated slot allocation
- Delayed service completion caused by manual coordination
- Billing inaccuracies resulting from human calculation errors

Such operational limitations highlight the need for an integrated digital solution that can streamline service workflows and optimize resource utilization.

SYSTEM OBJECTIVES

The primary objectives of the proposed system are:

- To develop a centralized platform for managing vehicle service operations
- To automate technician assignment based on availability and workload
- To implement real-time monitoring and management of spare parts inventory
- To design an automated parking slot allocation mechanism for optimal space utilization
- To generate accurate and transparent digital invoices
- To enhance service execution speed and customer satisfaction

PROPOSED SYSTEM ARCHITECTURE

The system follows a multi-layered architecture consisting of presentation, application, security, and data management layers.

The presentation layer is implemented using React.js, enabling responsive and interactive user interfaces. Users such as administrators and technicians interact with the system through web dashboards that provide real-time service status updates.

The application layer consists of RESTful APIs responsible for handling service requests, technician allocation logic, parking slot management operations, and billing computations.

A dedicated security layer ensures role-based authentication and authorization using JSON Web Tokens. This mechanism protects sensitive operational data and restricts unauthorized system access.

The data management layer utilizes MongoDB for storing structured and semi-structured service information. The database design supports scalability and efficient query execution.

METHODOLOGY

The system workflow is organized into multiple sequential stages.

Initially, customer and vehicle details are registered in the system database. Service requests are then created with detailed descriptions of required maintenance tasks.

The technician allocation module evaluates current technician workload and assigns tasks accordingly to ensure balanced resource utilization.

Simultaneously, the automated parking module checks slot availability and dynamically assigns parking space to incoming vehicles. Slot status is continuously updated to reflect vehicle movement within the service center.

During the servicing process, spare parts consumption is recorded and inventory levels are updated automatically. Upon service completion, the billing module generates itemized invoices based on labor charges and parts usage.

Finally, service records are archived for performance analysis and future reference.

AUTOMATED PARKING ALLOCATION MECHANISM

Efficient parking space management plays a vital role in ensuring smooth operational workflow within automobile service centers, especially during peak service hours. The proposed system incorporates an Automated Parking Allocation Mechanism designed to optimize parking slot utilization and minimize vehicle congestion within the service facility.

The parking management module maintains a real-time representation of parking slot occupancy by continuously tracking slot status through database state monitoring. Each parking slot is associated with a unique identifier and status attribute indicating whether the slot is available, reserved, or occupied. This structured representation enables the system to perform dynamic parking allocation decisions with minimal computational delay.

When a vehicle arrives at the service center, the system initiates an allocation procedure that evaluates the availability of parking slots based on predefined priority parameters such as proximity to service bays, slot accessibility, and current occupancy distribution. The allocation algorithm identifies the most suitable slot and assigns it to the incoming vehicle, thereby reducing unnecessary vehicle movement and optimizing spatial efficiency.

During the servicing process, the assigned parking slot remains reserved within the system to prevent allocation conflicts. Upon completion of the service and vehicle

exit confirmation, the system automatically updates the slot status to available. This real-time synchronization ensures accurate visibility of parking resources for subsequent service requests.

The implementation of this automated mechanism significantly reduces manual parking coordination efforts typically performed by service center staff. Additionally, it improves vehicle flow management, minimizes waiting time, enhances safety within the service premises, and contributes to faster service turnaround. By integrating intelligent parking allocation with service workflow automation, the proposed system provides a comprehensive approach to resource optimization in modern vehicle service environments.

PERFORMANCE ANALYSIS

The performance evaluation of the proposed Smart Vehicle Service Management System with Automated Parking Slot Allocation was conducted to analyze its effectiveness in improving operational efficiency and service quality within automobile service centers. The system was assessed based on multiple performance indicators such as service processing time, parking space utilization, inventory management accuracy, billing transparency, and overall customer satisfaction. The implementation of automated service request handling significantly reduced the average time required for task allocation and service initiation. By eliminating manual coordination between administrators and technicians, the system enabled faster workflow execution and minimized service delays. The intelligent technician assignment mechanism ensured balanced workload distribution, which contributed to improved productivity and reduced idle time.

The automated parking allocation module demonstrated notable improvements in parking space management. Real-time monitoring of slot availability enabled efficient vehicle placement, thereby reducing congestion within the service premises. This optimized spatial utilization not only improved vehicle movement but also reduced waiting time for customers during peak service hours.

Inventory tracking performance was enhanced through real-time synchronization of spare parts usage data. The system provided accurate visibility into stock levels, reducing the risk of unexpected shortages and enabling timely procurement decisions. Additionally, automated digital billing ensured precise calculation of service charges and spare parts costs, thereby improving financial transparency and minimizing human computation errors.

Overall, the integration of workflow automation and intelligent resource management resulted in measurable improvements in service reliability, operational consistency, and customer experience. The proposed system demonstrates strong potential for practical deployment in modern service centers seeking to adopt digital transformation strategies.



Fig. 1. Comparison of Service Processing Time Reduction and Parking Slot Utilization Improvement After System Implementation

FUTURE SCOPE

The proposed Smart Vehicle Service Management System provides a strong foundation for further technological enhancements and scalability improvements. With the rapid evolution of intelligent transportation systems and smart infrastructure solutions, several advanced features can be incorporated to enhance the functionality, efficiency, and adaptability of the system in real-world environments.

One of the major future enhancements involves the integration of Internet of Things (IoT) sensors for real-time parking space monitoring. Sensor-based detection mechanisms can automatically identify vehicle presence and update slot occupancy status without manual intervention. This will significantly improve parking allocation accuracy and reduce dependency on administrative monitoring.

Another important direction for future development is the implementation of machine learning and predictive analytics techniques. By analyzing historical service data, customer behavior patterns, and technician performance metrics, the system can estimate service completion time, recommend optimal technician allocation strategies, and predict spare parts demand. Such intelligent decision-support capabilities can further improve service efficiency and operational planning.

The development of dedicated mobile applications can also enhance user accessibility and convenience. Customers may be able to book service appointments remotely, receive real-time notifications regarding service progress, view digital invoices, and track parking slot allocation through mobile interfaces. This

will improve customer engagement and reduce waiting time at service centers.

In addition, cloud-based deployment of the system can enable centralized data management and support multi-branch service center operations. Cloud infrastructure will provide scalability, high availability, data backup mechanisms, and remote accessibility for administrators and technicians across different geographical locations. Future research may also explore integration with automated payment gateways, advanced data visualization dashboards, and smart vehicle communication systems. These enhancements will contribute to transforming conventional service centers into fully digitized and intelligent service ecosystems capable of adapting to emerging technological trends.

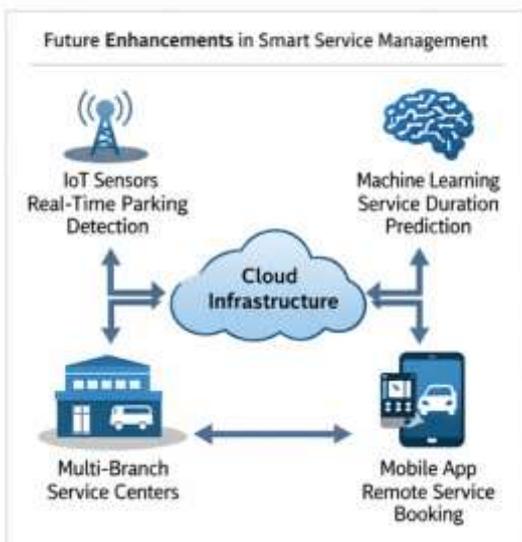


Fig. 2. Conceptual Model of Future Improvements Using IoT, Cloud and Mobile Technologies

CONCLUSION

The proposed Smart Vehicle Service Management System with Automated Parking Slot Allocation presents an effective and scalable digital solution for addressing the operational challenges faced by modern automobile service centers. With the increasing volume of vehicles requiring periodic maintenance and repair services, traditional manual management approaches are no longer sufficient to ensure efficient coordination of service activities and optimal utilization of available resources.

The integration of workflow automation within the service center environment enables systematic handling of customer registration, service request processing, technician task allocation, inventory monitoring, and billing operations. By minimizing human intervention in repetitive administrative tasks, the system

significantly reduces the probability of data entry errors, service delays, and miscommunication between different operational units.

A key contribution of the proposed system is the implementation of an automated parking slot allocation mechanism that enhances spatial efficiency within service premises. The dynamic monitoring of parking slot availability and intelligent assignment of vehicles to appropriate slots helps in reducing congestion, improving vehicle movement, and ensuring better management of limited physical infrastructure. This feature directly contributes to faster service turnaround time and improved customer convenience.

Furthermore, the adoption of modern full-stack web technologies ensures that the system remains scalable, secure, and accessible across multiple devices and operational environments. The modular architecture of the system allows for seamless integration of additional functionalities such as predictive analytics, mobile service booking, and cloud-based deployment in future implementations.

Overall, the proposed solution demonstrates how digital transformation can significantly improve service center productivity, operational transparency, and customer satisfaction. By combining administrative automation with intelligent physical resource management, the system provides a comprehensive technological framework capable of supporting real-world service center requirements and adapting to evolving industry demands.

REFERENCES

- [1] R. S. Pressman and B. R. Maxim, *Software Engineering: A Practitioner's Approach*, 8th ed. New York: McGraw-Hill, 2015.
- [2] I. Sommerville, *Software Engineering*, 10th ed. Boston: Pearson, 2016.
- [3] M. Fowler, *Patterns of Enterprise Application Architecture*. Boston: Addison-Wesley, 2003.
- [4] E. Gamma, R. Helm, R. Johnson, and J. Vlissides, *Design Patterns: Elements of Reusable Object-Oriented Software*. Boston: Addison-Wesley, 1995.
- [5] M. Richardson, *Getting Started with MongoDB*. Sebastopol, CA: O'Reilly Media, 2013.
- [6] A. Banks and E. Porcello, *Learning React: Functional Web Development with React and Redux*. Sebastopol, CA: O'Reilly Media, 2017.
- [7] L. Richardson and M. Amundsen, *RESTful Web APIs*. Sebastopol, CA: O'Reilly Media, 2013.
- [8] N. M. Josuttis, *SOA in Practice: The Art of Distributed System Design*. Sebastopol, CA: O'Reilly Media, 2007.

- [9] H. Chen, L. Li, and K. Chen, “Smart parking systems: A survey,” *IEEE Access*, vol. 8, pp. 45634–45650, 2020.
- [10] S. Revathi and T. Dhulipala, “Vehicle service management system using web technologies,” *International Journal of Computer Applications*, vol. 182, no. 12, pp. 25–30, 2019.
- [11] P. S. Reddy and V. Krishna, “Cloud-based vehicle maintenance management framework,” *International Journal of Engineering Research and Technology*, vol. 9, no. 5, pp. 112–118, 2020.
- [12] J. Nilsson and A. Svensson, “IoT-based intelligent parking allocation mechanism,” *International Journal of Smart Technology*, vol. 4, no. 2, pp. 65–72, 2021.
- [13] T. Erl, *Cloud Computing: Concepts, Technology and Architecture*. Upper Saddle River, NJ: Prentice Hall, 2013.
- [14] S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed. Boston: Pearson, 2021.
- [15] K. Schwaber and J. Sutherland, *The Scrum Guide*. Boston: Scrum.org, 2020.