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Design and Implementation of a Web-Based Car Park Access System

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Abstract
The growing complexity of traffic and parking management at event venues emphasizes the importance of automated systems that improve efficiency and customer experience. This study introduces PARKACCESS, a web-based car park access solution that automates parking slot reservations, digital payments, and access control. Built using the Waterfall methodology, the system was created in stages, from requirements analysis to deployment, with React.js for the frontend, Express handling backend logic, and MongoDB managing data storage. PARKACCESS provides two major user roles: attendees and event managers, allowing for authentication, slot reservation, event creation, real-time monitoring, and secure payment processing. The technology replaces manual, error-prone parking procedures with a centralized platform that improves coordination, minimizes traffic, and streamlines data management. Testing results show significant improvements in parking flow, slot utilization, and overall user satisfaction. This solution contributes to the digital transformation of parking operations in Nigeria's event industry and demonstrates the growing potential of smart infrastructure in urban environments.

Keywords: Web-based, Park access, Centralized, Data management, and Real-time

1. Introduction

The provision of smart and efficient parking systems is becoming increasingly critical in urban cities, especially in countries experiencing rapid population growth and motorization. As urbanization grows faster, the demand for structured infrastructure such as road networks and parking spaces also rises. According to the United Nations (2018), over 55% of the world's population lived in urban areas as of 2018, with that number expected to grow to 68% by 2050. This increase places significant pressure on city infrastructure and event-based venues, many of which lack the necessary systems to handle high volumes of vehicular traffic efficiently.

In Nigeria, and many developing countries, event centers often experience chaos in managing parking spaces during large gatherings. The absence of organized parking facilities results in congestion, delays, miscommunication, and even conflict among drivers. Ahmed (2017) emphasizes that solving parking-related issues is not just about increasing parking space but about integrating smart, efficient systems to manage them. Traditional manual systems are often reliant on physical tickets, cash payments, and human intervention are bound by inefficiencies, human error, and operational bottlenecks. This creates a frustrating experience for both attendees and event managers, highlighting the need for innovation in this sector.

Technological advancements have made it possible to automate and digitize various urban services, including transportation and parking. A well-designed digital parking system can enable real-time monitoring of available spaces, reservations, automated payments, and efficient access control. These features enhance the attendee experience, reduce operational risks, and support effective decision-making for facility managers. Web-based systems, particularly, offer accessibility and centralized data tracking, helping event organizers manage resources with greater accuracy and speed (Benelli & Pozzebon, 2013)

PARKACCESS, the system proposed in this study, is a web-based parking reservation and access control platform tailored for event centers. It aims to provide an alternative to the existing manual system by offering a centralized solution where event attendees can search for parking spaces, reserve slots in advance, make secure payments, and receive validated e-tickets for entry. Event center managers, on the other hand, gain administrative tools to monitor slot usage, track transactions, and manage bookings in real-time. This digital intervention is designed not only to streamline parking operations but to improve accountability, transparency, and customer satisfaction.

With the rise of digital adoption and mobile

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penetration in Nigeria, systems like PARKACCESS align with broader smart-city goals and offer scalable solutions that can be replicated across various event facilities. As more cities turn toward digital transformation, the need for structured and intelligent systems that reduce friction and enhance service delivery becomes even more pressing (Mehta, 2019). The successful implementation of a system like PARKACCESS could serve as a model for solving similar mobility and infrastructure challenges in urban environments.

2. Related Works

Parking systems integrated with Information Technology (IT) are designed to streamline parking operations by linking human interactions, assigned tasks, and the application of automated systems (Benelli & Pozzebon, 2013). The human component includes end-users such as drivers and attendants who input data or respond to system feedback, while the task and application layers handle data processing, decision-making, and system responses. Despite advances in automation, human oversight remains necessary for initiating and completing various parking-related activities.

Several studies have explored smart parking systems with varying levels of digital integration and technological sophistication. Gu, Lo, and Niemegeers (2012) developed a wireless sensor network-based parking system that detects and transmits real-time data on parking occupancy. Their system employed embedded sensors to communicate slot availability to users, thereby minimizing the time spent searching for available parking and reducing traffic congestion. Similarly, Khanna and Anand (2016) introduced an IoT-based smart parking system using Arduino boards and mobile applications to notify users of available parking spaces. Their study demonstrated how microcontroller-based solutions can effectively reduce manual intervention and enhance urban parking efficiency.

Wafa and Zeba (2018) designed a digital payment integration system for car parks to replace outdated manual cash handling methods. Their system allowed users to complete parking transactions via mobile devices and receive e-tickets linked to payment confirmations. This contributed to transparency in revenue collection and improved the user experience through automation. In another study, Maddock and Calcutt (2015) highlighted the role of Intelligent Transportation Systems (ITS) in automating urban parking, including the use of digital platforms to track usage trends, provide analytics, and manage parking reservations.

More recently, Kabir, Singh, and Gupta (2015) emphasized the importance of user-friendly interfaces in online parking systems. Their work explored how usability factors such as system responsiveness, simple navigation, and real-time updates influence user adoption and satisfaction. Their findings revealed that a poor interface design can affect the benefits of a technically sound parking platform, underscoring the need for inclusive design in parking software development.

Additionally, Ndunda, Okoro, and Wanjala (2015) examined the implementation of electronic parking fee collection systems using number plate recognition technologies. Their solution was particularly effective in public car parks, where fast identification and authorization reduced queues and manual errors. The system also reduced fraud by linking parking entries directly to authorized vehicle plates, a feature now being adopted in modern smart cities.

In Nigeria, Asianuba and Aliyu (2023) developed an improved IoT smart parking system targeted at densely populated urban centers. Their research addressed limitations in previous models by incorporating solar-powered sensors and GSM-based communication, ensuring functionality in areas with inconsistent internet or electricity supply. Their findings validate the viability of smart parking models in emerging economies, where infrastructure limitations require innovative adaptations.

These existing works provide a foundation for the development of PARKACCESS, the web-based parking reservation and access control system proposed in this study. While previous systems primarily focus on public car parks, PARKACCESS is tailored for event centers, integrating advance reservation, e-ticket validation, and real-time monitoring into one centralized platform. This specialization addresses the high-pressure, time-sensitive nature of parking during events, offering a unique contribution to the body of knowledge in smart parking solutions.

3. System Analysis and Design

3.1 Methodology

This study adopted the Waterfall model as its development methodology. This approach follows a linear and sequential flow, moving through defined phases: requirements gathering, system design, implementation, testing, deployment, and maintenance. Each phase must be completed before the next begins, ensuring that outputs of one serve as inputs to the next. Bi et al. (2021) and Hamidi & Abid (2022) have noted that this model is well-suited for projects with stable requirements, because its structured nature and clearly defined deliverables minimize ambiguity and rework. Furthermore, a recent simulation study (Saravanos & Curinga, 2023) demonstrates how Waterfall's predictability aids in estimating project timelines when resource levels are well understood. The methodology was chosen for its advantages in documentation, reliability, and progress tracking, ensuring that all system features were planned from the start, thereby avoiding scope expansion and false starts.

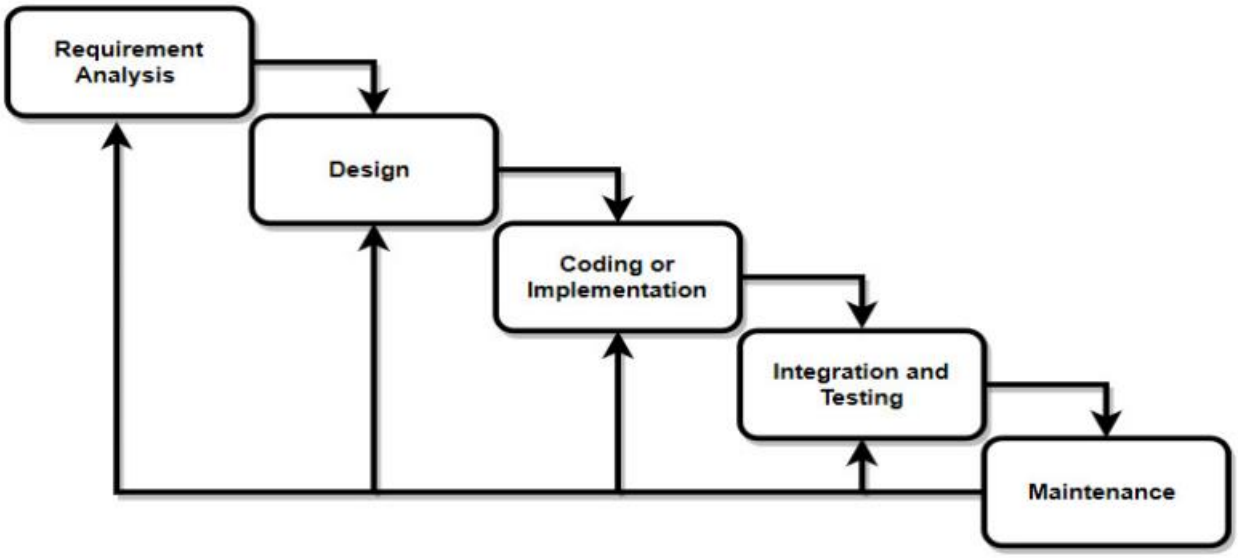

Figure 1: Waterfall development model

3.2 Analysis of the Existing System

The current system used by most event centers in Nigeria for parking is largely manual and inefficient. Attendees arrive without prior knowledge of parking availability, leading to congestion and confusion. Parking attendants often issue tally numbers or tickets by hand, which introduces delays and errors. Payments are collected in cash, making financial tracking difficult and prone to leakage. There is no real-time system for slot monitoring or historical data analysis, which limits the ability of event centers to optimize their operations or plan for high-traffic events.

3.2.1 Drawbacks of the Existing System

Several issues plague the traditional parking systems. There is no platform for real-time availability updates or reservations, making it difficult for attendees to plan. Manual ticketing processes are prone to errors and fraud, and there is no proper documentation or accountability. Event managers struggle to track financial transactions and monitor slot usage. Additionally, the lack of digital tools contributes to long queues at entry points, slow vehicle movement, and a generally frustrating experience for both event staff and guests. These issues highlight the urgent need for an automated solution.

3.3 Analysis of the Proposed System

The proposed system, PARKACCESS, is a web-based application designed specifically for managing parking at event centers. It provides a centralized platform where attendees can search for and book parking slots in advance. The system generates digital e-tickets for entry validation and allows event managers to create, edit, or remove listings of available parking spaces. It also provides real-time slot monitoring, transaction tracking, and analytics dashboards. By digitizing these processes, PARKACCESS offers a more reliable, convenient, and efficient alternative to manual systems, enhancing both operational control and user experience.

3.3.1 Benefits of the Proposed System

PARKACCESS addresses the shortcomings of manual systems by introducing advanced features such as digital reservations, e-ticketing, and real-time monitoring. Event attendees benefit from a stress-free parking experience through pre-booking and seamless entry. Event center managers can track revenue, monitor bookings, and make informed decisions using data insights. The system reduces cash handling, minimizes fraud, and improves customer satisfaction. Furthermore, it eases congestion at entrances, ensures smoother vehicle flow, and promotes transparency through digital transaction records.

3.4 Requirement Specification

The requirements of the system are divided into functional and non-functional categories. Functional requirements include user authentication, parking lot listing, search and reservation, e-ticket generation, and booking history. The system must support both event attendees and event managers, with specific permissions and features for each. For instance, attendees can reserve slots and view their history, while managers can manage listings and monitor analytics. Non-functional requirements include user-friendly interface design, responsive layout across devices, scalability to handle large numbers of users and bookings, and strong security measures like encryption, role-based access, and secure payment gateways.

3.5 System Design

The system uses a client-server architecture, where users interact via web browsers and all data is managed centrally. The design includes separate user interfaces for attendees, event center managers, and validation staff. Core data entities like users, parking lots, bookings, and payments are managed in a structured database to prevent conflicts and ensure timely updates. To support accurate booking confirmation and access validation, the system uses validation state

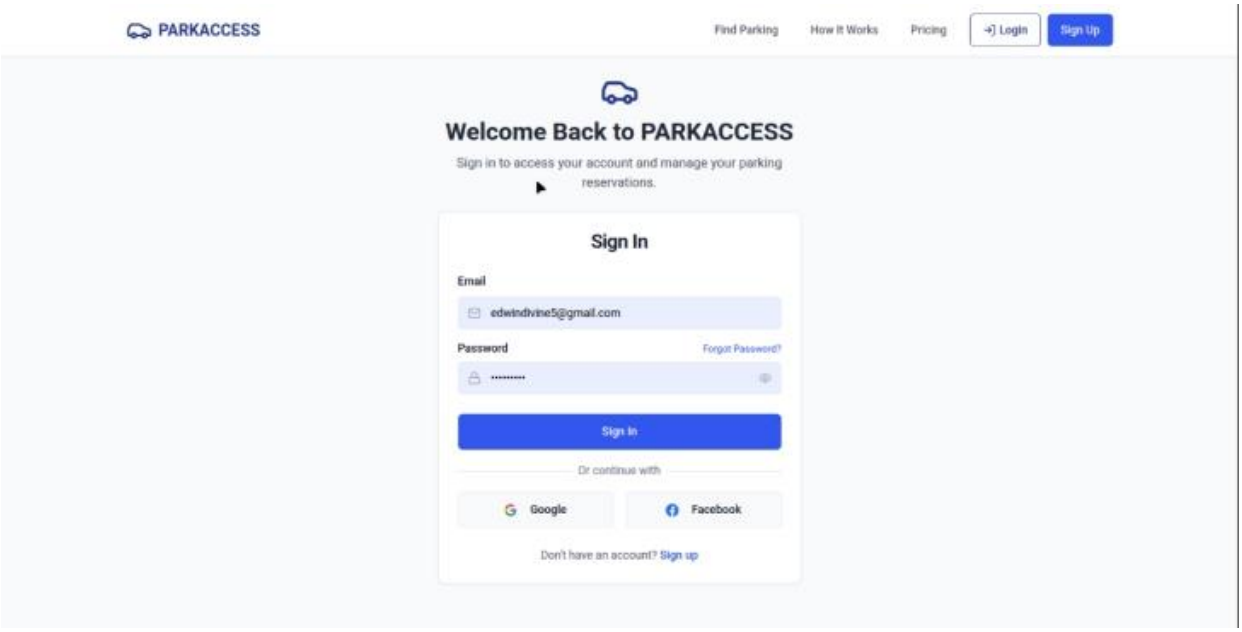

Figure 1: Sign up page

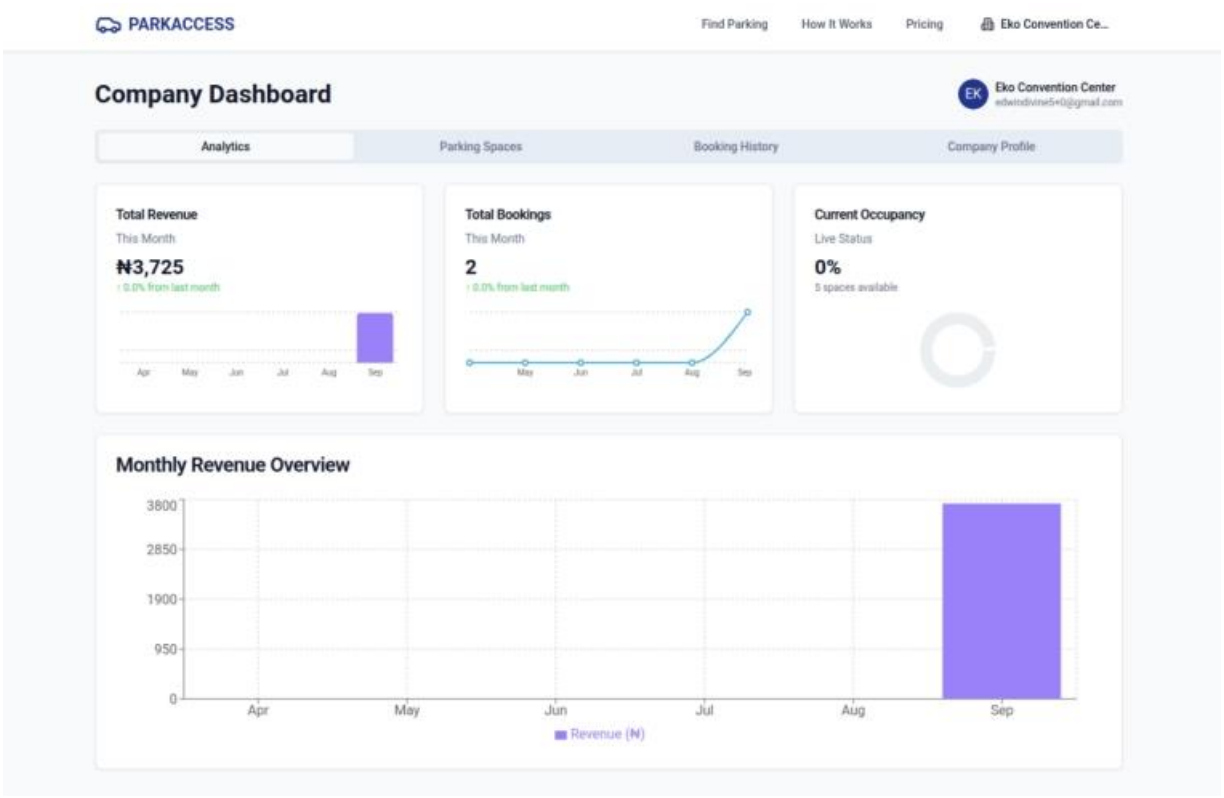

Figure 2: Event center dashboard

checks, a technique aligned with the approach of Knežević et al. (2025). Architectural diagrams, use case models, and flowcharts depict user interaction flows from registration through booking and access validation.

3.5.1 Database Design

MongoDB, a NoSQL database, was chosen for flexibility and scalability. It includes collections for users, parking lot owners, parking spaces, reservations, and payments. These collections allow the system to store and retrieve data efficiently while ensuring fast access to reservation history and transaction logs. The design supports real-time updates, ensuring that users cannot double-book the same slot. It also facilitates secure storage of user credentials and payment

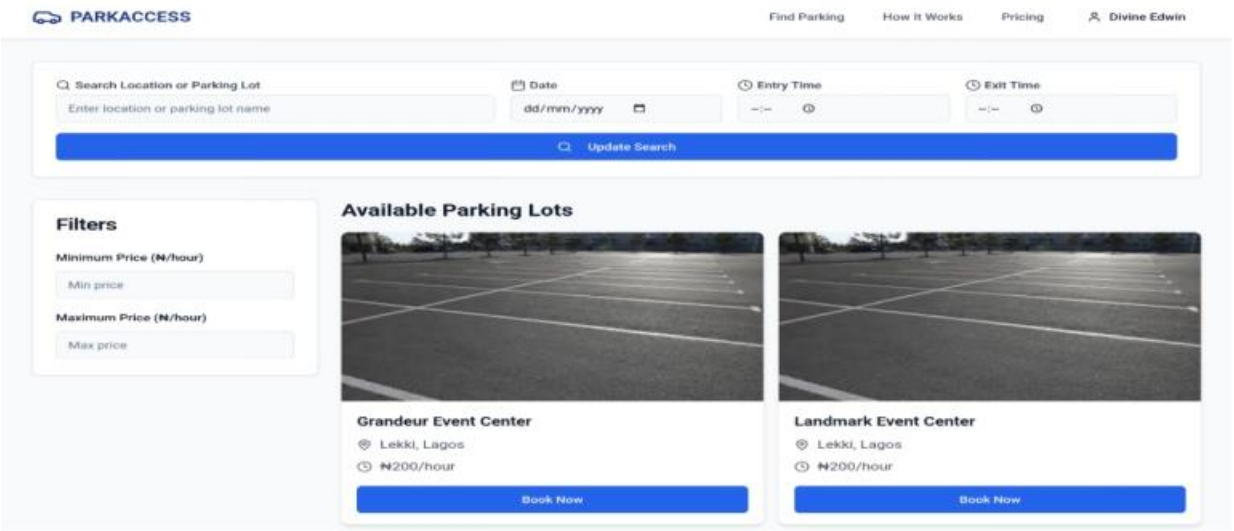

Figure 3: Find parking lot

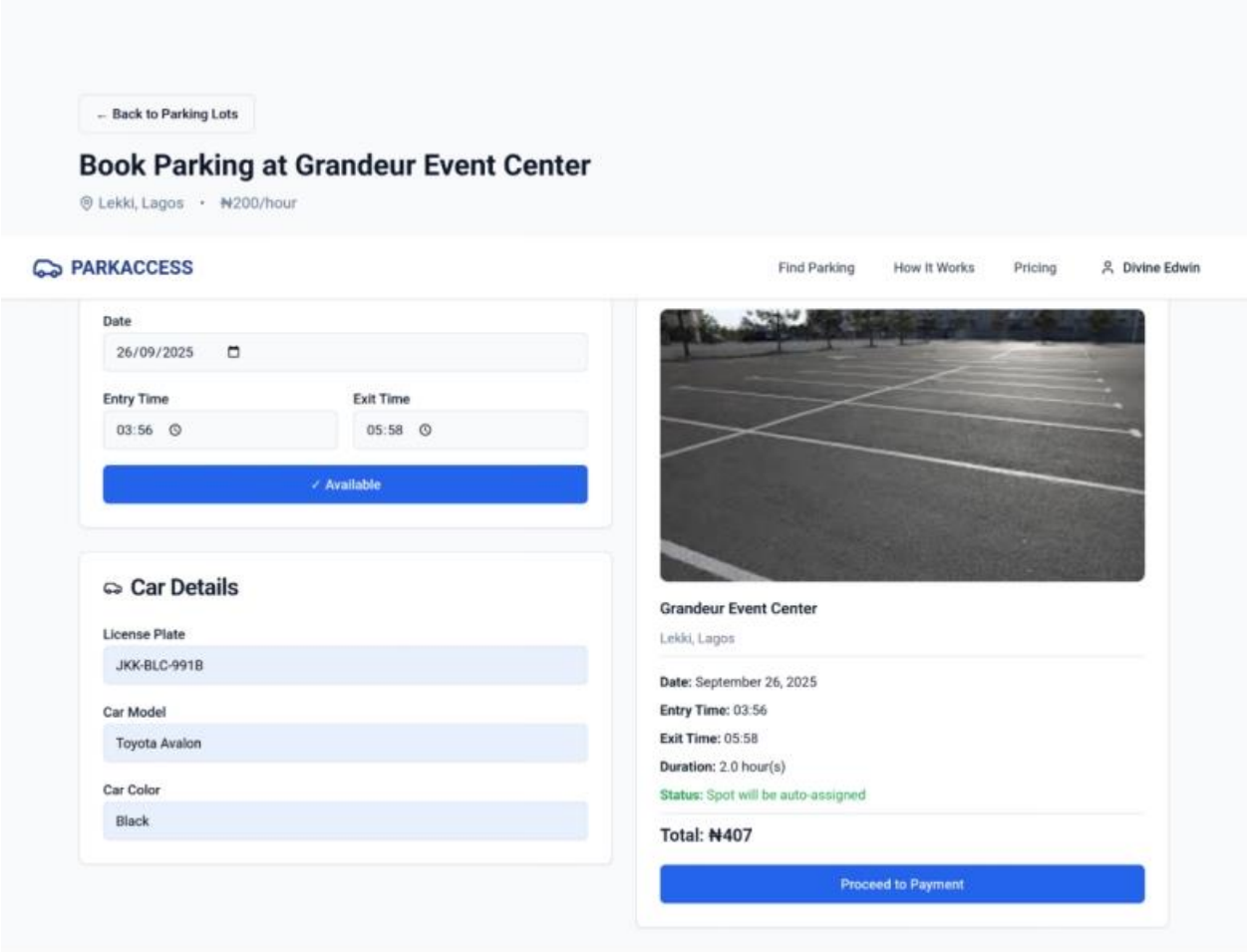

Figure 4: Booking

references, forming the backbone of the system's integrity and reliability.

3.6 Programming Languages and Development Tools

The frontend of PARKACCESS was built using HTML5, CSS, Typescript, and React.js to ensure a modern, responsive, and accessible user interface. React's component-based structure enabled dynamic updates and efficient rendering of key features like slot search and real-time availability. On the backend, Node.js and Express.js were used to handle server-side logic, API routing, and authentication processes. MongoDB served as the database. The system was

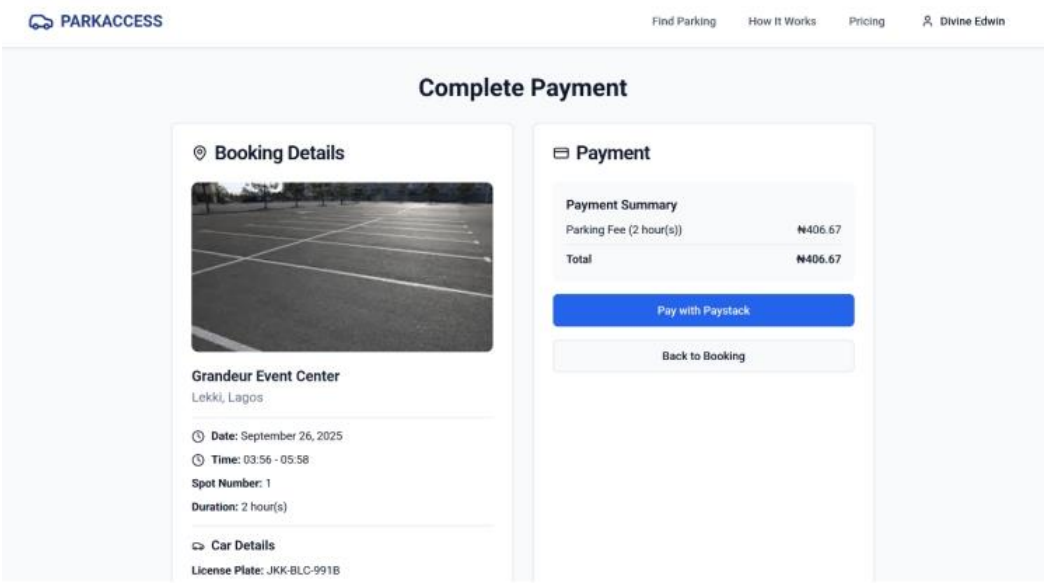

Figure 5: Payment

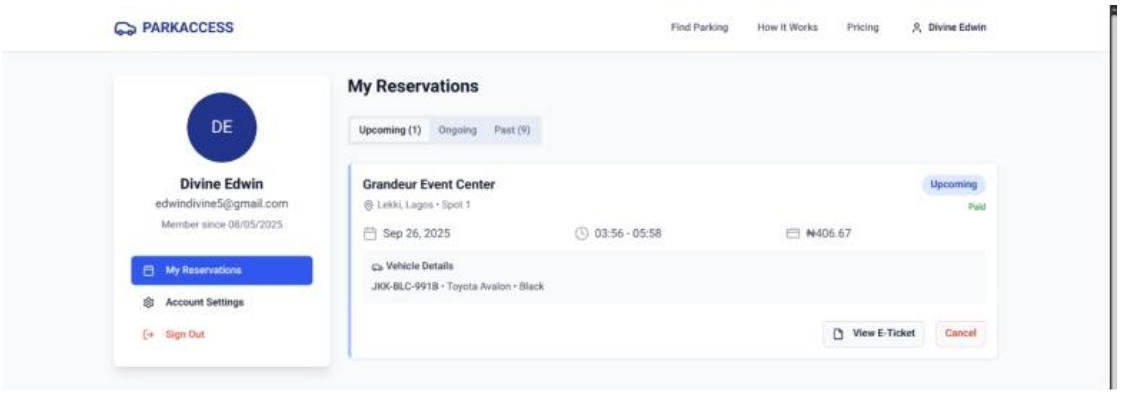

Figure 6: User dashboard

built with scalability, maintainability, and security in mind, ensuring it could grow and evolve with minimal disruption to users.

4. System Implementation, Testing, and Evaluation

4.1 Introduction

This chapter discusses the implementation of the PARKACCESS system, including how the various features were built and how users interact with the platform. It also covers how the system was tested to ensure its reliability, usability, and performance, and how the outcomes were evaluated to confirm that the solution met its design goals. The implementation process is explained from both the event center and attendee perspectives, detailing the step-by-step experience and interface flow.

4.2 System Implementation

The system was developed to cater to two main user types: event center managers and event attendees. For event center managers, the platform provides robust features including registration, login, event profile setup, creation and management of parking lot listings, monitoring of reservations, analytics dashboard access, and oversight of parking history. These functionalities are accessed through an intuitive dashboard, enabling managers to maintain control over parking logistics, monitor user activity, and manage their event center's digital presence.

On the attendee side, the system supports account registration and login, searching for parking lots based on event centers or location, booking available slots, making secure online payments, and receiving validated e-tickets for access. The attendee interface includes a user-friendly dashboard where users can view their booking history, manage their account, and track reservations. The platform's layout ensures a smooth user experience by clearly segmenting functionality based on user roles, maintaining clarity, responsiveness, and ease of navigation across devices.
The overall system architecture emphasizes a seamless flow from initial access to successful booking and entry by integrating all components into a responsive and accessible design. This dual-interface structure was carefully implemented to enhance operational efficiency for event organizers and convenience for attendees.

4.3 System Testing

The system underwent comprehensive testing to validate its performance, detect bugs, and ensure functionality across various scenarios. During unit

Table 1. Test Cases Executed

S/N	Requirement	Expected Result	Actual Result	Result
1	Event center registration	When an event center submits registration details through the sign-up form, the system should validate the inputs, store them as a unique record in the database, and create an account with access to the event center dashboard.	Account created successfully and dashboard accessible.	PASS
2	Event center login	After entering valid credentials, the system should authenticate the event center and redirect them to their dashboard, granting access to all available features.	Login successful and dashboard displayed.	PASS
3	Event center uploads parking slots	When the event center uploads parking slot details, the system should validate and store them in the database. The slots should appear in the dashboard with their availability status visible to users.	Slots uploaded, stored, and displayed correctly.	PASS
4	Event center edits parking slots	Upon editing parking slot information, the updated details should be validated, saved, and instantly reflected on the dashboard without affecting existing bookings.	Changes reflected successfully.	PASS
5	View booking history (event center)	The system should retrieve and display a list of all past reservations associated with the event center, including booking details, payment status, and timestamps.	Booking history displayed accurately.	PASS
6	View analytics dashboard	The analytics dashboard should aggregate data and display key metrics such as total bookings, revenue generated, and slot utilization trends in real time.	Analytics data displayed correctly.	PASS
7	Update event center profile	When profile details are modified, the system should validate the changes, update the database, and display the updated information immediately.	Profile updated and displayed correctly.	PASS
8	User registration	When a user submits their registration details, the system should validate inputs, create a unique user account, and provide access to the user dashboard.	User account created successfully.	PASS
9	User login	Upon entering valid credentials, the system should authenticate the user and redirect them to their personalized dashboard, granting access to booking features.	Login successful and dashboard displayed.	PASS
10	Search for parking lot	When a user searches for parking lots by event name or location, the system should query the database and display a list of available parking lots matching the criteria.	Lots displayed correctly based on search query.	PASS
11	Reserve a slot with valid payment	On confirming a booking and completing payment, the system should validate the transaction, reserve the slot, update availability, and generate a downloadable e-ticket for access.	Booking confirmed and e-ticket generated.	PASS
12	Attempt to reserve an already booked slot	If a user tries to book an unavailable slot, the system should deny the request and display a message indicating that the slot is already taken.	Booking denied and error message displayed.	PASS
13	Cancel reservation before scheduled time	When a user cancels a reservation before the scheduled event, the system should remove the booking, update the database, and free the slot for future reservations.	Reservation cancelled and slot released.	PASS
14	View booking history (user)	The system should retrieve and display a list of the user's past reservations, including event details, payment records, and ticket status.	Booking history displayed accurately.	PASS
15	View and update user profile	user profile On updating profile details, the system should validate and save the new information, reflecting changes immediately on the user dashboard.	Profile updated successfully.	PASS
16	Logout (user or event center)	When a user or event center logs out, the system should end the current session, clear cached data, and redirect them to the login page.	Session cleared and redirected to login.	PASS

testing, each module was tested in isolation. Integration testing ensured that end-to-end processes such as signing up, booking, and ticket validation worked together without errors. Emphasis was placed on transaction integrity, accurate slot availability updates, and prevention of duplicate bookings. Edge cases such as invalid payment attempts or expired tickets were also examined to confirm system resilience. These layered tests helped identify and fix minor glitches before the final deployment, following testing strategies recommended by Aljaedi et al. (2023). The table 1 outlines the test cases executed, covering both event center administrators and regular users:

4.4 System Evaluation

System evaluation was based on how well it met its stated objectives and user expectations. Key performance indicators included booking speed, system responsiveness, transaction success rate, and accuracy of slot management. The system proved to be efficient, secure, and reliable during testing, successfully automating the parking reservation process and enabling real-time updates. Overall, the evaluation showed that PARKACCESS significantly reduced manual errors, improved transparency, and enhanced user satisfaction, positioning it as a viable solution for modern event centers.

5. Conclusion

The PARKACCESS system successfully demonstrated how technology can streamline car park management in event environments. It offers a significant upgrade from manual methods by enabling features such as secure digital payments, real-time slot visibility, and e-ticket authentication. Event center managers benefit from improved control over reservations and revenue, while attendees enjoy a seamless and stress-free experience. The system enhances operational efficiency and customer satisfaction and aligns with broader smart city goals. Although certain limitations like internet dependence and lack of full automation remain, the study shows strong potential for future growth and application beyond event centers.

5.1 Recommendations

For future improvements, the study recommends the development of a mobile application version of the platform to increase accessibility and convenience for on-the-go users. Additional payment options such as QR codes and NFC-based methods should be introduced to expand financial flexibility. The system should also include automated SMS or email notifications to remind users of their bookings and provide real-time updates. To support larger-scale deployments, further testing for scalability under high traffic is advised. Finally, expanding the use of the system to other facilities like shopping malls, hospitals, and airports could increase its impact and commercial viability.

References

Ahmed, A. (2017). Solving parking challenges in urban areas. *Urban Transport Review, 10*(1), 45–53.

Aljaedi, A., Siddique, S., Satti, M. I., Alharbi, A. R., Alotaibi, M., & Usman, M. (2023). Underpinning quality assurance: Identifying core testing strategies for multiple layers of Internet-of-Things-based applications. *Sustainability, 15*(22), Article 15683.

Asianuba, S., & Aliyu, I. (2023). An improved IoT smart parking system for urban mobility. *Nigerian Journal of Smart Technology, 6*(1), 48–55.

Benelli, G., & Pozzebon, A. (2013). Telecommunication-based payment systems for car parks. *International Journal of Computer Applications, 65*(10), 1–6.

Gu, Y., Lo, A., & Niemegeers, I. (2012). A wireless sensor network for smart parking. *IEEE Transactions on Network and Service Management, 9*(1), 50–63.

Hamidi, M. S., & Abid, M. I. (2022, March 15). Classical system development approach: Waterfall model. *Journal of Software Engineering Tools & Technology Trends (JoSETTT), 8*(3), 8–12.

Kabir, A., Singh, M., & Gupta, P. (2015). User experience and interface design in parking applications. *Journal of User-Centered Design, 6*(3), 120–131.

Khanna, A., & Anand, R. (2016). IoT based smart parking system. *International Journal of Computer Applications, 135*(12), 40–45.

Knežević, D., Stojić, M., & Murić, M. (2025, February). Architectural framework for developing a travel agency information system. In Proceedings of the International Conference on Challenges of Contemporary Higher Education (ACCHE), Kopaonik ,Serbia.

Maddock, J., & Calcutt, R. (2015). ITS and parking efficiency in the US. *Journal of Intelligent Transportation Systems, 19*(1), 33–42.

Mehta, R. (2019). The role of smart parking systems in traffic reduction. *Journal of Engineering Science and Technology, 14*(5), 1021–1029.

Ndunda, C., Okoro, J., & Wanjala, T. (2015). Electronic parking fee collection using plate recognition. *International Journal of Smart Systems, 11*(2), 56–62.

Saravanos, A., & Curinga, M. X. (2023). Simulating the software development lifecycle: The Waterfall model. Applied System Innovation, 6(6), Article 108.

United Nations. (2018). *World urbanization prospects: The 2018 revision*. UN DESA.

Wafa, M., & Zeba, F. (2018). Digital payments in car parking systems: A review. *International Journal of E-Transactions, 5*(2), 33–39.