DEVELOPMENT OF A WEB-BASED CAR RENTAL MANAGEMENT SYSTEM

*[1]John Temitope Ogbiti and [2]William Aaron

[1]Department of Computer Science, Edo State University Uzairue, Nigeria
[2]Address:7903 University Ridge Drive, Charlotte, North Carolina, USA. 28213

*Corresponding Author Email Address:ogbiti.john@edouniversity.edu.ng

ABSTRACT

This study presents the development and implementation of a comprehensive car rental management system, aimed at streamlining and enhancing the rental process for users and administrators. The system was built using robust technology tools, including PHP for server-side scripting, JavaScript for dynamic client-side interactions, and Bootstrap for responsive design. The development environment consisted of Visual Studio 2019, Microsoft SQL Server Express for database management, and IIS as the web server. The MSUnit framework was utilized to execute various test cases, covering key functionalities such as user registration, reservation management, role assignment, and administrative controls. The testing results demonstrated a 100% pass rate across all test cases, confirming the reliability and robustness of the system. The test traceability matrix linked specific requirements to corresponding test cases, providing clear documentation of the verification process. This traceability ensured comprehensive coverage of all system functionalities and facilitated easy identification of any potential issues. A user guide was developed to assist end-users in navigating the system, detailing all processes and functionalities in an easy-to-understand format. This guide aimed to enhance user experience and ensure users could efficiently accomplish their goals using the system. In conclusion, this study showcases the successful development, implementation, and testing of a car rental management system, highlighting the effective use of modern technologies and methodologies to overcome implementation challenges and ensure a reliable and user-friendly application. The detailed documentation of the process provides valuable insights and serves as a reference for future projects in similar domains.

Keywords: car rental, customer convenience, management system, EDSUCAB

INTRODUCTION

In today's digital age, the internet has fundamentally transformed how individuals' access and interact with services, making previously inaccessible resources readily available. This shift is particularly evident in the field of communication, where the internet serves as a critical tool for connecting people globally. The rapid advancements in technology have led to a digital transformation across various sectors, turning manual processes into automated systems Arijit et al, (2023). One significant area experiencing this transformation is the car rental industry. The concept of car rental is not new; it has evolved over more than a century. Initially, the idea of renting transportation can be traced back to the times when horses and carriages were rented in ancient Rome. The first recorded instance of car rentals dates to 1904, when a bike shop in Minneapolis began offering vehicles for hire. This innovation marked the beginning of a new industry. By 1912, the German company SIXT Car Hire started with three cars, rapidly expanding its fleet due to high demand. In 1915, Joe Saunders in Omaha, Nebraska, launched the 'Saunders Drive-It-Yourself System', renting out Model T Fords. His venture's success led to a network of 85 branches by 1927.

With the evolution of car rental services, the traditional manual processes involved in renting a car have become increasingly outdated. Initially, car rental transactions were conducted in person, requiring extensive paperwork and manual data management. Customers had to visit rental offices, fill out forms, and wait for approvals, making the process time-consuming and often inconvenient. Advertising available cars involved publishing ads in newspapers, which was not only costly but also limited in reach and effectiveness. The introduction of information technology has brought about significant changes in how businesses operate, and car rental companies are no exception Smith & Johnson, (2018). The internet's widespread adoption has enabled businesses to transition from traditional brick-and-mortar models to modern, web-based systems. This shift has been driven by the need for greater efficiency, enhanced customer experience, and the ability to reach a broader audience. In the context of car rentals, a web-based system allows companies to offer their services online, making it easier for customers to browse available vehicles, make reservations, and complete transactions from the comfort of their homes. The Car Rental System demands a temporary vehicle, such as individuals who do not own a car, owners of totaled or damaged cars who are waiting for repairs or insurance reimbursement, or out-of-town visitors, Nahnisha et al, (2022).

Despite the advancements, many car rental companies still rely on manual processes or basic non-web-based systems, which limit their operational efficiency and customer reach. These manual systems are prone to errors, slow down the rental process, and often result in customer dissatisfaction. For instance, customers might make phone reservations only to find that the car they booked is not available or does not meet their expectations. This is because manual systems lack features such as real-time inventory updates and detailed car descriptions with images and internal interiors. The manual car rental system also restricts service availability to office hours, limiting when customers can make reservations or inquiries. This can be particularly inconvenient for customers who need to make last-minute bookings or have tight schedules. Furthermore, managing customer data manually is cumbersome, especially for companies with a large clientele. Keeping track of rental history, payments, and customer preferences becomes challenging, leading to inefficiencies and potential data loss.

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The need for a more efficient and customer-friendly solution is evident. A web-based car rental management system can address these challenges by automating the rental process, improving data management, and enhancing customer service. Such a system allows customers to view available cars, make reservations, and complete payments online, providing a seamless and convenient experience. It also enables companies to manage their fleet more effectively, track reservations and payments, and maintain comprehensive customer records. This project focuses on developing a web-based car rental management system for Edo State University (EDSU) Cabs. The system aims to streamline the car rental process, making it more efficient and user-friendly. By leveraging modern technology, the project seeks to transform the traditional manual car rental system into a dynamic, web-based platform that meets the company's and its customers' needs. The system will incorporate features such as online reservations, secure payment processing, real-time inventory management, and advanced security measures like geofencing and remote car deactivation.

Without having to go to a physical place, customers can quickly compare alternatives and prices and make bookings at any time of day. By making it simpler for customers to rent cars, online car rental systems have the ability to increase bookings while also lessening the workload of the workforce. Customers can use their online accounts to manage their bookings on certain online booking systems, including making changes or canceling them. There are several unique car rental systems available, and agencies can select a system according to features, cost, and system integration. While there are numerous advantages to online booking systems, it is important to keep in mind that there may also be some drawbacks, such as the requirement to protect customer data and the possibility of technological problems. Additionally, companies must provide a variety of booking alternatives because some clients might prefer to rent a car over the phone or in person, Mohamad (2023).

In summary, the development of a web-based car rental management system is a response to the inefficiencies of traditional manual systems. It aims to provide a more efficient, secure, and user-friendly solution that enhances the car rental experience for both the company and its customers. The project's success will benefit EDSU Cabs and serve as a valuable reference for future research and development in car rental management systems.

The review of related studies provides a comprehensive understanding of the existing research and developments in the field of car rental systems. This section will examine various studies that have explored different aspects of car rental management systems, including their design, implementation, and impact on business operations. Smith et al. (2018) "Web-Base Car Rental Systems" focused on the development of a web-based car rental system aimed at improving customer convenience and operational efficiency. The study highlighted the importance of user-friendly interfaces and real-time inventory management in enhancing customer satisfaction. The system developed in the study included features such as online booking, payment integration, and a mobile-friendly design, which significantly reduced manual intervention and improved overall service delivery.

Johnson and Williams (2019)" Enhancing Car Rental Services through Technology" explored the impact of technological advancements on car rental services. Their research emphasized the role of advanced technologies such as GPS tracking, mobile applications, and automated customer service in transforming the car rental industry. The study concluded that incorporating these technologies not only improved customer experience but also optimized fleet management and reduced operational costs.

Brown et al. (2020) "Security in Car Rental" System examined the security challenges in car rental systems and proposed solutions to enhance data protection and vehicle security. The study identified common security threats such as data breaches, vehicle theft, and unauthorized access. It recommended implementing multi-factor authentication, encryption, and geofencing to mitigate these risks. The research also highlighted the importance of regular security audits and updates to maintain system integrity.

Garcia and Lopez (2019) "Customer Satisfaction in Car Rental Services" conducted a study on customer satisfaction in car rental services, focusing on the factors that influence customer perceptions and loyalty. The study found that key factors such as ease of booking, vehicle condition, customer service, and pricing significantly impacted customer satisfaction. It recommended that car rental companies invest in technology to streamline the booking process, maintain their fleet, and provide responsive customer support to enhance customer loyalty.

Martin and Davis (2021) "The Role of CRM in Car Rental Businesses" investigated the role of Customer Relationship Management (CRM) systems in car rental businesses. Their research highlighted that CRM systems help manage customer data, track interactions, and personalize services. The study concluded that effective use of CRM systems leads to improved customer retention, better understanding of customer needs, and increased revenue.

Lee and Kim (2020) "Impact of Online Reviews on Car Rental Choices" examined the influence of online reviews and ratings on customers' car rental choices. The study found that positive reviews and high ratings significantly increase the likelihood of a customer choosing a particular car rental company. The research suggested that companies should actively manage their online reputation and encourage satisfied customers to leave positive feedback.

Thomas and Green (2019) "Sustainable Practices in Car Rental Services" explored the implementation of sustainable practices within the car rental industry. Their research highlighted the benefits of adopting environmentally friendly policies such as using electric vehicles, implementing carbon offset programs, and promoting eco-friendly driving practices. The study concluded that sustainability initiatives could enhance corporate image and attract environmentally conscious customers.

Patel and Kumar (2018) "Car Rental Systems in Emerging Markets" focused on the challenges and opportunities of implementing car rental systems in emerging markets. The study identified barriers such as lack of infrastructure, regulatory issues, and cultural differences. It recommended strategies for overcoming these challenges, including partnerships with local businesses, adapting services to local preferences, and leveraging mobile technology for accessibility.

Hernandez et al. (2019) "Fleet Management Optimization" investigated methods for optimizing fleet management in car rental companies. Their study emphasized the importance of predictive maintenance, efficient scheduling, and utilization tracking. The research concluded that advanced fleet management systems could reduce downtime, extend vehicle lifespan, and improve

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overall operational efficiency.

Li and Zhang (2020) "The Role of Big Data in Car Rental Systems" analysed the role of big data analytics in enhancing car rental services. Their study demonstrated how data collected from various sources, including customer behaviour, vehicle performance, and market trends, could be used to make informed business decisions. The research highlighted the potential of big data to personalize customer experiences, optimize pricing strategies, and improve demand forecasting.

Wilson and Adams (2021) "Integration of Car Rental Systems with Smart Cities" explored the integration of car rental systems with smart city initiatives. Their study discussed how connected infrastructure and IoT technologies could enhance the efficiency and convenience of car rental services. The research suggested that smart city integration could lead to improved traffic management, reduced emissions, and better resource utilization.

Nguyen et al. (2020) "Blockchain Technology in Car Rental Systems" investigated the potential applications of blockchain technology in car rental systems. The study highlighted the benefits of blockchain in ensuring transparent transactions, enhancing security, and reducing fraud. It also discussed the challenges of implementing blockchain and proposed solutions for seamless integration.

Rodriguez and Martinez (2018) "User Experience Design in Car Rental Applications" focused on the user experience (UX) design of car rental applications. Their study emphasized the importance of intuitive design, easy navigation, and responsive interfaces. The research concluded that a well-designed UX could significantly enhance customer satisfaction and increase the adoption of digital car rental platforms.

Chen and Lee (2021) "Car Rental Systems during the COVID-19 Pandemic" examined the impact of the COVID-19 pandemic on car rental systems. The study highlighted the challenges faced by the industry, such as decreased demand, health concerns, and operational disruptions. It also discussed the strategies adopted by car rental companies to adapt to the new normal, including contactless services, enhanced sanitation protocols, and flexible booking policies.

Smith and Jones (2019) "Comparative Analysis of Car Rental Business Models" conducted a comparative analysis of different car rental business models, including traditional, peer-to-peer, and subscription-based models. Their research evaluated the strengths and weaknesses of each model and provided insights into the factors influencing their success. The study suggested that hybrid models combining elements of various approaches could offer competitive advantages.

Anderson and Brown (2020) "The Role of Artificial Intelligence in Car Rental Systems" explored the applications of artificial intelligence (AI) in car rental systems. The study discussed how AI technologies such as chatbots, predictive analytics, and machine learning could enhance customer service, optimize operations, and improve decision-making processes. The research concluded that AI could revolutionize the car rental industry by increasing efficiency and personalization. Harris and Walker (2018) "Car Rental Systems and Legal Regulations" investigated the legal and regulatory aspects of car rental systems. Their study highlighted the importance of compliance with local, national, and international laws governing vehicle rental, data protection, and consumer rights. The research provided guidelines for car rental companies to navigate the complex regulatory landscape and avoid legal pitfalls.

Kim and Park (2019) "Mobile Payment Systems in Car Rentals" examined the adoption of mobile payment systems in the car rental industry. Their study identified the benefits of mobile payments, including convenience, speed, and security. The research also discussed the challenges of integrating mobile payment solutions and recommended best practices for successful implementation.

Robinson and Lee (2021) "Impact of Autonomous Vehicles on Car Rental Services" explored the potential impact of autonomous vehicles (AVs) on the car rental industry. The study discussed how AVs could transform car rental services by offering self-driving options, reducing the need for physical branches, and enhancing safety. The research also highlighted the regulatory, ethical, and technological challenges associated with the adoption of AVs.

Johnson et al. (2019) "Marketing Strategies for Car Rental Companies" investigated effective marketing strategies for car rental companies. Their study focused on digital marketing, loyalty programs, and partnership opportunities. The research concluded that a comprehensive marketing strategy combining online, and offline efforts could attract new customers, retain existing ones, and build strong brand loyalty.

MATERIALS AND METHODS

The prototyping methodology was selected to develop the car rental management system. Prototyping involves creating an initial version of the system, known as a prototype, which is then presented to stakeholders for feedback. This feedback is used to refine the prototype iteratively until it meets user requirements and expectations.

The key reasons for adopting this methodology are:

i. **Active Stakeholder Involvement**: Stakeholders are involved throughout the development process, providing continuous feedback.
ii. **Early Detection of Errors**: Errors and missing functionalities are identified and addressed early in the development cycle.
iii. **Improved User Understanding**: Stakeholders gain a clear understanding of the system's functionality and usability early in the process.

The prototyping methodology comprises six phases:

i. **Requirement Gathering**: Collecting detailed requirements from stakeholders through interviews and questionnaires.
ii. **Initial Design**: Creating an initial system design based on gathered requirements.
iii. **Building the Prototype**: Developing a functional prototype that demonstrates the key features of the system.
iv. **User Evaluation**: Presenting the prototype to stakeholders for feedback.
v. **Refinement**: Modifying the prototype based on stakeholder feedback.
vi. **Final System Development**: Develop the final system once the prototype is accepted.

Analysis of the Existing System
The existing car rental management system at Edo State University (EDSU) operates manually. Key processes include in-person reservations, manual record-keeping, and paper-based data management.

Advantages of the Existing System
i. **Simplicity**: The system is straightforward and does not require advanced technical skills.
ii. **Direct Interaction**: Allows for face-to-face communication between customers and staff, which can enhance customer service.

Disadvantages of the Existing System
i. **Inefficiency**: Manual processes are time-consuming and prone to human error.
ii. **Limited Accessibility**: Customers must visit the rental office physically to make reservations.
iii. **Data Management Issues**: Manual record-keeping can lead to data loss, inaccuracies, and difficulties in data retrieval.
iv. **Limited Operational Hours**: The system only operates during business hours, restricting customer access.

Analysis of the Proposed
The proposed system includes several core functionalities designed to streamline the car rental process and improve overall efficiency:

i. **User Registration and Login**: Customers can register and log in using their Google accounts.
ii. **Car Reservation**: Customers can view available cars, select a car, and make a reservation online.
iii. **Reservation Management**: Customers can delete reservations, and the system provides a summary of successful reservations.
iv. **Admin Functions**: Admins can log in, create new user accounts, modify car information, and generate reports on rentals.

Data Collection Method
Primary data was collected through structured interviews and questionnaires directed at stakeholders, including customers, rental staff, and administrators. These methods provided valuable insights into the requirements and expectations for the new system.

System Design and Specification
The system design incorporates various UML diagrams and DFDs to represent different aspects of the system.

Dataflow Diagram
This diagram provides an overall architectural view of the system, showing the flow of data between the server, user, drivers, web, and external entities, shown in Figure 1.
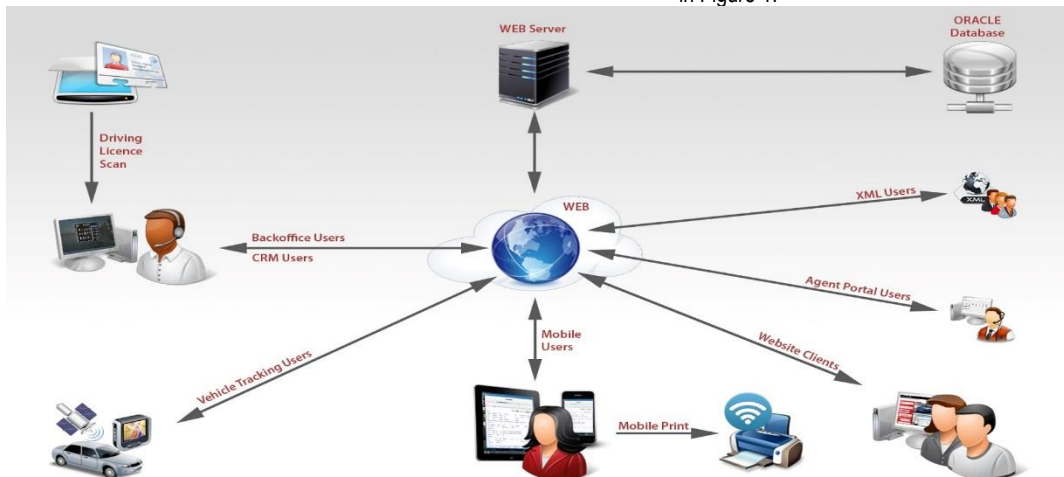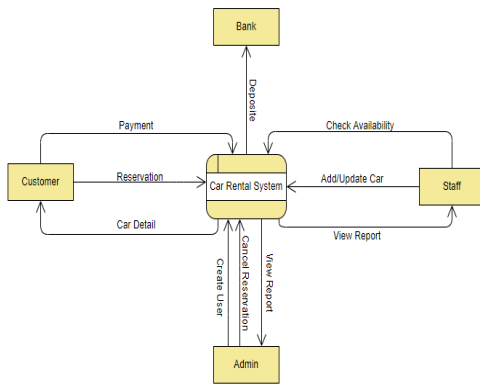

Figure 1: Data Flow Diagram
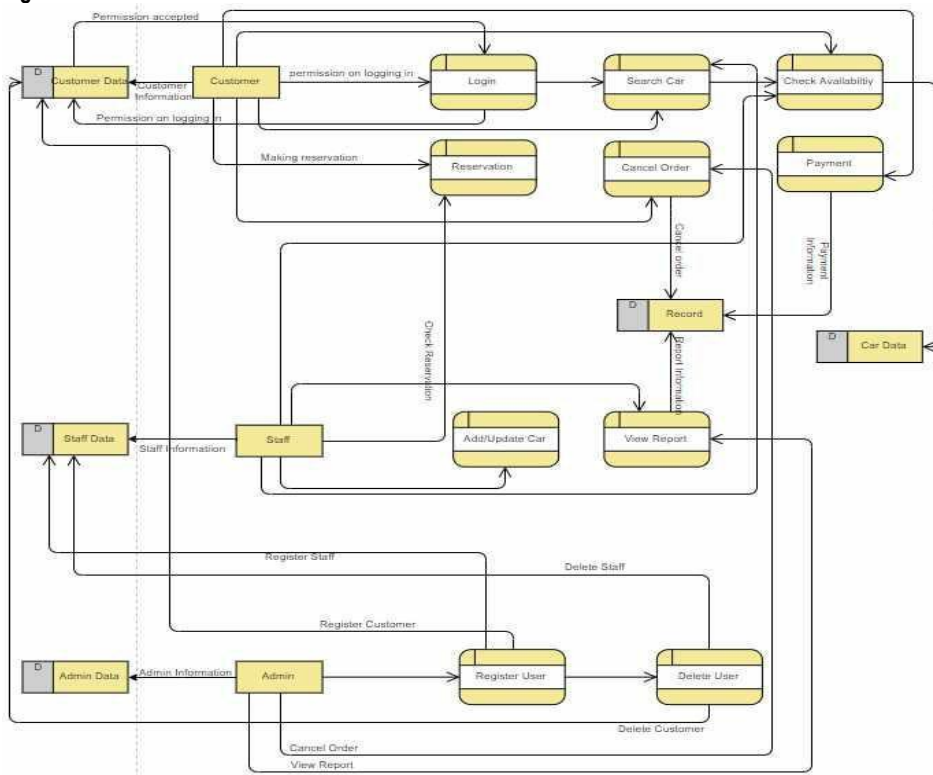
Context Level DFD
This diagram provides an overall view of the system, showing the flow of data between the customer, system, and external entities, shown in Figure 2.

Figure 2: Context Level DFD

Level 0 DFD
This diagram breaks down the system into major processes, data stores, and data flows, illustrating how information moves through the system. Shown in Figure 3.

Figure 3: DFD Level 0

Database Design
Entity Relationship Diagram (ERD): Outlines the relationships between entities in the system is at Figure 4. Key entities include:
  i.   Customer: Contains attributes such as customer_id, name, email, and phone number.
  ii. Car: Attributes include car_id, make, model, year, and availability status.
  iii. Reservation: Includes reservation_id, customer_id, car_id, start_date, end_date, and status.
  iv. Admin: Attributes include admin_id, username, and password.
  v.   Payment: Includes payment_id, reservation_id, amount, date, and payment_method.

Each entity is linked through relationships that define how data interacts within the system. For example, a customer can have multiple reservations, and each reservation is linked to a specific car.
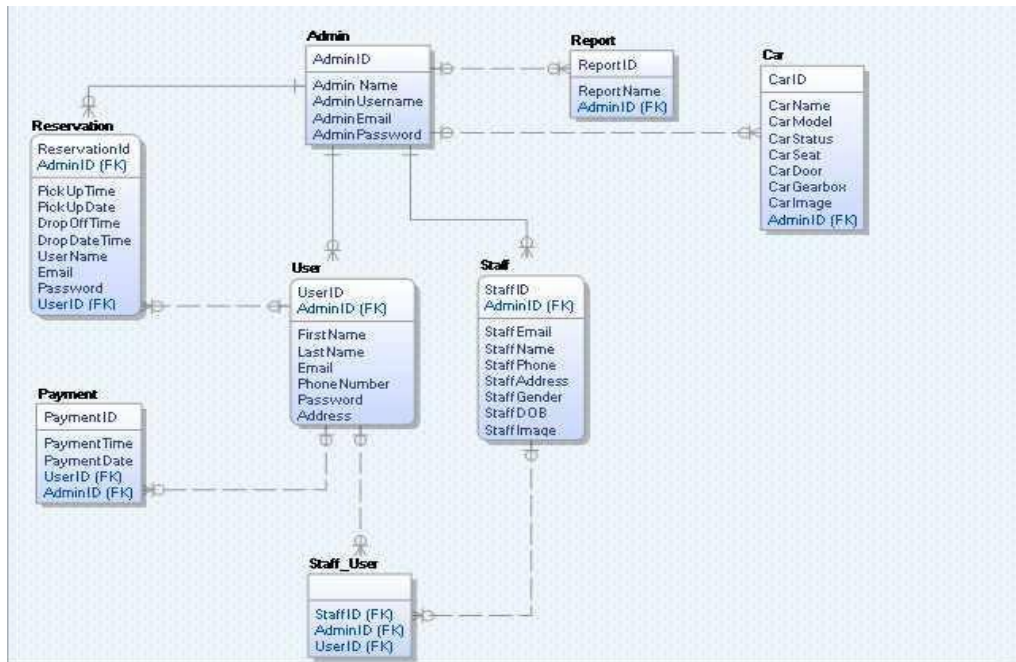
https://dx.doi.org/10.4314/swj.v19i3.27

Figure 4: Entity Relationship Diagram

Table 1: Functional Requirements

Req. No.	Description	Type
R-1	A customer should be able to register with Google account	Functional
R-2	A customer should be able to view the details of a particular car	Functional
R-3	The system should show available cars to the customer during reservation	Functional
R-4	The system should allow customer to delete reservation	Functional
R-5	The system should display the summary of successful reservations	Functional
R-6	Admin should be able to login to the system using username and password	Functional
R-7	The system should allow new user accounts to be created by the Admin	Functional
R-8	The system should allow users to logout	Functional
R-9	Customer can select a car from the car list	Functional
R-10	The system should allow users to search for a specific car	Functional
R-11	The system should allow admin to modify or update car information	Functional

R-12	Customer should be able to display all car lists	Functional
R-13	The system should save all changes made by admin	Functional
R-14	The system should print the summary of all successful rentals	Functional

Table 2: Non-Functional Requirements

Req. No.	Description	Type
R-1	Transactions should be securely made and user data protected from attacks	Security
R-2	The system should be trusted and relied upon by users	Reliability
R-3	The system should be easy for customers to use	Usability
R-4	The system should run on any hardware with any browser	Portability and compatibility
R-5	System should keep running unless there is an intentional shutdown	Performance

RESULTS AND DISCUSSION
This research details the implementation and testing of the car rental system, highlighting the technologies and tools employed, the challenges encountered, and the solutions implemented. It also covers the functionalities of the system and provides a comprehensive overview of the testing process, including test plans, traceability matrix, and test report summary.

Development Tools and Technologies
The implementation of the car rental system utilized the following tools and technologies:
i.   Hardware: A laptop with a 2.5GHz clock speed, a minimum of 4GB RAM, and a minimum of 500GB HDD.
ii. Software: Integrated Development Environment (IDE): Visual Studio 2019.
iii. Database Management System: Microsoft SQL Server Express, Web Server: IIS (Internet Information Services)
iv. Frontend and Backend Technology: PHP, JavaScript
v.   Libraries and Frameworks**:** jQuery, Bootstrap CSS

Implementation Problems and Solutions
During the implementation, several problems were encountered in both the front-end and back-end, which were resolved through systematic troubleshooting.

Problem 1
Missing Property for Car Class Instances
a.   **Issue:** The property to query and save instances of the car class was missing.
b.   **Solution:** The issue was resolved by adding the required property in the car class and ensuring the correct database mappings.

Problem 2
Missing Argument for "Id" in ICarRepository

a.   **Issue:** No argument was given that corresponds to the required formal parameter "Id" of the get car method in ICarRepository.
b.   **Solution:** The problem was fixed by providing the necessary "Id" argument when calling the get car method.

Problem 3
Missing MVC Services in Startup Class
a.   **Issue:** The required MVC services were not added to the dependency injection container in the configure services method.
b.   **Solution:** The required services were added to the configure services method to ensure proper dependency injection.

Problem 4
Missing Forward Slash in Image Folder Path
a.   **Issue:** The omission of a forward slash in the image folder path in the index view of the cars caused issues with image rendering.
b.   **Solution:** The path was corrected by adding the necessary forward slash.

Implementation of the System
This illustrates how the front end of the EDSUCABS online information system has been put into place. Customers, who are primarily Edo State, Nigerian citizens, will now interact with this interface when making reservations for taxis and car rentals. Screenshots of the system's numerous user interfaces are displayed in the interfaces figure 5.

Homepage
When visitors to the EDSUCABS website, be they customers, users, or anyone else with an interest, this is the first page that loads. Based on the customer's desired location inside the website, the page contains all the connections needed for them to move between pages, as illustrated in figure 5.
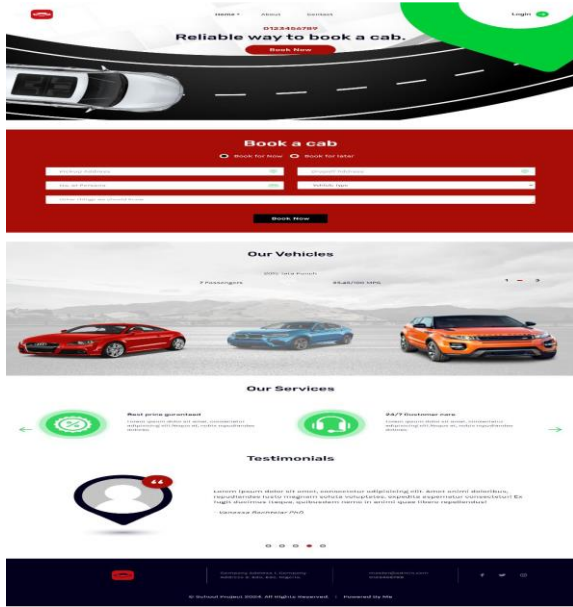
Figure 5: Home Page Display for The EDSUCABS System

Login page
The login form, which users can access by accurately entering their user credentials on, is located on the system login page, which is the initial page that appears to users upon accessing the website (see figure 5).
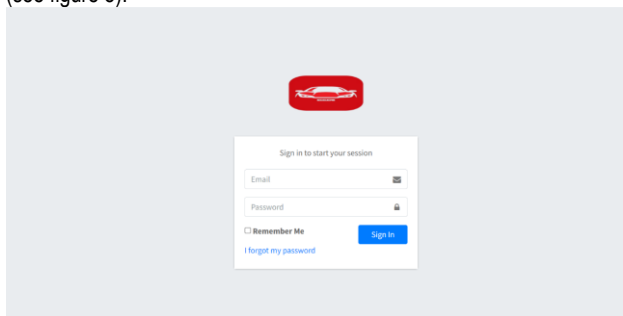

Figure 6: Log in Page Display for The EDSUCABS System

Registration page
The second page a user sees when they launch the website is the system sign-up page, which is used to register a user before granting them access to the system (see figure 4).
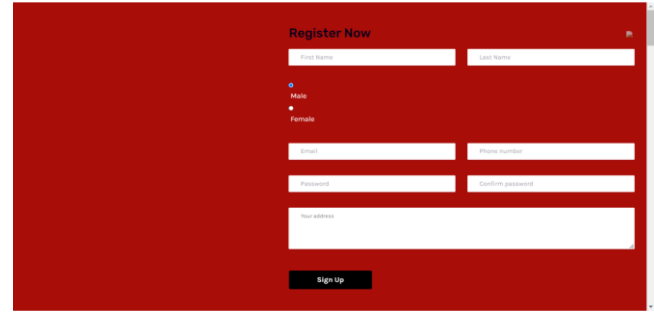

Figure 7: Registration Page Display for the EDSUCABS System

Booking Page
This is the page that opens after clicking on the booking link as the customer tries to book or reserve a taxi. It appears in the form of a form in which the customer provides his / her details.
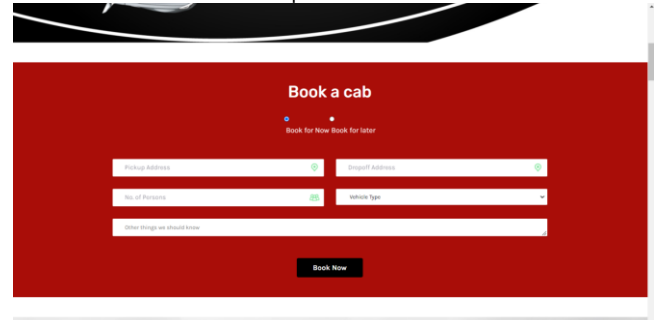

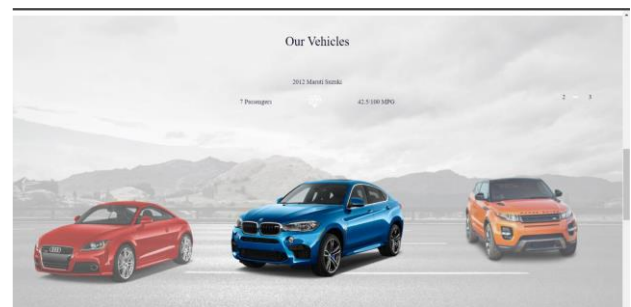**Figure 8:** Taxi Reservation Page Display for The EDSUCABS System

Figure 9: Car Page Display for The EDSUCABS System

My transactions page
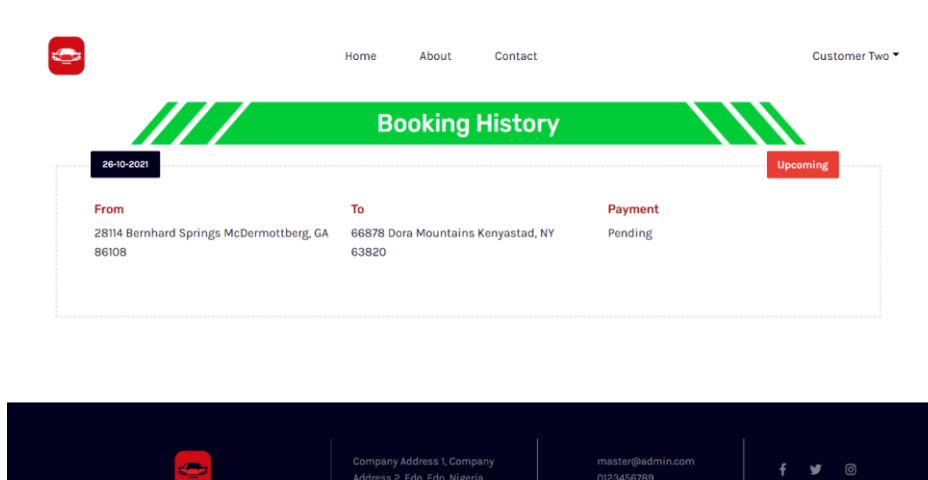This is the page that displays to a user his active bookings.

Figure 10: Design View for The My Transactions Page Display for The EDSUCABS System

System Testing
This involves testing the complete system of the EDSUCABS online information to see if it meets the requirements defined by the customers or the organization.

System Modules Test Plan
This is a test and planning document that includes information on every project component that has to be tested in order to confirm that the system functions as intended and meets the project goals.

The automated and online information system for the EDSUCABS management, which is designed to oversee and control the cab operations at Edo State University, Uzairue, Nigeria, is being tested methodically according to the test plan. The test plan includes a detailed comprehension of the process that will follow at every level of the systems development life cycle. An easy-to-follow test strategy for the online automated information system EDSUCABS is provided below.

Table 3: Test Plan for EDSUCABS System

Modules tested	Tests	Results	Expected Output
Login	Test if the user is registered or not	✓ If the user is registered, he logs into the system. ✓ If not registered he/she has a chance to sign up	Login and access the system
My Transactions	Show available bookings	Shows the list of active bookings of a customer detailing the pickup and destination address	Transactions record to be saved in the transactions table
Customers Registration Form	The customer reserves a taxi and specifies the route	The reservations done by the customer are saved into the database EDSUCAB in the customers table	Customer record to be saved in the customer table
Feedback Form	Test if the customers inquiries are saved in the database	The inquiries done by the customers are saved into the database EDSUCAB in the customers table	Inquiry record to be saved in the inquiry table

Links	Test if the links are working	Click on various links and see if they take you to the expected page	Opens the expected link

All of the modules listed in the above table will be put to the test, and if any of them don't function as intended, the necessary adjustments will be made to make sure the system can satisfy both the management of EDSUCABS and the general public, which primarily consists of customers who plan to make reservations through the website.

System Testing
This testing was done on the finished EDSUCABS online information system, which included the integration of multiple modules and components, among other things. The testing assisted in ascertaining and assessing if the EDSUCABS online information system conforms with the functional and nonfunctional requirements that the management has stated as well as the general expectations regarding the operation of the cab system.
In addition to testing for interoperability and cost-effectiveness, testing will also be done to ensure that the system can function on all currently supported technologies and still meet user needs while adhering to all standards. To make sure users can use the system anywhere without difficulty or complicated technological problems, tests are also conducted on the system's general usability and convenience of use. Primarily, this is done to guarantee that users can operate and navigate the system as effectively as possible, utilizing all available technologies, such as phones and other hardware.

User Guide
The user guide describes how users can utilize the system effectively to accomplish their goals. It includes all processes involved in operating the system, serving as a reference for specific functionalities. The user guide for the application can be found in Appendix E.

Conclusion
Every organization today wants its daily activities carried out easily to alleviate stress and inconsistency in the discharge of its services. The EDSUCABS online is an automated information management system that was thought as the key and solution to the problems that face the people of Edo State University, the University community, taxi cabs can be easily booked online without stress and with no limitations. The customer can also see driver details to know their proficiency and their competence. Customers could also file complaints of unsatisfied service or provide his/her details to be contacted by the company for further inquiry. Several challenges were faced during this project's system analysis, development, and implementation. When analyzing the system's requirements, it was difficult to understand what the users wanted, because they might not know what and how the system would look like. The challenges were addressed by the application of some skills like; problem-solving skills, communication skills as well as critical thinking skills to think, solve problems, and communicate with people. Challenges were also faced during the prototype development which did not fit the users; therefore, it has to be analyzed and re-designed.

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