DESIGN OF WEB-BASED CAR RENTAL INFORMATION SYSTEM USING EXTREME PROGRAMMING AT CV. NUGROHO

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Abstract— *This study discusses the development of a web-based car rental information system for CV. Nugroho Trans Surabaya using the Extreme Programming (XP) methodology. The system was designed to address issues in the previous manual rental process, such as transaction recording on paper, which was prone to errors and delays in data management. The developed system includes key features such as car booking, fleet data management, rental confirmation, and payment integration. Testing was conducted through various methods, including performance testing, usability testing, and security testing. Performance testing using PageSpeed Insights in desktop mode showed the following scores: performance 93, accessibility 84, best practices 93, and SEO 82. Meanwhile, testing with GTmetrix yielded a performance score of 96%, a structure score of 72%, a Largest Contentful Paint (LCP) time of 909 ms, and a fully interactive time of 1.3 seconds, indicating excellent speed and interface stability. In terms of security, testing with Pentest Tools indicated an overall medium risk level, with 1 medium risk finding, 5 low-risk findings, and 13 informational findings, and no high-risk vulnerabilities. The application of the XP method enabled adaptive system development tailored to user needs and iterative changes. This system has proven to increase the company's operational efficiency by up to 40%, based on faster transaction completion times compared to the manual system. However, some limitations remain, such as user interface constraints and suboptimal integration of online payment channels. For future research, it is recommended to improve user experience, optimize the mobile interface, enhance server security protection, and expand system features to support the broader business growth of CV. Nugroho Trans Surabaya*

Keywords: *Car Rental, Extreme Programming (XP), Web-based System.*

Abstrak— *Penelitian ini membahas pengembangan sistem informasi sewa mobil berbasis website pada CV. Nugroho Trans Surabaya dengan menggunakan metode Extreme Programming (XP). Sistem ini dirancang untuk mengatasi permasalahan penyewaan mobil yang sebelumnya dilakukan secara manual, seperti pencatatan transaksi dengan media kertas yang rawan kesalahan dan keterlambatan dalam pengelolaan data. Sistem yang dikembangkan mencakup fitur utama seperti pemesanan mobil, manajemen data armada, konfirmasi penyewaan, serta integrasi pembayaran. Pengujian dilakukan melalui berbagai metode, termasuk performance testing, usability testing, dan security testing. Hasil pengujian performa menggunakan PageSpeed Insights pada mode desktop menunjukkan skor: performa 93, aksesibilitas 84, praktik terbaik (best practices) 93, dan SEO 82. Sedangkan hasil pengujian melalui GTmetrix menunjukkan performance score sebesar 96%, structure score 72%, dan waktu Largest Contentful Paint (LCP) sebesar 909 ms, dengan waktu interaksi penuh 1,3 detik. Ini menunjukkan sistem memiliki kecepatan dan kestabilan tampilan yang sangat baik. Dari sisi keamanan, pengujian menggunakan Pentest Tools menunjukkan tingkat risiko keseluruhan berada pada kategori sedang (medium) dengan 1 temuan risiko menengah, 5 risiko rendah, dan 13 informasi umum, tanpa adanya risiko tinggi. Penerapan metode XP memungkinkan pengembangan sistem yang adaptif terhadap kebutuhan pengguna dan perubahan selama iterasi. Sistem ini terbukti meningkatkan efisiensi operasional perusahaan hingga 40%, berdasarkan waktu penyelesaian transaksi yang lebih cepat dibandingkan sistem manual. Meski demikian, terdapat beberapa kekurangan seperti keterbatasan antarmuka pengguna dan belum optimalnya integrasi kanal pembayaran online. Untuk penelitian selanjutnya, disarankan peningkatan pada aspek user experience, optimasi tampilan mobile, peningkatan proteksi keamanan server, serta*

ekspansi fitur guna mendukung pertumbuhan bisnis CV. Nugroho Trans Surabaya secara lebih menyeluruh.

***Kata Kunci**: Sewa Mobil, Extreme Programing (XP), Sistem Berbasis Web.*

INTRODUCTION

An Information System (IS) is an integrated system that collects, processes, and distributes information to support organizational decision-making, operations, and control. It encompasses not only technology but also business processes, people, data, and policies (Anggi Prameswari et al., 2024; Soufitri, 2023). As technology and business environments evolve, organizations must adapt their information systems to optimize information use and achieve their goals. Effective integration of people, processes, and technology strengthens information management, enhancing responsiveness, adaptability, and efficiency (Widarti et al., 2024).

In the rapidly evolving digital era, information technology and the internet have become essential in various industries, including the car rental business. The integration of technology has significantly enhanced the efficiency of rental services, allowing businesses to streamline operations and improve customer convenience (Agus Julianto et al., 2024). Car rental services provide customers with the flexibility to rent vehicles for specific periods, whether for business trips, vacations, or special events, with options for self-drive or chauffeur services (Rifky et al., 2023). By implementing a computerized system for car rentals, the process of creating rental data will be faster and more accurate. It is expected that this car rental information system will assist the management or rental department in handling the car rental and return processes, as well as make it easier for the admin to generate reports (Saputra & Meilina, 2022).

The car rental industry still faces various challenges, particularly in conventional business processes, manual bookkeeping, transaction recording errors, and difficulties in obtaining accurate rental information. Several studies have addressed these issues by proposing web-based solutions to improve operational efficiency.

In the current digital era, the car rental industry requires an integrated platform that not only optimizes business operational activities but also simplifies customer access. This system must cohesively combine information, business workflows, and cutting-edge technology to create efficient and practical vehicle rental services, while enabling customers to access comprehensive service-related information online .

Similarly, (Akbar & Maulana, 2023) emphasized the inefficiencies of conventional car rental methods and the need for a more flexible transaction and data management system. Their study utilized the *Waterfall* model to develop a web-based car rental information system, allowing customers to access rental services online while rental companies could manage their data more effectively through a centralized database.

(Agus Julianto et al., 2024) extended this research by introducing a *Location-Based Service* (LBS) method in a car rental marketplace application. Their findings demonstrated that integrating LBS enhances customer experience by providing location-based recommendations for rental services, making it easier for users to find nearby available vehicles. The car rental transaction mechanism includes payment data management, such as payment account information, payment confirmation, payment status, and invoice generation (Rafa Kaiza et al., 2024). Finally, there is a process for advertising the website through social media. Thus, the website is expected to be a promotional tool and connect customers with vehicle owners more efficiently (Raihan & Eviyanti, 2022).

Building upon these prior studies, this research proposes the development of a web-based car rental information system using *Extreme Programming (XP)* at CV. Nugroho Trans Surabaya. Unlike traditional models such as *Waterfall*, XP offers a more flexible and iterative approach to system development, ensuring rapid adaptation to user requirements and continuous improvements throughout the development cycle. The implementation of XP in this system is expected to enhance usability, efficiency, and the overall customer experience in car rental services.

Extreme Programming (XP) was designed and developed to meet the specific needs of software development by small teams dealing with unclear and constantly changing requirements (Suryantara, 2017). Extreme Programming is an Agile software development method focused on delivering high-quality software, where initial analysis and design do not cover the entire system, and it emphasizes flexibility in development (Akhtar et al., 2022). Extreme Programming (XP) is a software development approach that simplifies various stages of the development process, making it more adaptive and flexible (Dwi Putra, 2023). While this method is known for being fast, efficient, low-risk, flexible, and predictable, it lacks formal documentation. This is because the process of gathering system requirements is primarily carried

out through direct observation during the planning phase (Pasha et al., 2023).

CV. NUGROHO Trans Surabaya is a company engaged in the car rental business. One of the key challenges it faces is the continued reliance on paper-based processes for estimating rental costs, which slows down transactions and increases the risk of human error. Additionally, the company's promotional strategies remain limited to word of mouth and personal networks, limiting its market reach and competitiveness compared to other technology-driven rental services. These issues highlight a critical gap: the absence of an integrated, real-time, and scalable digital platform that supports operational efficiency and effective customer engagement.

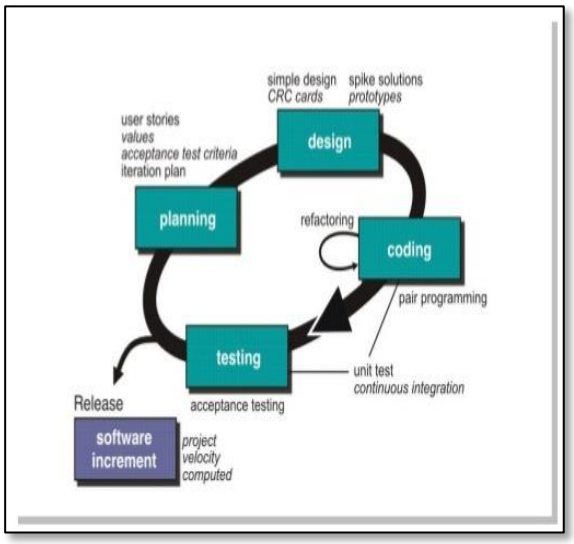
The primary challenge in designing a web-based car rental booking system lies in ensuring the real-time synchronization of vehicle availability, seamless user management, and reliable transaction handling. The proposed system includes core functionalities such as user account registration and management, vehicle categorization and availability tracking, payment processing, rental verification, penalty management for late returns, and automated report generation. Moreover, to support business growth, the system integrates promotional features via social media platforms to enhance visibility and customer reach.

To address these challenges, the Extreme Programming (XP) methodology is particularly well-suited due to its iterative, flexible, and user-centered development approach. XP enables rapid prototyping and continuous feedback, which is essential for refining system features in response to evolving business needs and user expectations. Unlike traditional development methods, XP facilitates close collaboration between developers and stakeholders, allowing the system to adapt swiftly to changes, reduce development risks, and deliver high-quality software. Thus, applying XP not only bridges the identified research and operational gap but also ensures that the resulting web-based solution is both technically robust and aligned with the strategic goals of CV. NUGROHO Trans Surabaya.

MATERIALS AND METHODS

In this design, the method used is Extreme Programming (XP). Extreme Programming, an agile model, was invented by Kent Beck in the year of 1996. He later presented his work on Extreme Programming in a more refined and advanced manner through his book, *Extreme Programming Explained.* Extreme Programming is a flexible approach to software development aimed at producing better software. programmers use popular agile techniques, such as Extreme Programming (XP), Crystal, SCRUM and adaptive software development, to increase productivity without losing their quality of work (Shrivastava et al., 2021). The goal was to increase the effectiveness and efficiency of car rental management processes at the targeted company. The first step in the research was to analyze the needs of the car rental company regarding car rental management systems. The application development was carried out using the Extreme Programming method. After development, a final test was conducted to verify whether the application met the requirements. The test results were evaluated to identify shortcomings and necessary improvements. The expectation was that this research would produce an efficient and reliable web-based car rental management application that met the company's needs. This research also contributed to understanding the application of Extreme Programming in web-based software development for the car rental industry (Moh. Fauzan & Noor Al Azzam, 2023).

Extreme Programming (XP) consists of several key stages, starting with Planning, where user requirements and development strategies are defined. This is followed by Designing, which involves creating prototypes and interface layouts. The next stage is Coding, which also includes integration, ensuring all components work seamlessly together. Finally, the process concludes with Testing, where the system is evaluated to ensure functionality and reliability (Narahaba & Lee, 2024). The framework of Extreme Programming (XP) is illustrated in Figure 1.



Source : (Narahaba & Lee, 2024)

Figure 1. Extreme Programming

Planning

Planning focuses on obtaining an overview of the features and functions of the product to be produced. The planning process starts with

gathering the visuals or narrative offered by the end user, which will serve as a basic description of the program.

Design

XP emphasizes simple design, ensuring that the system remains easy to understand and modify as needed. CRC cards (Class-Responsibility-Collaborator) are used to map out the relationships between objects, making the design more intuitive. This process also includes spike solutions and prototypes, which allow the team to explore and test potential solutions before committing to full implementation.

Coding

This stage is where the actual coding happens based on the planned design. XP emphasizes pair programming, where two developers work together at one computer to write and review code in real-time, improving quality and reducing errors. Refactoring is done regularly to clean up and optimize the code without changing its functionality, ensuring long-term maintainability. To keep everything stable, unit testing is applied to verify individual components, while continuous integration ensures that new code integrates smoothly with the existing system and remains functional at all times.

Testing

Testing involved performance and security evaluations to ensure effective and secure system operation. Performance was assessed using Google PageSpeed Insights and GTmetrix, focusing on load time, TTFB, and page size, while security testing via Pentest Tools identified vulnerabilities such as SQL Injection, Cross-Site Scripting (XSS), and misconfigured security headers.

Release

Once the testing iteration is complete and the features meet the acceptance criteria, the software is released as a software increment, delivering functional improvements in small, manageable updates. At this stage, project velocity is measured to track how quickly the team is completing tasks, helping to plan future iterations more effectively and maintain a steady development pace.

RESULTS AND DISCUSSION

Planning

The planning phase aims to outline the key features and functionalities of the product to be developed. This process begins by collecting visual elements or descriptive narratives provided by the end user, which act as a foundational reference for defining the program's overall structure and objectives.

The purpose of this research is to define the functional requirements that will be implemented in the application. The application will include features designed to meet user needs. In this system, there are two main users: Customers and Admins, each with different levels of access and functionality. Customers can perform actions such as account registration, login, viewing car details, making an order, processing payments, receiving payment confirmation, and printing invoices. On the other hand, Admins have broader control over the system, including the ability to confirm payments, add and edit car data, manage customer data, view transaction history, generate financial reports, and change passwords. These functionalities ensure that the application operates efficiently, providing a seamless experience for both Customers and Admins.

The users of this website consist of Admins and Customers, with the functional requirements for users as follows:

1. Admin
   a. Can log in and log out.
   b. Can view car data.
   c. Can confirm payments.
   d. Can view order history.
   e. Can manage car data.
   f. Can manage customer data.
   g. Can view and print financial reports.

2. Customer
   a. Can create an account.
   b. Can log in and log out.
   c. Can view car data.
   d. Can place orders.
   e. Can make payments.
   f. Can view order history.
   g. Can print invoices

Non-functional requirements:

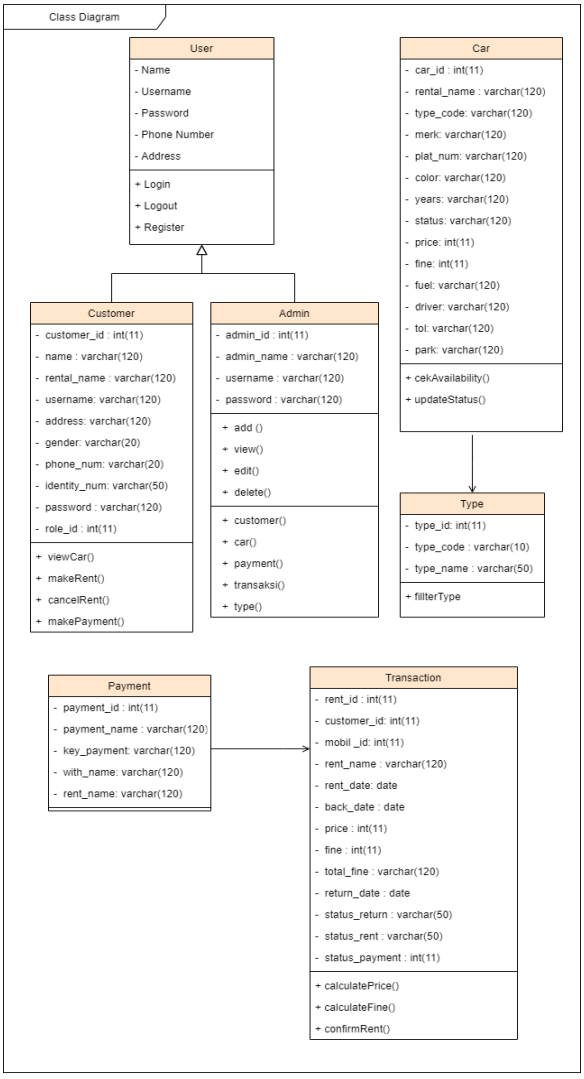
1. Customer registration cannot use the same username.
2. Account registration must have a password of at least 8 characters.
3. Customers can only place orders using a registered account

Design

Figure 2 explains the features available to each actor, where each actor has it's role in the website created. Every customer who wants to place an order must log in first, and if they do not have an account, they can register through the provided menu.

Source: (Research Results, 2025)

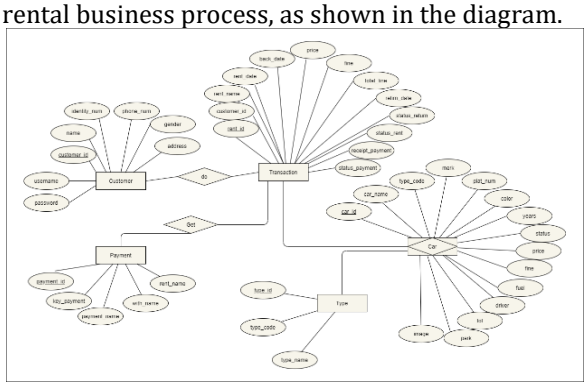
Figure 2. Use Case Diagram



Source: (Research Results, 2025)

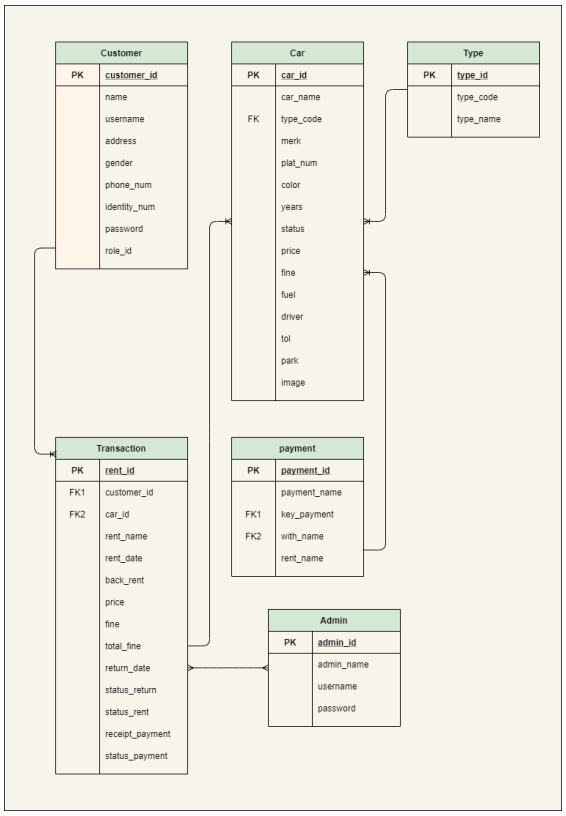
Figure 3. Class Diagram

Figure 3. describes the database of the website created along with the relationship and primary key. Depicts entity attributes and relationships between entities in the database. Main entities such as Customer, Car, Rental Type, and Payment are described with their attributes. Relationships like "Make" between Customer and Rental and "Own" between Rental and Payment explain the interactions between entities in the car rental business process, as shown in the diagram.



Source: (Research Results, 2025)

Figure 4. Entity Relationship Diagram (Chen's)



Source: (Research Results, 2025)

Figure 5. Entity Relationship Diagram (Crow's foot)

Figure 5 provides a more in-depth explanation of the relationships between entities, including primary and foreign keys. It also explains many-to-many and one-to-many relationships. There are several main tables like Customer, Car,

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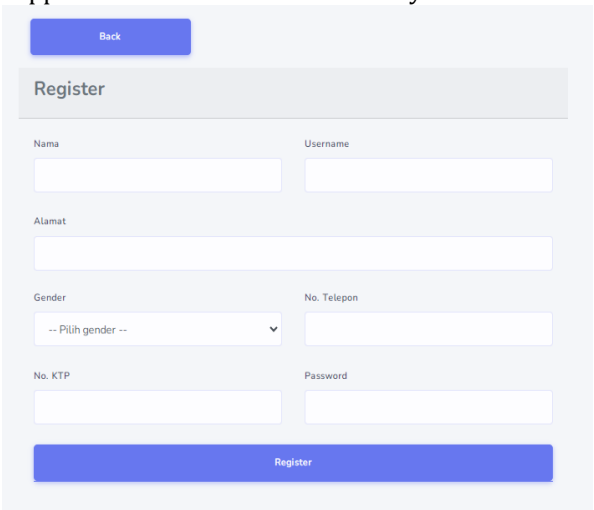
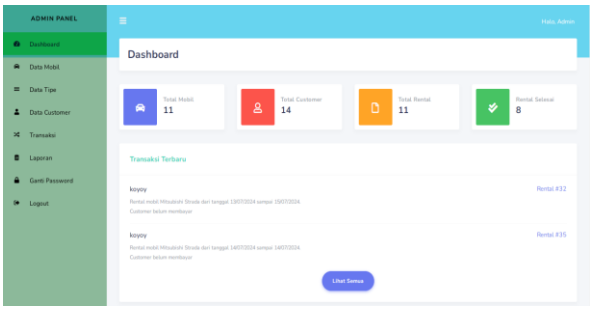
Type, Transaction, Payment, and Admin. The Transaction table relates to the Customer, Car, and Payment tables to represent the car rental process performed by customers, including payment information. The Car table relates to the Type table to specify the types of cars available. These two diagrams provide a complete overview of the data structure and entity relationships required to support the car rental information system.



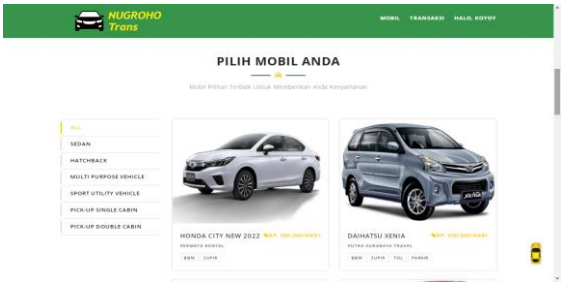
Source: (Research Results, 2025)
Figure 6. Account Registration Page

The Account Registration page serves as the initial interface where users can create their accounts. The page includes fields for entering personal information such as name, username, address, phone number, identity number, and a secure password. Easy-to-use validation mechanisms ensure the accuracy of the data entered, thus enhancing the overall registration experience and system security.



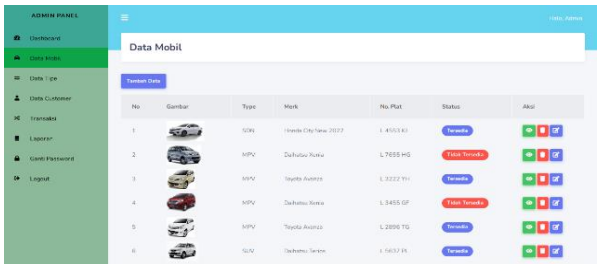
Source: (Research Results, 2025)
Figure 7. Dashboard Admin

The Admin Dashboard is the central management hub for administrators. It provides of key metrics such as the data of vehicles available, ongoing rentals, successful transaction and pending transactions. The dashboard also features navigational links to manage cars, users, and transactions, enabling efficient system operation.



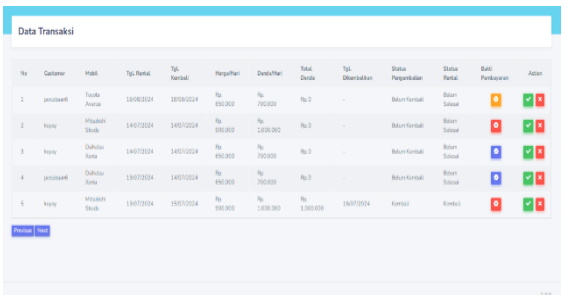
Source: (Research Results, 2025)
Figure 8. Dashboard Customer

The Customer Dashboard provides a personalized interface where users can view their current bookings, rental history, and available car options. Designed with usability in mind, the dashboard facilitates quick access to essential functions like making new bookings or managing payment information.



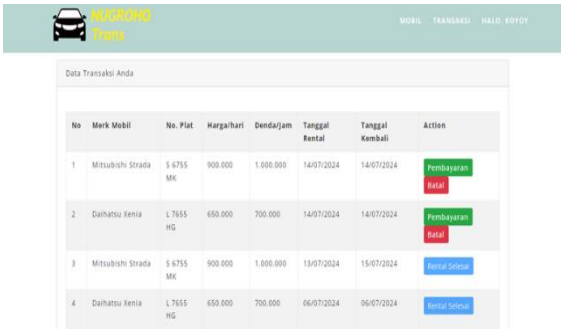
Source: (Research Results, 2025)
Figure 9. Admin Car Management

The Admin Car Management page is where administrators can add, update, or remove car details from the system. This page includes fields for entering car specifications such as model, brand, year, and rental price, along with options to upload images for visual representation.



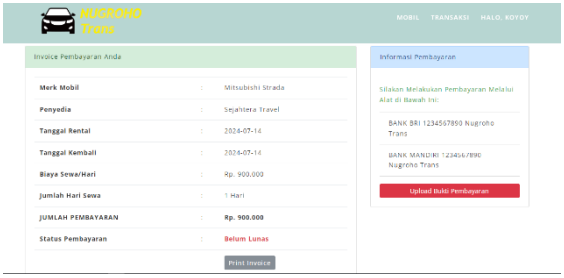
Source: (Research Results, 2025)
Figure 10. Admin Transaction Page

The Admin Transaction Page allows administrators to monitor and manage rental transactions. This page includes a comprehensive list of transactions, showing details such as customer names, car models rented, transaction dates, and payment statuses. Administrators can update or confirm transactions as needed.



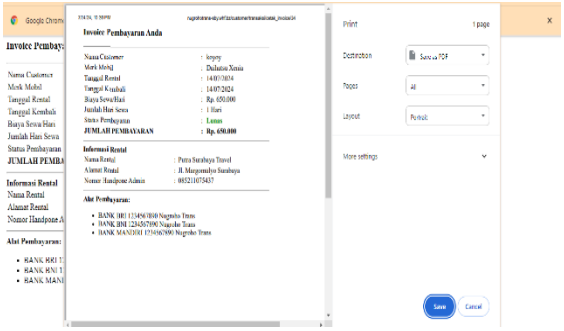
Source: (Research Results, 2025)
Figure 11. Customer Transaction Page

The Customer Transaction Page displays the customer's rental history and current bookings. It provides transparency by detailing transaction statuses, payment history, and upcoming rental schedules. The page is designed to ensure customers can track their transactions with ease.



Source: (Research Results, 2025)
Figure 12. Customer Payment

The Customer Payment page is where users complete their rental payments. It integrates various payment methods such as bank transfers ensuring convenience and accessibility. The page also provides a payment summary and confirmation details for customer reference.



Source: (Research Results, 2025)
Figure 13. Invoice Page

The Invoice Page generates a detailed receipt for completed transactions. It includes essential information such as customer details, car rental specifics, payment amounts, and due dates. This page ensures transparency and acts as a formal record for both the customer and the system.

Testing

Tabel 1. Blackbox Testing

No.	Test Process Use case	Test Result [Success] [Fail]
1.	Use case Test: Account Registration Description: Customers who wish to rent a car must first register by entering the required information. Test Case: Name: Tester Username: tester Password: 12345678 Address: Surabaya Gender: Male Phone Number: 081111111111 ID Number: 1434143134134143 Expected Results: - If account registration is successful, the system will notify that the account was created. - If registration fails, the system will display a validation message.	Success
2.	Use case Test: Login Description: Customers or admins can log in to the system to access its functionalities. Test Case: customer Username: tester Password: 12345678 admin Username: koyoy99 Password: koyoyadmin Expected Results: - If login is successful, the main customer page will be displayed. - If login fails, a pop-up message will display "incorrect username/password."	Success
3.	Use case Test: Placing an Order Description: Customers can select a car and place an order for a specific period. Test Case: Car Data: Automatically displayed based on the selected car Rental Date: 07/26/2024 Return Date: 07/28/2024	Success

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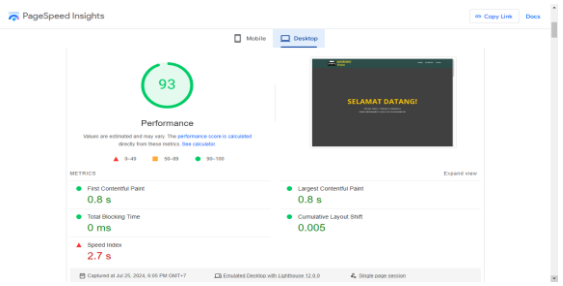
No.	Test Process Use case	Test Result [Success] [Fail]
	Expected Results: - If all data is successfully entered, the system will proceed to the transaction page. - If data is incomplete, the booking page will be displayed again.	
4.	Use case Test: Payment Description: Customers make payments for the rented car. Test Case: Car Details: Automatically displayed based on the selected car Price Details: Automatically displayed based on the selected car and rental period Upload Payment Proof: Upload an image file Expected Results: - If the payment proof is successfully uploaded, the status will change to "waiting for confirmation."	Success
5.	Use case Test: Payment Confirmation Description: Admin confirms payment from the customer for the rented car. Test Case: Payment Proof: Download payment proof Confirmation: Check the confirmation box Expected Results: - If the payment proof is valid, the admin will check the confirmation box, and the payment status will be confirmed. - If the payment proof	Success
6.	Use case Test: Financial Report Description: Admin can print financial reports with a date filter. Test Case: Print Financial Report: Automatically displayed based on the transaction history Expected Results: Display all financial reports according to the selected filter.	Success

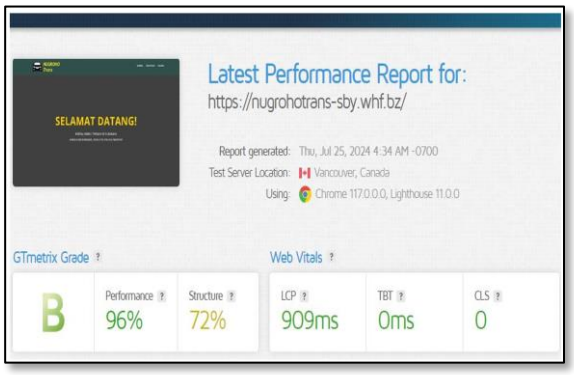
Source: (Research Results, 2025)



Source: (Research Results, 2025)

Figure 14. Testing Performance Desktop Page Speed Insight

Describes the performance results of the desktop mode website with the first contentful paint with a time of 0.8 seconds, total block time 0 milliseconds speed index 2.7 seconds, largest contentful paint 0.8 seconds and cumulative layout shift 0.005 with a total score of 93 out of 100. this explains that the test results have met the standards for website operation.



Source: (Research Results, 2025)

Figure 15. Testing Speed GTMatrix

The testing results obtained through the GTmetrix website showed a grade of B, with a performance score of 96% and a structure score of 72%. These results indicate that the system's performance falls into a good category.

Discussion

Several technical issues were identified and resolved during the development process of the system using the CodeIgniter 3 framework. One of the main issues was managing user authentication

and access control between customers and administrators; this was addressed by implementing custom session-based access control and session validation on each controller. Another challenge was the lack of synchronization between the payment status on the user and admin sides, which was resolved by adding a status field and implementing validation logic during transaction data updates. The large volume of vehicle and transaction data caused the dashboard page to load slowly, so we optimized the database queries, implemented pagination, and applied simple caching using CodeIgniter's built-in features. Additionally, since payment verification was handled manually by the admin, the manual payment integration process was prone to errors. As a temporary solution, a feature was added to allow users to upload proof of transfer, with payment status that can be periodically reviewed by the admin. From a security perspective, testing revealed that HTTP methods such as PUT, DELETE, and TRACE were still enabled; these were subsequently disabled by modifying the .htaccess file and server configurations to reduce potential vulnerabilities.

CONCLUSION

The Extreme Programming (XP) method was successfully used to construct the vehicle rental information system for CV. Nugroho Trans Surabaya. Customers may make reservations and payments online thanks to the technology, which improves consumer ease and service effectiveness. By providing standardized data management, expedited administrative procedures, and real-time access to vehicle availability, it also enhances operational performance. Nevertheless, the study included some shortcomings. Performance and scalability may be impacted because the system was tested in a local setting and has not yet been assessed in high-traffic real-world scenarios. Furthermore, the security mechanisms put in place mainly addressed fundamental vulnerability checks; more sophisticated threat modeling and penetration testing might fortify the system even more. It is advised for future projects to do more testing in real production settings, include sophisticated security features like multi-factor authentication and intrusion detection systems, and think about mobile app development to increase accessibility. GPS tracking for improved fleet management and interaction with third-party payment systems are possible additional improvements.

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