Decentralized Car Rental System: Ensuring Security with Blockchain Smart Contracts

Chiraz El Hog[1,2][a], Raoudha Ben Djemaa[3][b], Rania Aldaas[1], Buthainah Alnaeem[1], Rand Alageeli[1], Atheer Almutiri[1] and Hadeel Alharbi[1]

[1]*Department of Computer Science, College of Computer, Qassim University, Buraydah, 52571, Saudi Arabia*

[2]*ISSAT, University of Sousse, Tunisia*

[3]*ISITCOM, University of Sousse, Tunisia*

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Keywords: Blockchain, dApps, Smart Contract, Data Security, Data Privacy, Car Rental.

Abstract: In today's fast-paced digital economy, efficiency and trust are crucial, particularly in financial transactions and resource-sharing services. The growing interest in car-sharing platforms and blockchain technology has paved the way for decentralized solutions that enhance security, transparency, and automation. This paper presents a decentralized car rental solution built on blockchain technology, using smart contracts to ensure secure, tamper-proof, and trustful transactions. The proposed system allows users to browse and rent available vehicles, select suitable options based on their needs, and set rental terms seamlessly. Furthermore, car owners and businesses can rent out their unused vehicles for rent while specifying features, images, and pricing. The rental process is governed by blockchain-based identity management and smart contract enforcement, eliminating intermediaries and reducing operational risks. A key focus of this work is privacy and data protection. The system incorporates cryptographic techniques, access control mechanisms, and smart contract security best practices to mitigate risks such as fraud, unauthorized access, and data manipulation. Using blockchain immutability, decentralized identity verification, and secure payment channels, the platform improves user trust and prevents common vulnerabilities seen in traditional rental systems. Through this blockchain-based approach, we provide a secure, efficient, and transparent alternative to conventional car rental services, fostering greater trust among users while minimizing costs and enhancing operational efficiency.

1 INTRODUCTION

Intelligent Transportation Systems play a key role in transportation and traffic management systems around the world. They are a combination of advanced information and communication technologies used in transportation to enhance safety, efficiency, and improve driver experience(Souki et al., 2023). Car sharing and rental are significant subfields of transportation systems that use these technologies to simplify vehicle access and use. Currently, most existing car rental systems are centralized. They rely on third parties to manage the rental process between customers and car owners. The customer must therefore select the right vehicle in person at the rental office. The rental agreement is achieved by accepting the rental fees and terms of a contract created by the middleman along with the need that a driver's license and national identification be shown. However, many issues arise with this approach, such as the high leasing costs resulting from the commission of the middleman and the possibility of misuse of the customer's personal papers due to the lack of confidentiality guarantee.

Furthermore, contract management remains a significant challenge for companies that use traditional paper contracts or digital systems. Paper contracts are prone to damage, forgery, and loss, making them unreliable for long-term records and significantly increasing the risk of fraud. Although digital contracts offer greater efficiency, they remain susceptible to hacking and data manipulation, posing a risk of security breaches and unauthorized alterations. Furthermore, contract mismanagement, such as delayed cancellation of a rental agreement, can lead to du-

[a] https://orcid.org/0000-0002-0367-5439
[b] https://orcid.org/0000-0002-7831-112X

El Hog, C., Ben Djemaa, R., Aldaas, R., Alnaeem, B., Alageeli, R., Almutiri, A. and Alharbi, H.
Decentralized Car Rental System: Ensuring Security with Blockchain Smart Contracts.
DOI: 10.5220/0013505400003929

In *Proceedings of the 27th International Conference on Enterprise Information Systems (ICEIS 2025) - Volume 1*, pages 1110-1120
ISBN: 978-989-758-749-8; ISSN: 2184-4992

plicate bookings, where a vehicle is rented to a new customer while still being registered under the previous renter. Moreover, if any fines or penalties (for example, traffic violations) occur during this period, they can be incorrectly assigned to the previous customer, leading to conflicts, financial liabilities, and unfair charges. Managing their cars once they are rented out presents serious difficulties for car rental companies as well. Without adequate tracking, a car could be damaged or utilized for illicit purposes without the company's knowledge. Customers may exceed the predetermined mileage limits,Customers may exceed the predetermined mileage limits, violating rental terms and ruining trust between the parties.

Blockchain technology is a decentralized peer-to-peer network composed of a series of blocks where data are stored. These blocks are linked based on cryptographic hash methods(Souei et al., 2023). It is a particularly promising and revolutionary technology because it helps reduce security risks, eliminate fraud, and bring transparency in a scalable way [15]. It is also considered ideal for delivering information because it provides immediate, shared, and completely transparent information stored on an immutable ledger that can be accessed only by permitted network members. This technology cancels the participation of a third party between the seller and the buyer. In fact, participants are connected in a peer-to-peer network, and data are shared in a distributed manner. It is a series of blocks closely related to each other. Each block has a hash that is like its own fingerprint, which changes with changing content of the block, and also contains the hash of the preceding block. Whereas, when the content of the block is modified, it will appear that it has tampered because it will change its hash and the hash that follows it all. The strength of the blockchain lies in its features such as immutability, decentralization, security, and anonymity. In fact, each node has copies of all transactions, but with encrypted data. Therefore, blockchain improves trust across a business network (Shanker, 2019). With the advent of blockchain technology, smart contracts appeared, which are piece of code executed on the blockchain to automatically trigger transactions upon the occurrence of predefined events (Souei et al., 2023). The smart contract is immutable; therefore, it cannot be modified once created. The smart contract is executed automatically (self-executing code) when the agreement conditions are met. To ensure that a blockchain can execute a contract between two parties safely without the need for a lawyer or any middleman, smart contracts can hold the agreed-upon funds. Once the specified conditions are met, the funds are automatically transferred to the rightful recipient. Many research studies have been conducted in academia and industry to take advantage of these technologies in various areas. Especially, in the domain of car sharing and rental, some solutions were proposed (Auer et al., 2022) (Nair et al., 2020) (HireGo, 2018).

Blockchain technology offers decentralization, immutability, and security, making it an ideal solution for the car rental industry. This study aims to develop a decentralized car rental system that enhances security, transparency, and trust. To achieve this goal, we define the following objectives:

- Build a decentralized car rental system allowing direct peer to peer transactions
- Enhance security and trust between car owners and customers using smart contracts.
- Reduce rental time and costs by automating agreements and payments.
- Ensure privacy and data protection through blockchain-based identity management.
- Improve overall transparency and reliability in car rental transactions.

To address these objectives, our study explores the following research questions:

- What are the essential requirements for building decentralized car rental system that allows anyone to rent out his unused cars?
- How can blockchain improve privacy and trust in car rental systems?
- How can traditional contracts be replaced by smart contracts on a distributed ledger?
- How can smart contracts ensure fair and secure transactions between car owners and renters?

The remainder of this paper is organized as follows: Section 2 presents a review of related works. Section 3 describes the proposed decentralized car rental system, including its architecture, technologies, and implementation. Section 4 details the experimentation and testing procedures. Section 5 highlights the major findings, and Section 6 concludes the paper with future research directions.

2 REVIEW OF RELATED WORKS

Traditional car-sharing platforms rely on centralized systems which are prone to data breaches and service downtimes due to their single points of failure. In recent years, the intersection of blockchain technology with shared mobility has gained significant traction,

addressing key challenges posed by traditional car-sharing systems. Blockchain enables enhanced security, transparency, and efficiency through decentralized applications (DApps). In this section, we will explore existing research on this topic. Our study is categorized into centralized systems and blockchain based applications to provide a comprehensive comparison of both approaches.

2.1 Centralized Systems

The process of renting a car is highly centralized, where the car rental company being the main point of contact for the driver to rent cars. Car rental companies need to maintain a fleet of cars, as well as car stations and staff to efficiently run their operations, which makes up for bulk of their operating costs. Car rental companies cover these costs from (high) rental rates charged to their customers.

- The SECREDAS (Doe et al., 2022) project developed a secure car-sharing system including an embedded access device, a backend server, and a mobile application. The system combines identity management, secure authentication mechanisms, and REST API security to mitigate threats such as unauthorized access and API abuse. Secure vehicle unlocking is accomplished by Bluetooth Low Energy (BLE) and Near Field Communication (NFC) using a symmetric rent token (car key).
- Ekar (ekar, 2021), launched in February 2016 in Dubai, is a mobile application for car booking that aims to simplify the car rental process. Competing with platforms like Uber and Careem, Ekar allows users to conveniently rent vehicles on demand via a smartphone application. The service offers various benefits, including free fuel, insurance, and parking, as well as the flexibility to choose a preferred car type and locate nearby available vehicles. Users can rent a car instantly and conclude their trip seamlessly. Despite its convenience, the platform has been criticized for trust and security concerns. It relies on a centralized platform for authentication, payments, and fleet management. Additionally, it requires a highly skilled support team and multilingual customer service to effectively manage operations.
- Sharik (sharik, 2021) Application Company for Information Technology is a Saudi-based car-sharing platform. It is the first licensed electronic rental broker approved by the General Transport Authority, enabling individuals to rent out their cars through mobile applications and websites. The platform allows users to book nearby vehicles on an hourly or daily basis. However, users have reported trust, privacy and security concerns, along with software-related issues. Additionally, high rental costs have been a common complaint based on user feedback.
- Shift inc (shiftinc, 2021) offers a fully automated car rental experience, where a user's smartphone serves as the key for accessing vehicles. By integrating advanced technology, the platform enhances the efficiency, speed, and quality of the rental process. Shift Inc combines hardware and software solutions to provide better operational oversight and maintain high service standards for users. The platform also emphasizes competitive pricing, aiming to maximize customer satisfaction while minimizing resource usage. However, Shift Inc operates as a centralized system, requiring staff and intermediaries for management. Despite its automation, users have raised concerns regarding trust and security within the platform.

2.2 Blockchain-Based Systems

In the car rental industry, blockchain operates similarly to other blockchain transactions. Car owners (or service providers) and clients registered on the blockchain can sign digital smart contracts, which automatically enforce rental terms based on pre-defined rules, just like a traditional rental agreement.

- The study (García-Moreno et al., 2022) emphasizes the development of a decentralized car rental application that uses blockchain technology to eliminate intermediaries and allow car owners to hire vehicles directly to clients without paying commission fees. The researchers propose a decentralized application (DApp) that utilizes smart contracts to facilitate peer-to-peer transactions securely. They highlight the importance of using Ethereum and tools like Ganache to create a reliable framework for these transactions. The document mentions the use of smart contracts however the programming language and features are not covered. In addition, by building the DApp on the Ethereum network, the solution may be subjected to Ethereum's scalability issues, including transaction speed and cost fluctuations, especially during high network congestion periods
- The work presented by (Kim et al., 2021) fills the gap by introducing a decentralized model where stations, acting as intermediaries, manage a blockchain that maintains user anonymity while securing transaction records. The proposed sys-

tem undergoes a comprehensive security analysis using BAN logic and AVISPA simulations, demonstrating resilience against various attacks. Overall, it advances the field by ensuring mutual authentication, protecting user privacy, and providing integrative solutions to security vulnerabilities identified in earlier research. This paper presents a secure and decentralized car-sharing system model and authentication scheme. The system uses blockchain for data integrity and user anonymity, addressing security vulnerabilities in traditional systems. However, there is no real-world implementation or system simulation. Additionally, it requires high Communication Costs due to the authentication process consisting of interaction among three parties (users, vehicle owners, and stations). This could affect scalability and responsiveness during periods of high usage. Despite being decentralized, the system still issues credentials and manages keys through a trust authority. It does not explicitly mention the use of smart contracts in the proposed decentralized car-sharing system.

- The paper (Dwivedi et al., 2024) proposed a decentralized vehicle rental system utilizing blockchain technology to eliminate intermediaries and commission fees typically associated with traditional car-sharing services. By implementing a secure, transparent, and tamper-proof model, the paper demonstrated how blockchain can enhance user trust and system reliability in peer-to-peer vehicle rentals.
- HireGo (HireGo, 2018) is a UK based company that builds a decentralized car hire and car sharing application. HireGo prioritizes security and ease of use. Payments are made in advance and assist the Ethereum chain‘s deposit contract. The HireGo team is notified of the disagreement. However, the user is unaware of the technical complexity. This solution increases confidence and trust in the authenticity of the Identity-based Blockchain user platform. In addition, this solution presents low cost. But, there is no documentation available about this application, no information about the programming techniques
- Volvero (volvero, 2022) proposes blockchain technology to create a straightforward, reliable and sustainable solution that connects vehicles' owners with drivers. Also, Volvero provides full insurance and customized protection to guarantee the safety of Drivers and Owners who join Volvero. Unlike other renting or sharing services, there are no time or location restrictions. As a security measure, Volvero creates smart contracts at the start of the ride while a built-in insurance covers drivers and all kinds of vehicles during the whole period of sharing. Volvero's patent technology tracks speed, acceleration, braking and the car's location. But, there is no information about the programming techniques: blockchain platform, wallet management, monitoring smart contract...

2.3 Limits of Existing Works

Previous studies have identified various security threats, including data integrity issues and potential attacks such as impersonation and man-in-the-middle attacks. Some have proposed authentication protocols; however, they often rely on centralized structures that expose users to risks. For instance, earlier efforts have explored hierarchical systems and smart token-based access without fully leveraging blockchain's decentralized capabilities. Recent works have explored blockchain-based car-sharing as a decentralized alternative. Solutions such as HireGo and Volvero utilize smart contracts to automate rental agreements, ensuring tamper-proof transactions, identity verification, and secure payments. Unlike traditional systems, blockchain eliminates intermediaries, reducing fraud risks and operational costs. However, blockchain solutions often face latency issues, as seen in Ethereum-based smart contracts, where transaction validation can take several seconds, impacting user experience. To compare between existing works presented in the previous section we defined the following criteria: platform type, cost, Security , Trust, smart contract usage. Table 1 compares existing works according to the predefined criteria.

According to the table 1, we found that centralized solutions (eKar, Sharik, Shift Inc.) have lower security and trust due to reliance on third parties. They are more prone to security breaches and have higher operational costs. Decentralized solutions (HireGo, Volvero, blockchain-based research) use smart contracts, improving transparency, security, and cost efficiency. However, some lack implementation details. These solutions present some challenges in relation to blockchain limitations include scalability, gas fees, and communication costs in some implementations. Furthermore, our analysis revealed that existing solutions lack detailed information on the programming methodologies used for implementation. None of the reviewed works provide insights into the user experience (UX), such as interface design, ease of use, or customer interaction with the system.

Table 1: Comparison of related Works.

Solution	Platform type	Security	Trust	SC Usage	Key Limitations
(ekar, 2021)	centralized	low	low	No	Requires third party intermediaries, security concerns and high costs
(sharik, 2021)	centralized	low	low	No	Security, trust, software related issues, high rental costs
(shiftinc, 2021)	centralized	low	low	No	trust security
(HireGo, 2018)	decentralized	high	high	yes	No detailed documentation on programming techniques
(volvero, 2022)	decentralized	high	high	Yes	No information on blockchain platform, wallet management, and smart contract management
(García-Moreno et al., 2022)	decentralized	high	high	Yes	Uses Ethereum; may suffer from high gas fees and network congestion
(Dwivedi et al., 2024)	decentralized	high	high	Yes	Transaction Costs (must pay transaction fees in Ethereum),Testing Limitations,issues related to scalability on the Ethereum network
(Kim et al., 2021)	decentralized	high	high	Not explicitly mentioned	Requires trust authority for credential management, high communication costs

3 CONTRIBUTION: CarChain

The proposed system is to implement a decentralized application **CarChain** based on blockchain technology allowing the owner or car rental offices to rent cars in a safe, less cost and reliable way by using smart contract which Highlights all relevant stages including duration, pickup and payment. The concept of blockchain in car rental industry works similarly to any other blockchain transaction. Service providers (or car owners) and end clients registered on the blockchain can sign digital smart contracts which execute agreement terms based on predefined terms and obligations. The smart contract is self-executable computer code that lives on a blockchain platform. When the conditions defined in the smart contract are met, the code executes itself without the need for an intermediary (third party) to provide permission. The smart contract is immutable and it allows the owner to detect if the customer fulfills the conditions described in the smart contract in order to increase the mutual trust. The smart contract also contains the necessary information, such as information about the customer (driving license proof, insurance) and rental data such as car registration number, rate, mileage, duration of rental, and credentials of the car owner. The financial transactions (rental payment) can be done by using associated cryptocurrency to get registered on the blockchain. Figure 1 shows the proposed car rental life cycle.

3.1 System Requirements

This section outlines the functional and non-functional requirements necessary for the development of the decentralized car rental system.

Functional Requirements

- User Management. The application allows users (car owners or renters) to register and authenticate securely.
- Create Digital Identity for Car. The application allows the owner to create digital identity for car like(type of car,car number,car insurance).
- Negotiate a Contract. Allows the owner to negotiate a contract with the customer.
- Check Wallet Value. Allows the owner to check wallet if the customer complete the payment or not.
- Rate a Customer. Allows the owner to rate the customer usage of his car.
- Search and Choose. Allows the customer to look for cars depending on the availability or nearest cars using the map and the appropriate car depending on his preferences.
- Negotiate a Contract. Allows the customer to negotiate a contract with the owner. The customer then can complete the rent process by agreeing on contract and choose the way the car is delivered.
- Rate an owner: Allows the customer to rate the car and the way that customer get it.

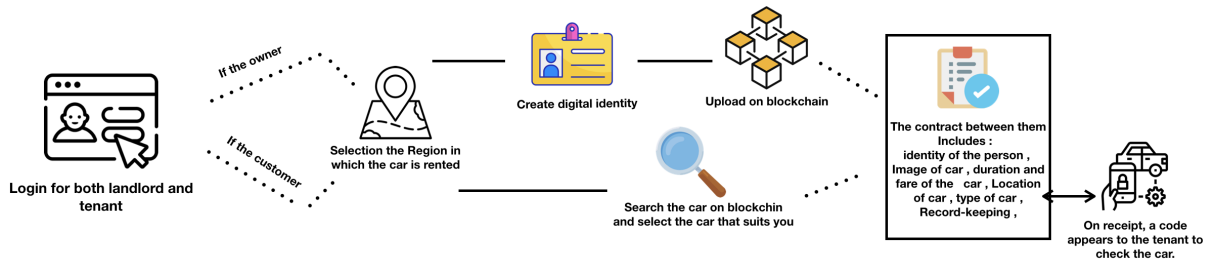

Figure 1: CarChain rental life cycle.

- Select the Ways to Receive the Car. Allows the customer to choose the way to receive the car by Bar code and SMS or the customer can take the key of car from the owner.

Non-Functional Requirements: explain the quality aspects of the system to be constructed.

- Security and Privacy Requirements: The application must provide integrity, verification, and non-repudiation of the reservation details and the ability to prove the validity of the data and the possibility to access it safely by the renter and the owner only such as the time of reservation and the type of vehicle. The identity of the consumer and the car should be hidden to anyone except the owner, the consumer and the car. (Madhusudan et al., 2019)
- Confidentiality of Booking Details: Only the owner and consumer should have access to the information stored in booking details.
- System Scalability: The maintainability and scalability of the system should be fully considered to facilitate the follow-up work of the developer.
- Saving Time,Money and Effort: The way to create a fast binding financial agreement in the form of a smart contract. Like traditional contracts, smart contracts specify the obligations of both parties, unlike traditional contracts,they programmatically enforce them (Apriorit, 2023).
- Traceability and Reliability: In the proposed system, the risk of fraud or damage will be minimized. Data from various sources will be shared on a blockchain network, enabling the execution of different transactions, such as signing leasing contracts, renting cars, and selecting insurance plans. This creates the need for a single, reliable source of truth for the stored data, ensuring that all users have access to the same information. Moreover, the recorded data will be accurate, addressing both short-term and long-term needs. Therefore, the system will require an immutable history log of executed transactions and car-related data, including information on damages, maintenance, and repairs.(Auer et al., 2022).
- Usability and User Experience (UX): The application will be user-friendly and flexible, offering all services in one place without the need for additional programs. Every user can navigate the application easily.

Sequence Diagram is an interaction diagram that details how operations are carried out. It captures the interaction between objects in the context of a collaboration. Figure 2, depicts the sequence diagram of create car digital identity.

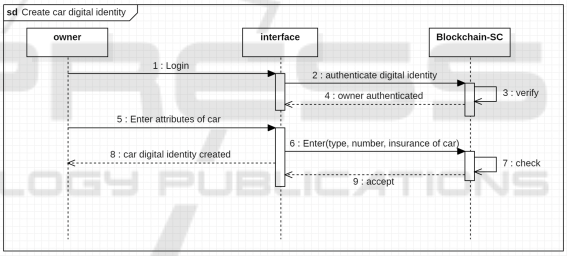

Figure 2: Sequence Diagram of Create car digital identity.

Figure 3, depicts the sequence diagram of negotiate smart contract. This diagram shows the interactions after authenticating each one of the owner and customer.

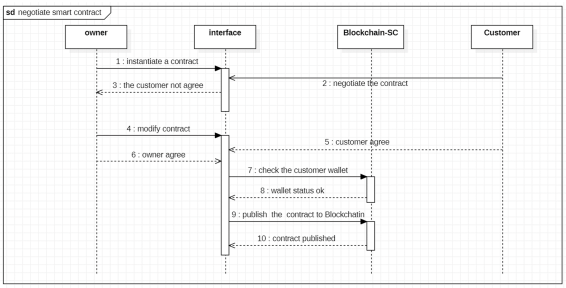

Figure 3: Sequence Diagram of negotiate smart contract.

To represent the workflow of Carchain and entire process, flowchart diagram is used for designing, documenting and visualizing what is going on. The following flowchart, figure 4, shows how actions or de-

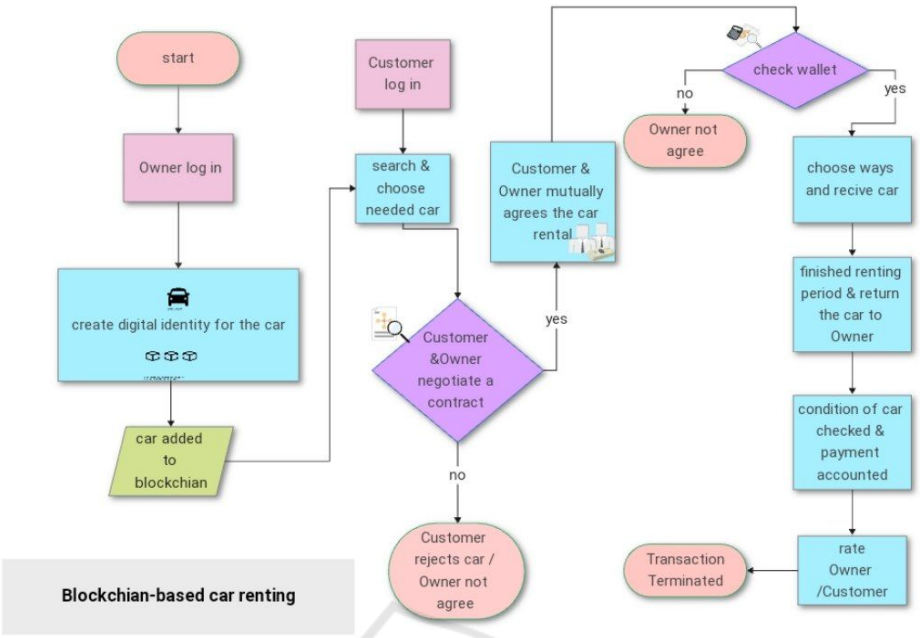

Figure 4: CarChain Flowchart Diagram.

cisions flow between the owner and the customer.

3.2 System Architecture

An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviors of the system. A system architecture can consist of system components and the sub-systems developed, that will work together to implement the overall system. The proposed CarChain decentralized application is a hybrid architecture that combines the features of on chain systems and off chain. This architecture helps to reduce the cost and to improve the trust and data protection.

1. **OFF Chain.** For Cross-Platform development and Cost-Effective Solution, we use flutter platform with dart language to design and mange all the front end interfaces. For, fast and Secure Data Storage, we use Firebase as our system back end off chain to collect, store and retrieve data.
2. **ON Chain.** We use (Metamask, Solidity, Binance smart chain) to check the balance in wallet, make the payment, write the smart contract using solidity then deploy it on Binance chain. Binance Chain is chosen because of its high transaction throughput, low fees, and fast processing capabilities, which are essential for a scalable and efficient car-sharing platform. Its seamless integration with the Binance Smart Chain (BSC) enables rapid and cost-effective smart contract execution, making it an ideal solution for supporting decentralized car-sharing applications. Additionally, the robust security features of Binance Chain, along with its large user base and liquidity, further strengthen its suitability for ensuring smooth, secure, and transparent car rental transactions.

Figure5 shows the System architecture.
The languages used are:

- **Dart:** is a client-optimized language for developing fast applications on any platform. Its goal is to offer the most productive programming language for multi-platform development, paired with a flexible execution runtime platform for application frameworks (DartTeam, 2024).
- **Solidity:** is an object-oriented, high-level language for implementing smart contracts. Smart contracts are programs which govern the behaviour of accounts within the Ethereum state(SolidityTeam, 2024).

The Development Tools used are:

- **Flutter.** Flutter is a mobile application development platform created by Google. It allows developers to create web, desktop, and cross-platform applications that run on Android and iOS devices. Flutter uses a reactive programming language called Dart, making development faster and easier than traditional methods(EduCBA, 2024).

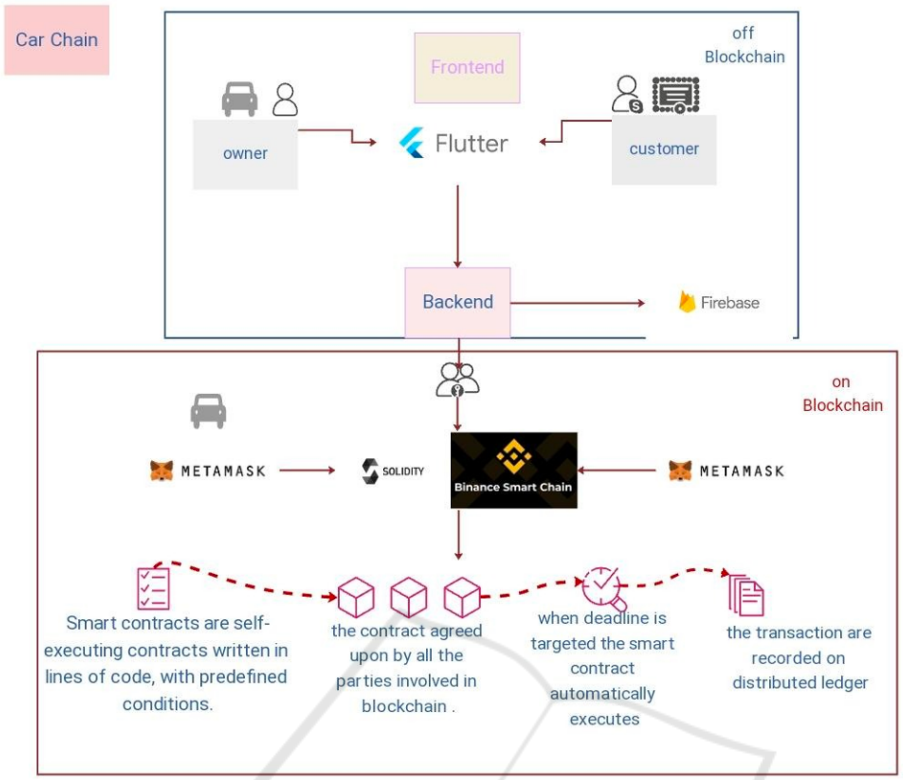

Figure 5: Carchain architecture.

- **Firebase.** Firebase is a development platform known originally for its real time database that's still at its core a multi-node, key-value database optimized for synchronizing data, often between user machines or smartphones and centralized storage in the cloud(VentureBeat, 2024).
- **MetaMask.** MetaMask provides an essential utility for blockchain newcomers, token traders, crypto gamers, and developers(MetaMask, 2024).
- **Remix.** Remix IDE allows developing, deploying and administering smart contracts for Ethereum blockchains. It can also be used as a learning platform(Project, 2024).
- **Truffle Suite.** The most comprehensive suite of tools for smart contract development. It helps to quickly build, test, debug, and deploy using the truffle Command line interface. Also to write scripts and plugins in order to automate common processes(Suite, 2024).
- **Ganache.** Ganache is a component of the Truffle Suite ecosystem that can be used to launch an Ethereum blockchain. It provides a personal Ethereum blockchain which you can use to run tests, execute commands, and inspect state while controlling how the chain operates(Suite, 2024).

3.3 Smart Contract Implementation

We developed a smart contract with solidity language and we used remix as its editor. MetaMask is also used to create a wallet for deploying the smart contract.

Figure6 shows the Smart contract to be used in CarChain application.

```
FullCarChain.sol M
contracts > FullCarChain.sol > FullCarChain
5
6   contract FullCarChain{
7
8       uint public count = 0;
9
10      constructor() {
11
12      }
13
```

Figure 6: Solidity smart contract definition.

- **contract:** name of the contract
- **Count:** that is responsible for Id, and it is also responsible for giving the number of cars in the system.
- **Struct car** represents the car information such as: id for the car , model, number, size car, car image, also contains address wallet of the owner and customer ... etc.

- **Function createCar.** this function will push a new car to our map (allCar) by recording some field for example (model car , price , number car , carImage ..etc), if something is missing from the recorded data the car is not push to the map. Figure8 shows the function createCar().
- **Function rentCar:** It is responsible for renting the car to the customer. It requires to take the id of the car and the period of rent days. Also, it calculates the final price of all the rent period and pays the fees from the customer wallet. Figure8 shows the function rentCar().

Figure7 shows the car struct.

```
FullCarChain.sol M
contracts > FullCarChain.sol > FullCarChain > Car
6   contract FullCarChain{
14      struct Car {
15      uint id;
16      string model;
17      string number;
18
19      bool rent;
20
21      address  payable owner;
22      address  payable renterAddress;
23      uint price;
24      uint rentDaysNumber;
25      string carSize;
26      string carImage;
27      bool fuel;
28      string details;
29
30
31      }
```

Figure 7: Car struct in solidity language.

4 EXPERIMENTATION AND TESTING

This interface includes the car data that the owner will display for rental, as follows: (car model, car number, exact price, fuel, type). The owner must take a picture of the vehicle and the insurance to be able to display it within the application. Once all data is entered, it is securely stored in Firebase and on the blockchain. After clicking the Save button, a confirmation message appears, notifying the owner that their data have been successfully saved.

Figure9 shows the car registration page.

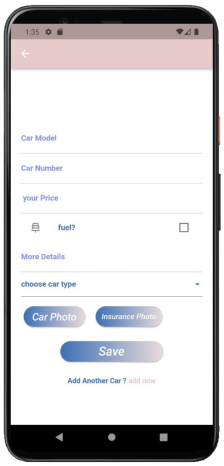

Figure 9: Car registration page.

Account Screen. This interface displays the public account address of the car owner and their connected wallet. To use the platform, the owner must have a preexisting wallet with sufficient balance. The wallet consists of:

- A private key, known only to the user, ensures security and confidentiality.
- A public address key is used for blockchain transactions and to verify ownership.

The public address key will be obtained as well as the balance of wallet by entering private key by the user. If he wants to change the address it is by using the button (change account address). Figure10 shows the account screen.

For choosing the way to receive the car we use google map. We added our project in google cloud platform in order to enable maps SDK and to get API key for IOS and Android.

The smart contract is deployed on the Binance Smart Chain (BSC). The BNB smart chain is known by its fast transactions, reduced fees, and integration with the Binance ecosystem (Cryptomus, 2025). Figure11 shows the smart contract and the corresponding transaction. After confirming rent, the transaction details (transaction hash, sending address, receiving address and the transaction fee) will appear immediately on transaction details as shown in figure 12.

```
function createCar(string  memory model, uint price, string memory number,string memory carSize,
    string memory carImage,bool fuel,string memory details) public {

function rentCar(uint _id, uint _numberRentDays) public payable {
```

Figure 8: Function createcar()/rentCar().

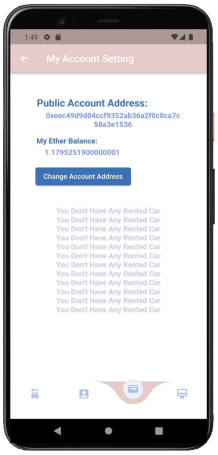

Figure 10: Account screen.

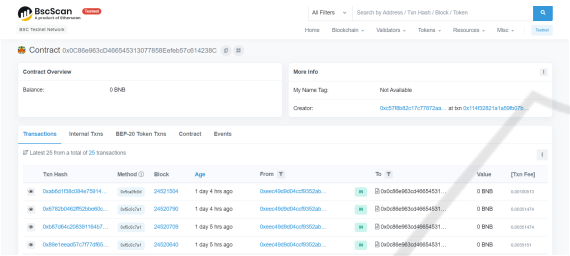

Figure 11: Contract deployed on BNB Smart Chain Network.

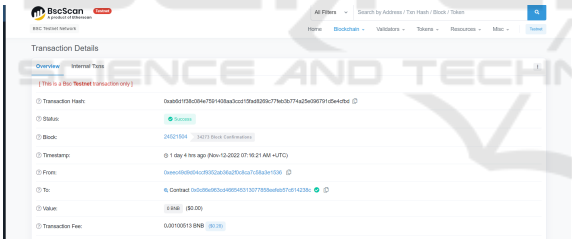

Figure 12: Rent transaction details.

5 MAJOR FINDINGS

The security benefits of using blockchain technology for car rentals in the proposed decentralized application are as follows:

1. **Decentralization.** The process is decentralized, which eliminates the need for a third party or intermediary. This reduces the risk of fraud and manipulation since there's no central authority that can alter the contract terms or mishandle the transaction.
2. **Immutability.** Once a smart contract is deployed on the blockchain, it cannot be altered. This immutability ensures that the terms agreed upon by both parties remain unchanged, increasing trust between the car owner and the renter.
3. **Automated Execution.** Smart contracts automatically execute when predefined conditions are met. This automation reduces the chances of human error and ensures that the rental terms (such as payment, duration, and pick-up) are enforced as agreed without the need for intervention.
4. **Transparency.** All transactions and contract details are recorded on the blockchain, providing a transparent audit trail. This means all parties can verify agreements and transactions, enhancing trust and accountability.
5. **Security of Data.** The use of smart contracts involves storing sensitive information (like customer verification documents) in a secure manner, often encrypted, that protects against unauthorized access and data breaches.
6. **Digital Integrity.** The verification of transactions through consensus mechanisms ensures that only legitimate transactions are recorded, reducing the risk of fraud or double spending.
7. **Fast and Less Expensive.** Binance Chain is chosen because of its high transaction throughput, low fees, and fast processing capabilities (Cryptomus, 2025), which are essential for a scalable and efficient car-sharing platform.

These features make the car rental process more secure and trustworthy for both car owners and renters by minimizing risks typically associated with traditional rental systems, which often involve centralized control and numerous intermediaries.

6 CONCLUSIONS

The CarChain system is a decentralized application developed using Dart and Solidity. The CarChain system offers cars from owner to the customer for rent in peer to peer model. It addresses the problems of traditional car rental systems which are centralized and require a third party or a middleman who administrates all the rental process between the owners of cars and customers. Additionally, a smart contract is used to automatically create rental cars. It saves time and money for the consumer and makes renting a car easier and safer for both the owner and the renter. This work can be improved by integrating Service Level Agreements (SLAs) with smart contracts to ensure Quality of Service (QoS). As highlighted in the survey paper (Hamdi et al., 2022), SLAs define and guarantee the required service levels. Furthermore, the

study (Abdelhamid et al., 2024) highlights the benefits of utilizing Artificial Intelligence (AI) techniques to improve blockchain-based solutions. These techniques can be used to optimize the selection process for the most suitable car.

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