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Smart Parking System Using Blockchain

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Abstract: The presented smart parking system integrates multiple private and public parking services under an integrated medium with the aim of providing one-stop parking information services to commuters in a smart city. However, the adaptation of such a system is prone to tampering, while large amounts of data are shared among various parties, leading to problems related to trust and enforcement. To address this challenge, we propose a specific blockchain-based solution for smart parking systems. The smart parking system offered facilitates checking the availability of parking slots. It is easy to find nearby private or public parking areas with pricing policies and a secure payment gateway. The system benefits in reducing pollution and fuel consumption by avoiding wastage of time. Finally, we propose a set of design principles that demonstrate the applicability of our proposed smart parking system.

Index Terms **- Decentralization, Smart contract, Ganache, MetaMask, Mapbox, consortium blockchain, consensus mechanisms.**

I. INTRODUCTION

The proposed Blockchain-based architecture for the smart parking system aims to address the challenge of trust and performance in sharing data among different parties. By leveraging Blockchain's decentralized and immutable nature, the system can ensure transparency, security, and accountability in the parking information services provided to commuters in a smart city. The system can integrate with MapBox, a location data platform, to provide accurate and up-to-date information on parking availability and location. Smart contracts can be used to automate and enforce parking rules and regulations, ensuring compliance and reducing human errors. One of the key features of the proposed smart parking system is the ability to check the availability of parking slots in real-time. This feature helps users find nearby private or public parking spaces quickly, saving time and reducing fuel consumption associated with searching for parking spots. The system also provides information on pricing policies and secure payment gateways, making it convenient for users to make informed decisions about where to park their vehicles. The system's ability to operate 24 hours a day allows for flexibility in parking durations, accommodating the needs of different users. A set of design principles is presented to ensure the proposed smart parking system's applicability. These design principles outline the key considerations and guidelines that should be followed in the development and implementation of the system. These principles may include data privacy and security, consensus mechanisms for validating parking information, interoperability with existing parking infrastructure, and user-centric design for ease of use.

II. LITERATURE SURVEY

The literature survey of the paper "A Blockchain-based Architecture for Integrated Smart Parking Systems" concerns several existing blockchain-based parking systems, including Parksen, Parkgene, and Parknav. However, these methods mainly concentrate on delivering a parking spot reservation service, and their architecture is not integrated with different smart parking strategies. The paper also assesses various consensus mechanisms, such as Proof of Work (PoW), Proof of Stake (PoS), and Delegated Proof of Stake (DPoS), and assesses their appropriateness for the presented system. The study figures that DPoS is the most suitable consensus mechanism for the proposed system as it offers a balance between decentralization and scalability.[1]

The paper "Design of Secure Decentralized Car-Sharing System Using Blockchain" suggests an assured decentralized car-sharing strategy utilizing blockchain technology. The literature survey of the paper reviews several existing car-sharing techniques, such as Car2Go, Zipcar, and Turo, and emphasizes their constraints, such as lack of safety and clearness. The proposed system aims to deliver a safe and decentralized car-sharing representative by utilizing blockchain technology. The method utilizes smart contracts to control the ownership, access, and revenue of the car-sharing service. The paper presents a multi-layered authentication method, which retains uniqueness proof, smart contract-based charge validation, and blockchain-based transaction verification, to provide the security of the system.[2]

The paper "Smart Parking Systems: A Survey" provides a complete survey of parking systems. The literature survey inspects different parking systems, such as classic parking systems, sensor-based parking systems, and smart parking strategies. The paper concentrates on smart parking systems, which use refined technologies, such as sensors, cameras, and data analytics, to enhance parking efficiency. The survey also examines different challenges faced by parking systems, such as deficiency of parking spaces, traffic congestion,

and parking infractions. The paper presents a database of parked vehicles via a shared server as a possible answer to these challenges. Overall, the survey underlines the possible benefit of smart parking systems and the demand for further investigation in this area.[3]

The paper "Cloud Based Smart Parking System" presents a cloud-based smart parking system. The presented system is an Internet of Things (IoT) method based on the reservation of parking spaces utilizing an Android application. The design utilizes diverse technologies, such as cloud computing, IoT, and mobile applications, to enhance the efficiency and convenience of parking. The paper examines the various elements of the proposed system, such as the mobile application, the cloud server, and the parking sensors. The study infers that the proposed system can address the challenges encountered by conventional parking systems and deliver a more suitable and efficient parking experience.[4]

Overall, the literature survey of these papers emphasizes the importance of technology in enhancing parking systems' efficiency and convenience. The papers propose different technologies, such as blockchain, cloud computing, and IoT, to address the challenges faced by conventional parking systems. These technologies offer potential benefits such as increased security, transparency, and decentralization. However, further research is required to investigate the feasibility and scalability of these proposed systems.

III. TERMINOLOGIES

A. Blockchain -

Blockchain is a digital ledger technology that is used to hold and transfer data in a protected and decentralized manner. It is a spread database that is handled by a network of nodes, where an individual node has a replication of the whole ledger. The ledger consists of blocks that include data, and the separate block is connected to the prior block in a chain-like system, constructing a "blockchain."

B. Smart Contract -

A smart contract is a self-executing computer program that runs on a blockchain network. It is a piece of code that is stored on the blockchain and automatically performs when specific pre-determined states are met. Smart contracts are designed to stimulate, demonstrate, and implement the negotiation and implementation of a contract between two or more additional parties.

C. Wallet -

The wallet is a digital application that authorizes users to hold, control, and transmit cryptocurrencies and other digital assets. Effectively, a wallet is a secure digital container that holds the user's private keys, which are used to sign trades and prove ownership of assets on the blockchain.

D. DApps -

Dapp, a "decentralized application", is a type of application that is built on a decentralized network such as a blockchain. Unlike traditional centralized applications, Dapps do not rely on a specific point of authority or a single server for use. Instead, they use a diffuse network of nodes that work together to run applications and validate transactions.

E. MapBox -

MapBox is a mapping medium that authorizes developers to combine interactive maps and location-based components into their applications. MapBox delivers a variety of tools and services, including custom map styling, geocoding, and real-time spot data.

F. Ganache -

Ganache is a confidential blockchain for Ethereum development. Ganache entitles developers to simulate an Ethereum network locally, delivering a swift and efficient method to experiment and design Dapps.

G. React

React is a famous JavaScript library for creating user interfaces. React permits developers to build elaborate UI elements using declarative syntax, creating it more uncomplicated to handle and modernize the application state.

H. Interoperability

The ability of a system to work seamlessly with existing infrastructure or systems allows for smooth integration and interaction between different components or entities.

IV. ARCHITECTURE DIAGRAM

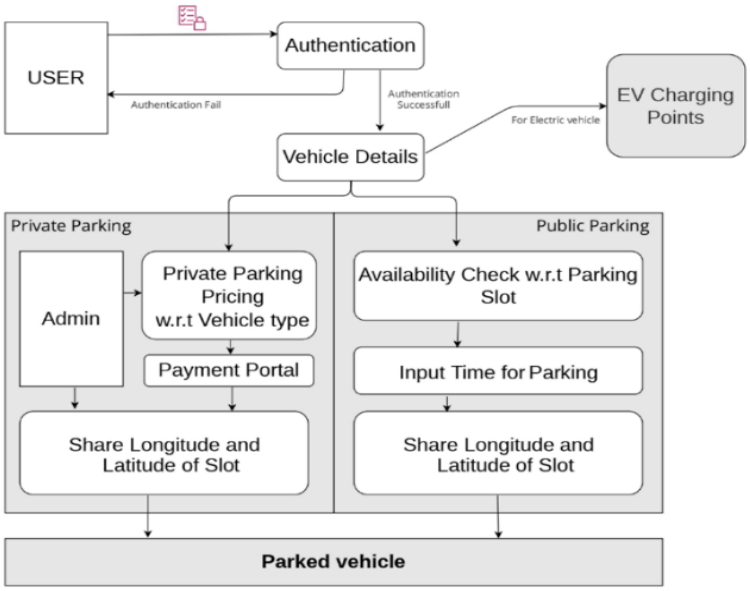

Fig. 1. The architecture of the proposed system

V. SYSTEM DESIGN

System design for the smart parking project involves two key roles: the vendor and the user, Both the vendor and the user must register themselves on the platform to interact with the user interface. The vendor is responsible for registering the available parking places by selecting a location on the map combined with MapBox and delivering information on the available space size for parking. These details are recorded on the distributed ledger using smart contracts to assure clarity and accountability.

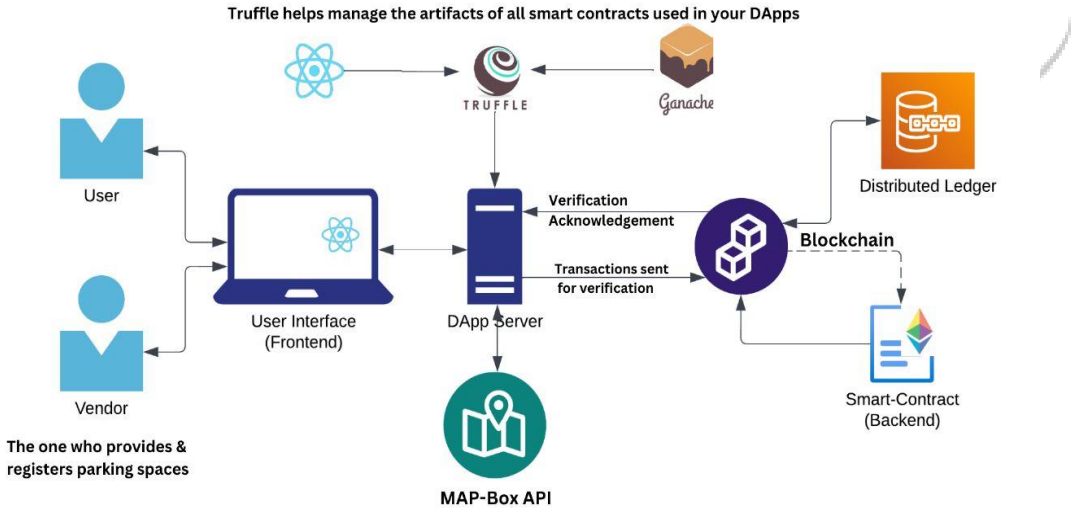

Fig. 2. System Design

The user interface is designed using React and delivers a seamless experience for users to search for nearby parking spots and complete payments securely. Truffle is used as the development framework to make and deploy smart contracts on the Ethereum network. Ganache is used as a local blockchain network for testing and debugging smart contracts. Overall, the system design guarantees that the platform is user-friendly, secure, and dependable for both vendors and users.

VI. IMPLEMENTATION

The system design of the proposed smart parking solution using blockchain technology includes several key components, including a user and vendor signup process, an interactive user interface, and the integration of MapBox for location-based services. The solution strives to deliver users with real-time parking availability details and a secure and transparent price strategy while helping vendors operate their parking areas more efficiently. In this system, the implementation of the method applies the use of Truffle, a development environment for smart contracts, and Ganache, a personal blockchain for Ethereum development, to develop and deploy the smart contract that controls the parking registration process. The smart contract is used to manage the parking spot registration and revenue process, confirming that the data is transparent and unchangeable, while the Distributed Ledger supports a tamper-proof ledger of all transactions. To interact with the smart contract and the blockchain network, the solution uses MetaMask, a digital wallet that allows assured transactions on the Ethereum network. The user and vendor registration function allows users to

create an understanding and access the solution's user interface, where they can view real-time parking availability details, pricing policies, and other relevant details. The vendor signup process enables vendors to enlist their available parking slots by picking a location on the MapBox-integrated map and delivering information on the dimensions and availability of the space. These details are then stored in the smart contract and can be accessed by users exploring available parking spots. The implementation of the presented smart parking solution using blockchain technology provides a safe, transparent, and efficient system for organizing parking spaces in a smart city.

VII. MATHEMATICAL MODEL

The mathematical model of the system using Blockchain, Truffle, Mapbox, Ganache, and DApp can be divided into several main elements that determine the overall performance of the system. A parking management system is reliable for allocating parking spaces and handling the parking process. The system can also interact with the blockchain network to record and manage parking transactions.

Let:

- N be the total number of parking spaces available in the area
- P = {p1, p2, ..., pn} be the vector of all parking spaces, where each parking space pi is defined by its unique identifier, location, and availability status (0 if occupied, 1 if available)
- M be the total number of users who want to park their vehicles in the area
- U = {u1, u2, ..., um} be the vector of all users, where each user UI is defined by their unique identifier, location, and the desired parking space they want to reserve
- S be the set of all smart contracts used to manage parking space availability and reservations
- B be the blockchain used to store all transactions between parking spaces and users
- D be the DApp used to provide a user interface for the smart parking system

The subsequent algorithm defines the key functions of the smart parking system:

1. Smart Parking Algorithm: Input: user UI, location L Output: a confirmation message. The search algorithm searches the vector P for all available parking spaces that are within a certain distance of the user's location L. The algorithm returns the vector PA of available parking spaces, along with their location and availability status. The user UI selects a parking space pi from the vector PA and initiates a reservation using the reservation algorithm.
2. The reservation algorithm creates a new transaction t between the user UI and the parking space pi. The transaction includes the user's payment information and the reserved parking space. The smart contract S verifies the availability of the parking space and locks it until the transaction is complete. The transaction t is recorded on blockchain B for transparency and immutability. The payment algorithm processes the payment information included in the transaction t. The smart contract S verifies that the payment is valid and releases the lock on the parking space pi. The confirmation message is sent to the user UI to confirm the successful reservation and payment.
3. The visualization algorithm uses MapBox to visualize the location of all parking spaces in the area. The algorithm overlays the availability status of each parking space onto the map to provide a real-time view of parking space availability. The testing algorithm uses Ganache to test the smart contract S and DApp D in a local blockchain network. The algorithm verifies the reliability and security of the system under various scenarios, such as high traffic volume and attempted fraud.

VIII. RESULTS

The submitted smart parking system delivered in this research paper has been successfully executed and has demonstrated a significant improvement over conventional parking systems. The system offers a complete solution to the problems faced in conventional parking, such as the determinate availability of parking slots, absence of transparency in pricing, and inefficiency in payment and revenue allocation. The developed system overcomes these challenges by allowing users to locate nearby public and private parking spaces with pricing approaches and a secure payment gateway. The system was developed using a hybrid of cutting-edge technologies, including Truffle, Ganache, MetaMask, Mapbox, and smart contract performance utilizing Solidity. The integration of a consortium blockchain delivers secure storage of parking suggestions on a shared ledger, ensuring clarity and availability while decreasing the risk of fraudulent activities. Smart contract performance enables the computerized execution of parking transactions and revenue allocation, providing an efficient and trustworthy system.

The proposed workflow presents a secure network for a smart city parking system, and the utilization of blockchain technology improves security, transparency, and decentralization. The designed system can potentially revolutionize the parking experience, supplying a more convenient and efficient resolution to the challenges encountered by traditional parking systems. The technique's ability to predict entry and departure times and forecast expected costs saves users time and reduces pollution and energy consumption. In conclusion, the offered smart parking system delivers a comprehensive solution to the challenges faced by established parking approaches and has the potential to bring about a notable change in the parking industry

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