International Journal of Computing and Digital Systems
ISSN (2210-142X)
Int. J. Com. Dig. Sys.13, No.1 (Apr-23)

http://dx.doi.org/10.12785/ijcds/130184

Implementing Blockchain based Payment system for Smart Parking

Abdulrahman AlMeasam[1], Fatma AlQubaisi[1], Shoug Ahmed[1], Ahmed Alsuwaidi[1] and Deepa Pavithran[1]

[1]*Information Security Engineering Technology, Abu Dhabi Polytechnic, Abu Dhabi, United Arab Emirates*

Received 2 Sep. 2022, Revised 3 Jan. 2023, Accepted 6 Feb. 2023, Published 16 Apr. 2023

Abstract: Nowadays with the rising number of personal vehicles, finding a parking space has become an issue for many residents. Advancements in technologies like Internet of Things (IoT) have helped to maximize the productivity and reliability of urban infrastructure. In this paper, we propose an online parking rent system to reserve a parking space for the residents and other users, via a blockchain on the Ethereum platform which uses a non-fungible token as currency and a barcode for ease of use. A barcode will be provided while reserving the parking space, and is used when unlocking the bollards. This will help residents to save time by knowing their parking spot.

Keywords: blockchain, Internet of Things, Parking system, blockchain architecture

1. INTRODUCTION

With increased urbanization, more demand for housing, and a rise in the number of automobiles on the road, finding a parking spot has become one of the most pressing issues for individuals. This is mostly due to the limited number of available parking spaces and the difficulty of finding an empty lot during busy hours. To alleviate this limitation, our proposal is to create smart parking places that are easier to find and use. We propose a blockchain-based method for reserving parking space that can provide transparency. Blockchain helps to create a tamper-proof payment system for reserving parking. A detailed implementation of the system is provided and performance is measured. Because of the scarcity of parking spaces in cities, parking has become a major source of annoyance for residents as cities continue to grow in size. One solution is to build multi-level parking infrastructure, which enables for more cars to be parked in a given geographical area. This is a more common alternative, but the main downside is the substantial infrastructure investment and ongoing maintenance. Another option for eliminating parking is to encourage people to use public transit, such as buses, rail transportation, and metro. However, in developing countries, public transportation may be insufficient and may not reach the periphery. As a consequence, if we can create smart parking spots that are more usable, people will save time and money by decreasing gas waste and time spent hunting for a parking spot, as well as cutting emissions. This will also assist to reduce highway traffic congestion[1]. The blockchain is widely recognized as a disruptive breakthrough with the potential to reshape banking, economics, and even macrosocial systems. In reality, blockchain is a new decentralized architecture and distributed computing paradigm that was originally intended for cryptocurrencies. The fundamental advantage of blockchain technology is that it is a decentralized and trustworthy mechanism. The technique is based on peer-to-peer networking principles [2]. In this paper, we propose a transparent system where transactions are parking slots linked with its payment is added to the blockchain. A detailed implementation of the system is provided and its performance is evaluated. Section 2 provides Background about blockchain and smart contracts, Section 3 provides Related Work, Proposed System is provided in Section 4, System Implementation in Section 5,Results in Section 6 and Finally Conclusion is provided in Section 7.

2. BACKGROUND

Blockchain is a distributed ledger system that uses a consensus technique to give members with trust, transparency, and immutability of data. That is a distributed network of servers that work together to verify transfers by executing technologically challenging tasks. This technique removes the need for a trusted person by letting users to sign contracts electronically, which are subsequently validated as authentic and legal. It presents the idea of distributed agreement, which eliminates the need for a single authority. The blockchain is basically a chain of blocks that include

E-mail address: author 1, author 2, author 3

the data from all transactions that occurred over a certain time period, as well as a reference to the block before it. The cryptography used to construct a block varies according to the blockchain protocol, but in general, one may traverse the whole blockchain and every single transaction ever done, all the way back to the first, known as the genesis block. Hashing algorithms are used to verify that all blocks are produced correctly and unchanged, allowing the blockchain to stay secure and basically immutable. The decentralized nature of blockchain, as well as the consensus process, may be used to enable a smart contract powered parking lot rental system.

Without blockchain, each company must maintain its own database. Transactions and data are recorded identically in different locations because blockchain employs a distributed ledger. All network members with authorized access view the same information at the same time, ensuring complete openness. Every transaction is immutably documented and time and date stamped. This allows members to see the whole history of a transaction, practically eliminating the possibility of fraud [3].

Blockchain generates an audit trail that documents an asset's origins at each stage of its travel. This helps give verification in areas where consumers are worried about environmental or human rights concerns around a product, or in industries plagued by counterfeiting and fraud. It is feasible to exchange data regarding provenance directly with customers using blockchain. Traceability data may also reveal flaws in any supply chain, such as when products are sitting on a loading dock awaiting transit[3].

Smart contracts can be utilized in a decentralized digital parking platform to reserve or secure a parking space. When end users utilize a blockchain network to find a parking place, a smart contract is formed. Each reservation or transaction is electronically confirmed by such smart contracts, and the registered driver is given a parking place. Users can also utilize cryptocurrency to conduct a transaction on a blockchain network. Parking lot owners and government entities can also monetize in new modes of currency and earn revenue in this manner.

In the blockchain network, a public ledger maintains immutable data that is protected by encryption technologies. Because the digital platform is likewise decentralized, the stored data is unfiltered and tamper-proof. This provides more transparency to all nodal shareholders, such as the parking facility owner and the governing government entity.

3. RELATED WORK

There are several works that highlight the Smart Parking System in the literature. Each uses different types of blockchain platform, technologies and method of implementation varies. In [4] Author proposes a parking system where parking logs and transactions are by the blockchain system whereas the parking payment is done through the user credit card. [2] propose a model where drivers can find parking space of their preference and for the parking service providers, a trusted third party is not required to share sensitive data. An idea to implement a multi-blockchain system with IoT Integration in smart parking for data management which saves the cost persistence and to process real-time data is proposed in [5]. The system is implemented through a combination of public and private blockchain. Authors in [6] proposes privacy preserving blockchain based parking system. While having a multiple technological integration to the parking systems, the system becomes more prone to outside and inside attacks, which also has an incremental number of threats regarding with blockchain [7][8]. Authors in [9] propose "ParkChain", a decentralized IoT application using blockchain. The system is implemented using License Plate recognition and raspberry Pi to control the access on parking space. Authors in [10] proposed parking system based on blockchain by creating sequence diagrams and non-deterministic finite automata to represent system behavior. In [11], AI and blockchain were used in helping a smart parking system with transacting and predicting parking availability. "TChain"[12] is a hierarchical consortium blockchain for parking system. It provides privacy by anonymizing the contents of blockchain data and avoid the exposure of vehicle-track and traffic transaction information. Authors in [13] have used fog nodes as a middleware layer for blockchain based smart parking system. This will provide the transactions closer to the IoT based edge nodes. Their proposed system also provides security and privacy. Authors in [14] have proposed Parking Assistance Alliance Scheme that encourages vehicles in the alliance to provide parking information for other vehicle users. To reserve a parking slot securely, a blockchain and Interplanetary File System (IPFS)-based parking price prediction scheme (PADaaV) is proposed in [15]. The focus is on ensuring security, privacy, and transparency for parking slot owners and users. In this paper, we propose a system where parking slots are considered as transactions and payment is linked to slots. These are then added to the blockchain. The system is implemented and the performance is evaluated.

4. PROPOSED SYSTEM DESIGN AND WORKFLOW

When a user login to the system, he/she can choose the parking lot based on the availability. The user will then enter his/her information, date of booking, and number of days. The application will then display the total amount and will save all the information in the database. The user will then be transferred to another page where he/she can pay for the parking. Once the parking has been paid, the smart contract will be generated using Metamask and deployed to a ropsten test network (blockchain), All the information saved will be stored in the blockchain including the user's personal information, booking confirmation, and the transaction hash. Figure 1 provides the workflow of the parking reservation.

When the user reaches the parking area, using his/her transaction hash (barcode), the user will scan the barcode in the entrance gate for the parking area. Once the barcode

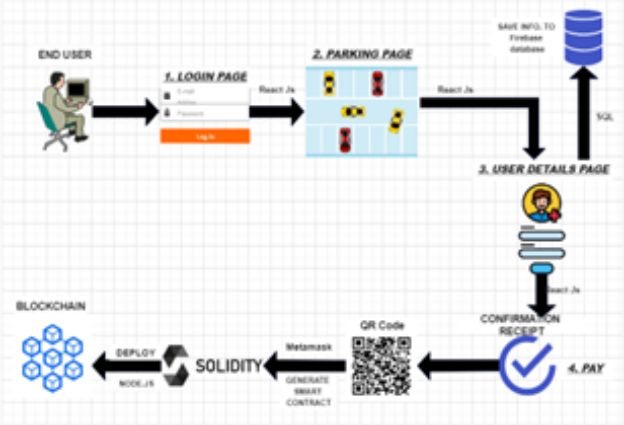

Figure 1. Parking Reservation workflow

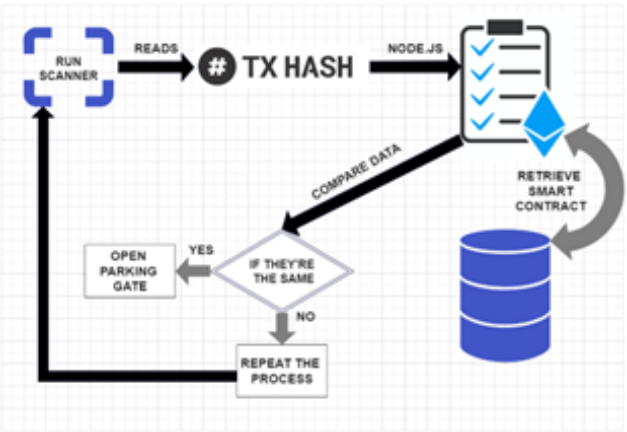

Figure 2. Retrieving the Parking data

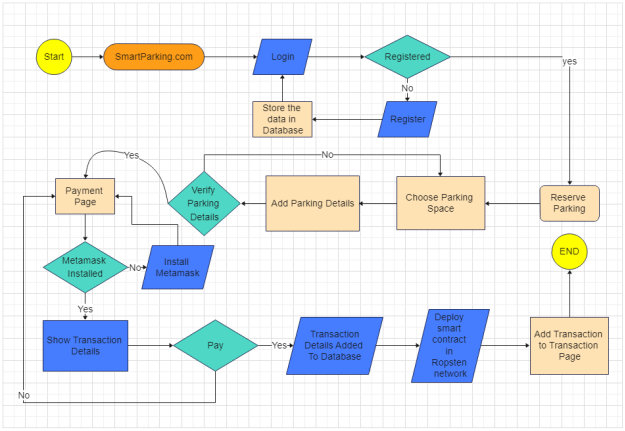

Figure 3. Flowchart

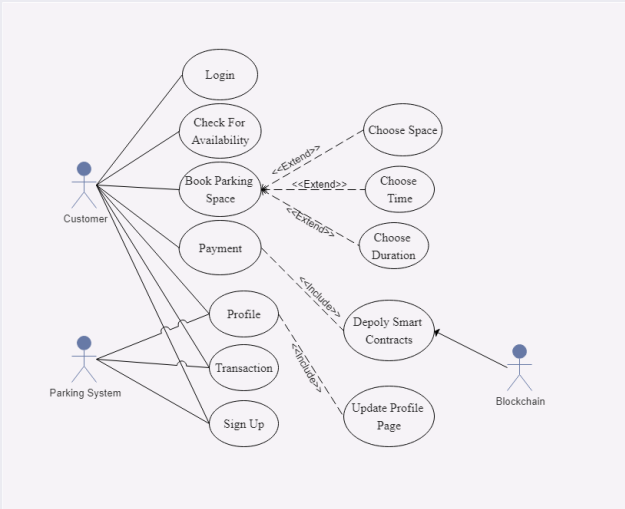

Figure 4. Use case Diagram

(transaction hash) was scanned, the smart contract code will compare and verify the information given. If the information is authenticated, the gate and parking space that was booked will open, if it was not authenticated, the scanner will restart and be ready for next barcode. This is provided in Figure 2

The overall workflow is provided in Figure 3 and the use case diagram is provided in Figure 4

5. SYSTEM IMPLEMENTATION

A. *Implementation Environment*

To construct the proposed system, we created private blockchain using ganache and truffle suite framework. To deploy the smart contracts over the private blockchain to test them before moving to the Ropsten test network, we created the smart contracts using visual studio code and programmed them using solidity programming language. The following tools and technologies were used for implementation: React Js[16], Truffle Suite[17], Ganache[17], Node Js and NPM, Visual Studio Code [18], Remix IDE, Metamask[19], Firebase (Google Database)[20], Web3[21], Materializecss[22], Local tunnel, Zbarcam[23], SSH Connection, HTML, CSS ,JavaScript, Python, Solidity Table I provides the hardware specs of the experiment as well as the version of the platform utilized to build the blockchain. The website is created using React Js. It is a user interface library written in JavaScript, in addition React Js has the ability to combine HTML and CSS along with the JavaScript, using React Js we were able to create multiple pages for the website which are Profile page, Transaction page, Sign in page, Sign up page, Reserve page and Home page. And then we connected the website to the firebase. Firebase is a platform developed by google and it contains a database that can store data and its very secure. Firebase has the ability to let the users sign in using another provider like Google, Facebook, Microsoft.

We connected the firebase to the website using the firebase configuration file as show in Figure 5.

When the customer wants to pay for the requested parking, Metamask will pop up immediately and if MetaMask is not installed the website will alert the user to install it,

TABLE I. Hardware Specification

Platform and Machine	Version and Specification
Truffle Suite	Truffle v5.0.2 (core: 5.0.2)
Solidity	Solidity v0.5.0 (solc-Js)
Node Js	Node v16.13.2
React Js	React Js v17.0.2
Visual Studio Code	Version 1.65
Development machine	CPU: AMD Ryzen 5 2600x, RAM: 16,384 MB, Storage: 500 GB NVMe SSD
Raspberry pi	CPU: Quad core Cortex-A72, RAM: 4,096 MB, 2 USB 3.0 ports; 2 USB 2.0 ports.

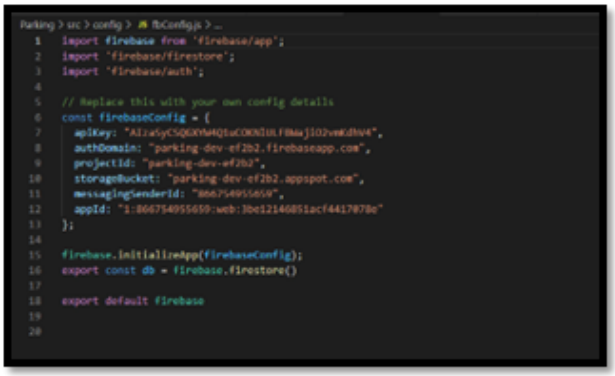

Figure 5. Firebase Config file

we connect MetaMask to the website using web3.js.

B. Process of reserving parking

To reserve a parking, the end user need to sign in first using his own details and then must forward himself to the reservation page and then will have to connect the webpage to the MetaMask and provide the wallet details. After it is connected, the website will refresh automatically and it will move from the loading page to the reservation page. In the right side of the reservation page the end user will pick a parking space of their choice, and it is easy to differentiate between the reserved parking and free parking due to the colors used which are Red, Blue, and Orange. Red: Reserved parking Blue: Free parking Orange: Accessible parking

Meanwhile on the left of the page we can see the account the MetaMask provided, and the end user will provide the parking details for example Parking Date and Duration as shown in Figure 6.

The application will validate and verify the user and redirect to the payment page. The payment page shown in Figure 7 shows the orders, and end user will find his order and must click on pay and reserve the parking, and every transaction is recorded in the blockchain.

The algorithm used for the search and request process is shown in Figure 8 and Figure 9.

Figure 6. Reservation Page

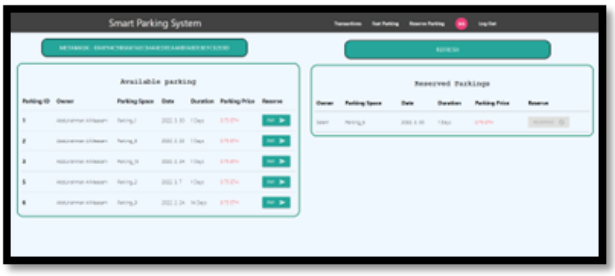

Figure 7. The payment page

Algorithm 1: Search and Request Processing

INPUT:

- Choose parking space.
- Add parking details.

OUTPUT:

- Reserve the parking that requested by the user.
- Update public ledger.
- Store the data in Database

```
1:  Foreach reservation request do
2:      Validate the requested reservation details
3:      if (space available in own server && time is not conflict)
        then
4:          Reserve for the customer
5:          Update public ledger
6:          Store reservation details in firebase
7:      else
8:          No parking space available
9:      end if
10: end for
```

Figure 8. Algorithm1

Algorithm 2: Finding and Updating the Parking

INPUT:

- **x:** - number of free and occupied spaces of a parking system

OUTPUT:

- **y:** - a set {x_1, x_2, x_3, … x_n} of all available spaces in parking area.

```
Foreach Parking Area do
    xi <- Free Space
    if vehicle in then
        xi <- increment
    else if vehicle out then
        xi <- decrement
    end if
    If authenticate with smart contract, then
        Update the parking area
        Update the firebase store
    end if
    end if
end for
```

Figure 9. Algorithm2

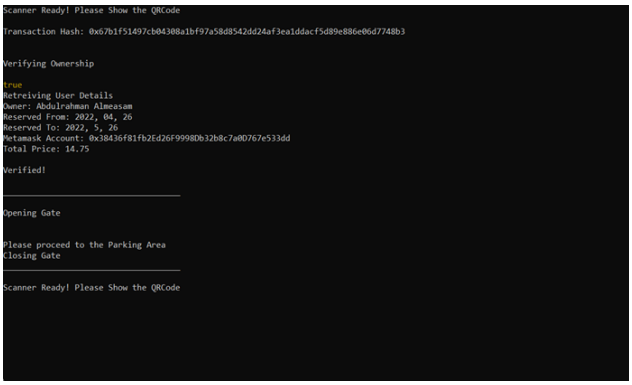

Figure 10. Verified User

The QR Code in the transaction page make it easier to the end user to capture and scan at the entrance gate. The QR Code stores the transaction hash of the smart contract deployed. SSH connection is used to fully control the raspberry pi, attached to the parking gate. When user scan the QR code, system takes the transaction hash to the ganache to check if the block is existing in the ganache, if its not existing it will provide an invalid message. The final Verification page is shown in Figure 10.

6. RESULTS

On the Ethereum blockchain, gas refers to the cost necessary to perform a transaction on the network. For the implementation, we measured the Ethereum gas required for parking. The graph shows the number of transaction in x-axis and the Ethereum gas required in y-axis. We observed the ratio of transactions and gas. The result obtained is provided in Figure 11. The cost necessary to reserve the parking space based on the implementation can be calculated from the results.

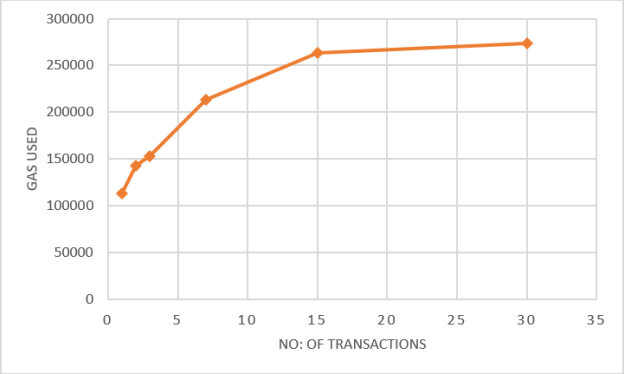

Figure 11. Gas used Vs No: of Transactions

7. CONCLUSION

With smart cities on the horizon and an ever-increasing number of cars on the road, effective traffic control systems will be in high demand. In this paper, we proposed a Blockchain-based IoT-powered transparent system for reserving parking space and enabling payment through blockchain. This Blockchain ecosystem also allows for a transparent payment method to be implemented on a decentralized platform. The parking process is managed by IoT enabled sensors connected to the ecosystem, and the website serves as the handler for clients and end users, assisting with payment and reservation.We provided details of system design and implementation and the performance is evaluated.

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