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Toll Gate Integration System

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Abstract: *Toll collection contracts have certain guidelines and rules for collection of toll tax from vehicles against the use of constructed roads. Representation of such rules for collection of toll taxes using a smart contract, which is a paradigm based on blockchain, will solve some of the drawbacks of current toll collection and management system. The proposed methodology uses the strengths of blockchain to propose a solution to the current toll tax collection system, by ensuring complete transparency between tax payers and collectors and also attempts to curb the malicious collection of taxes from commuters. Blockchain will enable a radical way of approaching transactions as compared to the traditional society approved method where trust is placed on a central third party to carry out transactions. This paper is to provide a alternative method of processing toll tax transactions, using ethereum based smart contracts, written in solidity language, to transform traditional desktop applications into blockchain based web application, which perform better, consume lesser resources and are much more secure as compared to the current system.*

Keywords: Intelligent Transportation Systems, Deep- Learning, Blockchain, Markov Queues, Smart Contracts, IPFS

I. INTRODUCTION

In Bitcoin is simply a first file system which leverages blockchain architecture to work. Blockchain on the other hand is a peer-to-peer network paradigm in which nodes combine transactions into "blocks" which are then linked to each other in an ever growing "chain", with a consensus process allowing for the inclusion of new nodes in the network. The only way a block gets added to the chain is by proof of work, which requires that each node constantly attempt to form a block of transactions, hash of which, falls below a dynamically defined target value. The method of seeking such hash is solely trial and error, and thus expensive to execute computationally, stopping attacks. Nodes (called miners) that connect the block (mine) to the chain successfully are entitled to a reward.

Ethereum aims to extend the core fundamentals of blockchain to provide the ultimate abstraction layer, which gives its users access to a built-in blockchain and a turing- complete programming language, and a PoW based consensus protocol. It makes developing applications that leverage blockchain very easy, and allows modifications to transaction formats and state transition functions. It is turing- complete value-aware and blockchain(State) aware

Ethereum Accounts - Ethereum state is made up of objects called as accounts, with each account recognized by a 20-byte address. Two main types of accounts are EOA (externally owned accounts controlled by their private keys) and CA (contract Accounts controlled by their contract code) Four main fields in a ethereum account are:

- Nonce, which is a counter to make sure a transaction gets processed only once.
- Ether balance.
- Account's contract code.
- Account's storage.

Contracts and External accounts have the same power in Ethereum (first-class citizens). Contracts may send messages to other accounts or even create new contracts, which allow diverse use- cases to be implemented using Ethereum.

Ethereum Messages - Messages in Ethereum behave similar to the transactions in bitcoin, but with following differences:

- Ethereum message can be generated by a contract as well as externally, whereas in bitcoin transactions are created externally only.

- Ethereum messages have an option to contain data.
- If an Ethereum message is directed to a contract account, it has the option of returning a response which acts much like the notion of functions.

Transactions are essentially packages of signed data
that contains a message sent from any account. Transactions carry information like recipient of message, a digital signature that identifies sender identity, ether amount to be sent and additional data (if any). Along with the above there are two more values in a transaction, called GASPRICE and STARTGAS. Each transaction must specify explicitly, the upper limit on the number of steps of computation (code execution) that it allows. This limit is the STARTGAS and GASPRICE is the fee to be paid per computational step to the miner.

Transition functions - Every transaction in Ethereum results in the modification of the global state. A transaction is applied to a state to transition into a new state, based on following steps:

- Ensure well-formed transaction, which includes matching the nonce with sender's account, checking for valid signature and making sure transaction has all the necessary values.
- Determine the fee for transaction by the expression FEE = STARTGAS * GASPRICE.
- Determine the address of sender. Subtract the FEE from sender's account, and increment it's nonce value. Throw an error if sender's balance is not sufficient. 4. Start with initial GAS = STARTGAS, and remove gas required for bytes in the transaction header.
- Increment the transaction value in receiver's account. If there does not exist any such account, it is newly created. In case the receiver is a contract account, the code inside the account is executed, either till it ends or till gas is finished.
- Refund the fees equal to gas remaining, back to the sender, and give FEE computed above as a reward to miner's account.

Code and Contracts - "Smart Contracts" is a popular buzzword surrounding Ethereum, and essentially refers to the ability of Ethereum accounts (contract accounts) to execute code, written in a turing-complete language. This language is known as "Ethereum Virtual Machine code". EVM code contains a set of bytes where each byte corresponds to a unique operation. All the operations are entitled to three different storages:

- Stack which is LIFO storage with 32-byte size, in which values can be pushed and popped.
- Memory, which is a byte array, whose size is infinitely expandable.
- Long term storage, also called contract storage, which is a key- value store (both 32-bytes in size).Unlike the above options, the contract's storage is persistent and does not get reset after end of computation.

Mining in Ethereum - Mining in Ethereum works similar to Bitcoin. It refers to the process of creating a new block (a group of transactions) from the pool, and chaining it into the blockchain. A miner (node) will create a block of transactions from the pool and calculate its hash value. A random number (usually called nonce) can be modified using trial and error to change the output hash. The network sets a dynamic target value of this output hash. The task of a miner hence, is to find a nonce that makes hash of the block fall below this target. If these criteria are met, block gets added to the chain, and the miner receives reward for his work. The fact that nonce cannot be generated through some algorithm other than pure guesswork, makes the miner's task computationally expensive and the miner is essentially giving proof of his work if he succeeds to find this nonce.

II. CURRENT SCENARIO

In India, the majority of road contracts and toll collection still take place manually, requiring human participation at every stage of the system, from the allocation of tenders to the collection at booths.

A. Road Contracts

In India, each state is completely responsible for its own state's road construction. Although each state's road administration manages the timetable and procurement of roads, central help is offered for execution methods. For the distribution of road projects, all states employ a standardized bidding-based procedure.

A unified set of standards for construction and material quality must be followed when building roads. The auction process used by the bidding system is cost-based. To submit a legitimate bid, a contractor must meet all fundamental quality and construction requirements. The lowest bidder is ultimately chosen. Both digital and manual paper-based systems use this technology in exactly the same way. This laborious process typically involves the cooperation of several departments and a mountain of documentation, the majority of it written on paper. This makes it possible to treat some candidates more favorably in exchange for payments.

B. Toll Collection

As at the time this paper was being written, the Indian government had just introduced FASTAG, an RFID-based sticker that each client (the owner of the car) must apply to the inside of the windscreen. Each RFID is linked to a customer-selected bank account. The toll plaza scanners then pick up this RFID and process the payment, which involves deducting a set sum dependent on the kind of vehicle. The authority in charge of that road project controls the regulation of this deduction.

The sole difference between this system's implementation and Dubai's (salik) implementation is the absence of a human operator at tollbooths. Initial interest in FASTAG usage was lukewarm, but it has since increased as a result of lower costs for buying them and a double toll charge for anyone using the cash lane.

Although there are a number of issues, such as detectors that don't work, unhappy customers, and operators who lack adequate training, The most dependable method of toll collection from vehicles is thought to be RFID-based collection.

C. Processing

The component that connects the two—the road contract and toll collection—is their essential component. The majority of approaches that aim to create a digital toll collection system rely on a centralized system that distributes funds after the toll is paid. The part that happens after toll collection is always in the background, despite the fact that there is a clear focus on reducing friction between the customer and tollbooth to shorten waiting times. The current system does a good job of addressing the question of "How will the toll tax be collected?" but falls short in addressing the question of "When to stop collection of toll tax?" Like any other business model, road contracts essentially give the contractors a chance to profit from margins. The cost of building the roads is borne by the contractors who invest money, which is later recouped from the moving traffic as a toll or tax. Profit is the difference between an investment and its return. The money raised is also put toward maintaining the road through maintenance activities. Despite all of this, a toll plaza (or group of plazas) is always required to abide by regulations that make sure they don't operate indefinitely and are shut down once the required amount, which includes the margin and the maintenance costs, is collected from the vehicles, or in the case of frequent rework, operate at a subsidized collection model. The current system does a poor job of preventing the misconduct of road contractors. Although there is a check on how each toll plaza operates, it is not strong enough to stop a workaround. The system is not set up in a way that will stop toll plazas from continuing to collect money from moving objects long after they have stopped being tolled. Furthermore, the government is not legally obligated to ensure that no toll plaza is operational unless absolutely necessary.

III. PROPOSED METHODOLOGY

Every time a vehicle approaches a toll booth, a web-based toll collection system using the blockchain paradigm smart contract acts as a binding barrier to toll collection. This system ensures fraud prevention due to immutability and allows end-to-end transparency for all the system's stakeholders. With this system, relying on a single third party is eliminated, and contractors are directly responsible for tolls that are collected from each customer. Additionally, the system enables each user to access transaction history and recharge their account through a flexible gateway.

Every new user of the system goes through the steps listed below:

1. In order to add a vehicle or vehicles to your account, you must first register as a customer. Before leaving on a trip, recharge your wallet using the provided gateway and make sure you have enough money in it. The status of the toll-booth is checked upon arrival at the interface for toll-paying vehicles, and if the status is "CLOSED," the vehicle may proceed. Any of the methods (RFID, NFC, or manually) are used to collect the

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data from the vehicle. The user account to which the vehicle is mapped can be retrieved using this information. The smart contract receives the user and vehicle data and verifies the following criteria:

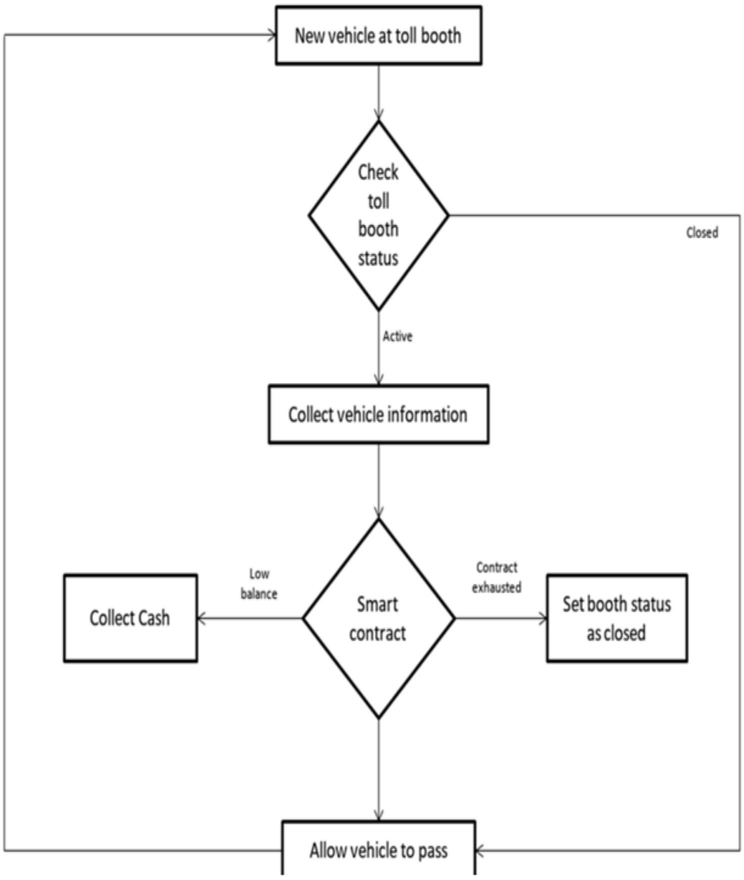

Fig 1. Flow chart of Toll collection system

- If the road project's recovery amount is less than zero, the road will be marked as "CLOSED."
- If the user's wallet balance is greater than the deduction, returns an error and requests payment in cash.
- Booth is a part of the road project; if not, return an error and let the vehicle through.
- The vehicle has a valid user mapping; otherwise, an error is returned and a cash-based payment is requested.

2. The smart contract transfers money from the user's account to the wallet connected to the contract and reports on its success.
3. After receiving a success status, let the car through the booth.
4. After logging back in, the owner of the vehicle can now track every transaction in his profile.

Each new toll authority takes the following actions:

- Create an account as a toll authority and add a road project with information about the road contract, such as the recovery amount, time frame, and location.
- Assign various toll booths for the road project that make up the blockchain.
- The authority has a dashboard for tracking collection data.

Every new booth goes through the following steps:

- Enter your credentials to log into the system.
- In the case of an automated system, vehicle information will be automatically fetched, and the operator will need to press the collect toll button to activate the contract.
- Upon completion, the contract returns a status code; if it is positive, the vehicle may proceed.
- If the status code is unsuccessful because of a low balance or a problem with the system, the toll must be manually collected with cash.

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IV. IMPLEMENTATION

4.1 Contract completion and gas usage

The system's smart contract was created in the solidity programming language, which is supported by the Ethereum Virtual Machine. Nodes serve as EOAs (externally owned accounts) on the public blockchain platform known as Ethereum, and contract accounts, also known as CAs, are accounts that store contract code.

The contract must receive a message from either an EOA or a CA before it can be put into action. Each message must include the amount of gas the contract code will use and include payment for that amount in fees.

Note that gasprice, which is typically set in ether (a cryptocurrency), is set by the message sender and that setting a low value will lengthen the time it takes to include the transaction in a block. This system needs to spend as little ether as possible because the contract must be fulfilled for each vehicle.

Reducing the complexity of a contract code and reducing gas consumption are two easy ways to accomplish the same thing. The suggested system uses mappings rather than arrays in an effort to reduce contract complexity. To maintain the overall complexity of O (1), mappings guarantee O (1) time retrievals and O (1) time insert operations.

4.2 Interaction with Ethereum

To carry out its operations, the user interface must be able to access the contract that has been deployed on the blockchain network. RPC, or remote procedural call, is used to accomplish this. A library of functions called Web3.js was created to communicate with contract code using a JavaScript-based framework.

The system sends a message from an external account (EOA) to the contract's deployed location (CA) to invoke the contract's methods. The system uses web3 to access the contract's interface.

The only drawback to using blockchain for programming is that, unlike a publisher subscriber model used by many protocols, a new contract call must be made each time the information inside a contract is modified.

4.3 Tools and Technologies

Web3.js is used to communicate with a smart contract running on the public blockchain network ethereum by the web application, which was developed in angular and used a local blockchain for development.

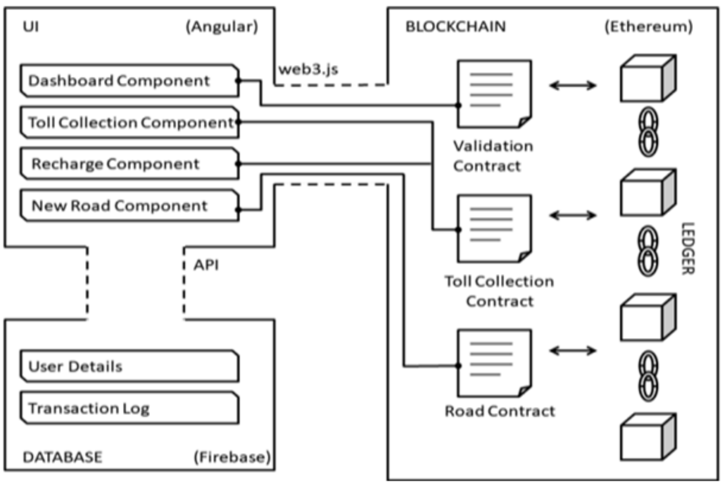

Fig 2. Internal structure diagram

In order to reduce the amount of data stored on the chain itself, authentication is carried out using the Google Firebase authentication service, and a lightweight noSQL database called Cloud Firestore is used to store information that isn't important.

V. OUTCOMES

An online website for toll collection system using the blockchain paradigm smart contract functions as a legally binding barrier to toll collection each time a vehicle approaches a toll booth. Due to immutability, this system ensures fraud prevention and enables end-to-end transparency for all system stakeholders. This system eliminates the need for a

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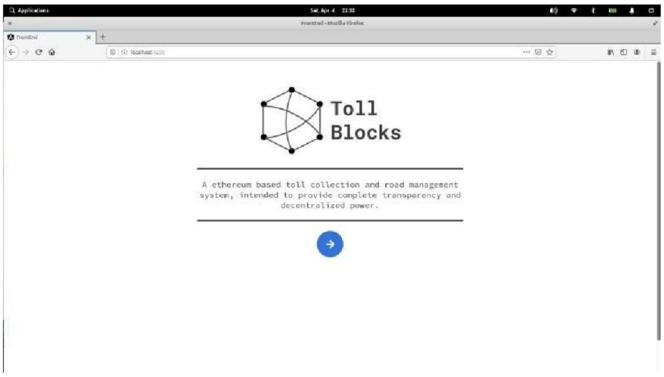

Fig 3. Home page

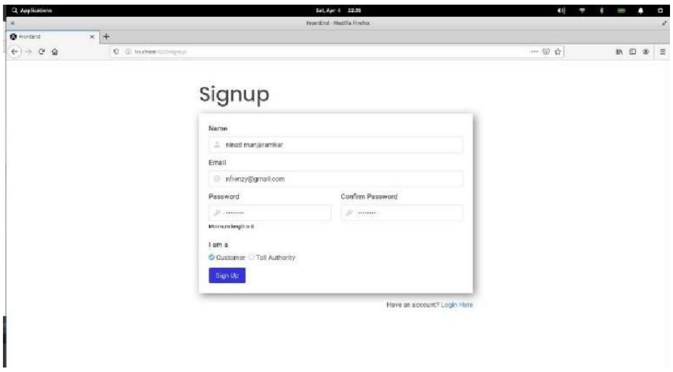

Fig 4. Customer sign up

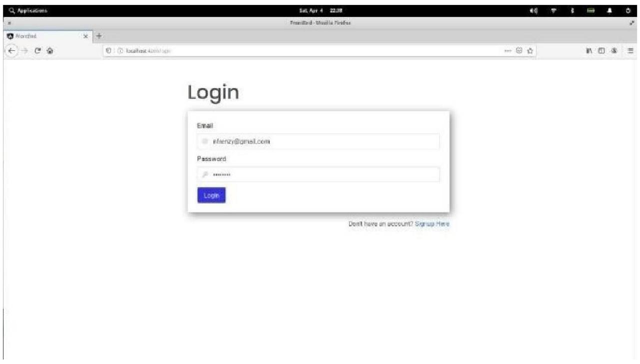

Fig 5. Customer login

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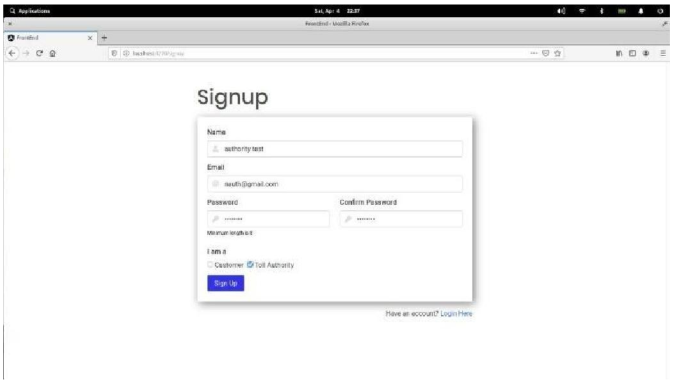

Fig 6. Authority sign up

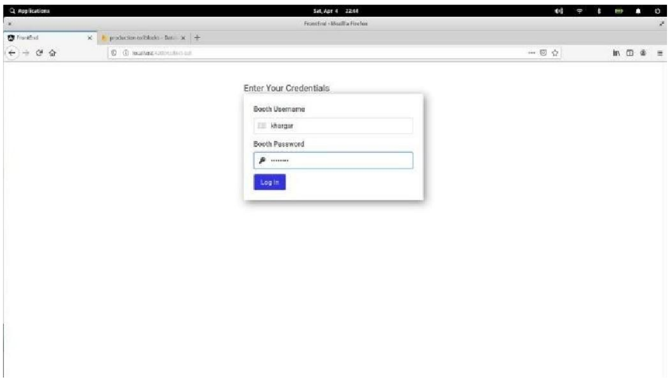

Fig 7. Booth controller

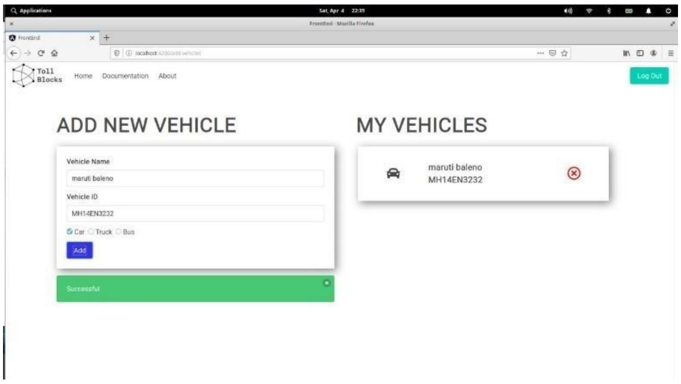

Fig 8. Add vehicle

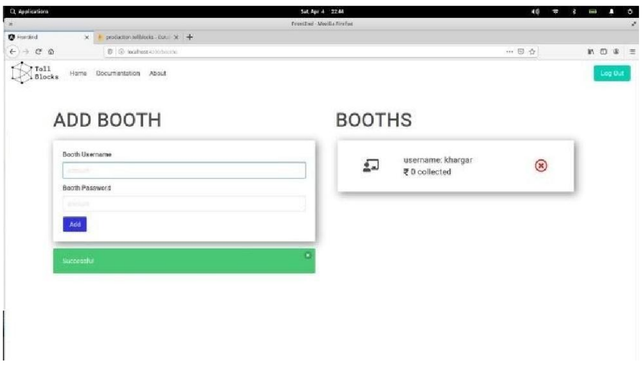

Fig 9. Add Booth

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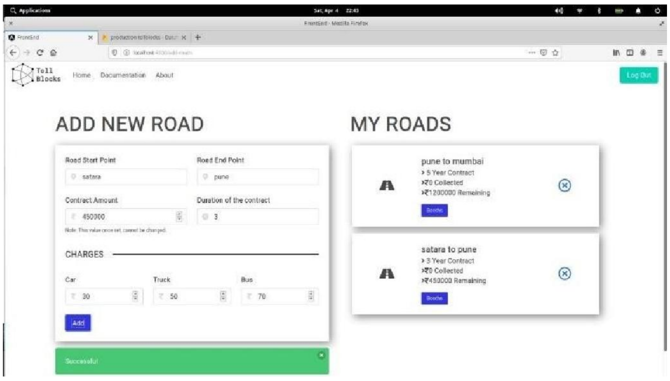

Fig 10. Add road

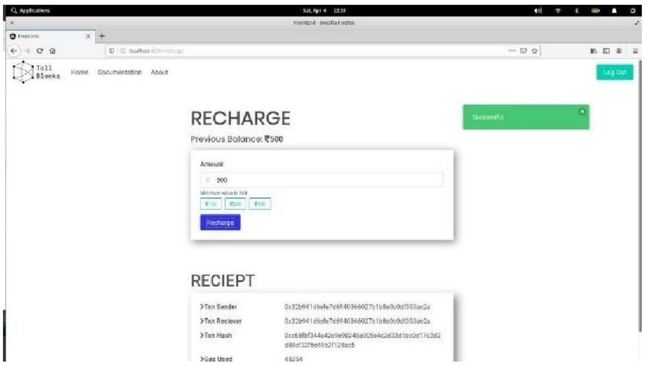

Fig 11. Recharge

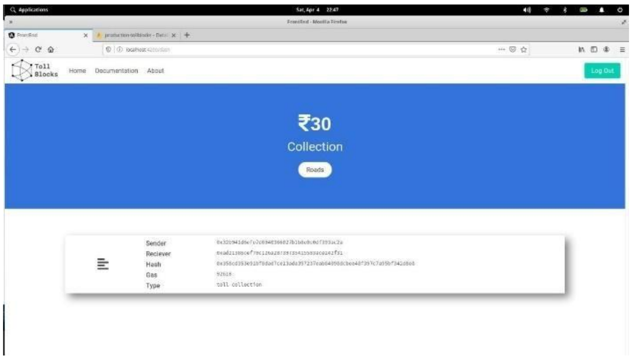

Fig 12. Customer dashboard

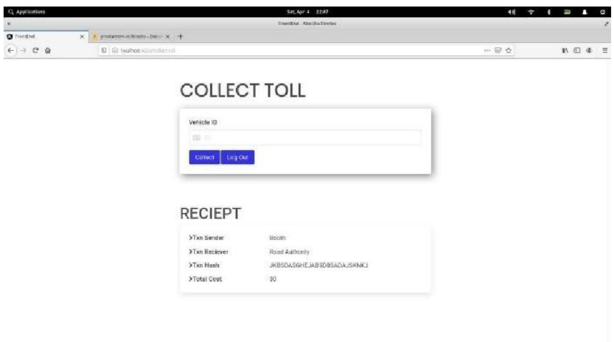

Fig 13. Receipt

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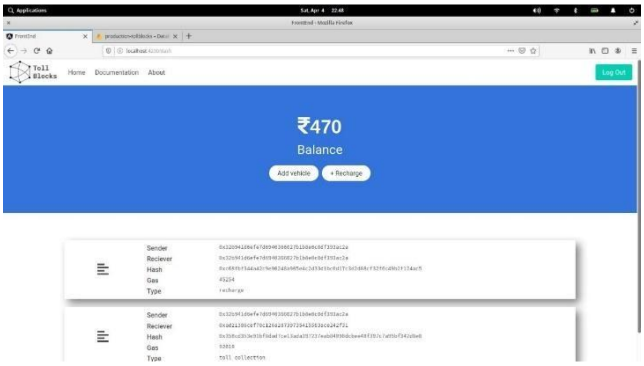

Fig 14. Check recharge validity

The proposed system thus addresses some of the most pressing issues with current toll collection, integrates with existing technology like RFID to offer a fresh perspective on toll collection, and establishes a stepping stone for the further inclusion of entire governance over blockchain-based platform, according to the paper's conclusion. This paper tries to point the reader in a similar direction, toward a decentralized government, as current efforts by governments around the world indicate a positive trend towards blockchain.

VI. FUTURE WORK

The proposed system offers a chance to delve deeper into the issue and enhance the resolution to even better suit the current circumstance. To do this and get rid of the need for ether for each transaction and the risk associated with its volatile price, one option is to switch to a private or enterprise blockchain platform like hyper ledger [insert reference here]. This system also presupposes that all toll plazas have internet access, but that may not be the case for those situated in rural areas of the nation. It may consume too much ether to execute the contract for each vehicle, but this can be easily avoided by batching the transactions and then executing the contract after a predetermined amount of time. In order to prevent any level of fraud and maintain total transparency in the system, the authors' future work will focus on expanding the scope to include road contract auctioning and tender systems inside blockchain

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