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# A microtransaction model based on blockchain technology to improve service levels in public transport sector in Sri Lanka

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***Abstract*: Ticketing mechanism in a public transportation system is a major factor which defines the service quality of the system. Current online payment systems (credit/debit cards, PayPal, etc.) are not compatible with micropayments because transaction processing companies need a minimum transaction amount to make the transaction profitable for them. Therefore, an acceptable micro-transaction model is required in the micropayments domain. In blockchain systems, a third-party intermediary is not facilitating the transactions. Therefore, transaction fees decrease drastically. Using consortium blockchain concept, these fees can be further minimized when proof of work is also handled by a set of approved entities. In this study, an Ethereum based micro-transaction model is proposed to be implemented within the ticketing system in Sri Lankan public transport sector. Bus tickets are programmed as Ethereum smart contracts to handle the payment distribution. Consortium blockchain concept is used in the blockchain-based model where there are regulated bodies as nodes such as the national transport commission to handle the proof of work. Digital currency and Quick Response (QR) codes are incorporated to identify and complete the transaction process. The methodology of this development-oriented research can be described under three major phases. In the first phase, interviews were carried out with relevant stakeholders to identify the process of the current system and its limitations. Also, a broad and extensive study of literature was done parallel to this. During the second phase, identified issues, limitations and downfalls were addressed by designing a novel architecture. In the final phase a prototype is being developed to demonstrate the architecture, In the final phase a prototype is being developed to demonstrate the architecture, then prototype validation and testing were done with simulated data and several key use cases in the domain. The preliminary results of the prototype model show signs of considerable improvement in the service level of the public transport ticketing process and a significant reduction of transaction fees.**

***Keywords:*** *Consortium blockchains, Ethereum, Micro-payments, Smart contracts, Transportation*

## I. INTRODUCTION

This paper addresses the potential of blockchain technology to be applied in the public transport ticketing system with the possibility of lowering the transaction fees in a microtransaction system. Section (I) of this paper provides an introduction into the state of public transport ticketing system, blockchain technology and microtransactions. Section (II) provides an overview of the related work done through a thorough literature review. Section (III) discusses the requirement of the new platform and proposed new architecture with its functionality. Section (IV) discusses the testing and validation plan of the model with a set of case studies to be carried out with the system. Section (V) discusses the benefits and limitations of the model with overall results. Also, the section provides future areas of work in the field with proposed improvements of the current model.

### *A. Public transport*

The public transportation system in Sri Lanka mainly consists of buses and railway systems, which the railway system, only serves a small percentage of the country's transportation needs. Railway system is primarily used for goods transportation with a fraction of capacity available for passengers to use compared to goods. Railway network in Sri Lanka is very slow compared to other developed countries.

As of 2017 National Transport Commission (NTC) report, there are,

- 6955 - Sri Lanka Transport Board (SLTB) buses
- 19614 privately operated buses

are operating in Sri Lanka. Annually 4 billion citizens in Sri Lanka use the above-mentioned amount of buses to fulfill their transportation needs [1].

There are service quality attributes of public transportations systems. Convenience is the main factor when it comes to measuring the service quality of public transportations systems Convenience is defined here as to how simple the Public Transport service can be used and how well it can be used to fulfill the transportation needs. Also, it can be distinguished by considering the ease and simplicity of the payment and planning process of a public transportation trip [2].

#### *1) Ticketing system in public transport*

Passengers using public transport in Sri Lanka only have one option to purchase tickets which is using cash and purchasing tickets on premise. Currently, there is no way to purchase digital tickets on the premise in Railway or Bus transportation systems in Sri Lanka. Considering about Sri Lankan public transportation system, convenience is being questioned always. Ease and simplicity of paying for tickets

are very less. Passengers always argue with the conductor to obtain their change and they never get their change correctly.

Most of the western and European countries including developed Asian countries are adopted to the Travel Pass system. And now they are moving towards mobile ticketing platforms.

### *B. Blockchains*

One way of defining Blockchain is "A decentralized, secure and distributed ledger". And there is no standard definition exists for blockchain. It is a software protocol which can be used to securely transfer unique instances of value (Ex. Property, Money, Credentials, etc.) via the internet without any of third parties involving in the transaction process which can be a bank or government organization. Blockchain consists of public/private key cryptography, cryptographic hash functions, distributed databases, consensus algorithms, and decentralized processing.

To perform a transaction User X selects User Y address. Using the platform protocol User X forms a transaction and signs the transaction using their private key and announces the transaction to the network. Other peer nodes listen for new transactions and form a candidate block; a hash digest of valid transactions that have yet to make the ledger. The node announces the candidate block to the network in order to add it to the ledger. Other nodes check the candidate block is valid to ensure that the block contains no fraudulent or incorrect transactions included by the block's creator. A consensus mechanism prevents block duplication and a bottleneck of network traffic. As the process continues, the ledger continues to expand as a chain of these blocks of transactions; hence the term blockchain. Most importantly Blockchain infrastructure ensures trust, security and transparency.

#### *1) Blockchain ticketing*

Tickets for anything can be defined as a type of contract. Also, tickets have some face value, these can be treated as smart contracts to imitate the current tickets and proceed onward to discover programmable approaches to make a totally new kind of tickets and a broad framework. Smart contracts also bring a lot of scalability for the ticketing Ecosystem. Around the global event (movie, music, etc.) ticketing industry (including ticket booking systems), companies Gare starting to use blockchain based ticketing systems for movie ticketing, booking, music industries, etc. with programming tickets as smart contracts. Some of the examples for global companies are Aventus in Europe, Guts in Holland, Lava in the US, Blocktix. However, all the platforms that exist focus on the prevention of fraud and the distribution of event tickets.

#### *2) Consortium blockchains: A brief introduction*

Consortium blockchain is another recent blockchain topic that came into the discussions. Consortium blockchain is a specific blockchain implementation with authorized nodes. Consortium blockchains evolved as an important concept and architecture that benefits from the flexibility and anonymity of private blockchains transactions while exploiting the democratic administration of public blockchains [3]. Transaction efficiency is much needed in public transport. Consortium blockchain will ensure,

- Transaction limitation will be reduced which resulted from transaction confirmation delays
- No transaction fee
- Improved privacy in blockchain data

### *C. Microtransactions*

Microtransactions are small commercial transactions in digital form. Defining the monetary value of micro-transactions depends on the nature of the transactions and the fiat currency type. In terms of Sri Lankan Rupees, any transactions under 1000 rupees can be considered as micro-transaction value. Most of the ticketing transactions in the public transport system in Sri Lanka can be classified as micro-transactions as 95% of these transactions are below 1000 LKR. The minimum fare of a bus ticket as of now in Sri Lanka is 12 rupees. Out of these ticket transactions, there are very few happen as online transactions. Only some of the bookings happen as online transactions. NTC booking, BusBooking.lk are some of the booking portals and they charge a heavy transaction fee for every booking.

Traditional credit card-based systems not able to handle micropayments due to the reason for high processing fees. When a card transaction occurs, the buyer gives his permission to get a payment from his account, however, in this process lot of intermediaries are involved.

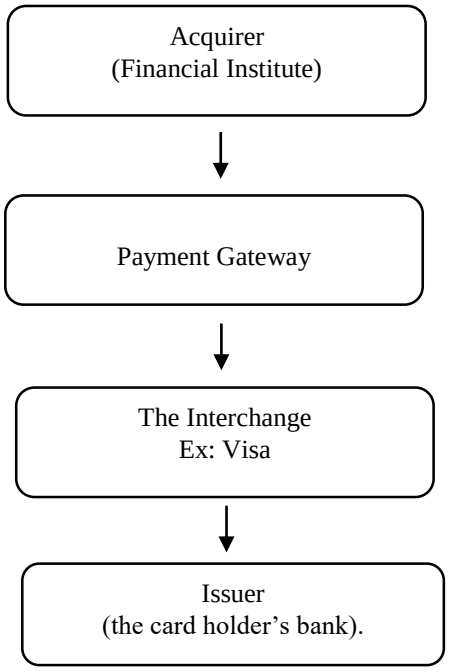


Fig. 1. Financial intermediaries

Therefore, to process a typical transaction processing companies should keep these intermediaries profitable. Hence the minimum transaction amount these processing companies can process is too large. But, blockchain protocol is promising in addressing this issue with its key principle of decentralization. Blockchain gives a great opportunity to get rid of the "middlemen fees" scenario by eliminating multiple intermediaries mentioned above.

## II. LITERATURE REVIEW

### *A. Public transport*

The public transportation sector in Sri Lanka is a major factor in the lifestyle of the citizens as a developing country in the world. Public transportation is a method of travelling maintained by a state which enables more people to travel as a group in predefined routes. Traditional instances of types of public transportation are buses, trains, and trams. Bullet trains, airplanes, and omnibuses are heavily used for public transportation between cities. [1]

There are service quality attributes of public transportations systems. Convenience is the main factor in measuring the service quality of public transportations systems. Convenience is described here as to how easy it is to use the PT service and how quickly it adds to your mobility. [2].

[4] discusses the factors that are affecting the service quality of public bus transportation in Sri Lanka. Developing public transport facilities will result in reducing the privately owned vehicle usage on roads eliminating common problems in Sri Lanka such as,

- Huge congestion on roads
- Environmental pollution
- Road accidents etc.

Further, results imply that customers are highly satisfied when they are provided with a higher quality service and they could not see much difference between private vehicles and public vehicles. And, through discussion and analysis paper state that although a lot of transport facilities such as touch travel cards, "Sisusariya" etc. are provided, most of those services are not effective and not properly executed to get the highest return.

#### *1) Public transport ticketing*

European Metropolitan Transport Authorities (EMTA) have been working on addressing the issues of electronic ticketing. Study on electronic ticketing in public transport [5] done by an established group of EMTA to find knowledge and learn from the experience in the field of electronic ticketing. This study was assisted by public transport consultant Mohamed Mezghani. key factors to consider when defining and designing a ticketing system as follows,

- Ease-of-use for passengers
- Easiness of revenue collection
- Conformity for operators
- Attractive service to passengers
- Intramodality (transfer tickets)
- Transparent revenue sharing
- Maximizing farebox revenues
- Fraud reduction

Also, the paper discusses the existing ticketing medias such as cash, tokens, paper tickets, contact-based smartcards, contactless cards, mobile ticketing, etc. Talking about the e-ticketing systems these are only about payments, but these systems hold a huge amount of data which can be used to make public transport convenient and easy to manage. The long-term objective of this e-ticketing system as mentioned in the study is to "customers should be able to pay for the public transportation with a fraction of time in a fully automatic manner without waiting for the validation of the card."

### *B. Microtransactions*

Microtransactions are small commercial transactions in digital form. Microtransactions in Bitcoin [6] study describes the nature of micro-transactions and they state the importance of low-cost microtransactions. "As the global economy is moving towards an era of using more intangible goods globally, delivering those goods with traditional payment methods tend to be more expensive than the product cost."

Experiences in Developing a Micro-payment System for Peer-to-Peer Networks [7] is a study that discusses various researches done to implement a micropayment system. And they present their novel P2P-Netpay micropayment platform and its architecture. P2P-Netpay delivers an offline micro-transaction model that uses a light-weight hashing-based encryption method. They also state the importance of peer to peer transactions in this paper.

### *C. Blockchain*

[8] is a study that gives an overview of blockchain technology with the current applications and stating the impact of blockchain. As stated in the study in a blockchain network data is not controlled by any third-party intermediaries and all the transactions should go through a cryptographic validation process. Every transaction ever done is documented in an unalterable ledger in a verifiable, safe, precise and everlasting manner, with a timestamp and additional information.

In 2008, a person anonymously (or group) identified under the name of Satoshi Nakamoto published a white paper titled [9] Bitcoin: A Peer to Peer Electronic Cash System and they proposed a novel structure for electronic transactions without depending on trust and mentioned that using a peer-to-peer system of electronic online transactions would give the ability to send money directly from one user to another without involving financial intermediaries.

The Ethereum yellow paper came out in 2014 which was written by Dr. Gavin Wood and functions as a formal definition of the Ethereum protocol. Ethereum is an approach which focuses on building a technology that can build all transaction-based state machine concepts [10]. Also, this paper introduces the concept of Smart Contracts.

Later, blockchain ideas emerged into a lot of other domains without limiting only into cryptocurrencies. Within emerge of second-generation blockchain applications are derived to many fields.

Gartner Top 10 Strategic Technology Trends for 2020 list out Blockchain, quantum computing, augmented analytics and artificial intelligence (AI) drive most business models in 2019 [11]. The report also says other than finance applications blockchain has begun its impact on government, healthcare, manufacturing, supply chain and other areas, with blockchains eventual potential reducing the costs and reducing clearing time of the transaction.

#### *1) Blockchain ticketing*

Tickets for anything is nothing else but a type of contract [12]. Also, tickets have some face value, these can be treated as smart contracts to imitate the current tickets and proceed

onward to discover programmable approaches to make a totally new kind of tickets and a broad framework. Smart contracts also bring a lot of scalability for the ticketing Ecosystem. Around the global event (movie, music, etc.) ticketing industry (including ticket booking systems), companies are starting to use blockchain based ticketing systems for movie ticketing, booking, music industries, etc. with programming tickets as smart contracts. Some of the examples for global companies are Aventus in Europe, Guts in Holland, Lava in the US, Blocktix.

A blockchain based privacy preserving ticketing service [13] present an Ethereum based privacy preserving event ticketing model. The study also discusses the integrity that blockchain brings into the ticketing Ecosystem. And the focus of this study is about how to ensure the privacy of the ticket purchaser, for this Non-Interactive Zero-Knowledge (NIZK) schema is used with the goal of protecting the privacy and confidentiality of the end-user.

The world's first Blockchain Bus is set to ride in the Netherlands [14]. A company called VMC initiated a bitcoin-based payment system for public transport buses in the Netherlands recently. Passengers can pay for tickets via bitcoin where cryptocurrencies are regulated in the Netherlands. But in Asian countries still, cryptocurrencies are considered as illegal.

*2) Consortium blockchains*

Consortium blockchain is a modified version of blockchain concept with approved nodes to maintain the distributed ledger. Consortium blockchains evolved as a promising concept which uses the transaction efficiency and privacy of private blockchains while getting the benefits of decentralization in public blockchains [3]. Transaction efficiency is much needed in public transport.

Consortium blockchain is another recent blockchain topic that came into the discussions. [15] further exploits consortium blockchain knowledge to develop a unified and secure P2P energy exchange scheme with consortium blockchain, named energy blockchain. And, they addressed the issue of transaction delays in the bitcoin network with a credit-based payment schema model. Consortium blockchain concept is very little addressed in researches. This concept can be applied to public transport ticketing to maintain a better infrastructure while enhancing the service quality of the sector. Consortium blockchain will ensure,

- Transaction limitation will be reduced which resulted from transaction confirmation delays
- No transaction fee
- Improved privacy in blockchain data

### *D. Research objectives*

An identified main issue of the microtransaction domain is the high transaction fee with the existing payment channels. This is due to a lot of third-party intermediaries involving in the transaction process, and blockchain technology is promising with addressing this issue. Without addressing this specific problem related to microtransactions, implementing an online portal with existing payment channels will result in the same issue.

This study introduces a novel digital low fee payment platform to be used within the public transportation system which can be also extended to other microtransaction systems using blockchain technology to achieve the following goals.

- A platform that retains all requirements of current ticketing systems
- A platform to Minimize transaction fees with microtransactions
- Improve the transparency of the ticketing system
- A platform to Ensure fair payment distribution
- Eliminate the need for paper tickets and other materials

Further, this study uses the public transport system in Sri Lanka as a reference for a microtransaction system.

## III. METHODOLOGY

The research approach of this development-oriented research can be explained under three major phases. In the first phase, interviews were carried out with relevant stakeholders to identify the process of the current system and its limitations. Also, a broad and extensive study of literature was done parallel to this. During the second phase, identified issues, limitations and downfalls were addressed by designing a novel architecture. In the final phase, a prototype has been developed to demonstrate the architecture, which was tested in a simulated environment with generated data to arrive at conclusions.

This platform took several user roles and their nature into consideration when designing the architecture.

### *A. User roles*

- Passenger
- Bus owner or Conductor
- Governing Authorities (National Transport Commission etc.)

*1) Passengers:*

Common observation in Sri Lanka public transport system considering the passenger is that obtaining their change of the ticket. Passengers always caught up with arguments with the conductor to get their change and they never get their balance correctly. Passenger is the major object of the application. The Passenger can use the application to purchase and authenticate. Also, the history of the tickets can be viewed by the passenger. The actions of the passenger are:

- Create an account (wallet) to purchase a ticket.
- Check the balance of his account.
- Scan a QR to transfer tickets.

*2) Bus owner or conductor:*

Considering the Sri Lanka public transportation system, it is crucial to have a fast and fair payment distribution system in place. The reason for this is on most buses conductor and drivers relying on the daily income and also, their daily allowances are paid for them. So, the bus owner needs this money as soon as possible to settle these payments.

The actions of the conductor are:

- Able to verify tickets presented by passengers.

- Check the wallet balance and transfer money.
- Generate QR based tickets.

*B. Platform architecture*

Figure 2 illustrates the overall blockchain model. A key difference to highlight in this proposed model is how the Proof of Stake (POS) is conducted compared to the public Ethereum Blockchain. In public, Ethereum blockchain POS is done by miners in the network who will get Ether (Crypto money in Ethereum blockchain network) as an incentive for the computational power they spent. In this model, POS is handed over to a set of authorities like NTC, ICTA, etc. This type of blockchain is known as Consortium Blockchains. Therefore, when a new transaction happens and a block creates, validation (traditionally known as mining) happens between the authorities. After the validation from the authority's block will be added to the blockchain.

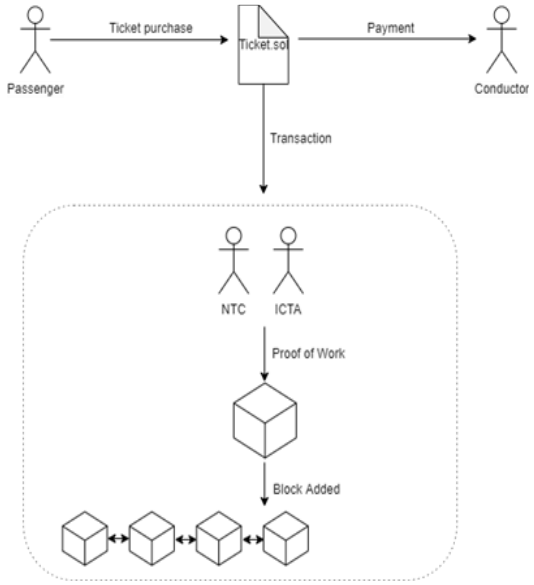


Fig. 2. overall blockchain model

*1) Smart contract (ticket. Sol)*

A smart contract will be the one that is acting as the intermediary in the system which is a collection of code reside at the blockchain itself. Smart contracts are written solidly. In this model Ticket. So smart contract executes the work related to the following process.

- Payment distribution between passenger and bus owner upon the verification of QR code

There are four types of transactions happens on an Ethereum blockchain network, (or any kind of blockchain network which involves smart contracts)

1. User to User transactions
2. User to Contract transactions
3. Contract to Contract transactions
4. Contract to User transaction

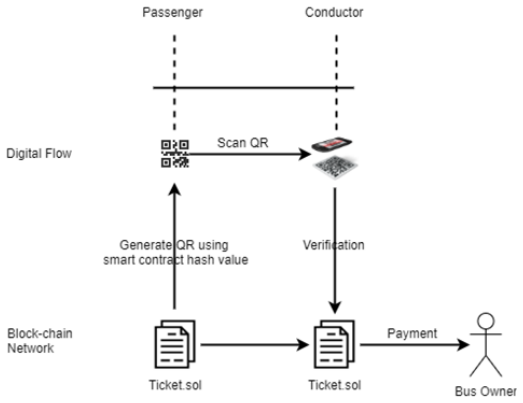


Fig. 3. Digital flow

Out of these in this blockchain model (2) and (4) will be used in the Ethereum network. Purchasing a ticket will be a type (2) transaction where paying the bus owner upon successful QR verification will be a type (4) transaction.

Ticket.sol will insert Customer ID, Balance, Ticket value and Ticket ID into the block as the data. With the verification, the block will be added to the blockchain.

*C. Process flow of the platform*

Within the development process of DApp, QR based Digital flow was developed which is illustrated in figure 3.

Upon the purchase of the ticket customer will be issued with a QR code by Ticket.sol smart contract that will include contract hash. When the conductor scans the QR code smart contract will call blockchain and validate it. A valid contract will automatically move money from the passenger's wallet to the bus owner's wallet, at the same time showing the verified message on the screen.

*D. Implementation*

In Ethereum, Decentralized Applications (DApps) are the applications which have a graphical user interface enabling users to interact with the blockchain in a more friendly manner. Smart contracts handle the business logic of the application, and the front-end contains technologies like HTML, JavaScript, etc. Because smart contract code is very costly to execute, DApps are designed to perform only the required calculations on the blockchain, and everything else that can be done by the client side is executed on the front end of the application to save costs and utilize resources.

Within the application development process of the DApp which is described in Figure 4 following tools and technologies are used,

- Truffle Framework

Truffle is an integrated development environment which can be used to easily develop Ethereum DApps. Truffle provides a separate testing framework for solidity smart contracts and also truffle can be configured as a delivery pipeline. In the implementation, truffle was used mainly to compile the contracts, migrate the contracts, and deployment, etc.

- Web3.js

Ethereum node provides a Remote Procedure Call (RPC) interface which is used in DApps to interact with blockchain. Web3.js is a JavaScript library that offers a layer of

abstraction and operates on top of Ethereum RPC. Web3 includes the eth object - web3.eth and the shh object - web3.shh

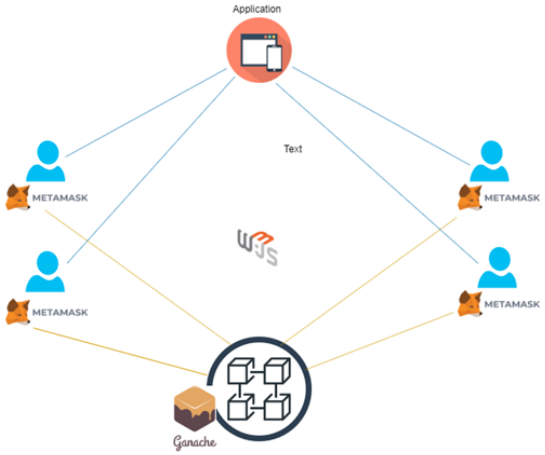


Fig. 4. Platform Architecture

- MetaMask

To use the DApp GUI, the user must have to use a web browser like Mist or MetaMask plugin for chrome and an Ethereum account. First of all, MetaMask will inject web3.js instance into the HTML webpages and it will allow the user to import his Ethereum accounts to the current system he is using. Then the system will connect to the blockchain network through MetaMask making the user system a virtual blockchain node.

- Ganache

Ganache is a simulated blockchain environment which can be used as a private Ethereum blockchain. Ganache allows us to inspect the blockchain state while controlling the operations of the chain. As this is a simulated environment it allows performing all actions that would on the main Blockchain without any costs.

The bus conductor can enter the value of the ticket into the system and can generate the QR code. QR is generated using the contract hash value. The user interface to insert ticket value and generate Quick Response (QR) code is shown in figure 5. System generated QR code will contain the ticket value and the wallet address of the conductor/bus owner.

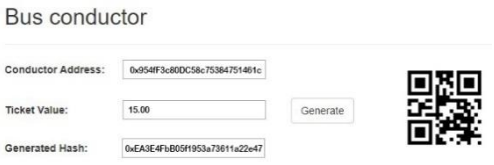


Fig. 5. Interface to insert ticket value and generate QR code

Then this QR code will be presented to the passenger to be verified and upon successful verification, funds will be transferred into the conductor/bus owner wallet. The user interface created for testing the verification is shown in Figure 6. Before completing any transaction on the platform MetaMask will ask for the authentication to verify the user.

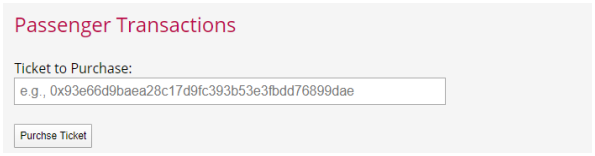


Fig. 6. Interface to verify ticket

MetaMask notification upon a transaction is shown in figure 7. This authentication will happen before any transaction happens on the platform. The transaction summary is shown in MetaMask with details and gas prices. The transaction should be confirmed by the user to complete it. And, the user can set his desired gas price.

Ganache local test client will generate 10 Ethereum wallets to use within the development process. These 10 wallets are preloaded with 100 ETH each and gas prices can be set as desired. This environment is a simulated environment specific for testing purposes. Figure 8 shows the generated wallets with their wallet addresses.

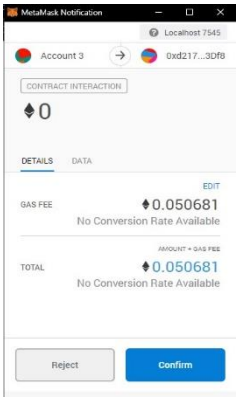


Fig. 7. Interface to insert ticket value and generate QR code

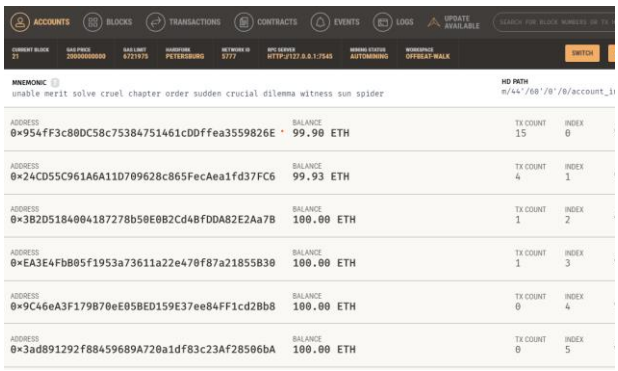


Fig. 8. Ganache Test Client

## IV. TESTING AND VALIDATION PLAN

In order to test the capabilities of the platform following case studies are performed. These case studies are generated from the perspective of different user roles after identifying the nature of them. Mock data is used to simulate the input and output data required in the testing process.

- Passengers are seeking to purchase a ticket.
- Bus conductor seeking to verify and vend tickets

### *A. Case Study: passengers*

A hypothetical passenger exists to test the platform against the passenger considerations and requirements mentioned in Section (III-A)

1. Passenger connects to the application and creates a personal wallet for him through MetaMask or a similar application.
2. Passenger logs in to his wallet and checks his account balance.
3. A passenger scans the QR presented to him by the conductor and verifies the transaction to purchase a ticket.

This test checks the passenger's ability to purchase a ticket through the system and successful transfer of funds through the DApp.

### *B. Case study: Bus conductor*

A hypothetical bus conductor exists to test the platform against the vendor considerations and requirements mentioned in Section (III-A)

1. The bus owner or conductor uses to create a wallet using the application.
2. Conductor logs in to his account and enter ticket value and generate a QR based ticket.
3. The conductor presents the QR code to the passenger.
4. A passenger scans the ticket and upon successful verification, the conductor receives the funds to his wallet.
5. The conductor checks his wallet balance and history of transactions whenever necessary.

This test checks the Conductor's ability to generate a QR based ticket and fund transfer mechanism of the DApp.The architecture and the mechanics of the platform combine the requirements of public transport ticketing with state-of-the-art technologies. The symbiotic development of the platform results in several beneficial aspects.

### *C. Technical benefits*

Platform mining work is handed over to set of authorities like national transport commission, hence ticket prices and other regulations can be set by the government and the transaction fees are reduced. They have the same control over the platform as the existing one to limit fraudulent activities.

Furthermore, the customer's privacy is secured with no tracking of their identity. Using blockchain technology will provide a secure, distributed platform that will result in decentralized data. This will prevent network downtime and tampering of data. Also, all the peer nodes store a local copy of data allowing real-time ticket inquiries and lowering the network bandwidth.

### *D. Other benefits*

Paper tickets and additional plastic travel cards will be eliminated with the use of this platform. This is a huge cost saving aspect for the organizations in the transportation domain. Environmental pollution with plastic and paper can be lowered as well by a considerable percentage.

From the perspective of the passenger, a huge paradigm shift would not be necessary to operate on this platform. Almost everyone in the modern world owes a smartphone; the only requirement to use the platform. Also, bus owners would not need to invest in ticketing machines and paper rolls to operate in the platform as a service provider.

Most importantly both parties do not need to worry about physical money, especially coins as everything happens with digital currency. So, obtaining a change of the ticket will not be a problem anymore with this platform.

## V. CONCLUDING REMARKS & FUTURE WORK

This paper presented an innovative approach to use blockchain technology in the microtransaction domain, with a digital ticketing platform to use within the public transportation domain in Sri Lanka. The core principle of decentralization of blockchain technology is used to eliminate traditional middleman scenarios in existing transaction processing systems to benefit the passenger, bus owner and governing organization.

Identified business logic and the user scenarios in the thorough literature review were analyzed and implemented with the usage of Ethereum smart contracts. It was effective to use tickets as smart contracts within the system. Quick Response (QR) codes were recognized as a practical and viable mechanism to verify tickets within the system which was also an environmentally friendly solution. Using a digital currency in the system also eliminated the problem of dealing with the change of the ticket. Especially a paradigm shift is not required to use the platform presented here as the platform preserves all the properties of the existing system.

Lowering transaction fees in a digital payment system is the focus of this research, Therefore, those micro payments can be facilitated via online payments. Properties of consortium blockchain concept are used in the architecture to get the utmost benefits of both public and private blockchain characteristics. Using consortium blockchain concept public mining process has been totally eliminated from the model presented here. Mining is done by a set of governing authorities from the public transportation domain. Basically, transaction fees on a public blockchain system occur due to the public mining process because miners should be paid for the transaction validation. This fee can also be eliminated in a consortium model where the validation will happen from the governing bodies of the domain. The only cost to bear is the computational power that they need to use for the mining work. This was tested within the implemented demonstration system using ganache and setting zero gas prices for the transactions. Data were stored in a blockchain. Thus, microtransactions are facilitated by the proposed novel architecture with minimum transaction fees involved.

Crypto payments like bitcoin, Ethereum also faced a problem of the slowness of the network. Transaction in a blockchain network takes a couple of hours to complete. This was a huge limitation regarding micropayments. A solution came with the lightening network concept. Lightening network moved the transactions “off the blockchain" increasing the processing speed up to thousand transactions per second. Basically, the lightening network creates a second layer on top of blockchain which will open a payment channel between two wallets. This was specifically designed to

facilitate microtransactions. So, the lightening network concept can be integrated into the system to increase the transaction processing speed for a more efficient transaction distribution.

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