VIVA-TECH INTERNATIONAL JOURNAL FOR RESEARCH AND INNOVATION

ANNUAL RESEARCH JOURNAL

ISSN(ONLINE): 2581-7280

A Study of Tokenization of Real Estate Using Blockchain Technology

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Abstract : *Real estate is by far one of the most trusted investments that people have preferred, being a lucrative investment it provides a steady source of income in the form of lease and rents. Although there are numerous advantages, one of the key downsides of real estate investments is lack of liquidity. Thus, even though global real estate investments amount to about twice the size of investments in stock markets, the number of investors in the real estate market is significantly lower. Block chain technology has real potential in addressing the issues of liquidity and transparency, opening the market to even retail investors. Owing to the functionality and flexibility of creating Security Tokens, which are backed by real-world assets, real estate can be made liquid with the help of Special Purpose Vehicles. Tokens of ERC 777 standard, which represent fractional ownership of the real estate can be purchased by an investor and these tokens can also be listed on secondary exchanges. The robustness of Smart Contracts can enable the efficient transfer of tokens and seamless distribution of earnings amongst the investors. This work describes Ethereum blockchainbased solutions to make the existing Real Estate investment system much more efficient.*

*Keywords -**Blockchain, Ethereum, Real Estate, Security Token, Tokenization, Vehicle.*

I INTRODUCTION

Real estate is a unique and complex asset class. The commercial real estate market makes up a significant economic global segment in terms of the asset base and the transactional activity. Although the investment market for real estate is huge, it has been dominated by a relatively closed network of firms and organizations able to make large investments which are not liquid. Real estate is different from various other asset classes as it involves high transaction costs, land use regulations and other barriers to entry. These characteristics of real estate have implications for the overall efficiency of the market. While there have been improvements in the information flow and transaction set up and completion – we are only at the initial few steps in terms of digitization [14]. A significant portion of the digitized information is hosted on disparate systems, which results in a lack of transparency and efficiency, and a higher incidence of inaccuracies that creates a greater potential for fraud. There is still a lot of improvement that can be made in real estate when it comes to the use of digital technology and the representation of physical assets in digital forms.

Blockchain technology could enable the real estate industry to address these inefficiencies and inaccuracies. Simply said, a blockchain is essentially a shared and distributed database or ledger. Transactions are processed and bundled in blocks and the blocks encrypted and cryptographically linked in a chain. The processing takes place within a network of nodes – either public or private – with a consensus design intended to decentralize authority such that no single source is the sole decider of transactional integrity. Rather authority is decentralized across the operators of the nodes, with each node validating and maintaining verified copies of the ledger [18]. By recording and combining transactions into a decentralized, secure ledger, a blockchain network creates a "chain" of chronological data that no one party has control of or can change and such that each block and the individual transaction can be verified via cryptography. The transaction records are further protected by the replication of the data across nodes allowing for multiple and verifiable sources of truth. The main contributions of this paper are:

Providing an approach for Real Estate Asset tokenization by using Ethereum, thus making it liquid, secure and efficient.Extend the approach to provide an automated solution for the transfer of tokens and distribution of earnings to investors.The remainder of this paper is organized as follows: Section 2 describes the existing system and its flaws. Section 3 discusses the preliminaries for this work. Section 4 describes the proposed

VIVA-Tech International Journal for Research and Innovation   *Volume 1, Issue 4 (2021)*
ISSN(Online): 2581-7280
VIVA Institute of Technology
9thNational Conference onRole of Engineers in Nation Building – 2021 (NCRENB-2021)

workflow and Section 5 elaborates on the implementation architecture. Finally, Section 6 concludes the paper and suggests directions for future scope.

II EXISTING SYSTEM AND ITS FLAWS

Real estate is real and tangible property made up of land as well as anything on it including natural resources, flora and fauna, and buildings. Any real estate falls into one of the three categories - Residential, Commercial, and Industrial. One of the traditional methods to invest in real estate is to buy land or property directly through a real estate broker. Some of the advantages of real estate investments are competitive risk-adjusted returns, high tangible asset value, and attractive and stable income returns in the form of rent and leasing fees. Fig. 1 depicts the various ways to invest in real estate.

There are numerous drawbacks to traditional real estate investment. First of all, the initial cost required to buy property is very high. Most of the investors are not able to meet this required amount and hence cannot invest in real estate. The system also suffers from a lack of liquidity. Real estate investments are highly illiquid. To keep earning rental income from the underlying property, the owner also has to find suitable tenants. One cannot sell a fraction of their asset and have to sell the entire underlying asset. Moreover, there are generally numerous intermediaries such as brokers, lawyers, etc. involved in the system. The transaction costs associated with the real estate market are high and it takes a lot of time for a real estate deal to get finalized. All these factors make the system cumbersome and unattractive to a retail investor [2].

Another alternate method to invest in real estate is through Real Estate Investment Trusts (REIT). A REIT is a trust, corporation or an association that owns, or finances income-producing real estate and can be publicly listed or privately owned [6]. The income of a REIT is generated through rent earned from its owned-asset portfolio, interest earned by financing real estate assets or sale proceeds upon sale of assets under management.
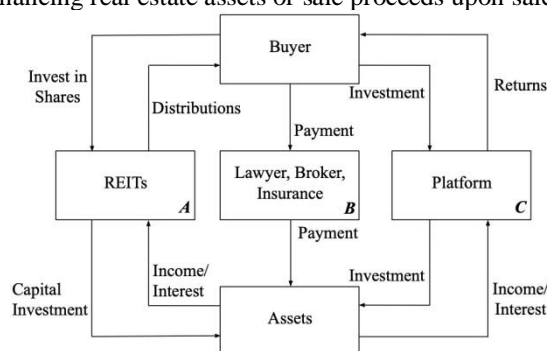

Fig.1. Investment through A. REITs B. Traditional System C. Crowdfunding

Although REITs help to mitigate the problem of illiquidity in real estate, they have several disadvantages. Historically, public REITs have had lower returns than private REITs. They also trade on an average at a premium to the underlying Net Asset Value. The total value of the commercial real estate assets value captured by the REITs is significantly smaller than the total Commercial Real Estate market. Hence, a large number of commercial real estate is out of reach for investors. Moreover, the retail investors are also dependent upon the REIT managers and do not have the option of customizing their real estate exposure. An investor might want access to a specific type of asset in a specific geography and currently, REITs do not provide the benefit of such a granular level of investment. Some REITs also incur high management and transaction fees, leading to lower payouts for investors [13].

Crowdfunding is defined as a collection of equity and debt to be invested in several kinds of projects through a web-based platform able to create opportunities by matching lenders and sponsors. The capital raised in real estate crowdfunding is used in order to purchase, develop or refurbish a Real Estate asset with the aim of subsequent use or transaction [1].

Real estate crowdfunding has failed to take off for multiple reasons. One of the biggest reasons is the quality of assets listed on the crowdfunding platform. When assets that were unable to raise capital through traditional means of the financing end up on crowdfunding platforms. Other issues with crowdfunding are multi-year lock-in periods required. This locks investor capital and even with some platforms providing a secondary market for these assets this reduces overall liquidity. Certain platforms allow investors to sell their holdings after one year but these secondary markets are siloed [13]. All these factors make REITs and crowdfunding undesirable for retail investors.

III PRELIMINARIES

3.1 Blockchain: Blockchain technology is a type of distributed ledger technology that uses a Peer-to-Peer (P2P) network model consisting of immutable and time-stamped records of data. This work employs the use of Ethereum blockchain. As the name suggests, Blockchain is an append-only chain of blocks that are back-linked. It was first introduced by Satoshi Nakamoto in [11]. Some of the main advantages of this technology are security, immutability, decentralization, and transparency. It uses public-key cryptography as the base for identifying users and granting them access to their assets on chain stored in these wallets. Cryptographic hash functions, or simply hash functions, are known to be one way, i.e., the input cannot be deciphered from the hash value of the input. These are used to create a tamper-proof record of any form of transactions on the ledger.

A blockchain system consists of users or computers which are called nodes [11]. These nodes form the peers in the network. Any communication or sharing of resources between two peers is called a transaction, like, in Bitcoin blockchain, the transfer of bitcoins is called a transaction. A block is a collection of transactions that are verified and added to the blockchain. A block consists of a block header and a block body. The block header consists of a previous block hash as one of its elements, which serves as a link to the previously added block and the block bodyconsists of the transactions. The validation of the transaction is done by miners on the blockchain. These miners contend to solve a cryptographic hash algorithm-based difficult mathematical puzzle. A consensus protocol enables all the nodes of the network to reach a common agreement and ensures that there is only one version of the truth that is agreed upon by all the nodes in theBlockchain.

When a transaction occurs, it is broadcasted to the entire network. The nodes in the network validate the transaction and the user's status. A set of verified transactions is considered to be added to the block. Miners solve the mathematical puzzle and the one who solves it first broadcasts it to the entire network and mines the new block on the blockchain. This new block is permanent and unalterable. The new state of the blockchain is updated in the ledger present with each node, and it is distributed to each and every node on the network, it makes it decentralized.

3.1 Ethereum: Ethereum is a global, open-source platform for decentralized applications. It is a specific blockchain-based software platform that enables the possibility of building and running smart contracts and Distributed Applications (DApps) [10]. Ether is the cryptocurrency asset employed in the Ethereum blockchain. In some extent, Ether is the fuel for operating distributed applications over Ethereum. Using this cryptocurrency, it is possible to make payments to other accounts or to the machines executing some requested operation. Ether thus enables running DApps, enabling smart contracts, generating tokens during Initial Coin Offering (ICOs), i.e., a type of funding using cryptocurrencies, and also for making standard P2P payments.
A transaction on Ethereum consists mainly of five elements [17], namely, From (sender), To (Receiver), Gas (fees to be paid for performing operations), Data/Input (message), and Value (amount transferred in Wei). A consensus algorithm is a procedure through which all the peers of the Blockchain network reach a common agreement about the present state of the distributed ledger. Consensus algorithms hence achieve reliability in the Blockchain network and establish trust between unknown peers in a distributed computing environment. Proof of Work (PoW) is a consensus algorithm that aims at solving a costly and time-consuming mathematical puzzle for a new block to be added to the blockchain and at the same time easy for other nodes to verify it. Proof of Stake (PoS) concept states that a person can mine or validate block transactions according to how many coins he or she holds. This means that the more cryptocurrency owned by a miner, the more mining power he or she has. At present, Ethereum is using Proof of Work. But, it is transitioning into using Proof of Stake eventually.

3.3 Smart Contracts: Smart contracts are portions of codes where the logic is implemented. Ethereum provides a Turing complete programming language e.g. Solidity that allows creating programs and running them on the blockchain. When users send the transactions, the portion of code is executed [8]. The execution of a smart contract occurs when a miner includes a transaction in a block and re-run by every recipient of this block upon arrival. These are open to all other users and once the transactions are completed, they cannot be reversed. In this way, the merits of the blockchain of immutability and cryptographically provided security are further strengthened by the efficacy of smart contracts. Smart Contracts on the Ethereum Network are generally written using the programming language Solidity. This Solidity-based smart contract is compiled using Ethereum Virtual Machine (EVM) bytecode and subsequently executed and deployed on the Ethereum Blockchain [16].

3.4Tokenization: The tokenization of assets refers to the process of issuing a blockchain token (specifically, a security token) that digitally represents a real tradable asset [7]. Tokenization is in many ways similar to the

traditional process of securitization. These security tokens are created through a type of initial coin offering (ICO) sometimes referred to as a security token offering (STO) to distinguish it from other types of ICOs, which can produce different tokens such as equity, utility, or payment tokens. An STO can be used to create a digital representation—a security token—of an asset, meaning that a security token could represent a share in a company, ownership of a piece of real estate, or participation in an investment fund. These security tokens can then be traded on a secondary market. The main benefits of tokenization of assets are:

Liquidity - By tokenizing assets, the tokens can be then traded on a secondary market of the issuer's choice. This access to a broader base of traders increases the liquidity [9].

Faster and cheaper transactions - Because the transaction of tokens is completed with smart contracts, certain parts of the exchange process are automated. This automation can reduce the administrative burden involved in buying and selling, with fewer intermediaries needed, leading to not only faster deal execution but also lower transaction fees.

Transparency - A security token is capable of having the token holder's rights and legal responsibilities embedded directly onto the token, along with an immutable record of ownership. These characteristics promise to add transparency to transactions, allowing you to know with whom you are dealing, what your and their rights are, and who has previously owned this token.
Accessibility - Importantly, tokenization could open up investment in assets to a much wider audience thanks to reduced minimum investment amounts and periods. Tokens are highly divisible, meaning investors can purchase tokens that represent incredibly small percentages of the underlying assets.

3.5 Special Purpose Vehicle:A Special Purpose Vehicle is a separate legal entity created by an organization. The Special Purpose Vehicle is a distinct company with its own assets and liabilities, as well as its own legal status. Usually, a Special Purpose Vehicle is created for a specific objective [3]. Special Purpose Vehicles can be viewed as a method of distributing the risks of an underlying pool of exposures held by the Special Purpose Vehicle and reallocating them to investors who want to take those risks.

This allows investors to be able to invest in those opportunities which would not otherwise exist and provides an additional source of revenue generation for the firm sponsoring the Special Purpose Vehicle. Some of the most common uses of a Special Purpose Vehicle are:

Securitization - Special Purpose Vehicles are the key characteristic of securitization and are commonly used to securitize loans and other receivables.

Asset Transfer - Many assets are either non-transferable or difficult to transfer. By having a Special Purpose Vehicle own a single asset, the Special Purpose Vehicle can be sold as a self-contained package, rather than attempting to split the asset or assign numerous permits to various parties.

Financing - A Special Purpose Vehicle can be used to finance a new venture without increasing the debt burden of the firm sponsoring the Special Purpose Vehicle and without diluting existing shareholders. The sponsor may contribute some of the equity with outside investors providing the remainder

3.6 Legal aspects of Security tokens, Smart Contracts, and Special Purpose Vehicle : The Securities and Exchange Commission (the "SEC") has regulatory authority over the issuance or resale of any ethereum token or other digital asset that has the characteristics of an "investment contract". Under Securities Act § 2(a) (1) and Securities Exchange Act § 3(a)(10), a security includes "an investment contract.". An "investment contract" has been defined by the U.S. Supreme Court as an investment of money in a common enterprise with a reasonable expectation of profits to be derived from the entrepreneurial or managerial efforts of others. On September 11, 2018, the U.S. District Court for the Eastern District of New York held that a digital token can be deemed to be a security under the Howey test [5].

According to the Financial Conduct Authority (FCA) in their Policy Statement 19/22, the security tokens are within the regulatory parameter [4]. This means that firms carrying on specified activities involving security tokens need to ensure that they have the correct permissions and are following the relevant rules and requirements.

To make the smart contract associated with the platform legally binding, we can use the approach as suggested in [12]. The approach involves digitally signing the legal contract by the different entities involved in the transaction. Once the legal contracts have been signed, they are added to an immutable distributed database such as the InterPlanetary File System (IPFS) and the hashes of these legal documents are added to the smart contract. This ensures that the smart contract was legally agreed upon by every party in the transaction and any disputes can be upheld in a court of law.

VIVA-Tech International Journal for Research and Innovation   *Volume 1, Issue 4 (2021)*
ISSN(Online): 2581-7280
VIVA Institute of Technology
9ᵗʰNational Conference onRole of Engineers in Nation Building – 2021 (NCRENB-2021)

The Special Purpose Vehicle owning the asset would be tokenized and the shares of the Special Purpose Vehicle would be distributed to the token holders. The Special Purpose Vehicle is treated as a corporation and is subject to laws pertaining to the respective jurisdictions. A shareholder certificate can be provided to token holders. The token holders will have to comply with the respective KYC/AML norms.

IV.PROPOSED WORKFLOW FOR TOKENIZING REAL ESTATE

The process involves background verification of users (asset owners and investors) and registering them on the platform. Later, a Special Purpose Vehicle is created which holds the title of the asset and is tokenized. The tokens are issued initially through a security token offering and using smart contracts the monthly distribution of the income generated by the asset is done to the investors. These processes are described in detail below:

4.1 Registration of entities:

We propose a common platform where the asset owners can be connected with the investors. Every Real estate owner, as well as the investors, will have to register on the platform. A Know Your Customer (KYC) and Anti Money Laundering (AML) verification for every user registered on the platform would be conducted through a third-party provider. Basic details regarding the User's identity would need to be submitted by the user electronically to the platform. Once the KYC and AML requirements are satisfied, the user can be able to access the services of the platform.
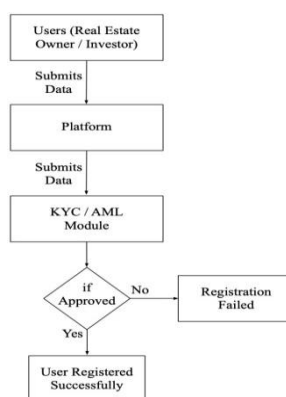

Fig.2. Registration of Users on platform

4.2 Creation of special purpose vehicle:

Once an Owner of the property is registered, he/she can now submit the necessary documents and paperwork in accordance with the local jurisdiction. A Special Purpose Vehicle is created. The Special Purpose Vehicle would serve as the legal owner of a real estate. Also, the Special Purpose Vehicle would be responsible for the operation of the real estate or, in general, the underlying assets. These operations can be the functioning of a hotel or renting the property for commercial purposes. It is the Special Purpose Vehicle that would be responsible to verify the documents with the concerned authorities. The Special Purpose Vehicle is only created upon successful verification of the paperwork. In case of any inconsistency with either the information of the asset or the Special Purpose Vehicle, the entire deal is called off, on grounds of not complying with legal formalities. The reason for opting for a Special Purpose Vehicle instead of direct tokenization of an asset is that in most countries, directly tokenizing the underlying asset is not possible due to the lack of legal and technical frameworks for enabling the tokenization of property rights [15].

4.3 Tokenization and smart contract:

Once everything is verified, the Special Purpose Vehicle is successfully created and the process of tokenization can be proceeded with. It is the Special Purpose Vehicle and not the underlying asset which would be tokenized. The tokens generated would represent shares of the Special Purpose Vehicle. It means that every token holder would have some percentage of ownership in the Special Purpose Vehicle based on the number of tokens they hold. From the legal perspective, the ownership of these Security Tokens is guaranteed owing to an Special Purpose Vehicle that we establish for each of our clients. The Security Tokens issued are an economic right to share the profits of the Special Purpose Vehicle.

It is at this stage that the crypto tokens are actually minted on the Ethereum blockchain of ERC 777 standard. These security tokens, which are blockchain native, are now a representation of the fractional ownership of the Special Purpose Vehicle and by extension the asset. Subsequently, these tokens must be embedded with subjected regulation on a Smart Contract. The underlying Smart Contract would contain the entire business

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ISSN(Online): 2581-7280
VIVA Institute of Technology
9ᵗʰNational Conference onRole of Engineers in Nation Building – 2021 (NCRENB-2021)

logic of transfer of ownership and validating the users and transactions. Moreover, the use of a Smart Contract can be further extended to incorporate additional features of the token.

4.4 Security token offering (sto) / initial coin offering (ico) :

Once the Special Purpose Vehicle has been tokenized, the tokenized securities will be issued to the investors through a Security Token Offering. Unlike the tokens issued through an ICO, Security tokens are backed by an asset. Hence, the tokens of Special Purpose Vehicle would be issued through an STO. The asset would be listed on the platform. Target price and the number of tokens would be set based on the value of the asset. The registered user will be able to
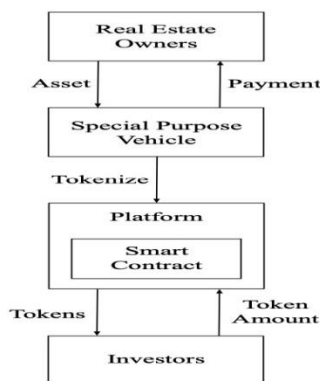

Fig.3.Tokenization of Real Estate

view all the asset features such as the location, cost, expected returns and other details of the asset on the platform. Once the user decides to purchase the token of the given asset, they will pay the required amount based on the number of tokens purchased.If the STO is successful, which means if the STO is able to raise the required target amount of funds, the investors will receive their corresponding tokens and the asset title would transfer in the name of the Special Purpose Vehicle offline. Whereas, if the STO is not successful and is unable to raise the required amount necessary to purchase the asset, the amount paid by the existing investors would be refunded and the title ownership would still lie in the name of the original asset owner.Once the investors have received their tokens, they would be able to benefit from the monthly returns of the tokens as well as from the capital appreciation due to the rise in token value. Since the implemented token is based on Ethereum and is of the ERC 777 standard, the investors can also freely sell these tokens in the secondary market via different exchanges where the tokens can be traded. This ability of trading the tokens ensures liquidity to the investors.

4.5 Distribution of dividends to the investors:

As discussed earlier, the real estate can be used for various purposes. It could be rented for commercial or residential purposes or it could be a hotel business. In any case, revenue can be generated from the asset. The profits can be distributed to the investors in the proportion of the number of tokens they own. This system can be automated and efficiently implemented using a smart contract. The smart contract can have the functionality of calculating the percentage of ownership and smoothly transfer the proportion of profits to the investor without any scope for frauds or discrepancies. Along with functionality for dividends' distribution, additional features for voting of investors in case of any decision taking can also be implemented.
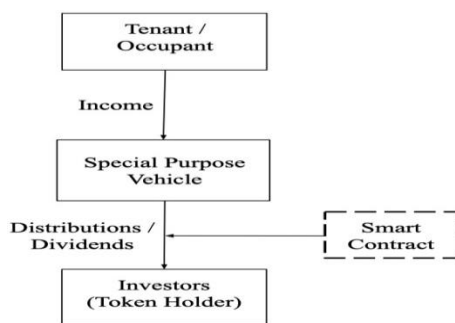

Fig.4. Distribution of dividends to Investors

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V.IMPLEMENTATION ARCHITECTURE OF THE PROPOSED SYSTEM

The platform will be based on the ethereum blockchain which allows us to use smart contracts. The security tokens which are backed by the shares of the Special Purpose Vehicle will be embedded in the smart contract. The tokens will follow the ERC 777 standard protocols. ERC 777 standard defines a common list of rules which all ethereum tokens must adhere to.

ERC 777 defines 13 different functions for the benefit of other tokens within the Ethereum system. The Thirteen functions defined by the ERC 777 are:

- – name() - This function returns the name of the token in string format
- – symbol() - This function returns the symbol of the token in string format
- – totalSupply() - This function identifies the total number of tokens created
- – balanceOf() - The balanceOf function returns the number of tokens that a particular address, in this case, the contract owner, has in their account.
- – granularity() - This function gets the smallest part of the token that's not divisible.The granularity is the smallest amount of tokens (in the internal denomination) which may be minted, sent or burned at any time.
- – defaultOperators() - It gets the list of default operators as defined by the token contract
- – isOperatorFor() - This function indicates whether the operator address is an operator of the holder address.
- – authorizeOperator() - This function sets a third party operator address as an operator of the sender to send and burn tokens on its behalf.
- – revokeOperator() - This function removes the right of the operator address to be an operator send and burn tokens on its behalf.
- – send() - This function sends the amount of tokens from the address of the sender to the address of the recipient.
- – operatorSend() - This function sends the given amount of tokens on behalf of the address of sender to the receiver.

Altogether, this set of functions and signals ensures that Ethereum tokens of different types will uniformly perform in any place within the Ethereum system. As such, nearly all of the digital wallets which support the ether currency also support ERC 777 compliant tokens. Following the ERC 777 standard for the tokens would allow the tokens to be listed and traded in numerous secondary market exchanges that are compatible with ERC 777 tokens.

Algorithm 1 Transfer Tokens

Input: recipient address tokens

function *transfer*:

1: **if** (recipient address 6= stakeholder **or**

Balance of *msg.sender* <tokens) **then**

2:     Abort session

3: **else**

4:     Debit tokens from account of *msg.sender*

5:     Credit tokens to account of recipient address

6: Emit tokens is transferred from *msg.sender* to recipient address

7: **end if**

On top of these above listed six functions, a function for Asset income distribution is also implemented in the smart contract. The algorithm takes as input the accumulated wealth which denotes the income accumulated by the Special Purpose Vehicle over the years and the income which denotes the income of the Special Purpose Vehicle during the current month. The algorithm is invoked by the Special Purpose Vehicle at the end of each month. The algorithm first verifies whether the account which invoked the contract is the Special Purpose Vehicle. Then for every token holder it calculates the proportion of tokens that the token holder owns and calculates the dividend distributed to them accordingly. The contract then credits the dividend into each token holders account. A transaction is emitted to the blockchain stating the respective dividend has been credited in the Tokenholder's account.

Algorithm 2 Distribution of Dividends

Input: accumulated –wealth

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9ᵗʰNational Conference onRole of Engineers in Nation Building – 2021 (NCRENB-2021)

income

function *distribute*:

1: **if** (*msg.sender* 6= Special Purpose Vehicle) **then**

2:      Abort session

3: **else**

4:      **for** every token holder **do**

5:      Calculate Percentage of ownership (percent own)

6:      dividend = income * percent own

7:      accumulated wealth - dividend

8:      Balance of token holder = Balance of token holder + dividend

9:      **end for**

10:     Emit dividends distributed to token holders

11: **end if**

VI. CONCLUSION

In this paper, we present an approach to introduce liquidity in a real estate investment by leveraging the use of Blockchain technology. We have used a Special Purpose Vehicle for the purpose of holding the underlying asset. Special Purpose Vehicle is tokenized and is providing the investors the flexibility to purchase ERC 777 standard security tokens as per their convenience. A Smart Contract is developed for the transfer of tokens and also an automated solution for distribution of dividends is implemented.

The future directions for this work focus on using a Decentralized Autonomous Organization (DAO) instead of a Special Purpose Vehicle to further improve decentralization. We can also provide functionality for additional features like voting and loyalty rewards for token holders. Moreover, each token can also be structured to represent ownership in the Special Purpose Vehicle which not only owns a single asset but holds the title for multiple assets belonging to the same class. For example, tokens can be made to represent shares of a Special Purpose Vehicle which holds two or more assets.

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