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Evaluating the Performance of Blockchain-Based Land Registration Management Using Hyperledger Caliper

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Abstract: ***The land is a fixed property. Finding the details of property and involvement of third-party is a challenging task. Fraudsters may forge documents and mislead thepurchaser and if it's a disputed land it takes many years in the court battle, a waste of time and resources. Problems escalate in this current land registration process which is notclear. Such calls were made to integrate technologies and lead to the growth of blockchain technology. Blockchain isa decentralized and transparent ledger. The smart contract is an empirical and permanent document between two parties. This proposed model is used to develop a land registration application system in which the new buyer has to register and continue with the further process. The proposed research work is implemented using the SHA256algorithm which provides unique hash values for the messages getting stored in blocks and Ethereum blockchaintechnology is used to store both smart contract and transaction details.***
Keywords: Decentralized, Ethereum Blockchain, Land Registration Management, Smart, Contract, SHA Algorithm.

I. INTRODUCTION

Blockchain technology is productive, it had significant growth from the past few years. Blockchain technology canbe widely used in multiple regions finance, land registry, sensor networks, and IoT [2]. It is originated from the kernel of the component Bitcoins. Currently, individuals have to carry hard cash or need to do the online transfer which may lead to transaction frauds if a single digit in theaccount number is misplaced. Since a huge amount of data is being exchanged, providing security will be an increased task. This may lead to distrust, corruption, hacking of data,insecurity, and deceit. Such demands made to integrate technologies and lead to the opening out of blockchain technology. The key to solving these problems using blockchain technology is by encrypting the information andthus storing it in distributed ledger or data which is decentralized and provides transparency of information [3].In Blockchain Technology, a digital currency called Bitcoins or Cryptocurrency is used for transactions. Due tothe advance of digital currency security can be achieved in financial transactions. These technologies and techniques are centralized and owned by authorities. Every country follows its government rules, to transfer the land or propertyto other individuals. These days' frauds are more inland registration because tracking the details of property like who owns the property, rate of the land, single owned or multi-owned property, and does it have any wrangle issues are difficult tasks. And more importantly, the third party is involved where they may quote a high price or else time- delay in the registration process [3]. So, to avoid all issues or frauds we are implementing a land registry platform by using blockchain technology [3]. On this note, a concept called smart contract is used in blockchain technology which is a self-agreement encapsulated code in a system. This code contains a certain set of rules to be followed by the involved individuals in the land registration process and further procedure will be continued if smart contract conditions are met. This smart contract will be automatically activated if conditions specified in the contract are met. This will help to stamp outthe need for a third-party person and the registration process will be faster and more efficient. Thus, a smart contract is placed in a decentralized server. By decentralizing, these contracts are not controlled by anyparty, but they will be distributed in a shared database run by many systems. Thus, none of them will have control overthe data, which means it is near impossible to hack it [3]. Suppose the hacker need to misuse the data they need to attack blockchain blocks or smart contract block where it isstored. To get that information they need to access more than half nodes to get information. Smart contracts will thenrun securely and instantly, without anyone being able to modify them. Along with a smart contract, Ethereum is also used becausetransactions that occurred as bitcoins details have to be stored securely [4]. So, these documents are also stored in Ethereum blocks where the smart contract is also stored. Since this is also stored in the decentralized server, security is achieved for the transaction. Ethereum based smart contract is developed using the solidity programming language. SHA256 hash algorithm is used to generate unique hash values for each block where all bitcoins transaction details and smart contract is stored.

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II. RELATED WORKS

Various blockchain implementations in the field of land registry have been reviewed. Majority of implementations are either in initial or development stage. Some of them have been in pilot testing phase. This section presents a brief discussion of the existing blockchain implementation projects in the field of land registry. Thakur conducted a comprehensive study about existing land records management system of India, how it can adopt Blockchain technology to improve the current system and possible questions that need to be addressed to move in that direction. They provide a model of Blockchain-based land titling system for India but fall short of describing the smartcontract scenarios, public key infrastructure (PKI) and typeof architecture (i.e., public, private, hybrid) to be adopted toimplement that. As recommended by the authors of Graglia and Mellon, 2018, it is not practical to move an old model to Blockchain without laying out an incremental policy forreal-life adoption [11].

In Mukne authors present another land title managementsystem for India using permissioned Blockchain such as Hyperledger Fabric and store documents using Inter Planetary File System (IPFS). The authors mention that the biggest challenge is to move existing land records to the Blockchain system [14]. In Hasan and Salah, authors present an Ethereum based digital asset (e.g., file, book,image, video, or music) exchange system with a proof-of-delivery mechanism using a viable PKI model. In thispaper, the authors present implementation details and algorithm models to reproduce the proposed system [13]. When we look at the examples of the Blockchain-basedland registration, it is seen that the applications in Brazil,Honduras, and Sweden come to the fore. US-based Blockchain technology company Factom has developed a Blockchain-based land registration solution for Honduras.Honduras' application is the first application to use Blockchain technology for land registration. The mainreason why the Honduran government wanted to switch to a Blockchain based land registration system was that it wanted to prevent irregularities in the land registration. For this reason, they made a radical decision and agreed with Factom to implement a Blockchain-based system. Thesystem was operated for 3 months starting from November2015.

Brazil, which carries out the ownership transfer in 13 steps, is another country that has switched to the Blockchain- based land registration system. In addition to reducing costsand irregularities, the Brazilian government decided to use Blockchain technology to ensure accuracy, transparency, traceability and high security in transactions, and a solution developed by Ubitquity was put into use in Rio Grande do Sul Province in May 2017. When the data obtained as a result of the system, which was operated for a period of 3 months, was evaluated, it was seen that the errors in the recording system decreased and an important convenience was obtained in archiving [15].

Almost all of the authors talk about how blockchain-based land registration management or land titling management system model was developed in other to reduce the requirednumber of physical documents, necessary steps, and overallexpenses, while others like Georgia try to implement blockchain-based model to reduce corruption and mismanagement for their land ownership registries. Furthermore, all the models are based on different countries land registration system. However, most of the models considered the smart contract scenarios, mode of payment for land purchases to be made either in full or partial, publickey infrastructure (PKI) and the types of architecture open permissioned, permissioned blockchain, consortium or hybrid), to be adopted for implementation.

A. Current Challenges

These days fraud is accomplished in any transaction. Tracking the details of property like who owns the property, rate of the land, single owned or multi-owned property, does it have any dispute issues are all difficult tasks. The challenges that are existing in the present land registry are [9]

1) *The Increasing Number of Fraud Cases:* There have been several cases of imposters posing as the seller of a property. If an imposter successfully pretends as a property owner, they may receive the full amount after completion and escape with the funds. In many of the cases, both sellers and buyers were unaware of the fraud until discoveredby the land registry as part of a spot check exercise.
2) *Time Delays:* It may take several months to complete the land registration. Suppose if the landhas any litigated issues, then that leads to a court battle between parties.
3) *Traceability:* In some countries, through paper documents, you can only know the current owner.It does not allow us to find out who else owned that land before.
4) *Human error/Intervention:* Currently, updates to the land registry records are made manually and the accuracy of those changes depends on a particular individual. It means that the land registry is more vulnerable to human errors. Human intervention can increase the chances of errors in the land registry system.

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III. METHODOLOGY

The purpose of the implementation of this methodology is to avoid fraudulence in land registration and to secure theirtransaction details. The main problem in the existing systemis purchaser did not use to get the actual property details dueto imposters. So here we are using Ethereum blockchain technology which is transparent, immutable, and decentralized [3]. In the blockchain, we arecreating a land registry platform where all the details of theproperty which are earlier registered will be stored on a decentralized database, which is transparent, so any individuals who wish to purchase a property can cross- verify the complete details of the property. Details of each land will be stored in the form of a block and a digital title will also be given to make search efficient, where for each block a unique hash value will be assigned by using the SHA256 algorithm. Searchers can search the property withdigital titles in that land registry platform. The overview ofthe model is shown in Figure.1

Suppose the property is already registered and owned by a particular owner, those details will be stored in the registry platform means a decentralized database by the land administration person, and it is placed in the form of blocksin the blockchain. Thus, the admin gives a created land ID to the owner so that a particular owner can access the details of the property [9]. Furthermore, Hyperledger Caliper, a blockchain benchmark tool has been used to measure the performance of our Blockchain-based land registration management system using the following performance evaluation metrics: Throughput, Execution Time and Latency.

A. The System Architecture

The architecture of an application defines how logically connected. Here the design principles of layered architecture are adopted which are used to design effective implementation deployment of the blockchain applications and the smart contracts scenarios. Blockchain is a decentralized distributed ledger the application layer iscomprised of smart contracts, chain code, and DApps where transactions are arranged in blocks, and placed in a Peer-to-peer network the other layers. Ensures that nodes can discover each other and can communicate, propagate and synchronize with each other to maintain the valid current state of the blockchain network.

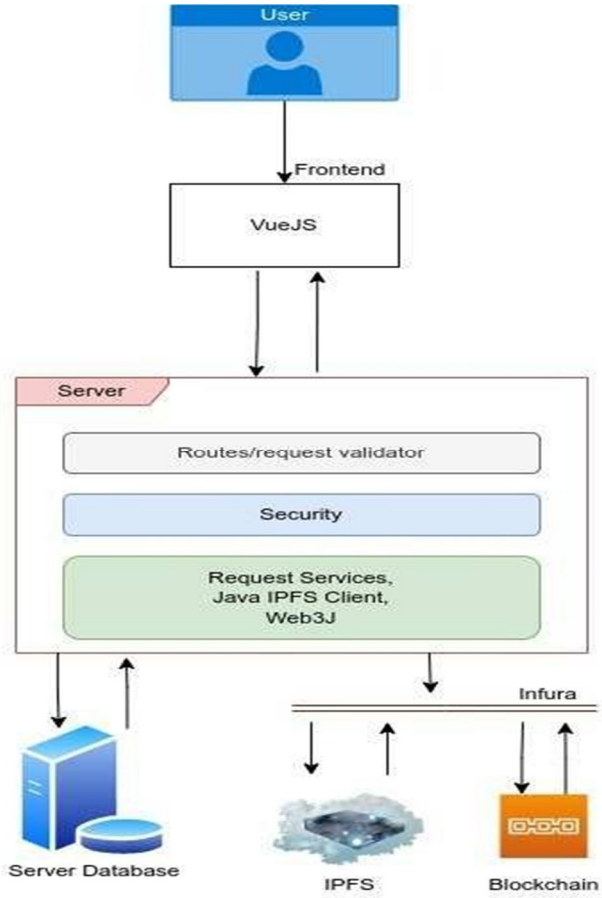


Figure 1 Architecture of the prototype

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Figure 1. shows how the user interacts with the system using the frontend (built with VueJS) by sending requests to the server. Server The routes/request validators check and validate URLs and requests. The security layer checks and verifies whether the client (user) should have access tothe resource or not. The last layer performs the request's operation. It uses the Java IPFS client to store and retrieve files on IPFS through an IPFS and Ethereum service provider (Infura). Similarly, it uses the Web3J Java library to perform the transaction on Ethereum through Infura.

B. Land Registration ManagementSystem Model

Figure 2. Show the smart contract to be used for the land purchasing process. The buyer has to register and login intothe system, and search for the registered land for sale alongwith the seller's address and phone number to contact with the buyer and the seller must agree to each other's terms and conditions in real life and should settle for a price. If the buyer can pay the total amount and registration fee at the registration time then the process will continue. Otherwise, they set a pledge for partial payment and set a date to complete the pending balance. They should communicate with the land office after setting the price.

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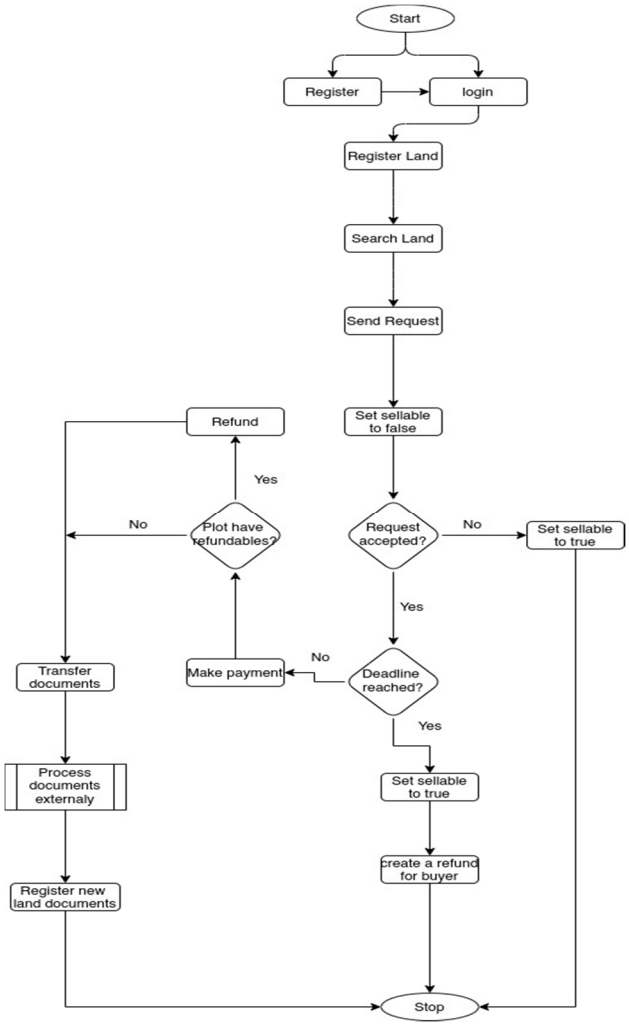


Figure 2. Blockchain-based land registration managementsystem model

The land office verifies the documents related to the property. If the seller has legal ownership, the land office logs into their account and creates an agreement with the pledge and the rest of the money (convert automatically to land currency) with two different dates since the buyer can'tcomplete a full transaction at a time. If he/she can pay the total amount at a time then the pledge is set to zero and therest of the amount will be set to the price amount with the date.

The seller has to agree to the pledge through his/her account. When he agrees to the pledge, the property'ssellable field will be set to False and it can't be sold while this agreement is alive. If the buyer accepts the pledge, he/she has to pay the amount within the fixed date.

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To pay for this money, he/she has to go to the land office and buy the land currency. When this currency is paid to theseller, the seller can't cash that until the total price of the land is paid. This currency is kept secured in Government Land Purchasing Account against the agreement which is the 3rd wallet account. If the buyer failed to pay the pledgemoney during the given time frame, the sellable field of theland will be set to True and the agreement will be void.

When the buyer completes the pledge, a new contract is created with the rest of the money and a new date, and the registration process restarts. Later ownership of the land is handed over with the new agreement. Otherwise, pledge money will be redeposited to the buyer's account and buyable property will be reset to True.

Whenever a blockchain is incorporated into a newblockchain transaction or some new block is added to the blockchain means several nodes are required to execute algorithms to evaluate, verify, and process the blockchain context within the same blockchain implementation. The new block of blockchain transactions will be accepted intothe ledger when most nodes authenticate the block's historyand signature, and the new block with data will be added tothe database. If a consensus is not achieved, they refuse to add the block to the blockchain. This distributed consensusmodel allows blockchain to operate as a distributed ledger,without any central or unifying authority having to authorize blockchain transactions. So, the transaction is highly secure in the blockchain [9].

Below is the registration page from the platform where usercan register his/her self into the platform

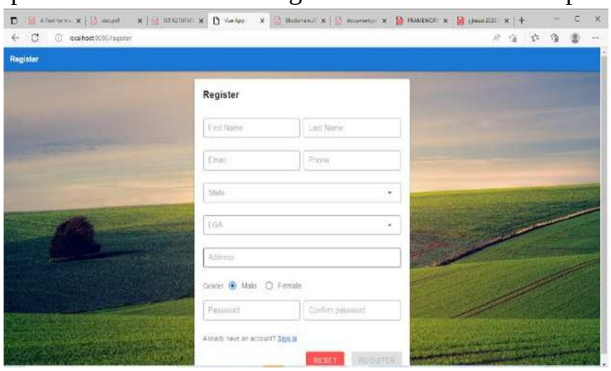


Figure 3. show the registration page on the blockchainplatform

A new buyer who wishes to purchase land has to register themselves for the land registry platform, by providing complete information that has been mentioned in the form.After successful registration particular ID will be given to the new user, as referred to in Figure 3.

IV. RESULT

A. *Performance Evaluation Metrics*

Implementation is done using Hyperledger Fabric consisting of four peers and used Hyperledger Caliper, blockchain benchmark tool to evaluate the performance of our Blockchain-based land registration management system. Hyperledger Caliper enables users to test blockchain solutions with predefined use cases and get performance indicators such as Execution Time, throughput, latency. Table 1. below give the details of the parameter used for evaluation.

B. *Parameters for evaluation in Hyperledger Caliper*

Table 1. Parameters for evaluation in Hyperledger Caliper

S/N	Transaction type	£Transactions	Block size	Arrival rates
1.	Insert	100	10	20 – 110tps
2.	query	100	10	3 – 11 tps

1) Evaluation Metrics

a) Average Latency: Transaction latency is defined as, time taken by a transaction to get added in Blockchain.

b) Throughput: Rate at which the valid transactions committed into the Blockchain.

c) Execution Time: Time taken to commit all thetransactions in the Blockchain.

Transactions done in the blockchain network is classified under two categories,

a) Insert transaction

b) Query transaction.

In the Hyperledger Caliper tool, transactions are committed to the blockchain network in batch, and there exists an optimal throughput for every blockchain network. If the arrival rate of the transactions lesser than the optimal throughput, each transaction waits less time in the networkto get it confirmed, thereby decreasing the latency time. In the same way, if the arrival rate of the transactions higher than the optimal throughput, each transaction stays a long time in the network queue and so increase in latency time. Experiments were conducted on two categories of transactions to understand the impact of arrival rate on optimal throughput of the blockchain network. Experimentfor insert transaction: For Insert transactions, we kept a number of transactions to 100, with a block size of 10 and arrival rate from 3 to 11 transactions per second(tps). Figure4 shows the impact of arrival rate on evaluation metrics forinsert transaction. We have observed that the latency decreases until the arrival rate of transactions reaches the optimal throughput (80tps). After that, the latency tends to increase. Moreover, execution time decreases till optimal throughput but increases beyond it.

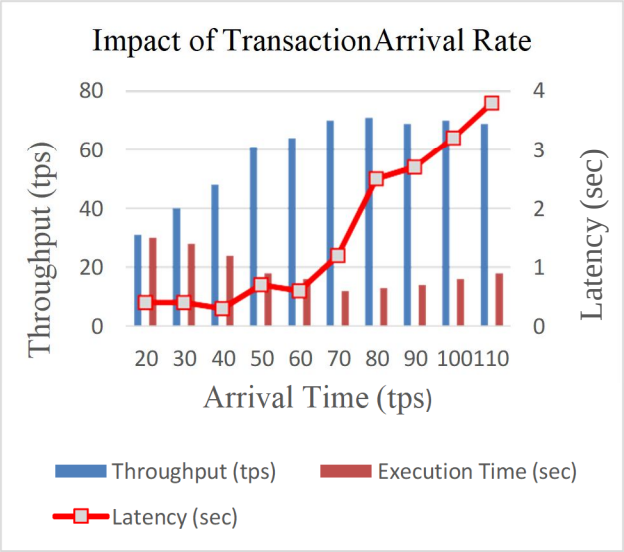


Fig. 4. Impact of arrival rate on evaluation metrics forinsert transaction

Experiment for query transaction: In query transactions, each transaction does the search operation in CouchDB andhave a higher number of operations when compared to insert transaction. For query transactions, we kept #no of ledger transactions to 100, with a block size of 10 and arrival rate from 3 to 11 transactions per sections (tps). Figure 3 shows the impact of arrival rate on evaluation metrics for insert transaction and observed that the optimalthroughput for query transactions is 7tps. It is flimsy whencompared to the optimal throughput (80tps) for insert transactions as the query transaction takes time to search entire ledger as shown in figure 5.

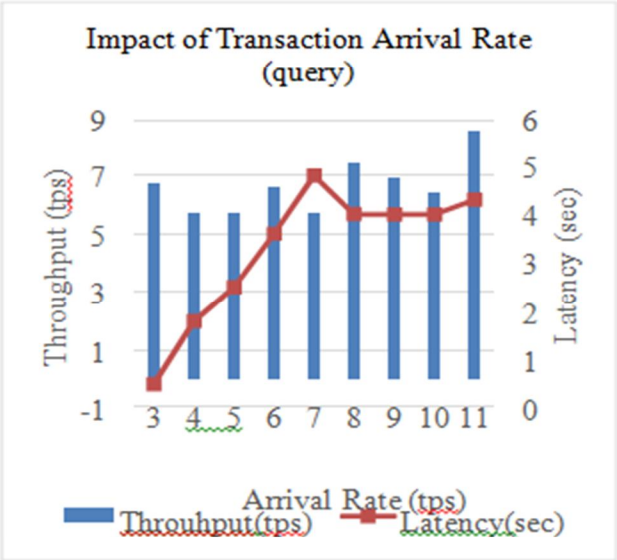


Fig. 5. Impact of arrival rate on evaluation metrics forquery transaction

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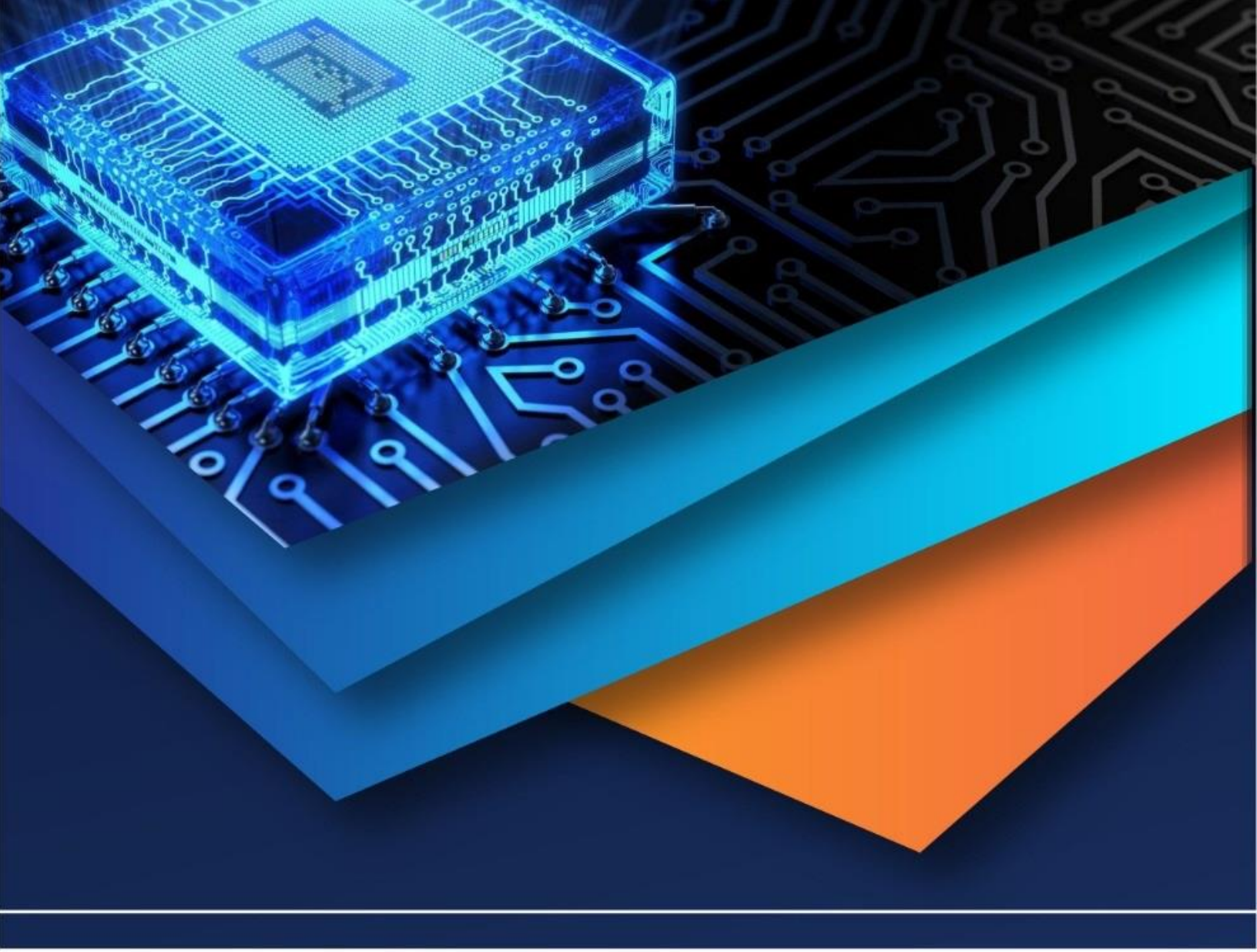
V. CONCLUSION

With the use of smart contracts in blockchain technology, worldwide transactions are occurred in a more secure viewpoint, because all transaction details are stored in the decentralized server, which means the data is stored in multiple nodes, where misuse of information is nearly impossible. Ethereum block is used to store all transactionsdetails which occurred in the form of bitcoins and also smart contracts. Third-party involvement is completed avoided and there will be no forged documents since the administrator is going to upload all registered documents. A registered buyer can easily know the complete information of the property if the land has any litigate issues, so frauds occurring can be avoided and security is achieved.

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