Secured Data Storage Framework for Land Registration using Blockchain Technology

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***Abstract*—Land registration requires a complex of sensitive data that requires a decentralized environment. Current technology only concentrates on the less secure database storage and expose to any misconduct. This is due to the characteristics of the database, which still has some problems with unstructured data and non-relational databases. As the land registration methods require complexities and challenges in terms of land tenure security at a high-risk scale, the security level of the land registration system needs to be put at the highest level. Fraud is one the major problem which is currently a severe problem in the land registration methods. Also, the land registration process takes a long duration of time to complete. The land title indicates that the land is confirmed and already registered to an owner. The reason for ownership is to perceive property rights, which incorporates data relating to land region, area, limits, just as proprietorship and title of the ardent property. However, the land is registered, but still, there are lots of causes of fraud happened in which land registration data can be quickly deleted and or edited. Since land is an asset, and any fraud can cause a loss in a lot of money, it becomes very crucial that the registration of land becomes speedy, transparent, and with less hustle. In this research, we propose a framework for secure data storage of land registration using Blockchain. Blockchain offers the solution with its underlying technology. Blockchain is decentralized, transparent, and fast compared to the traditional centralized software approach. For the validation of the proposed framework, we performed a comparison between the proposed and existing methods.**

Keywords—land registration, blockchain, land fraud

I. Introduction

Land registration and transfer are some of the critical areas of a government. It keeps track of the land, in the events of land creation or transfer of ownership of the land, from one party to another. Since land is an asset, and any fraud can cause a loss of a lot of money, it becomes very crucial that the registration of land becomes speedy, transparent, and with less hustle. Blockchain offers the solution with its underlying technology. Blockchain is decentralized, transparent, and fast compared to the traditional software approach. Beginning with David Chaum's work [1], decades of research have been devoted to the value of the digital currency. However, this did not make them commercially successful. The birth of Bitcoin brought it to the mainstream. Bitcoin put blockchain technology on the world map. Once the general public started treating bitcoin as a value, it became evident that there is a possibility of circumventing the institutions which control the money: the institutions or central finance gatekeepers. The inherent trust in the public ledger helped increase the use and confidence between people and the digitalization of money. The arrival of Bitcoin, proposal for cryptocurrency and digital cash has been recognized without the participation of banks. Since the appearance of Bitcoin in 2008 [2], Blockchain as its foundation and core structure has initiated a new research boom. Blockchain has the advantages of cost reduction, efficiency improvement, and risk reduction. The discovery of blockchain technology has seen the adoption of cryptography-related technologies at the technical level. Therefore, it has received extensive attention from various industries.

People took cryptocurrencies as the only use case of the public ledge in the early phase due to bitcoin [3], [4], as the technology became available in the public domain as open-source, people started expanding on the idea, and implementation of new use cases began. One such use case is e-governance systems among other public domain sectors [5], [6]. Our thesis will focus on the problem of land records which is a sub-problem of e-governance. In the latest research report "China blockchain technology market overview" [7], Frost's Sullivan believes that blockchain technology, which will enter the Chinese market, will snowball and break the existing financial architecture. By 2025, blockchain technology will help banks and other financial industries save nearly 30 billion in funds.

At present, many have begun to develop application systems based on blockchain [8], but they lack sufficient attention to security issues. They have been highly secure, but there are still weak links in the privacy and security of the entire blockchain network. The research directions for blockchain security at home and abroad are also varied. Because Blockchain uses private key encryption and decentralized structures, most of the research is focused on securing data and facilitating people's management. With the continuous development of technology, we must consider security problems. A complete information security system can ensure the constant progress of technology and avoid the disclosure of personal and enterprise secret information.

II. Literature Review

The government of the countries is responsible for the improvement of social, physical, spatial, and economic inequality in their respective country, for this very reason they have some land policy and land planning systems [9]. National

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development plans usually involve local, state, and regional level plans, which are defined, directed by the land polices. Land policies are the backbone and provide a framework for all the developmental work in the ground. The Malaysian government supervises the land policies which are enforced by a broader framework [10]. National Land Code (NLC) has been the basis of implementation for some of the land policies. Sabah uses the Sabah Land Ordinance of 1930. Sarawak uses Sarawak Land Code 1958, but Peninsular Malaysia and Federal Territory of Labuan adopted the National Land Code 1965. It was adopted on 1st January 1966 to administer all matters related to land. The purpose of NLC is to unify and standardize the process and procedure of land registration, land sale, land purchase, the fees, charges, rent, lease, evaluation, and other rights and interests of the land. Due to the increasing land development and other various necessities for protecting the interests of owners, the land administration is under heavy demand. To study and understand the land registration system, we have focused on the systems in Pakistan and Malaysia. In Pakistan, the method of land registration is still manual. The government issues land registries. When a person wants to buy or sell the land, the buyer and seller write all necessary details in an agreement to sell or a stamp paper, as shown in Figure 1.

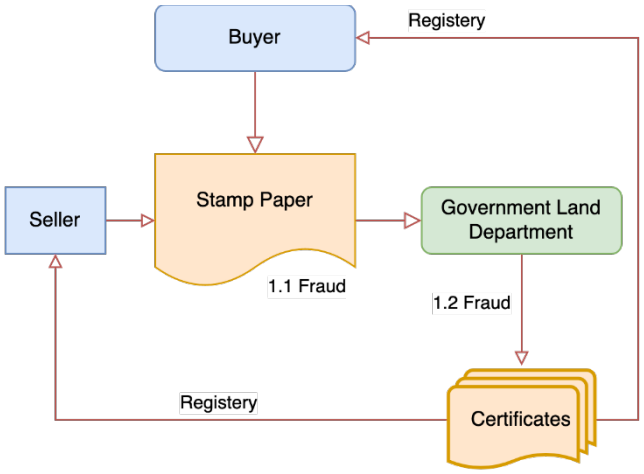

Fig. 1. The land registration process in Pakistan.

The address of current residency, the NIC (National Identification Card) number of both parties. The details of the land which is being bought/sold. Also, it includes the clause of not only ownership but also a passion for the property. It also has the amount to which both parties agree to sell the property. Once the parties reach an agreement, the stamp paper is signed by both parties, which includes two witnesses, their NICs, address, and signs. The contract is then sent to the Deputy commissioner's office. The commissioner's signed copy of the agreement is then taken to the revenue department clerk called Patwari(under the department of revenue). Patwari role is to make the entry to revenue department register.

The land registration process in Malaysia is different as compared to Pakistan. As shown in Figure 2, there are two stages of land registration, one is the processing stage in which all the documents goes through processing for validation, and after the verification, the next step is, land transfer in which the land officer transfers land.

Land registration requires a complex of sensitive data that requires a decentralized environment. Current technology only concentrates on the less secure database storage and expose to any misconduct. This is due to the characteristics of the database, which still has some problems with unstructured data and non-relational databases. As the land registration methods require complexities and challenges in terms of land tenure security at a high-risk scale, the security level of the land registration system needs to be put at the highest level. Fraud is one the major problem which is currently a severe problem in the land registration methods. Also, the land registration process takes a long duration of time to complete. This is due to the centralized transaction system, which resulted in bottlenecks at the processing system.

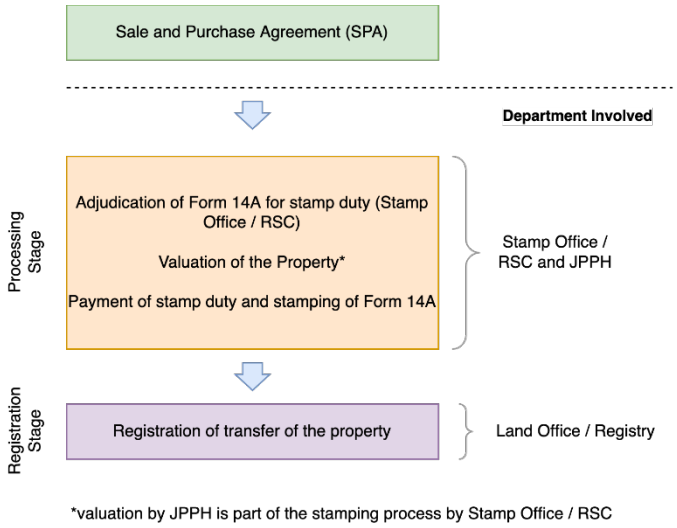

Fig. 2. The land registration process in Malaysia.

Blockchain technology can create public ledgers from all complex transactions that have a high potential to replace the complicated systems with one simple database. Consequently, the security system will be easy to manage. Even though we can see that blockchain technology has a great potential for the land registration process, the fundamental aspects, especially in term of technical challenges, needs to be addressed. This is primarily for the land registration system which is currently facing significant issues such as a lengthy registration process, identifying a parcel or lot of land, and determining the ownership interest.

The problems faced by the land registration are land title registration, serial number to the corresponding parcel of land, location, boundaries, and other land's details such a freehold, leasehold, period of years, caveat, easements, and encumbrances. Furthermore, land registration still exposes to fraud, alteration, and inequitable. Therefore, the need to identify the model of blockchain technology for land registration is essential. Also, we need to make the foundation of the blockchain technology for the land registration system.

A. Security of Land Records

Despite various existing land registration methods used to maintain the data of land registration, and land transfer, there is still minimal study that controls the fraud cases in land registration and transfer. Currently, the government is using traditional RDBMS to manage land records. It requires the whole hierarchy of software, software engineers, and administrative staff to keep up with the management of the data. It is costly and requires a lot of technical knowledge to upgrade or to make changes.

1) Centralized Architecture

The critical thing to consider is that all these transitions mentioned, work under traditional centralized databases. In any centralized database, the architecture is similar to a hierarchical pyramid where people up the chain are in a position to abuse power—these kinds of attack, in general, are called as an Insider Attack. In information security, insider attacks pose a more significant problem. As an insider, the traditional methods of detection are effortless to fail. There is a well-known argument that is using proper logging mechanisms; the system can detect insider attacks. We believe that even with the logging mechanisms in a centralized structure, any employee with admin privileges can attack the system and even corrupt the logging mechanism. This way, it will make him/her untraceable.

2) The Integrity of Data

The integrity of data refers to the consistency, accuracy, and completeness of data; it is the assurance that the data we are accessing is attributable, legible, contemporaneously recorded, original, and accurate. More often than not in traditional centralized database systems, the integrity of data is usually not maintained, i.e. we don't have the absolute certainty that the information shown on the application is, in fact, the original data.

3) Trust in Cross-organizational Work

We have seen that in a property transfer, many departments are involved. They work on this shared data, for example in mutation proceedings of a property. One department does the verification of sale deed procured, which is the responsibility of another department before moving to the next process. Each department works independently from another. Lack of sharing data among different departments results in asynchronous data. The organizations suffer from the lack of trust due to the inconsistency in data present in various departments.

4) Public Verifiability

The digitization of public records does not solve the out of sync data or problem, even after they are stored. The out of sync data is partly because the current system is prone to insider attacks or due to the lack of trust between the parties involved. Due to these discrepancies, the buyer has to go back to several decades of documents to verify the property titles, and such a process is highly inefficient.

Then we have the following problem which is general and can occur in or outside of the system

Fraud by forgery which comprises of Forging of Transfer Form (i.e. Form 14A) or Charge Form (i.e. Form 16A/B):

- Forging of Signature
- Registering Dealings Using Power of Attorney
- Fraud by the solicitors at the different authority level

Using Court Order to Register Dealings in Favour of Prospective Title or Interest Holders Without Verification of Validity:

- The validity of Court Order
- Forging of signature or the power of attorney
- Fraud by Misrepresentation

Presentation and Collection of Conveyancing Instruments by Unauthorized Persons:

- Fraud by False identity or imposter
- Fraud by Alteration
- Fraud by Land office administrator
- Fraud by System Administrator
- Fraud by Hackers Who Compromise Network and System

B. Current Business Process of Land Registration

Currently developed or proposed systems of land registration vary from one country to another, and thus the majority of the descriptive literature directs the attention of the domestic reader. The emphasis of most literature is on the systems developed locally or nationally, and they produce literature in their local language. The literature gives some focus to some general ideas on land registration, including short descriptions of some main classifications. In several countries, the laws made in the 19th century under the geographic-political (colonial rule) still provide the basis of the system of land registration, even though the conditions of the past have changed quite radically since that time. The methods developed in these countries not only share the basis, but these countries also have common official languages. Important groups can be divided into the Spanish (and Portuguese) speaking countries, the French-speaking countries, and the British Commonwealth. There is an exception, more recently the countries with territories that belonged to Habsburg's Austro-Hungarian Empire have common laws or same regulations regarding land registration (even though they do not have a common language). Since the majority of the countries of the world have been under British rule at some point in history, this is the reason the majority of the countries will find their essential land registration being the same. Native English speaking experts have the upper hand in the field. There are relatively more, and for them to study a lot of countries' systems becomes relatively easy. Besides, English is the most used academic language in the world as well. Unfortunately, some of these British authors or their opinions seem not to ignore other types of systems, and the practices outside of their design. However, the situation has improved in the 1990s. Even if they become informed about different types of systems, they often map the terms to the English common law terminology. Even within the Anglo Saxon world, there is a great diversity in legal traditions and vocabularies, especially between Great Britain and the United States.

Many attempts at computerization have been mostly unsuccessful. [Toaha and Khan, 2008] propose a system that intends to digitize all the steps, from cadastral surveying to creating new database records. The satellite images of Google Earth software that are available for the public would greatly assist cadastral surveys. Diverse issues ranging from security of data to access and data entry. The proposed system should minimize hassle, expenditure, delays, and staff dishonesty. In [Tembo et al., 2014] address the possible hurdles of electronic registration of Land records and proposes a model for re-engineering the Land registration system. The proposed system will necessitate changes in the Law concerning what and how the people must submit the land records for registration and what is admissible as evidence of submission. Publicly online (web) systems also play an essential role in the land registration process. Different authors have addressed the various challenges regarding online land registration application. In [Oyetayo et al., 2016], an online network of the processes involved in the land registration was done having investigated the quickest way to solve the problem. They

designed an online web-based solution so that an applicant can check the status of their application through the web.

C. Land Registration and Blockchain

A white paper by the title of "Bitcoin: a peer to peer electronic cash system" was published around the year 2008, the name on the paper was Satoshi Nakamoto. That can be one person or maybe more than one were behind it. The paper was essentially about a new crypto-currency named bitcoin, but it had used a novel idea of Blockchain. Blockchain was the base on which this new currency dependent. In this white paper, Bitcoin author or authors showed a currency that they can use without any intermediary or central banks or banking systems. The Bitcoin also solved the problem of digital currency, namely the double-spending problem. They solved the double-spending by using the erecting the foundation upon the decentralized network.

Along with a decentralized network, they introduced trust by building a verification process at the core of the Blockchain. Each node on the decentralized network verified the data which it received. The verification process is crucial for data integrity and storage. The data has all the information of the sender, the receiver, the amount, and the timestamp. Some people use both terms, but in reality, Blockchain is the core foundation or base protocol, and bitcoin is the higher level use case, just like HTTP is a protocol while HTML is the high-level use case.

This section deals with the problems currently faced by the approaches taken by early solutions. The previous methods still lack the solid ground from which security concerns can be neglected or removed altogether. The problems are listed:

1) Client-server structure

In recent decades we have seen the transition from manual to digital records and online portals. The main thing is users with higher privileges can abuse their privileges. A user who has access and knows the inside security measures, he is tough to be detected by traditional methods. One of the solutions for the detection of insider attack is using proper logging mechanisms even though this solution seems that it will work. Still, even the attacker can block or stop the logging functionality. Direct access to data also leaves the data vulnerable.

2) Blockchain a P2P network approach

Blockchain operates on a peer-to-peer / p2p networking structure rather than a client/server structure. The internal structure of Blockchain is represented by a list of blocks with data or transactions in a particular order. Two critical data structures used in Blockchain include:

- **Pointers** — variables or place holders which keep information about the location of another variable
- **Linked lists** — a sequence of blocks where each block has specific data and links to the next block with the help of a pointer until we reach the end in which case the pointer points to NULL or no object

Linked lists are very closely related to the Blockchain structure. In the Blockchain, there are several blocks. Pointer connects each block to the previous block. In a nutshell, the block has the following parts:

- **A header**
  a) Pointer to the previous block
  b) Timestamp
  c) Difficulty
  d) Nonce
  e) Markel root
- **Blocks of Transactions**

Transactions: In bitcoin, an electronic coin is defined as a chain of digital signatures. The coin contains the hash of the previous transaction and the public key of the next owner. The algorithm then appends this information to the end of the coin. The algorithm also solves the double-spending problem by the consensus mechanism where if the payee is double-spending, then only the first transaction arrived and accepted by the nodes be honoured, and nodes will reject any later ones.

Hash Function: The primary way of identifying a block in the Blockchain is via its block header hash. These hash calculating are one-way functions. One-way functions are defined as easy to compute the output of any input but guessing or calculating what the input might have been would be nearly impossible. The block header hash is computed by the SHA256 algorithm twice on the block header. The verification process takes each block, each node does not send the hash value of each block to others, but instead, each node computes the hash value on runtime.

III. The Proposed Blockchain-based Land Registration Framework

The proposed framework treats the core blocks like blocks of land record. Each block contains the name of the owner, owner unique identification number (this can be his National ID, Passport Number), land title, the address of the land, owner public key, the previous hash of the block, timestamp, and the signed data of all the attributes mentioned above with the public key of the owner.

These attributes are flexible, and we can add more according to the need of the country or the governing body. We define the key factors of our frameworks which help prevent frauds as:

A. Land Transfer

The second phase of the proposed framework is land transfer. Once the administrator adds the land, then that land becomes available in the Blockchain. The framework must make sure that the land record has the following conditions before the procedure can transfer the land:

- The land record must be unique
- The owner must provide his/her private key file.

The next phase is to validate the private keys of the old owner. This step requires the old owner to input the private key file; the framework uses it to decrypt the signed data. The framework stores the signed data in the block with all the attributes. The successful decryption of the signed data fulfils two things.

- The owner is indeed the one who initially registered with the department (Authentication)
- The land and owner data is secured (Integrity)

B. Verification Process

Once we have decrypted data, the framework verifies that the original owner indeed has access. The land transfer process can begin after this. The web framework shows a form

to the owner to give private keys of the owner, public keys of the buyer, provide name and id/passport of the buyer. The address and title of the land are unchangeable.

The process of land transfer begins by decrypting the signed data and getting the land title and land address from the old block using the private key of the old owner. The new transaction has the new owner's name and id/passport. The framework encrypts this new data set with the public key of the new buyer and stores the signed data in an attribute of the block. The framework then sends the block to the mining process. The remaining nodes then include the block to the Blockchain. In this process, if decryption fails, then the whole verification process is failed, which indicates that the keys are not correct, which means the land does not belong to the client.

C. Private Key

Private keys are needed if the client wants to sell his land. The absence of keys indicates that the land is in a locked state and cannot be moved.

The locked state is significant to keep them safe and stored before the framework can encrypt. The client needs to understand the importance of keeping the keys safe. Each public key has a counter private key that needs to be protected as the loose of the private key will lead to loss of land transfer. The key generation process can be done independently from the system where people give the generated keys to the admin for secure encryption of the land and owner record of the data.

This process cannot be handed to admin because the admin will not be able to change any ownership without the presence of private keys from the original owner. The system will not store private keys which further makes the process secure and protects against insider attacks.

D. Public Key

The public key is the public pair of the prime number used by the public to encrypt any message which can only be decrypted by the public key. The following is the ASCII (Base64) representation of that prime number. The bits representing the prime number begin after the first line.

Our framework makes use of the public key to encrypt the data; we call it signed data. This data is used for two purposes, one for safekeeping second to prove the ownership of the land record. Hence both the public and private keys are crucial for our framework. This process removes fraud via insider attack.

IV. Implementation Details

A. Encryption Process

For implementation, we are using RSA based public key with 16 bytes of random session keys. We are storing the session keys along with the encrypted data for later decryption. The session key is based on AES. We have given the details in figure 3.

B. Decryption Process

The decryption process works in reverse of encryption. First, we need to unpack the encrypted data as in Figure 4. The purposed framework packs the session key, nonce, tag and ciphertext in the encryption process, so they are first unpacked and stored in their respective variables.

```
function encryption(public_key, data):
  session_key ← get_random_bytes(16)
  cipher_rsa ← PKCS1_OAEP.new(public_key)
  enc_session_key ← cipher_rsa.encrypt(session_key)
  cipher_aes ← AES.new(session_key, AES.MODE_EAX)
  ciphertext, tag ← cipher_aes.encrypt_and_digest(data)
  encrypted ← (enc_session_key, cipher_aes.nonce, tag,
ciphertext)

   return encrypted
```

Fig. 3. Algorithm for Land Record Registration.

```
function decryption(private_key, data):
  enc_session_key, nonce, tag, ciphertext ← data
  cipher_rsa ← PKCS1_OAEP.new(private_key)
  session_key ← cipher_rsa.decrypt(enc_session_key)
  cipher_aes ← AES.new(session_key, AES.MODE_EAX,
nonce)
  plain_text ← cipher_aes.decrypt_and_verify(ciphertext, tag)

   return plain_text
```

Fig. 4. Algorithm for Land Record Registration.

C. Hashing Algorithm

The block is initialized with the attributes. After which the attributes are accessed using the internal access. block string is computed after each attribute is added in a key-value pair with JSON dump facility. Then the block string is then hashed using SHA256, and then hex digest is used. This is usually used to exchange the value safely in email or other non-binary environments. Since we are using the data in our webapp over the HTTP protocol, then it is safe to use hex digest over the bits produced. Figure 5 shows the steps of computing hash for our Blockchain.

```
function computing hash(block)
  block_string ← encode(JSON_String(index, transactions,
timestamp, previous_hash, nonce)) computed_hash ←
hex_digest(sha256(block_string))

  return computed_hash
```

Fig. 5. Algorithm for Land Record Registration.

D. Adding/Registering Land Record Algorithm

The land registration or addition algorithm takes the land record attributes and address and the public key of the owner. The address must be unique in order for the land to be registered. This is to prevent any double owner problem and prevent any frauds by the insider. Figure 6 shows the algorithm through which a new block is added into the existing Blockchain. The constraint that the address must be unique is there to prevent any fraud. Only one land title with the address can exist. At the time of creation, the public key is needed to encrypt the land record data. The original data and the signed data are both preserved for any data restoration or corruption check.

```
function submit_land_record_to_blockchain (id, name, address,
title, public_key):
    all_blocks ← fetch_blockchain()
    data_to_add ← id, name, address, title, public_key
    if address is unique:
        signed_data ← encrypt(public_key, data_to_add)
        data_to_add ← data_to_add + signed_data
        add_new_transaction(data_to_add)
```

Fig. 6. Algorithm for Land Record Registration.

E. Transfer of Ownership Algorithm

The algorithm for transfer of the land records works by the taking the block id of the land record the name of the owner the old private key of the old owner and the new public key of the new owner. The block can only be decrypted by the old public key of the old owner. This is a security feature to prevent any false allotment by any 3rd party. Only the old owner can provide the old private key.

The current owner's private keys and new owner public keys are required before this operation can be performed. Once given the data, it is then checked if the current owner is indeed the owner of the block by successful decryption. After which address and title are fetched from decrypted data so that nobody can change it. New owner name and id are encrypted and added to a new block along with the public key. The flowchart of the land transfer process is shown below in Figure 7.

```
function transfer_owner(block_id, old_private_key,
new_pubilc_key, id, name):
  block ← fetch_block_from_blockchain(block_id)
  decrypted ← decrypt_signed_data(old_private_key,
signed_data)
  if decrypted is success
    old_address ← decrypted.address
    old_title ← decrypted.title
    data_to_add ← (id, name, old_address, old_title, public key)
    signed_data ← encrypt(new_public key, data_to_add)
    data_to_add ← data_to_add + signed_data
    add_new_transaction(data_to_add)
```

Fig. 7. Algorithm for Land Record Transfer.

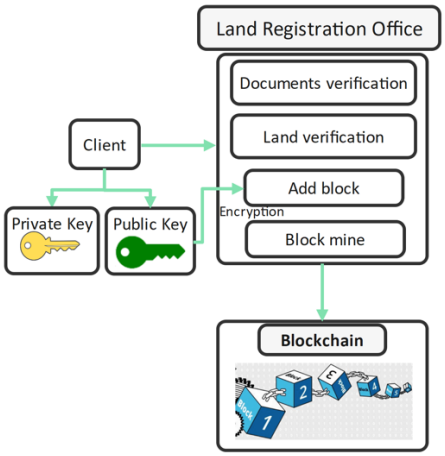

Fig.8 Secure Land Registration using blockchain

In the land registration using blockchain process (Figure 8), when a client wants to registration a land, he/she has to visit the land registration office. In the land registration office, the administrator checks all the required documents of the client. After verifying these documents, the administrator checks the record in the Blockchain that is this land already registered or not. If the land is not registered yet, it meant this client is the first land-owner. The administrator enters the public key of the client, client id/passport, land title, and land address.

V. Conclusion And Future Works

In this article, we discussed the framework of the land registration process for Pakistan and Malaysia. After the literature review, it is analyzed that in almost many countries, fraud commonly occurs in the administrator side in the land registration process. We present through this paper, the blockchain solution and how blockchain decentralization and immutability of the data can help solve the problem in land registration fraud. Also, we observed at the gaps of traditional systems. Then we looked at the implementation details of a working framework which can deal with fraud prevention by using the standard methods of Blockchain combined with public/private or asymmetric cryptography technique. We also looked at the flexibility of *JSON* data structure to be adaptable for any new requirement for any country outside of our scope.

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