Blockchain-based framework for secure and reliable land registry system

Mohammed Shuaib[1], Salwani Mohd Daud[2], Shadab Alam[3], Wazir Zada Khan[4]
[1,2]Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Malaysia
[3,4]Department of CS and IT, Jazan University, Saudi Arabia

Article Info

ABSTRACT

The land registry system is one of the very important department in any governance system that stores the records of land ownership. There are various issues and loopholes in the existing system that give rise to corruption and disputes. This requires a significant chunk of valuable government resources from judiciary and law enforcement agencies in settling these issues. Blockchain technology has the potential to counter these loopholes and sort out the issues related with land registry system like tempering of records, trading of the same piece of land to more than one buyer. In this paper, a secure and reliable framework for land registry system using Blockchain has been proposed. The proposed framework uses the concept of smart contract at various stages of the land registry and gives an algorithm for pre-agreement. First, we describe the conventional land registry system and reviews the issues in it. Then, we outline the potential benefits of employing Blockchain technology in the land registry system and presented a framework. Finally, a number of case studies are presented.

Corresponding Author:

Salwani Mohd Daud,
Razak Faculty of Technology and Informatics,
Universiti Teknologi Malaysia,
Kuala Lumpur, Malaysia.
Email: salwani.kl@utm.my

1. INTRODUCTION

Land registry system refers to the system that records the details of ownership entitlement by several government bodies. The stored record can be used as the proof on entitlement and avoid any short of fraud and smooth transition whenever required. The old land record leads to hindrances in the verification of land title and may result or cause frauds. According to the survey conducted by the world bank around 70 % of the population do not own any land title [1]. Land entitlement is an essential prospect for social and economic resilience of citizen [2].

The secure and up-to-date land record will also help governments in tax collection, service delivery and other aspects of governance [1]. The world bank is actively working in this direction and providing support for improving land registration system in several countries and funding conferences as well as land registration modernisation projects [3, 4]. Various government agencies are exploring and working in the direction of a secure, reliable and tamperproof digital system for the land record. There are many stakeholders involved in the process that makes the system complex and needs various checks and balances to counter different type of threats and create an environment of mutual trust [5]. The blockchain-based solution is appropriate in the applications where multiple entities are collaborating and transacting but having

little confidence among each other. The blockchain is helpful where some information is shared on multiple system or platforms.

2. LAND REGISTRY SYSTEM

The Fundamentals of a land registry system can be mainly into four sections:

a. Unique identification: The main aim of the land registry system is to identify the right/ genuine owner of the land and then finally submit the documents for registration. Currently, the user identification process is not readily available and standardized. The existing blockchain technology built in a fashion that does not require to disclose the identity of the user [6].

b. Initial transition process: Blockchain is and the mechanism that can be used to validate and store all the land-related transitions and it can be further used to transfer the land ownership records [6].
Before applying the blockchain technology for land transition, the existing land title records to be registered in the blockchain that is referred as the genesis block. All the parties involved in the system must agree to it before proceeding further on [6].

c. Consent Principle: The permission of the real owner as per the land record is necessary to transfer the land to the buyer. The main issues identified during this process are:
   - Identification of the genuine owner.
   - Availability of digital signatures to all the users/ owners.
   - The mechanism or the middle man to verify the coercion/transfer under threat without free will.
   In the blockchain, the idea is to remove any middle man but in this case coercion cannot be checked [6].

d. Publicity of records/ownership databases: The main idea is to make record easily accessible and trusted that could be either publically available for inspection or any trusted third party that can cater the needs of a probable purchaser [6].

The present paper-based traditional land registry system has been presented in Figure 1 that can be defined in the following steps:

a. Step-1: Verifiaction of property
In the current land registry system, all the documentation is done physically with paper and verified by checking physical registers. The land buyer will ask for the copy of the land title from the seller to get it verified by the registry office [7, 8].

b. Step-2: Pre-agreemet B/W seller and buyer
When the buyer gets the satisfactory results (authentication) from the registry department, then he/she further can approach the seller for the pre-agreement.

c. Step-3.0: Sales deeds
The buyer will approach the notary department to prepare the official documents for the transfer of land. Notary department will consult the revenue department for the stamp duty on the land and inform the required stamp duty to the buyer.
Step-3.1: Surveyor
At the same time, the buyer will approach the surveyor department to verify the actual physical measurements and location of the land as specified in the land record/papers. If the buyer gets the satisfactory result from the surveyor, then he can proceed to the registration office with the official documents given by the notary department and pay the requisite registration fee in the form of stamp duty and other charges applicable based on the notary documents.

d. Step-4: Registration department
After receiving the official documents from the buyer send it to the recording office. Recording office Take Buyer, seller identity and verify it. After verification Recording Office take the Photo, Biometrics of all parties (seller, buyer, and witnesses), id and photo, and payment fees proof to be included in the official land record paper. Recording office then submits the final official documents to the registration department.

e. Step-5: Land mutation
Registration department then sends this official paper to the land mutation department and to transfer the land ownership.

f. Step-6: Registry department
Land mutation department then submits and update all the land documents to the revenue and registry department for the final updating of the records.
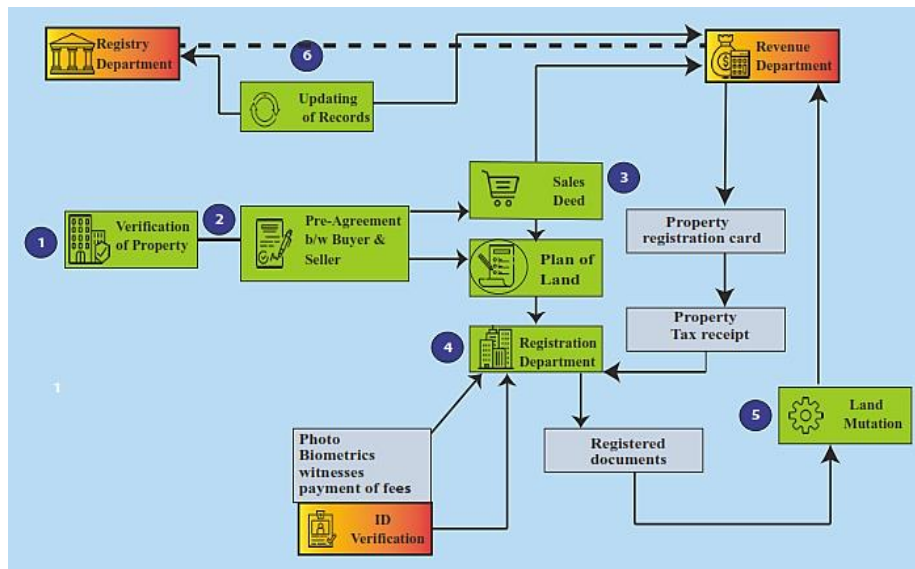
Figure 1. Traditional land registry system

3.   ISSUES WITH CURRENT SYSTEM

In the existing land registry system, the land registrar cannot verify any existing dues on the land and registrar will act assuming that all the land dues are clear [9]. The registry office only makes a record of land transactions, and it works based on the payment proof submitted by the seller and buyer but cannot verify its validity independently and actual payment made [10]. The corruption in the current system led to the rise of the unidentified owners as well as it makes the record updating process tedious and costly due this reason poor farmers cannot register the land title under their name, and consequently they become inaccessible to various government schemes like loan on low rate, loan waivers and support for cultivation. The informal moneylenders are trapping the poor farmers in the absence of any formal land title for money lending, and they pay the very high cost on the lending amount and in the majority of cases are unable to repay the loan amount [11]. The land registry system depends upon the government departments for processing and the verification. As all the land register database are not connected to the land registry system, it reduces the efficiency and equality of the system. There are many issues related to Paper-based land registry system that has been summarized in this section. As the land registry system is not digitalized, it is prone to the alteration [12]. The process of land registery is lenghthy and requires lots of paper verification, physical visits, check and bribery at every stage that causes a lot of delay and wastage of time and money [13-15]. Availability of record is another major issue as the process of land registry involves a change of owners from time to time that takes time and it can not provide real time details for any verification. Assessing these records require time, lots of visits and bribery and that records also may not be synchronized [3]. Land title issue is very conflict arising matter as most of the cases in the court of land related issues are of land title dispute due to various reasons like double spending, fake records and unable to rightly identify the genuine owners [16, 17]. Land double spending issue arises due to the synchronization issue in the land registry system, and it is prone to tampering. The same person can sell the same piece of land to multiple parties, and it can be traced at the later stage when the land mutation is being done. Paper-based systems are very much prone to such issues [18].

Otther issues related to land registry system is related to Land encroachment as in most of the countries, the unoccupied land and old houses are prone to encroachment. Moreover, the land of the elderly and the NRI peoples are the most natural target for land encroachment. In some cases, online registration is being done to sort out some of thes issues but the server issue is a big concern. At the same time, any online system is prone to various type of hacking issues, and users cannot easily trust the system unless and until there is a full proof mechanism to counter any tempering. Middle man issue is another problem as in land registering system the middle man charges a considerable amount to smoothen the land registry process. In some cases, the false middle man can sell the land with fake documents [19]. Due to all these reasons a big chunk of asets remain unutilized and unregistered that affect economic growth [20]. The financial benefits like revenues in the form of income tax, property tax etc. lost from the national exchequer [21]. All these issues reflect as Trust Gap in land registry system and land investors have lost money due to these reasons. Also, there is high transition cost for the purchase of land as compared to the other investments, and after getting the registered paper of land, there is a risk of criminal threats from local criminals [22].

4. BLOCKCHAIN AND LAND REGISTRY

The land registry system involves a massive amount of registration documents to be stored on central databases that facilitate the transaction for the trading of land title. This system is prone to various type of manipulation and alterations and to sort out these issues, manual records stored that it can be manipulated with the help of corrupt employees in the registry office and involves many overheads in t he form of time, storage requirements and cost involved in storing and processing the documents. The land registry departments have taken initiatives to take advantage of the ICT technologies for increasing openness and transparency. By distributing, the data from a single database to a distributed database protect the central storage by copying and replication of data [23]. However, the correctness of records is still a question, and it is still prone to alterations and scams. The Blockchain in reference to the land registry system can be described as a distributed ledger having functions such as storing all the transaction record, owner of the land for a certain period, time of transaction. It also offers ways to track the data of previous transactions [24, 25].

Application of blockchain technology in the land registry solve many problems that arise due to keeping a centralized record of titles. A blockchain based land registry system will provide many abilities as compared to the old registry system. In blockchain, there is a decentralized control and storage of records that have the potential to increase the trust and give rise to the collaborative system. By using blockchain, the efficiency of the land registry system will be increased and result in better synchronization and countering the security issues resulting from human-made disasters and availability issues of information [25, 26]. Blockchain technology consist of peer to peer network connected by distributed network in which each peer is holding the same copy of transaction made via consensus of all the peer in the network [24, 27]. The blockchain categorized based on Public or private and the permission of peer in the network. The tampering with the authentic transitions in land registry record or the efforts to temper the old records creates the audit trail on the ledger [28]. The blockchain technology permits to have peer defined chains for the entry of the transactions, Peer-based validation of entries, a consensus mechanism for storing the entries and a medium to guarantee the security of the system [5, 29].

The records of the transitions are stored in a distributed ledger which prevents the system from fault, insulation and careful spontaneous changing the record. All the record in blockchain is protected by proof of existence [30]. In which each step of the land registry is published on the blockchain which provides the security and record stability by stamping the entire record with notarization [31]. By publishing each step on the blockchain establishes "Proof of process" that secure the records and provide accountability. The only possible case for the non-owner to transfer ownership of the land title is to have the private key of the owner and uploads the transaction. In those cases, the owner has an option to have a backup system to use his/her private key in case of a crash of devices [32].

5. POTENTIAL BENEFITS

The decentralized standard system for land registration records will reduce the role of intermediaries, decrease the time and cost of the process and the system will strengthen the process and will build the trust between the transacting parties. Recording rights of property through Blockchain will help in annual cost savings and provide tamper-proof ledger book. Blockchain usually reduces the expenditure and time of registration process and will help Judiciary to settle down most of the civil cases related to property [33, 34]. The benefits of using Blockchain in land registry system summarized in the following points:

a. Transparency: Every node has a complete overview of transactions and holds a history of the transactions that can be visible from anywhere at any time [35].
b. Increased trust: Trust build due to immutable record keeping and verification of data at multiple nodes [19, 36-39].
c. Increase predictive capability: History information stored at multiple nodes can be traced back, that increases the predictive capability [40].
d. Reliability: Data is stored in multiple places in the blockchain based system. Consensus mechanisms ensure that only information changes when all relevant parties agree [7, 40].
e. Increased control: Consensus mechanism to add transaction increases the control over the database [37].
f. Cost reduction: Cost decreases as no human third party involved in conducting and validating the data [24, 41].
g. Reduced energy consumption: Increased efficiency and transaction mechanisms through network reduces the energy consumption [42].
h. Security: Data is stored at multiple systems using encryption methods that stop the data from being altered without proper authentication [19, 41, 43-46].
i. Ease of access: Information stored at multiple nodes, enhances easy and speedy access [36].

j. Privacy: The information must be secure from secret surveillance. Users need secret keys or access mechanism to ensure that the information is safe from unauthorized view [8, 40, 47, 48].

k. Reducing corruption: Distributed ledgers storage allows for preventing corruption in land ownership due to the secure and reliable mechanism of transfer and changing ownership records [18, 49].

l. Error reduction: Automated transactions reduces chances of errors done by humans [40, 50].

m. Data integrity and higher quality: Not accessed by hackers or unauthorized users mean the originality of the data maintained [8, 40].

6.   CASE STUDY: CURRENT BLOCKCHAIN IMPLEMENTATIONS IN LAND REGISTRY

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.

6.1. Japan (Project status: Initial stage)

Japanese government has initiated a blockchain based project that will record all the land records on one platform instead of current system where several ministries and real estate companies have their separate land record system. The new system has been implemented in few cities as pilot test and once the results are positive, it will be implemented at national level in next five years. Apart from government initiative, a property firm named Zweispace has already started a blockchain based patented system for evaluation and transaction of property that can substantially reduce the time cost of transfer.

6.2. Republic of Georgia (Project status: Completed)

Blockchain-based land titling system in the Republic of Georgia, a pilot project developed in collaboration with the Bitfury Group, the National Agency of the Public Registry (NAPR), and the Blockchain Trust Accelerator. By using Blockchain technology, the Georgian government aims to be a leader in governance and security and to restore public trust in institutions and government agencies. In 2016, Bitfury Group and the National Agency of the Public Registry (NAPR) developed a Blockchain-based land titling system in Republic of Georgia. In the first stage of the project, a blockchain based time-stamping was initiated in the existing land registry system to make the system verifiable and secure. In the second stage the land purchase and sell process was made available using blockchain and bitcoin technology that has reduced the transaction cost to around just 0.1 percent of land valuation. All the records can be made online and it will be secured by public blockchain.

6.3. Russia (Project status: Project in development)

Ministry of economic development and trade of Russia has started a project that will record all the land titles on blockchain based system and facilitate the online secure transaction of land records. In the first stage, all the record will be moved to blockchain based system where you can verify all the land records, previous owners and any liability on the property etc.

6.4. Sweden (Project status: Project in test phase)

The Swedish land-ownership authority Lantmäteriet in cooperation with telecommunication firm Telia, consulting firm Kairos Future and blockchain company Chromaway has developed a blockchain based project for land registry. The project will be three tiered. In the first stage a test run was conducted to test the technological benefits and in the second stage concluded with publication of report that demonstrate the benefits of using smart contracts in land transactions. In the third stage, actual transactions were made using digital signatures and smart contract. The system is currently being evaluated and once the results are satisfactory, it will roll out.

6.5. Brazil (Project status: Project in test phase)

The land registrar offices of Brazil have collaborated U.S. Company Ubiquity LLC to develop a blockchain based system for land registry. In the initial stage the project is being test implemented in two Brazilian municipalities Pelotas and Morro Redondo that aims to make all the land records and transaction 100 % paperless and corruption free. In the initial stage, a parallel system is being created along with the existing land registry system and later on all records will be moved to blockchain based system only.

6.6. Canada (Project status: Initial stage)

The BC Land Titles and Survey Authority (LTSA) is currently working on project to utilize blockchain technology in land transaction and record management in Canada along with Digital Identity and

Authentication Council of Canada (DIACC) and Identity North (IDN). The aim of the project is analyses the social and legal complications, usefulness of blockchain in BC Land Titles and Survey Authority's tasks. In this regard a challenge was initiated by University of British Columbia to analyze the various challenges and issues related with Blockchain application in land registry.

6.7. Ghana (Project status: Development stage)

Few motivated engineers created a team named BenBen to improve the land registry system using blockchain and crypto-currency techniques. BenBen is creating a top-of-stack land registry and verification platform that will coordinate various financial institutions and government authorities in updating the current records and enable smart land transactions digitally for properties.

6.8. Ghana (Project status: Completed)

Bitland Land Registry System is a joint venture of Ghana and Bitland. Bitland is a non-profit organization working in order to resolve the property related issues using blockchain and using Ghana as test case to further apply the technology in African region. Specifically, the project is being implemented as pilot project in Kumasi region.

6.9. India (Project status: Project in development stage)

Indian states of Telangana and Andhra Pradesh in collaboration with Centre for Development of Advanced Computing (C-DAC) are working on project that applies the blockchain technology to improve the land registry system. Currently the project is undergoing review and development phase and further it will be implemented in capital city Hyderabad and surrounding areas as a test case before implementing it in these states completely.

6.10. Ukraine (Project status: Initial stage)

State Land Cadastre of Ukraine government is working on blockchain based land title system with Bitfury Group. Bitfury is a non-profit group helping Ukraine to resolve the issues of corruption and black-market control. Pilot project was started in 2017 and in the beginning the project is covering the aspect of record authentication without any direct land transaction but it will be later on included in next phase. This project is using Exonum platform for private blockchains. At the same time a Paolo Alto based global property store Propy is partnering with government to help it in online real estate transaction using Ethereum blockchain.

6.11. United States - state government (Project status: Initial stage)

Paolo Alto based real estate firm Propy has signed a collaboration agreement with South Burlington Clerk Office to provide blockchain based real estate transactions and record keeping to make it cost effective, efficient and secure. It's a pilot project that will be replicated in other states after successful implementation. Meanwhile Wyoming, Teton County signed a MoU with Medici Land Governance in 2018 to shift the existing land records to new blockchain based platform.

6.12. Netherlands (Project status: Project in development phase)

The Land Registry organization of the Netherlands, generally referred as the Kadaster initiated a land registry project in May 2018 that utilizes blockchain and AI. The land registry department registers the ownership details and geographical coordinates for correct identification. This information can be accurately stored using blockchain and time stamping techniques. The project is in development phase. This project is a part of Government's program "Blockchain Pilots" to introduce blockchain in all the aspects of e-governance.

7. IMPLEMENTATION: PROPOSED FRAMEWORK FOR BLOCKCHAIN BASED LAND REGISTRY SYSTEM

During the process of land trading, the buyer and seller have to sign a pre-agreement contract (smart contact) and then further send the request of transfer to the registry office. The registry office verifies the identity of seller and buyer then verify the land title with the help of surveyor and departmental records. Once the authentication and verification are complete, the financial transaction record is verified, and required revenue in the form of transfer charges and taxes are collected then the transfer request further processes. After completing all these steps, the ownership is transferred, and the ownership certificate issued to the buyer, and the updated record sent to all concerned departments. The verification of seller and buyer is done with the help of pre-agreement Id that stores the seller and buyer ID and agreement details.

7.1. New transaction block

Once the transaction process is complete and ownership records are created, these records need to be updated at all department (parties involved namely Registry office, surveyor, revenue office and banks) that stores and verifies these records. These parties or nodes store a separate distributed ledger that records these transactions and all the historical transaction records using distributed ledger technology (DLT) of that specific property. The specific office can check and validate the transaction based on ownership records previously stored in its distributed ledger.

The newly created transaction blocks are verified by the by validating node and then it is broadcasted to all the nodes within the DLT network. The other validating nodes will verify and agree on the generated node with the help of a consensus mechanism and then finally the new block is added in the blockchain. The contents of the generated block have been shown in Figure 2.
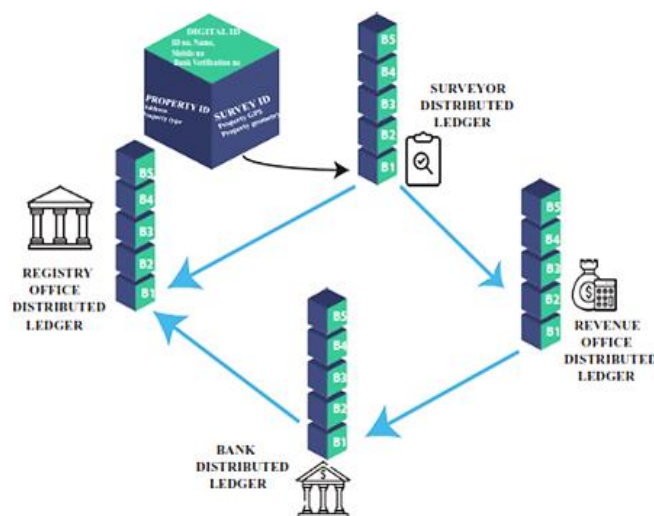

Figure 2. New transaction block

7.2. Smart land title contract

The pre-agreement contract process between buyer and seller has been shown below that requires the following details given in Figure 3. The internal contents have been explained in detail and given below;
a. Identity: It stores the information (ID, name, sign) of all the users in the system and the KYC feature for the verification of legal identity.
b. Title: It stores and updates the information related to the Title on the blockchain like Id, Address, status, the current owner.
c. Deed: Store and Manages the information related to Deed like- ID, Seller ID, Buyer ID, Payment status.
d. Agreement: Store various legal agreements, an inspection report by the surveyor, purchase agreements, and this is digitally signed for deed transitions.
e. Electronic Signature: Store digital signatures of all the participants in the system and allow to store multiple signatories acting in different capacities in the same documents. Validates the digital signature format.

7.3. Algorithm for pre-agreement

The pre-agreement is executed between buyer and seller based on IDs of both, land ID and payment details. The buyer and seller will agree on the amount of land and based on this they will create a pre-agreement contract. The title will be generated based on property ID, owner ID and payment record. Further Taxation ID will be generated based on the Property ID and rate of taxation as per revenue department rules. The payment ID will be null until verified by Registry office and payment is done by the buyer. Once the registry office verifies all the details of land, ownership records and dues etc. the buyer will initiate the payment. After verification of payment details, the registry office will create the payment approval and start the transfer process. The proposed blockchain based pre-agreement algorithm for land registry system has been given below;

Algorithm: Pre-Agreement contract

```
If (Seller Id [] <= Null)
        Seller Id [] ← (Id, Name, Sign);
        return Seller Id [];
                else If (Buyer [] <=Null)
        Buyer Id [] ← (Id, Name, Sign);
        return Buyer Id [];
                else
        Title Id [] ← (property Id, Owner pub key, Payment status);
        Taxation Id [] ← (Property Id, rate of taxation);
        return Title Id [], taxation Id []
        exit;
If (Payment status >= Null) && (Buyer Id or Seller Id [] or Title Id [] >= Null)
        {
        Deed Id [] ← (Seller Id [], Buyer Id [], Title Id []);
        Agreement Id [] ← (Taxation Id [], Deed Id []);
        Pre-Agreement Contract ← (Agreement Id [], Seller Id [], Buyer Id [], Hash);
        }
        return Pre-Agreement Contract []
        exit;
```
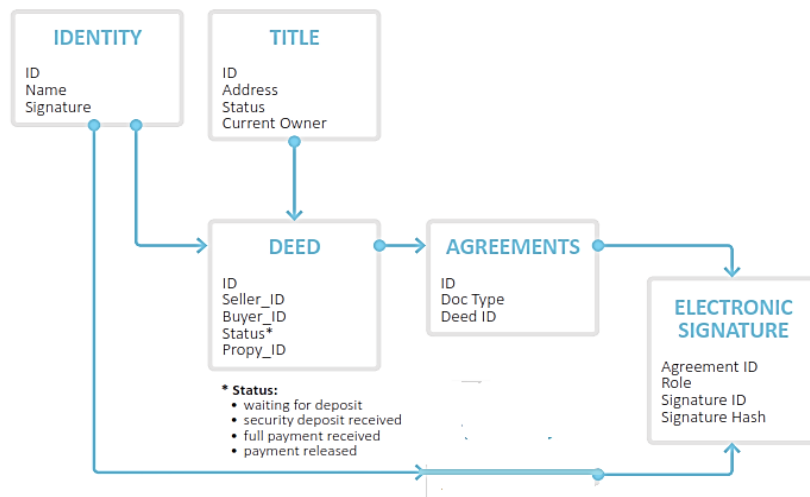

Figure 3. Pre-agreement contract process

8. FRAMEWORK FOR LAND REGISTRY SYSTEM USING BLOCKCHAIN

A new framework for blockchain based secure and reliable land registry system has been proposed in this paper given in Figure 4. The proposed framework uses blockchain for storing land records and is tamperproof and reliable.

a. Step-1: Preagreement

In step 1, the seller and buyer sign a Pre-agreement title contract containing Sign, Seller ID, Buyer ID, sell ID, Amount of transfer, payment status.

b. Step-2: Sell request

In this step, the pre-agreement title contract then sent to the Registry office for sell request.

− For making the trust in the system for a land registry using BC and solve the double spending problem, the system will put a LOCK on the specific land title and will not allow any other transaction on same Sell ID until the Approval or the Disapproval is received from the registry office.

c. Step-3: Verification

Further in step 3, the registrar office can then send an ownership and dues verification and validation request to bank, Revenue, Surveyor & registry office.

− Registrar office ask the surveyor for the validation and the report of the property geometry, property GPS Location and property ID.

− Registrar office asks the bank for verification and report of the Credit history of buyer and seller, credit history of the property.

    − Registrar office asks the Revenue department for verification and report of the type of property and appraisals.

    − The registry office notifies all the departments and sends the Blockchain hash to all the departments in the land registry system.

d.   Step-4: Approval

In step 4, the registry office will get information from all the department to whom the verification request has been sent.

e.   Step-5: Notification

After getting positive verification reports from the departments, the registry office notifies the Buyer that Ownership verification has been verified and notifies them to sign the agreement digitally, otherwise disapprove the request.

f.   Step-6: Initiate fund transfer

After the notification, in this step the system tracks the amount listed in the pre-agreement to be transferred to the bank by the buyer.

g.   Step-7: Approve fund transfer

In Step 7 the Bank checks the fund transferred with reference to the pre-agreement title contract and approves it. And marks the payment as received on Pre-agreement title contract

h.   Step-8: Transfer detail

After approval of the Fund transfer in step 7, in this step the bank send the transfer details to the registry office.

i.   Step-9: Ownership transfer

In this step, Registry office approves the Ownership transfer request and notifies the Seller and the Buyer about the land title transfer. Recording office in registry office changes the ownership records.

j.   Step-10: Ownership certificate

After transfer, in this step the Registry office generates an Electronic title deed with Bloch chain hash and QR code to the buyer. Ownership certificate is given to the buyer

k.   Step-11: Record update

In the final step 11, the ownership transfer certificate updated to all the departments (registry office, bank, suryer, revenue office) with blockchain hash to all the departments in the land registry system.
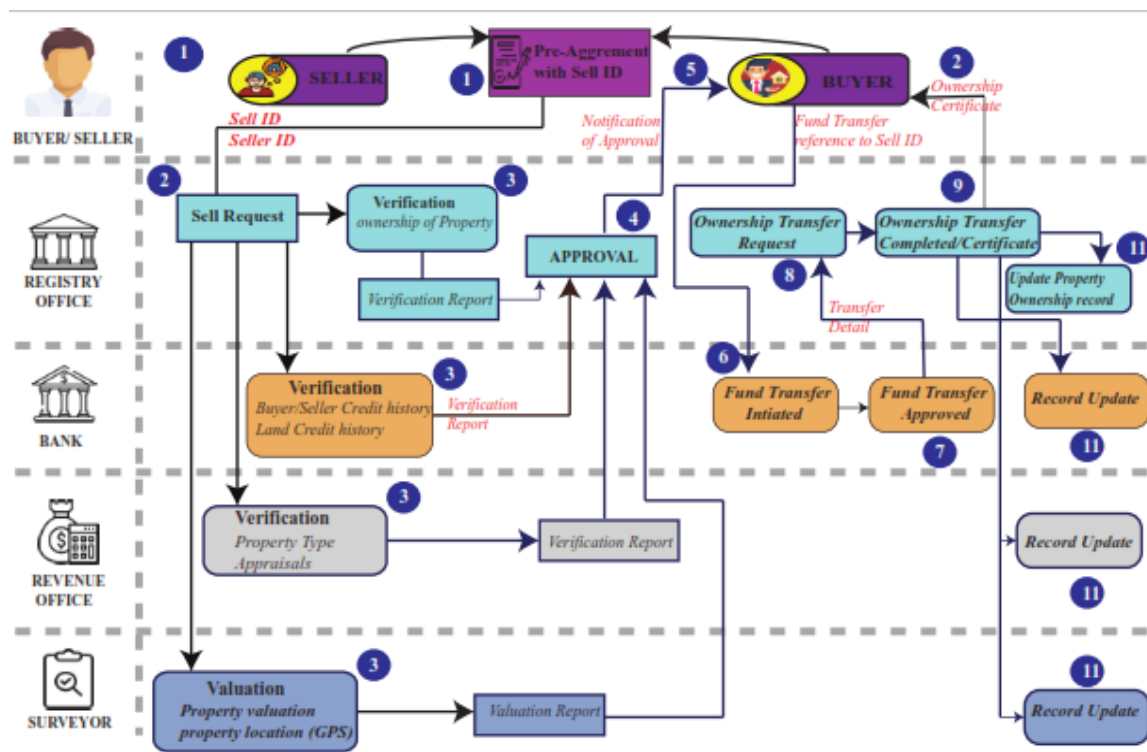

Figure 4. Framework for land registry system using blockchain

9. CONCLUSION

This paper reviewed the existing procedures and issues in the traditional land registry system. The traditional system is prone to various types of tampering at every stage and indirectly affects the costing also in the form of paper resources, storage requirement of vast record keeping, security issues of these records. The system is also time-consuming and requires much time in verification and updating process that give rise to bribery and chances of double spending (selling the same piece of land simultaneously to more than one buyer) increases. These issues affect the economy, and people are sceptical in investing in land trading that excludes a large chunk of money from the regular economy cycle that hinders the growth of any country. These issues also affect the tax and revenue collection for government and black money in the form of unnamed properties increases. Blockchain technology has the potential to counter all these issues. In this paper, a framework for secure and reliable land registry system has been proposed that counters the significant issues of tampering, double spending and provide near real-time updating of land records. The proposed system is very economical, as it requires very less human resources and more reliable. This paper also proposed an algorithm for a pre-agreement contract between buyer and seller. The process of ownership record generation and the process of updating these records at various interconnection nodes (offices) has been discussed in detail. In future, the proposed framework and algorithm will be implemented in the real environment.

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BIOGRAPHIES OF AUTHORS

Mohammed Shuaib received the B-Tech. and M-Tech degrees in computer Engineering majoring in Sofware Engineering from the Aligarh Muslim University (AMU), Aligarh, India in 2010 and 2012 respectively. He has also served for three years as an Assistant Professor in the Department of Computer Engg., Integral University, Lucknow, India. Currently, he is a Ph.D. candidate in Advanced Informatics Department from Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia (UTM) Kuala Lumpur, Malaysia. His research area is focusing on Blockchain, Security, IoT, Cloud Computing and Identity Managemnt.

Salwani Mohd Daud is a Professor of Advanced Informatics Department in Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia (UTM). She obtained her B.Eng. (Hons) Electronics Engineering from University of Liverpool in 1984. Then she received her M.Eng. in Electrical Engineering in 1989 and Ph.D. in Electrical Engineering in 2006 from Universiti Teknologi Malaysia. She is a member of Institute Electrical Electronic Engineer (IEEE), registered Professional Technologist from Malaysia Board of Technologists (MBOT) and registered graduate engineer with the Board of Engineers Malaysia (BEM). She has been with UTM for more than 30 years and has vast experience in teaching and research. Her research area is focusing on artificial intelligence, blockchain and IoT. Currently she is teaching machine learning and system design for security for postgraduate program. She is also leading few research grants in the related topics and had secured more than RM2 millions of R&D funds. She also has published more than 100 academic articles in journal, proceedings and books.

Shadab Alam is of Indian origin currently working as Assistant Professor in Department of Computer Science, Jazan University, Jazan, KSA. He earned a doctoral degree in Computer Science from Aligarh Muslim University, Aligarh as well as Bachelor and Master degree in Computer Science also. His main area of research is Cryptography and Information Security and further research interests include Internet of Things (IoT), Blockchain Technology and E-learning. He has published more than 20 research papers in reputed international conference proceedings and journals. He is a member of the Computer Society of India (CSI), Cryptology Research Society of India (CRSI), ACM, IAENG, CSTA, IACSIT and ICSES.

Wazir Zada Khan (M'16-SM'17) received his bachelor's and master's degrees in computer science from COMSATS University Islamabad, Wah Campus in 2004 and 2007, respectively. He received his PhD from the Electrical and Electronic Engineering Department, Universiti Teknologi PETRONAS, Malaysia in 2015. Dr. Khan is currently working with Farasan Networking Research Laboratory, Faculty of CS & IT, Jazan University, Saudi Arabia. His current research interests include wireless sensor networks, security and privacy, IoT and Blockchain. He is a SMIEEE.