A smart contract approach in Pakistan using Blockchain for Land management

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(March 2022)

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A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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Evaluation of M. Phil. Thesis

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My Parents & Teachers

Abstract

Management of land records includes actions such as registration and transfer of property ownership. For many nations, land ownership and management are important sources of income, but a 2011 UN research found that bad governance is a major contributor to corruption in these sectors in more than 60 countries. Currupted spans from small-scale payments to large-scale abuse of government authority at all levels of government.In the literature, a number of concerns have been raised about Land Record Management. There are several problems with Land Record Management in developing nations, such as tampering with land records and no methods of retrieving a full property ownership record, operating of multiple linked Land Record Management Systems independently, etc.. Traditional land record management solutions do not solve these challenges. We propose a Blockchain-based Land Record Management system for Pakistan to solve these concerns. It has been decided to use the suggested system, and the specifics of its implementation are described in this thesis.

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Keywords: Blockchain, Private Blockchain, Land management, Smart Contracts

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Chapter 1 **Introduction**

Bitcoin cryptocurrency is the first to develop in the blockchain world using a decentralized transaction approach with data management technology. Therefore, the interest in Bitcoin has been increased since the idea of blockchain has been introduced in 2008. The crucial reason for the recognition of Blockchain is its major factors that provide anonymity, security and data integrity without the involvement of third party in control while transactions. Hence with Blockchain, various research areas have been formed in the regards of technical challenges and limitations [2].

In a distribution fashion and without the central authority implementation, blockchains are used in the manner of tamper evident and tamper resistant digital ledgers. On the initial level, blockchains are used to enable the community of user for record transactions in a balance sheet within that community in a specific manner that no transactions can be altered after the normal operation once the transaction is published [1].

1.1 Importance of Blockchain in the field of transaction

Blockchain technology has multiple admirable features such as decentralized structure, storage mechanism, and distributed notes, solidarity algorithm, intelligent contracting and asymmetric encryption to ensure the network security, visibility and transparency while making any kind of transactions [3].

Blockchain is an innovative, distributive and decentralized technology that plays the crucial role maintaining data confidentiality, integrity and availability of entire transactions. With the usage of peer-to-peer network, Blockchain plays a vital role using a cryptographic value while storing the data and transactions because of its primary features such as distributive ledger [4].

With the factor of digital shared ledger in blockchain, it is conveyed over the network. The preliminary reason for the safety perspective of Blockchain is that once the record is added in the system cannot be altered without changing the previous records using the consent of all the participants involved in the transactions which makes it safe using the business operations. Blockchain has been applied in various fields for the privacy concerns such as smart contracts to track frauds in finance or secure the medical records in healthcare domain [5].

Blockchain technology has upgraded the ways of business, finance and commerce world along with the Blockchain technology 2.0 which is smart contract. With the continuous enhancement in Blockchain technology, its potential has an enormous impact to construction industry. With the distributed consensus mechanism of Blockchain, the participants are allowed to be informed of every occurred event by using an irrefutable record using public ledger. With the advancement in Blockchain technology, many industries like banking, supply chains, real estate, healthcare, E-healthcare, are disrupted. Blockchain is making a powerful impact in these sectors due to its decentralized, verified and immutable nature [4].

1.2 Structure of Blockchain.

Like every enhancement in technology, each technology has its structure to organized its working paradigm. In this section we discuss the main components of Blockchain. To adhere the Blockchain features mentioned in the above sections, it has 3 main structures such as public, private and consortium. Public Blockchain is accessible to all involved parties on the network using peer-to-peer network. Private Blockchain provides the access to date using role-based and for the improvement of flexibility uses cloud networks. Blockchain is helpful in social media analysis. Consortium Blockchain is known as hybrid, has both function of private and public Blockchains to provide the balance between them [5].

In supply chain industry, Blockchain has tremendous potential to transform every step of it, from raw material procurement to distributed to the consumers. Blockchain established the Business process reengineering framework with supply chain reengineering. In supply chain industry, each transaction using Blockchain provides more faster and secure approach in the restructured transaction manner [6].

The Blockchain structure is organized in a paradigm to ensure security and transparency of supply chains. We discuss the mechanism of Blockchain system in a following manner. In blockchain every block has a hash number based on 256 bits created by the scientific algorithm with consensus. The block is linked to each other by having the references of the prior block's has such as link list. In order to add a new block in the Blockchain, each block is needed to be validated which is called Blockchain Mining. After the validation process, the block becomes the part of Blockchain. For the privacy aspect, Blockchain has built-in defense mechanism. If any corruption occurs and detected by the Blockchain as malicious is captured and defended. If the malicious attack tried to corrupt the Blockchain, the corrupted block in the infected node is also corrected [7].

1.3 Modules of Blockchain

Literature has revealed there are various modules of blockchain have been used to create the protocols while establishing the blockchain application [7-8].

- *The first module is data source module. Data source module enable the Blockchain feature to the distributed and shared databased. It is helpful in the privacy aspects where the data is retrieved by the users cannot be altered and uncorrupted. Blockchain key aspects are data immutability, tamper proofed storage and shared data ledger.*

• The second module is Transaction module. Transaction module is quite impactful to monitor the journey of the transaction in Blockchain. It is useful to validate and facilitate any addition to the Blockchain. Transaction module plays a crucial role in smart contracting with the shared visibility of transaction when the transaction reach to every node in the form of block. After the execution of the transaction, it is impossible to delete or roll back in Blockchains.

- The third module is creation module. Block can be considered as data structure which is created by miners They contain information and transaction details that are replicated to all network nodes. By providing hash values and connections from the previous block, the block creation module allows the addition of new blocks to an existing supply chain. Transaction sequences are saved in "chronological blocks," and blocks containing invalid transactions can be easily identified and tracked.
- The forth module is Consensus module. To avoid data corruption, proof of work and proof of state algorithms are used to confirm and validate all transactions. The distributed network's data consistency is maintained by carefully designed "consensus algorithms." Distributed consensus aids in both the verification of transaction validity and the creation of links between blocks in the blockchain system.
- The fifth module is Connection and interface module. It monitors transaction tracking and assists in providing real-time data on smart contracts. This module synchronises all of the necessary information technology (IT) platforms, algorithms, and software for blockchain applications. Depending on the use cases, multiple distributed ledger

platforms with consensus algorithms for the blockchain system could be made available in the market, regardless of whether the blockchain is public, or private.

1.4 Permissionless and permissioned blockchains

There are various (often conflicting) classifications of blockchain types, and for the purposes of this section, we focus on the different types of blockchain based on whether network nodes that act as verifiers require authorization, and whether access to the blockchain data itself is public or private. For the first classification, we have [9-10]:

- Permissionless blockchains, in which anyone can participate in the verification process, i.e. no prior authorization is required, and a user can contribute computational power, usually in exchange for monetary compensation. The blockchain used in the Bitcoin network, the prototypical example of a blockchain, is 'permissionless.' Permission refers to the authorization to perform network tasks, and anyone can join the network to be a verifier without obtaining any prior permission to do so. Because these verifiers are critical to the network's operation, their participation is encouraged (and indeed incentivized) by the issuance of new currency that is paid to them once they have verified a block of transactions, a concept known as 'Proof-of-Work.' Consensus is reached inside the network by several voting techniques, the most prevalent of which is Proof-of-Work, which is based on the amount of processing power provided to the network. Because of the computing effort that has already been employed to construct the blockchain ledger entries, the Proof-of-Work concept allows the network to safeguard itself against malicious attempts to tamper with the blockchain structure. A permissionless blockchain is beneficial in that it may accommodate anonymous or 'pseudonymous' players while also protecting against a

Sybil (i.e. identity-forging) assault Douceur [2002]. However, the incentive mechanism must be properly designed to guarantee that verifiers are incentivized to participate.

- Permissioned blockchains are those in which the verification nodes have been pre-selected by a central authority or consortia. Permissioned blockchains are designed to be purpose-made and may thus be constructed to work with current applications (financial or otherwise). They can be totally private (write permissions are kept within an organisation) or consortium blockchains (consensus is managed by a pre-selected set of nodes). Because the network's actors are identified, the objective is for them to be held legally accountable for their actions. Off-chain assets (such as digital representations of securities, fiat currencies, and titles of ownership) will predominate over on-chain assets (such as virtual currency tokens) in terms of transactions handled by these blockchains. Scalability is one advantage of a permissioned blockchain. Data is saved on every computer in the network in a permissionless blockchain, and all nodes validate all transactions.

The second category includes:

- Public blockchains, which let anybody to read and publish transactions to the blockchain.
- Private blockchains, in which this authority is limited to users inside a single organisation or set of organisations.

In actuality, most permissionless blockchains allow for public access, whereas most permissioned blockchains are designed to limit data access to the firm or coalition of companies that operates the blockchain.

1.5 Problem statement

In recent years, industry focus has shifted to second generation blockchain applications such as digitising asset ownership, intellectual property, and smart contracts. The latter usecase is especially intriguing since the terms of a contract may be encoded in computer code, which is duplicated and performed throughout the blockchain's nodes. Such a contract can be self-enforcing, monitoring external inputs from reliable sources (for example, the weather service or a financial exchange) in order to settle according to the contract's terms.

In [11] proposed the notion of smart contracts more than 20 years ago, but we have only lately seen tangible blockchain-based implementations. These blockchains expand the network's capability, allowing it to go beyond establishing consensus on data streams to reaching consensus on computation [12]. Ethereum, for example, proposes to give a "built-in blockchain with a fully fledged Turing-complete programming language" [13].

The basic processes of any Land Record Management System include property registration, property transfer, property monitoring, and property sale and FORM-II certifications. The use of traditional technology to support these operations may result in a variety of challenges, such as the issuing of numerous sale certificates, error-prone ledger updating, tampering with ledger data, a purchaser or seller having to visit a number of relevant offices, and so on.

Several technologies, including central and distributed systems, have been employed in e-government Land Record Management. Land records controlled by central servers confront a number of challenges, including scalability, security, and failure tolerance. Distributed systems have been used to address such issues; however, such solutions do not address other Land Record Management issues, such as the issuance of multiple sale certificates, error-prone updating of

ledgers, tampering with ledger data, a purchaser or seller needing to visit a number of concerned offices, and so on.

1.6 Contribution

In the context of Pakistan, the majority of Land Record Management is now carried out manually, albeit these manual procedures are aided by technology such as web-based apps and centralised databases. Many attempts have been made to use technology to overcome the challenges of manual Land Record Management. However, many of the concerns raised previously remain unresolved. Furthermore, the departments related to Land Record Management, such as the National Database and Registration Authority (NADRA), Revenue, and Registrar office, work in isolation, which causes a number of issues, such as requiring the seller and purchaser of the property to visit each of the related departments for production and verification of the same documents.

To overcome the aforementioned difficulties, we offer a Blockchain-based Land Record Management system for Pakistan. Because the operation of Land Record Management Systems is more or less the same in all provinces of Pakistan, with the propose approach it may be implemented with little or minor alterations throughout Pakistan.

1.7 Thesis Organization

This thesis is organized into five chapters. Chapter 1 states core notions of Blockchain. It discusses the problem statement of our thesis and our proosed approach to overcome the problem. Chapter 2 discussed the extensive literature review of previous approaches used to improve the building energy performance while Chapter 3 purposed our approach of improving the energy performance of building in Pakistan climates and it also states the optimization problem, design variable, and

algorithm used for optimization. Chapter 4 discuss the results achieved by this approach and the improvement potential found in the climate of Pakistan. In last Chapter 5 tells about the conclusion and our future goals toward this problem.

Chapter 2 **Literature Review**

2.1 Introduction

In this chapter, we eloabore the primilinaries of Blockchain with other domains. Blockchain technology based on decentralized ledger and its was primarily used for bitcoin cryptocurrency. But it is now used in various fields for health care ,land records and many other fields due to its security and data integrity with out involvement of any third party .There are various unaddressed challenges in blockchain technology and purpose of this research is to reveal new research areas in this technology because above 80% is research is on bitcion and below 20% in other areas using blockhain [13].

Blockchain based on decentralized database that is public ledger shared among the parties. Once a digital transaction is recorded it can not be removed ad it can be verified easily .Although bit coin and cryptocurrency is contravourtial but its underlying blochain technology is much powerful and has been adopted in various fields . But its adoption is low due to risks involved with the technology adoption but it would be faster in future [14].

Blockchain technology has very good effects on health industry for medical and pharmaceutical management it ensures a reliable transaction .It provides new digital modes for heath care management [15]

The use of blockchain technology in biomedical can enhance the medical research can facilitate to keep the records maintained more precisely as compared to traditional distributed database as distributed ledger is used in blockchain but there are various issues that need to be handled by carefull implantation of blockchain [16].

Patient-driven interoperability the data of the patient need to be exchanged for the further process and meditation blockchain technology deals with this transaction with five mechanism. But there are still various barriers that need to be addressed in patient-driven interoperability [17]

2.1.1 Security issues solved by Blockchain

The architecture and implementation of blockchain technology have several specific security vulnerabilities. Blockchain security vulnerabilities are often linked to problems with the traditional consensus mechanism used to confirm and verify transactions [31].

The present secure communication architectures of EHR are insensitive to the privacy of users or patients, as shown by the exchanging system disclosing all data without the authorization of owners or the presence of noise in the data requester summary, among other things. If, on the other hand, the current EHR apps are built on the blockchain, the requester will need exact patient data in order to give individualised services [32].

In the field of healthcare, we have witnessed the rise of Internet of Things (IoT) applications that have appeared in recent years. Almost at the same time as the rise of IoT, there has been speculation about possible applications for Blockchain Technology outside of the financial industry in a variety of other contexts, including those in healthcare. This study gave an overview of Internet of Things (IoT) health technologies, with a particular focus on those that were suggested to make use of Blockchain Technology. The authors explored both the beneficial elements of such implementations for the future, as well as the drawbacks of existing designs, and they addressed the future problems of this fresh field of study in their research. It reviewed the most recent research in this highly particular subject and provided an impartial vantage point to help academics

traverse this new vista for healthcare, IoT, and Blockchain Technology as they look to the horizon of the future [33].

Iot is emerging field but Iot devices faces various limitations and most specially security issues . Blockchain technology could solve many iot security problems .In this paper various IoT security issues had discussed and their solution was proposed with the help of literature .Map the problems and various open challenges are discussed that iot faces [18].

In the modern era we are dealing with the various IOT devices .These iot devices can be monitored by using blockchain and could be made more secure .As all operation can be stored using blockcahin and in case of any disaster they could be retrieved . we can add more security to the model and can made it more decentralized .We can protect other blockcahins to read by suing the chain nodes .It would secure the iot devices [19].

Blockchain based iot devices are offered with the advancement in technology but these devices also face some issue in their deployment. These issue should be identified and best solution should be proposed. Various aspects that should effect deployment of Boit devices are explained [20].

Blockchain technology can used be for digital record keeping it addresses the issues and security problems in keeping and maintaining the digital records but it also have some limitation .But some limitations risks and opportunities are discussed [21].

2.1.2 Artificial intelligence with Blockchain

Intelligent vehicles can drive own its own without driver but there are various dangers and self driving is not secure .All these issues can be solved by using blockchain technology. Blockchain technology provide trusted and secure IV communication with out sharing the personal information in a decentralized manner [27]

Blockchain technology can be employed for the 4^{th} industrial revolution like machine to machine communication to creat a electricity market . This technology has much potential and it should be employed to enhace the efficieny of 4.0 revolution [28].

The article is about the potential impact of blockchain on society .Block chain uses and its limitation . Block chain could be used to protect personal information due to its decentralization and other features as all the personal information on cloud is handled by the other entity .Could blockchain technology serve in this way [29].

The goal of this research was to investigate the role of big data, blockchain, and artificial intelligence in cloud-based accounting information systems via empirical analysis. I support my case using statistics from Capterra, Eurostat, Intuit, Market Research, and Software Advice. The authors conducted analyses and made estimates regarding the most frequently used accounting software features (percent), the accounting software's impact on financial errors (percent), the use of cloud computing services in enterprises (by purpose, percent), and the cloud accounting software's most significant benefits and top concerns (percent). The research mode was evaluated using the structural equation modelling approach [34].

Blockchain technology can be used to avoid the double taxation problem. A investor can demand tax return due insufficient information available between the countries but this can be over come

by using blockchain data base to avoid the tax fraud .It could be made more transparent and reliable. It can be used for international and interorganizational tracking of records [30].

The new coronavirus illness COVID-19 is quickly spreading, with a higher mortality toll and transmission rate in high-income nations than in low-income ones. In resource-limited contexts, overloaded healthcare systems and inadequate disease monitoring systems may struggle to deal with the COVID-19 epidemic, necessitating a specialised strategy response for these settings. As a result, the authors proposed a low-cost blockchain-based self-testing and monitoring system paired with artificial intelligence for COVID-19 and other emerging infectious illnesses. Prompt deployment and application of the proposed approach have the potential to significantly reduce COVID-19 transmissions and associated deaths, especially in locations with limited access to laboratory facilities [36].

There is no doubt that artificial intelligence (AI) and blockchain technologies are gaining traction at a breakneck pace. Both technologies are technologically complicated and have a plethora of commercial ramifications. However, a widespread misconception regarding the blockchain idea in general is that it is decentralised and not controlled by anybody. However, the development of a blockchain system's underlying technology is still ascribed to a cluster of core developers. Consider a smart contract, which is simply a collection of codes (or functions) and data (or states) that are developed and published on a blockchain (say, Ethereum) by various human programmers. As a result, it is less likely to be without gaps and defects. In this paper, authors discussed how artificial intelligence can be utilised to produce bug-free smart contracts in order to meet the aim of blockchain 2.0. Likewise, authors highlight how different AI approaches can be used to aid or improve the blockchain implementation. The combination of AI and blockchain was supposed to open up a plethora of possibilities[35].

Despite this, the exponential growth of drone use in a variety of social and military applications needs advances and stability in drone communication. Drones have shown their ability to provide cost-effective real-time solutions for a variety of applications, including healthcare, smart grid surveillance, smart city monitoring, and border surveillance. While there are several security and privacy concerns, experts from across the world have proposed numerous techniques to safeguard drone communication against cyber-attacks. The majority of these solutions are based on cryptographic methods and require a significant amount of computation. There are a few blockchain-based alternatives available, but they all suffered from high transaction storage costs, as well as concerns with communication dependability, latency, and bandwidth. We conducted a complete analysis of secure drone communication in this research and suggested a blockchain-based secure and intelligent drone communication architecture based on 5G communication networks and artificial intelligence (AI) algorithms. The suggested design made, use of the InterPlanetary File System (IPFS) as a data storage platform, which improved network efficiency, communication security, and privacy, while also lowering the cost of transaction storage. Additionally, it enabled efficient drone communication by enabling dynamic, adaptable, and on-the-fly decision-making capabilities using 5G and AI technology[37].

2.1.3 Smart contract and Land management with Blockchain

This article proposed a supply chain game in which two enterprises participate, one as a supplier and one as a retailer. The supplier supplied items to the retailer and oversaw the store's service approach. The store established the ideal buy amount and selling price. The supply chain may be controlled in one of two ways: through a conventional internet platform or using a blockchain. Previously, businesses faced business risks associated with delivery and service, as well as

significant transaction expenses. In the latter, they developed a blockchain platform to eliminate all supply chain risks and reduce transaction costs. The blockchain, on the other hand, required early installation expenses in addition to variable costs. Additionally, the companies benefited from increased visibility, transparency, and security, all of which were summarised in tokens. The authors identified the circumstances and stochastic scenarios in which adopting the blockchain was not worthwhile. After that, the authors examined the applicability of a smart wholesale pricing contract and a smart revenue sharing contract for improving the coordination of businesses' connections and discussions. The paper emphasize all instances in which the implementation of smart contracts enhanced the operational convenience and commercial attractiveness of blockchain applications.[38-39].

The emergent Internet of Things (IoT) is confronted with serious scalability and security issues. On the one hand, IoT devices are "fragile" and need additional support. Edge computing is a viable avenue for overcoming centralised cloud computing's inability to scale vast numbers of devices. On the other side, owing to resource limits, IoT devices are also very "susceptible" to hostile hackers. Blockchain and smart contract technologies are bringing a slew of new security features to the Internet of Things and edge computing. To overcome these issues, the authors developed and prototyped an edge-IoT framework dubbed "EdgeChain" that is based on blockchain and smart contracts. The primary concept was to incorporate a permissioned blockchain and an internal currency or "coin" system in order to connect the edge cloud resource pool to each IoT device's account and resource utilisation, and hence the IoT devices' behaviour. EdgeChain used a credit-based resource management system to limit the amount of resource that IoT devices may access from edge servers based on predetermined criteria about priority, application kind, and previous behaviour. Smart contracts were used to enforce rules and norms governing the behaviour of IoT

devices in a non-discriminatory and automated way. All IoT activity and transactions were logged and audited using blockchain technology. The authors built an EdgeChain prototype and carried out thorough tests to validate the concepts. The findings indicated that although blockchain and smart contracts provide significant security advantages, the cost of incorporating them into EdgeChain is within a realistic and acceptable range [40].

The authors described a decentralised technique for establishing safe and reliable traceability to the original video maker or source in this article. Our solution made use of an IPFS-based decentralised storage system, an Ethereum-based name service, and a decentralised reputation system. Our solution framework, system architecture, algorithms, sequence diagrams, and implementation and testing details were sufficiently general to be applicable to different forms of digital material, such as audios, pictures, images, and manuscripts. Our technology may aid in the fight against deepfake films and audios by assisting consumers in determining if a video or digital material can be traced back to a respectable and reliable source. If a video or digital material cannot be traced, it cannot be trusted. Our solution, which was built on smart contracts, provides a secure mechanism for secondary artists to obtain permission from the original artist to duplicate and alter films. The whole code for the smart contract is accessible on Github. The smart contract's critical features and functioning have been thoroughly tested. The authors explained how our approach complies with security criteria and is resistant to well-known security threats. When the smart contract was deployed on the actual Ethereum network, the authors assessed the operating cost in terms of Ether and Gas. Cost estimates were kept to a minimum and were always less than 0.095USD per transaction. [41].

Blockchain can be used for the land record management . There are various issues like tranpancy and accountability in land titling and these can be solved with the help of blockchain

implementation so to avoid wrong ownership and fallacies. In india blockchain technology could be implemented for trusted land ownership and to secure the land records . By adopting the technology land titling system should improve and people could trust to whom the land belong [22].

The study of two countries Honduras and Georgia in Honduras digital land record implementation fails due to socio political affairs because present system was not fair while in Georgia technology successfully implemented due to private public partnership because people want land system to be more reliable .The study would help to identify the factors that constrained the technology[23].

With the supply chain globalization supply chain management is facing various issues .The study of blockchain technology and supply chain management reveals various barriers that supply chain and blockchain faces. The implementation of this technology will reduce the middle man and supply cahin management can be done with the help of blockchain technology but there are still various issues that need to be examined and addressed [24].

Blockchain technology is emerging in various fields , the current state of block chain and issues that the blockchain is facing there are various issues that needs to be addressed .it can not completely replace traditional database there are some situations where we need to implement traditional data base . Blockchain all features combines to make it more useful and secure as it mature its use is spreading in various fields but it need to be studied more precisely to be implemented in an efficient and fruitful way [25].

Blockchain that is basic of bitcoin has gained popularity in many other fields and has been widely used like health, iot and numerous other fields but there are various issues like scalability and security that need to be solved .There are different algorithms used for blockchain implementation.

Blockchain has much potential due to its key character decentralization . There are various future trends for blockchain implementation [26].

Numerous additional cutting-edge technologies, such as cloud computing [42,43], mobile edge computing [43], fog computing [44], big data analytics, artificial intelligence [45], and cyber physical systems [45], may be applied with Blockchain. Cloud computing enables wide use of compute resources for further processing. Numerous backend apps may be implemented on the cloud end due to its high scalability. When the Blockchain's size gets too large for other nodes to manage, cloud storage may be employed to store it. Cyber physical systems enable machines to interact and function autonomously. This independent behaviour may be multiplied via the use of Blockchain-based smart contracts, since actions can be programmed. These principles are simply implemented, resulting in several advantages. By analysing vast volumes of data, big data analytics evolved in the previous decade and has supplied individuals with an enormous quantity of business insight. Comparing the data collected and kept in the cloud side by side might reveal important insights that can result in better efficiency and revenues. By putting nodes between the cloud and the end user, fog computing brings processing capabilities closer to the end user. The architecturally suggested management nodes also assist in comparable data processing before it is transferred to the other end. Fog computing decreases latency, which is critical in certain use cases. Numerous more technologies, such as the utilisation of software defined networking, are being brought into the market these days. The majority of these may aid in improving the quality of service and data processing for users and devices, respectively [29-32]

According to the literature, there are few research initiatives that have identified and provided answers to land registry concerns. For instance, in [45], offered a method for digitalizing land records via the use of Blockchain technology by identifying the primary challenges associated with property registration and the political and social impacts on land records. They created and installed their suggested system in two states, Honduras and Georgia, and also tested the system by soliciting input from users to ascertain the proposed system's effectiveness in resolving the difficulties.

In [46], offered three alternative methods for maintaining records in three distinct fields: land records, medical records, and financial records. Additionally, the study discusses the challenges and solutions associated with implementing record keeping in the genuine ledger.

In [47], the Land Administration System's (LAS) limitations and difficulties are emphasised, including delays in registering and transferring land ownership, and supply of erroneous/conflicting data. Additionally, they have offered a Blockchain approach to address the aforementioned LAS concerns. Private Blockchain, according to this study, is a superior alternative for the LAS.

The authors have presented a Blockchain-based solution for monitoring, managing, transferring, boosting the transparency of public money distribution, and reducing manual tasks associated with the Brazilian Development Bank's development programmes [48].

Chapter 3 **Methodology**

3.1 Private Blockchain

The private-based blockchain is a controlled and permissioned approach for users in IoT platforms and intelligent apps to access information. This approach authorises information in private slots using a permission-based procedure that supports several essential criteria such as privacy level, dependability, and security conditions. Small platforms, such as social commitments and behavioural data management, are supplied using a private-blockchain technique. Social community apps and behavioural applications are two examples of established case studies for using private-based blockchain. [50].

A private blockchain is comprised of a single node capable of recording and maintaining data in a ledger. A private blockchain is often not accessible to outside parties. A private blockchain platform is utilised for a company or organisation; only authorised entities may join the system. Predetermined nodes record and maintain a consortium blockchain. The specified nodes decide whether a member has access to a consortium blockchain system. A consortium blockchain is a combination of semi-public and semi-private networks with unique applications for organisations and members. [51-53].

In terms of performance, private blockchains outperform public blockchains, which need more time and compute power to approve a transaction due to PoW (proof of work) [63].

Because of the lower scope of the network compared to the public blockchain, a restricted number of nodes, and the majority of honest nodes, the PoA (Proof-of-Authority) consensus mechanism can be used in the private blockchain.

Predefined permission nodes generate blocks in the PoA consensus method, and authorised nodes vote to add new nodes or delete rogue nodes. The transaction cost and block interval may be greatly lowered with this approach, significantly improving the transaction processing speed of the whole blockchain network and achieving the throughput necessary for practical implementation [64-65].

3.2 Hyperledger Fabric Framework

Fabric enables a paradigm that is fundamentally different from most blockchains in order to provide enhanced performance, flexibility, and privacy features. Fabric employs an execute-order-validate paradigm rather than an order-execute architecture. [55].

Hyperledger Fabric is a permissioned blockchain implementation that provides a secure, private, adaptable, scalable, and resilient framework for the deployment of multi-purpose distributed applications. Fabric uses plug-and-play membership and consensus services to execute the concept of customisable smart contracts, often known as chaincoodes, to manage interactions among framework participants. A typical transaction flow in a Fabric framework may be broken down into four stages: proposal, endorsement, ordering, and commit.

The flow begins when a client node sends a transaction proposal to one or more network peers in the hopes of receiving transaction approvals. The peers simulate and approve the transaction. Once the transaction has been endorsed, it is returned to the client, who subsequently submits it to the blockchain's ordering service. The ordering service then runs the consensus process and presents it to a committed peer, who performs final validation before adding the transaction to the ledger [54].

3.3 Hyperledger Composer

In this study, we employed HyperLedger Fabric in conjunction with HyperLedger Composer, which is a development toolkit for creating business networks. Identity management is one of Fabric's key functionalities. This feature enables a developer to handle user authentication and authorisation. Another possible feature is connected to privacy and confidentiality services. Fabric does this by employing private channels, which are restricted communications methods that guarantee both secrecy and privacy for transactions. Additionally, Fabric is atomic, and its smart contracts can fail in two ways: 1) If an error occurs during the execution of chain-code, the peer will fail and the error will be returned. 2) If a transaction is authorised but subsequently fails, it is denied and documented as a failure [56].

It implements business networks and transaction logic using a simpler modelling language. Assets and activities done on these assets may be represented using Hyperledger Composer. In the web browser, applications may be emulated. It also allows you to establish a business network REST API and a skeleton Angular application using the Yeoman framework.

Hyperledger Composer's modular nature allows it to handle three alternative runtime implementations: Hyperledger Fabric, Playground, and Node.js. The state is saved in the Hyperledger fabric ledger, the local browser using Playground, and RAM with Node.js [57].

3.4 cURL

cURL is used in command lines or scripts to transfer data. curl is also used in cars, television sets, routers, printers, audio equipment, mobile phones, tablets, settop boxes, media players and is the Internet transfer engine for thousands of software applications in over *ten billion installations*. cURL is used daily by virtually every Internet-using human on the globe [58].

3.5 Node.js

Node.js is a JavaScript application runtime platform. JavaScript is a popular programming language that is mostly used in online applications. Node.js was created in 2009 to provide an asynchronous event-driven JavaScript engine for scalable web applications. Given that JavaScript was created to be used in the area of client-side scripting, many developers rely on third-party modules, such as the I/O framework, to bring in some server-side capabilities, and these modules are significantly dependent on one another. The majority of Node.js modules are maintained by Node Package Manager (NPM), and the number of Node.js modules registered in NPM is expected to exceed one million by December 2020.

The majority of available Node.js module vulnerability analysis tools are based on statistical analysis of previously reported vulnerabilities. For example, target module "A" is considered susceptible since its version is known to be vulnerable, but this technique cannot investigate previously unknown vulnerabilities. Other tools that attempt to find security flaws in JavaScript apps without statistical studies tend to focus on detecting faulty code rather than immediately detecting vulnerabilities [59].

3.6 Docker

Docker is a well-known example of container technology that has become a de facto standard in software development and has played an essential part in moving the paradigm away from full-stack virtualization. Docker defines enclosed environments (i.e. containers) and container orchestration standards using domain-specific languages [59].

Docker-based infrastructures and imagine better solutions to enable these behaviours while addressing any underlying issues. Docker allows for the containerization of a software package as well as the accompanying configuration and setup data. Such containers may be deployed quickly and simply while avoiding compatibility difficulties. In fact, according to a recent research, Docker can speed up the deployment of software components by 10-15 times.

Docker is now one of the most popular containerization systems. Docker has seized 83 percent of the containerization industry, which is expected to generate $2.7 billion in sales by 2020. In 2018, Datadog estimated that around a quarter of their clients had already used Docker [60].

3.7 Proposed system

We discuss the proposed system architecture and its demonstration. We describe a high-level architecture of the proposed system - Blockchain-based Land Record Management in Pakistan - as well as a brief overview of its components. The suggested system architecture (shown in Figure 1) is organized into three stakeholders: the Registrar Department, the Revenue Department, the NADRA Department, and Blockchain technology.

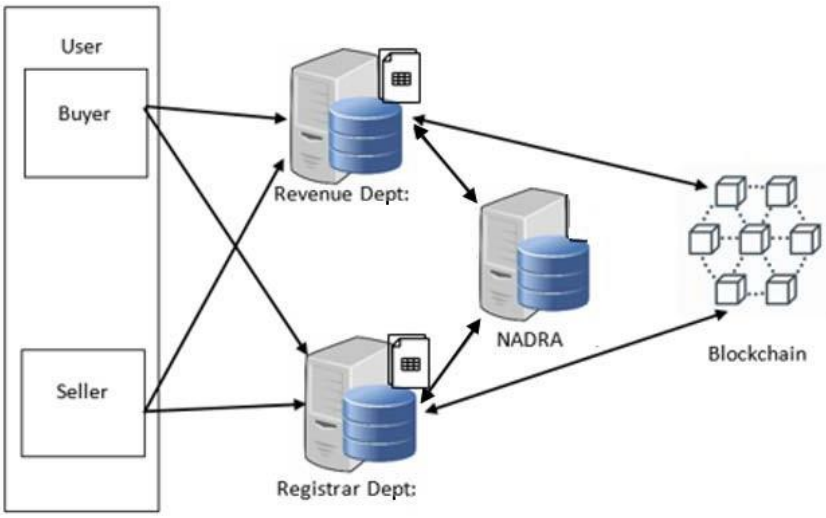

Figure 1 shows the architecture of the proposed system.

3.8 Registrar department

The Registrar Department is in charge of issuing sales and entry (FORM-II) certifications, as well as storing data locally and on the Blockchain network. This department has its own ledger and broadcasts data to all nodes in the network.

3.9 Revenue department

The Revenue Department is responsible for issuing the challan and providing property paperwork for further registration procedures, and it keeps all prior documents, as well as new owner's documents, in local storage and Blockchain.

3.10 NADRA department

NADRA is in charge of verifying the buyer's and seller's bio-data given by the Revenue and Registrar departments from its own local storage and sending feedback to the asking department.

Blockchain technology offers immutable ledgers, smart contracts, and proof of work, among other benefits. An immutable ledger stores data on property ownership that cannot be changed. Smart contracts allow you to limit the issuing of many certificates at the same time.

Chapter 4 **Results and Discussion**

In this chapter, we discuss the work flow of the proposed approach and demonstrate the results. The proposed system implemented at the Revenue department creates a challan in the name of the owner and saves the challan data on local storage in response to a request from the owner.

After the owner submits the challan to the bank, the proposed system at the Revenue Department checks the owner's given information through NADRA.

Following the conclusion of the verification procedure, a sales certificate in the name of the owner is provided for a set length of time. Data from the sale certificate and the paid challan are maintained in both the local database and the Blockchain network.

The planned technology, which will be installed in the Registrar's office, would connect with the NADRA system to validate the purchaser's bio-data as well as the issued sale certificate. Following successful verification, the system creates a property register and records all data locally as well as on Blockchain.

Following property registration, the proposed system at the Revenue Office gives the FORM-II certificate to the new owner (purchaser). This procedure completes the transfer of property ownership. The suggested system's operation is depicted in Figure. 2 by a data flow diagram.

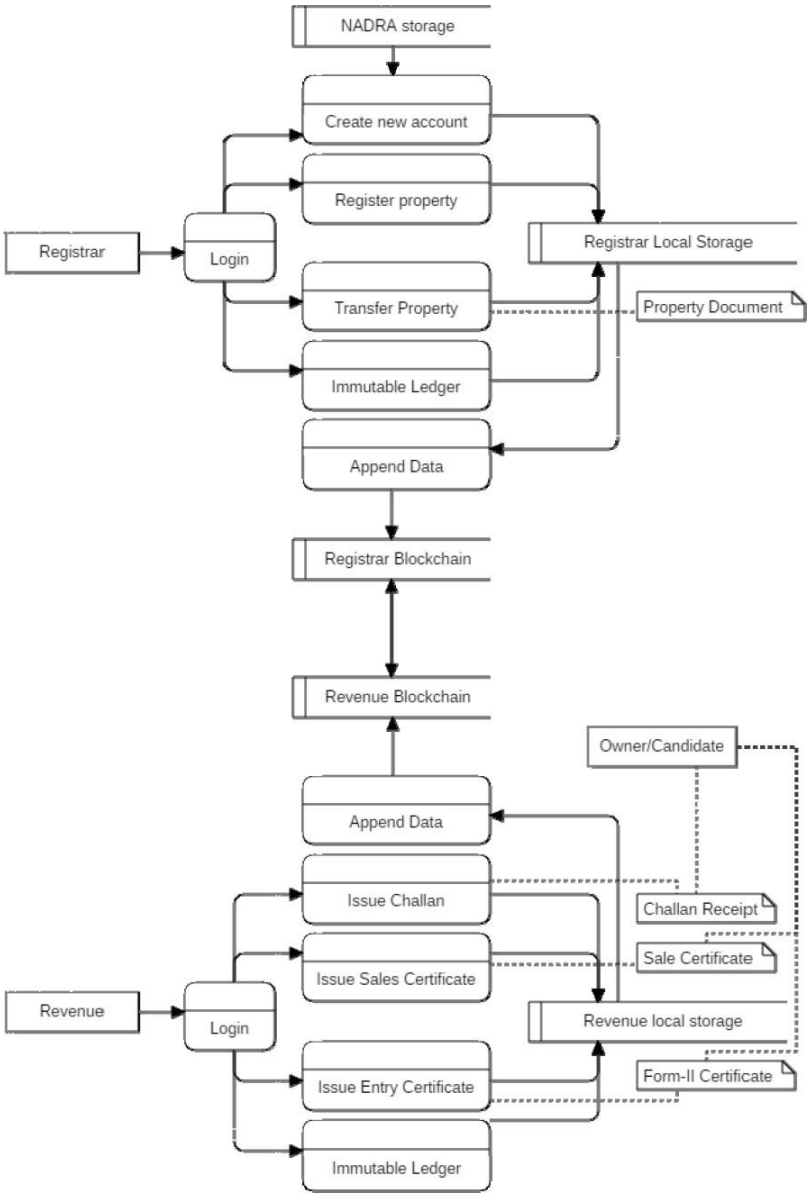

Figure 2 shows the demonstration of the proposed system

4.1 Implementation

A snapshot shown in the Figure 3 illustrates creation of an account of seller and/or buyer. The interesting party shares the details of themselves and click on transact to create the account.

Figure 3 shows the creation of an account

After the creation of the user. NADRA needs to verify the authenticity of the user. Figure 4 shows the snapshot of NADRA verification. NADRA adds the customer account number to verify the user. In the figure below, the green message shows the verification of the user.

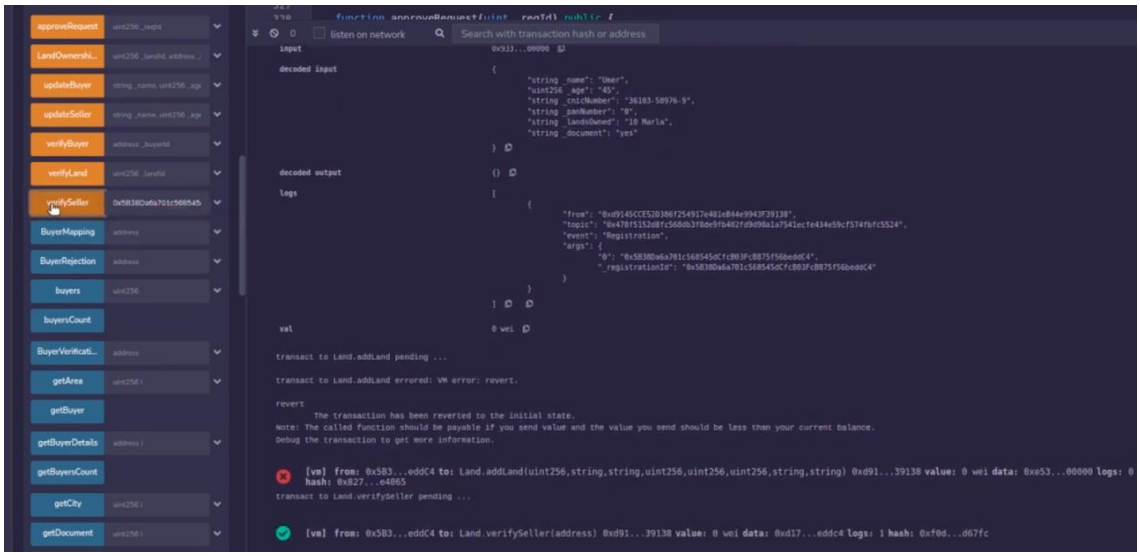

Figure 4 shows the verification of the user

Figure 5 shows the snapshot of the addition of the land in the respective user's account. After clicking on transact. The system checks whether the user is verified or not. If the user is verified. The system adds the land on the respective user's name.

Figure 5 shows the addition of the land.

After the addition of the land, the NADRA verifies the land as shown in figure 6. After the verification of the land, any verified buyer can purchase the land.

Figure 6 shows the verification of the land

Figure 7 shows the snapshot of requesting a land for purchase. In order to purchase the land, buyer adds the seller id and land id for the requestLand. After clicking on the transact button. The green message shows the verification on the requestLand.

Figure 7 shows the land request to purchase the land

In order purchase the land, after the land request, the user transfer the payment to the corresponding buyer as shown in figure 8. For the payment, it needs to be added the same amount as the seller added during the addition of the land.

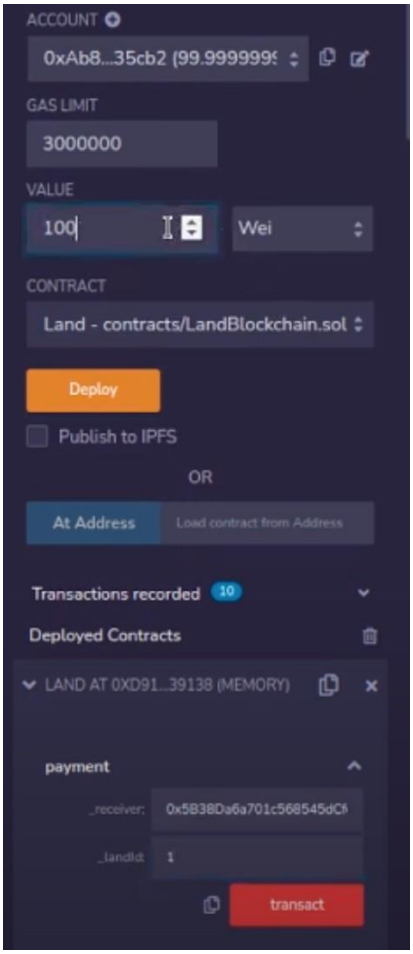

Figure 8 shows the payment transaction

After clicking on the transact, the green message shows on the screen to verify the purchase. The last step is to change the ownership of the land as shown in figure 9. To do so, the new owner id is added with the land ID for the ownership transfer.

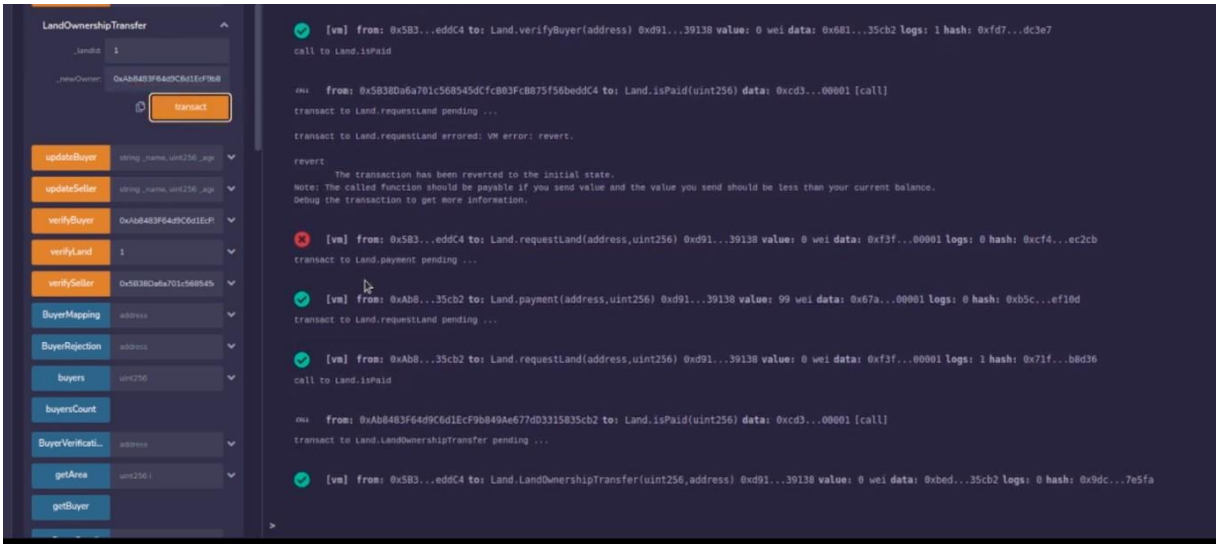

Figure 9 shows the land ownership transfer

Chapter 5 **Conclusion and Future Work**

Due to the many distinguishing characteristics of Blockchain technology, such as immutable ledger, security, interoperability, and scalability, the literature has emphasised the importance of using Blockchain technology in multiple fields in general and land management in particular. We have identified a number of Land Management concerns in the literature. While several nations have lately offered solutions based on Blockchain technology to address these difficulties, relevant departments in Pakistan responsible for land management seem to have relied on conventional land management methods, leaving the challenges raised unsolved. To solve the constraints of Land Record Management in Pakistan, we developed a Blockchain-based Land Record Management solution and detailed its design and execution in this paper. We have validated the proposed system's functionality using fake data and intend to seek authorization from the relevant departments in the future to install and test it in real-world circumstances. The feedback and difficulties identified during real-world deployments may result in the development of a new version of the planned system. In the future, we will seek to reduce the costs associated with blockchain in land management and to make the system more functional and efficient from a Pakistani perspective. Conduct further research on the scalability of Blockchain. The majority of current research on Blockchain technology is concerned with security and privacy concerns. Scalability concerns like as throughput and latency must be solved before Blockchain technology can be widely used.

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