A Hyperledger Fabric Based Tamper Proof Decentralized Land Registry System For Bangladesh

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Declaration

It is hereby declared that

1. The thesis submitted is our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

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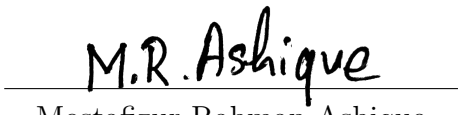

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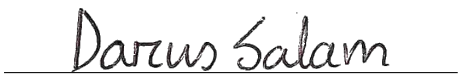

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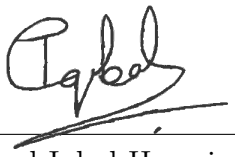

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Abstract

In many countries, authorities in charge of land registration are commonly charged for the improper treatment and manipulation of land records. This is the case in both developed and developing nations. Property records in Bangladesh are particularly unprotected to fraud and corruption for the country's widespread indigence and low literacy rate. As a consequence of this, numerous parties assume several levels of authority over a specific plot of property and claim that it belongs to them in its entirety. The combination of these datasets has made it significantly more likely that it will be subject to a variety of security threats. Research on decentralized systems has attempted to find ways to improve the dependability of these systems. These kinds of problems with centralized systems are currently being addressed through the development of decentralized solutions that are based on blockchain technology. As the starting point for our investigation, our group plans to create a hyperledger fabric system that can be used in the future and is based on significant land record registration models. The Bangladeshi government agency in charge of land registration will benefit in particular from the conceptual framework that we have suggested. In this paper, we propose a conceptual working prototype for the Bangladeshi government to use in constructing a decentralized land record registration system. The prototype would structure the major components of the system.

Keywords: Decentralized Land Record Registration System, Tamper Proof, Blockchain Technology, Hyperledger Fabric

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We owe it all to Allah (SWT), thus first of all, we are grateful to Him. Finally, we would want to thank our respective supervisor, Muhammad Iqbal Hussain sir, whose unwavering encouragement and insightful guidance were vital to our success.

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Chapter 1

Introduction

Land registration is a time-consuming process that requires numerous steps in every country because it requires the participation of all the stakeholders who will be involved in the registration in some capacity, be it directly or indirectly.Concerns about data fraud, the security of sensitive data, and the risk issue of system failure due to natural calamities, such as a server failure, are major problems with the current method for preserving land record titles. These are all very serious concerns. In addition, there is an excessive amount of corruption among the people who provide related services, making it exceedingly difficult to keep the land records protected against fraud. There are a lot of concerns that are quite similar to those in Bangladesh, such as an escalating conflict surrounding candidates or many claims to the same piece of property. Blockchain is a cutting-edge technology and database that has the potential to fully do away with the problems that are now experienced by the systems that are in place. This is because blockchain is superior to the techniques and procedures that are now used for the maintenance of land titles and the storage of data. The fact that the blockchain is decentralized is the technology's most crucial and defining feature. Each node's data contribution is checked by every other node in the network. The only way the shared data can be added to the blockchain is if all of the users agree on how it should be included.

1.1 Motivation

In many aspects, the nation of Bangladesh is becoming more digitized; yet, there are still some essential industries that suffer from poor management and inefficiency, which we notice. One of these is the system for land registration, which is where people confront a great deal of difficulty that needs to be handled. A framework is wished to be offered by us that makes use of blockchain technology, which is relatively new in comparison to the technology that is currently in use, in order to make the entire process more effective and visible to the people. We want to build a permanent land registration system so that the fraud can be cut down and protect the rights of the people. This system will ensure that only the authenticated person can obtain the authentic information easily and without any hassle, which will prevent people from wasting money and time in the wrong place.

1.2 Problem Statement

Everyone is aware that Bangladesh is a nation that is developing at a rapid rate. The Gross Domestic Product is expanding as the economy continues to grow. In conjunction with each and every great aspect of this, there are also some drawbacks. It is general knowledge that corruption, mismanagement, and manipulation are widespread in Bangladesh. Since it requires the cooperation of all of the stakeholders who will either directly or indirectly be involved in the registration process, land registration is a time-consuming procedure that involves a number of different steps in every country. The current technique of land record title storage system causes major worries among the linked service holders, including data fraud, fragile data security, and corruption. These issues are caused by the system. In addition, because individuals who live in rural areas have less information about these topics, they are required to seek assistance from third parties who are willing to take advantage of their weakness. Sometimes, the most fundamental knowledge, which was basically a human right to know about own properties and inheritance, needed to be purchased with money in order to be obtained. In a nation such as ours, one of the primary challenges that lies ahead for land administration is the upkeep of an accurate and current land registry that is safe from invasion by hackers, dishonesty, or corruption. There are several countries that are still developing, such as Bangladesh, that do not have an appropriate ledger to keep track of land transactions. The land registry offices' physical records are prone to inaccuracies, deterioration, a lack of transparency, and manipulation, which makes them difficult to use. Because uncertain ownership leads to widespread conflict and attempts to illegally claim lands, one of the most difficult difficulties is to keep property records that are accurate and real. Keeping records in a fashion that is both organized and manageable is especially challenging in Bangladesh due to the country's extremely high population density. It is seen that our nation is becoming increasingly digitized in a variety of contexts. It is essential to simplify the process of land registration, and improved technology has the potential to be a savior in this respect. The land sector is currently facing its most significant issue yet, which is preventing property disputes, frauds, and corruption while also ensuring authenticity, transparency, and people's rights. People have to go through a lot of intricate processes when they want to buy or sell land, and some of those processes aren't even helpful occasionally. This causes them to waste their time as well as their money, and in the meantime, some dishonest and greedy people make money in an unethical way. Therefore, these problems need to be fixed, and all of the information pertaining to real estate should be arranged in such a way that it is clear to everyone, regardless of their background, so that they do not require the assistance of a go-between.

The Present Land Registry System of Bangladesh: At present, there are a number of procedures involved in registering land in Bangladesh, all of which are principally governed by the Land Registration Act, 2002, and the Registration Regulations, 2014. [10] The Ministry of Land's Department of Land Records and Surveys is in charge of the procedure. These are the broad, overarching steps that make up Bangladesh's land registration system:

- **Application for land registration:** Submitting an application to the local land office is the initial step in the land registration procedure. Accurate

property details are required to be filled out in the application form.

- **Verification of documents:** Next, the provided documents will be checked for accuracy. Those working in the land office are the ones responsible for doing the checks to ensure the documents are genuine and accurate.
- **Payment of fees:** The applicant is responsible for paying the registration fee, stamp duty, and any other applicable fees after the verification process is complete and at the current rates.
- **Preparation of deed:** The land office then drafts the deed of transfer, which lists the property's address, the buyer's name and address, and the seller's name and address. The parties involved have signed and witnessed this deed.
- **Registration of deed:** Last but not the least, the deed must be registered with the land office. Once the transaction is recorded, the purchaser has full ownership rights.

Getting land registered in Bangladesh can be really a lengthy and complicated procedure. The government is, nevertheless, making efforts to improve the efficiency and effectiveness of the system.

1.3 Objective & Contribution

We propose building a hyperledger fabric-based solution to the problems that the current centralized land record data storage system faces. In Bangladesh, land registry data is stored in centralized servers, which creates several limitations for this proposal. When real-world property records are digitized, it is necessary to design secure computer systems that can thwart hacking efforts significantly more effectively than in the past. These kinds of systems ought to be built on frameworks that guarantee their perseverance and structural soundness. It is not possible to deploy a decentralised land record registry in practice in Bangladesh because no such framework exists at present. Since blockchain technology is just getting started, this is to be expected. This study will make a significant and verified contribution by developing a conceptual framework for hyperledger fabric-based land registration systems that can guarantee transparency, security, and proper rights without the need for a trusted third party. Data loss from natural disasters or from a powerful adversary who can forge all accessible data are just two of the threats that a centralised server storing land record data is vulnerable to. Among all these problems, the possibility that the land record authorities that deal with the data are themselves forging the data is the most serious and practical. So, many parties interested in a property who are the rightful owners are unaware of their ownership. Our primary goals in making this contribution are to bring attention to the challenges that exist in the current land manipulation systems and to increase awareness among government authorities about the potential applications of one of the most disruptive technologies, blockchain. Our primary goal is to use blockchain technology in a decentralised and distributed fashion to address and ultimately triumph over these deficiencies in the existing land management system. Hence, to achieve our goal, we developed a hyperledger fabric-based conceptual framework and tested it with

a system built on the same technology. we attempted to make contributions to the wider research community in the following ways:

(a) We have made an effort to investigate the shortcomings and problems that the existing land register systems in our nation are causing at the moment. Also, we found that the conflicts and corruption were concentrated primarily in the rural areas, which is where the defenseless people were most easily taken advantage of by third parties.

(b) We concentrated our attention on the difficulties that the authors of the earlier papers encountered when attempting to solve comparable problems by reading those papers and having a discussion within our group about the various potential solutions.

(c) **Tamper Proof:** A product, system, or document is said to be tamper-proof if it is created in a way that makes any attempt to change or modify it obvious. Tamper-proofing is a crucial security precaution that guards against unauthorized individuals tampering with or manipulating sensitive data or priceless objects. A system or product that is tamper-proof is often built with characteristics that make it challenging or impossible to access or modify without leaving clear signs of tampering. When someone tries to open or tamper with tamper-proof packaging, for instance, seals or special tapes may be used that shatter or change color. Encryption, digital signatures, and other security methods that guarantee the integrity and authenticity of data may be used in digital systems to prevent tampering. A product, system, or document should generally be tamper-proof in order to guarantee that any illegal attempt to change or tamper with it will be quickly discovered and stopped. We, therefore, want to make the system as tamper-proof as possible.

(d) **Decentralized:** A system, organization, or network that runs without a central authority or control is referred to as decentralized. In a decentralized system, control and decision-making are shared among all participants or nodes in the network as opposed to being exercised by just one. Each participant in a decentralized system has an equal amount of authority and autonomy to decide what to do and how to do it based on the network's agreement. In blockchain technology, transactions are checked and confirmed by a network of nodes rather than a centralized authority, and this form of system is frequently employed. By eliminating the possibility of a single point of failure or corruption, decentralization is frequently considered as a strategy to improve transparency, security, and trust in a system. When no one needs to wait for clearance from a centralized authority, it can also result in more effective and quicker decision-making. Our system tends to be decentralized for better performance and intractability.

(e) **Efficient & Optimized:** Our system will work fast and will provide the best possible outcome with improved efficiency and effectiveness. Here, handling the owner is easy and secure. So our system will work as an efficient and optimized solution.

Chapter 2

Background

The land register system in Bangladesh is riddled with inconsistencies and other problems. This system is extremely flawed due to its lack of transparency, corruption, and ignorance of the law, as well as its inefficiency, unreliability, and lack of development. It is believed that the courts are now processing about 3.2 million litigation connected to land issues at this time. [3] A significant number of people who have been treated unfairly do not possess the legal standing required to initiate legal action. Land disputes have the potential to spiral into acts of violence and criminal behavior. It's truly bad that land disputes are responsible for roughly 60–80 percent of everyday criminal activities, yet they are. [1] The bulk of those who are victimized are those living in rural or landless areas who, due to a lack of financial resources, are denied their right to access justice. In a nation that is developing at the rate that ours is, the method by which land is distributed is frequently accused of fostering inequality. This constitutes a violation of both the fundamental rights and the fundamental principles of a state's policy, both of which promise to promote economic and social fairness among all of the people living in a nation.

2.1 Related Studies

1. **Blockchain:** Blockchain technology can be visualised as a series of blocks, each of which contains a specific piece of data or information. A direct line connects each pair of blocks. A "hash" is a unique code assigned to each block that links it to the block preceding it in the chain. Using complex cryptography, the whole chain is protected, making it nearly impossible to change or tamper with any of the data in the blocks. Each block in the chain also has a record of the transactions that have already happened on the blockchain. This lets users see the history of the data and make sure it is correct. The fact that a blockchain is decentralized means that it is spread across a network of computers instead of being kept in one place. This makes it hard to change or censor.

2. **Merkle Tree:** The Merkle tree algorithm is an integral feature of the blockchain system. It's a mathematical data structure that summarizes the transactions that occurred within a given block by comparing the hashes of those blocks with one another. The content of a huge dataset may be verified quickly and safely. The accuracy and completeness of the information may be confirmed

as well. Both Bitcoin and Ethereum are founded on the data structure known as the Merkle Tree. The Hash Tree is another name for the Merkle Tree. A digital fingerprint of the entire set of transactions is generated by a Merkle tree before it is used to store each individual transaction in a block. The user is given the ability to determine whether or not a transaction can be included in a block. Merkle trees are created by repeatedly hashing each pair of nodes until there is only one hash left. Merkle trees are a type of binary tree. This particular hash is referred to as the Merkle Root. The Merkle Trees are constructed beginning at the base and working their way up. Each node that is not a leaf is a hash of the hashes that came before it, while every leaf node is a hash of the transactional data that it contains. As Merkle trees are contained within a binary tree, the number of leaf nodes absolutely have to be even. In the event that there is an even number of transactions but an odd number of hashes, the most recent hash will be replicated once in order to produce an even number of leaf nodes.

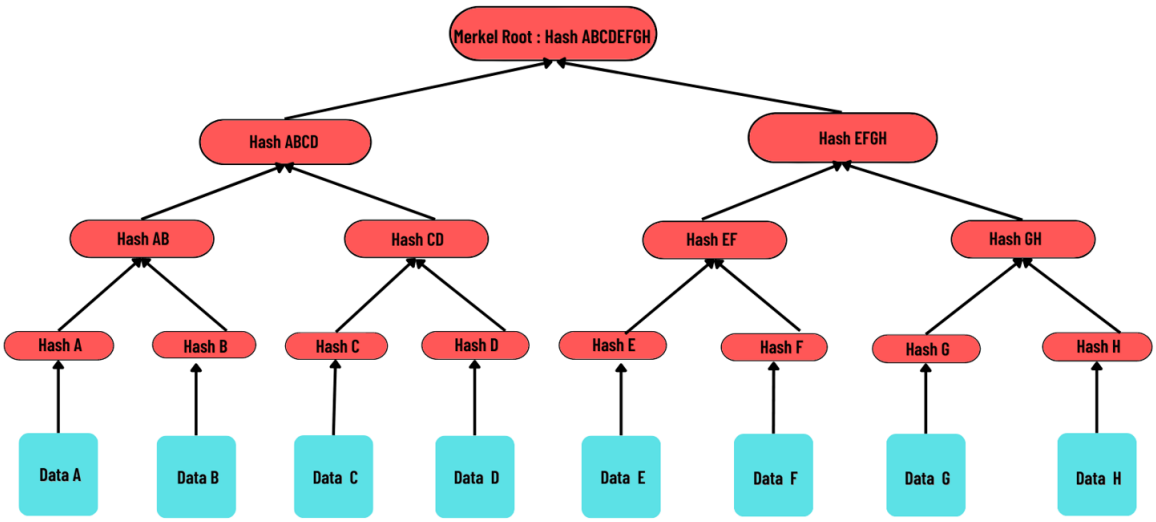

Figure 2.1: Merkle Tree

3. **Cryptography:** The purpose of cryptography is to protect information from prying eyes. Cryptography is employed in the blockchain to ensure the safety of transactions between nodes in the network. Two of the most important aspects of a blockchain are encryption and hashing. A P2P network encrypts communications with the help of cryptography, but a blockchain relies on hashing to keep the block information and the link blocks secure. To prevent duplicate spending and ensure the safety of all involved parties, cryptography is essential. In this way, various transactions on the blockchain may be protected. It makes sure that only the people for whom the transaction data was intended may access, read, and handle the data.

4. **Digital Signature:** A cryptographic procedure known as a digital signature can be used on digital data in order to validate both its authenticity and its integrity. We may think of it as the digital equivalent of the traditional

handwritten signatures, but with increased degrees of both complexity and safety. The best way to explain what a digital signature is and how it works is to think of it as a code that is appended to a message or document. The code, after it has been produced, serves as verification that the message has not been altered in any way while it is being transmitted from the sender to the receiver.

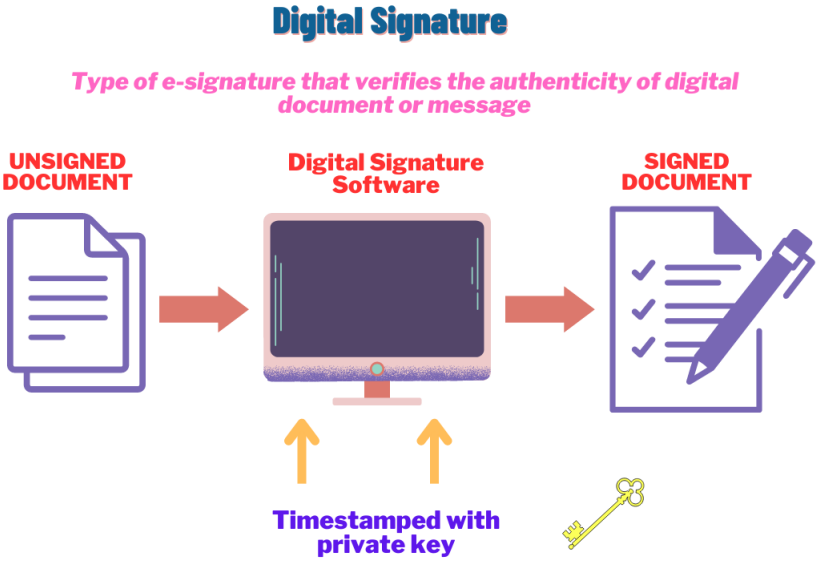

Figure 2.2: Digital Signature

5. **Types of Blockchain:** All nodes in a public blockchain have equal permissions to view the blockchain, upload new data blocks, and validate data blocks, while in a private blockchain, a centralized authority determines who can participate as a node. Each node may or may not have equal access to administrative resources depending on policy. As the general public cannot easily access private blockchains, they are only partially decentralized. There are issues with both public and private blockchains. For instance, validating new data on a public blockchain can take longer than on a private one, and malicious actors are more likely to gain access to private blockchains. Unlike private blockchains, which are managed by a single entity, consortium blockchains are managed by a consortium of entities. Consortium blockchains are safer than private blockchains because they have fewer central points of failure. Hybrid blockchains are private blockchains managed by a single company, with the public blockchain keeping a close eye on them for transaction validation purposes.

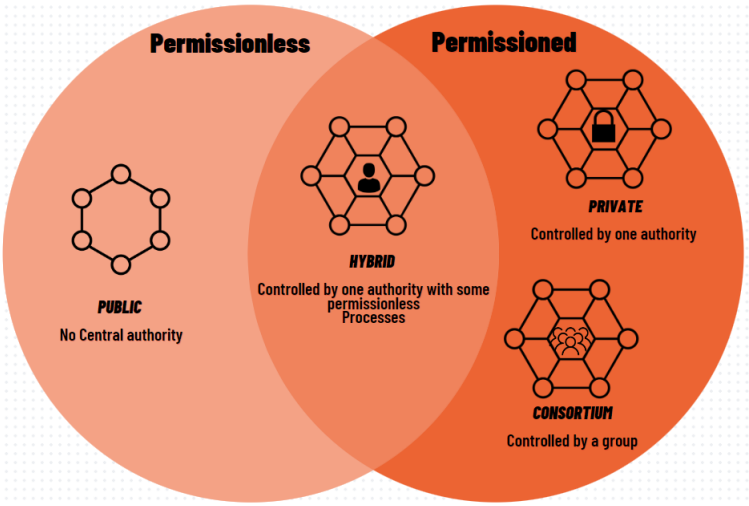

Figure 2.3: Types of Blockchain

6. **Consensus Algorithms:** Consensus algorithms in blockchain are the agreements achieved among the honest nodes in a network. These are achieved to make the system distributed and ensure reliability in the existing network. This is to ensure that every node is working in the same manner and receiving requests in the same sequence. There are many consensus algorithms used in blockchain.

7. **Hyperledger Fabric:** In order to facilitate blockchain technology, The Linux Foundation created the Hyperledger Fabric platform. The group of programmers working on it is large and increasing. Permissioned fabric networks require the identities of all nodes to be known and validated before they may be used. This benefit is especially relevant in sectors where data must be protected from unauthorized parties, such as the healthcare, supply chain, banking, and insurance sectors. Channels in a fabric network create a secret "subnet" of communication between two or more designated members of the network, allowing for the conduct of confidential business between those members. Each participant to a blockchain transaction must be verified and granted permission to use the channel on which the transaction is conducted. Hyperledger Fabric's consensus process allows for high transaction throughput, making it suitable for enterprise-level use cases. Fabric avoids the speed hit that Byzantine Fault Tolerance can deliver during transaction validation since it is a permissioned blockchain platform.

8. **Peers:** Peers in a blockchain network are the nodes or machines that carry out the same functions and have the same influence as one another. Blockchain is a peer-to-peer network that functions as a distributed ledger for digital assets, wherein each node keeps an immutable copy of the ledger and checks the authenticity of entries with all other nodes to ensure data integrity. A group of peers communicating with one another is essential to the operation of the Hyperledger Fabric blockchain. When the ledger and smart contracts are managed by peers, they play a crucial role.

9. **Orderer:** The consensus process, which entails the ordering and consolidation of transactions into blocks, is open to all nodes in several distributed

blockchains, including Ethereum and Bitcoin. Hyperledger Fabric operates in a fundamentally different way, eliminating the need for probabilistic consensus algorithms that eventually guarantee ledger consistency to a high degree of probability but leave the system open to divergent ledgers (also known as a ledger "fork"), in which participants in the network disagree on the accepted order of transactions. An "orderer" node, also known as an "ordering node", is responsible for coordinating the ordering of incoming transactions, and together with similar nodes, a "ordering service" is built. Due to the fact that Fabric is built on deterministic consensus procedures, all blocks that have been certified by their peers are verified as being correct and final. Ledgers can fork in many other decentralized, permissionless blockchain networks.

10. **Certificate Authority:** Digital certificates are electronic documents issued by a certificate authority (CA), also called a certification authority, to verify the legitimacy of an entity (such as a website, email address, company, or individual person) and to affix that entity to a cryptographic key (CSR). A certificate signing request (CSR) is an encoded text file that contains the public key and other information that will be included in the certificate (e.g. domain name, organization, email address, etc.). Certificate signing requests (CSRs) and associated key pairs are normally generated on the same server or workstation where the certificate will be installed, and the CSR's contents vary with the certificate's validation level and intended use. After the CSR has been generated, the applicant sends it to a CA, which verifies the data contained within it is accurate and, if so, digitally signs the certificate with an issuing private key and returns it to the application.When the signed certificate is delivered to a third party (for instance, when that third party visits the certificate-website), the third party verifies the signature using the applicant's public key, which is kept secret and never given to the CA. The certificate can also be used by the recipient to verify that the signed information was sent directly from the owner of the associated private key and that no alterations were made to the data after signing. This aspect of the certificate relies heavily on a trustful chain of certification authorities.

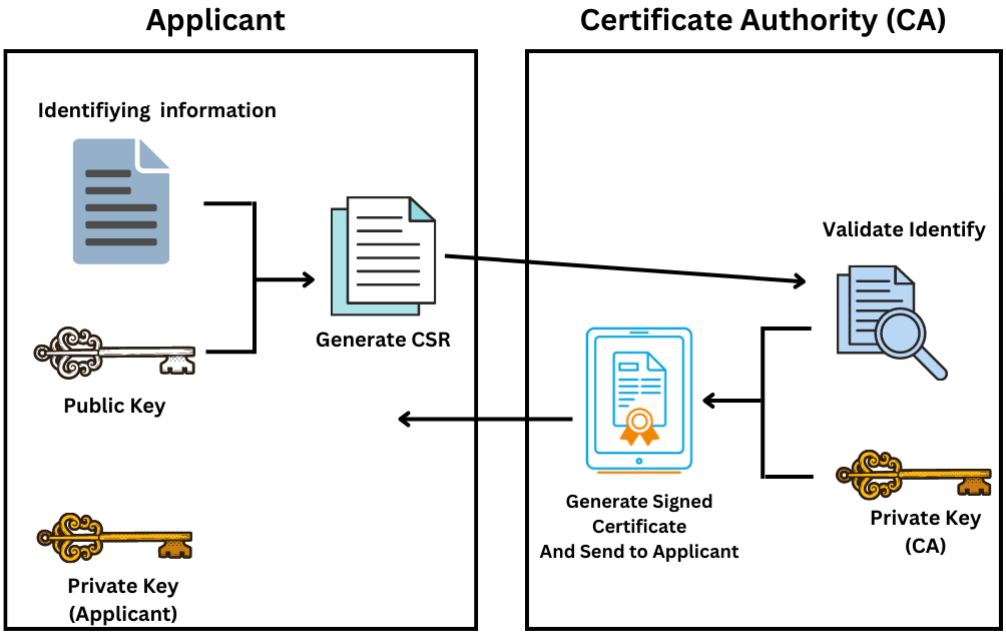

Figure 2.4: Certificate Authority

11. **Membership Service Provider:** Membership Service Providers (MSPs) are used to verify that peers are authorized to support transactions. The signature is verified using the peer's certificate's public key to ensure the legitimacy of the transaction. MSP is the technique by which the rest of the network accepts and trusts this identity. A set of folders used for administrator) to define the permissions to do what you're trying to do) is part of the MSP configuration that represents the organization both internally (the organization decides who the administrator is) and externally (other organizations can verify the entity owns it legally). CAs bring about certificates that represent identities, while MSPs maintain lists of approved identities. MSP determines root CAs and intermediate CAs that are approved to define members of the trust domain. This includes listing the member's ID or identifying CAs authorized to issue valid IDs to members.

12. **Shared Ledger:** A database that is replicated and kept in sync over multiple computers, networks, or geographic locations is referred to as a distributed ledger. A shared ledger is a database that is agreed upon by multiple users to be shared and kept in sync with one another. This type of ledger is also known as a distributed ledger, distributed ledger technology, or DLT. It enables transactions to have public "witnesses." The participant at any node of the network is able to access the recordings that are shared throughout that network and can hold an identical copy of it. Any alteration or addition that is made to the ledger is reflected and replicated to all of the participants within a number of seconds or minutes, depending on the situation. Because it only has one point of failure, a centralized ledger is more vulnerable to cyber attacks and fraud than decentralized ones.

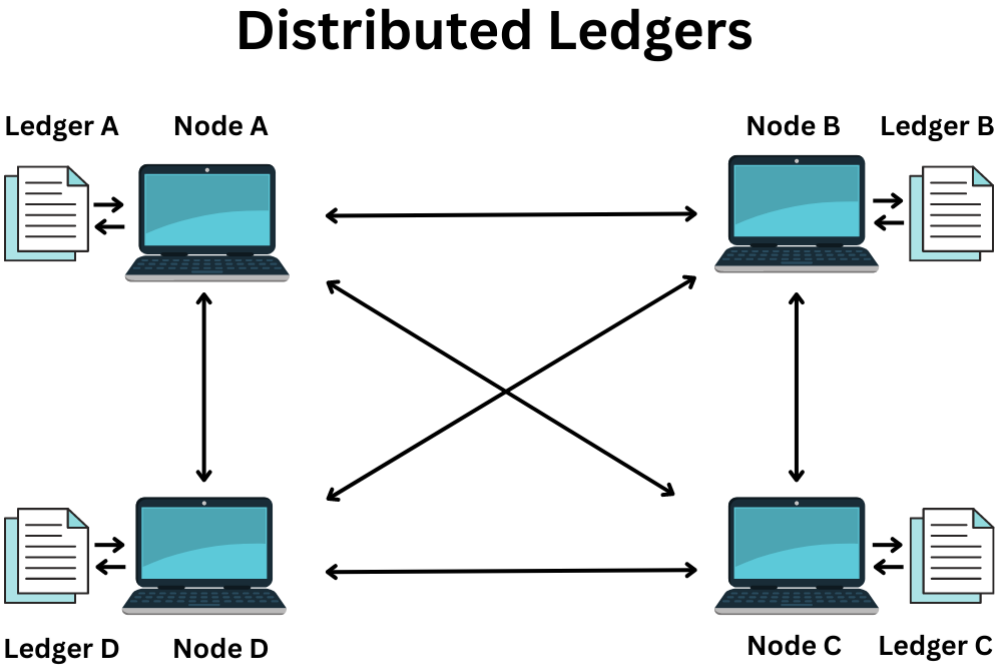

Figure 2.5: Distributed Ledgers

13. **World State and Transactional Log:** In computer science, the term "world state" refers to a database that stores the latest values of a group of ledger states. Instead of calculating these values by walking through the full transaction log, a computer may just query the world state to retrieve the most up-to-date value. As we'll see, Hyperledger Fabric offers some leeway in how ledger states are expressed beyond the conventional form of key-value pairs. With the ability to establish, update, and eradicate states, the global state is subject to regular shifts. Second, the status of the world is recorded in a transaction log called a blockchain. All transactions that have occurred since a certain block was added to the blockchain are recorded within it. This allows one to piece together the chain of causes and effects that culminated in the current situation. The immutability of the blockchain data structure stands in stark contrast to the global state. Data blocks (transactions) are recorded chronologically and securely in a distributed ledger called a blockchain. The transaction log is more useful when looking into long-term actions.

14. **Asset:** Assets recorded on a blockchain may be thought of as digital currency. Some of them signify ownership in a company or a project. Others, like Bitcoin, are designed to function as currencies rather than as representations of ownership in a company. If one has something recorded on a blockchain, it is digital, fully owned, and can be transferred to another person instantly and without any delays. Bitcoin, ethereum, and other cryptocurrencies, code, digital content, and film clip, non-fungible tokens (NFTs) and other valuable data and code kept digitally are all examples of digital assets.

15. **Docker:** Docker is a free and open-source software environment for build-

ing, releasing, executing, and managing containerized applications. Containers simplify the development and delivery of distributed applications since they are standardized, executable components that contain the application's source code as well as the OS libraries and dependencies required to run the code. Cloud-native development and hybrid multi cloud configurations have seen explosive growth as more and more enterprises adopt them. Developers may build containers without Docker by utilizing the native features of Linux and other OSes. Containerization was already quick, simple, and secure before Docker came around. Docker's widespread adoption may be attributed to its many useful features, including its increased portability, automated creation, versioning, reuse, shared libraries, and precise updates.

16. **Docker Container:** A container is an integrated software unit that encapsulates an entire programme along with all of its dependencies so that the programme can be executed quickly, reliably, and portably in a variety of computing environments. An application's source code, runtime, system tools, libraries, and configuration information are all included in a Docker container image, which is a software package that can be executed on its own and is independently executable. Docker containers, which are based on container images, transform into actual containers when deployed on the Docker Engine.

17. **Chaincode:** Chaincode is a programme that can be written in Go, node.js, or Java and must conform to a particular interface. Chaincode was developed by Chain.io. Execution of Chaincode takes place in a safe Docker container that is isolated from the peer process that validates it. It is reasonable to think of a chaincode as a "smart contract" because it often deals with business logic that has been agreed upon by network participants. Chaincode leverages application-submitted transactions to construct and maintain the ledger's state. Each and every part of the state that a chaincode generates is exclusive to that chaincode and cannot be accessed by any other chaincodes. It is impossible for a chaincode to access the state of another chaincode that is not part of the same network unless the author gives permission.

2.2 Literature Review

In our nation, registering land is a process that is notoriously tough to complete. In order to obtain one's inheritance, a person must first complete a number of required tasks. The individuals who live in rural areas have the most significant challenge, despite the fact that city dwellers somehow find a way to circumvent all of the obstacles that stand in their way. As a result of their inability to read and write as well as their ignorance of the operation of the land registry system, it is extremely challenging for them to acquire ownership of their lands. In addition, the register system in our country does not uphold transparency. The people who work in this system are typically tainted with corruption, and they prefer to conduct business with third parties from whom they can derive some form of financial gain. These third parties attempt to deceive the poor people in a variety of different ways, taking advantage of the fact that the impoverished people are defenseless

and illiterate. When it comes to selling or purchasing land, the average person is required to go through an excessive number of steps that are overly complicated. They are forced to seek assistance and go to a variety of locations in order to exercise a fundamental human right. However, while they are there, dishonest and corrupt individuals will attempt to defraud them in a variety of ways and steal money from them illegally. When a customer wants to access any information, he is required to pay a fee or squander their valuable hours at the land register office only to receive the most fundamental information about a piece of property, such as the information about the land's owner. Additionally, individuals who are fraudulent and who should not have access to this information are able to quickly obtain access to it by unethical means; hence, the idea of a third party or broker originates from here. Therefore, despite the fact that we own the company, still it is needed to seek assistance from a separate organization, which will require an increase in our typical financial outlay. When it comes to rural locations, these things become more complicated, and the majority of the time, the people who live in rural areas do not even get to know about their own properties, which finally leads to such properties being disowned. According to the findings of one study, the forgery of property papers is one of the most significant obstacles that a government administration needs to contend with in order to successfully use the land registration process. There is a lack of administration and time stamping in the database system, which means that the data can be altered or hacked. This is despite the fact that every effort is made to maintain the information as secure as possible. The issue can be resolved through the implementation of a use case using blockchain technology. Because this is a decentralized system, anyone can access the information that is stored on the blockchain network; however, only the manager and those who have been granted permission to do so are able to make changes to the database. This is because the blocks that are newly added to the system are time stamped, making it extremely difficult to edit the papers. Additionally, proof-of-work is required in order to add new blocks. The paper states that the use case for land registration involves uploading the documents into a blockchain and validating them with the one.

The United Nations conducts and releases its e-government survey, commonly known as the e-governance development index (EGDI), every two years. The Electronic and Globalization Disparity Index (EGDI) is composed of the Online Service Index (OSI), the Telecommunications Infrastructure Index (TII), and the Human Capital Index (HCI). [11] The most current poll was distributed on July 19, 2018, and it focused on the topic of "Gearing E-Government to Promote Transformation towards Sustainable and Resilient Societies." This represents an improvement of 11 spots for India from its 2016 ranking of 107th out of 193 countries. The graph shows how the public sector is being altered by the advent of digital technology and other developments. The study focuses on the major challenges that need to be fixed before e-Governance can be successfully implemented in India. They classified the problems into the following four groups: ecological, social, economic, and technological. There may be doubts about the government's confidence in the e-Government infrastructure as a result. The technology that underpins e-governance should be designed in such a way that it strikes a compromise between thwarting fraudulent transactions and conducting exhaustive background checks on stakeholders like cit-

izens and government employees. The implementation of software for e-Governance has resulted in a suitable separation from long lines, the tendency of authorities to delay complicated procedures, and requests for both direct and indirect bribery. The upkeep and storage of official records pertaining to citizens is the responsibility of the government.

The Chinese government has launched a project called "The Comprehensive Experimental Area of Big Data in Guangdong Province" with the intention of incorporating Blockchain technology into China's e-Government in order to improve the quality, efficiency, transparency, and accessibility of government services in China. [6] Also, several potential answers to problems that may occur from using Blockchain technology to China's electronic government are examined and analysed in the essay. It will involve the development of guidelines, the implementation of efficient management systems, and the maintenance of strict security measures.

According to the Swedish government, implementing blockchain technology for the land register will save taxpayers more than $106 million USD annually. The amount of paperwork needed can be cut down, the possibility of fraud is decreased, and the procedure can be completed more quickly to achieve these savings. More than 20 million rural families in India lack legal title to the land they live on and do not own the property there, according to statistics. [8] The term "blockchain" can refer to a wide range of different technical processes, such as the transmission of data and the transaction of digital assets across multiple distributed networks. They believe that the blockchain technology is an excellent way to create a platform for exchanging data that has significant value, and they hold this belief in accordance with their beliefs. Trusting the system itself rather than an intermediary is one component of blockchain technology. Other components include public key and cryptography, which is an essential aspect of trusting the ledger, and decentralization, which ensures the information is secure even if a single node fails.

It was in December 2014 when Estonia made history by becoming the first country in the world to open its digital borders and make it possible for anyone, no matter where they are located, to become an "e-resident." The primary goal is to issue electronic identification documents (e-IDs) to e-Residents so that they may engage in business with Estonia's government and private sector without actually being present in the country. For instance, an e-Resident is permitted to create a bank account in Estonia even if they do not physically have to be present there to do so. The Estonian government, in conjunction with Bitnation, offers e-Residents a dependable digital identification service that is based on Blockchain technology. e-Residents can obtain this service via the Estonian government. The decentralized public ledger that is employed in the process of establishing and upholding the identification of an electronic resident. It may be possible for this to improve the control as well as the authentication of digital identities. In addition to this, the information that is stored in the ledger is both encrypted and guarded in a decentralized fashion. One of the appropriate applications of blockchain technology for land registration, which was carried out by the Dubai Land Department (DLD). [5] DLD built the Blockchain

system with a secure database that tracks all real estate contracts, such as lease registrations, and links them to utility providers like DEWA, the telecommunications infrastructure, and other property-related bills. Registrations for leases and other real estate contracts were kept in this database. Tenants no longer have to deal with paper checks or receipts thanks to Blockchain's secure electronic real estate network, which combines personal tenant details like Emirates Identification Cards and the status of resident visas. Tenants won't have to print anything or write checks anymore. There is no need to visit a government office because the entire process may be performed online in a few short minutes, at any time of day or night, and from nearly anywhere in the world. Another one of the very earliest applications was called Exonum. End users may validate blocks with ease with Exonum thanks to its user-friendly interface and lightweight implementation. The following is how exonum operates:

- **Known Good Data:** The blockchain is used to hash, distribute, and store data.
- **History Log:** Give users access to a back historical log of all the transactions that have taken place.
- **Audability:** Provides the opportunity for a third party, such as the government or non-governmental organizations, to see and audit the data.

The Abu Dhabi Municipality (ADM) and Aldar Properties, the preeminent real estate developer in Abu Dhabi and one of the most recognizable brands in the United Arab Emirates and wider Middle Eastern area, were brought on board for the project's pilot phase. Tech Mahindra implemented the following three features for Smart Hub:

- Citizens can access information or finished paperwork connected to their land deed, and they can believe the data to be legitimate. [2] In order to submit a document to Smart Hub, users cannot use any kind of editing software (such as Photoshop) to alter the content. In summary, you cannot utilize the materials for illicit reasons.
- This feature allows property owners to offer access to papers to a company or individual for a limited period in order to fulfill particular activities, such as re-negotiating a loan or gaining authorization to work on site. [2] Multiple entities or government agencies can be granted time-limited access, and when that period ends, the app will immediately withdraw their permissions.
- Smart Hub's Share With feature allows current and future owners to know exactly how and when each document was utilized. You can also check to see whether there is a debt secured by the apartment's deed besides the mortgage. [2]
- On the back end, these functionalities require seven separate APIs written on node.js to enable for data to be correctly sorted, read, and saved. Smart Hub's existing multi-tier architecture—consisting of a web tier, an application layer, and a database tier—serves as the foundation for the whole network.

Chapter 3

Methodology

In short what our application does: Our application will work as a tamper proof, effective, scalable and decentralized solution.

Architecture: Architecture is broken down into few parts.
Under our proposed framework, the Ministry of Land will have full authority over who can access the network and how each node interacts within it. To solve this problem, we choose to employ Hyperledger Fabric, which is only possible with a permissioned consortium blockchain rather than a public or fully private one.

3.1 Network Overview

Our system will be powered by the combination of the Hyperledger network and CouchDB in the background. The front end of the system will consist of a web application with three distinct user interfaces (administrator, user, and verifier). Users can look through their own land listings and submit requests to buy or list properties after logging in.

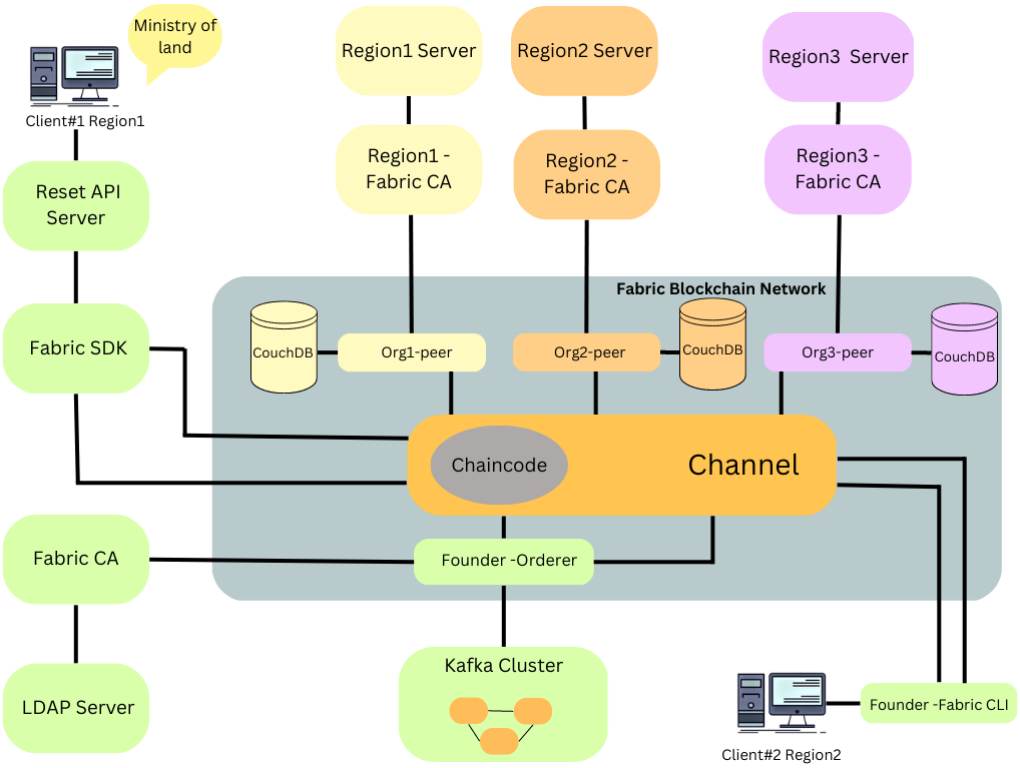

Figure 3.1: Network Overview Diagram

When a user requests it will be recorded in the admin dashboard as pending. Only when admin is done verifying the request will be accepted.

3.2 Organization Breakdown

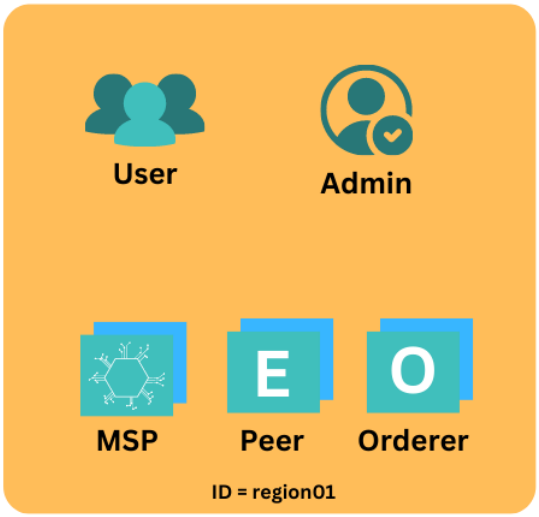

Figure 3.2: A Good Regional-based Organization

Every Regional based organization must consist:

- Membership service Provider (MSP) for identifiers
- Regional Admins
- End Users
- Peers
- Orderers
- Organization ID

The model relies on response from the administrator. In the event that an update is necessary to the ledger after the admin accepts anything, the ordering peer will do that change for every peer.

3.3 Stakeholder and role

Stakeholders and Role: First we have assigned the roles to the stakeholders in the following manner.

1. **Admin:** Admin will be able to read and write both.
    1.1. **Identity validator:** He will authenticate the user's identity by requesting and reviewing official government identification documents and National ID information before allowing them access to the network.
    1.2. **Registrar:** A registrar's job is to add new information about land to the system after the ownership of those lands has been confirmed. Following appropriate verification, he may also transfer ownership.
2. **Client:** The client will only be able to read and request to update.
    2.1. He will request to join the network by providing his National ID information.
    2.2. He can request for adding a new property.
    2.3. He will be able to request to update land status (selling / not selling).
    2.4. He can also be able to request for ownership change.
    2.5. Users sell/buy properties registered on this network. To buy/sell properties on the network, they must register.

3.4 Ledger

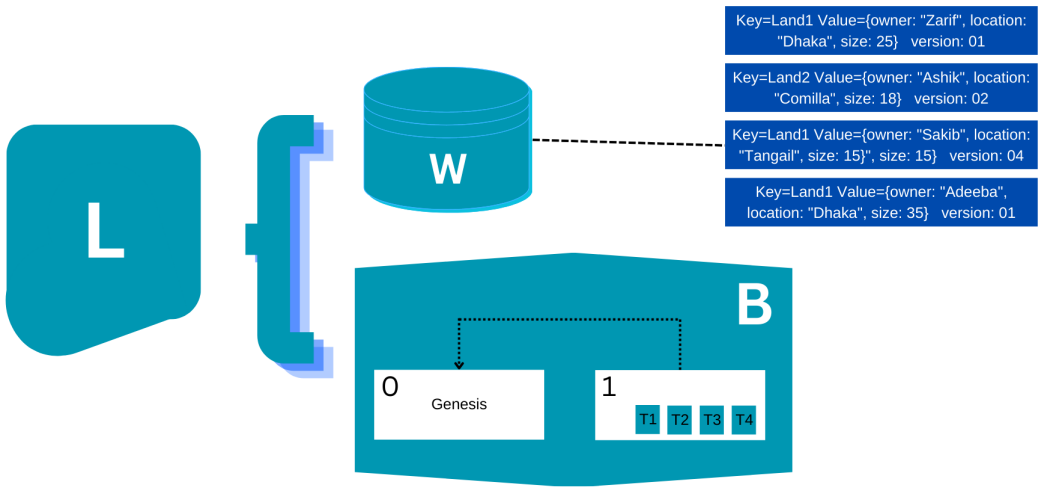

Figure 3.3: Blockchain Ledger

The following are typical parts of a blockchain ledger's structure:

Blocks: The blocks that make up a blockchain are its most fundamental units. All of the transactions in a given block have been checked and confirmed by the network. The term "blockchain" originates from the cryptographic hash function that connects each block to the one before it in the chain.

Transactions: Data units representing the movement of value or information on a blockchain ledger are called transactions. Before being added to the chain of blocks, each transaction is verified by the network.

Cryptographic Hash Functions: It accepts data from a block as input and produces a hash that is both unique and of a defined size. Each block in the chain is tracked and connected to the one before it using the hash.

Distributed Network: In order to keep the blockchain's distributed ledger updated, a network of computers called "nodes" must work together to verify and add new blocks. Each node is equipped with its own copy of the blockchain ledger and takes part in the consensus procedure to safeguard the data in the distributed database.

Consensus Protocol: To guarantee that all nodes in the network concur on the status of the blockchain ledger, a consensus mechanism is used. Confirming transactions and adding new blocks, the consensus mechanism guarantees the blockchain's integrity and security.

Smart Contract: Smart contracts are blockchain-based, autonomous computer programs. Agreements or contracts between participants on the blockchain can be made automatic and their terms enforced with the help of smart contracts.

In summary, the structural breakdown of a blockchain ledger includes blocks, transactions, cryptographic hash functions, a distributed network of nodes, a consensus system, and smart contracts. Together, they form a distributed ledger that is both trustworthy and flexible in its use.

3.5 Membership

3.5.1 Membership Service Provider (MSP)

How the identities of applicants, endorsers, and orderers are handled To be held accountable for creating an authorization list Our system allows for read/write access to all system controls and the creation of channels.

- At channel level read/write access for the peers
- This invocation/trigger occurs at the chaincode level.

3.5.2 Certificate Authority (CA)

Access must also be allowed to those who want to join the network. The Ministry of Land Nodes cannot, however, effectively assign a role to every user in every location by itself.
Intermediary CAs have a role in this. The Ministry of Land will create some intermediary nodes depending on region (division), giving each regional CA the ability to manage and have Access Control Limit (ACL) for users within this region. This speeds up, balances load and increases the security of the network's access control procedure.

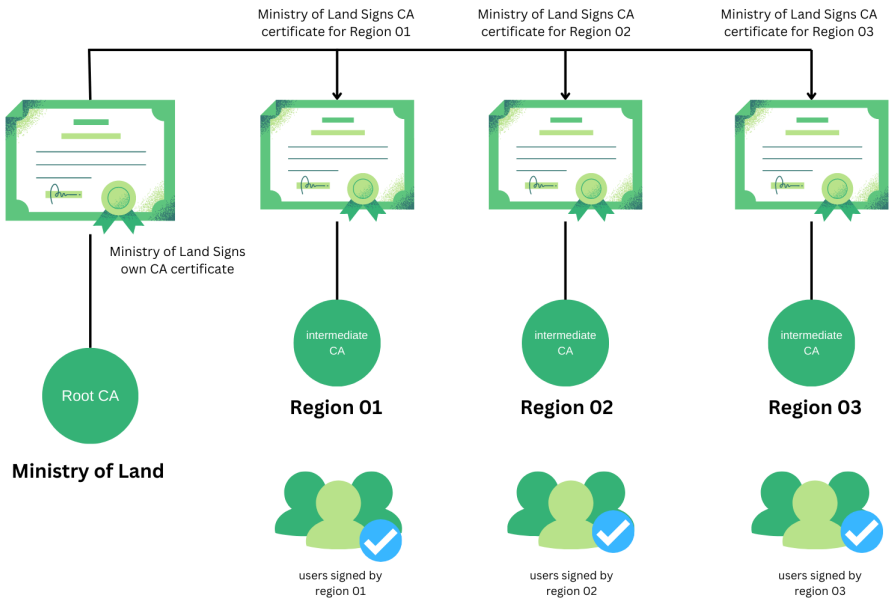

Figure 3.4: Root Certification Authority

3.5.3 New user enrollment

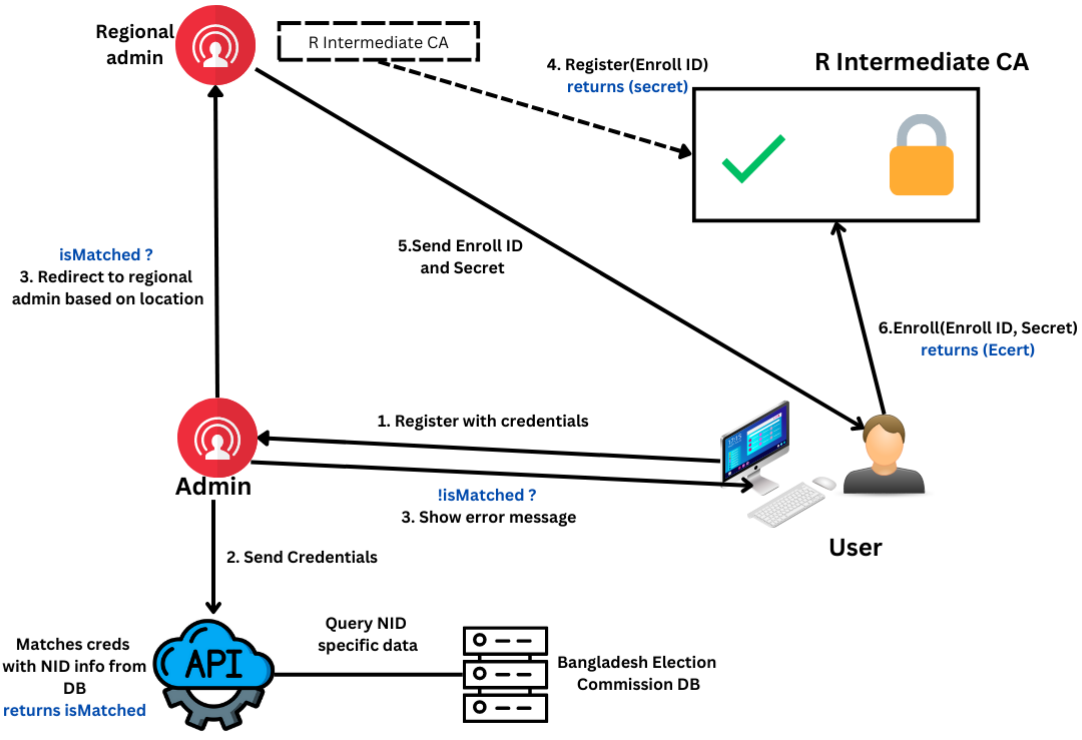

Figure 3.5: Register with Credential

1. User register with credentials from client side

2. Admin requests an api call with credentials as payload to Bangladesh election commission API to validate and match User given credentials with info from NID and phone number will be validated by OTP.

3. If the given credentials don't match then the user's request will be dropped and and error message will be shown to the client side else admin will redirect the request to regional based admin

4. Regional admin registers new users with Enrol ID.

5. Users enroll and receives enroll id and secret

6. Then the user sends the enrollment id and secret to regional intermediate CA to receive the enrollment certificate.

3.6 Consensus

A distributed ledger platform called Hyperledger Fabric offers a modular architecture to enable flexibility and anonymity in business blockchain networks. The RAFT algorithm is one of the several consensus algorithms supported by Hyperledger Fabric.

The RAFT consensus technique is used in Hyperledger Fabric to achieve fault tolerance and guarantee network consistency. In Hyperledger Fabric, the RAFT method is implemented as a pluggable consensus module that network administrators can choose from and customize.

The stages taken by the Hyperledger Fabric RAFT consensus method are as follows:

- **Leader Election:** A new leader in the network is chosen by the followers through a vote-exchange mechanism. The winner receives the most votes and takes over as the next president. To keep its position as leader, the leader periodically transmits heartbeat messages.

- **Log Replication:** When a new leader is chosen, the previous one takes client requests and replicates them to the new leader's followers. The request is subsequently approved by the followers, who then update their own records. Before making any adjustments, the leader waits for the followers' approval.

- **Commitment:** A request is deemed committed and can be applied to the system state if it has been repeated and approved by the majority of followers. The followers receive a commit message from the leader instructing them to update their state machines.

- **Recovery:** In the case that the leader fails, the followers launch a fresh election to select a new leader. Candidates are the followers with the most recent logs. The candidate with the highest ID is chosen as the new leader if the logs are identical.

The RAFT algorithm makes sure that every follower has a duplicate of the same log in order to maintain fault tolerance and consistency. If a leader falters or disappears, a replacement is elected right away, and the system keeps running as usual. The RAFT consensus technique is utilized by Hyperledger Fabric in order to guarantee that all of the network's nodes share an identical copy of the distributed ledger and that all transactions are processed in a manner that is both fault-tolerant and consistent.

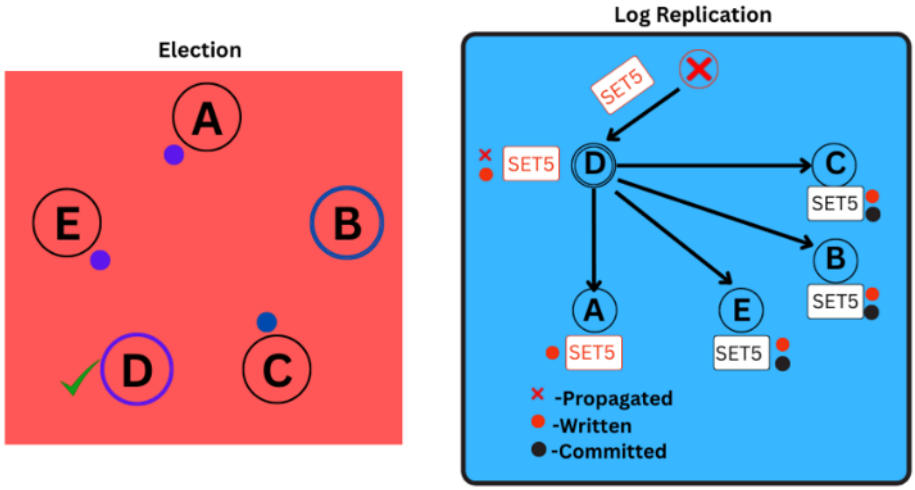

Figure 3.6: RAFT Algorithm

3.7 Transaction flow

The process behind every transaction inside our Network.

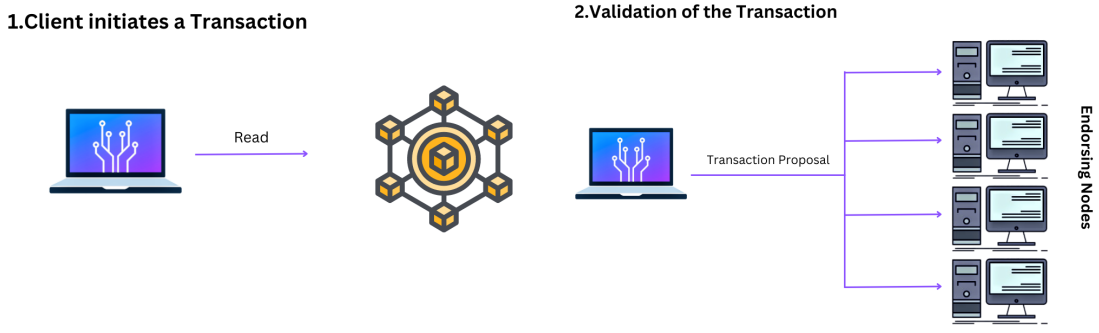

Figure 3.7: Transaction Flows (1 & 2)

1. When a client or any node from the Ministry of Land requests to read/write. The request will be checked whether this member is a part of this member from MSP, if valid then It will be checked that this user is eligible to trigger this read/write request from the access control list.

2. Send this transaction proposal to endorsing nodes then endorsing nodes will invoke related chain codes.
    - Query state DB for reads
    - Build RWset

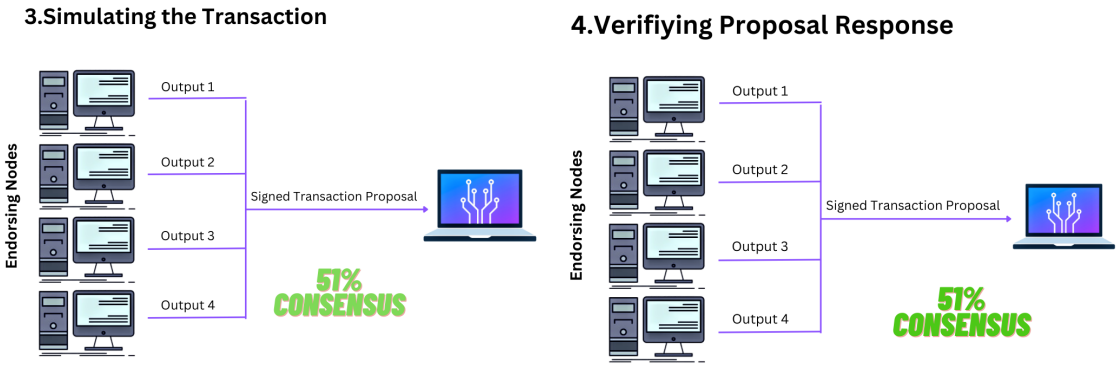

Figure 3.8: Transaction Flows (3 & 4)

3. The third step in the process involves a peer of an Endorser checking the details of the Certificate along with other information to ensure that the transaction is legitimate. The endorsement answers are then sent back to the client when the Chaincode (Smart Contract) has been executed. An endorsement answer includes a peer endorser's acceptance or rejection of a transaction with RWset.

4. Then the client will validate the signed transaction output based on consensus.

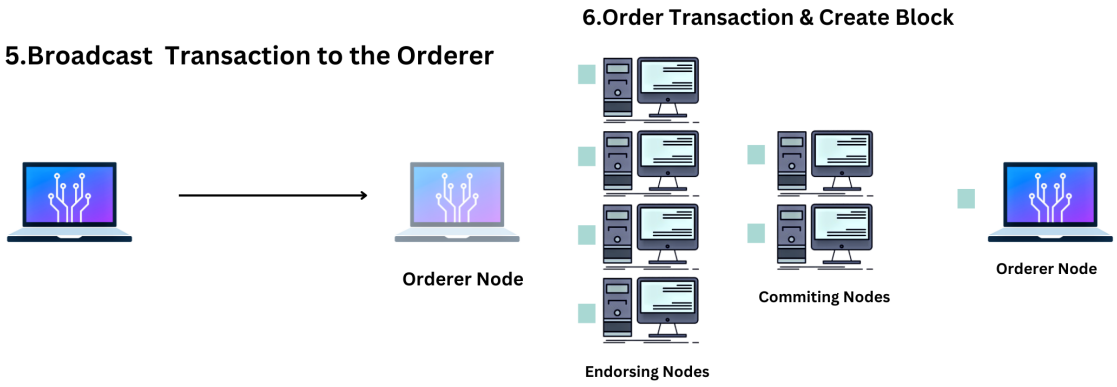

Figure 3.9: Transaction Flows (5 & 6)

5. Then this transaction will be broadcasted to the orderer node to order this transaction.

6. The transaction is added to a block by the Orderer node and distributed to the Anchor nodes of the various Hyperledger Fabric member companies.

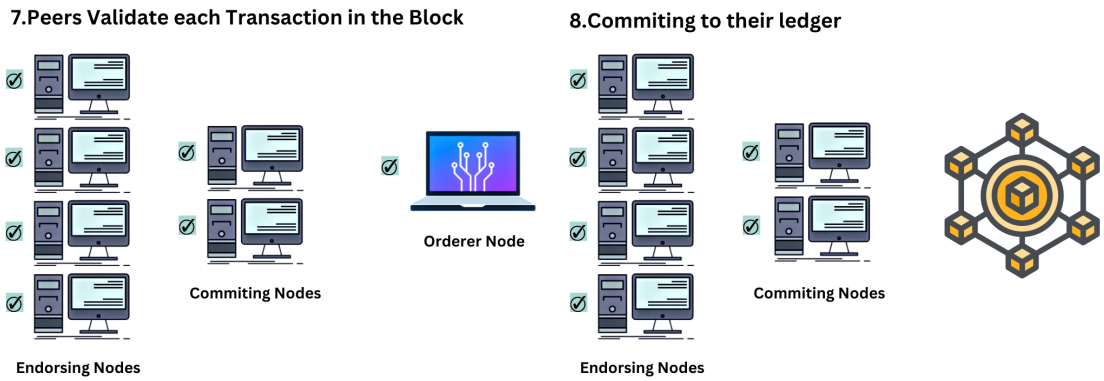

Figure 3.10: Transaction Flows (7 & 8)

7. Committing peer (all nodes) will validate each transaction in the block based on

   - Endorsement policy
   - Readset version in state DB

   and broadcast to the client...

8. Finally, it will be recorded in their ledger and uploaded to or updated in the state database.

3.8 Request and Response flow

When a user requests it will be recorded in the admin dashboard as pending. Only when admin is done verifying the request will be accepted.

The model relies on response from the administrator. In the event that an update is necessary to the ledger after the admin accepts anything, the ordering peer will do that change for every peer.

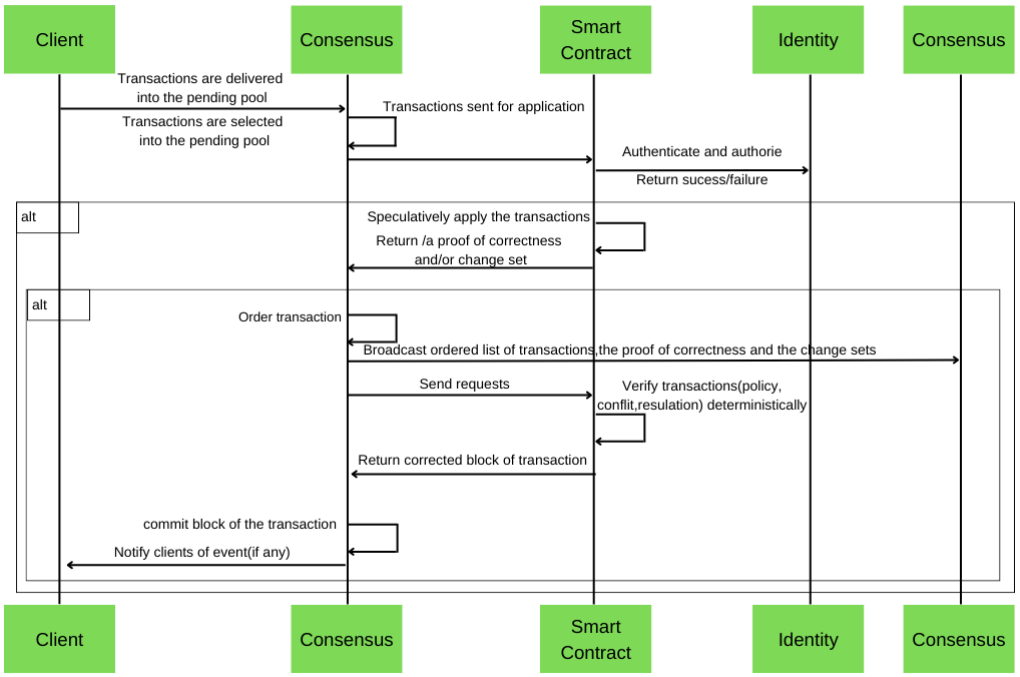

Figure 3.11: Request & Response Flow Diagram

- A transaction request is initiated by an administrator through the customer application.
- The client app announces the request to the Endorser peer to begin the transaction.
- In the third phase, another peer of the Endorser checks the Certificate details and other information to make sure the transaction is valid. Once the Chaincode (Smart Contract) has been completed, the endorsement responses are returned to the client. An endorsement answer includes a peer endorser's acceptance or rejection of a transaction.
- The fourth step is for the client to send the transaction to the orderer peer after it has been validated so that it can be sorted and added to a block.
- The transaction is added to a block by the Orderer node, and the block is then sent to the Anchor nodes of the many companies that make up the Hyperledger Fabric network.
- Once the block has been broadcast by the anchor nodes, the other peers within the same organization will get it. This distributed network of peers then makes the necessary adjustments to their own copy of the ledger. The network as a whole benefits from a synchronized ledger.

3.9 Ownership

3.9.1 Ownership Validation

Our ownership validation will be a semi digital system for now. At first,the system will call an api from the ministry of land which contains the information of land as nowadays all registration is occurring based on an individual's NID number. When a client wants to register his/her land, the NID number will pass to the fetching api of the ministry of land. It will help to verify in seconds.

For Bangladesh being a developing country, a digital system using NID for land registration can not be accomplished as most of our older generation doesn't have NID yet. In that case we will go for,

- Chain of ownership from the ledger + documents + validate info with owners NID + the plot (dag) number, khatian number, present possessor, holding address.
- First time Migration → Validate through original copy from the sub registry office + checking khatian/porcha from DC office + The land tax (Khajna) record should be checked + PHYSICAL VERIFICATION OF THE PROPERTY (if needed)

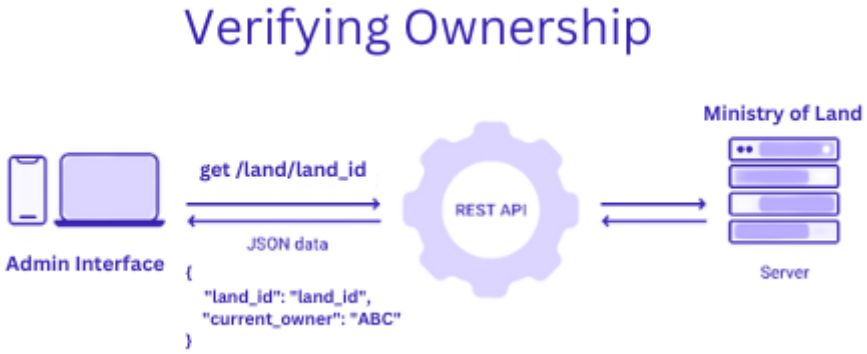

Figure 3.12: Verifying Ownership

3.9.2 Ownership Modification:

Checking the history of the particular land and its current ownership, ownership can be changed and be recorded in the network.

3.10 Data Storage

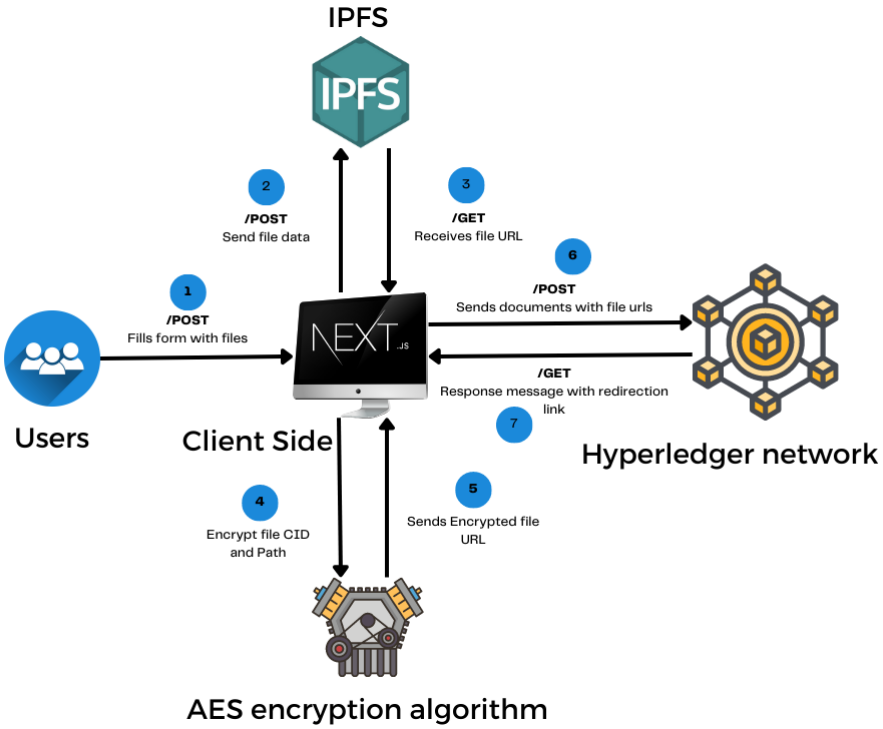

Figure 3.13: Data Storage

1. User fills forms with required credentials including images.
2. From the client side, an asynchronous post request will be triggered with image data as payload using ipfs http client to infura ipfs.
3. In return IPFS will send the path and CID(content identifier) of the image.
4. In the client side, after receiving all the image CIDs, we will create a JS object and post the object to the ledger
5. In response from the backend, we will get response text, that will be shown the client side, and the client app will redirect to another location.

3.11 HLL Coin

We have developed a coin here, which will be used to sync with the user's bank account with real time updates. The coin will also be used to check the eligibility whenever a user wants to request to change the ownership or to buy a land. HLL coin will work in the following process:

```
Eligibility = price of the land + network fee (registration fee +
land mutation fee) <= HLL coin;
```

here at first one needs to join the network with the bank account information. The bank account then will be synced with the network and the current balance will be converted to HLL coin. If the HLL coin is higher than the land fee, only then one will be able to purchase the property, otherwise he will not be able to do so. The following are the steps of how the whole process is working uniquely in our model:

- After the request is ledgered, the registrar reads the request and stores the user's data/credentials on the ledger after manually verifying their identity.
- Users have HLL coins as digital currency and this network accepts only this currency. New users have no HLL coin at first.
- At first, a registered user requests network property registration from the registrar.
- The ledger then stores the request.
- After verifying the request, the registrar adds the property to the ledger. The client registers on the network and requests to register his property. Before registering it on the ledger, the registrar must verify that the property is real and belongs to that particular user.
- Only the registered users can buy the land if its owner lists it for sale.
    - The property owner must list it initially.
    - The buyer must have more HLL coins than the property's price. If not, users must recharge at first.
    - If the two requirements are satisfied, the buyer obtains possession and the seller receives HLL coins equal to the property's price and ledger assets.
- Before buying/selling properties on the network, users must provide their name, email, national ID information, etc. Ledger states store user credentials.
- Users must seek network registration or ledger property from the registrar. These requests are ledgered.
- The ledger stores users' properties as assets.

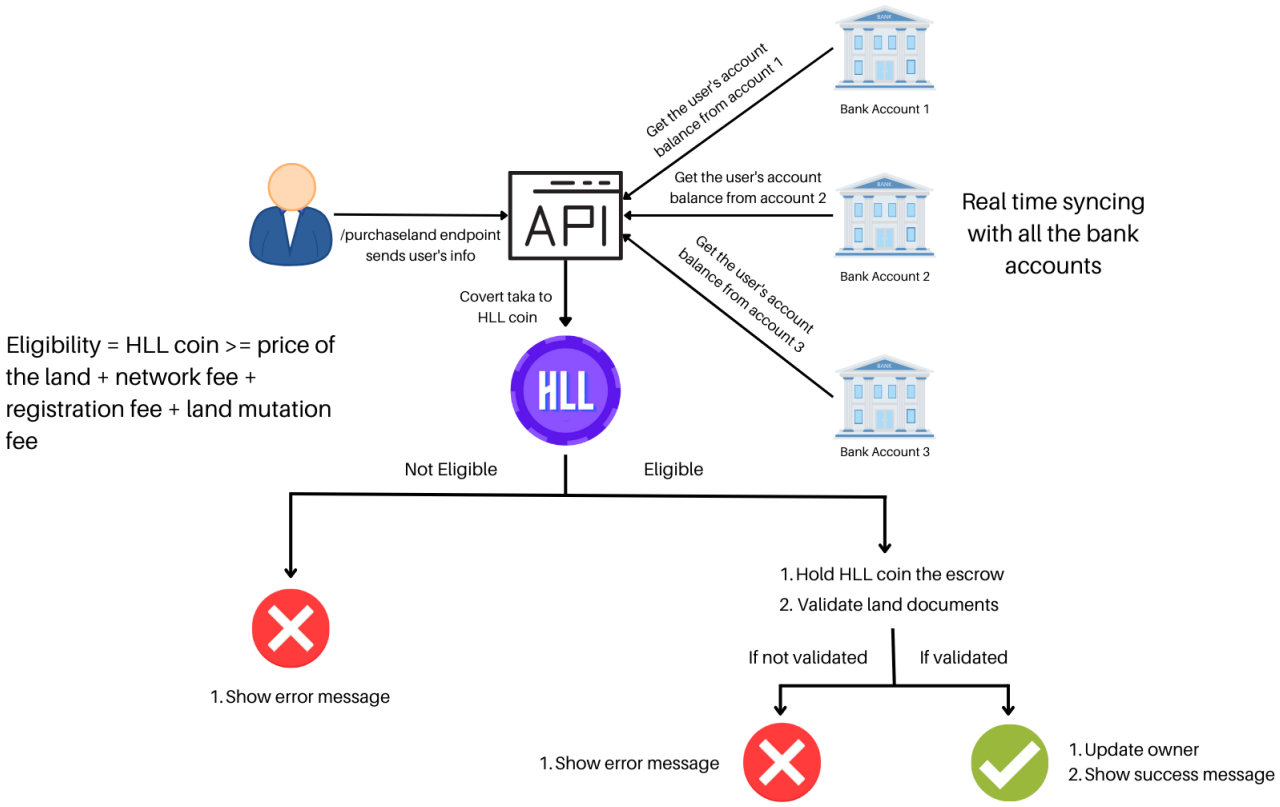

Figure 3.14: HLL Coin

Benefit:

- By using HLL coin, it will help to remove a country's threat which is black money. As HLL coin is based on an individual's bank account and the bank is connected with NID, so there will be no room for black money.
- Users can pay land tax without any hassle just by transacting the corresponding money through HLL coin.

3.12 HLL Escrow

When a buyer takes the next step toward completing the purchase of a parcel of land, HLL Escrow will take possession of the HLL coins and place them in escrow. At this stage, all of the deeds and processes will have been carried out to their conclusion. Using HLL Escrow, the funds that have been kept safe in escrow will be transferred to the account of the seller.

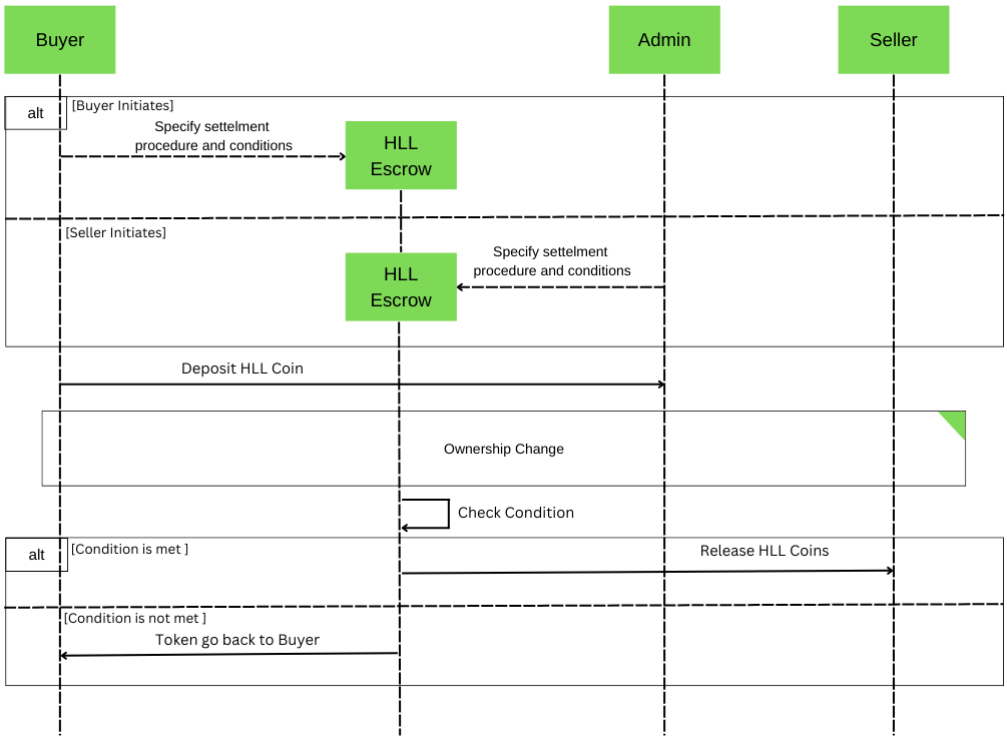

Figure 3.15: Flow Diagram for HLL Escrow

Chapter 4

Implementation

4.1 Environment Setup

Several pieces of software and tools were installed and set up to serve as the prototype's development environment. The Hyperledger Fabric Software Development Kit (SDK) was utilized to acquire the software components required to construct and launch the blockchain application. Node.js and Express.js, both of which are open-source JavaScript run-time environments and web application frameworks, were used to construct the prototype's back end and make it possible to implement a RESTful API.

Typescript and the NextJS frontend framework were utilized throughout development of the frontend. With NextJS, developers have the best possible experience building feature-complete, production-ready applications. TypeScript is supported, smart bundling and route prefetching are built-in, and there is no need for any additional configuration for any of these capabilities to work. Property records, user profiles, and other relevant data were stored in a CouchDB database that was connected to the blockchain network. User's National Identification (NID) and property-related images and documents were saved and retrieved via the InterPlanetary File System (IPFS).

4.2 Development Dependencies

4.2.1 Blockchain Network and REST API

1. Curl Installation
2. NodeJS Installation
3. Git Installation
4. Docker CE Installation
5. Docker Compose Installation
6. Hyperledger Installation
7. Express Installation

4.2.2 Client Side

1. NextJS Installation

4.3 Tech-stack

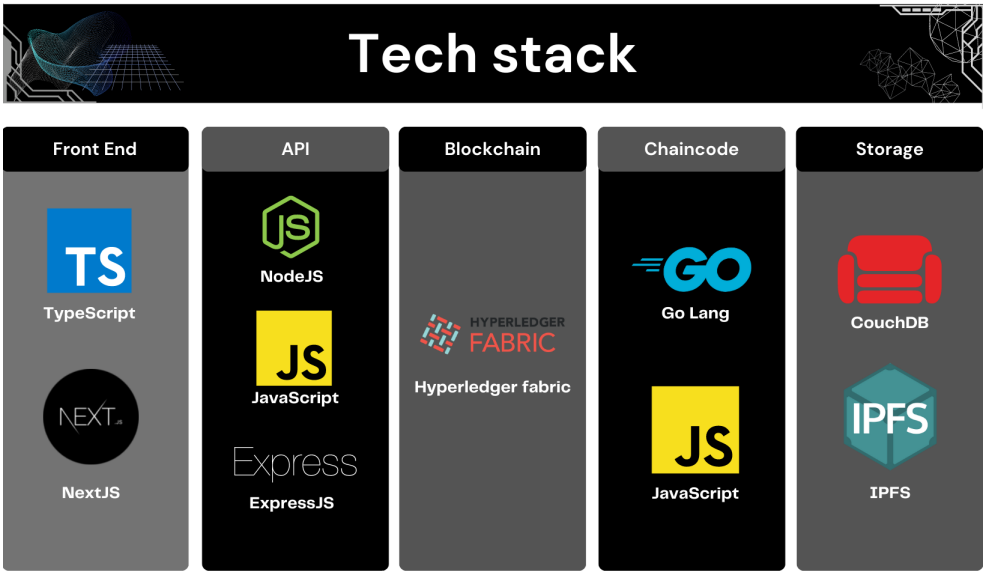

Figure 4.1: Tech-stack

Front End: Typescript and the NextJS front end framework were used to create the front end. NextJS gives developers the finest opportunity to create feature-rich, production-ready applications. Smart bundling, TypeScript support, and route prefetching are all built-in features that don't require any further settings to function.

API: Using NodeJS and Express, we built the demo backend for the API. NodeJS is an open-source server environment that works on a wide variety of platforms, including Windows, Linux, Unix, Mac OS, and more. To put it simply, NodeJS is a server-side JavaScript runtime environment that uses the V8 JavaScript Engine to run JavaScript code even when the user is not viewing the page in a web browser. ExpressJS is a framework for developing RESTful APIs on the back end of websites using the NodeJS web server. With the utilization of these tools, a RESTful API was created to facilitate interaction between the user interface and the blockchain infrastructure.
Blockchain: Hyperledger Fabric is used to create the blockchain demonstration. Open source blockchain architecture, Hyperledger Fabric, is hosted by the Linux Foundation. As a result, it has a robust and expanding community of programmers. Permissioned networks made of fabric have verified the identity of all users.
Chaincode: In this demonstration, we use JavaScript and Go for the chain code, and Docker containers for the secure isolation of the endorsing peer processes.
Storage: The prototype uses IPFS (InterPlanetary File System), a protocol, hypermedia, and file sharing network for storing and sharing data in a distributed

file system, to save and retrieve the user's National ID, property photographs, and documents. Furthermore, we employ couchDB, an open-source document-oriented NoSQL database written in the Erlang programming language, as our state database.

4.4 Application flow

Web applications and chaincode are developed and maintained by programmers.

- To manage the ledger's state, the blockchain network uses Chain Codes.
- The app manages the UI and sends out network transactions that trigger chaincodes.

Once a transaction occurs, the network sends out an event, facilitating the connection of many systems.

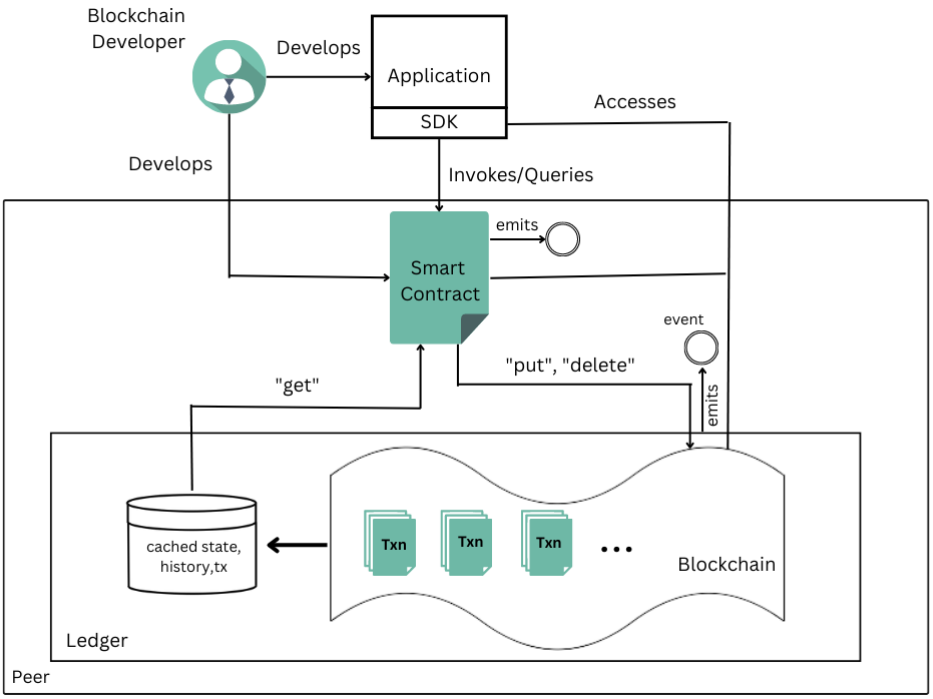

Figure 4.2: Application Flow Diagram

4.5 User Experience

One of our main targets was to develop a user-friendly interface as our application will be engaging with users from all over the country despite their location, gender, ethnicity. The users will interact with the application to register, add property, and apply for ownership change.

At first our target is to build a navigation bar that directs all the necessary routes for the end user. Consist of Search Bar, where users can search property by land ID, sign in/registration button and Request to add property option.

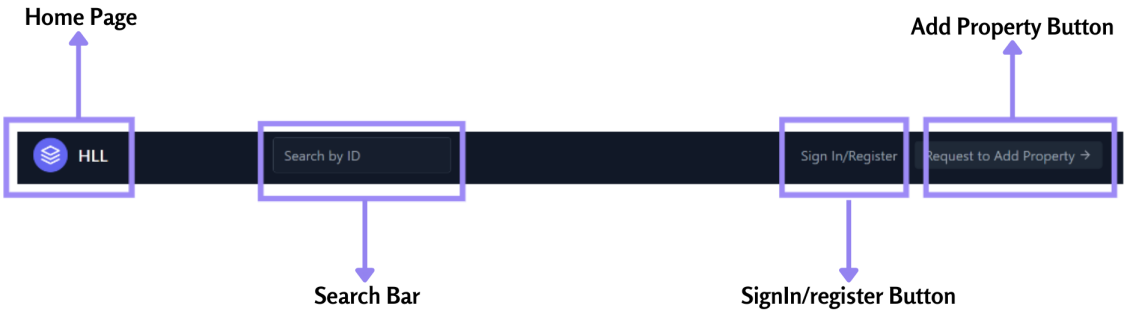

Figure 4.3: Search Bar

Our target was to make the registration for the end user as simple as possible thus no one face problem joining the network.

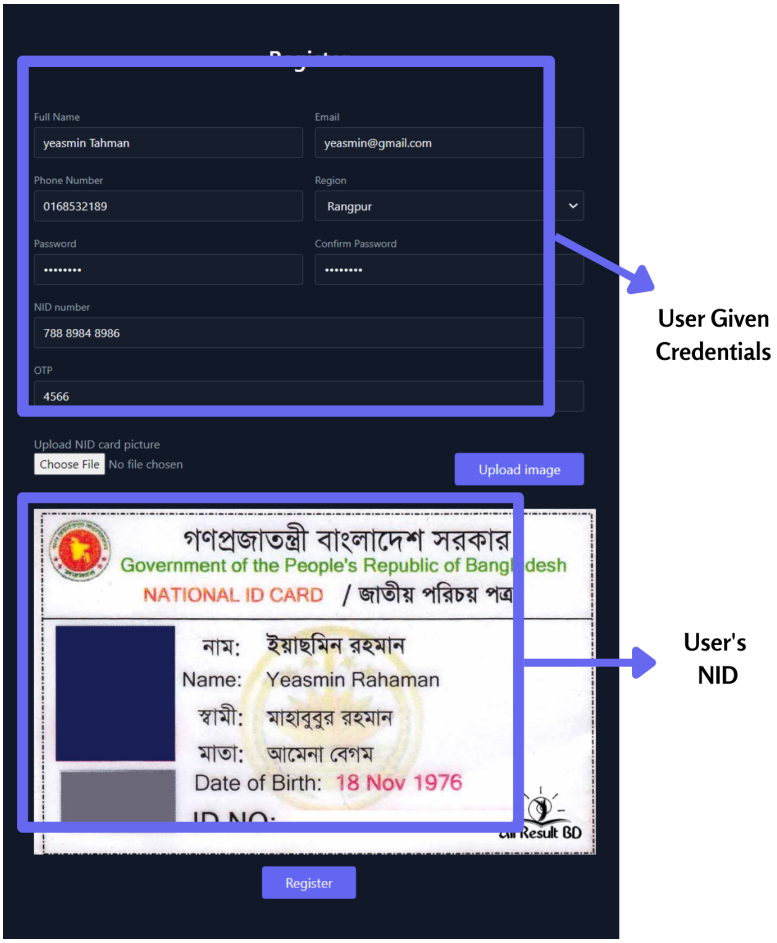

Figure 4.4: User Giving Credentials

To give the best experience we try to give our home page a social media kind of look. By scrolling through users can loot at different listed properties. Our target was to give users the ability to get a primary idea(location, owner, selling status, listing date) of properties from the home page.

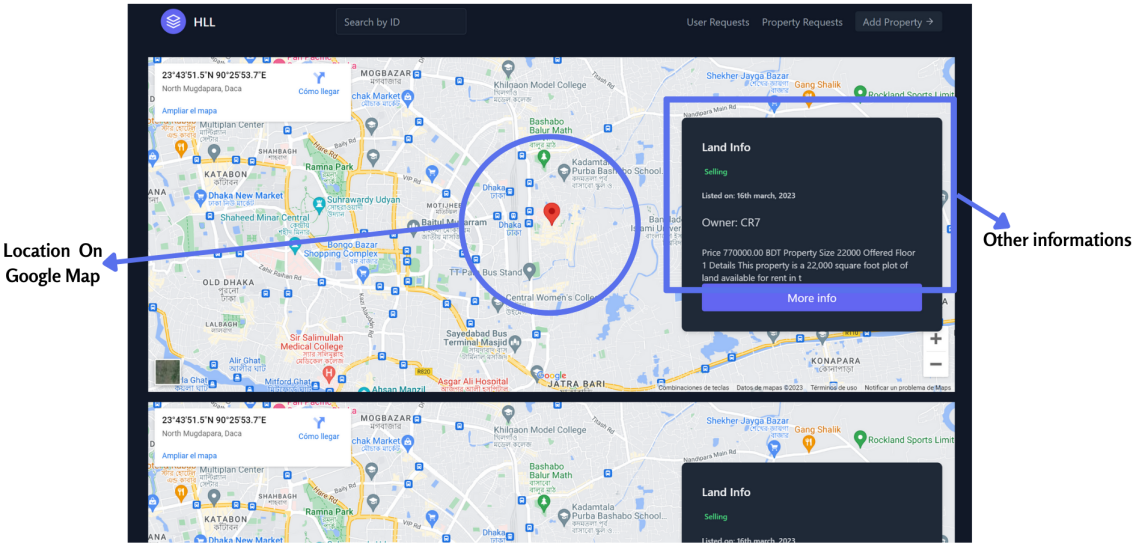

Figure 4.5: User Viewing Land Location On Google Maps

Every property information must consist of all the necessary details. That's why we try to show every important information on the page.

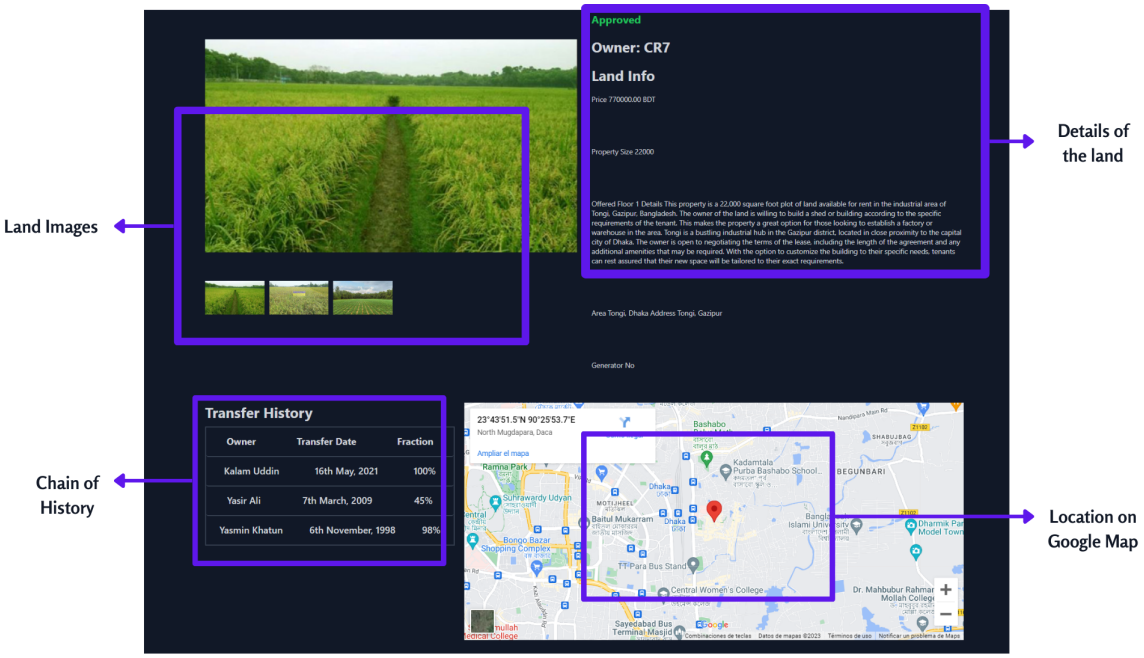

Figure 4.6: User Viewing Land Information

In order to migrate or add new property users must fill in all the necessary information about the property. Thus validator or admin can validate, accept the addition/migration request and add this property to the network.

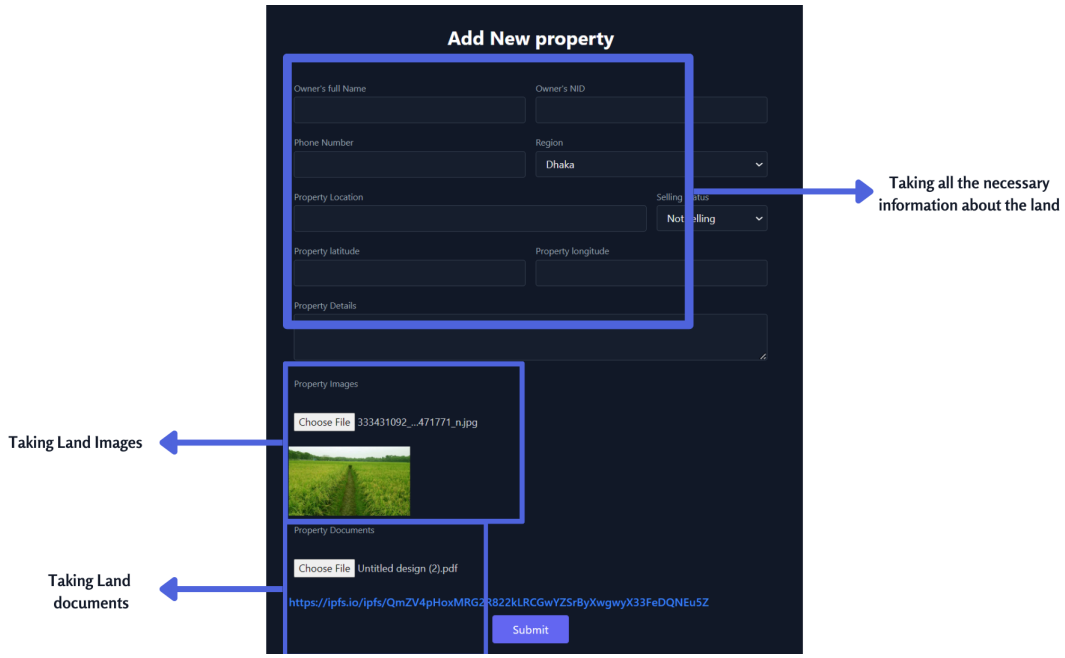

Figure 4.7: User Adding New Land Property

Users can link his bank accounts to the network and convert his account balance to HLL coin. Later, with HLL coin users can buy lands, pay taxes.

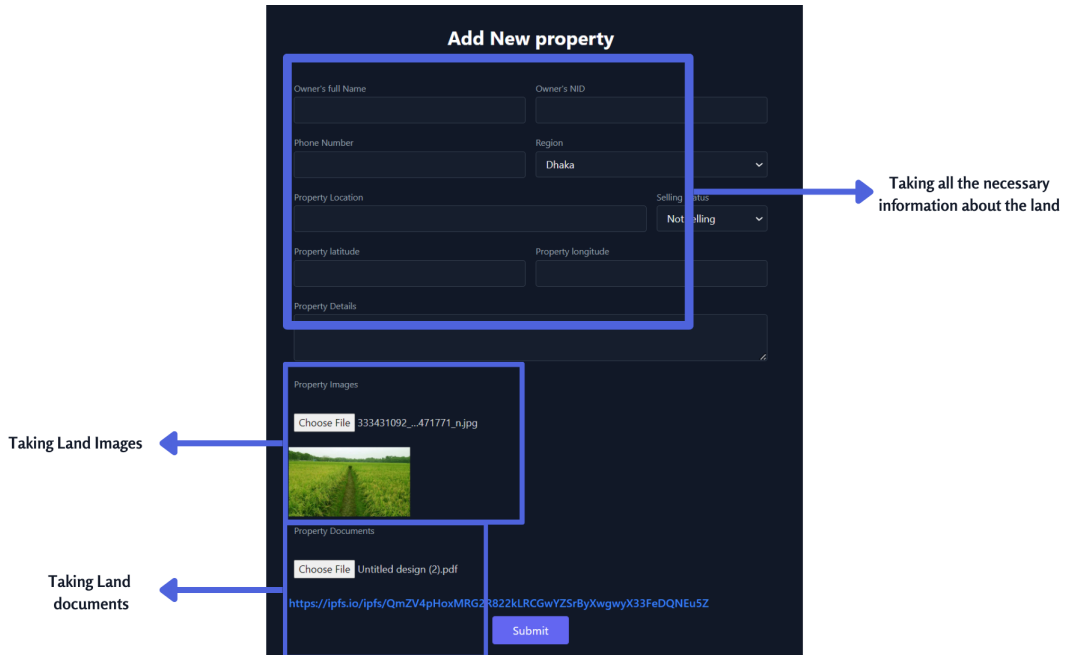

Figure 4.8: User Adding New Land Property

Users can link his bank accounts to the network and convert his account balance to HLL coin. Later, with HLL coin users can buy lands, pay taxes.

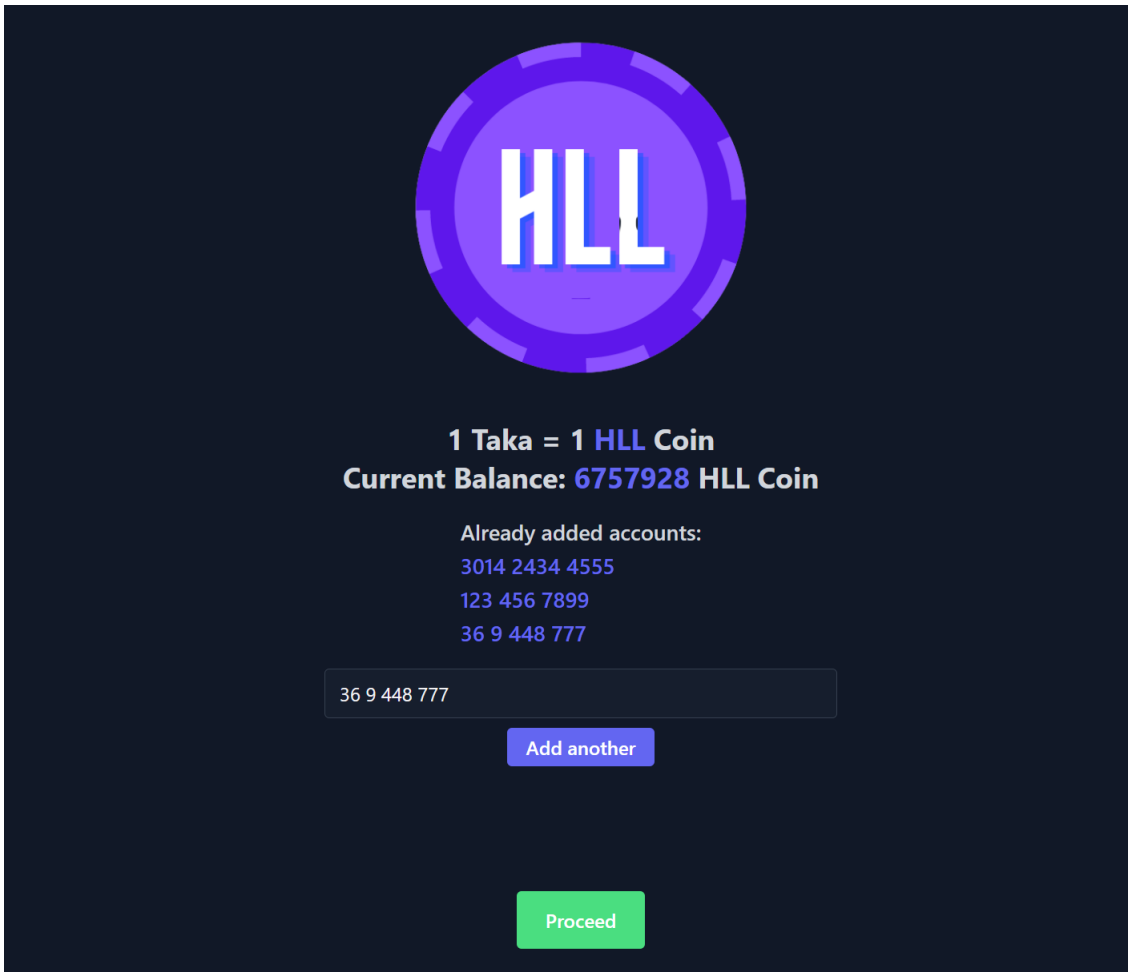

Figure 4.9: User Adding Bank Accounts

4.6 Admin Experience

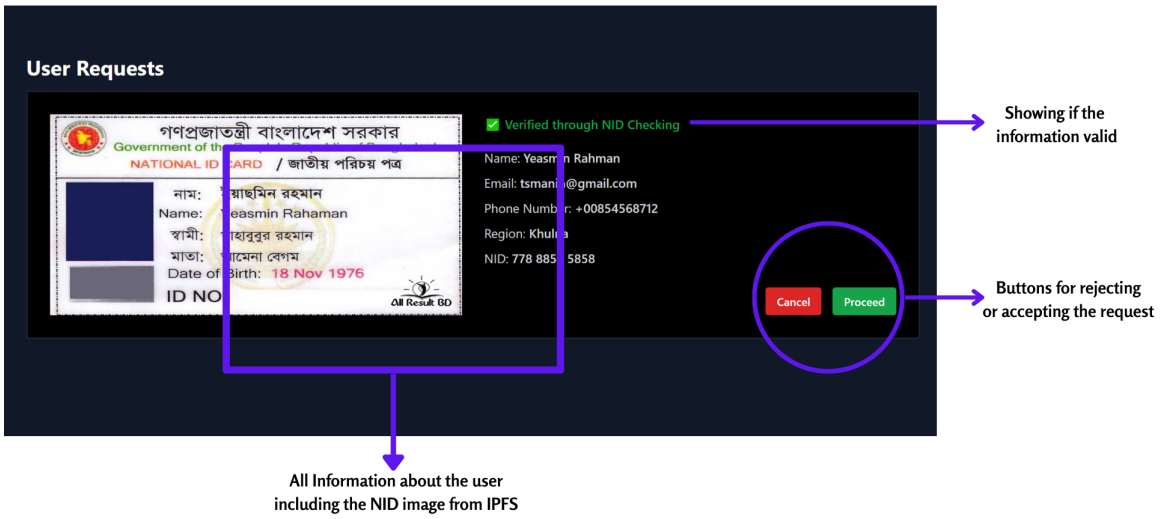

Figure 4.10: Admin Reviewing User Requests

After a user requests to join the network with his user information, this request will be displayed to the admin's dashboard `/user` requests endpoint with all the user's information, the verified bar (If user given information matches, information from Bangladesh Election commission data) and buttons for accepting or rejecting this user's joining request to the network.

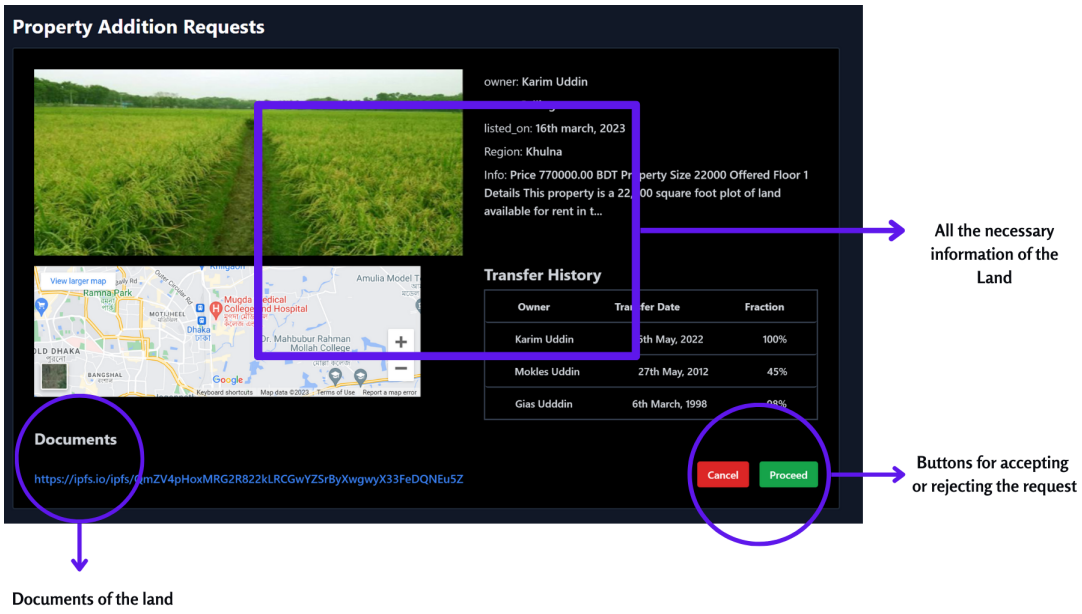

Figure 4.11: Admin Reviewing New Property Requests

After a user requests to migrate/add a new property, this request will be displayed to

the admin's dashboard `/property` requests endpoint with all the information about the land, its documents and buttons to proceed the process or reject. If the admin proceeds the request the function for migrating land chaincode will be invoked.

4.7 Pseudo-code and Explanation

4.7.1 Data Storage Pseudo-code

Firstly, we take file input from the user. Then using Infura IPFS http client we upload the file in IPFS. In response, we receive the CID and path of the file. For privacy and security purposes we encrypt the CID and path of the file using AES encryption. Lastly, we request the backend to add the entire object to the ledger.

```
// Initializing IPFS instance
const ipfs = ipfsHttpClient(ipfsUrl, credentials);

async function onSubmitHandler() {
    //user input
    const file = files[0];
    // upload files
    const result = await ipfs.add(file);

    // Encryption
    const encryptedFile = await AESEncryption(result, adminPrivateKey)

    // Storing upload image path
    setUploadedImage(encryptedFile)
}
```

Figure 4.12: Pseudo-code for IPFS File Upload

4.7.2 API Connection

The Backend will receive a POST request at `/landmigration` endpoint with land information as payload. It is necessary to check the payload. If invalid, the system will throw an error and show an error message. Then the system will initialize the wallet and using that it will get the user's identity. Then the system will check if the user is authorized by MSP to trigger this function. Next step is to validate the ownership. For that reason `validateOwnership` middleware will be called to validate if the requester is the actual owner. If not, the system will throw an error. After that, the system will invoke the `landMigration` function to trigger the chaincode to add the information to the network.

```
recieves a POST request to '/api/landmigration'
    recieves land information as payload

    if (payload is valid)
        throw error with status 400 'Invalid Data'

    // Initialize wallet instace
    const wallet = Wallets.newFileSystemWallet(walletPath)

    // Getting the user's identity
    const identity = await wallet.get('appUser');

    // Checking if this user is eligible
    if(identity not authorized to trigger this chaincode by MSP)
        throw error 'Not authorized to avail this option'

    // Calling validateOwnership middleware to validate is the user is
    // the actual owner of the land
    const isOwnershipValidated = validateOwnership()

    if(isOwnershipValidated is false)
        throw error with status 400 'Invalid Owner'

    // Calling the function that will trigger chain code
    try {
        await landMigration(payload)
        response with status 201 'Land migrated'
    } catch (error) {
        response with status 400 'Unable to Migrate'
    }
```

Figure 4.13: Pseudo-code for API

4.7.3 Adding land to the Ledger Pseudo-code

The `landMigration` function will receive land information as payload. The next step is to get the network path. Then convert the path to `UTF-8` readable. Next part is to get the user's identity using the wallet. After that, it will be checked if this user exists in the network. If not it will throw an error. Next step is to create a gateway for connecting to the peer node. Next part is to get the channel using the gateway. After that, it will get the contract or chain code from the network/channel. Next step is to trigger the contract with the land information payload. Lastly, it will disconnect the gateway.

```
function landMigration( params ) {
    // load the network configuration
    const ccPath = networkPath

    // Covert ccPath to UTF8
    const ccp = convert(ccPath, UTF8)

    // Creation of wallet for managing identities
    const wallet = Wallets.newFileSystemWallet(walletPath)

    // Checking the user's identity
    const identity = wallet.get('appUser');

    if (!identity)
        throw error "An identity for the user does not exist in the wallet"

    // Create a new gateway for connecting to our peer node.
    const gateway = new Gateway();
    gateway.connect(identity)

    // Getting the network (channel)
    const network = gateway.getNetwork('HLLNetwork');

    // Get the contract from the network.
    const contract = network.getContract('landMigration');

    contract.submitTransaction(params)

    // Disconnect from the gateway.
    gateway.disconnect();
}
```

Figure 4.14: Pseudo-code for Ledger

Chapter 5

Novelty of Analysis

We mainly focused on the drawbacks and limitations of previously done projects on blockchain based land registry systems. We wanted to keep our system tamper-proof and decentralized with more easier and optimized user interaction. We have gone through so many projects done previously and found few which are mostly proof of work and proof of stake based, they have their own limitations, which we have tried to overcome in our system.

- **Hyperledger fabric based:** Hyperledger fabric based land registration system still needs research. In many countries, people proposed this type of system, so we wanted to design it specially for our country. Hyperledger is a permissioned blockchain, so read and write access can be controlled efficiently by the authority, which will make the system easy to handle. It can ensure transparency as well. We tried to make our system a combination of the advantages of both types of work and added special features to make it more optimized.
- **Coin usage:** We have proposed a coin here to make the transactions easy for the users which is the most unique feature in our system. Users can buy/sell lands and even can pay land taxes easily through HLL coin. The coin will also be used to check the eligibility whenever a user wants to request to change the ownership or to buy a land.

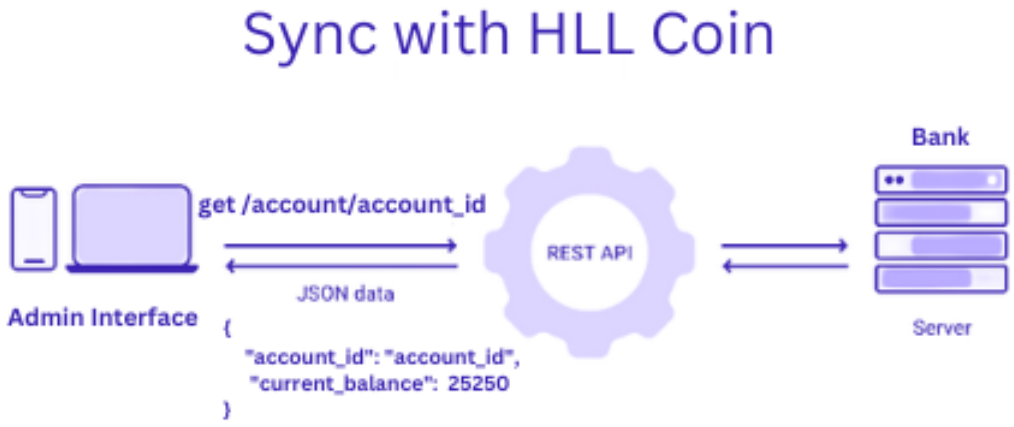

Figure 5.1: Sync with HLL Coin

HLL coin will work in the following process:

```
Eligibility = price of the land + network fee (registration
fee + land mutation fee) <= HLL coin;
```

- **Less computational power:** Hyperledger fabric needs less computational power whereas proof of work needs much computational power, so our system is time, cost and energy effective. [4]
- **Energy efficient:** Our system is energy efficient as it needs less operational power, so it is healthy for the environment.
- **Better Scalability:** Our system is flexible and can be changed in future with a broader perspective. We can add new features to the system over time, which will not be an issue. Proof of work based works don't have this opportunity.
- **Offline data storage functionality:** Our system doesn't need to be connected with computers all the time, it can perform offline and therefore, offline data storage is possible which is not available in proof of work and proof of stake. [12]
- **Faster Ownership Validation:** Our system takes less time to verify ownership even than proof of stake based systems.
- **Better Information Security:** Information security is very high than other works in our system, as offline data storage is possible. In other systems, if any nodes get corrupted, the data can be lost and security gets compromised.
- **Stays decentralized over time:** Our system will always be decentralized, but one of the limitations of proof of stake is it can eventually lead to be centralized which hampers our main and foremost target.

Figure 5.2: Comparison Chart

Chapter 6

Preliminary Analysis

When we refer to a blockchain-based land verification system, we are really referring to a decentralized land registration system. The benefits of blockchain technology for verifying land registration data require storing this data in the distributed ledger system. Legal entities record one's property documents. Property registration lets one legally own, use, and sell a unit bought directly from a builder. Legal ownership reduces the risk of fraud or misappropriation.

Property registration is essential for the continued ownership of land and other real estate. Property registration has numerous benefits:

- Real estate registration is an effective tool for avoiding legal conflicts over ownership of land.
- Registration of property also serves to establish ownership.
- It delivers title documents and other require Blockchain solution.

6.1 Blockchain Based Solution

Blockchains are chains of interconnected data blocks that are secured using cryptography. The previous block's cryptographic hash, a timestamp, and transaction data are included in each block. Due to its properties, blockchain is the only solution. Blockchain is a shared, immutable ledger. Each user interacts with the blockchain via a public-private cryptographic key. Blockchain records are immutable, making them difficult to alter, improving security. Users and roles in Hyperledger Fabric help secure and identify owners. Blockchains can help the government streamline property registration. Buyer, seller, bank, registration authority, and notary can create a distributed ledger. The blockchain can store and retrieve immutable property data. Blockchain features:

- Ensures persistent data records.
- Blockchain can readily track an item's provenance through the transaction history.
- Digital signatures and encryption make blockchain a secure system. It's safe, easy, and tamper-proof.

- Every blockchain entry is securely timestamped (permanency prevents backlogging). [7]
- The blockchain's participants' nodes disseminate the ledger and distribute it. [7]
- Multiple consensus protocols validate the submission, preventing duplicate entries and fraud.
- Only authority holders can view the transaction.
- Businesses can pre-set blockchain conditions with smart contracts. The circumstances initiate the automatic transactions.

6.2 Why is Hyperledger Fabric used?

The hyperledger fabric blockchain platform is attractive for other reasons as well. That would be:

- Hyperledger Fabric includes a comprehensive permission framework. We can have complete control over who has access to our blockchain and at what level of access.
- A transactional level consensus will be reached by Hyperledger. This means that only the specific transaction itself needs to be validated, not the entire block, before it can be accepted.
- At present, Node.js, Java, and Go are all supported languages for use with Hyperledger fabric.
- In contrast to ethereum, Hyperledger may function without a dedicated cryptocurrency implementation.
- Hyperledger doesn't require computers to solve problems 24/7, and it doesn't require users to own cryptocurrencies in order to establish consensus. [9]
- The Hyperledger fabric is open source and is maintained by IBM. [2]

Chapter 7

Conclusion

7.1 Summary of our work

Our system is tamper-proof and decentralized. A coin has been introduced to make the system transaction friendly. In our system, ownership validation is easy, accurate and takes less time. As we have no complex algorithm here, the system is faster than most other systems. Our system needs less computational power, hence, our system is cost, time and energy efficient. Security is much higher in our system and data loss is almost impossible. Our system does not need to be connected online with computers 24/7, so offline data storage is possible here.

7.2 Future works

The validation system of ownership is currently semi digital, so we wish to make it fully digital in future. We will implement the feature of users being able to buy/sell lands through HLL coin. Users will also be able to pay utility bills through HLL coin.

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