Smart Bangladesh: Blockchain-based Land Registration System

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CANDIDATE'S DECLARATION

We, hereby, declare that the project presented in this report is the outcome of the investigation performed by us under the supervision of Mr. Md. Khairul Hasan, Department of Computer Science and Engineering, Ahsanullah University of Science and Technology, Dhaka, Bangladesh. The work was spread over two final year courses, CSE4100: Project and Thesis I and CSE4250: Project and Thesis II, in accordance with the course curriculum of the Department for the Bachelor of Science in Computer Science and Engineering program.

It is also declared that neither this Project nor any part thereof has been submitted anywhere else for the award of any degree, diploma or other qualifications.

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CERTIFICATION

This Project titled, **"Smart Bangladesh: Blockchain-based Land Registration System"**, submitted by the group as mentioned below has been accepted as satisfactory in partial fulfillment of the requirements for the degree B.Sc. in Computer Science and Engineering in November 21, 2023.

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ABSTRACT

Bangladesh, a densely populated country experiencing rapid economic growth, faces challenges in its land registration process. This intricate procedure involves multiple government bodies handling various document sets, leading to bureaucratic loopholes and cumbersome processes. Consequently, the current land registration system is vulnerable to exploitation, allowing fraudulent individuals to deceive both the public and the government. Fraudulent activities range from forging paper documents to tampering with electronic records to manipulate land ownership records. These issues primarily arise from the reliance on outdated paper trails or poorly maintained centralized systems lacking transparency. To address these challenges, this paper presents a solution based on blockchain technology, which offers enhanced data synchronization, transparency, accessibility, immutable record management, and cost-effectiveness. Our proposed approach involves a phased adoption model for blockchain, commencing with a public blockchain ledger and progressively integrating two levels of hybrid blockchain. Through our experimental setup, we utilize local and live Ethereum test networks to showcase the effectiveness of this proposed system. Significantly, the transaction processing time of this blockchain-based system proves notably faster than the existing one. Considering the current landscape, the future of blockchain technology appears promising. Implementing blockchain in land registration processes, particularly in developing countries like Bangladesh, holds significant potential to revolutionize the infrastructure of land registration.

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Chapter 1

Introduction

1.1 Objective

Land registration refers to the formal recording of ownership, possession, and other rights related to land in a designated government agency or department. The main objective of land registration is to provide and establish evidence of title, prevent illegal disposal of land, and facilitate transactions. The scope of data that is documented and the degree of safeguarding ensured through land registration can significantly fluctuate depending on the specific legal system in which it is implemented. Adhering to the established regulations is an essential requirement for the transfer of real estate. The transaction process varies depending on the type of property, including whether it is singly or jointly owned. In today's environment, relying solely on a centralized database system can pose significant risks. Thus, it has become imperative to explore the adoption of blockchain technology to establish a decentralized system. Blockchain is a type of technology that utilizes a distributed ledger system, allowing for the secure and accurate tracking of information. Through this system, it provides an authentic and trustworthy source of data while also guaranteeing data ownership.

1.2 Motivation

The land registration process in Bangladesh is notorious for being a lengthy and complicated affair. One must ensure that all documentation is up to date to avoid any hassles from the local land office, which unfortunately often leads to fraudulent activities perpetrated by office employees. As a result, selling a piece of land without running into problems can be challenging. Additionally, potential buyers must undergo rigorous inspections before purchasing land, as sales documents frequently omit ownership details. The overabundance

of paperwork exacerbates these issues, leading to a rise in fraudulent activities, as well as requiring the assistance of legal advisers to verify the documents. Unfortunately, documents are only issued once and cannot be retrieved if lost. Furthermore, land ownership can be complicated due to factors such as government ownership, and the use of duplicate deeds to sell the same land to multiple parties. The absence of any intermediary and the utilization of a consensus-based verification system for accessing records results in a system that is free from conflicts. In other words, the approach adopted for record access ensures that there are no discrepancies or disputes within the system. All of these complications increase expenses and cause unnecessary inconvenience for all parties involved

1.3 Purpose

The digitization of the land registration process in Bangladesh is an ongoing effort that has been implemented partially in various regions across the country. While the adoption of online registration has the potential to decrease corruption, the current blend of online and offline procedures can be confusing and time-consuming for the citizens. Additionally, the centralized nature of the process may not ensure adequate protection against cyber threats and hackers who can manipulate the information and take ownership of the land illegally. Therefore, to streamline the registration process and decrease expenses, a decentralized network is necessary. Blockchain technology has gained widespread recognition worldwide due to its encrypted data, which enhances its security. The decentralized aspect of the blockchain technology enables the distribution of the ledger to all network members, and the unalterable nature of the data blocks. The implementation of this technology can significantly improve the lives of Bangladeshi citizens by mitigating corruption, reducing costs, and encouraging other sectors to adopt this innovative solution, contributing towards the digital transformation of Bangladesh and building a smarter nation for the future.

1.4 Summary

Blockchain technology presents a viable solution to the numerous challenges faced in the land registration sector. It offers a means of creating an unalterable digital token asset that represents physical property ownership, thereby simplifying the registration process and reducing associated costs. While it has the potential to revolutionize land registration in Bangladesh, it cannot address all the issues associated with the sector. For instance, discrepancies may arise where the land area does not match the deeds or the location of the land cannot be traced via blockchain technology, making it cumbersome for prospective buyers. Nevertheless, the integration of blockchain technology is likely to significantly en-

hance the quality of service received by the general public in the land registration sector of Bangladesh.

Chapter 2

Background Study

2.1 Related Works

2.1.1 Blockchain-Based Land Management for Sustainable Development

Reference [1]

Extensive research has been conducted to assess the progress of blockchain technology worldwide, with the review categorized into two distinct components Global North and Global South. This division was necessary as different regions around the world have approached the technology in diverse ways, necessitating a nuanced evaluation of its advancements.

Global North Findings

The works of Vos shed light on the immense potential of blockchain technology in ensuring trust and transparency in land registration processes, thereby curbing corruption and promoting order. His research highlighted ongoing blockchain projects in Ghana, Honduras, Sweden, Georgia, and the state of Illinois, USA. However, Vos also emphasized the importance of involving a Trusted Third Party in the blockchain process for land registration.

Lemmen explored the standardization of Land Administration in preparation for blockchain technology implementation in this field. They discovered that the European Union lacked a unified approach to land administration, with each country functioning independently. This lack of standardization could have severe consequences in the future. As a result, northern territories have yet to fully embrace the application of blockchain technology in

the management of land records.

Verheye's PhD thesis delved into Swedish and Georgian pilot projects and concluded that the role of blockchain technology in land registration is neither overly optimistic nor overly pessimistic. Meanwhile, Deši´c and Lenac provided a jurist's overview of blockchain technology and discussed how its implementation in Georgia, Dubai, Honduras, Brazil, Sweden, and Estonia had resulted in significant improvements. They also highlighted the pressing need for blockchain technology in the Croatian Land Registration system.

In Germany, Müller and Seifert recognized the flaws of the current land registration system and emphasized the importance of blockchain technology in reducing unnecessary paperwork and inconsistencies. Lastly, Shang and Price initiated a pilot project on blockchain technology in Georgia to tackle the possibility of frauds in the land registration system. Georgia was the first country in the world to employ blockchain technology in land registration, with Ukraine following suit.

Global South Findings

In the southern hemisphere, there seems to be a relatively lower level of activity at the state level in terms of implementing blockchain technology for land administration. However, Indian scientists have been publishing a significant number of papers on the topic, indicating their keen interest in exploring its potential applications for improving land administration in their country.

Müller and Seifert's research revealed that some actions were initiated at the state level in Andraha Pradesh, India, aimed at improving land registration and transparency through blockchain technology. Meanwhile, Ghana has also expressed its openness to implementing blockchain technology, given that approximately 80% of rural landowners remain unregistered.

Although there were pilot projects in Honduras and Brazil, they faced obstacles during implementation, preventing them from being put into official use. In contrast, Dubai has successfully implemented blockchain technology in land administration, with plans to achieve complete digitization of state administration in the near future.

Table 2.1: Total Number of Papers Per Country

Country	**No. of Papers**	**Country**	**No. of Papers**
Malaysia	14	Ghana	5
Italy	14	Iraq	6
Bangladesh	15	Indonesia	6
Spain	18	Hong Kong	6
Netherlands	18	United Arab Emirates	7
Canada	19	Switzerland	7
Saudi Arabia	20	Norway	7
Germany	26	Iran	7
Russia	27	Denmark	8
China	32	South Korea	10
UK	35	France	10
Australia	36	Sweden	11
US	50	Pakistan	11
India	89	Turkey	12

Summary

The research conducted on the use of blockchain technology in land registration has revealed an encouraging trend of annual growth in scientific paper publications on the topic across the globe. Even in regions such as Africa and South America, an increasing number of countries are engaging with the subject, at least in the scientific community, through their published works.

India has shown a particular interest in this area, likely due to the numerous challenges they face in land governance. Moreover, highly developed countries are also keen to explore ways to enhance their solutions through the use of blockchain technology. While the number of papers published on the topic can provide valuable insights, it is essential to note that outcomes must be realized at the state level for this technology to truly improve land management.

For instance, the USA, Australia, and the United Kingdom have published 50, 36, and 35 papers, respectively. However, there is no concrete evidence of practical outcomes in their land administration systems yet. The implementation of blockchain technology in land registration has the potential to enhance the performance of every state in which it is utilized, as demonstrated by Georgia's successful adoption. However, meeting the necessary prerequisites is crucial for realizing its full potential.

Future research should take into account the differences between developed and non-developed countries when exploring the potential applications of blockchain technology in land registration. Developed countries would benefit from research that focuses on legislation and standardization, while non-developed countries would benefit from research that focuses on establishing land registration systems. From our findings, it is evident that blockchain technology has a promising future in the field of land governance for numerous countries around the world. Although its implementation may not happen immediately, with the creation of a conducive environment, it has the potential to bring immense benefits to society. As researchers and developers, we should strive towards creating an environment that fosters the growth and adoption of this technology in order to achieve our collective goal of creating a better world.

2.1.2 A secured land registration framework on Blockchain

Reference [2]

Our extensive research into the implementation of blockchain technology for land registration has revealed noteworthy developments across several countries worldwide. Notably, Sweden, Netherlands, Honduras, India, and Dubai have all embarked on plans to adopt a

blockchain-based land registry system, demonstrating a growing recognition of the transformative potential of this technology.

Of these, the Sweden project stands out with its comprehensive documentation, outlining the technical framework for the implementation of blockchain technology in land registration. The project's current technical demo utilizes ChromaWay's cutting-edge technology and programming structure, Esplix, which enables the creation of smart contracts and embedded contracts within a blockchain network. Such advancements represent a significant step towards a more secure, efficient, and transparent land registration system, with the potential to drive further adoption of blockchain technology in the domain of property rights and land governance worldwide.

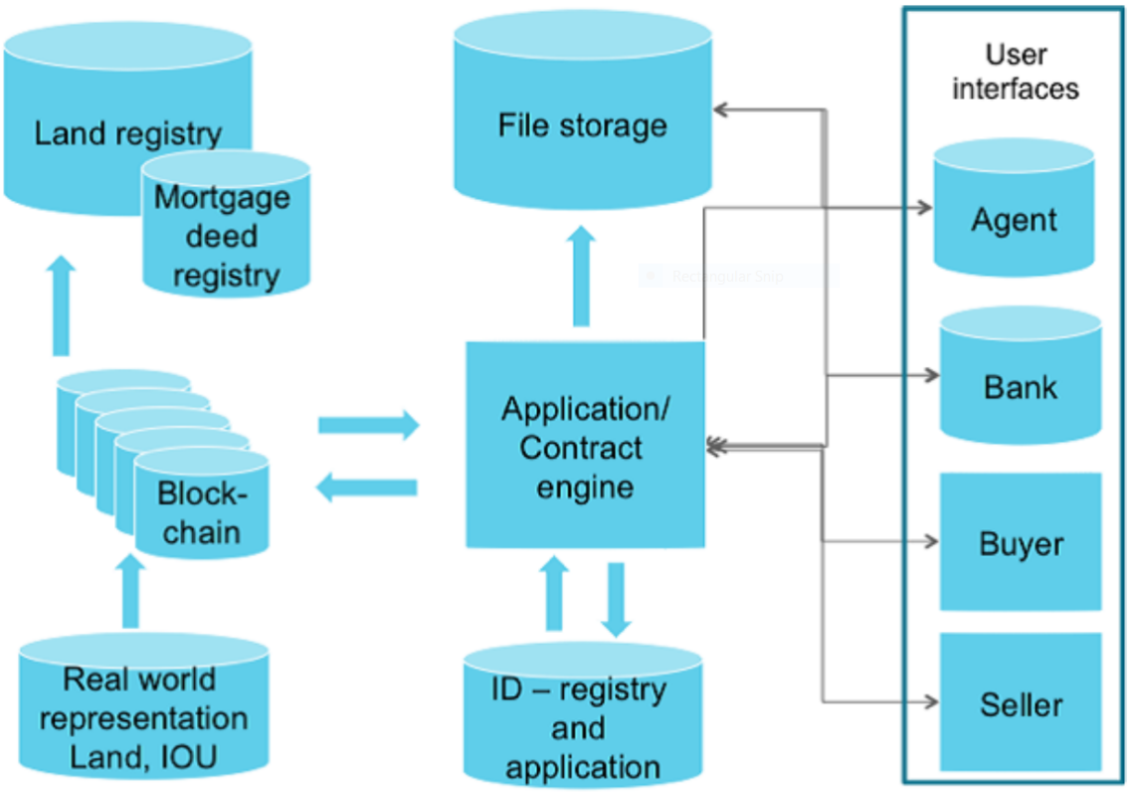

Figure 2.1: The Architecture of the Sweden Land Registry Project

Our research into the global implementation of blockchain technology for land registration has revealed significant developments in several countries worldwide. The Netherlands Land Registry, for example, has expressed a willingness to explore the use of blockchain technology, alongside artificial intelligence, to generate predictive models for real estate data. Similarly, Russia, the United Kingdom, and Brazil have also launched projects exploring the use of blockchain for land registry systems. In this context, Dubai stands out as a global pioneer in the adoption of blockchain technology for land ownership registration. Dubai has successfully leveraged blockchain as a secure database of records, linking lease registrations to key utilities, telecommunication systems, and property related billing

systems. The use of IPFS for storing Emirates Identity Cards and validating resident visas, coupled with the provision of electronic rent payments, has significantly enhanced the overall efficiency and effectiveness of the land registration system for residents of the UAE.

Our findings suggest that blockchain technology has emerged as a crucial tool for securing not only land registration systems but also other critical sectors worldwide. Given its potential to improve transparency, accountability, and efficiency, blockchain technology is poised to play an increasingly central role in the design and implementation of innovative, secure, and reliable governance systems across various domains.

2.1.3 Securing Land Registration using Blockchain

Reference [3]

Blockchain technology has been widely adopted in various fields such as health, finance, real estate, and education, among others, to provide a distributed approach to secure data and reduce intermediary costs. In the healthcare industry, blockchain is used to protect patients' medical records from unauthorized access, while in finance, it provides a reliable payment platform without the need for a third party, thus preventing network attackers and security issues. Additionally, it eliminates the problem of double spending through a distributed timestamp server that generates a computational proof of transaction in chronological order.

Within the real estate sector, the utilization of blockchain-powered smart contracts guarantees the systematic tracking of events, thereby diminishing the necessity for intermediary brokerage fees. One illustrative instance is the Evarium platform, which presents a digital framework for real estate investment, leading to decreased costs and enhanced profit distribution in commercial property transactions.

In the realm of education, blockchain technology has found application in the EDuCTX system, which facilitates the consolidation and exchange of students' academic information among universities and industries. This system operates with registered higher education institutions serving as network nodes, enabling them to award credits to students upon successful course completion. This innovative approach effectively mitigates issues related to language barriers and administrative hurdles that international students typically encounter when pursuing courses at foreign universities. When a student grants authorization for an educational institution or prospective employer to access their academic records, the selection process becomes more streamlined and less cumbersome.

Overall, the adoption of blockchain technology in various industries has offered an innovative solution to address security, intermediary costs, and administrative issues.

2.1.4 A Blockchain-based Land Title Management System for Bangladesh

Reference [4]

Our investigation into the third research paper related to the utilization of blockchain technology in land registration has provided us with valuable insights into the global evolution of land registration practices. The Republic of Georgia initiated the process of land titling in 2016, adopting a phased approach to implement blockchain technology with the aim of combating corruption and mismanagement within land ownership registries. The successful pilot project led to the adoption of a more integrated system in 2017, resulting in the publication of 1.5 million land titles on the blockchain by 2018.

In an effort to preserve patient privacy and facilitate easier access to necessary data, Sweden began experimenting with blockchain-based land registration in 2017 to streamline their existing system. Meanwhile, Andhra Pradesh, a state in India, partnered with startups to pilot blockchain-based land registry systems, ensuring transparency in governance.

The United Arab Emirates (UAE) and Dubai are striving to become global leaders in adopting blockchain technology through the "UAE Blockchain Strategy 2021." They have ongoing projects spanning various sectors, including energy and water, transport and logistics, economic development, tourism, safety and justice, municipality and land, health, social services, and smart districts.

Thakur et al. introduced a model for a blockchain-based land titling system in India; however, their work lacks a comprehensive description of smart contract applications. In another study by Mukne and colleagues, an alternative land title management system for India is presented, employing permissioned blockchains like Hyperledger Fabric and storing documents through the Inter Planetary File System (IPFS). Additionally, in a separate work from 2018 by Hasan and Salah, an Ethereum-based digital asset is showcased, providing detailed implementation specifics and algorithmic models for replicating the proposed system.

For Bangladesh, a hybrid blockchain-based land titling system has been proposed to address issues related to information availability and transparency. This proposal includes a three-phase plan for blockchain adoption, a comprehensive design of the public blockchain, and the necessary smart contracts. The system has been implemented using Ethereum. However, the complexity of land management in Bangladesh, involving multiple departments, presents a challenge in transitioning the entire process to blockchain technology in a timely manner.

Table 2.2: Comparison of Blockchain-based Land Title Proposals

	Shang et al.	**Thakur et al.**	**Mukne et al.**	**Proposed System**
Country Challenge	Georgia Corruption Control	India Transparent Ownership	India Digitized	Bangladesh Archieve digitization ongoing
Digitization Level	Land database available	Land database available	Land database available	Digitization is sloth
Proposed Model Blockchain Architecture	Incremental two phase Public	Single phase Public or private	Single phase Permissioned Blockchain	Incremental three phase Phase one public, next two phases hybrid
PKI	N/A	Certificate authority	OAuth	Multi-party
IPFS	N/A	N/A	Enabled	Enabled
Project Implementation	Bitcoin as a layer	Conceptual Study	Hyperledger Fabric prototype	Ethereum as a layer at public phase
Government initiated	Assigned startup	Academic	Academic	Academic
Experimental Result	Phase one successful now moves to phase two	N/A	prototype	Compared with benchmark

2.2 Related Terms

2.2.1 Concept

Blockchain

Blockchain is a decentralized digital ledger technology that offers a secure, transparent, and unchangeable record of transactions. While it was initially developed as the foundational technology for the cryptocurrency Bitcoin, it has found applications in numerous industries outside of finance.

At its core, blockchain functions as a distributed database that spreads data across a network of computers instead of centralizing it in one location. This decentralization makes it highly resistant to hacking and manipulation since there is no single vulnerable point. Each block within the blockchain contains a cryptographic hash of the previous block, creating an unbroken chain of data that cannot be retroactively altered without consensus from the network. This technology has the potential to bring about significant changes in various industries by enhancing efficiency, security, and transparency. For example, in supply chain management, blockchain can be utilized to monitor the movement of goods from the manufacturer to the end consumer, thereby reducing the risk of fraud, counterfeiting, and errors. Furthermore, blockchain enables peer-to-peer transactions, eliminating the need for intermediaries like banks and reducing transaction fees.

Despite its potential advantages, the adoption of blockchain has been sluggish due to various challenges, including regulatory uncertainties, issues related to scalability, and difficulties in interoperating with existing systems. However, as the technology continues to evolve and tackle these challenges, it is anticipated to become more prevalent in a range of industries, leading to more secure and efficient transactions.

There are several key features of blockchain technology that make it unique and valuable. Here are some of the most important features of blockchain:

1. **Decentralization:** Blockchain is a decentralized technology, meaning that it operates without a central authority or intermediary. This makes it highly resistant to censorship, manipulation, and hacking.

2. **Distributed ledger:** Blockchain is a decentralized database that keeps an ever-expanding collection of records or blocks. Within each block, there is a cryptographic hash of the preceding block, forming an uninterrupted sequence of data that cannot be changed in the past without agreement from the network.

3. **Security:** The decentralized nature of blockchain and the use of cryptographic tech-

niques make it highly secure. Transactions are verified and validated by multiple parties in the network, making it difficult for any single party to tamper with the data.

4. **Transparency:** Blockchain enhances transparency by enabling every participant in the network to access and confirm transactions, fostering trust and responsibility. This is because all parties possess a shared and unchangeable ledger of the transactions.
5. **Immutability:** Once a block is incorporated into the blockchain, it becomes immutable and resistant to alteration or removal. This characteristic ensures a high level of reliability and guards against fraudulent or manipulative actions on the data.
6. **Smart contracts:** Blockchain enables the utilization of smart contracts, which are contracts that execute themselves automatically to enforce agreed-upon terms. This has the potential to simplify and automate numerous business processes, diminishing the reliance on intermediaries and boosting efficiency.

In general, these attributes render blockchain a groundbreaking and potent technology capable of revolutionizing multiple industries through the delivery of enhanced security, transparency, and efficiency.

Proof of Work [5]

Proof of Work (PoW) is a consensus mechanism used in blockchain networks to validate transactions and create new blocks. Here are some key points about PoW:

1. PoW relies on cryptographic hash functions to solve complex mathematical puzzles.
2. Miners engage in a competition to discover a nonce, which, when combined with the block's data, generates a hash value that satisfies specific criteria.
3. The difficulty of the puzzle is adjusted to maintain a consistent block creation rate.
4. PoW requires significant computational power and energy consumption.
5. The first miner to find a valid solution broadcasts it to the network for verification.
6. Other nodes verify the solution by performing the same calculation.
7. Once verified, the new block is added to the blockchain, and the miner is rewarded with cryptocurrency.
8. PoW provides security by making it computationally expensive and impractical to tamper with the blockchain.
9. However, PoW has drawbacks, including high energy consumption, scalability challenges, and the centralization of mining power.

Proof of Stake (PoS) [6]

Proof of Stake (PoS) is a consensus mechanism used in blockchain networks as an alternative to Proof of Work (PoW). Here are some key points about PoS:

1. PoS selects validators based on the number of coins they hold and are willing to stake in the network.
2. Validators are chosen to create new blocks and validate transactions based on their stake.
3. Validators alternate between suggesting and verifying blocks, with their likelihood of selection directly related to their stake.
4. Block verification is done by other validators in the network to ensure the proposed block's validity.
5. Consensus is reached when a supermajority of validators agrees on the validity of a block.
6. Validators are rewarded for their participation in block creation and validation.
7. PoS reduces energy consumption compared to PoW and improves scalability.
8. Challenges in PoS include the "nothing-at-stake" problem and the potential for centralization.

Smart Contract

A smart contract is a self-executing computer program that automatically enforces the terms of an agreement between two or more parties. It is a digital contract that operates on a blockchain platform, such as Ethereum, and is executed when certain predefined conditions are met.

Smart contracts are designed to eliminate the need for intermediaries, such as lawyers and banks, by automating the process of verification, execution, and enforcement of contracts. This can reduce transaction costs and increase efficiency.

Smart contracts can be used for a variety of purposes, such as:

1. Facilitating secure and transparent voting systems
2. Managing supply chain logistics
3. Automating insurance claims processing

4. Enforcing intellectual property rights
5. Facilitating peer-to-peer lending and crowdfunding
6. Creating new digital currencies or tokens
7. One of the key advantages of smart contracts is that they are transparent and immutable. Once a smart contract is deployed on a blockchain, it cannot be altered or tampered with, providing a high degree of security and trust.

Overall, smart contracts have the potential to transform many industries by streamlining and automating business processes, reducing costs, and increasing transparency and security.

The main difference between a traditional contract and a smart contract is that a traditional contract is a physical or digital document that is typically enforced by a third party, while a smart contract is a self-executing program that is enforced by a blockchain platform.

Here are some of the key differences between traditional contracts and smart contracts:

1. **Enforcement:** Traditional contracts require a third party, such as a lawyer or a court, to enforce the terms of the contract. Smart contracts are enforced automatically by the blockchain platform when certain predefined conditions are met.
2. **Intermediaries:** Traditional contracts often require intermediaries, such as banks or lawyers, to facilitate the transaction and ensure that all parties meet their obligations. Smart contracts eliminate the need for intermediaries, as they are self-executing and automated.
3. **Transparency:** Traditional contracts are often opaque, as they are typically only seen by the parties involved. Smart contracts are transparent, as they are stored on a blockchain platform and can be viewed by all parties in the network.
4. **Security:** Traditional contracts can be vulnerable to fraud or manipulation, as they are often stored in a centralized location and can be altered or destroyed. Smart contracts are highly secure, as they are stored on a decentralized blockchain platform and are immutable once deployed.

Overall, smart contracts provide many advantages over traditional contracts, including increased efficiency, transparency, and security. They have the potential to revolutionize many industries by automating and streamlining business processes, reducing costs, and increasing trust between parties. [7]

Ethereum

Ethereum, established by Vitalik Buterin in 2013 and officially launched in 2015, is a decentralized and open-source blockchain platform renowned for its ability to facilitate the creation of smart contracts and decentralized applications (dApps). Smart contracts are self-executing agreements that automatically enforce their terms, offering versatile applications such as secure and transparent voting systems, supply chain logistics management, and the creation of new digital currencies.

Distinctively, Ethereum features its native cryptocurrency known as Ether (ETH), serving as the platform's fuel and means for covering transaction fees. Unlike Bitcoin, Ethereum goes beyond being a digital currency; it serves as a versatile foundation for constructing decentralized applications that operate on its blockchain.

In summary, Ethereum stands as an innovative and robust platform with the potential to revolutionize numerous industries through the empowerment of decentralized applications and smart contracts. Its open-source nature and the active engagement of its developer community have greatly contributed to its widespread adoption and growth.

2.2.2 Backend

Solidity

Solidity is a high-level programming language used for writing smart contracts on Ethereum and other blockchain platforms. It was created by the Ethereum Foundation and is designed to be easy to learn and use, while also providing powerful features for writing complex smart contracts.

Solidity is a statically typed language, which means that variables and data types must be declared before they can be used. It is similar to languages like C++ and JavaScript, making it accessible to developers with a wide range of programming backgrounds.

Some of the key features of Solidity include:

1. **Contract-oriented:** Solidity is a contract-oriented programming language, meaning that it is specifically designed for writing smart contracts.
2. **Strongly-typed:** Solidity is a strongly-typed language, which helps to prevent programming errors and makes code more reliable.
3. **Ethereum-specific features:** Solidity includes special features that are specific to the Ethereum platform, such as the ability to create and manage digital assets, write decentralized applications, and interact with other contracts on the network.

4. **Safety features:** Solidity includes safety features like error handling and exception handling to help prevent programming errors and ensure that contracts are executed correctly.

5. **Open-source:** Solidity is an open-source language, which means that its source code is freely available to anyone who wants to use it.

Overall, Solidity is a powerful and versatile language that is widely used for writing smart contracts on the Ethereum platform. Its features and ease of use have contributed to the growth of decentralized applications and the wider adoption of blockchain technology. [8]

2.2.3 Frontend

Metamask

Metamask, introduced in 2016, stands as a widely embraced Ethereum wallet in the form of a browser extension and a mobile app. Its primary function is to enable users to engage with decentralized applications (dApps) on the Ethereum blockchain while offering security and user-friendliness.

As per the official Metamask website, the platform furnishes a safe and intuitive interface for the management of digital assets and seamless interaction with Ethereum dApps. It empowers users to securely store, oversee, and transfer Ethereum and various ERC-20 tokens. Notably, private keys are encrypted and stored locally on the user's device, bolstering security.

Moreover, Metamask serves as a crucial link between the user's web browser or mobile device and the Ethereum blockchain, granting them direct access to decentralized applications. Integration with numerous popular Ethereum dApps simplifies user accessibility and interaction.

Metamask caters to both browser users, with extensions available for Chrome, Firefox, and Brave, and mobile users through iOS and Android applications. It is an open-source endeavor, with its source code accessible for public scrutiny and contributions..

In summary, Metamask is a favored and user-friendly tool that facilitates interaction with Ethereum's decentralized applications. It not only ensures the secure management of digital assets but also offers a convenient entry point to participate in the decentralized finance (DeFi) landscape. [9]

TypeScript

TypeScript is a programming language that enhances JavaScript by incorporating static typing and additional functionalities, thereby enhancing its suitability for developing large-scale applications with increased robustness. The following points highlight key aspects of TypeScript:

1. TypeScript is an extension of JavaScript, meaning that any legitimate JavaScript code is equally valid TypeScript code.
2. It introduces the concept of static typing, enabling developers to specify and uphold data types for variables, function parameters, and output values.
3. The TypeScript compiler provides static type checking and converts the TypeScript code into JavaScript.
4. It has gained popularity for web development, especially in projects built with frameworks like Angular and React. [10]

Ethers.js

Ethers.js is a TypeScript library for interacting with the Ethereum blockchain. It provides a user-friendly and flexible interface for developers to interact with the Ethereum network, including sending transactions, reading data from the blockchain, and interacting with smart contracts.

According to the Ethers.js documentation, the library is designed to be modular and flexible, allowing developers to use only the features they need. It supports both Node.js and browser environments and includes a wide range of utility functions and classes to simplify common Ethereum tasks.

One of the key features of Ethers.js is its support for interacting with Ethereum smart contracts. It includes a Contract class that makes it easy to interact with smart contracts using a high-level API. Developers can use Ethers.js to deploy new smart contracts, read data from existing contracts, and send transactions to modify the state of a contract.

Ethers.js is also fully compatible with the Ethereum JSON-RPC API, which allows developers to interact with any Ethereum node or client that supports the API. This makes it easy to integrate Ethers.js with existing Ethereum infrastructure and tools.

In summary, Ethers.js is a powerful and flexible library for interacting with the Ethereum blockchain and smart contracts. Its modular design and support for the Ethereum JSON-RPC API make it a popular choice for Ethereum developers. [11]

React

React stands as a well-known JavaScript library created by Facebook, widely utilized for crafting web and mobile application user interfaces. The core concept of React revolves around enabling developers to construct components that represent distinct parts of a user interface, which can then be combined to create intricate and dynamic interfaces. React utilizes a virtual DOM (Document Object Model) to efficiently manage the interface's state and rendering.

As per the React documentation, the library is intentionally designed to be declarative. This means that developers specify the desired user interface, and React takes care of the intricate rendering aspects. Moreover, React adopts a unidirectional data flow, which not only aids in preventing common programming errors but also simplifies the comprehension of the application's state.

React's widespread popularity can be attributed, in part, to its vibrant and engaged community, which has produced a diverse array of tools and libraries to facilitate React development. Furthermore, React is exceptionally adaptable and can be seamlessly integrated with various other technologies, including backend frameworks and databases.

In summation, React is a robust and versatile library tailored for constructing user interfaces in web and mobile applications. Its declarative approach, unidirectional data flow, and the extensive and active community render it a favored choice among front-end developers. [12]

Bootstrap

Bootstrap, initially created by Twitter, stands as a highly popular front-end web development framework, offering a comprehensive set of tools in HTML, CSS, and JavaScript. It serves as a valuable resource for developers in crafting responsive and mobile-first websites and web applications.

Within Bootstrap, there exists an extensive array of user interface components, encompassing items like buttons, forms, and navigation menus. These components are easily customizable to align with the desired design of a website or application. Additionally, Bootstrap incorporates a grid system, simplifying the creation of intricate layouts.

A notable advantage of utilizing Bootstrap is its innate responsiveness, where the layout of a website or application automatically adapts to the screen size on which it's displayed. This feature is especially crucial in the contemporary digital landscape, where users access content from diverse devices with varying screen dimensions..

Furthermore, Bootstrap offers a collection of JavaScript plugins that augment the function-

ality of websites or applications. For instance, the carousel plugin facilitates the creation of image sliders, while the modal plugin enables the development of pop-up windows.

In summary, Bootstrap serves as a potent and versatile framework, empowering developers to swiftly and effortlessly construct responsive and mobile-first websites and web applications. [13]

Vite

Vite is a modern build tool for web applications. It is designed to be fast and efficient, allowing developers to build and bundle web applications quickly and easily.

One of the key features of Vite is its fast development server, which is based on the native ES modules in modern browsers. This means that Vite can serve the application in development without bundling it, resulting in faster hot-reloading and a faster development cycle overall.

Vite also supports a wide range of modern web technologies, including TypeScript, JSX, CSS preprocessors, and more. It includes a built-in plugin system that allows developers to extend its functionality and customize the build process to meet their specific needs.

Another advantage of Vite is its tree-shaking and code-splitting capabilities. This means that Vite only includes the parts of the application that are actually used, resulting in smaller and faster-loading builds.

Overall, Vite is a powerful and modern build tool for web applications that offers fast development and build times, support for modern web technologies, and customizable plugin system. [14]

Hardhat

Hardhat serves as a development environment tailored for the creation and testing of smart contracts within the Ethereum blockchain. It proves to be a robust tool for developers seeking a quick and straightforward means of writing, deploying, and testing smart contracts.

A standout feature of Hardhat is its adaptability, as it accommodates a wide spectrum of development workflows and empowers developers to personalize their development environment to cater to their specific requirements. It encompasses various plugins that can be utilized to expand its capabilities and integrate with other tools and services.

Hardhat also incorporates a robust console that allows developers to engage with smart contracts in real-time. This simplifies the process of testing and debugging smart contracts, ensuring that they perform as intended before deployment on the main Ethereum network. Another noteworthy aspect of Hardhat is its comprehensive testing framework, featuring an

array of testing tools that facilitate the creation and execution of tests for smart contracts. This guarantees the reliability and security of contracts before they are deployed on the primary Ethereum network.

Furthermore, Hardhat includes an in-built deployment tool that streamlines the process of deploying smart contracts to the Ethereum network. It supports various deployment strategies, encompassing local networks, test networks, and the primary Ethereum network.

In conclusion, Hardhat emerges as a potent and versatile development environment for constructing and evaluating smart contracts on the Ethereum blockchain. [15]

Remix IDE

Remix IDE stands as a web-based integrated development environment (IDE) designed for the creation and validation of smart contracts on the Ethereum blockchain. It has gained popularity among developers seeking a swift and straightforward means of crafting and deploying smart contracts.

A prominent feature of Remix IDE is its simplicity, boasting a user-friendly interface that simplifies the process of writing and testing smart contracts. It offers various amenities like code highlighting, auto-completion, and debugging tools to aid developers in crafting clean and dependable code.

Furthermore, Remix IDE comes equipped with an in-built compiler that translates smart contracts into bytecode, allowing them to be executed on the Ethereum network. This serves as a crucial step in ensuring that the smart contracts perform as intended before being deployed to the primary Ethereum network.

Another notable benefit of Remix IDE is its comprehensive testing framework, incorporating a variety of testing tools for crafting and executing tests on smart contracts. This quality control process assures the reliability and security of contracts before their deployment on the Ethereum mainnet.

Additionally, Remix IDE is compatible with a range of plugins, enabling developers to expand its functionality and integrate it with other tools and services. This adaptability facilitates the customization of the development environment to meet specific requirements and workflows.

In summary, Remix IDE stands out as a potent and user-friendly tool for the construction and evaluation of smart contracts within the Ethereum blockchain ecosystem. [16]

IPFS

When a file joins a network, it gets a special code called a cryptographic hash. This code is like a unique ID for the file and all its parts. After that, the system removes any extra or repeated content and keeps a record of all the changes over time. In the end, only the important information is kept, and other devices in the network can choose what they want to get. The network determines which node holds specific information through Distributed Hash Table (DHT). When a user searches, the network reveals details linked to a file's hash. The Merkle Directed Acyclic Graph (DAG) interconnects file structures, allowing user access via human-readable names in the InterPlanetary File System (IPFS).

In the realm of IPFS, a decentralized protocol, files on the network are uniquely identified and linked through cryptographic hashes. Eliminating redundant content and tracking historical changes enhance network efficiency. IPFS introduces IPNS, enabling users to access files through human-readable names, streamlining the overall user experience.

IPFS boasts reduced hosting expenses facilitated by a peer-to-peer network that ensures cost-effective bandwidth by eliminating data replication, thereby saving on storage space. It delivers outstanding performance as servers experience minimal disruptions while ensuring the availability of extensive data through the concurrent utilization of multiple nodes. The decentralization aspect removes control over data output from biased internet service providers, guaranteeing the freedom of content from censorship. Additionally, the entire system is not vulnerable to security threats; only specific nodes are susceptible, yet the overall functionality remains intact. Ongoing efforts by software developers to upgrade nodes contribute to continuous security enhancements.

IPFS operates as a web independent of traditional internet connectivity, providing offline access and availability in low-connectivity areas. Even if nodes go offline, hosted content remains accessible. The network ensures permanent availability of data files and modifications over time, allowing editing without duplicating the original data and maintaining data integrity.

IPFS is currently in the developmental phase, despite its widespread adoption. Certain features, such as IPNS, exhibit sluggish performance and possess a subpar user interface, aspects that users anticipate will enhance with ongoing development. Moreover, the overall concept of IPFS is intricate for the average user, potentially dissuading widespread use. Finally, there is a critical need to emphasize the establishment of robust long-term data backup mechanisms in the event that nodes opt to delete the original files.

The introduction of IPFS marks a new era in web development, aiming to address issues with HTTP, such as slow connection speeds, centralization, and duplication. It offers a versatile framework for various applications, but refinement is needed for secure and user-friendly

services. The ultimate goal is faster file searching, sharing, and superior content delivery, anticipating a significant transformation in the Internet landscape upon project completion. [17]

Sepolia Test Network

The Sepolia testnet acts as a secure testing ground for developers to experiment with and launch decentralized apps (dApps) on a blockchain. Functioning as an open-source platform, it operates with the support of Cosmos, a protocol that links different blockchains together. Developers leverage this platform to construct and trial their dApps within a fully decentralized network. Recognized for its speed, security, and reliability, the Sepolia testnet is constructed on Tendermint, a dependable system that swiftly and securely reaches agreements within the network.

After the Ethereum Merge in September 2022, an enhanced Proof-of-Stake mechanism was introduced, allowing users to stake their tokens for maintaining the network's security and integrity. Engineered with scalability and security in focus, the Sepolia testnet can efficiently process a high volume of transactions and accommodate a substantial user base. With a dedicated emphasis on security, it incorporates measures to prevent issues like double-spending and counteract malicious activities. Additionally, the testnet offers a comprehensive set of developer tools to facilitate the swift development and deployment of applications. These tools encompass lightweight node software, a developer dashboard, and a secure wallet. The wallet provides a secure space for developers to store and manage their tokens, while the dashboard offers an intuitive interface for effective network management. [18]

Chapter 3

Implemented Model

3.1 Implemented Model

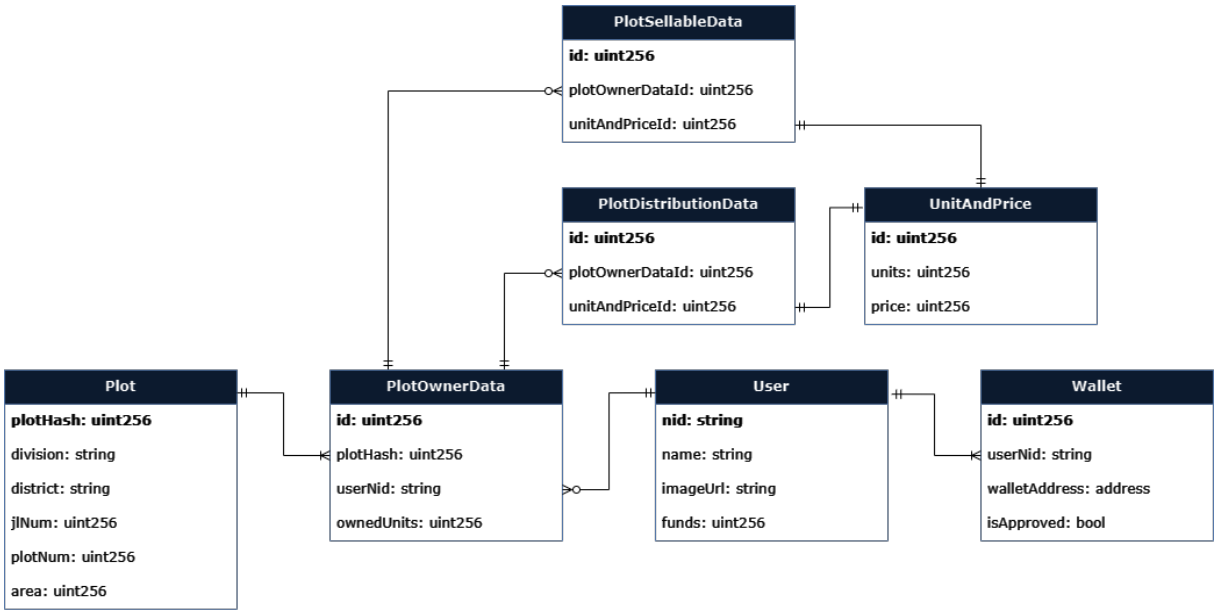

Figure 3.1: Implemented Model

Plot

It holds all the detailed information about the plot.

PlotOwnerData

It has details about which owner possesses which plot and the quantity of land units owned by that specific owner.

User

It has all the user information, including the user's personal image URL sourced from IPFS.

Wallet

It includes wallet details, along with the approval status.

PlotDistributionData

It enables us to understand how the plots are assigned to each user, including the total units for each plot and their respective prices.

UnitAndPrice

It keeps information about the quantity of units for each plot and their respective prices.

PlotSellableData

It gives details about the offers made by each user for specific plots, including the number of units and the suggested price.

3.2 Flowchart

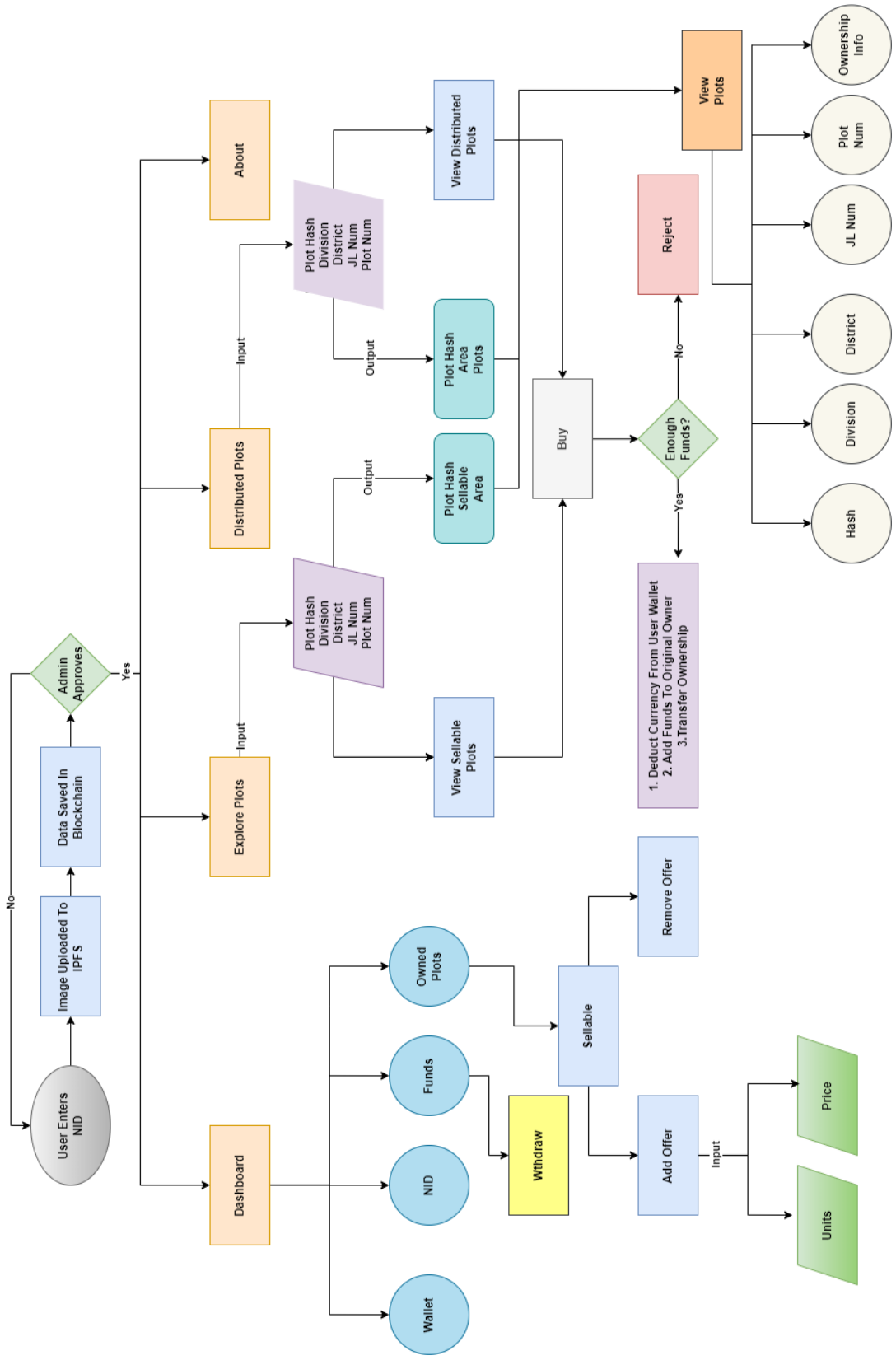

Figure 3.2: Features for User

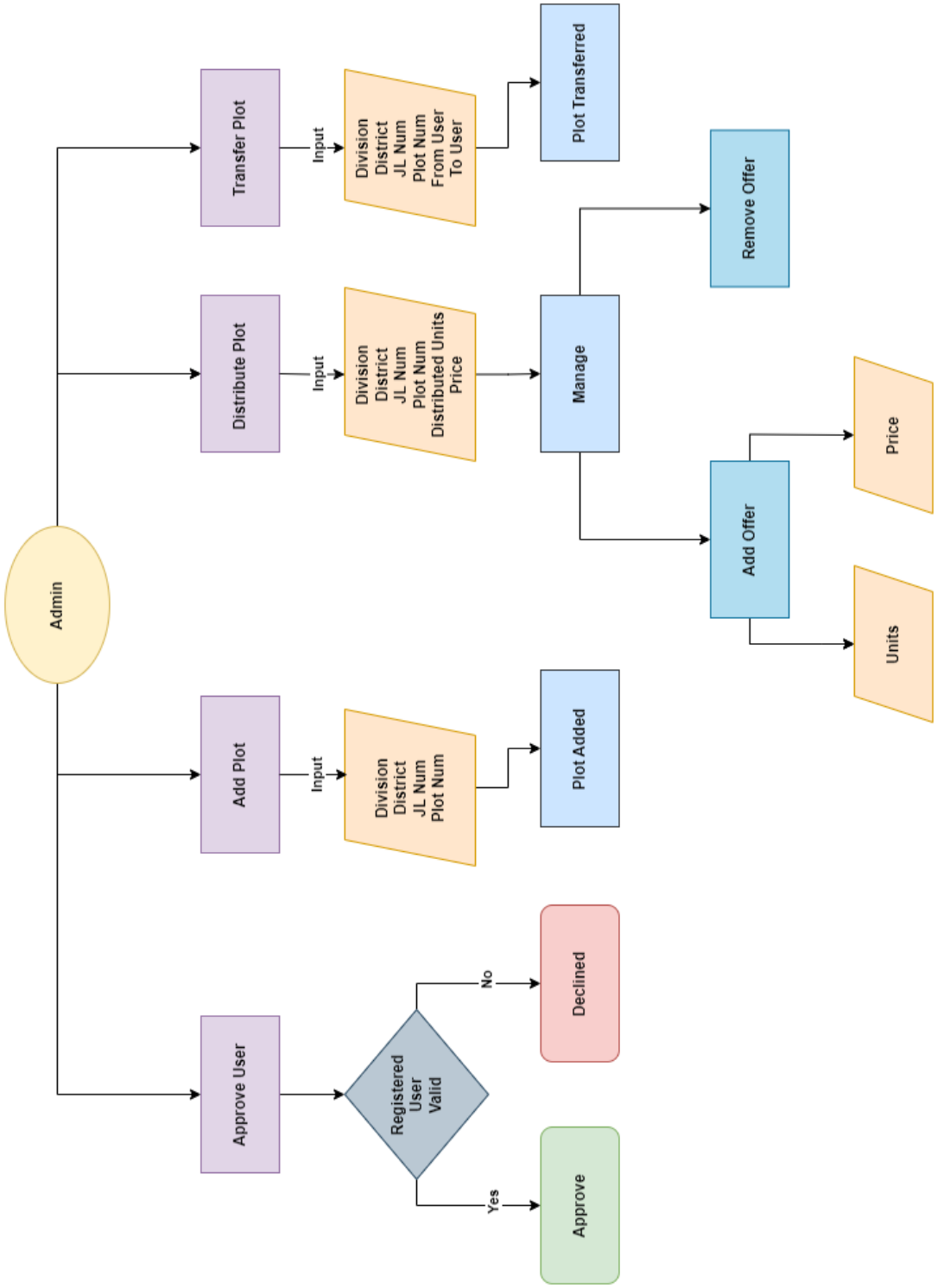

Figure 3.3: Additional Features for Admin

Chapter 4

Simulation

4.1 Simulation

4.1.1 Home Page

The entire land registration process is thoroughly summarized. Initially, users are greeted on the home page where the individual simply inputs their National ID (NID) and proceeds by selecting "Continue" to access the subsequent pages. The progression to the next stage is contingent upon approval from the system administrator.

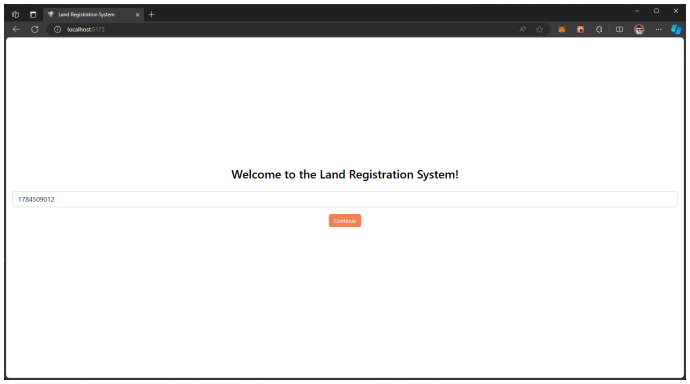

Figure 4.1: Home Page

4.1.2 User Dashboard

After moving to the next step, users can now explore four different pages: Dashboard, Explore Plots, Distributed Plots, and About. These pages let users check out different things and learn more about the land registration system. On the Dashboard, users find four key pieces of information: their Wallet ID, National ID (NID), total available funds for withdrawal, and a list of plots they own. If a user clicks on the "Owned Plots" section, they can explore detailed information about the plots they own.

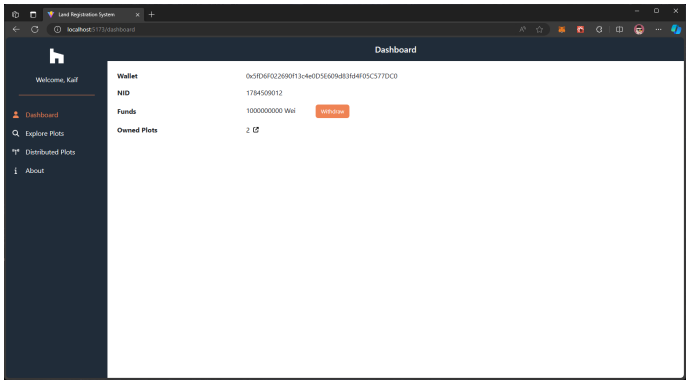

Figure 4.2: User Dashboard

4.1.3 User Owned Plots

In the Plot Details section, users can find crucial information such as the plot hash, the amount owned, and the sellable portion. Additionally, users have the option to manually input the plot hash, division, district, JL number, and plot number to explore specific plot details. Alternatively, selecting the plot hash allows users to view comprehensive plot details. Each plot entry includes a small gear icon that, upon selection, directs users to the management page for that specific plot.

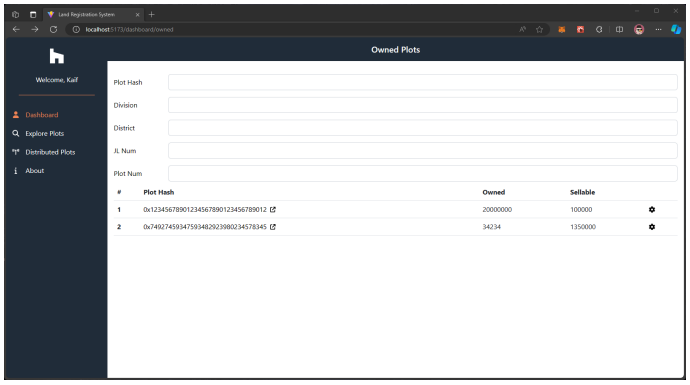

Figure 4.3: User Owned Plots

4.1.4 User Management for Owned Plots

The Management Page presents comprehensive plot details, including the hash number, division, district, JL number, plot number, the user's land ownership amount, and the sellable portion. Users have the option to manually input the quantity of the sellable portion they wish to sell and propose a total price. Additionally, users can conveniently delete existing offers or add new ones directly from this page.

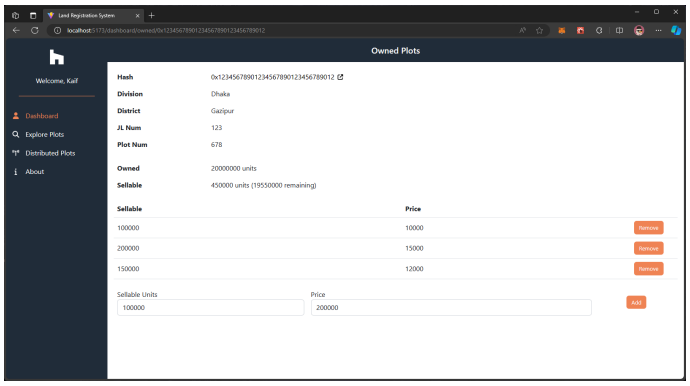

Figure 4.4: User Management for Owned Plots

4.1.5 Explore Plots

In the Explore Plots section, users discover a comprehensive list of plot details, including the plot hash, total land area, and available sellable portions for purchase. Additionally, users have the option to manually input specific details such as plot hash, division, district, JL number, or plot number to identify particular plots they may be interested in purchasing.

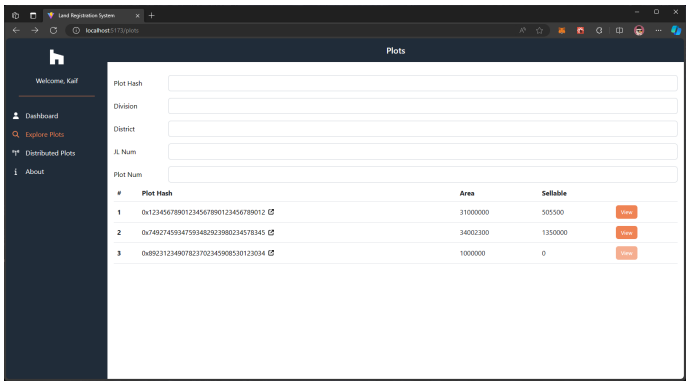

Figure 4.5: Explore Plots

4.1.6 Plot Details

By selecting the plot hash of each plot entry, users are directed to a page where they can overview the plot. Here, users can access comprehensive details, including the plot hash, division, district, JL number, and plot number. Additionally, a table provides information about the plot's owners, including their names, the quantity they own, and the sellable portion available.

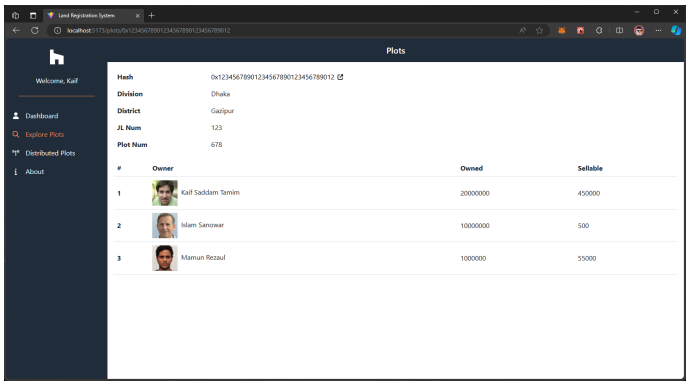

Figure 4.6: Plot Khatiyan

4.1.7 Buy Plots

Upon selecting the "View" button at the end of each plot entry, users are redirected to the Buy Plot page. Here, details such as the plot hash, division, district, JL number, and plot number are prominently displayed. A table further outlines the names of plot owners, available sellable portions, and proposed prices. If owners have submitted multiple offers, all will be visible, allowing users to select a specific offer by clicking the "Buy" button.

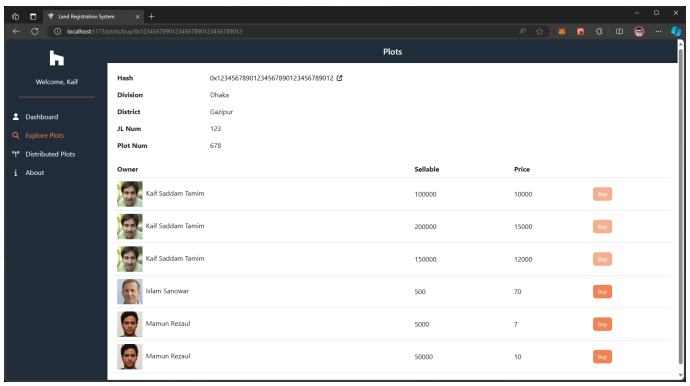

Figure 4.7: Buy Plots

4.1.8 Explore Distributed Plots

Users can manually navigate to the Distributed Plots section, where all government-distributed lands available for purchase are listed. In this section, users can explore details such as the plot hash for each available plot, the total land area, and the government's proposed price. Additionally, users have the option to manually input specific details, such as plot hash, division, district, JL number, or plot number, to identify particular plots they may be interested in buying.

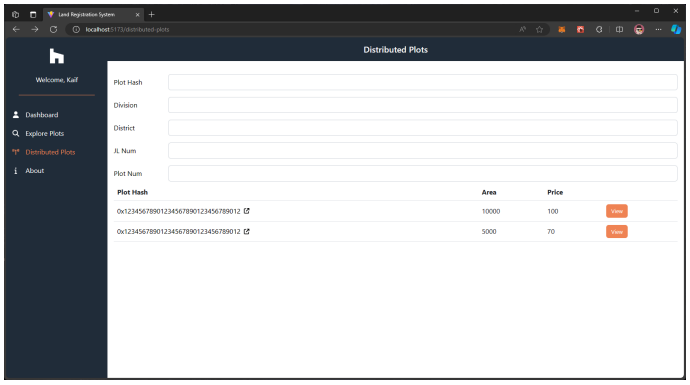

Figure 4.8: Explore Distributed Plots

4.1.9 Buy Distributed Plots

Choosing the "View" button at the end of each plot entry guides users to a dedicated page where they can explore comprehensive plot details. On this page, users can review information such as the hash number, division, district, JL number, plot number, distributed quantity, and the total price set by the government. To complete the purchase, users can simply click the "Buy" button for the desired piece of land.

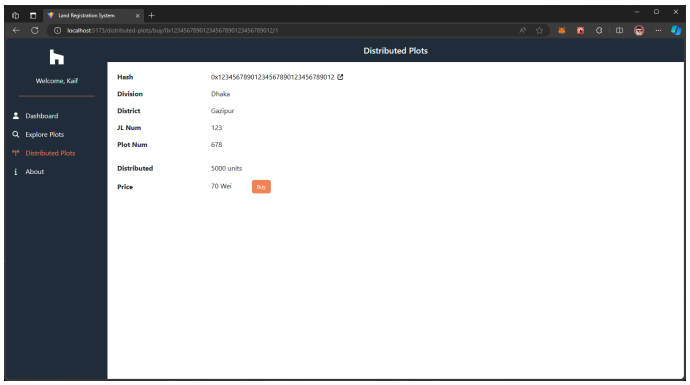

Figure 4.9: Buy Distributed Plots

4.1.10 About

Users have the option to manually navigate to the About page to learn more about our team.

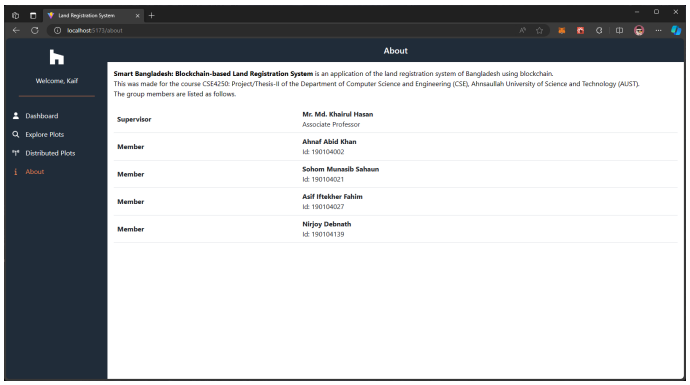

Figure 4.10: About

4.1.11 Admin - Approve Users

The admin has access to four distinct pages: Approve User, Add Plot, Distribute Plot, and Transfer Plot. On the "Approve User" page, the admin can view a list of users requesting access to the land registration system, displaying their names, National ID (NID), and Wallet ID. Clicking "Approve" grants access to the user, while the "Decline" button denies entry.

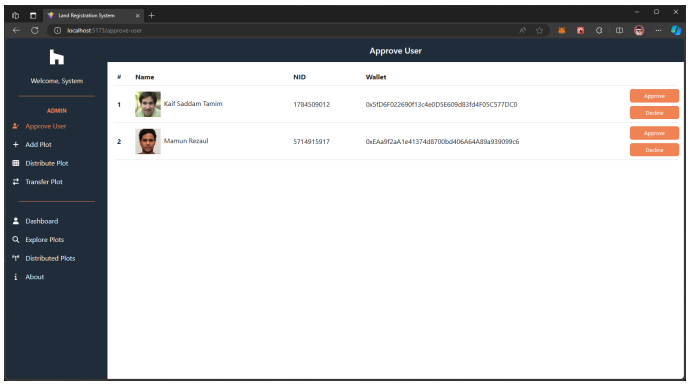

Figure 4.11: Admin - Approve Users

4.1.12 Admin - Add Plot

The admin can manually navigate to the "Add Plot" section. In this area, the admin is required to enter details such as division, district, JL number, plot number and area. By pressing the "Add Plot" button, the admin can add the specific plot to the system.

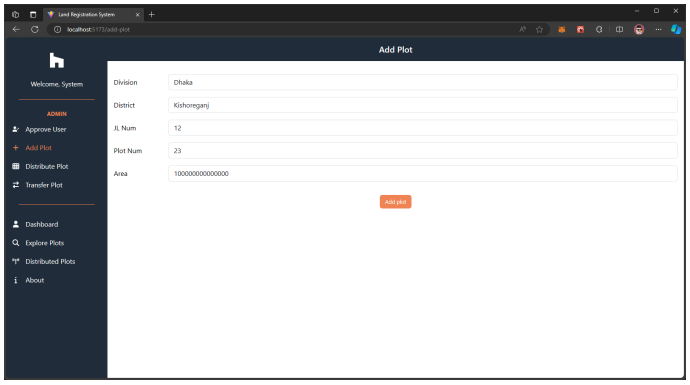

Figure 4.12: Admin - Add Plot

4.1.13 Admin - Distribute Plot

The admin can manually access the "Distribute Plot" section. Here, details such as plot hash, division, district, JL number, and plot number are prominently displayed. To propose the distribution of land, the admin must enter the quantity of land and the total price. Selecting the "Add" button fulfills the distribution proposal. Additionally, the admin can review previously posted land distribution proposals along with their pricing. To remove a proposal, the admin can simply select the "Remove" button located at the end of each proposal.

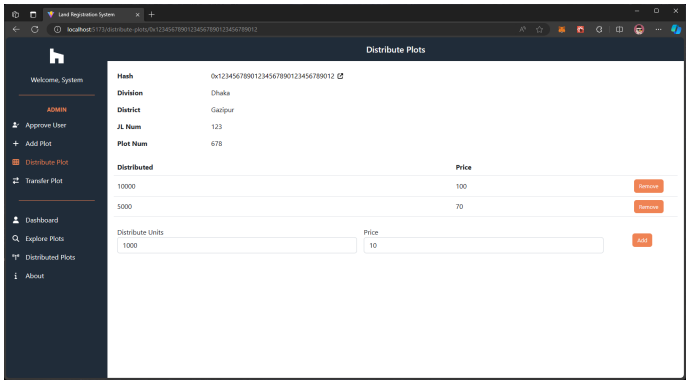

Figure 4.13: Admin - Distribute Plot

4.1.14 Admin - Transfer Plot

The admin can manually navigate to the "Transfer Plot" section. On this page, the admin is required to enter details such as division, district, JL number, plot number, the NID of the current owner, and the NID of the intended new owner. After inputting these details, selecting the "Transfer" button initiates the transfer process, officially assigning the plot to the new owner.

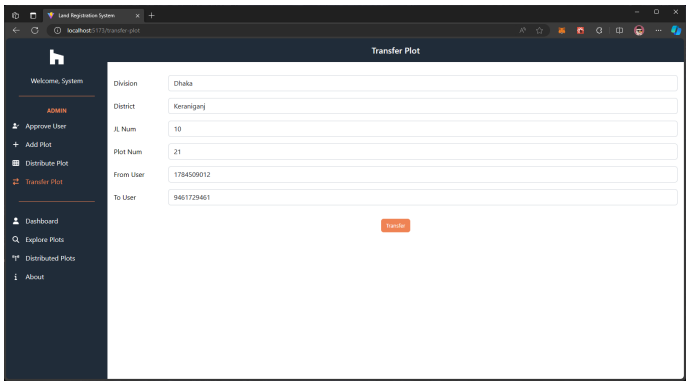

Figure 4.14: Admin - Transfer Plot

4.2 Cost Estimation

Table 4.1: Cost Estimation

No	Expense Type	BDT
1	Total Laptop Depreciation	9000
2	Total Desktop Depreciation	3000
3	Approximate Electricity Bill	3000
4	Approximate Internet Bill	6000
5	Total Printing Cost	3000
	Total	24000

4.3 Gantt Chart

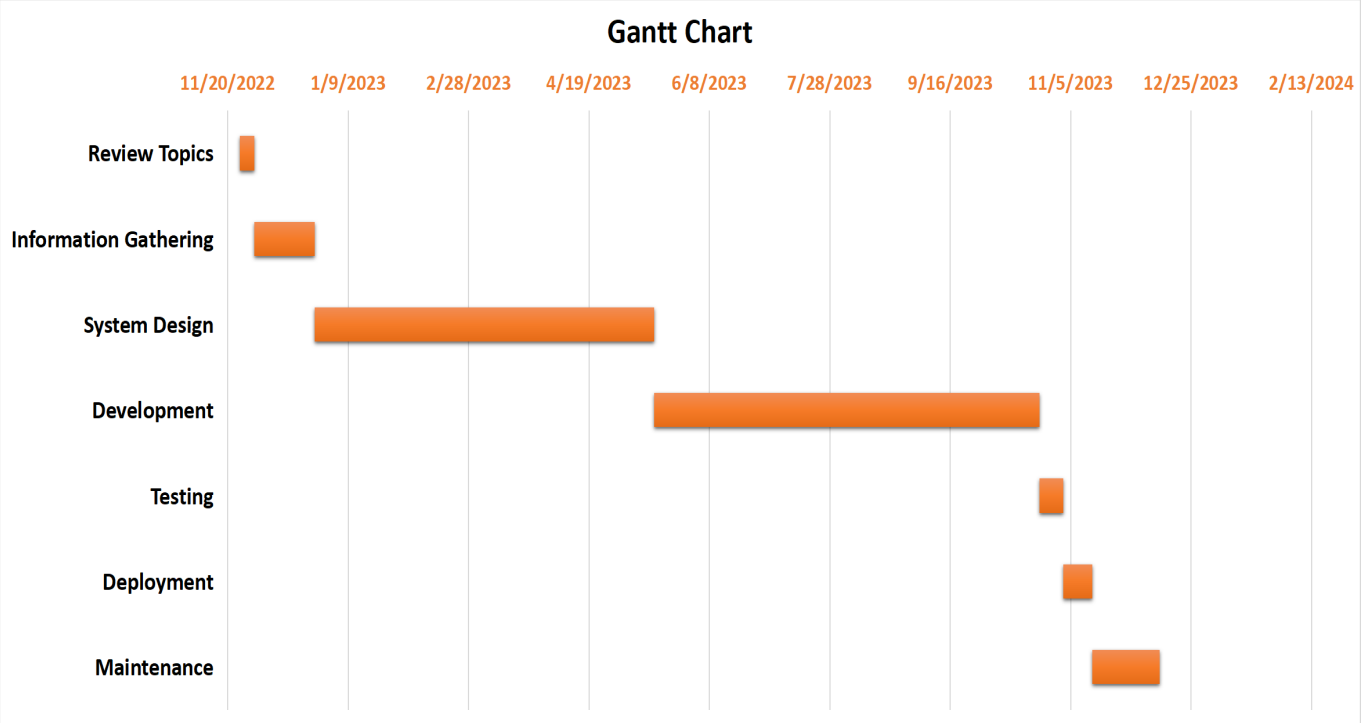

Figure 4.15: Gantt Chart

4.4 Future Work

1. **Creating wills:** In addition to the features covered within the given time frame and resources, it is important to acknowledge certain notable aspects that were not addressed but hold significant potential for future development. One such aspect pertains to the creation of wills, which often leads to disputes among successors and creates unnecessary complications. To address this issue, it is recommended that future work focuses on incorporating autonomous capabilities into the program, enabling it to generate wills with equitable division among the beneficiaries.

2. **Managing successors:** Another important feature that could not be implemented due to physical limitations is the ability to withdraw funds from the Ethereum platform. Although this functionality was not feasible within the scope of this project, it should be considered for future enhancements. Efforts can be directed towards integrating the necessary mechanisms to enable secure and efficient fund transfers within the program.

4.5 Limitations

Even though our system is secure within a blockchain network, there are some challenges with our land registration process. Many areas in Bangladesh still prefer traditional methods over online registration. Also, the use of blockchain technology is new in Bangladesh, so getting used to it will take time. Regular updates are necessary for the system to work well. Another challenge is that some people who are not familiar with technology may find it hard to use the system. It's important to note that in Bangladesh, there's no local platform for cryptocurrency. This means that by using a private network, other countries may benefit by earning cryptocurrency for storing our data. Due to a lack of resources, we cannot make a proper private network.

Chapter 5

Conclusion

Land registration is a critical process in the domain of land governance, which demands a secure and reliable platform. Traditional land ownership transfer procedures are fraught with various challenges such as the investment of significant time and monetary resources, forgery of documents, and illegal activities committed by middlemen, land sharks, and corrupt officials. These problems are amplified in countries with weak legal and regulatory frameworks, leading to the burdening of judicial systems with numerous civil cases. To address these issues, we suggest a mixed blockchain solution that offers synchronization among involved parties, guarantees data transparency, facilitates convenient access, and oversees unchangeable transaction records.

In this paper, we have crafted a detailed plan for smart contracts on the public blockchain and constructed a prototype system on the Ethereum blockchain's testing network. Our assessments demonstrate that this solution offers cost-effectiveness, time efficiency, and user-friendliness, benefiting both land management authorities and regular users. We have demonstrated that smart contracts enhance transparency and diminish the reliance on third-party entities, consequently lowering the time and resources required for the procedure.

Nevertheless, due to the frequent fluctuations in the cost of Ethereum gas, there remains an ongoing uncertainty regarding the gas expenses associated with each transaction. Despite this limitation, our proposed solution effectively addresses the challenges encountered by conventional land registration systems. We have also identified several potential avenues for future research, including the utilization of a hybrid blockchain, the introduction of a land-associated currency, as well as simulation and deterrence of security attacks, enhancement of smart contract security, vulnerability analysis, and the proper management of public key infrastructure (PKI).

It's essential to emphasize that the implementation of blockchain technology in land governance must be approached differently for developed and non-developed countries. In

developed nations, considerations should revolve around legislation and standardization, while non-developed countries need to establish their land registration systems. Consequently, it can be inferred that blockchain technology, within the realm of land governance, holds promising potential for numerous countries across the globe.

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