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Secure and Transparent Land Management with AI and Blockchain

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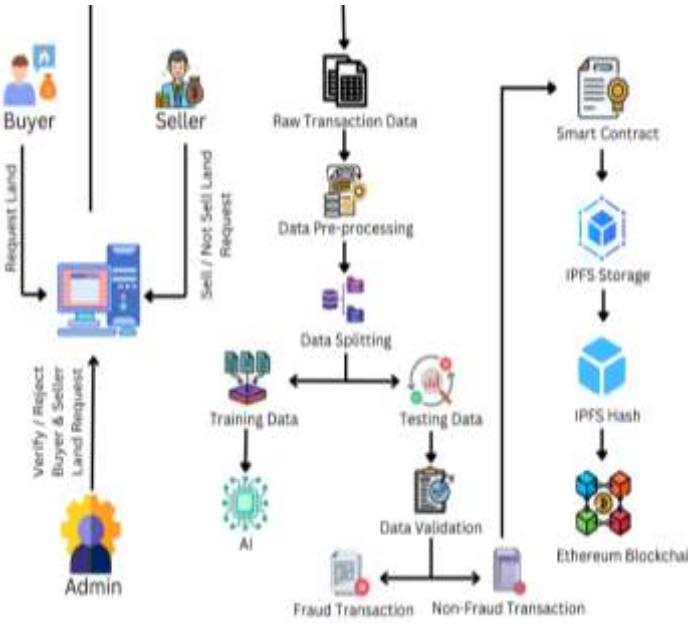
Abstract -Enabling cryptographically enforced access controls for data hosted in untrusted cloud is attractive for many users and organizations. However, designing efficient cryptographically enforced dynamic access control system in the cloud is still challenging. In this paper, we propose Crypt-DAC, a system The rapid increase in textual data in navigation tasks for devices like GPS or smart assistants creates challenges for managing and storing data in large-scale systems. Data deduplication, which reduces storThis project presents **AgriSafe**, a secure and transparent land registration system designed specifically for the agricultural sector, integrating **blockchain** and **artificial intelligence (AI)** technologies. Recognizing the challenges posed by fraud and manipulation in traditional land registration systems, AgriSafe leverages blockchain to ensure **immutability and tamper-proof** storage of land ownership records. Advanced AI models—including logistic regression, support vector machines, and random forests—are employed to detect and eliminate fraudulent data before it is committed to the blockchain, ensuring only verified land data is stored. The system utilizes **smart contracts** for automated validation of land data, improving efficiency and accuracy. Furthermore, verified land information is securely stored on the **Interplanetary File System (IPFS)**, with only the data hash stored on the blockchain, ensuring both security and accessibility. AgriSafe undergoes comprehensive evaluation, including AI model accuracy, blockchain scalability, and smart contract vulnerability assessment, delivering a robust, scalable, and fraud-resistant solution for agricultural land registration.age needs by eliminating duplicate data, offers a solution but raises security concerns. This paper introduces DEDUCT, a new method that combines cloud-side and client-side deduplication to achieve high data compression while protecting data privacy. Designed for devices with limited resources, such as IoT devices, DEDUCT includes lightweight preprocessing and safeguards against security risks like side-channel attacks. Testing on a navigation dataset shows that DEDUCT can compress data by up to 66%, significantly cutting storage costs while keeping data secure, making it an efficient choice for managing large-scale data systems.

***KeyWords*: :**Blockchain, Artificial Intelligence, Land Registration, Agriculture, Fraud Detection, Smart Contracts, IPFS, Logistic Regression, Support Vector Machine, Random Forest, Data Integrity, Scalability, AgriSafe.

1.INTRODUCTION

Traditional land registration systems in the agriculture sector are heavily dependent on centralized databases, making them vulnerable to fraud, forgery, data tampering, and inefficiency.



These issues result in frequent land disputes, loss of trust, and reduced investment opportunities, which are critical challenges as the agricultural industry moves toward the Industry 5.0 era. Although blockchain technology provides immutability and transparency, existing blockchain-based solutions often lack mechanisms to verify the authenticity of data before recording, allowing fraudulent records to become permanent. Similarly, conventional AI models like Logistic Regression and SVM struggle to detect complex fraud

patterns in large datasets and are limited by their lack of real-time monitoring capabilities.

To overcome these limitations, there is a need for a secure and intelligent land registration system that combines advanced AI models with blockchain technology. The proposed system must accurately detect fraudulent land data before blockchain insertion, ensuring only verified records are stored. It should also offer scalability, real-time fraud monitoring, decentralized identity protection, and interoperability with external land and GIS systems. By integrating blockchain's tamper-proof record-keeping with AI's predictive capabilities, the system can foster trust, transparency, and efficiency in land transactions, promoting sustainable agricultural growth and supporting the objectives of Agriculture Industry 5.0

2.OBJECTIVES

The main objective of the project is to develop a secure, transparent, and tamper-proof land registration system specifically for the agricultural sector. By integrating advanced blockchain technology, the system ensures that land records are immutable and verifiable, reducing the risks of fraud and disputes. Artificial intelligence models, including Logistic Regression, SVM, Random Forest, XGB, and LGBM, are used to detect and filter out fraudulent land data before storing it on the blockchain, thereby improving data integrity. Additionally, the project implements smart contracts to automate land validation processes, ensuring efficiency, legal compliance, and security. Verified land information is securely stored in the Interplanetary File System (IPFS) for decentralized access. The system is rigorously tested for AI accuracy, blockchain scalability, gas cost optimization, and smart contract vulnerability, aiming to build a highly reliable and scalable solution. Overall, the project fosters trust among stakeholders, supports sustainable agricultural practices, and contributes to the broader vision of Agriculture Industry 5.0 by promoting transparency, security, and innovation.

3. SCOPE OF THE PROJECT

The scope of the project includes designing and implementing a decentralized, fraud-resistant land registration system specifically for the agriculture sector. It involves using blockchain technology to ensure the immutability, transparency, and security of land ownership records while applying AI-based fraud detection techniques to filter out fraudulent or tampered data before it enters the blockchain. The project also covers the development of smart contracts for automating land verification and transaction processes, reducing human errors and increasing efficiency. Additionally, the system will incorporate decentralized storage through IPFS for maintaining original land documents securely. Performance aspects such as AI model accuracy, blockchain scalability, gas costs, and security vulnerabilities are thoroughly assessed. The scope extends to enhancing user trust, supporting sustainable agricultural development, enabling real-time fraud monitoring, and ensuring the system's adaptability to future advancements in Agriculture Industry 5.0.

4. PROPOSED SYSTEM

The proposed system enhances the existing system solution by integrating advanced features for stronger land registration, improved performance, and broader applicability across agriculture and other industries. AI models, including XGB and LGBM, will improve fraud detection and handle more complex data. A real-time monitoring system will detect and alert authorities to potential fraud, ensuring quicker intervention. Dynamic smart contracts will adapt to changing laws and improve data validation. Interoperability with external land registries and GIS will enhance accuracy. Scalability improvements, such as sharding, will handle increased data volume. Decentralized identity management ensures privacy and security for landowners. Advanced vulnerability detection tools will enhance smart contract security. AI will also promote sustainable land practices. The system will feature an intuitive interface for better user experience and easier access to land records. These improvements ensure a more secure, efficient, and scalable solution for land registration.

5. Existing System

The existing system utilizes blockchain and AI-based technologies to address land registration challenges in agriculture. Blockchain is used to store land records in an immutable and secure manner, ensuring that ownership is verifiable and protected. The system incorporates AI models such as logistic regression, support vector machines, and random forests to detect and classify fraudulent land data before it is recorded. Only verified, non-fraudulent data is stored, which reduces computational load and ensures the integrity of the land registry. Smart contracts are employed for data validation, improving efficiency and security. Additionally, non-fraudulent land data is stored on the Interplanetary File System (IPFS), with its hash recorded on the blockchain to ensure data protection and easy access. The system also includes performance assessments for AI accuracy, blockchain scalability, and smart contract security testing, aiming to provide a reliable land registration solution

6. BLOCKCHAIN INTRODUCTION

With the emergence of Digital Currency (aka Crypto currency), several enterprises or financial institutions are experimenting with the Distributed Ledger system as a trusted way to track the ownership of the assets without any central authority.

The core system behind the new currency system is Blockchain technology. A walkthrough of the basic building blocks of the Blockchain technology is described below.

A Blockchain is basically a chain of Blocks. Blocks are hashed using SHA-256 hashing algorithm to generate the signature of the data associated with it.

Imagine a Blockchain as a linked-list whose node contains below attributes:

1. Block number – a sequence number (monotonically increasing) assigned to the block
2. Nonce – a random number which is used to generate Hash (as in #5) value which starts with 4 zeroes (0000). The process of generating this Nonce is called Mining.
3. Data – the actual user data associated with the block
4. Prev – contains the Hash of the previous block (e.g. current block # -1). The value for the first block in the chain is 64 zeroes (0000000000000000000000000000000000000000000000000000000000000000).
5. Hash – current block's Hash value (generated using SHA-256). All of the above attributes excluding Hash e.g. Block #, Nonce, data, Prev are used to calculate the Hash of this block.

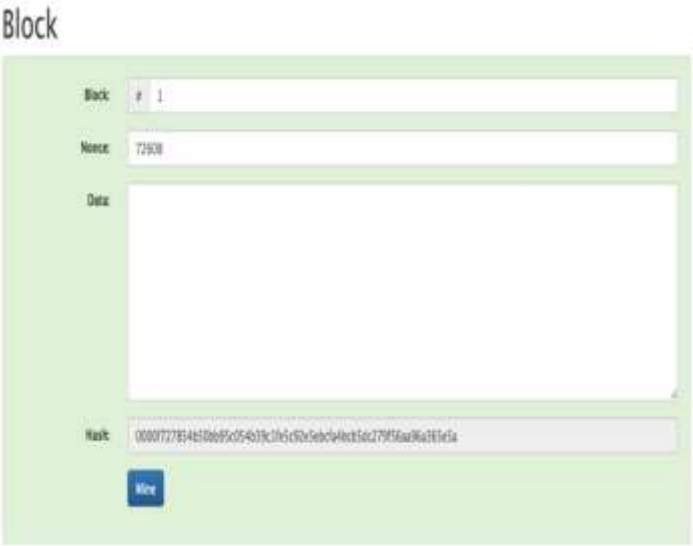
[#=1, Nonce=3409, Data=x, Prev=00..0, Hash=0000ffgr5rg67j] <- [#=2, Nonce=4986, Data=x, Prev=0000ffgr5rg67j, Hash=000045tggr5rg..77yh] <-……and the chain goes on…

e.g. in above block #1, the value for Hash=0000ffgr5rg67j is generated using the values 1,3409,x,00..0. In case value for any of these 4 attributes changes, it will change the Hash value of this block. Once the Hash value of this Block changes (e.g. from 0000ffgr5rg67j to 34sdffgr5rg67j), it will break the next Block (#2) as its Prev field will point to invalid Hash (0000ffgr5rg67j doesn't exist anymore). This leads to a ripple effect and turns whole chain as invalid/tampered.

One way to fix it is to run mining and recalculate the Hash value of Block #1 which basically will generate new value for Nonce and hence leading to a valid Hash value which starts with 4 zeroes. Copying this to next Block #2's Prev field will fix these 2 Blocks. However in order to fix the whole Blockchain, we need to continue with this process for all the Blocks in the chain so that all Blocks point to new & valid Hash codes of their previous blocks.

The cost of fixing the tampered Blockchain as described in above process is very high. Because we have to go and fix the Chain from the starting Block to the last one. In case the Chain is large, it becomes costly operation. In case of Distributed Blockchain where several Peers are involved in the process and keeping the copy of the Blockchain, the repairing the Blocks becomes even more costly operation.

The other and more efficient process is to come up with the compensating data and add this Block at the end of the Chain. E.g. In case your Chain contains the financial transaction (money movement) in Data field of the Block, then instead of fixing each of the Block's Data with corrected financial transaction, come up with the adjusted financial transaction (aka compensating transaction) and create a Block (with Data=adjusted transaction record) and add this Block to the Blockchain (adds to the end of the Chain).



7.RESULTS & DISCUSSION

Blockchain and AI-Empowered Healthcare Insurance Fraud Detection" project combines the power of blockchain, machine learning, and decentralized technologies to address healthcare insurance fraud. In this architecture, healthcare providers, insurance firms, and patients interact within a secure, transparent framework. The system begins with patient and healthcare provider registration, followed by data recording, where every transaction—such as a claim, prescription, or medical procedure—is securely logged in a blockchain. Blockchain ensures data integrity and immutability, providing an auditable and tamper-proof record of all healthcare insurance interactions. The system uses IPFS (InterPlanetary File System) to store large files, with each file divided into chunks, assigned unique Content Identifiers (CIDs) for verification, and linked to the blockchain for enhanced security.

The core of the system is powered by machine learning models, such as Random Forest, Decision Trees, and Support Vector Machines (SVM), which are trained to identify fraudulent patterns based on historical healthcare insurance claims data. These models analyze the data to detect anomalies, such as duplicate claims or suspicious patterns, which are flagged as potential fraud. By combining blockchain's decentralized, immutable ledger with machine learning's predictive power, the system offers real-time fraud detection and alerts, providing a robust defense against fraudulent claims.

The architecture includes three main modules: Hospital Service & Patient Admission, Health Insurance Service, and AI-based Fraud Detection. The Hospital Service & Patient Admission module records patient visits, diagnoses, and treatments, while the Health Insurance Service module processes claims and connects to the blockchain network for secure data recording. The AI-based Fraud Detection module uses historical claim data to identify fraudulent behavior and predict the likelihood of fraud in new claims.

The entire system operates in a decentralized manner, with the blockchain providing transparency and trust, and AI enabling the detection of complex fraud patterns.

This approach offers a scalable, secure, and cost-effective solution to healthcare insurance fraud, significantly reducing losses for insurance providers and increasing trust among subscribers.

7.1 Modules

- **Admin (Land Inspector)**
- **Buyer**
- **Seller**
- **Land Verification and Transaction Management using Blockchain**
- **Machine Learning for Agriculture and Market Trend Analysis**

7.1.1 Admin (Land Inspector)

The Admin acts as the land inspector responsible for verifying the authenticity and ownership of a seller's land. Before any transaction, the Admin must approve the seller's land, ensuring all land records are accurate and meet regulatory standards. Admin can access blockchain-stored verification data, perform checks, and confirm if a land parcel is eligible for sale. Only after this verification can the seller proceed to list the land for buyers to view and purchase. Admin actions are recorded on the blockchain to maintain transparency and accountability.

7.1.2 Buyer:

The Buyer can browse verified land listings on the platform and make requests to purchase land that meets their criteria. Buyers are required to submit necessary identification and financial details to authenticate their requests. Once the Buyer submits a request, they can track the progress, communicate with the Seller, and complete transactions securely through blockchain. Only land verified by the Admin is available to the Buyer, ensuring the authenticity and security of their purchase.

7.1.3 Seller:

The Seller owns land that they wish to sell within the platform. Sellers must submit proof of ownership and any necessary documentation, which will be reviewed by the Admin for verification. Once the land is verified, the Seller can list it for sale, set a price, and receive requests from potential buyers. Sellers can only complete a sale after Admin verification, adding an extra layer of security to prevent fraud and unauthorized transactions. All transactions are recorded on the blockchain, ensuring a traceable and tamper-proof record of ownership transfer.

7.1.4 Land Verification and Transaction Management using Blockchain:

This module leverages blockchain technology to secure, record, and manage land verification and transactions. Blockchain ensures that each land asset is uniquely identifiable and that all ownership and transaction records are immutable and transparent. Through this module, the platform ensures compliance, verifies data integrity, and minimizes the risk of fraud. Buyers, Sellers, and Admins interact through this system, which guarantees that all records are trustworthy, secure, and traceable.

7.1.5 Machine Learning for Agriculture

This module leverages blockchain technology to secure, record, and manage land verification and transactions. Blockchain ensures that each land asset is uniquely identifiable and that all ownership and transaction records are immutable and transparent. Through this module, the platform ensures compliance, verifies data integrity, and minimizes the risk of fraud. Buyers, Sellers, and Admins interact through this system, which guarantees that all records are trustworthy, secure, and traceable.

And Market Trend Analysis:

Machine learning algorithms analyze market trends, land values, and agricultural productivity in the region. By processing historical and real-time data, the system provides insights to Sellers on ideal selling times and fair market values. Buyers can view predictions on land value appreciation or agricultural yield, aiding them in making informed decisions. This module uses data pre-processing, feature extraction, and correlation analysis to detect patterns that influence agricultural markets, adding value to the platform through predictive analytics.

7.2 Performance Evaluation

The performance of the proposed Blockchain and AI-enabled Land Registration System was assessed across various critical parameters. Machine learning models including Logistic Regression (LR), Support Vector Machine (SVM), Random Forest (RF), Extreme Gradient Boosting (XGB), and Light Gradient Boosting Machine (LGBM) were employed for fraud detection. Their performance was evaluated using accuracy, ROC curves, and log-loss scores. Among these, XGB and LGBM models demonstrated the highest accuracy, effectively distinguishing between fraudulent and legitimate land records.

In terms of blockchain performance, scalability was enhanced through the application of sharding techniques, enabling the system to handle larger volumes of data without performance degradation. Gas cost utilization was carefully analyzed and optimized to minimize transaction fees during smart contract execution on the Ethereum Sepolia test network. Additionally, bandwidth utilization was evaluated to ensure efficient communication between nodes, supporting smooth data transfers even under heavy load conditions.

The security of smart contracts was validated using the Slither static analysis tool. The analysis revealed no critical vulnerabilities, confirming that the smart contracts were safe for deployment. To manage data efficiently, the system utilized the InterPlanetary File System (IPFS) for decentralized storage. Original land data were stored securely in IPFS, while only their hashes were recorded on the blockchain, ensuring both data integrity and reduced on-chain storage requirements.

Furthermore, the integration of AI-based real-time fraud detection enabled immediate identification and flagging of suspicious activities, allowing for quick intervention and minimizing risks associated with land registry fraud. Finally, the user interface was designed to ensure fast response times and ease of access for all stakeholders, including admins, buyers, and sellers, thereby providing a seamless and trustworthy experience throughout the land registration process

7.3 Limitations

Although the proposed Blockchain and AI-enabled Land Registration System significantly improves security, transparency, and fraud detection in the agricultural land sector, it is not without limitations. The reliance on machine learning models means that the system's fraud detection accuracy heavily depends on the quality and size of the training data; insufficient or biased datasets can affect model performance. Additionally, while blockchain enhances data immutability and security, it introduces scalability challenges and high gas costs when the number of transactions grows significantly. The integration of external land registries and Geographic Information Systems (GIS) is complex and may lead to interoperability issues, affecting real-world deployment. Moreover, the dependency on decentralized storage like IPFS can create challenges in ensuring permanent data availability if nodes hosting the data become inactive. Another limitation is the need for users to have basic technical knowledge to interact with blockchain-based systems, which might create accessibility barriers, particularly in rural agricultural communities. Finally, legal and regulatory acceptance of blockchain-based land registries varies across regions, which could restrict the system's practical adoption on a large scale.

8.CONCLUSIONS

8.1 Conclusion

The GreenLand project successfully presents a secure, transparent, and efficient land registration system by

integrating blockchain and AI technologies tailored for the Agriculture Industry 5.0 ecosystem. By leveraging advanced AI models like XGB and LGBM, the system effectively detects and filters fraudulent land records, ensuring that only verified data enters the blockchain network. The use of smart contracts, decentralized storage through IPFS, and blockchain's immutable ledger enhances the system's trustworthiness, data integrity, and resistance to tampering. Performance evaluations demonstrate high accuracy, scalability, and robust security with minimal vulnerabilities. Despite certain limitations like scalability challenges and regulatory hurdles, the proposed system establishes a forward-thinking framework that addresses the persistent issues of land forgery and ownership disputes.

Overall, GreenLand provides a promising and intelligent solution to modernize land registry systems, fostering trust, sustainable agricultural development, and secure land ownership for the future.

8.2 FUTURE ENCHANCEMENT

Looking ahead, the GreenLand project offers several promising opportunities for future enhancements. To further improve scalability and transaction efficiency, integration with Layer-2 blockchain solutions like Polygon or Optimism could be explored, reducing gas fees and enhancing throughput. Incorporating advanced AI techniques such as deep learning models and real-time anomaly detection systems could boost fraud detection accuracy, even for complex or previously unseen fraudulent patterns.

Additionally, expanding interoperability by linking GreenLand with government land registries, satellite-based GIS mapping, and IoT-based soil and crop monitoring systems would enrich land record authenticity and support smart farming practices. The platform could also introduce decentralized identity (DID) frameworks to strengthen user privacy and security. From a user experience perspective, developing mobile applications and multilingual interfaces would make the system more accessible, especially for rural farmers and landowners.

Lastly, working towards legal recognition and collaboration with governmental bodies will be crucial to ensuring the GreenLand system can be officially adopted at national and international levels, revolutionizing land registration practices worldwide.

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