

Blockchain-Based Land Registry System Using Proof of Work and Dual Signature

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Abstract - Land records are among the most significant public records, defining ownership, inheritance rights, and mortgage rights. Despite their importance, land registration still largely relies on centralized databases and approval chains. Blockchain technology offers an effective means to address these issues by preserving an immutable chain of records, using cryptographic hashing for every property transaction. This paper presents a blockchain-based land registry system that employs Proof of Work (PoW) consensus and a Dual Signature approval mechanism, ensuring tamper-resistance, verifiability, and mutual consent of all parties. The proposed architecture comprises four layers: presentation, application, contract, and storage. Document hashes are committed on-chain via SHA-256, while both the property owner and a government verifier must sign each transfer before it is recorded. Security analysis shows resistance to tampering, Sybil attacks, and unilateral modification. Implementation considerations using smart contracts, Node.js, React, and MongoDB are discussed, alongside challenges related to energy consumption, privacy, and interoperability.

Key Words: Blockchain, land registry, proof of work, dual signature, smart contracts, SHA-256, property transfer.

1. INTRODUCTION

Land registries are not simply mechanisms for keeping track of property ownership; they are the foundation of legal and economic stability. As long as ownership records can be falsified or modified, conflicts arise and the authority of the registry declines. The majority of current land registration systems rely on centralized architectures, where updates are processed through a single central office or procedure. While this may appear efficient, it introduces significant vulnerability to tampering, corruption, and single points of failure.

A blockchain-based land registry, by contrast, distributes ledger information across numerous nodes, making historical transactions immutable. Every transaction is timestamped, cryptographically linked to the previous record, and protected by hash-based integrity checks. For land records, this is especially significant: the registry becomes a transparent, trackable, and tamper-resistant memory accessible to all concerned parties.

This paper advocates a two-part design combining Proof of Work (PoW) with a dual signature mechanism. PoW secures the blockchain ledger against retrospective alteration, while dual signature ensures that each transfer is authorized by both the current property owner and a government verifier. Together,

they address the content and process dimensions of land registry security.

2. RELATED WORK

Several blockchain-based land administration systems have been proposed and implemented. India's blockchain-based ownership data management solution demonstrates improved transparency and traceability in property transfers [3]. The United Nations Development Programme (UNDP) similarly reports that blockchain enables a unified chain of ownership records that prevents property rights disputes [10]. These examples confirm real-world viability, though wider adoption remains challenging.

Academic literature includes smart-contract-based models for automating ownership updates [5] and multi-tier or permissioned blockchain registry architectures [12][13]. However, almost all existing systems rely on external institutions for validation and none position the property owner as the final on-chain validator — a critical gap this paper addresses [6][7][8].

Proof of Work (PoW) is well established as a consensus algorithm in distributed systems. Despite its energy cost, PoW is effective at preventing Sybil attacks [9][2]. Dual signatures have been studied in e-commerce and financial contexts to guarantee bilateral authorization [5]. The combination of both mechanisms in a land registry context is novel.

3. PROBLEM DEFINITION

Current land registration processes involve multiple verification phases, yet the risk of document tampering cannot be entirely excluded. In centralized systems it is possible to alter a database record without any trace, since documents are stored separately from the main register. The citizen has no cryptographic proof that the state of the record is authentic [4][3].

A second problem is ownership exclusion. Existing systems involve the property owner in paperwork but exclude them from the cryptographic authorization phase. Consequently, the database could be changed without any on-chain consent from the current owner — a critical risk for high-value assets [5].

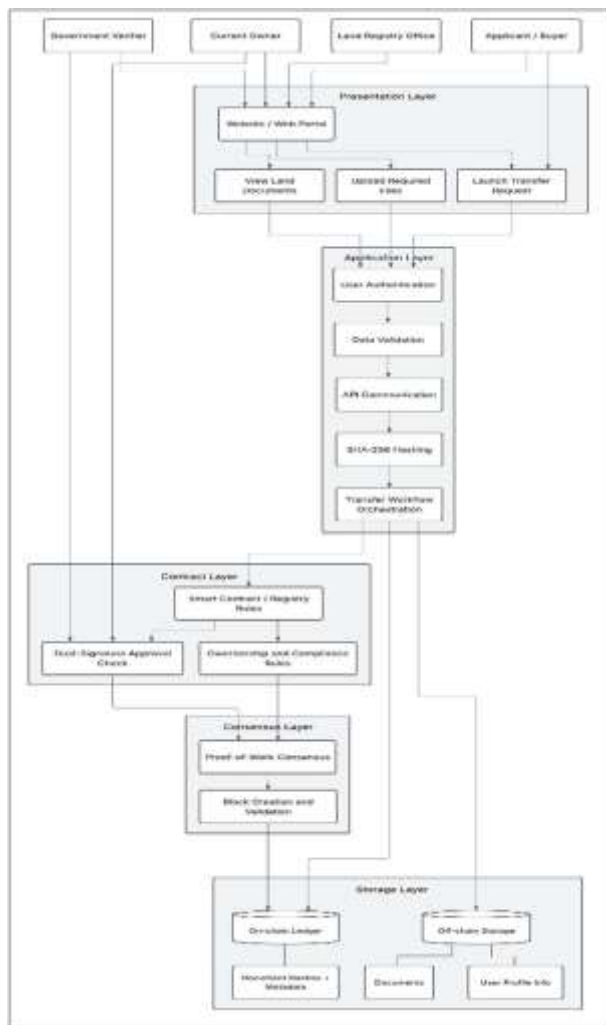
Third, auditability is limited. Traditional databases record only current state and do not preserve a verifiable history of modifications. Fraud investigations are therefore slow and inconclusive. A blockchain-based registry with dual signature makes the entire chain of events publicly verifiable and ensures no transfer occurs without two explicit authorizations [2][5].

4. PROPOSED ARCHITECTURE

The proposed system architecture is organized into four layers. The Presentation Layer provides a web interface for viewing land documents, initiating transfers, and uploading required files. The Application Layer handles user authentication, data validation, and application programming interface (API) communication. The Contract Layer executes registry rules on the blockchain. The Storage Layer holds large documents and user profiles off-chain, committing only cryptographic hashes and metadata on-chain [6][5].

When a transfer is initiated, the applicant submits a request with all required documents. The system computes a Secure Hash Algorithm 256-bit (SHA-256) hash for each document, ensuring any subsequent alteration is detectable. The current owner then digitally signs the request and forwards it to the government verifier for review. Both signatures are required before the transfer is recorded; the blockchain serves as the primary record while documents remain off-chain [4][5].

The PoW consensus layer validates transactions by requiring computational effort before a new block is appended to the chain. As the chain grows, the cost of retroactively altering any block increases proportionally, providing long-term tamper-resistance well suited to land record keeping. The dual signature layer ensures that only transactions bearing both required signatures are written to the ledger [2].



5. PROOF OF WORK CONSENSUS

Proof of Work guarantees blockchain validity by requiring miners to solve a computational puzzle before a new block is accepted. Because the difficulty of this puzzle makes historical alteration prohibitively costly — an attacker must redo the work for the target block and all subsequent blocks — PoW provides a reliable defense against history-tampering in land records [9][2].

PoW also fosters open participation. Unlike permissioned systems where validators are pre-selected, PoW allows any party to participate in consensus through mining, reducing dependence on centralized administrative trust and grounding security in cryptography and incentive-driven behavior. For land registration, this means the process is structurally resistant to capture by any single administrator [9].

The primary drawback of PoW is its energy consumption relative to newer consensus mechanisms. However, land registry transactions are infrequent and high-value; participants prioritize reliability and trustworthiness over throughput speed. This trade-off makes PoW an appropriate fit for the application domain.

6. DUAL SIGNATURE MECHANISM

The dual signature mechanism forms the consent component of the proposed system. Two independent signatures are required to execute a transfer successfully: the first from the current property owner and the second from the designated government entity. Both signatures are computed against the same transaction message, which contains the parcel identifier, the recipient's address, and the hashes of all required documents.

This design guards against fraudulent unilateral transfers. Neither party can complete a transfer without the other's explicit cryptographic authorization. The owner's signature cannot be bypassed, and no administrative change can proceed without prior owner consent. This bilateral control simplifies audit and oversight of the transfer process.

The mechanism also enhances dispute resolution. All records related to a transfer, including both signatures and document hashes, can be presented to an authority for verification. In judicial proceedings, this provides clear and cryptographically verifiable evidence of whether a document was tampered with and whether both parties consented to a transaction.

7. SECURITY DISCUSSION

A primary security benefit of the proposed system is tamper resistance. Any attempt to alter an on-chain document hash after the fact will produce a detectable discrepancy. Forged deeds, bribed officials substituting scanned documents, or unauthorized database edits are therefore immediately identifiable. The blockchain acts not merely as a storage medium but as a distributed proof system [4].

All transactions in the blockchain are traceable through the immutable ledger. In the event of a dispute, any discrepancy can be traced back to original signatures and hash values. In property law, transaction history may be as legally significant as current

state, and the blockchain makes that history publicly verifiable without reliance on private institutional databases [2].

Finally, PoW provides distributed trust. Unlike centralized systems where the compromise of a single node can be catastrophic, PoW makes any alteration attempt computationally costly and publicly visible. Combined with dual signatures — which require compromising two independent approval paths — the system offers layered defense particularly suited to high-value land records [2].

8. IMPLEMENTATION CONSIDERATIONS

A prototype could be developed using a smart-contract-capable blockchain platform combined with a React-based front-end for user interaction and a Node.js back-end application programming interface (API) for document upload, user authentication, and record retrieval [6][5]. Large documents and user metadata would be stored in an off-chain database such as MongoDB, while only their SHA-256 hashes are committed to the blockchain [6].

The smart contract must maintain: unique parcel identifiers, owner wallet addresses, pending transfer requests with their approval status, and a full event log. At transfer time, the contract must verify that both required signatures are valid and reject any transaction missing either authorization, thereby preserving owner rights and preventing unilateral action [5].

Performance evaluation should consider block confirmation latency, transaction verification speed, query processing time, and fault resilience. Usability is equally important: a system offering maximum security but an inaccessible citizen interface will fail in practice. User experience testing with non-technical participants should therefore form part of the evaluation methodology.

9. CHALLENGES AND FUTURE SCOPE

The primary challenge of PoW-based systems is energy consumption, which cannot be ignored for public infrastructure. Potential mitigations include constraining the network to a dedicated registry chain with a calibrated inter-block interval, or evaluating whether the security and decentralization properties of PoW justify its operational cost for land records specifically [9].

Privacy is a further concern. Land transactions involve sensitive financial and legal information that should not be exposed publicly on-chain. Future work could incorporate encryption schemes, role-based access control, and zero-knowledge proofs to preserve system transparency while protecting individual privacy [4].

Interoperability with existing government systems is also critical. A blockchain land registry must communicate with legacy parcel identification databases, district records, and standardized data formats rather than replacing them outright. A phased introduction — using blockchain as a tamper-evident evidence layer before full integration — is recommended [3].

10. CONCLUSIONS

This paper has proposed a blockchain-based land registry system that addresses the core problems of document

tampering, ownership exclusion, and limited auditability in current centralized systems. By combining a Proof of Work consensus mechanism with a dual signature authorization scheme, the proposed system achieves an open, tamper-resistant record that is appropriate for long-term land record keeping.

Smart contracts and digital signatures create a transparent, verifiable ownership transfer process anchored by SHA-256 document hashes. While operational challenges related to energy consumption, privacy, and interoperability remain, the architecture provides a practical foundation for a more reliable property registry. In property administration, where a single error can affect property rights for decades, immutability and bilateral consent are not optional features — they are the core of systemic trust. Blockchain-based land registry provides both [3][6][4][5].

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