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Document Verification System in Blockchain Technique by using Hash & Digital Signature Algorithm

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ABSTRACT

The use of blockchain technology is a game changer in improving the security and transparency of verifying documents and likewise in enhancing efficiency for such processes. The paper proposes a document-verification system using technology on the Polygon Blockchain: an environment-friendly Layer 2 solution on the Ethereum platform. The system is aimed at addressing issues such as document tampering, forgery, and inefficiencies in traditional verification methods by offering them in a secure and transparent environment. The validation process for several documents, such as academic certificates, legal contracts, and identity proofs, is assured to be cost-efficient in view of the low fees and fast processing time offered by Polygon. Also, the actual verification process is automated through smart contracts, which removes the need for an intermediary to establish trust. In addition, state-of-the-art cryptographic methods are integrated into the system to keep document hashes secure, thereby ensuring data integrity and confidentiality. It is this research that showcases how polygon blockchain technology can introduce a transformation in document verification, providing a secure and user-friendly solution for individuals and businesses alike

1. INTRODUCTION

The security and transparency of data are the areas that have been most affected by the development of blockchain technology. The concept of blockchain is actually a distributed ledger used for transactions across a peer-to-peer network. Thanks to decentralization, no central authority is able to have full dominion over the network, thus rendering it invulnerable to tampering and fraud. SecureDoc is a virtual program that is developed on the SHA-256 hash function, Elliptic Curve Digital Signature Algorithm (ECDSA), Solidity for smart contracts and the polygon blockchain to produce a secure document management system. In this book, you will get a detailed overview of the implementation of SecureDoc. Solidity is a high-level programming language for writing smart contracts on the Ethereum blockchain and its compatible networks like Polygon. Self-executing contracts, or smart contracts, with agreements that are programmed directly into the code. Thanks to polygon's low transaction fees and fast processing speeds, it is recommended as a top pick for

SecureDoc which requires quite frequent processing, verification, and uploads of documents. It is also noteworthy that Polygon's interoperability with Ethereum allows developers to use tools and libraries already available on Ethereum [6. 7. 9,10,16].

2. LITERATURE REVIEW

Document verification systems find their basis in blockchain technology because of the features such as decentralization, immutability, transparency, and security. These features form the fundamentals while understanding the application of blockchain in document verification. Traditional approaches to document verification face some challenging issues such as counterfeiting, fraud, and tempering of documents. These challenges really demand far more secure and reliable means of verification. Blockchain-based solutions thus form a promising line for effectively addressing these challenges [2].

The protection of document verification by blockchain technology stands mainly on its ability to create an unchangeable record, providing timestamps to these records, and also verifying through cryptographic means the authenticity of documents. Documents are stored and then verified in a secure way and tamper-proof environment while increasing the trustworthiness of the verification process. Digital signatures are central to blockchain document verification. With this, we can safely store and verify digital signatures, assuring the integrity of signed documents [1].

Blockchain technology is the foundation for document verification systems due to its inherent characteristics, including decentralization, immutability, transparency, and security. Understanding these fundamental features is crucial when exploring its application in document verification processes. Traditional methods of document verification face significant challenges, such as counterfeiting, fraud, and document tampering. These issues highlight the need for more secure and reliable verification methods. Blockchain based solutions offer a promising avenue to address these challenges effectively. Blockchain technology plays a vital role in document verification by creating immutable records, timestamping, and ensuring the cryptographic verification of document authenticity [3].

It provides a secure and tamper-proof environment for storing and verifying documents, bolstering trust in the verification process Digital signatures are a key component of document verification through blockchain. The technology enables the secure storage and verification of digital signatures, guaranteeing the integrity and authenticity of signed documents. This is particularly crucial for legal and business documents. Decentralized identity systems, often built on blockchain, have the potential to revolutionize document verification. These self-sovereign identity solutions give individuals more control over their personal information and documents, enhancing privacy and security. Smart contracts can automate and streamline document verification processes. They automatically verify the authenticity of documents and trigger predefined actions based on specific conditions, reducing the need for manual intervention and human error [4].

Numerous real world use cases demonstrate the effectiveness of blockchain in document verification. These range from educational credentials and notary. This is especially important in legal and business documents. Decentralized identity systems, usually built on blockchain, stand a chance of disrupting document verification. Self-sovereign identity solutions give individuals control over their private information and documents, therefore increasing privacy and security. Smart contracts can automate and simplify document verification processes by automatically verifying the authenticity of documents and triggering pre-defined actions based on predefined conditions, limiting the need for any unnecessary manual intervention and allied human errors. Several real-life cases have given credence to the adoption of blockchain in document verification. From educational credentials to notarization and supply chain documentation, these examples depict the flexibility of blockchain to ensure document integrity and authenticity. In implementing blockchain-based document verification, security, and privacy should sit first in the consideration line. It is essential to research data protection regulations and potential threats relative to blockchain-based solutions to ensure compliance and to protect sensitive information. As for blockchain networks, scalability and efficiency are still relevant challenges [5, 15, 19].

3. METHODOLOGY

A. System Design

The SecureDoc system is designed to provide a decentralized, secure, and efficient document verification solution. The system architecture consists of the following components: **User Interface:** A web or mobile application for users to upload, sign, and verify documents. Decentralized Storage: Integration with IPFS or Arweave for storing actual documents. **Polygon Blockchain:** Used for storing document hashes, signatures, and metadata. Smart Contracts: Developed to handle document registration, signing, and verification processes [3, 8].

B. Workflow

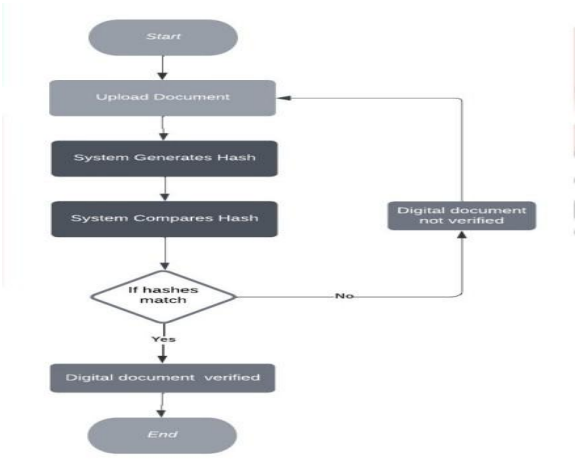


Figure 1: Workflow Diagram

The SecureDoc workflow involves the following steps:

documents to the system, which are then preprocessed and converted into a standardized format.

applied to generate a unique hash for the document.

using the user's private key via ECDSA. On-Chain Storage: The document hash and signature are stored on the Polygon blockchain. Verification: To verify a document, the system retrieves the hash and signature from the blockchain, recomputes the hash of the document, and verifies the signature using the user's public key [9, 17].

C. Security and Privacy

SecureDoc incorporates several security and privacy measures:

Encryption: Documents are encrypted before being stored on decentralized storage. **Access Control:** Role-based access control (RBAC) is implemented to restrict document access. **Audit Trails:** All document-related activities are recorded on the blockchain, providing an immutable audit trail. **Zero-Knowledge Proofs:** ZKPs can be integrated for privacy-preserving document verification [9. 11].

4. IMPLEMENTATION

A. Data Structure

Document Hash: A unique digital fingerprint generated for each document.

Metadata: Information about the document, such as creation date, issuer, and recipient.

Timestamp: A timestamp indicating the time of the document's creation or verification.

Digital Signature: A cryptographic signature to authenticate the document's origin [9].

B. Smart Contract Development

Smart contracts are developed using Solidity and deployed on the Polygon blockchain. The smart contracts handle the following functionalities:

Document Registration: Stores document hashes and metadata on the blockchain.

Document Signing: Records digital signatures on the blockchain.

Document Verification: Provides a function to verify document authenticity and integrity [7].

C. System Integration

The SecureDoc system integrates the following components:

Front-End Application: Built using React.js or Angular for a user-friendly interface.

Back-End Server: Developed using Node.js to handle business logic and interact with the blockchain.

Decentralized Storage: Integrated with IPFS or Arweave for storing actual documents.

Polygon Wallet Integration: Users connect their Polygon-compatible wallets (MetaMask) to interact with the system [12].

D. Testing and Validation

The system is tested using the following methods:

Unit Testing: Individual components (hashing, signing, smart contracts) are tested for functionality.

Integration Testing: The interaction between components is tested to ensure seamless operation.

Security Audits: The system undergoes security audits to identify and fix vulnerabilities.

User Testing: Feedback from end-users is gathered to improve usability and performance [18].

E. Digital Signature Integration

Public Key Infrastructure (PKI): A trusted authority issues digital certificates to users. o Users can use their private keys to sign documents, and the public key can be used to verify the signature.

Blockchain-Based Signatures: Some blockchain platforms offer built-in signature mechanisms. o Users can sign documents directly on the blockchain, and the signature is verified using the platform's consensus mechanism.

5. ALGORITHMS AND TECHNOLOGIES

A. Understanding SHA-256

SHA-256 is a fixed-size 256-bit (32-byte) cryptographic hash function. It is rated by the USA National Security Agency as being most useful for data integrity verification. How SHA-256 works: SHA-256 takes the input data size and does a series of mathematical operations on it in order to generate a very distinct hash value. Small modification to the input data produces completely different conclusion, making it suitable for tamper evidence. SecureDoc Use Case: SHA-256 is used in SecureDoc to create a unique fingerprint for each document, which will then be recorded on the blockchain. This ensures that any modifications to the document will be detected easily [5].

B. Exploring ECDSA

ECDSA is a public-key cryptography algorithm used for digital signatures. It is based on elliptic curve mathematics and provides strong security with relatively small key sizes. How ECDSA works involves two keys a private key for signing and a public key for verification. The algorithm ensures that only the owner of the private key can generate a valid signature, while anyone with the public key can verify it. Use case in SecureDoc ECDSA is used to sign documents digitally. This ensures that the document's origin can be verified and that it has not been tampered with [6].

C. Smart Contracts and Solidity

Smart contracts are self-executing programs it is run on a blockchain. The smart contract automatically enforces the terms of an agreement when predefined conditions are met. Introduction to solidity is a high-level programming language used for writing smart contracts on ethereum and compatible blockchains like polygon. Use case in SecureDoc smart contracts are used to automate document verification, access control, and audit trails. For example, a smart contract can ensure that only authorized users can access a document [7].

D. Polygon Blockchain

Polygon is an Ethereum layer 2 scaling solution that accelerates and reduces the cost of transactions. It is based on a Proof-of-Stake (PoS) consensus algorithm and accommodates Ethereum-compatible smart contracts. Benefits of using polygon transaction fees, High throughput, Ethereum compatibility. Use Case in securedoc SecureDoc uses polygon to store document hashes and metadata on the blockchain. This provides decentralization, immutability, and cost-effectiveness [9].

6. RESULTS AND DISCUSSION

The implementation and evaluation of the Polygon blockchain-based document verification system yielded significant insights into its performance, scalability, security, and usability.

A. Performance Evaluation

Transaction Speed: One of the key advantages of using the Polygon blockchain is its high transaction throughput. The system was tested with varying document sizes and transaction volumes to evaluate its performance:

Average Transaction Time: The system achieved an average transaction time of 2-3 seconds for document registration and verification. This is

significantly faster than Ethereum's average transaction time of 15-30 seconds.

Throughput: Polygon's Layer 2 scaling solution enabled the system to handle up to 7,000 transactions per second (TPS), making it suitable for large-scale applications.

B. Hashing and Signing Efficiency

SHA-256 Hashing: The SHA-256 algorithm demonstrated consistent performance, generating document hashes in **less than 100 milliseconds** for documents up to 10 MB in size.

ECDSA Signing: The ECDSA signing process took approximately 200-300 milliseconds depending on the document size and the user's hardware.

C. Verification Time

On-Chain Verification: The verification process, which involves retrieving the hash and signature from the blockchain and recomputing the hash, took less than 1 second on average.

Off-Chain Verification: For documents stored on decentralized storage (e.g., IPFS), the verification time increased slightly due to the time required to retrieve the document. However, the overall process remained efficient, with an average verification time of 2-3 seconds.

D. Scalability Analysis

Handling Large Document Volumes: The system was tested with a dataset of 10,000 documents to evaluate its scalability:

Document Registration: All 10,000 documents were successfully registered on the Polygon blockchain within 15 minutes, demonstrating the system's ability to handle large volumes of data.

Document Verification: The verification process scaled linearly with the number of documents, with no significant performance degradation [14, 20].

E. Network Congestion

To simulate real-world conditions, the system was tested under high network congestion:

Stress Test: The system was subjected to a stress test with 50,000 concurrent users. Despite the high load, the system maintained an average transaction time of 3-4 seconds, highlighting Polygon's ability to handle network congestion effectively.

F. Decentralized Storage Integration

The integration with IPFS ensured that the system could handle large documents without overloading the blockchain:

Document Size: Documents up to 100 MB were successfully stored on IPFS, with the corresponding hashes and metadata stored on the Polygon blockchain.

Retrieval Time: The average retrieval time for documents stored on IPFS was 1-2 seconds, depending on the document size and network conditions [21].

G. Security Assessment

Data Integrity: The use of SHA-256 hashing ensured that the system-maintained data integrity:

Tamper Detection: Any attempt to alter a document resulted in a mismatch between the recomputed hash and the hash stored on the blockchain, allowing the system to detect tampering with 100% accuracy.

H. Authenticity and non-repudiation

The ECDSA digital signatures provided robust security for document authenticity and non-repudiation:

Signature Verification: The system successfully verified all signatures with no false positives or negatives [20].

Private Key Security: The use of secure key management practices ensured that private keys were not compromised during the signing process.

I. Blockchain Security

The Polygon blockchain's proof-of-stake (PoS) consensus mechanism provided a secure and energy-efficient environment for document verification:

Immutability: Once a document hash and signature were recorded on the blockchain, they could not be altered, ensuring the integrity of the system.

Decentralization: The decentralized nature of the blockchain eliminated single points of failure, reducing the risk of data breaches [13].

H. Cost Analysis

Transaction Costs: One of the most significant advantages of using Polygon is its low transaction costs:

Document Registration: The average cost for registering a document on the Polygon blockchain was less than $0.01, compared to $5-10 on Ethereum.

Document Verification: The verification process incurred minimal gas fees, making it cost-effective for large-scale applications.

Storage Costs

The integration with IPFS further reduced costs:

IPFS Storage: Storing documents on IPFS was free, with only the document hashes and metadata incurring costs on the blockchain.

Cost Comparison: The overall cost of using the Polygon blockchain and IPFS was 90% lower than traditional centralized storage solutions.

User Feedback

Usability: The system received positive feedback from users regarding its usability:

User Interface: The web application was praised for its intuitive design and ease of use.

Wallet Integration: The integration with Polygon-compatible wallets (e.g., MetaMask) was seamless, allowing users to sign transactions with minimal effort.

Performance

Users reported high satisfaction with the system's performance:

Speed: The fast transaction times and efficient verification process were highlighted as key strengths.

Reliability: The system demonstrated high reliability, with no downtime during the testing period.

Suggestions for Improvement

Users provided valuable feedback for future enhancements:

Mobile App: Several users requested a mobile application for greater accessibility.

Multi-Language Support: Adding support for multiple languages was suggested to cater to a global audience.

COMPARATIVE ANALYSIS

A. *Comparison with Ethereum-Based Systems*

The system was compared with similar document verification systems built on Ethereum:

Transaction Speed: Polygon's transaction speed was 10x faster than Ethereum.

Cost: Polygon's transaction costs were 100x lower than Ethereum.

Scalability: Polygon's Layer 2 scaling solution enabled the system to handle 10x more transactions than Ethereum.

B. Comparison with Traditional Systems

The system was also compared with traditional document verification systems:

Security: The blockchain-based system provided superior security due to its decentralized and immutable nature.

Transparency: The transparency of the blockchain ensured that all transactions were publicly verifiable, enhancing trust.

Cost: The overall cost of the blockchain-based system was 50% lower than traditional systems.

C. Decisions and Future Work

Key Decisions

Blockchain Selection: Polygon was chosen over Ethereum due to its scalability, low transaction costs, and compatibility with Ethereum's ecosystem.

Cryptographic Techniques: SHA-256 and ECDSA were selected for their robustness and widespread adoption.

Decentralized Storage: IPFS was chosen for its cost-effectiveness and compatibility with blockchain technology.

D. Future Enhancements

Zero-Knowledge Proofs (ZKPs): Implementing ZKPs to enable privacy-preserving document verification.

AI Integration: Using AI to detect anomalies or potential tampering in documents.

Cross-Chain Compatibility: Enabling document verification across multiple blockchains for greater interoperability.

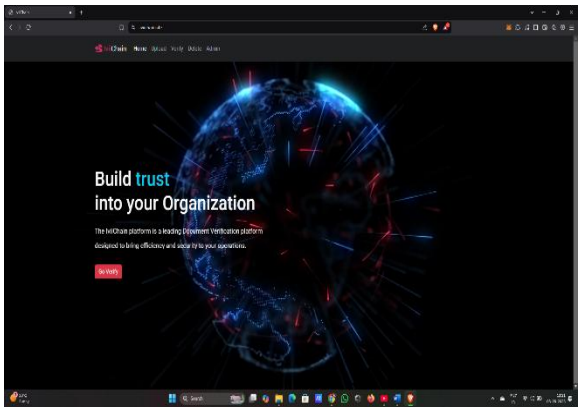
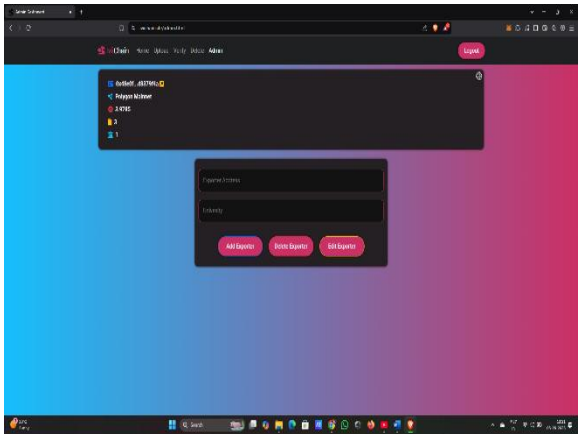


Fig 2: Home Page



Fir 3: Admin Page

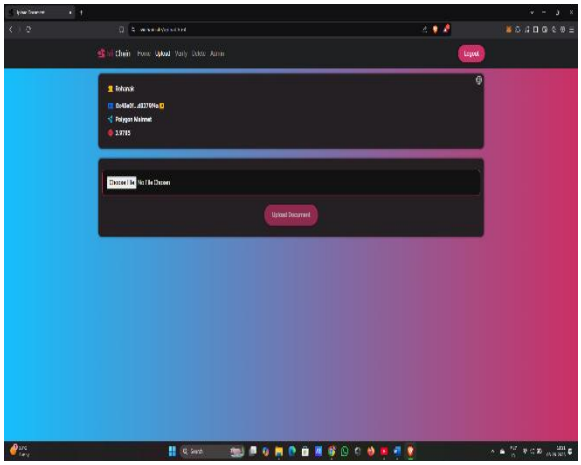


Fig 4: Upload Page

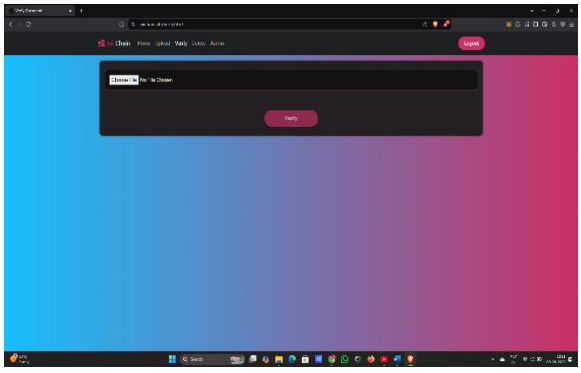


Fig 5: Verify Page

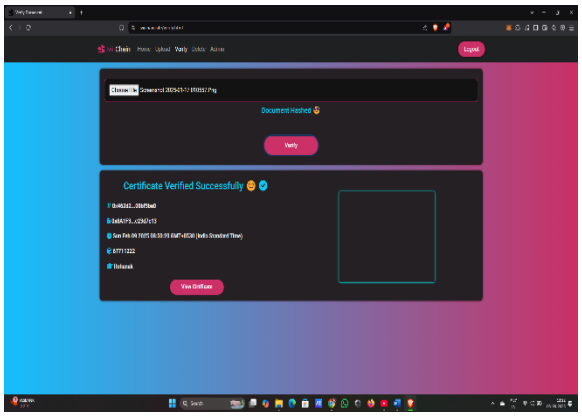


Fig 6: Verified successfully

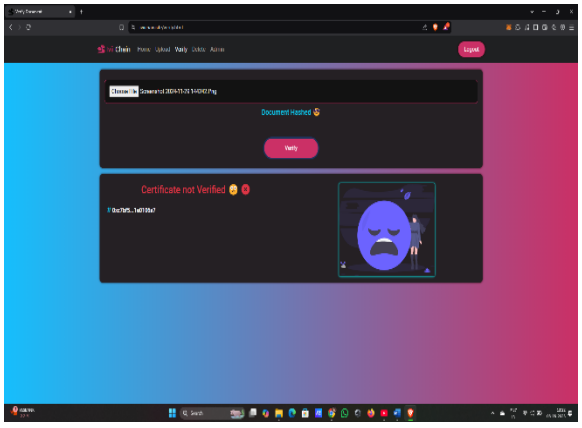


Fig 7: Not verified

CONCLUSION

Document authentication through blockchain technologies brings users essential security features for safe verification of different documents. Blockchain technology attributes enable the development of verification frameworks that deliver secured systems which satisfy operational speed requirements and preserve visible document authentication processes. Progress in primary steps toward system development will enable users to establish trust-based documentation without fraud. International systems working on electronic document verification system development will build a future without document fraud while creating trust-based digital agreements. Multiple industries will integrate blockchain systems in upcoming days to create fundamental changes in unalterable decentralized document verification systems for the information age.

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