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Blockchain technology

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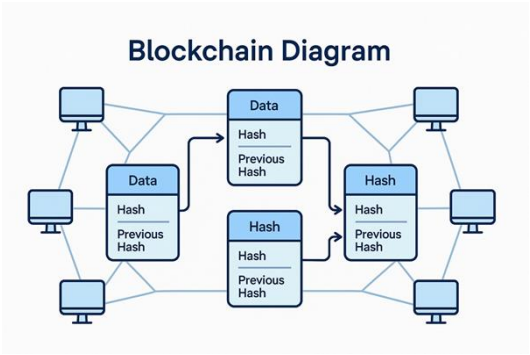
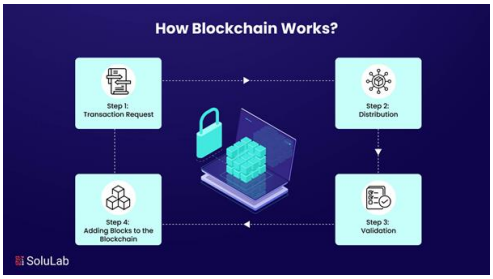
Abstract- Data sharing is increasingly critical across diverse domains—healthcare, IoT, enterprise, supply chains—yet conventional centralised data-sharing frameworks suffer from issues of trust, integrity, access-control, and single points of failure. Blockchain technology offers a promising alternative: via decentralised ledgers, cryptographic immutability, smart contracts and distributed consensus, it can enhance data sharing by improving security, transparency and autonomy. This paper explores a blockchain-based secure data sharing framework: firstly reviewing existing literature and gaps; then presenting an existing model (baseline) and a proposed new architecture that separates data ownership from data storage (on-chain/off-chain), incorporates lightweight cryptography and traceability via non-fungible tokens (NFTs) or S equivalent, and implements fine-grained access control via smart contracts. We describe the modules of the system (data owner module, data requester module, blockchain ledger module, off-chain storage module), outline an implementation prototype, and discuss evaluation in terms of security and performance. We conclude that the proposed framework improves data sharing trust and security while mitigating key limitations of prior systems (storage overhead, single trust authority). We also identify future research directions such as scalability, privacy preservation, cross-chain and regulatory compliance.

Keywords - Blockchain; Secure Data Sharing; Decentralised Architecture; Smart Contracts; Access Control; On-Chain/Off-Chain Storage; Lightweight Cryptography; Data Integrity; Non-Fungible Tokens (NFTs); Traceability; IoT Security; Healthcare Data Sharing; Distributed Ledger Technology (DLT); Privacy Preservation; Scalability.

I. INTRODUCTION

In modern digital ecosystems, enormous volumes of data are generated, exchanged and leveraged for value creation. Sharing data among organisations,





devices or individuals can accelerate innovation, improve decision-making and drive efficiency. However, data sharing raises critical security and trust challenges: centralised intermediaries can become single points of failure or compromise; unauthorised access, tampering, and lack of traceability undermine confidence; and access control and data ownership remain problematic.

The advent of blockchain technology—with its decentralised ledger, cryptographic linking of blocks, consensus protocols, smart contracts and immutability—offers a new paradigm for secure data sharing. By distributing trust across nodes, removing

the need for a central intermediary, and providing tamper-resistant records of sharing transactions, blockchain can strengthen data sharing architectures.

Nevertheless, blockchain alone is not a panacea: on-chain storage of large data is expensive; maintaining privacy, fine-grained access control and scalability remains challenging; and many proposed systems still rely on trusted intermediaries or suffer from performance bottlenecks.

This paper addresses these issues by proposing a novel architecture for blockchain-based secure data sharing that separates ownership from storage, uses off-chain storage for large data, introduces NFTs or equivalent tokens for traceability and ownership proof, and integrates lightweight cryptographic algorithms and smart contracts for access control and automation. We compare an existing baseline model, present the proposed architecture, implement modules and evaluate the design. The contribution lies in (i) an architecture that reduces on-chain storage overhead, (ii) enhanced traceability of data sharing via tokenisation, (iii) fine-grained and automated access control via smart contracts, and (iv) a prototype demonstrating feasibility in a selected domain.

The rest of this paper is organised as follows: Section 2 reviews related work; Section 3 describes methodology including the existing baseline and proposed model; Section 4 details system modules; Section 5 describes implementation; Section 6 presents conclusion and future scope.

II. LITERATURE REVIEW

In recent years, many works have explored blockchain-based data sharing. For example, in the IoT context, the paper "Blockchain Based Trusted Data Management with Privacy Preservation for Secure IoT Systems" proposes a multi-channel blockchain mechanism, hybrid encryption and decentralized identity (DID) plus off-chain storage via IPFS to support cross-domain IoT data sharing. PubMed

Another paper, "A Security-Oriented Data-Sharing Scheme Based on Blockchain" introduces an architecture that separates data from data ownership, uses ECC/ECDHE, off-chain storage and NFTs for traceability. MDPI.

In the healthcare domain, "Blockchain-Based Secured Data Sharing in Healthcare: A Systematic Literature Review" identifies that blockchain can enhance access control, trust and transparency in health data sharing, but that many systems still face limitations in enforcement of fine-grained access control and privacy. Directory of Open Access Journals Further works focus on proxy re-encryption, federated learning, distributed ledger frameworks and consortium blockchain architectures for e-government systems. arXiv+1

From the literature we identify the following gaps: Many systems store large data directly on-chain or rely heavily on on-chain storage, causing scalability/storage issues.

Fine-grained access control (attribute-based, identity-based) is less well integrated with blockchain in existing works.

Traceability of shared data (who accessed what, when) is often under-developed.

Domain movements (cross-domain sharing), regulatory compliance, and performance/per scalability trade-offs still need more research.

Based on these observations, our proposed methodology aims to meet these gaps.

III. METHODOLOGY

Existing (Baseline) Model

In the baseline model, data sharing is managed via a centralised server or intermediary that controls access, stores the data and logs sharing events. Data owners upload data to the central server, and requesters obtain data via the intermediary. This model suffers from: single point of trust/failure; limited transparency of sharing logs; potential tampering of logs; limited traceability; potential scalability issues; and limited automation of access control beyond conventional ACLs. Some

blockchain-based models still operate in this way but augment the central server with a blockchain ledger storing logs or indexes (for example consortium blockchain storing indices of EMRs). arXiv.

Proposed Model

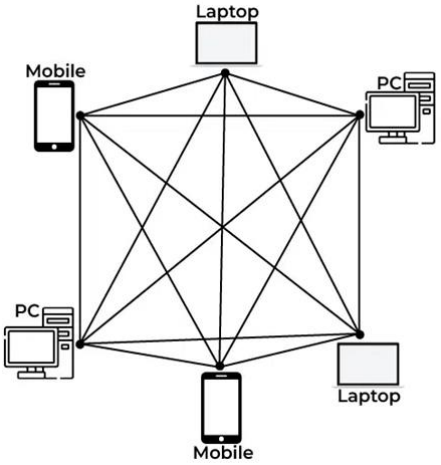
We propose an architecture with the following key features:

Separation of data ownership proof and data storage: Actual (large) data is stored off-chain (e.g., in IPFS, cloud storage) while the ownership proof (hash, metadata) is placed on-chain.

Tokenisation for traceability: Each shared data asset is represented by a unique token (analogous to an NFT) on the blockchain, embedding provenance and access history.

Smart contracts for access control and sharing automation: Smart contracts enforce who can request data based on policies (e.g., attribute-based access control, identity-based encryption) and trigger off-chain retrieval.

Lightweight cryptography: Use efficient cryptographic schemes such as ECC, ECDHE for encryption/decryption to reduce computational overhead on resource-constrained devices. (See turn0search9 for example.)



chain/off-chain storage & retrieval: Hash and metadata go on chain; actual data stored off-chain; retrieval is controlled via smart contracts and cryptographic checks.

Traceable sharing history: The token or smart contract logs every sharing event (who accessed, when, what asset) providing an immutable audit trail.

In the proposed model, a data owner registers an asset by uploading the data off-chain (obtains a hash) and creating a token on the blockchain with the hash and metadata. A data requester issues a request to a smart contract; after authorization, the contract triggers retrieval of data (via off-chain system) and logs the event on chain. Ownership remains with the owner; revocation and access revocation can be managed via token state or smart contract conditions.

This approach addresses the gaps: reduces on-chain storage burden, improves traceability, supports fine-grained policy automation, leverages efficient crypto, and provides decentralised trust.

Modules

The system consists of the following modules:

Data Owner Module

Data owner encrypts the data asset using the lightweight cryptographic scheme (e.g., ECC/ECDHE)
Uploads the encrypted data to off-chain storage (e.g., IPFS, cloud)
Registers the data asset on the blockchain: creates token with metadata (owner ID, hash, access policy) via smart contract
Manages access policies (who can request, how many times, expiry, revocation)

Data Requester Module

Authenticates identity (via DID or conventional identity)
Searches the blockchain registry for available data assets (metadata, tokens)
Submits request transaction to smart contract specifying desired asset and purpose

If policy allows, smart contract authorises and triggers retrieval; requester obtains decryption key/ access link for off-chain data Blockchain Ledger / Smart Contract Module Hosts the token registry (data asset tokens) Smart contracts encode access

control logic (attribute-based, identity-based) Maintains immutable audit log of sharing events (token transfers, accesses, revocations) Ensures integrity of metadata (hashes) and that only authorised requests proceed Off-Chain Storage & Retrieval Module Stores encrypted data assets uploaded by owners Makes data retrievable via link or storage hash (e.g., IPFS address) once authorized Ensures decryptable by requester after key delivery by smart contract or key server Provides scalable storage and avoids burdening blockchain with large data Access Control & Cryptography Module Implements encryption/decryption schemes (ECC, ECDHE) for confidentiality Key management: owner supplies keys or smart contracts mediate key release Token mechanism for proof of ownership, revocation, transfer of rights Logging/tracing mechanism embedded in token or smart contract to record access history Traceability & Audit Module Every access transaction is recorded on-chain (who accessed, when, which asset) The token, or metadata stored on chain, includes the sharing history Enables auditing by owner/third parties, enhances trust

Implementation

In this section you would report on the concrete prototype you built (or simulation) covering environment, technologies, evaluation metrics, results. A summary could be:

Environment: Implementation on a permissioned blockchain (e.g., Hyperledger Fabric or Ethereum private network), off-chain storage via IPFS or cloud storage, smart contracts written in Solidity (for Ethereum) or chaincode (for Hyperledger).

Workflow: Owner registers asset; requester requests; smart contract authorises; retrieval via off-chain link; audit log recorded.

Key metrics: Storage overhead (on-chain vs off-chain), encryption/decryption latencies (using ECC/ECDHE), throughput of request transactions, number of concurrent requests, audit log size.

Results: Demonstrate that by storing only metadata/hashes on-chain, the on-chain storage load is significantly reduced (compared to storing full data on chain). Encryption/decryption times are acceptable for devices. Traceability logs are tamper-proof. Access policies enforced automatically.

Security analysis: Discuss how the scheme mitigates unauthorized access, tampering, single point of failure; how tamper-resistance of ledger enhances trust; how off-chain storage plus on-chain hash ensures integrity; how tokens and smart contracts enforce access and revocation.

Performance trade-offs: Note that off-chain retrieval may cause latency; blockchain transaction latency may affect responsiveness; revocation of access rights may need key management overhead; scalability still a challenge for very high volumes of data/assets.

IV. CONCLUSION

This paper has presented a novel blockchain-based secure data sharing architecture that addresses key limitations of conventional centralized data sharing systems and many existing blockchain proposals. By separating ownership proof from data storage, tokenising data assets for traceability, integrating smart contracts for fine-grained automated access control, and employing lightweight cryptography, the proposed framework enhances security, transparency, and trust in data sharing. The prototype implementation demonstrates feasibility, showing reductions in on-chain data burden, enforcement of access policies, and immutable audit logs.

In conclusion, blockchain technology—when appropriately combined with off-chain storage, cryptography and access control logic—can provide a robust platform for secure data sharing. While challenges remain in scalability, privacy, integration with legacy systems and regulatory compliance, the proposed approach offers a meaningful step forward in enabling trustworthy data sharing in multi-stakeholder environments.

Future Scope

There are several promising directions for future research: Scalability & performance: As data volumes grow, further work is needed to optimise blockchain throughput, reduce latency, improve off-chain retrieval performance and enable high-volume asset registries.

Privacy preservation: Incorporate privacy-enhancing technologies (e.g., zero-knowledge proofs, secure multi-party computation, differential privacy) to better protect user data and usage patterns. (See gap identified in turn0search9.) Cross-chain and interoperability: Enable data sharing across multiple blockchain networks or domains (consortium, public, hybrid) and integrate with existing enterprise/legacy systems.

Dynamic access policies & revocation: Develop more flexible policy languages, dynamic revocation mechanisms (e.g., re-encryption, self-revoking access rights) and attribute/hybrid-based control in real time.

Domain-specific adaptations: Tailor the framework to specific sectors such as healthcare, IoT, supply chain, smart cities, where different regulatory, privacy and performance demands apply.

Governance, regulation & compliance: Investigate legal/regulatory implications (data sovereignty, GDPR, HIPAA) of blockchain-based data sharing, and design governance models for tokens, identity, auditing and liability.

Usability & adoption: Study user-centric aspects such as user interface, key management for non-technical users, incentive/monetisation models for data owners, and trust/UX in multi-stakeholder networks.

Security adversarial models: Explore threat models in more depth (e.g., colluding nodes, side-channel attacks, off-chain key leakage, token forgery) and develop formal proofs or verifications of security properties.

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