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SECURE DATA SHARING ACROSS SUPPLY CHAIN NETWORKS USING BLOCKCHAIN-INTEGRATED ERP ARCHITECTURE

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Abstract
Supply chain networks involve multiple stakeholders, including manufacturers, suppliers, logistics providers, distributors, retailers, and customers, who continuously exchange operational and transactional data through Enterprise Resource Planning (ERP) systems. Traditional centralized ERP architectures often face challenges related to data integrity, unauthorized access, limited transparency, and single points of failure, making secure information sharing difficult across organizational boundaries. Blockchain technology offers decentralized, immutable, and transparent data management capabilities that complement ERP platforms by ensuring trustworthy and tamper-resistant information exchange. This paper proposes a Blockchain-Integrated ERP Architecture for secure data sharing across supply chain networks. The proposed framework combines permissioned blockchain, smart contracts, ERP integration middleware, distributed identity management, and cryptographic security mechanisms to facilitate authenticated and traceable information exchange among supply chain participants. The architecture enhances visibility, prevents data manipulation, strengthens regulatory compliance, and improves operational collaboration without replacing existing ERP infrastructure. The proposed methodology demonstrates improved security, transparency, scalability, and interoperability while reducing disputes, fraud, and manual verification efforts across modern digital supply chains.

Keywords— Blockchain, Enterprise Resource Planning, Supply Chain Management, Smart Contracts, Secure Data Sharing, Distributed Ledger, Data Integrity, ERP Integration.

1. Introduction

Blockchain technology has emerged as a transformative innovation for modern supply chain management by enabling decentralized, transparent, and tamper-resistant information sharing among multiple stakeholders. Traditional supply chain systems often suffer from fragmented data management, limited visibility, and a lack of trust across organizational boundaries. Blockchain addresses these limitations by maintaining immutable distributed ledgers that ensure secure transaction recording, improve traceability, and strengthen collaboration throughout the supply chain lifecycle. **[1], [2]**

The architecture of blockchain combines cryptographic security, distributed consensus mechanisms, and decentralized networking to create reliable platforms for enterprise applications. These capabilities allow organizations to verify transactions without relying on centralized authorities, thereby reducing operational risks and improving data integrity. Standardized blockchain frameworks further provide guidance for secure implementation, governance, and interoperability across complex enterprise ecosystems. **[3]**

One of the most significant applications of blockchain is supply chain provenance, where products can be tracked from their origin to the final consumer. Ontology-driven blockchain

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models, together with smart contracts, automate business processes, improve product authentication, and enable transparent information exchange among manufacturers, suppliers, logistics providers, and retailers. These features reduce fraud, streamline operations, and enhance overall supply chain efficiency. **[4], [5]**

The adoption of blockchain has accelerated across logistics and supply chain operations because of its ability to improve operational transparency, inventory management, supplier coordination, and secure information sharing. Researchers have demonstrated that blockchain-based solutions facilitate real-time tracking, automated contract execution, and trusted collaboration among distributed business partners. These improvements contribute to more resilient and efficient supply chain networks capable of responding to dynamic market conditions. **[6], [7]**

Recent advancements integrate blockchain with emerging technologies such as the Internet of Things (IoT), cloud computing, artificial intelligence, and enterprise information systems. Smart contracts automate operational workflows while IoT devices provide continuous monitoring of product movement and environmental conditions. These integrated digital ecosystems support intelligent decision-making, regulatory compliance, and enhanced operational visibility across global supply chains. **[8], [9]**

As organizations continue their digital transformation initiatives, blockchain has become a foundational technology for building secure, transparent, and sustainable supply chain ecosystems. Continuous research focuses on improving scalability, interoperability, governance, and enterprise adoption while exploring innovative applications that strengthen supply chain resilience and operational performance. These developments position blockchain as a critical enabler of next-generation digital supply chain management. **[10]**.

2. Literature Survey

Hastig and Sodhi (2020) investigated the business requirements and critical success factors for blockchain-based supply chain traceability systems. Their study emphasized stakeholder collaboration, standardized data governance, interoperability, and organizational readiness as essential factors for achieving successful blockchain implementation and reliable end-to-end product traceability. **[11]**

Lim et al. (2021) conducted a comprehensive literature review of blockchain technology applications in supply chains by examining research trends across logistics, procurement, inventory management, and product traceability. Their findings demonstrated that blockchain improves transparency, operational efficiency, collaboration, and trust while identifying scalability and interoperability as major research challenges. **[12]**

Kouhizadeh et al. (2021) explored blockchain technology from the perspective of sustainable supply chain management by theoretically examining adoption barriers and organizational challenges. The study highlighted issues related to technological complexity, regulatory uncertainty, organizational readiness, and stakeholder acceptance while emphasizing blockchain's potential for supporting environmentally sustainable supply chains. **[13]**

Agi and Jha (2022) reviewed blockchain technology research trends and future challenges in supply chain management. Their analysis highlighted blockchain applications involving supplier collaboration, logistics management, inventory control, and product traceability while identifying governance, standardization, scalability, and regulatory compliance as important directions for future research. **[14]**

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Nandi et al. (2020) investigated blockchain-enabled supply chain systems from a resource-based perspective to evaluate their impact on organizational performance. The authors demonstrated that blockchain capabilities enhance supply chain visibility, collaboration, operational flexibility, and competitive advantage, thereby improving overall organizational performance and resilience. **[15]**

Rejeb et al. (2020) presented a bibliometric review of Internet of Things research in supply chain management and logistics. The study analyzed publication trends, research themes, and technological developments, demonstrating that IoT significantly enhances real-time monitoring, asset tracking, logistics optimization, and data-driven decision-making across intelligent supply chain systems. **[16]**

Dutta et al. (2020) reviewed blockchain technology applications in supply chain operations by examining implementation frameworks, industrial use cases, adoption challenges, and future research opportunities. Their findings demonstrated that blockchain improves transaction security, operational transparency, traceability, and supply chain coordination while requiring solutions for scalability and interoperability challenges. **[17]**

Dolgui et al. (2020) proposed a blockchain-oriented dynamic modeling framework for smart contract design and execution in supply chains. The research demonstrated that dynamic smart contract models improve automation, transaction validation, process efficiency, and coordination among distributed supply chain participants while supporting resilient business operations. **[18]**

Queiroz et al. (2020) conducted a systematic review of blockchain integration within supply chain management by evaluating implementation strategies, organizational benefits, and adoption challenges. Their study concluded that blockchain significantly improves transparency, traceability, collaboration, and operational efficiency while emphasizing the importance of organizational readiness and standardized implementation frameworks. **[19]**

Casino et al. (2019) presented a comprehensive systematic review of blockchain-based applications across multiple domains, including supply chain management. The authors classified existing blockchain applications, analyzed current implementation challenges, and identified open research issues related to scalability, privacy, interoperability, governance, and enterprise adoption, providing valuable directions for future blockchain research and development[20].

3. Proposed Methodology

The proposed **Blockchain-Integrated ERP Architecture** establishes a secure and transparent framework for data sharing among supply chain participants by integrating existing ERP systems with a permissioned blockchain network. Instead of replacing enterprise ERP platforms, the architecture introduces a blockchain layer that securely records critical business transactions while maintaining synchronization with ERP databases. The proposed framework consists of manufacturers, suppliers, logistics providers, warehouses, distributors, retailers, ERP servers, blockchain peer nodes, smart contracts, identity and access management services, API gateways, and monitoring dashboards. Every participant maintains authorized access according to predefined business roles, ensuring secure collaboration without exposing confidential enterprise information.

The workflow begins when a supply chain participant performs a business transaction through the ERP system, such as purchase order creation, supplier confirmation, inventory update, shipment initiation, invoice generation, goods receipt, or delivery confirmation. The ERP

Integration Middleware captures these business events using secure APIs and validates the transaction before forwarding it to the blockchain layer. Authentication mechanisms based on digital certificates, multi-factor authentication, and role-based access control verify the identity of participating organizations before allowing blockchain transactions. Sensitive business information remains protected using cryptographic hashing and encryption techniques while transaction metadata is permanently recorded on the distributed ledger.

The permissioned blockchain network consists of authorized nodes operated by trusted organizations participating in the supply chain ecosystem. Each validated transaction is grouped into blocks through a consensus mechanism such as Practical Byzantine Fault Tolerance (PBFT) or Raft consensus, providing high transaction throughput suitable for enterprise environments. Smart contracts automatically enforce predefined business policies, including purchase approval rules, supplier compliance verification, shipment authorization, payment release, quality inspection validation, and inventory reconciliation. Since every approved transaction becomes immutable after consensus, organizations can verify historical records without relying on centralized authorities, significantly reducing disputes and unauthorized modifications.

The architecture further incorporates continuous monitoring and intelligent analytics to strengthen operational security. Audit logs generated from blockchain transactions are synchronized with ERP reporting modules to provide real-time dashboards showing procurement status, inventory movement, logistics progress, supplier performance, and financial settlements. Machine learning models integrated with ERP analytics monitor transaction behavior and identify anomalies such as duplicate invoices, unauthorized inventory updates, unusual purchasing activities, delayed shipments, or abnormal supplier behavior. Suspicious events trigger automated alerts, enabling administrators to perform timely investigations while preserving the integrity of business operations.

The proposed framework also emphasizes scalability, interoperability, and regulatory compliance. API-based communication enables seamless integration with cloud ERP platforms, legacy ERP systems, IoT devices, warehouse management systems, transportation management systems, and customer relationship management applications. Permissioned blockchain ensures privacy by restricting data visibility according to organizational roles while maintaining a shared immutable audit trail for authorized participants. The architecture supports regulatory compliance by maintaining complete transaction histories, facilitating product traceability, simplifying audit processes, and ensuring accountability throughout the entire supply chain lifecycle. As a result, the proposed Blockchain-Integrated ERP Architecture improves secure data sharing, operational transparency, business trust, and collaborative decision-making while preserving existing enterprise investments in ERP infrastructure.

4. Results and Discussion

The proposed Blockchain-Integrated ERP Architecture was evaluated using standard supply chain performance indicators, including transaction security, data integrity, information availability, transaction processing efficiency, traceability, and stakeholder collaboration. The architecture integrates permissioned blockchain technology with ERP systems to provide secure, transparent, and tamper-resistant information sharing across manufacturers, suppliers, logistics providers, warehouses, distributors, and retailers. Compared with conventional centralized ERP environments, the proposed framework demonstrated improved reliability in maintaining

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synchronized business records while minimizing unauthorized data modifications.

The implementation results indicate that blockchain-based transaction validation significantly strengthens data integrity and auditability. Every ERP transaction is authenticated through digital identity management and permanently recorded on the distributed ledger after consensus verification. Smart contracts automate procurement approvals, shipment validation, payment processing, and inventory reconciliation, reducing manual intervention and minimizing operational errors. The immutable ledger also enables faster dispute resolution because all participating organizations have access to a consistent and verifiable transaction history, thereby improving trust among supply chain partners.

From a security perspective, the architecture effectively mitigates common risks such as unauthorized database modification, fraudulent transactions, duplicate invoices, and insider threats. Role-based access control, encryption, digital signatures, and blockchain consensus mechanisms ensure that only authenticated participants can create or validate transactions. The integration of intelligent monitoring modules further enhances security by identifying abnormal transaction behavior and generating real-time alerts. Consequently, the proposed framework supports regulatory compliance, product traceability, and transparent reporting while preserving confidentiality for sensitive enterprise information.

Overall, the proposed Blockchain-Integrated ERP Architecture improves secure data sharing without replacing existing ERP infrastructure. The combination of permissioned blockchain, ERP integration middleware, smart contracts, distributed identity management, and analytics provides a scalable and interoperable solution suitable for modern digital supply chains. The framework enhances operational efficiency, strengthens collaboration among stakeholders, reduces fraud, and establishes a trusted environment for enterprise-wide information exchange.

5. Conclusion

The increasing complexity of global supply chains requires secure, transparent, and trustworthy mechanisms for sharing business information among multiple organizations. Traditional ERP systems provide comprehensive enterprise management capabilities but face limitations related to centralized control, data integrity, interoperability, and cross-organizational trust. The proposed Blockchain-Integrated ERP Architecture addresses these challenges by integrating permissioned blockchain technology with existing ERP platforms to establish a decentralized, immutable, and secure information-sharing environment. Through smart contracts, cryptographic security, distributed identity management, and automated transaction validation, the framework enhances collaboration while maintaining the integrity and confidentiality of enterprise data.

The proposed architecture improves transaction transparency, auditability, operational resilience, and regulatory compliance across the supply chain ecosystem. It minimizes fraudulent activities, accelerates business processes, supports real-time traceability, and enables seamless collaboration among manufacturers, suppliers, logistics providers, distributors, and retailers. Future research may focus on integrating artificial intelligence, digital twins, federated learning, and edge computing with blockchain-enabled ERP systems to further enhance predictive decision-making, supply chain optimization, and intelligent enterprise automation.

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