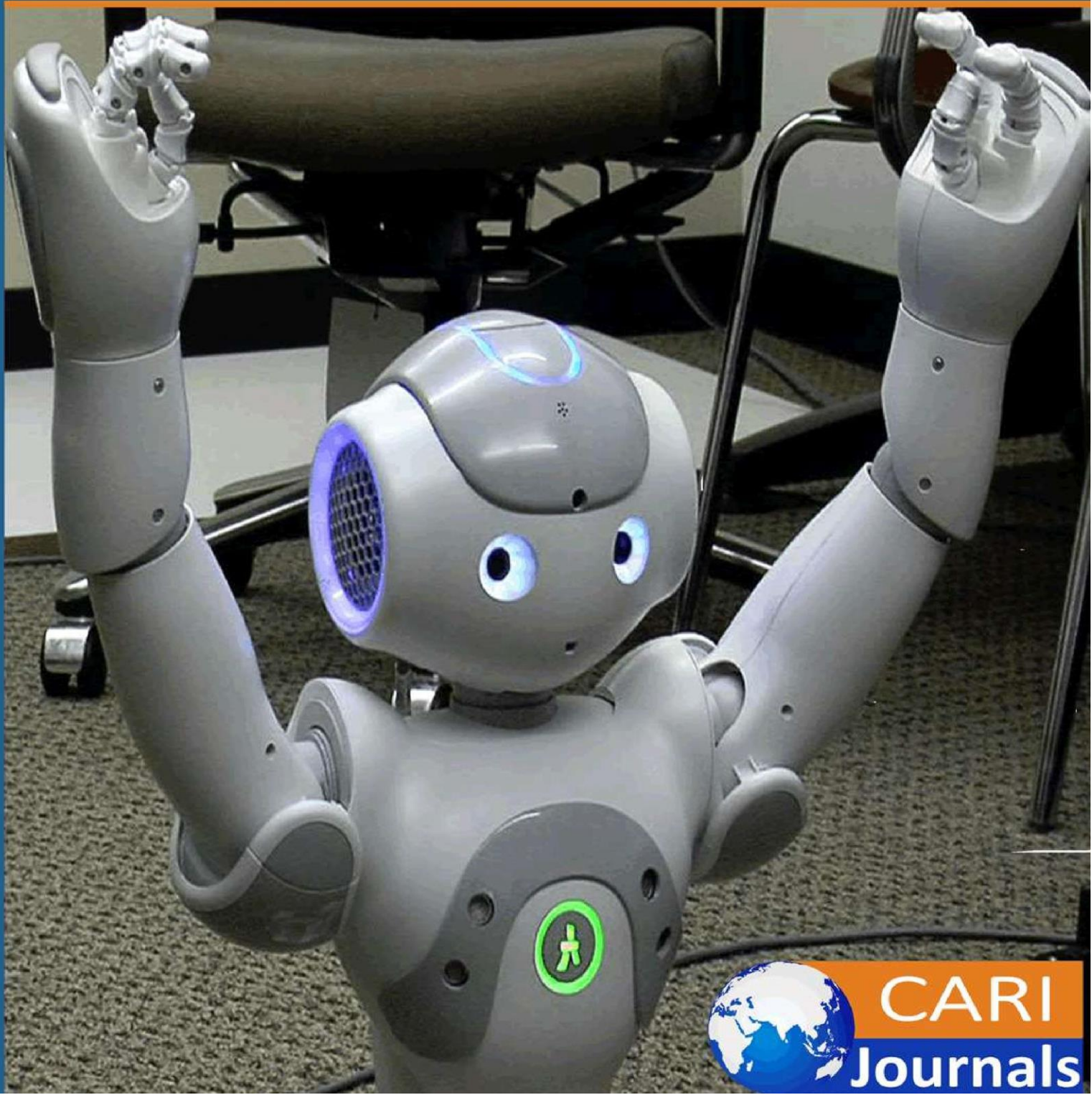


# International Journal of Computing and Engineering

(IJCE) Enhancing Logistics Operations Using Blockchain Based Smart  
Contracts in ERP Systems



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## Enhancing Logistics Operations Using Blockchain Based Smart Contracts in ERP Systems



Anand Kumar Percherla

SAP Business Analyst

Richemont North America Inc., Dallas, USA.

<https://orcid.org/0009-0000-1476-7825>

Accepted: 28<sup>th</sup> June, 2025, Received in Revised Form: 5<sup>th</sup> July, 2025, Published: 11<sup>th</sup> July, 2025



### Abstract

**Purpose:** The article aims to explore how blockchain-based smart contracts, when integrated into Enterprise Resource Planning (ERP) systems, can enhance efficiency, transparency, and security of logistics operations. It seeks to address the limitations of traditional ERP platforms and proposes a new model leveraging blockchain technology to overcome these issues.

**Methodology:** The research adopts a comprehensive literature review and secondary data analysis approach. This involves: Synthesizing existing academic and industry knowledge, identifying key technological trends, evaluating challenges and benefits of implementing smart contracts within ERP systems.

**Findings:** The integration of blockchain smart contracts with ERP systems can: Streamline key logistics processes such as procurement, shipment tracking, customs clearance, and proof of delivery. Enable automated payment settlements, real-time compliance validation, and fraud prevention in complex supply chains. Enhance real-time visibility, trust in multi-party transactions, and process integrity. Pose challenges related to technological architecture, interoperability, and implementation in platforms like SAP S/4HANA and Oracle ERP Cloud.

**Unique Contribution to Theory, Policy and Practice:** Offers a synthesized view of how two advanced technologies can be integrated to evolve traditional supply chain theories around trust, decentralization, and process automation. The study provides insight into the regulatory and data governance implications of blockchain in enterprise systems. Highlights the need for updated compliance frameworks that accommodate smart contracts in logistics. It also presents actionable insights and use cases from industry case studies and pilot projects. Offers a roadmap for implementation, helping logistics enterprises understand how to practically adopt and scale blockchain-enabled ERP solutions. Discusses workforce transformation needed to support such digital initiatives.

**Keywords:** *Smart Contracts, Blockchain Technology, Enterprise Resource Planning (ERP), Supply Chain Management, Logistics Digitization, Blockchain-Enabled ERP*

## I. Introduction

Logistics involves planning, execution, and management of the movement and storage of goods, services, and related information from the point of origin to the final customer. The primary objective is to meet customer requirements by ensuring that the right products are delivered in the appropriate quantity, quality, and condition, at the right time and cost [1]. This encompasses all aspects of inbound, outbound, and internal transportation and storage.

Enterprise Resource Planning (ERP) systems play a pivotal role in modern logistics by integrating advanced information technology with structured management practices. These systems facilitate the seamless coordination of various organizational functions—such as planning, design, logistics, finance, and operations—into a unified platform. By consolidating production, supply, and sales activities, ERP systems enhance resource efficiency and support informed decision-making [2]. As integrated information management platforms, ERP systems underpin strategic and operational functions, enabling organizations to navigate complex supply chain environments.

In recent years, blockchain and smart contracts have emerged as transformative technologies with the potential to reshape enterprise operations, particularly in the logistics and supply chain sectors. While often discussed in tandem, blockchain and smart contracts serve distinct but complementary functions. Blockchain, originally developed as the foundational technology behind cryptocurrencies, is a decentralized digital ledger that securely records transactions across a distributed network. Its consensus-based verification process ensures that all copies of the ledger remain consistent, trustworthy, and tamper-resistant, thereby enhancing transparency and data integrity [3]. Smart contracts, in contrast, are self-executing digital agreements written in code and deployed on a blockchain. These contracts automatically enforce and execute the terms of an agreement when predefined conditions are met, eliminating the need for intermediaries and manual intervention. This capability makes transactions not only faster and more reliable but also less prone to human error and fraud [3]. The synergy between blockchain and smart contracts presents significant opportunities for innovation in logistics and enterprise systems. Blockchain provides a trusted, transparent infrastructure on which smart contracts operate, while smart contracts leverage this infrastructure to automate and secure business processes. When used together, they enable consistent execution of agreements, reduce operational costs, and improve efficiency. The immutable nature of blockchain records, coupled with the autonomous logic of smart contracts, supports secure, verifiable transactions across multiple parties in a supply chain [3].

By integrating blockchain and smart contracts into ERP systems, organizations can address long-standing challenges such as real-time visibility, trust in multi-party transactions, and process integrity. This integration holds promise for creating more agile, transparent, and resilient logistics networks, paving the way for next-generation enterprise systems that are better equipped to navigate the complexities of the digital economy.

## II. Literature

Blockchain technology, introduced by the mysterious figure known as Satoshi Nakamoto, is a decentralized ledger that allows multiple parties to record and share data across many computers. Once information is added to the blockchain, it cannot be altered, which ensures the accuracy and trustworthiness of the data. Its main strengths are transparency, security, and the elimination of intermediaries [4].

Enterprise Resource Planning (ERP) systems, in contrast, are software platforms that integrate various business functions—such as procurement, inventory, customer relationships, sales, finance, and human resources—into one centralized system. These systems help streamline operations and improve the flow of information across the organization.

The merging of blockchain technology with ERP systems marks an exciting development in logistics and supply chain management. This integration combines ERP's powerful data coordination capabilities with blockchain's transparency and security. The result is a more trustworthy and efficient supply chain, with the potential to reduce fraud, enable real-time tracking, and improve cooperation across partners [4].

This article explores how blockchain-enabled ERP systems can enhance logistics operations, focusing particularly on the role of smart contracts. These digital agreements help automate trust between parties and streamline operations such as payments, inventory updates, and compliance checks—making logistics processes faster, safer, and more efficient.

**A. Integrating smart contracts into ERP systems:** The logistics and supply chain industry is undergoing rapid change, and blockchain technology is playing a key role in this transformation. One of the most promising innovations is the use of smart contracts in blockchain-based accounting systems. When combined with traditional ERP platforms, this integration provides a secure, transparent way to record transactions while automating business agreements. Here's a step-by-step look at how smart contracts can be incorporated into ERP systems:

### **Step 1: Create and deploy smart contracts**

When two parties agree on the terms of a transaction, those terms are programmed into a smart contract. This contract is then uploaded to the blockchain [5]. It includes specific conditions that must be met for the agreement to be executed.

### **Step 2: Smart contract execution and Ledge updates**

Once the conditions in the smart contract are fulfilled, the contract automatically carries out the agreed actions—such as transferring funds, updating inventory levels, or initiating payments. Each action is recorded as a new transaction on the blockchain, providing a transparent and verifiable “third entry” in a triple-entry accounting system [5].

### **Step 3: Connecting Blockchain and ERP Systems**

To allow communication between the blockchain network and the ERP system, an interface or API (Application Programming Interface) is developed. This link enables data sharing between the two systems [5]. Each ERP account is mapped to a corresponding blockchain account to ensure consistency.

#### Step 4: Data Synchronization between Systems

Once the blockchain is updated, the system syncs data back to the ERP platform. This ensures that changes made on the blockchain—such as payments or inventory adjustments—are reflected in the ERP’s double-entry accounting system [5].

#### Step 5: Ongoing Monitoring and Verification

It’s important to regularly monitor both systems to ensure the integration is functioning correctly [5]. By validating that data is consistent and accurate, businesses can maintain reliable records and avoid discrepancies.

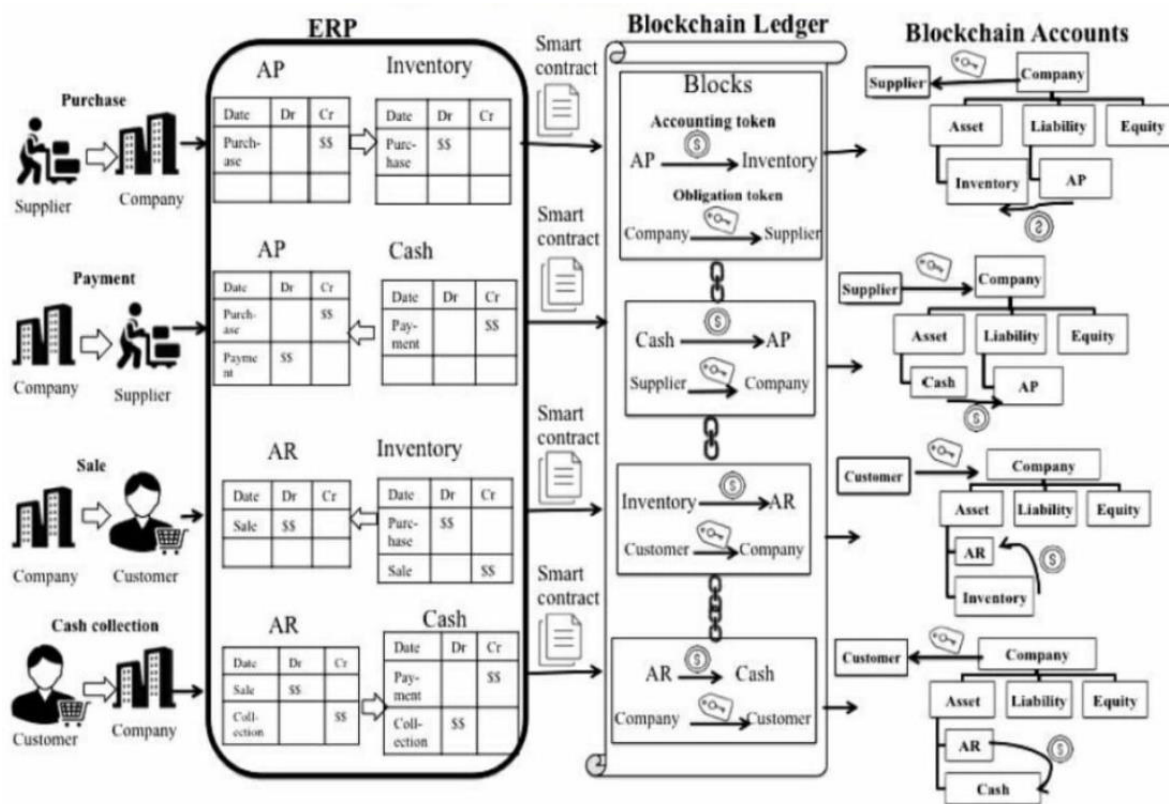


Figure 1: Establish a connection between the blockchain network and the ERP system (Image Source: [5])

### B. Key Components of a Blockchain-Based Smart Contract System for Logistics

**1. Data Ingestion Layer** This is where the system collects information from various sources.

Data Sources: IoT devices like sensors, RFID tags, GPS trackers, and ERP systems.

Ingestion Tools: Technologies such as Apache Kafka, AWS Kinesis, or Google Cloud Pub/Sub allow real-time data collection and streaming.

**2. Blockchain Layer** This is the core layer where transactions and smart contracts are recorded.

Blockchain Platforms: Systems like Ethereum, Hyperledger Fabric, or Quorum are used to log secure transactions.

Smart Contracts: These automate business rules and ensure that agreements are carried out when specific conditions are met.

**3. Data Storage Layer** Since not all data can or should be stored directly on the blockchain, a combination of on-chain and off-chain storage is used.

Distributed Storage: Technologies like IPFS (InterPlanetary File System) or cloud services such as Amazon S3 and Google Cloud Storage are used for storing large files.

Off-Chain Storage: Important files are stored off-chain, while only a digital fingerprint (hash) is saved on the blockchain to verify authenticity.

**4. Data Processing Layer** This layer handles the transformation and analysis of data.

ETL Tools: Software like Apache Spark, AWS Glue, or Google Dataflow is used to process and integrate data.

AI Integration: Artificial intelligence can be applied to predict demand, optimize routing, or detect inefficiencies.

**5. Data Retrieval Layer** This layer ensures users can access and query data quickly.

Query Engines: Tools like Presto, Amazon Athena, or Google BigQuery help with fast and efficient data searches.

Caching: Technologies like Redis or Memcached are used to store frequently accessed data for quicker retrieval.

**6. Integration Layer** This is how the blockchain system communicates with other platforms, such as ERP or warehouse systems.

APIs: RESTful or GraphQL APIs are used to connect with ERP systems, warehouse management systems (WMS), and customer portals.

Middleware: Tools like Node.js and Express help manage these integrations.

**7. Monitoring and Logging**

To ensure everything runs smoothly, the system must be continuously monitored.

**Monitoring Tools:** Prometheus and Grafana are commonly used to track system performance in real time.

**Logging Tools:** The ELK Stack (Elasticsearch, Logstash, Kibana) or AWS CloudWatch provides centralized logging for troubleshooting and audit trails.

**8. Security Layer** Security is critical to protect sensitive logistics and financial data.

**Access Control:** Identity and access management (IAM) roles define who can do what within the system.

**Encryption:** Data is encrypted using TLS/SSL for transfers and AES encryption when stored, ensuring confidentiality and protection.

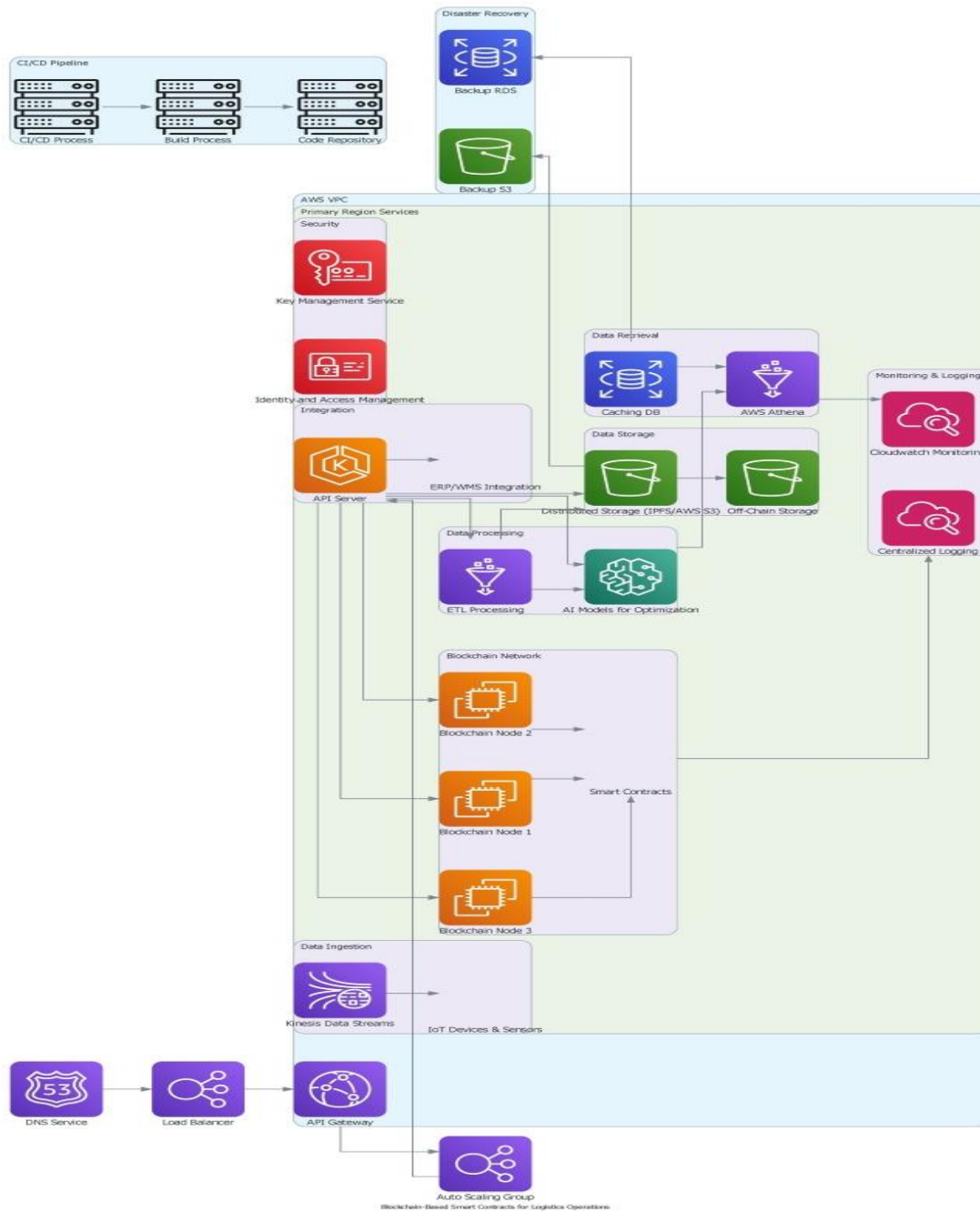


Figure 2: Blockchain based smart contract for logistics operations (Image Source: [6])

**C. Convergence of smart contracts and ERP systems streamlines logistics processes:** Logistics plays a crucial role in supply chain management. It covers tasks such as inventory tracking, warehousing, transportation, and coordinating with suppliers. However, traditional logistics



systems often rely on manual work and disconnected processes, leading to inefficiencies, delays, and higher costs. Integrating blockchain and smart contracts into ERP systems offers a modern solution. This technology helps automate tasks, reduce paperwork, lower costs, and improve collaboration between different parties in the supply chain.

### **1. Smarter Inventory and Warehouse Management**

Blockchain allows businesses to track inventory in real time. When combined with IoT devices like RFID tags and GPS trackers, companies can monitor goods accurately throughout their journey—from the warehouse to final delivery [7].

Example: A retail company can synchronize inventory across multiple warehouses using blockchain, reducing stock discrepancies and improving fulfillment accuracy.

Benefits: Better inventory control, less waste, and improved demand forecasting.

### **2. Faster Transactions with Smart Contracts**

Smart contracts automate routine logistics tasks such as processing orders, making payments, and verifying compliance. They execute automatically when set conditions are met, removing the need for manual checks or third-party approval [7].

Example: In global shipping, a smart contract can automatically pay the supplier once the delivery is confirmed at the destination.

Benefits: Shorter processing times, fewer human errors, and better cash flow management.

### **3. Lower Costs and Reduced Paperwork**

Blockchain replaces traditional paperwork with secure, digital records of transactions. This not only lowers administrative overhead but also reduces the risk of data loss or tampering [7].

Example: Freight companies use blockchain to issue digital versions of Bills of Lading (BOL), speeding up operations and reducing paperwork.

Benefits: Lower costs, faster settlements, and eco-friendly, paperless workflows.

### **4. Better Collaboration with Suppliers and Vendors**

Blockchain creates a shared and unchangeable record of transactions that all parties can access. This builds trust and helps ensure that everyone is working with the same accurate information [7].

Example: A manufacturer can track how well suppliers perform, ensuring timely deliveries and compliance with contract terms.

Benefits: Stronger supplier relationships, improved reliability, and a more responsive supply chain.

**D. Current state of research:** Research into combining blockchain and ERP systems has progressed rapidly in recent years. Early efforts showed promise, and now many studies and pilot projects are demonstrating how this integration can improve logistics and supply chain operations.

**Russell et al.** created a smart contract framework tailored for manufacturing supply chains [8]. Their system improved product traceability and increased transparency in production processes.

**Wang et al.** developed BizShare, a blockchain-based application designed to improve visibility across supply chain enterprises [8]. Their study showed how shared digital ledgers can enhance data transparency among partners.

**Al-Hudhud et al.** built and tested a blockchain prototype focused on manufacturing shop floor workflows [8]. It helped improve real-time monitoring, track product history, and prevent counterfeiting.

**Baralla et al.** introduced OSCM, an open-source middleware solution that connects traditional ERP systems with blockchain [8]. It improved collaboration and coordination between organizations by linking legacy systems with blockchain platforms.

In the healthcare sector, **Liu et al.** developed MedBlock, a blockchain framework for managing electronic health records [8]. The system connected various healthcare ERPs and streamlined record sharing. Evaluations showed gains in efficiency, security, and data transparency.

As blockchain adoption grows, major companies are also developing enterprise-ready platforms:

**Infor** launched the Infor Nexus blockchain network to enhance supply chain operations with improved product traceability, transparency, and dispute resolution.

**SAP** introduced the SAP Cloud Platform Blockchain service, allowing organizations to extend their existing SAP ERP systems with blockchain features like secure transaction logging and process integrity.

### **III. Considerations and Challenges implementing smart contracts in Existing ERP Systems:**

Smart contracts—automated digital agreements that run on blockchain—have the potential to transform how businesses manage transactions. By verifying and enforcing terms automatically, they reduce the need for intermediaries and manual processes. When integrated into ERP systems, smart contracts can streamline operations, improve accuracy, and enhance security.

Smart contracts can expedite financial transactions, automate purchase orders, and authenticate identities, providing a risk-free and efficient method for conducting business transactions. By integrating blockchain-based smart contracts into ERP systems, organizations can unlock numerous benefits, including increased data accuracy, optimized supply chain management, and improved cybersecurity. This powerful combination has the potential to revolutionize the way businesses operate, paving the way for a more secure and efficient future.

However, adopting this technology is not without its challenges. Below are some key issues organizations face, along with potential solutions.

### **Key Challenges:**

#### **Technical Complexity**

Creating smart contracts requires programming skills and a strong understanding of blockchain platforms. Many organizations lack in-house expertise to develop and deploy them effectively [9].

Solution: Partnering with experienced blockchain development firms can fill the skills gap. These experts can build secure, scalable smart contract solutions tailored to the specific needs of a business.

#### **Security Risks**

If smart contract code contains errors or vulnerabilities, it can be exploited—leading to financial loss or reputational damage. This is especially risky in sensitive sectors like finance or healthcare [9].

Solution: Thorough code audits and security testing during development are essential. Following secure coding standards and regularly reviewing smart contracts can help prevent issues.

#### **Integration with Legacy Systems**

Large enterprises often rely on complex, long-established IT systems. Connecting smart contracts to these legacy ERP platforms can be difficult [9].

Solution: Many blockchain developers now offer integration tools—such as APIs and middleware—that connect blockchain functions to traditional systems without disrupting daily operations.

#### **Legal and Regulatory Uncertainty**

The legal status of smart contracts is still evolving in many countries. Some organizations hesitate to adopt them due to concerns about enforceability and compliance [9].

Solution: Working with legal experts during development ensures that smart contracts comply with applicable laws and regulations. Some platforms also support embedding legal terms directly into the code.

#### **Scalability**

As organizations grow, their systems must handle more transactions. Many blockchains struggle with speed and cost as demand increases [9].

Solution: Emerging technologies—like layer-2 scaling solutions and more efficient blockchain protocols—can help smart contracts perform well even at large scales. Developers are also optimizing contracts to improve speed and reduce resource usage.

Despite these challenges, the integration of smart contracts into ERP systems holds great promise. With the right strategy and expertise, businesses can overcome obstacles and unlock powerful new capabilities.

#### **IV. Smart Contracts Use Cases in Logistics**

Smart contracts are bringing real-world improvements to the logistics industry by simplifying tasks, reducing fraud, speeding up processes, and eliminating the need for third-party services. By using blockchain, companies can create secure, automated systems for everything from payment processing to verifying shipment details.

Here are several practical examples of how smart contracts are being used in logistics today:

##### **1. Recording and Tracking Shipments**

Example:

ShipChain is a platform built for the logistics industry. It uses smart contracts to monitor shipments from the moment they leave the factory to when they reach the customer [10]. All data related to the shipment is recorded on the blockchain. When conditions are met—such as a successful delivery—the smart contract automatically triggers the next step.

Benefit:

Improves transparency, reduces delivery disputes, and creates a trusted record of shipment history.

##### **2. Digitizing Letters of Credit**

Example:

Letters of credit are widely used in global trade to guarantee payments between buyers and sellers. Traditionally, processing them takes days or even weeks. By digitizing this process with smart contracts, banks like Bank of America and HSBC (in partnership with Singapore's Infocomm Development Authority) have been able to automate and speed up international trade deals [10].

Benefit:

Faster payments, less paperwork, and fewer errors in cross-border transactions.

##### **3. Supporting Sustainable Fishing**

Example:

In a project backed by the World Wildlife Fund, blockchain technology is being used to ensure legal and sustainable tuna fishing. Each fish is tagged with an RFID device at the time of catch, and its location data is uploaded to the blockchain [10]. Consumers can scan a QR code at the store to trace the fish's entire journey—from ocean to shelf.

Benefit:

Builds consumer trust, supports ethical sourcing, and ensures product traceability.

#### **4. Tracking Pharmaceuticals**

Example:

Pharmaceutical companies must track medications at the unit level to meet legal requirements. GlaxoSmithKline is using blockchain, in collaboration with the Ethereum-based platform Viant, to ensure high-quality manufacturing and accurate tracking—even among third-party suppliers [10].

Benefit:

Better quality control, fewer counterfeit drugs, and stronger supply chain oversight.

These examples show how smart contracts are already solving complex problems in logistics. From improving shipment visibility to enhancing product safety and accelerating financial transactions, this technology is helping businesses run more efficiently and responsibly.

#### **V. The Future of blockchain based smart contracts in Logistics**

Looking ahead, smart contracts are expected to become a central part of logistics operations. As blockchain technology continues to develop, experts predict that smart contracts will grow more advanced, more widely adopted, and more deeply integrated with other technologies.

##### **What to Expect in the Future:**

Smart contracts will likely be combined with artificial intelligence (AI) to enable smarter, real-time decision-making. They will support more complex and flexible agreements, adapting to dynamic logistics conditions and global supply chain needs [11]. As this technology becomes more efficient and user-friendly, we can expect logistics operations to become more transparent, reliable, and automated.

##### **Overcoming Current Limitations:**

Future innovations will also address some of the current challenges, such as energy usage and slow processing times. New blockchain platforms are focusing on improving speed, scalability, and cost-efficiency [11]. These improvements will make blockchain and smart contracts more practical for large-scale logistics operations.

Key Innovations to Watch:

**AI Integration:** AI will help validate data, forecast delivery times, and improve supply chain decisions [12]. This will result in faster, more accurate logistics planning.

**Energy-Efficient Blockchain Protocols:** New consensus methods will reduce power consumption and lower operating costs, while also speeding up transaction processing [12].

**Advanced Product Tracking:** Blockchain will continue to improve product traceability from source to destination, especially in sensitive industries like e-commerce and food [12]. This will help ensure quality, safety, and compliance with regulations.

**Faster Customs Clearance:** Customs authorities can use blockchain to access real-time, verified data, which can speed up clearance processes and reduce delays in international shipping [12].

In short, the future of smart contracts in logistics looks promising. With ongoing innovation, these technologies will make supply chains more intelligent and efficient, and secure redefining how businesses deliver goods and services in the digital age.

## VI. Conclusion

Smart contracts are poised to reshape business operations in much the same way that enterprise software did decades ago. By embedding agreements directly into code, smart contracts allow organizations to automate tasks, enforce rules, and carry out transactions with greater speed and security.

However, adopting this technology on a larger scale will require more than just technical development. Organizations will need to educate stakeholders, legal, technical, and executive—build user-friendly interfaces and create industry standards. Real-world examples and cross-sector collaborations will also be essential to show the true value of smart contracts in action. To fully realize the benefits of this technology, it's important to approach implementation with care, responsibility, and a focus on long-term sustainability. A well-governed smart contract ecosystem can offer businesses new levels of efficiency, reliability, and innovation—without compromising trust or stability.

In the context of logistics, integrating smart contracts with ERP systems represents a major step forward. This shift enables organizations to streamline operations, enhance transparency, and improve overall performance. Embracing smart contracts isn't just about staying current, it's about using technology to unlock better ways of doing business in a fast-changing digital world.

## REFERENCES

[1]: D.John Mangan, Chandra Lalwani, "Global Logistics and Supply Chain Management" (Page no.9) - March 2016.

[2]: Qingping Li, Guoqiang Wu, "ERP System in the Logistics Information Management System of Supply Chain Enterprises" - October 2021.

[3]: FinaryLabs, "Understanding the Difference Between Blockchain and Smart Contracts" - July 2023.

[4]: Eastgate Software, "Enhancing Supply Chain Transparency with Blockchain-Enabled ERP Systems" - September 2024.

[5]: CA Jagdish Lade, "Integrating Smart Contracts in Blockchain-Based Triple Entry Accounting Systems with Traditional ERP" – April 2023.

[6]: Tayyab Javed, “Blockchain-Based Smart Contracts for Logistics Operations” – August 2024.

[7]: Emmanuel Ok, Barnabas Barnty, Oloyede Joseph, “Blockchain for Supply Chain Transparency and Logistics Optimization” – February 2025.

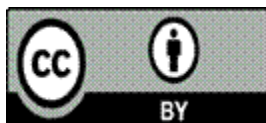
[8]: Arjun Reddy Kunduru, “Blockchain Technology for ERP Systems: A review” – July 2023.

[9]: KALP Studio, "Smart Contract Development: Key Challenges and Solutions for Enterprise Adoption" - November 2024.

[10]: Kristen, “Smart Contract Use Cases in Transport / Logistics” – November 2019.

[11]: Benjamin Gordo, “The Role of Smart Contracts in Streamlining Logistics Operations” – December 2023.

[12]: Knowledge Center, “Blockchain in Logistics: Definition, Role in Logistics, and Benefits” – June 2024.



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