Issue 17, 2025

https://doi.org/10.23939/sisn2025.17.319

UDC 004.75

ENHANCING IOT-DRIVEN LOGISTICS SOLUTIONS USING BLOCKCHAIN-BASED SMART CONTRACTS

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Modern logistics monitoring solutions increasingly depend on the integration of IoT devices for real-time data collection, shipment tracking, goods and vehicle monitoring, and informed decision-making. However, current IoT-based logistics systems face significant challenges, including complex data management, limited interoperability among stakeholders, and inefficiencies resulting from centralized control mechanisms.

Blockchain technology has emerged as a promising solution to address these critical issues within logistics and supply chain management. This paper presents a comparative analysis of traditional centralized logistics systems and blockchain-based decentralized solutions, emphasizing the evaluation of blockchain's strengths such as transparency, immutability, and automated transaction execution via smart contracts and its weaknesses, particularly scalability limitations and implementation complexity.

The research specifically examines how smart contracts can effectively manipulate IoT-generated data to automate logistical transactions and ensure secure, transparent data management. Through a structured analysis, this article identifies specific scenarios in logistics where blockchain technology adds significant value and discusses key practical considerations for its effective adoption.

Additionally, this research critically evaluates Ethereum Virtual Machine (EVM)-based smart contracts and proposes AWS Hyperledger Fabric smart contract (chaincode) as a more scalable and cost-effective alternative for enterprise logistics applications.

The study provides valuable insights and guidelines for logistics practitioners, facilitating informed decision-making about integrating blockchain solutions to enhance operational efficiency, trust, and interoperability within complex supply chain environments.

Keywords: Smart Contracts, Ethereum, EVM, AWS Hyperledger Fabric, Internet of Things (IoT), Logistics, Automation, Blockchain.

Problem statement

Logistics systems increasingly rely on IoT devices, including sensors, RFID tags, and tracking devices, to monitor shipments and manage supply chains. Maintaining consistent connectivity of these IoT devices is a fundamental challenge as goods are transferred between warehouses, vehicles, and across international borders. Devices frequently faced with poor network access, causing data transmission interruptions. For example: connectivity outages can last from several minutes to hours, creating significant gaps in shipment tracking data, negatively affecting inventory management and logistics efficiency.

IoT-generated data, such as sensor readings or location updates, must be secure, accurate, and resistant to tampering. Traditional centralized databases used for IoT data storage are susceptible to unauthorized modifications, errors, or cyber-attacks. Any compromise of this data can lead to incorrect inventory management, delayed deliveries, and loss of stakeholder trust. Consequently, ensuring the authenticity and immutability of IoT data becomes paramount for effective logistics operations.

Logistics operations inherently involve multiple stakeholders: manufacturers, carriers, retailers. Each stakeholder uses different software IoT platforms and data standards. This creates substantial interoperability challenges, leading to fragmented information and inefficient data-sharing processes. For example, incompatible data formats between stakeholders can result in delayed responses, miscommunication, and reduced overall visibility of the supply chain, hindering optimal decision-making.

The scalability of IoT systems in logistics also is a great challenge. Handling large volumes of data from thousands to millions of interconnected devices becomes increasingly challenging for centralized architectures. Such traditional infrastructures face performance bottlenecks and rising costs in maintaining real-time processing capabilities and reliable data storage. These limitations restrict the scalability required to achieve low latency and high availability, essential for responsive logistics management.

These critical issues highlight the need for robust, decentralized solutions. Blockchain-based decentralized architectures, specifically leveraging Ethereum-based smart contracts, provides promising approaches. These technologies inherently provide data immutability, improved trust among stakeholders, enhanced interoperability through shared standards, and scalable distributed processing, effectively addressing the core challenges outlined above.

Considering these factors, the primary goal of the research covered by this paper is the development and comparative evaluation of blockchain-based decentralized logistics solutions leveraging smart contracts in contrast to traditional centralized IoT logistics systems. Specifically, the study aims to identify the precise conditions under which blockchain technology provides the most significant benefits, determine effective approaches to automate logistical processes with IoT-generated data through smart contracts, and critically assess the suitability of Ethereum Virtual Machine-based smart contracts versus AWS Hyperledger Fabric smart contracts in terms of scalability, latency, operational costs, and overall efficiency for enterprise logistics applications.

Analysis of Recent Studies and Publications

Recent research indicates increasing interest in Blockchain-based smart contracts as a solution to IoT logistics challenges, particularly around data transparency, integrity, interoperability, and security (Yigit & Dag, 2024; Vovchak & Veres, 2024). Ethereum, one of the most adopted decentralized blockchains, introduced smart contracts which are self-executing code, deployed to a distributed system Smart contracts have attracted attention due to Ethereum's open infrastructure, large developer community, and a rich ecosystem of development tools (Baygin et al., 2022). Studies have demonstrated Ethereum's potential in enhancing transparency and reliability of IoT-generated logistics data. For example, researchers have developed Ethereum-based logistics systems that record sensor data such as GPS locations, temperature readings, and other events directly onto the blockchain, leveraging smart contracts to automate payments and refunds triggered by specific conditions (Paliwal et al., 2020). These implementations resulted in increased trust among stakeholders by ensuring data immutability. Other research exploring blockchain applicability to supply chains similarly identified blockchain's ability to improve resilience against data manipulation due to cryptographic guarantees as each block of the blockchain depends on the history of all predeceasing blocks (Vovchak & Veres, 2024), as depicted on Figure 1.

However, there are critical limitations with blockchain: Ethereum's low transaction throughput (approximately 15–30 transactions per second) and relatively high transaction fees ($1–$5 per event). These are the major factors restricting scalability in larger, real-time deployments (Paliwal et al., 2020).

Other studies indicate the ability for Ethereum's blockchain to serve as a neutral integration layer through standardized smart contract interfaces (Fazel et al., 2024). They also revealed significant complexity challenges to maintain, and update deployed smart contracts, especially across multiple stakeholders and distributed IT infrastructures (Sharma et al., 2025). Similarly, while Ethereum-based cargo tracking solutions provides enhanced end-to-end visibility across supply chain actors, it has practical limitations with transaction confirmation delays, especially in high-frequency data scenarios common for the logistics operations (Alqarni et al., 2023). Ethereum's throughput is a constraint and blocker for building large-scale implementations: research reported transaction rates at around 20 TPS (transaction per second) (Zhang, 2022) that is insufficient for extensive IoT networks (Li et al., 2023).

A comparative analysis across recent publications reveals Ethereum's key advantages, such as decentralization, immutability, security, and interoperability. Nonetheless, these advantages are balanced with disadvantages - transaction latency, high operational costs, and the complexity of managing smart contracts within stakeholder ecosystems.

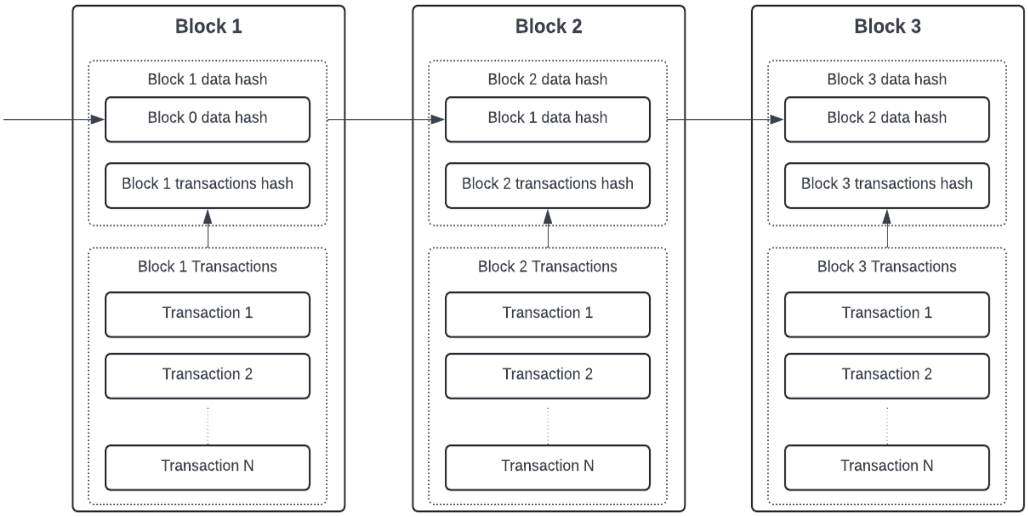

Fig. 2. Chain of blocks in a blockchain

In response to Ethereum's limitations, researchers focus on scalability enhancements such as Layer-2 solutions (e.g., Optimism and Arbitrum) and Ethereum's ongoing transition to Ethereum 2.0 (Proof-of-Stake). Preliminary evaluations indicate these advancements improves transaction throughput (potentially over 1,000 TPS) and significantly reduce transaction costs (up to 90 %), directly addressing many of the concerns identified in earlier studies (Yigit & Dag, 2024; Vovchak & Veres, 2024).

In conclusion, recent publications demonstrate EVM-based smart contracts have a huge potential in addressing critical IoT logistics challenges. The decentralization feature in the blockchain technology removes dependency on a ny single connectivity or database provider, boosting system reliability. The blockchain cryptographic security and immutability enhance data reliability – once IoT measurement data (e.g. a temperature reading or a GPS location) is recorded in the Ethereum transaction, it cannot be altered, addressing data authenticity concerns. Smart contracts allow robust way to execute the business logic that automatically applies across multiple participating parties, reducing manual errors and delays in supply chain workflows. All stakeholders have access to a single source of truth for shipment status and history. Research highlights demand for improvements in scalability and cost optimization before these blockchain-based solutions can be widely adopted by the logistics industry. An alternative to EVM-based blockchains that addresses key challenges to fulfill IoT system requirements is a key requirement.

Formulation of the Article's Objective

This article highlights blockchain's smart contract's potential in improving and automating logistics operations such as shipment tracking, inventory management and data sharing. Article provides a comparative assessment and comparison of blockchain-based decentralization and traditional centralized systems. This research reviews recent studies on the use of EVM-based smart contracts to address critical IoT challenges in logistics and acknowledge current limitations of EVM-based system (e.g. using them with large volumes of data and a need for immediate decision making).

An alternative solution to EVM-based blockchain based ones is proposed to increase throughput, latency and performance of the IoT system that would use these technologies.

Main Results

Blockchain's smart contracts, first introduced in the Ethereum blockchain, act as autonomous executable pieces of programmatic code on the blockchain that can implements business logic in logistics (alerts, notifications, payment releases etc.). Since Ethereum uses open protocol, other blockchains that use the same protocol emerged. This kind of blockchains is typically referred to as EVM-based blockchains as each node of the network run Ethereum Virtual Machine (EVM).

In an IoT logistics scenario, set of sensors (for example: location, temperature, humidity, etc.) deliver the measurement data into Application server through the IoT Device gateway. The server itself delivers the data into the blockchain to trigger smart contracts execution if needed. Figure 2 illustrates a typical data flow for the IoT solution with the EVM-based blockchain.

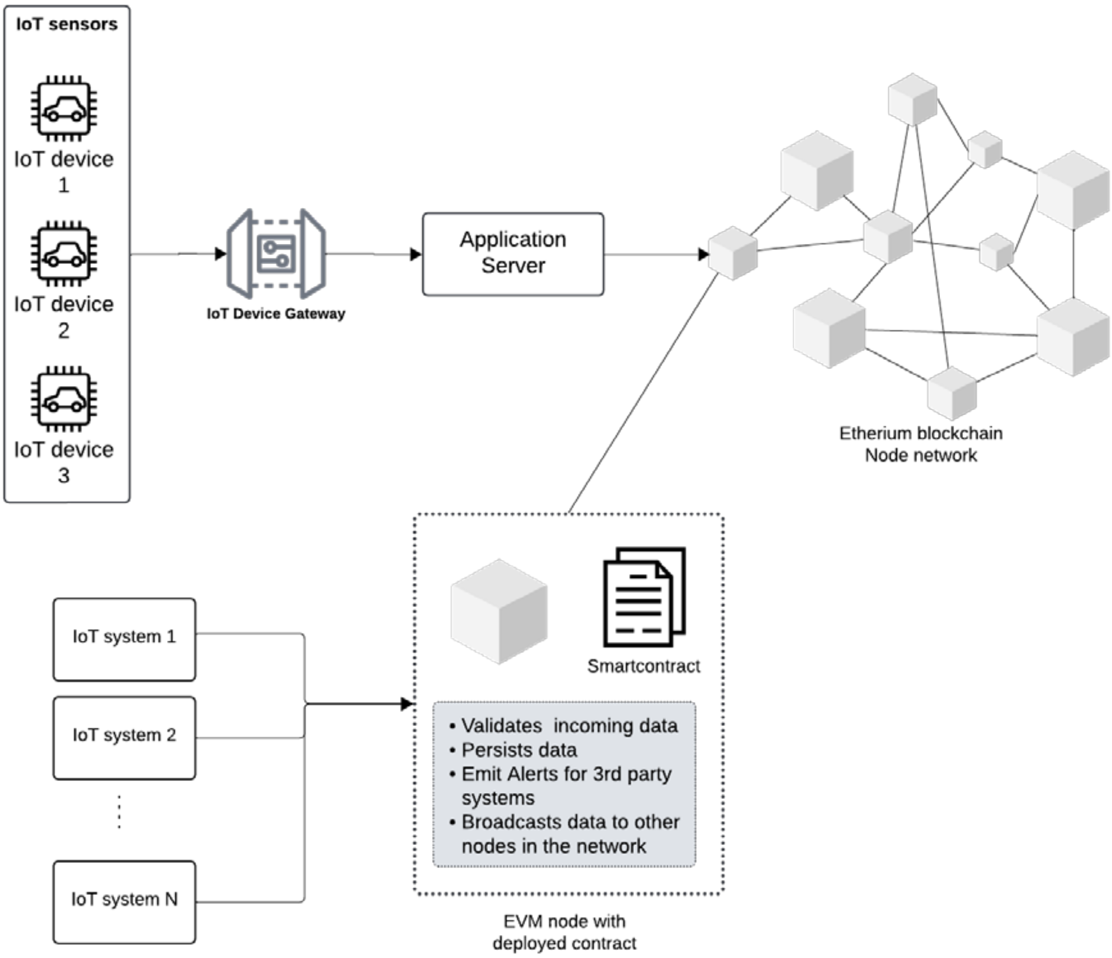

Fig. 2 Execution flow of IoT-device triggered EVM smart contracts in logistics

An IoT device collects real-time data and sends it to Application server. It packages it into a transaction call to a smart contract (signed with the device's private key or a gateway's key). This transaction is broadcast to the EVM (Ethereum Virtual Machine)-based network, where miners validate and append it into a new block. Upon block inclusion, the EVM executes the smart contract code with the IoT data as input.

For example, a temperature sensor's reading should trigger a contract function to check the value does not exceed a threshold and triggers an alert or notifies stakeholder otherwise. The contract's execution is atomic and deterministic: every node verifies the same outcome, ensuring consistency and trust without a central server. Once executed, results (such as a state update or event emission) are immutable on the ledger, meaning they cannot be altered. IoT systems listen for emitted events to take further action (e.g., rerouting a vehicle if some threshold violation event is logged, like engine malfunction). This end-to-end process enables transparent, verifiable logistics workflows where each handoff or condition change is logged on a n immutable chain, creating an audit trail of the shipment's status.

EVM-based network is an immutable ledger that guarantees these recorded events or state changes are tamper-proof, and ensures stakeholders trust in the data integrity. The smart contract acts as an events emitter or performs state updates. Off-chain systems monitoring the blockchain to detect these changes. For instance, a telematics platform watching for an "Alert" event send the notification to fleet managers in near-real time mode when a threshold breach is recorded on-chain.

This approach could be adopted in various IoT-based solutions:

- Scenario 1: An IoT system owned by a shipper company receives the confirmation about the cargo delivery and notifies payment information system to generate an invoice immediately. Additionally, a government-operated information system (for example, environmental protection office) receives a shipment report confirming that environmental conditions were not violated.
- Scenario 2: An IoT system belonging to a car go owner, generates an alert that the cargo was delivered to the wrong warehouse. Concurrently, the shipper information system is notified, and investigation is initiated. Cargo owner system start by reviewing additional GPS data to identify the source of the error.
- Scenario 3: An IoT system owned by a shipper company generates an alert about cargo's temperature regime violation to another information system that notifies to the driver about the malfunction and potential action items to fix the problem. It could include the requirement to deliver a report to the government-operated system with indication about violation and generate appropriate actions in response.

In summary, EVM smart contracts in IoT logistics systems serve as impartial logistics coordinators.

Blockchain-based Smart Contracts vs. Traditional Centralized IoT Solutions

Traditional IoT logistics platforms typically depend on centralized cloud databases and application servers to aggregate sensor data and support decision-making processes (Asiminidis et al., 2018). In contrast, blockchain-based solutions utilize smart contracts to securely accept and validate data inputs, automating business operations in a decentralized manner (Sharma et al., 2025; Vovchak & Veres, 2024; Zheng et al., 2022). These architectural approaches differ significantly in various aspects, including data integrity, security, transparency, throughput, latency, and operational complexity. Table 1 provides a detailed comparison between traditional centralized IoT platforms and blockchain-based smart contract solutions, emphasizing the strengths and limitations of each approach.

Table 1

Comparison of Traditional Centralized IoT Solutions vs. Blockchain-based Smart Contracts (Ethereum and Private Blockchains)

Aspect	Traditional Centralized IoT Solutions	Blockchain-based Smart Contracts (Ethereum and Private Blockchains)
1	2	3
Data Integrity	Data can be modified by administrators or high-level users. Audit logs depend entirely on provider trust.	Immutable data storage: transactions cannot be altered or deleted once recorded.
Security	Centralized server presents a single point of failure and a lucrative attack target. Vulnerable to breaches.	Decentralized consensus and cryptographic security (digital signatures, hashing). Resilient against attacks due to decentralized nodes.
Transparency	Limited transparency; dependent on provider disclosures and internal audits.	Full transparency: all transactions are visible and verifiable by authorized participants.

Continuation of Table 1

1	2	3
Throughput and Performance	High throughput (1000s transactions/sec). Optimized for real-time data ingestion.	Public Ethereum limited (~15–30 transactions/sec). Private blockchains (e.g., AWS Managed Blockchain) offer significantly higher throughput (~2000+ transactions/sec).
Latency	Low latency, often sub-second response times. Optimized for real-time decision-making.	Public Ethereum: ~12-second block times. Private blockchain solutions achieve significantly lower latency (~1–2 seconds).
Cost Predictability and Scalability	Generally predictable infrastructure costs; easy scalability within cloud environments.	Public Ethereum has unpredictable gas fees and limited scalability. Private blockchain solutions (e.g., AWS Managed Blockchain) provide predictable costs and better scalability through managed environments.
Operational Complexity	Lower operational complexity: centralized management simplifies maintenance.	Higher operational complexity in public Ethereum. Private blockchain solutions significantly reduce complexity through managed services.

Essentially, based on the comparison of traditional centralized IoT solution and blockchain-based smart contracts, the Ethereum’s public network has relatively limited throughput (~15–30 transactions per second) and variable latency (block time generation takes approximately 12 seconds). The scalability and efficiency are another strong side of traditional solutions. Additionally, traditional approaches outperform Ethereum in the real-time processing of massive IoT data flows. Also, every EVM-based blockchain transaction incurs a gas fee (paid in native token), while centralized system are “fee free” aside from infrastructure costs. These disadvantages, however, addressed in the private blockchain cloud solutions such as AWS Managed Blockchain, that offer blockchain functionality within a controlled environment. Private blockchain clouds poses blockchain advantages, like immutability and cryptographic security and has significantly improved scalability, throughput, and cost predictability by eliminating public network congestion and variable gas fees. The solutions based on blockchain technology offer transparency, immutability, and security for IoT logistic operations. The main disadvantages are mitigated through the adoption of private blockchain solutions or Layer-2 scaling techniques, that support smart contracts for enhancing business operations.

Blockchain’s Consensus Mechanism and IoT Impact. Hyperledger Fabric.

EVM-based blockchains uses consensus mechanism - a fundamental protocol in blockchain technology that ensures all participating nodes in a distributed network agree on a single, consistent version of the ledger. It enables the network to validate and confirm transactions before adding them as blocks to chain. Ethereum originally used Proof-of-Work (PoW) consensus mechanism which, while secure, was computationally intensive and had unpredictable transaction times. In 2022, Ethereum transitioned to Proof-of-Stake (PoS) consensus, which has several benefits for IoT logistics scenarios, but still does not fully satisfy throughput and performance requirements of the full-scale IoT system.

Given these constraints, there is a strong need for exploration of alternative blockchain solutions. Recent research indicates a potential of private blockchains, such as Hyperledger Fabric hosted on AWS Managed Blockchain as an alternative (Honar Pajooh et al., 2021). Hyperledger Fabric offer optimized consensus protocols specifically tailored for enterprise-grade IoT logistics scenarios. These private networks effectively address Ethereum's scalability and performance limitations, providing more predictable transaction times, higher throughput, and enhanced operational efficiency. Table 2 further illustrates the comparative advantages of adopting Hyperledger Fabric on AWS Managed Blockchain over traditional public EVM-based blockchains for IoT logistics applications.

Platforms such as AWS (Amazon Web Services) Managed Blockchain use consensus protocols that are optimized and particularly beneficial for IoT logistics (Amazon Managed Blockchain FAQs, 2024). Table 2 compares EVM-based blockchains with Hyperledger Fabric on AWS.

Table 2.

Comparison of Ethereum vs. Hyperledger Fabric (AMB) for IoT Logistics

Aspect	EVM-based blockchain	Hyperledger Fabric on AWS Managed Blockchain
Consensus Mechanism	PoW or PoS (for Ethereum 2.0)	Pluggable consensus (e.g. Raft or BFT ordering) with no mining.
Transaction throughput	Low–Moderate: ~15–30 transactions per second (TPS) on Ethereum mainnet. Block interval ~15 seconds, which limits transaction confirmation speed. Throughput is constrained by a global block gas limit and the need for all nodes to process every transaction. (Even in private Ethereum networks, typical TPS is on the order of tens) .	High: Up to ~2,000–3,000 TPS under typical consortium configurations. Throughput is tunable by adjusting block size and frequency improving efficiency.
Scalability	Limited horizontal scalability: Adding more nodes does not increase throughput, since consensus requires global agreement, and performance can even degrade with more nodes (e.g. more network propagation delay). Throughput is essentially fixed by protocol parameters (gas limit, block time). Public Ethereum faces network congestion under high load, leading to delayed transactions and rising fees.	Modular scalability: Designed for enterprise scale-out. The network can be scaled to dozens of organizations and nodes; performance remains high for moderate network sizes due to efficient consensus.
Interoperability & Integration	Designed primarily as a public ledger for decentralized apps, support alerting mechanism through 3rd party middleware	Design is modular and easily integrated with existing IT and IoT infrastructure. Client applications can use rich SDKs (in Java, Go, Node.js, etc.) to interact with the ledger, simplifying integration with IoT platforms. On AWS, Fabric integrates seamlessly with cloud services – e.g. AWS IoT Core and Lambda can funnel sensor data into the blockchain in real time. Hyperledger Fabric offers better interoperability with enterprise IoT systems and the flexibility to operate in hybrid cloud environments.

Continuation of Table 2

1	2	3
Cost Efficiency	High and unpredictable costs per transaction. E.g.: Every Ethereum transaction incurs a gas fee paid in ETH. The fee is proportional to the computational and storage operations a transaction uses (measured in gas units), and to the network's gas price. For example, after Ethereum's EIP-1559 upgrade: Fee ≈ (Base Fee + Priority Fee) × Gas Used	Lower and predictable costs: Hyperledger Fabric has no native cryptocurrency and thus no per-transaction fees. The costs are operational – running peer nodes and ordering service. On Amazon Managed Blockchain, pricing is pay-as-you-go for the resources (compute, storage)
IoT Use-Case Performance	Challenges in IoT scenarios: Ethereum's average confirmation time 10–15 seconds may be too slow for certain real-time monitoring needs. Finality is probabilistic (on PoW Ethereum, one might wait ~1 minute for ~5 confirmations for high confidence), which is problematic for time-sensitive logistics decisions. The limited throughput could easily overwhelm the network or incur prohibitive fees when producing hundreds of events per second.	Tailored for IoT logistics: Fabric's faster transaction commit (often 1–2 seconds or less). High throughput capacity means even thousands of IoT events per second can be ingested if the network is provisioned accordingly. In practice, IoT solutions have been built on Fabric networks to track assets at scale. This architecture ensures robust performance for IoT-driven logistics, with Fabric providing the trust and automation layer without compromising on speed or cost.

AWS Managed Blockchain supports Hyperledger Fabric, a p ermissioned blockchain framework specifically designed for high performance. It typically utilizes Practical Byzantine Fault Tolerance (PBFT) or RAFT algorithms, providing faster transaction validation, lower latency, and higher throughput. In RAFT, nodes elect a leader responsible for log replication across all participant nodes. This method significantly reduces the computational overhead compared to Proof-of-Work (PoW) and maintains transaction validation speed considerably faster than public blockchain counterparts.

AWS Managed Blockchain is highly effective for IoT logistics environments, where real-time or near-real-time transaction confirmations are critical. Hyperledger Fabric, powered by RAFT consensus on AWS, can handle transaction throughputs ranging from hundreds to thousands per second, dramatically surpassing EVM's Layer-1 performance. Moreover, transaction finality within RAFT is processed within milliseconds to a few seconds, that is acceptable for the time-sensitive logistics decisions, such as inventory updates, asset transfers, and shipment tracking.

Smart Contract Implementation: Ethereum Virtual Machine (EVM) vs Hyperledger Fabric.

The smart contracts are integral part of the blockchain-based logistics systems that automate and securely enforce business logic within decentralized networks.

EVM runtime environment was designed explicitly for executing smart contracts written primarily in Solidity, a high-level, JavaScript-like language. Solidity's domain-specific orientation simplifies contract coding but also limits flexibility and requires specialized developer knowledge. Contracts are executed identically on every node in the Ethereum network, ensuring consensus through redundant execution and imposing computational overhead, potentially limiting performance. EVM smart contracts benefit from extensive public validation due to the open and decentralized nature of the Ethereum mainnet. However, this transparency eliminates data privacy, as all contract data is publicly accessible. For logistics stakeholders who handle sensitive transaction data, this lack of confidentiality can represent a significant limitation unless additional off-chain privacy mechanisms are employed. Ethereum's smart contract execution is metered through "gas" fees paid in Ether (ETH) for computation and storage resources. Variable and sometimes unpredictable costs pose significant concerns for extensive IoT logistics deployments generating continuous real-time transaction streams.

Hyperledger Fabric solution was developed to address all issues with EVM smart contracts to use within the industries with data protection requirements. Hyperledger Fabric implements smart contracts, called "chaincode" using popular programming languages such as JavaScript (Node.js), Java, and Go (Amazon Managed Blockchain FAQs, 2024). This general-purpose language support significantly broadens the community adoption and allows to connect smart contract implementations with existing IT infrastructure and enterprise-level logistics applications. Fabric's execution model differs wherein contracts are first executed by designated node peers rather than by all network nodes. This model drastically reduces redundant computation, enhances scalability, and improves transaction throughput critical features for real-time IoT-driven logistics management. Fabric smart contracts do not require any native cryptocurrency fees by default. Instead, operational costs consist mainly of predictable infrastructure and maintenance expenditures that makes it preferable for logistics enterprises budgeting large-scale, IoT-based system deployments.

Despite notable implementation differences (particularly regarding programming models, execution environments, and privacy controls) the fundamental principle underlying smart contracts remains consistent between EVM-based and Hyperledger Fabric. Both enable decentralized, automated execution of transaction logic across participating stakeholders, thereby enhancing trust, transparency, and efficiency in complex logistics workflows.

Based on this analysis, it is evident that the differences between Ethereum's EVM-based smart contracts and Hyperledger Fabric's chaincode implementation do not represent incompatibilities or significant conceptual deviations. Rather, Fabric can be regarded as an optimized evolution of the blockchain smart contract paradigm and a better fit for the logistics use cases and scenarios. Fabric smart contracts deliver key enhancements directly addressing the specific operational, security, and scalability needs encountered in modern logistics environments, thus solidifying their suitability as a robust alternative to traditional EVM-based contracts.

Conclusions

This research is devoted to analysis and comparison of traditional approach for logistics systems development and blockchain-based alternatives. The main goal was to identify how blockchain technology could enhance supply chain management and figure out the circumstances when it is the most beneficial. The paper examined the limitations of logistics processes, which typically rely on centralized databases and third-party intermediaries, resulting in challenges such as data fragmentation, poor interoperability, and reduced stakeholder trust. Blockchain solutions were proposed and assessed as potential remedies due to their distributed, transparent, and tamper-resistant nature.

The study concluded that blockchain can significantly enhance logistics operations, improving transparency, securing data management, and automating trust mechanisms through smart contracts. The research highlighted main Ethereum's limitations, specifically noting its relatively limited transaction throughput of approximately 15–30 transactions per second and variable latency with approximately 12-second block confirmation times. Such limitations significantly impact Ethereum's suitability for real-time logistics applications. Additionally, operational costs on public Ethereum networks were identified as unpredictable due to variable transaction (gas) fees ranging from $1 to $5 per event, potentially becoming prohibitively expensive for extensive IoT deployments.

In contrast, the study identified private blockchain solutions, particularly AWS-managed Hyperledger Fabric, as highly effective alternatives. Hyperledger Fabric demonstrated significantly higher transaction throughput capabilities, achieving up to 2000–3000 transactions per second, coupled with substantially lower latency - typically 1–2 seconds per transaction. Moreover, AWS Managed Blockchain (Hyperledger Fabric) provided predictable operational costs due to the absence of transaction fees, addressing critical concerns associated with Ethereum's variable gas fees.

The comparative analysis highlights strengths of Hyperledger Fabric: modular scalability, reduced operational complexity through managed services, and seamless integration with existing enterprise IoT infrastructures. It is valuable for enterprise logistics environments where predictable costs, high throughput, and low latency are essential for performance-critical applications.

Overall, the effectiveness of blockchain-based logistics solutions largely depends on clearly defined business objectives and operational requirements. Hyperledger Fabric directly addresses the scalability, cost-efficiency, and latency challenges identified with Ethereum-based systems. Thus, based on the quantitative data presented, Hyperledger Fabric emerges as an optimal blockchain solution for enhancing logistics efficiency, security, and interoperability in enterprise-level IoT-driven logistics systems.

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УДОСКОНАЛЕННЯ ЛОГІСТИЧНИХ ІНФОРМАЦІЙНИХ СИСТЕМ ІНТЕРНЕТУ РЕЧЕЙ ШЛЯХОМ ВПРОВАДЖЕННЯ СМАРТ-КОНТРАКТІВ БЛОКЧЕЙН-ТЕХНОЛОГІЙ

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Сучасні інформаційні логістичні системи моніторингу дедалі частіше інтегрують IoT-пристрої для збору даних у режимі реального часу, відстеження відправлень, моніторингу вантажів та транспортних засобів, а також для прийняття обґрунтованих рішень. Проте такі інформаційні системи стикаються з низкою суттєвих викликів, зокрема із складністю управління даними, обмеженою взаємодією між зацікавленими сторонами та неефективністю, яка виникає через централізовані механізми контролю.

Технологія блокчейн є перспективним підходом для вирішення зазначених критичних питань у сфері логістики та управління ланцюгами постачання. У даній статті проведено порівняльний аналіз традиційних централізованих логістичних інформаційних систем та децентралізованих рішень на базі блокчейну з фокусом на оцінку прозорості, незмінності даних та автоматизованого виконання транзакцій за допомогою смарт-контрактів, та обмежень масштабованості та складності впровадження.

В дослідженні розглянуто, як смарт-контракти можуть ефективно оперувати даними, згенерованими IoT давачами, для автоматизації логістичних транзакцій та забезпечення безпечного, прозорого доступу до збереженої інформації. За допомогою структурованого аналізу визначено конкретні сценарії застосування блокчейн-технології в логістиці та представлено ключові практичні аспекти її ефективного впровадження.

Також в дослідженні розглянуто виконання смарт-контрактів на базі Ethereum Virtual Machine та запропоновано використання смарт-контрактів на базі AWS Hyperledger Fabric як більш масштабовану та економічно ефективну альтернативу для корпоративних логістичних рішень.

Отримані результати та рекомендації мають практичне значення, сприяючи прийняттю обґрунтованих рішень щодо інтеграції блокчейн-рішень з метою підвищення операційної ефективності, довіри та взаємодії в умовах складних ланцюгів постачання.

Ключові слова: смарт-контракти, Ethereum, EVM, AWS Hyperledger Fabric, Інтернет речей (IoT), логістика, автоматизація, блокчейн.