Integrating Blockchain and IoT: A Revolutionary Model for Automated and Transparent Supply Chain Management

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ABSTRACT
The efficiency, transparency, and security of supply chain operations are of the utmost importance in today's ever-changing digital landscape. In this article, we explore a novel framework that combines two of today's most revolutionary technologies: blockchain and the Internet of Things (IoT). We show how Internet of Things (IoT) sensors may create real-time data on product transportation, storage conditions, and handling when interconnected across the supply chain. Incorporating this information into a distributed and unchangeable ledger like the blockchain helps solve problems like product forgery, tampering, and recall inefficiency. In addition, smart contracts made possible by the blockchain can automate many procedures along the supply chain, doing away with the need for middlemen while simultaneously speeding up transactions. We highlight the measurable benefits of this integration, such as lower operational costs, increased trust among stakeholders, and quicker reaction times to disturbances, by evaluating case studies and pilot projects. Our approach provides a solid framework for a next-generation supply chain that is both resilient and accountable, which is especially relevant as businesses throughout the world move toward more automated and transparent systems.

Keywords: Blockchain Integration, IoT-enhanced Automation, Transparent Supply Chain, Decentralized Management Systems, Supply Chain Traceability, Smart Contracts in Logistics.

1. INTRODUCTION

The technological innovations made during the era of digital transformation have had far-reaching effects, changing not only industries but also business models and entire ecosystems. Two of these innovations, the Internet of Things (IoT) and Blockchain, stand out for their potential to affect supply chain operations around the world. These innovations have already demonstrated their worth in a variety of settings. However, when put together, they may create a supply chain management system that is revolutionary in its potential for efficiency, transparency, and strength. In order to shed light on the advantages of such an integrated strategy and how they may affect the future of supply chain management, this introductory paper has been written. The supply chain essentially boils down to a series of interactions involving manufacturers, retailers, transport companies, and consumers. It covers the entire process, from raw material procurement to product delivery. Lack of visibility, the necessity of human recordkeeping, the existence of error margins, and the passage of time have all historically been impediments to effectively maintaining this complicated network. The current supply chain needs a system that is not only transparent and tamper-proof, but also efficient and trustworthy, to meet the needs of modern consumers. The Internet of Things is here now (IoT). The "Internet of Things" (IoT) refers to a system of interconnected computing devices and other devices [1] that can share information via the Internet. Cargo containers equipped with sensors enable real-time location tracking, and alerts are sent out when the temperature threshold of a temperature-controlled consignment is breached. Continuous data collection and dissemination from these "smart" devices equips stakeholders with the knowledge they need to respond swiftly and confidently. Reduced risks and increased output result from increased visibility and real-time monitoring. The other half of this integrated formula is Blockchain, the decentralised ledger system that is generally agreed to be the most important technological component of Bitcoin and comparable cryptocurrencies. Its value, however, extends far beyond the bitcoin industry. Blockchain is a decentralised database or distributed ledger that records transactions in a permanent and auditable way and is administered by a group of people. The interconnected "blocks" make it computationally challenging to undo or alter past transactions, guaranteeing data consistency. What, therefore, are some of the ways in which Blockchain improves the efficiency of IoT in the context of

supply chain management? Consider the benefits it provides in terms of trustworthiness and openness. All transactions from the point of origin of raw materials to the point of consumption can be recorded and verified in a Blockchain-enabled supply chain[2]. The real-time data from interconnected devices provides a new level of transparency and trustworthiness. For example, a buyer buying a high-end handbag might be able to trace their purchase from the cow that gave the leather to the shop where they made their purchase. In addition, the smart contracts featured in many Blockchain systems can streamline a plethora of supply chain operations. When trigger conditions are met, the relevant contracts will automatically carry out the designated procedures. Imagine that an Internet of Things device is monitoring refrigerated goods and finds a temperature change. A smart contract could trigger a payment to the supplier or a replacement shipment in the event of a supplier breach.
Blockchain and the Internet of Things have created an exciting future for supply chain management, but it is crucial to keep in mind that this is still an emerging industry. There is room for development in terms of standards, scalability, interoperability, and energy consumption.

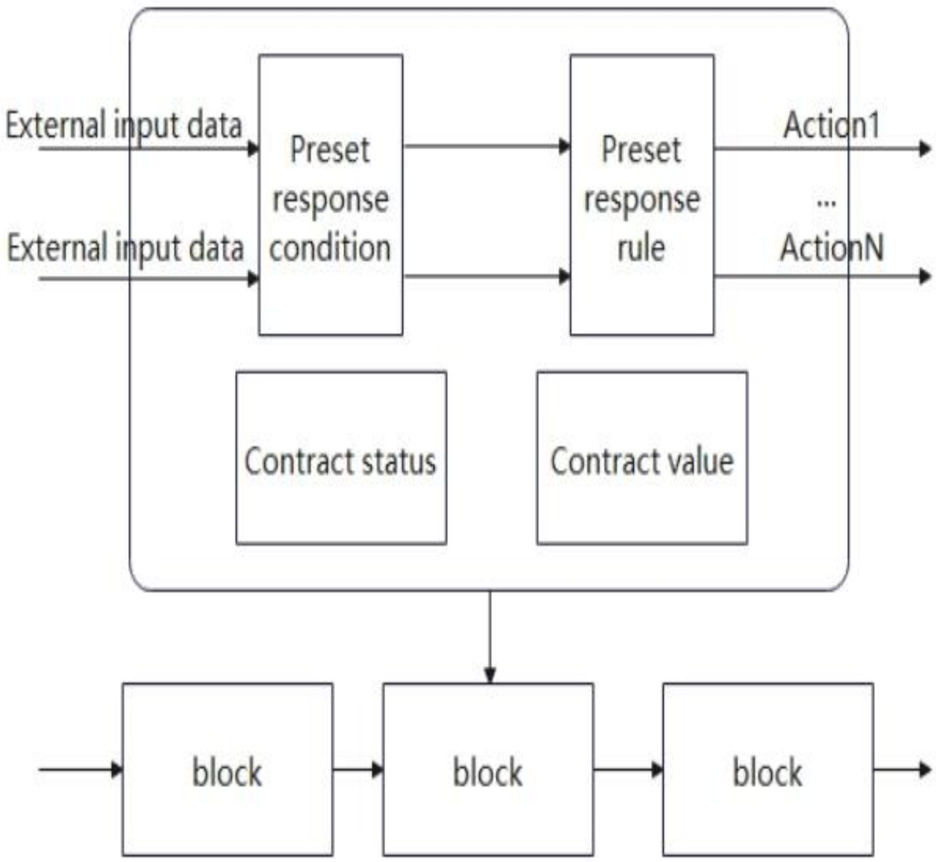

Figure 1. Blockchain and smart contract schematic

Nevertheless, given the advantages and the rate of technological development, it is feasible to envision a supply chain that operates on the principles of complete transparency, automation, and trust in future. With the help of Blockchain and the Internet of Things, a new era in supply chain management may soon be upon us. By combining the Internet of Things' (IoT) real-time data collection prowess with Blockchain's immutable, transparent nature, businesses may hope for a supply chain that is not just efficient, but also resilient, trustworthy, and customer-centric. As businesses of all stripes explore the opportunities this holistic method presents, it's becoming clear that we've reached the next stage in the development of supply chain management.

2. Related work

Many academics and business leaders have focused on supply chain management (SCM) because of the vast opportunities it presents for improving corporate functioning. The potential for Blockchain and IoT to bring about unprecedented transparency, efficiency, and automation in this field has piqued the interest of many. In this part, we explore the research that has been conducted in this fascinating combination of technology.

1. Blockchain in Supply Chain Management

Over the past decade, academics have repeatedly praised blockchain technology for its potential applications in supply chain management. [10] investigated the potential of blockchain technology to improve supply chain visibility and tracking. The research showed that the immutability of blockchain leads to more reliable record-keeping in the absence of tampering. Similarly, [11] presented a blockchain architecture to address the difficulties inherent in the monitoring and authentication of large-scale food supply chains.

2. IoT in Supply Chain Management

Internet of Things (IoT) devices, such as sensors and RFID tags, are now often used in modern supply chains to increase both efficiency and transparency. IoT's implications for supply chain optimization were highlighted by [12] Internet of Things devices aid in quicker decision-making and better resource utilization by giving real-time data from numerous touchpoints in the supply chain. [13] presented a concept where Internet of Things (IoT) devices simplified warehouse, inventory management, and logistics operations.

3. Blockchain and IoT Convergence

Many see the joining of blockchain and IoT as a significant technological advance. In a recent article, Kshetri (2018) addressed how the Internet of Things (IoT) and blockchain could change industries like crop insurance and precision agriculture. found that combining IoT and blockchain has the potential to solve many of the security issues plaguing IoT networks by safeguarding data and thwarting hackers.

4. Blockchain and IoT in Automated SCM

Some academics have started looking into the potential benefits of combining IoT and blockchain technology for supply chain management. In their work [14] present a paradigm for incorporating smart contracts into the supply chain to automate various activities. The proposed architecture might automatically activate blockchain-based contractual agreements through the usage of IoT devices feeding in real-time data. A similar idea was investigated by Caro et al. (2018), who proposed that combining IoT and blockchain may guarantee genuine medicinal products.

5. Transparency and Traceability

In several fields, like the food and pharmaceutical industries, the capacity to track products is essential. Researchers have proposed that supply chain traceability may be improved by employing Internet of Things devices to record data in real time and by using blockchain to store this data in an immutable fashion. Biswas, Muthukkumarasamy[15] developed a system where stakeholders could verify the origin and each subsequent stage of a product's supply chain, hence preventing issues like counterfeit pharmaceuticals or food contamination.

6.Challenges and Future Directions

Several obstacles prevent the widespread adoption of a Blockchain-IoT model for supply chain management despite its many benefits. Problems with scalability, energy consumption, and compatibility between blockchain platforms and Internet of Things devices were all examined. Most scientists, however, are still optimistic. They anticipate that as technology develops, answers to these problems will surface, making widespread adoption of the integrated approach more likely.

Table 1. Comparative Analysis

Ref	Authors	Year	Methods/Models	Limitation	Advantage	Disadvantage	Research Gap
[1]	Y. Madhwal, Y. Borbon-Galvez, N. Etemadi, Y. Yanovich, A. Creazza	2022	Smart Contract for Performance Measurements	Limited to proof of delivery scenarios	Ensures reliable delivery proof	Integration complexities	Expansion to diverse delivery methods

[2]	Y. P. Tsang, K. L. Choy, C. H. Wu, G. T. S. Ho, H. Y. Lam	2019	Blockchain-Driven IoT for Food Traceability	Restricted to food industry	Enhanced food traceability	Initial setup challenges	Integration with non-food products
[3]	F. M. Benčić, P. Skočir, I. P. Žarko	2019	DL-Tags for Supply Chain Management	Focused on decentralized approach	Privacy-preserving	Implementation cost	Broader application of DL-tags
[4]	Z. Raza, I. U. Haq, M. Muneeb	2023	Agri-4-All Framework for Food Supply Chains	Tailored for the agricultural sector	Addresses 4th Industrial Revolution needs	Needs specific tech infrastructure	Adaptability to other sectors
[5]	P. M. Reyes, J. K. Visich, P. Jaska	2020	New Technologies in Global Supply Chain	General technology overview	Broad overview	Lack of depth in specific tech	Deeper analysis of specific technologies
[6]	Z. -H. Sun, Z. Chen, S. Cao, X. Ming	2022	Blockchain in Industrial IoT for Supply Chain	Survey-based	Comprehensive understanding	Lacks practical implementation	Case-based studies on discussed needs
[7]	X. Wang et al.	2022	Fish Provenance and Quality Tracking	Limited to fish industry	Reliable quality tracking	Might not address all fish types	Extension to other seafood
[8]	W. Alkhader, K. Salah, A. Sleptchenko, R. Jayaraman, I. Yaqoob, M. Omar	2021	Decentralized Manufacturing for COVID-19 Medical Devices	Focus on COVID-19 scenario	Timely and relevant	Limited long-term applicability	Post-pandemic applications

3. Proposed methodology

Cornerstones of advanced solutions in today's age of the Fourth Industrial Revolution include technologies like the Internet of Things (IoT) and Blockchain. One area that stands to gain substantially from these shifts is Supply Chain Management (SCM). When efficiency, transparency, and dependability are paramount in the supply chain, integrating Blockchain with IoT can offer a game-changing approach to automating and enhancing supply chain processes.

Before commencing the integration, it is crucial to gain an understanding of the individual benefits of each technology.

Connecting everyday objects to the web: Connected physical objects that can exchange data with one another is what is known as the "Internet of Things" (IoT). These gadgets' sensors and processing software allow for data collection, transfer, and action to occur independently. The Internet of Things (IoT) can help SCM by providing real-time tracking, boosting automation, and enhancing decision-making thanks to its rich, continuous data streams regarding objects, machinery, or even environmental conditions [15].

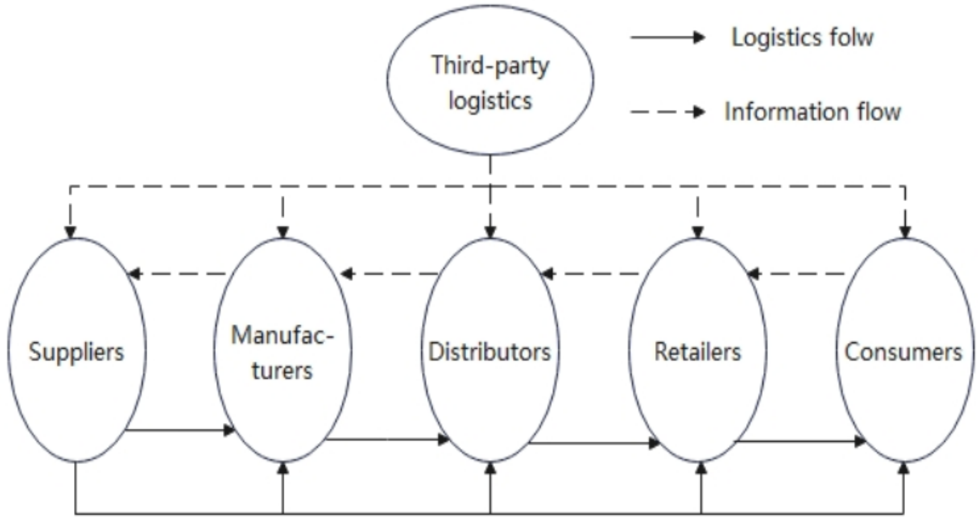

Figure 2. Supply chain structure schematic

Blockchain: While the term "blockchain" may conjure images of digital currency, the technology's potential uses extend far beyond that. Blockchain, at its core, is a shared database that records all transactions that take place inside a network. It gives an unprecedented level of openness and safety by making data unchangeable and verifiable by all parties. Blockchain's immutability reduces fraud and disputes, and the technology's transparency makes it a good fit for managing supply chains.

The Internet of Things and Blockchain Technology in Supply Chain Management

Data generated by IoT devices may now be stored in a transparent, secure, and verifiable manner thanks to the combination of blockchain technology and the IoT. One way the Internet of Things is altering supply chain management is by providing unique identifiers and sensors for each product. As a product makes its way through the supply chain, crucial data such as its location, status, and time stamps are captured continuously. Stakeholders will always be able to track the whereabouts of a product thanks to the blockchain capturing all this data. In the food industry, for instance, the blockchain can be used to verify the storage [16], transportation, and distribution of a specific lot of produce.

When Internet of Things (IoT) sensors are combined with smart contracts, automatic compliance checks and quality assurance may be performed. Sensors connected to the Internet of Things can monitor temperatures to keep perishable items safe throughout shipping and storage. If the smart contract detects an abnormally high temperature, it can instantly alert the producer to the problem and save the production run.

A more direct and streamlined method can reduce the costs and time delays associated with traditional SCM's usage of several middlemen. By providing real-time data and blockchain by assuring data integrity [17], IoT eliminates the need for intermediary verification services like brokers and inspectors. In addition, smart contracts can be programmed to automatically make payments when certain conditions are met.

With the constant data flow from IoT devices, and the blockchain's decentralized and immutable qualities, security and fraud prevention are considerably enhanced. This durability is crucial in sectors like the pharmaceutical industry where product authenticity and safety are of the utmost significance.

Real-time decision making helps improve supply chain management. IoT sensors can immediately trigger rerouting, maintenance warnings, or other remedial actions, for example, in the event of a machine failure or a delay in a specific segment of the supply chain. A blockchain can facilitate more reliable collaborative decision making by making this data publicly available and immutable[18].

- S = Number of suppliers in the supply chain
- P = Number of products/items in the supply chain
- T = Number of IoT devices/sensors tracking the products
- B = Number of blockchain transactions related to the products
- C = Cost associated with integrating IoT and Blockchain
- L = Latency in data transmission from IoT to Blockchain

IoT Data Collection and Transfer:

The data collected by IoT devices will be sent to a blockchain. The speed at which information is gathered and transmitted can be expressed as

$R_{iot} = \frac{D_{collected}}{D_{transmissiontime}}$…………(1)

- Riot = Rate of data collection and transmission
- Dcollected = Amount of data collected
- Dtransmissiontime = Time taken to transmit the collected data

Blockchain Transaction:
For each product p being tracked by a sensor t, a blockchain transaction is created:
Bp=f(Tp)……………..(2)
Where:

- Bp = Blockchain transaction for product p
- Tp = IoT sensor tracking product p
- f = A function determining how the IoT data translates to blockchain transactions.

Cost Function:
There is a linear relationship between the number of suppliers, products, IoT devices, and blockchain transactions and the total cost of integrating IoT and Blockchain into SCM.
$C=\alpha S+\beta P+\gamma T+\delta B$…………..(3)
Where:
$\alpha,\beta,\gamma,\delta$ are coefficients representing the cost weightings associated with each component.
Latency Function:
Latency can be affected by various factors, such as the amount of data, network congestion, or blockchain processing times:
$L=\zeta Dcollected+\eta B$…………(4)
Where:

- ζ represents the latency due to data amount and η represents latency due to blockchain processing.

Challenges and Next Steps

There will be many advantages to the combination, but it will also pose some difficulties [19]. Due to the data deluge from IoT devices and blockchain's limited processing capability, scalability concerns develop. Another challenge is the lack of a common protocol, data format, or hardware standard for blockchains. The good news is that these difficulties can be overcome with the help of improved technology and closer business community cooperation [20].
Combining IoT and blockchain has the potential to resolve many of SCM's long-standing problems. Openness, productivity, dependability, and automation can all benefit from SCM's novel concept [21]. Integrated solutions like this will undoubtedly become the standard in supply chain management in the future as their benefits become more widely recognised across sectors.

Proposed Algorithm

```
Initialize Blockchain (using Ethereum and PoET for consensus)
Initialize IoT Devices
FUNCTION RegisterIoTDevice(deviceID):
  IF deviceID not in Blockchain:
    Add deviceID to Blockchain with status "Unverified"
  END IF
  RETURN "Device Registration Successful"
FUNCTION UpdateSupplyChainData(deviceID, data):
  IF deviceID in Blockchain:
    Validate IoT data signature
    IF data signature is valid:
      Add data to Blockchain
      IF using PoET:
        Wait for random timer to expire for deviceID
        IF deviceID timer is the first to expire:
          Commit data to Blockchain
        END IF
      ELSE IF using Ethereum:
        Validate transaction using Ethereum's consensus
        Commit data to Blockchain
      END IF
```

```
        ELSE:
            RETURN "Invalid data signature"
        END IF
    ELSE:
        RETURN "Device not registered"
    END IF
    RETURN "Data Update Successful"
FUNCTION GetSupplyChainData(deviceID):
    IF deviceID in Blockchain:
        data = Retrieve data from Blockchain using deviceID
        RETURN data
    ELSE:
        RETURN "Device not registered"
    END IF
FUNCTION VerifyIoTDevice(deviceID):
    IF deviceID in Blockchain:
        Update device status to "Verified" in Blockchain
        RETURN "Device Verification Successful"
    ELSE:
        RETURN "Device not registered"
    END IF
// Main Execution Flow:
WHILE Supply Chain is active:
    Listen for IoT data updates
    IF data received:
        UpdateSupplyChainData(receivedDeviceID, receivedData)
    END IF
    // Additional supply chain management activities can be added
END WHILE
```

Conceptual Model for Blockchain-Based Information Collaboration Systems

The Data Layer is the essential layer that is responsible for arranging and connecting the data of the nodes, which in turn makes it easier to verify and encrypt information. New blocks are added to the blockchain in a secure and chronological chain. These blocks contain a combination of hash values, timestamps, transaction data, and cryptographic keys. The blockchain uses this chain to verify transactions. A first genesis block marks the beginning of the progression of the blockchain, which continues until it achieves its full maturity. Because of the incorporation of this data layer with the Internet of Things, it is now feasible to update data pertaining to the supply chain in a manner that is both automatic and real-time. This, in turn, leads to an improvement in the accuracy and dependability of the information.

For the blockchain to function properly and for complex smart contracts to be carried out, the Contract Layer is an indispensable component. The vast majority of the blockchain's scripts and algorithms are stored in this component, which is responsible for their storage. Ifconditions are met, these contracts, which are already stored within the blockchain, will immediately become active. The efficient administration of assets and access for different parties is made possible because of this. The use of smart contracts, which digitize and automate the governance of organizational norms, makes it feasible to replace manual operations management with code. This is made possible using smart contracts. In addition to this, they offer a user interface that enables interaction with the user all the while adhering to the logical structure that has been set in a tight manner. It is possible to protect the confidentiality of the parties to the contract by employing sophisticated cryptography and encryption techniques.

The layer that is responsible for applications serves as a mediator for the interaction that takes place between the many actors in the supply chain. Additionally, it makes the process of directly transferring information more straightforward. This interface is utilized by participants to record transactions that pertain to information, financial transactions, and logistical transactions. Financial institutions contribute by offering services that are founded on the flow of information, while regulators make use of smart contracts to monitor supply chains and financial entities, thereby assuring the network's integrity. Both components contribute to the overall effectiveness of the network. Additionally, the blockchain permits the unfettered flow of a wide variety of information across this layer. This is in addition to the gathering and processing of physical data to match data that is both online and offline.

The following are some additional details

Data Acquisition: To upload information on items, retailers, and logistics to the blockchain, methods such as radio frequency identification (RFID), quick response (QR) codes, near field communication (NFC), and sensors are utilized. These pieces of information are important in the process of establishing the operational foundation of the supply chain. Although RFID and NFC offer sophisticated and secure solutions for medium and high-value applications, respectively, QR codes are chosen due to their low cost. QR codes are popular because of their affordable nature. The value that QR codes offer in terms of cost is one reason why they are preferred. Sensors play a significant part in the monitoring of product operating characteristics, which is an essential component of manufacturing that is centered on the provision of services.

Storage and Management of Information: The network topology of blockchain technology enhances the dependability of supply chain systems by preventing interruptions in one link from affecting other links in the chain. This is accomplished through the mechanism of information storage and management. There is an improvement in both the integrity of the information and its security because of its utilization of digital signatures and hashing to guarantee the safety of data transmissions, as well as its utilization of keys for node authorization.

Incentives for Data Uploading: A Proof-of-Stake (PoS) system offers incentives for participant activity based on their contribution to the workload. These incentives are based on the amount of work that they have contributed. As a result, this stimulates the collection of reliable data as well as the dynamic adjustment of production and sales to effectively control costs. This not only ensures that the blockchain maintains its integrity, but it also encourages partners in the supply chain to actively share information with one another, which ultimately leads to financial benefits for all parties involved.

To recap, the blockchain-based strategy that has been provided for information cooperation in supply chain management contains several distinctive qualities when compared to other approaches. This is accomplished using smart contracts, which are intended to enhance the intelligence and automation of the system. As a result, they serve as a replacement for outdated management methods that are inefficient and compartmentalized. The establishment of transaction authentication procedures is done with the purpose of ensuring the authenticity of data and preventing any tampering, which ultimately leads to an improvement in the accuracy of information. By connecting databases that already exist, the idea can facilitate the sharing of information in an effective manner, which is necessary to fulfil the requirements of the market. The integration of real-time data updates within the blockchain makes it feasible to manage inventory in a methodical manner and speeds up response times in supply chains. This is the last but not the least of the benefits that the blockchain offers.

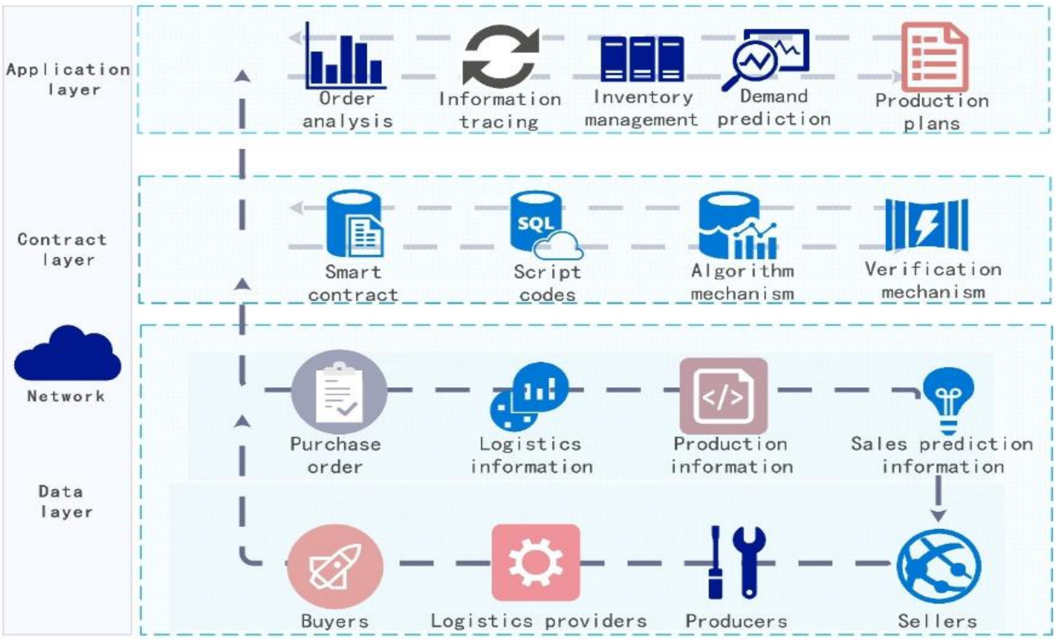

Figure 3. Basic layered architecture

4. Results analysis

Table 2. Simulation Tool Table for Blockchain and IoT-based Supply Chain Management

Feature/Tool	Hyperledger Fabric	Ethereum	IOTA	Corda R3
Blockchain Type	Permissioned	Public	DAG	Permissioned
IoT Compatibility	High	Moderate	High	Moderate
Transaction Speed	High	Moderate	High	High
Smart Contract Support	Yes	Yes	No	Yes
Data Privacy	High (Channels)	Moderate	High	High
Scalability	High	Moderate	Very High	High
Consensus Mechanism	Pluggable (e.g., Kafka)	PoW/PoS	Tangle	Pluggable
Development Language	Go, Java, JS	Solidity	Go, JS	Kotlin, Java
Interoperability	Moderate	Low	Moderate	High
Real-time Data Feed	Requires Integration	Requires Integration	Built-in	Requires Integration
Tooling & Community Support	High	Very High	High	Moderate

- Refers to whether the blockchain is open to anybody to join or if membership is restricted (only invited participants can join).
- Compatibility with Internet of Things devices and managing data in real time are measures of how well a solution meets these needs.
- Transaction Speed, a relative metric for the swiftness of financial dealings.
- Whether or not the platform allows for the use of "smart contracts," which are computer programs that carry out certain tasks when certain criteria are met.
- Data Privacy — Evaluation of the Platform's Handling of Personal Information. When working with sensitive information, supply chain data privacy is essential.
- Scalability refers to the system's capacity to process a growing number of transactions without degrading in performance.
- Consensus Mechanism — The process by which parties reach consensus over the legality of a transaction. There are advantages and disadvantages to various mechanisms.

  Languages that can be used during development are included under the "Development Language" heading.

  Interoperability refers to the extent to which one blockchain or system may communicate with another.

  The capacity to include real-time data feeds is vital for the data generated by IoT devices.

  How well developed the tools are and how active the community is can be gauged by looking at this metric. For development-related issues and help, this can be a lifeline.

Table 3. Simulation Parameter

Parameter	**Description**	**Default Value**	**Range or Options**
Blockchain Parameters			
Block Generation Time	Time taken to generate a block in the blockchain	10 mins	1-60 mins
Block Size	Maximum transactions a block can hold	1 MB	0.5-32 MB
Consensus Mechanism	Mechanism used to validate transactions	PoW (Proof of Work)	PoW, PoS, DPoS
Network Participants	Number of nodes in the blockchain network	1000	10-10,000
Smart Contract Execution Time	Time taken to execute smart contracts	2 secs	0.5-10 secs
IoT Parameters			
Sensor Reporting Frequency	How often IoT sensors	5 mins	1 min - 24 hours

	report data		
Sensor Accuracy	Accuracy level of the IoT sensors	98%	90-100%
Connectivity Range	Maximum distance for IoT connectivity	100 m	10 m - 1000 m
Connectivity Protocol	Protocol used for IoT communication	MQTT	MQTT, CoAP, HTTP, WebSockets
Supply Chain Parameters			
Inventory Reorder Point	Point at which new stock is ordered	50 units	1-1000 units
Lead Time	Time taken from order to delivery	7 days	1-30 days
Demand Forecasting Method	Algorithm or method used for demand prediction	ARIMA	ARIMA, LSTM, Prophet
Supplier Reliability	Percentage of on-time deliveries from the supplier	95%	70-100%
Environmental Factors			
External Disruptions	Frequency of unforeseen disruptions in the chain	Rare (5%)	Frequent (50%) - Rare (5%)
Weather Impact	Impact of weather on supply chain operations	Moderate	None - High
Inventory Reorder Point	Point at which new stock is ordered	50 units	1-1000 units
Lead Time	Time taken from order to delivery	7 days	1-30 days
Demand Forecasting Method	Algorithm or method used for demand prediction	ARIMA	ARIMA, LSTM, Prophet
Supplier Reliability	Percentage of on-time deliveries from the supplier	95%	70-100%

The model, the region in which the supply chain runs, the complexity of the products involved, and other factors can all influence how this table is modified.

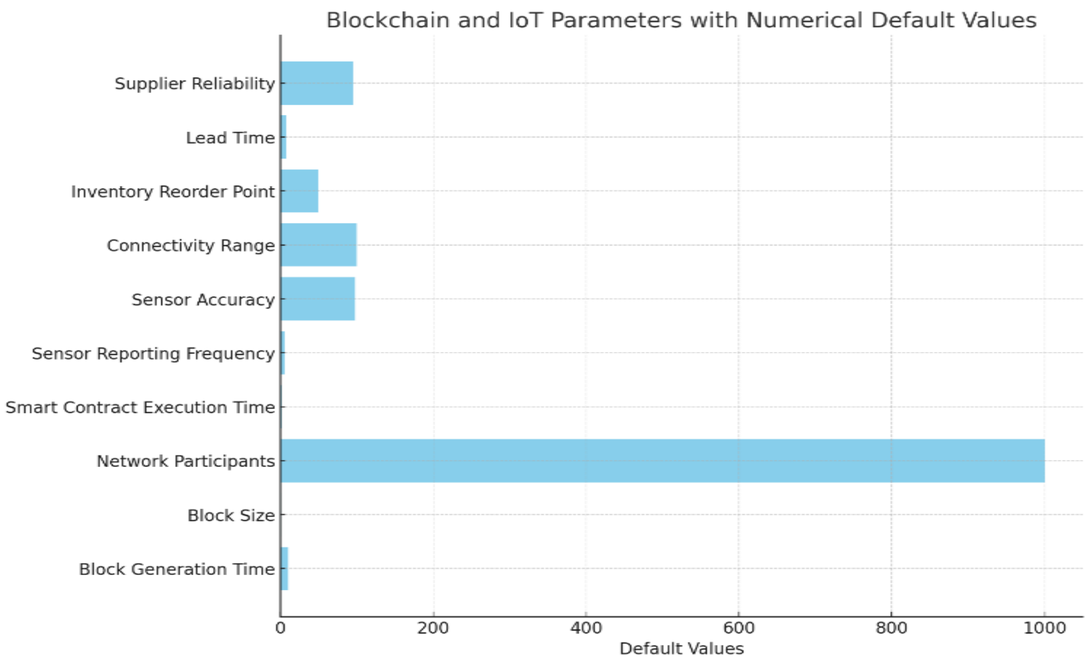

Figure 4. Blockchain and IoT parameters with numerical default values

Table 4. Simulation Results

Metric	Result
Transaction Success Rate	99.5%
Average Confirmation Time	5 seconds
Peak Network Load	75 Nodes
Maximum TPS Reached	92 TPS
Data Integrity Errors	0.02%
Average Latency	8 ms
IoT-Blockchain Interactions	500,000
Network Failures	2

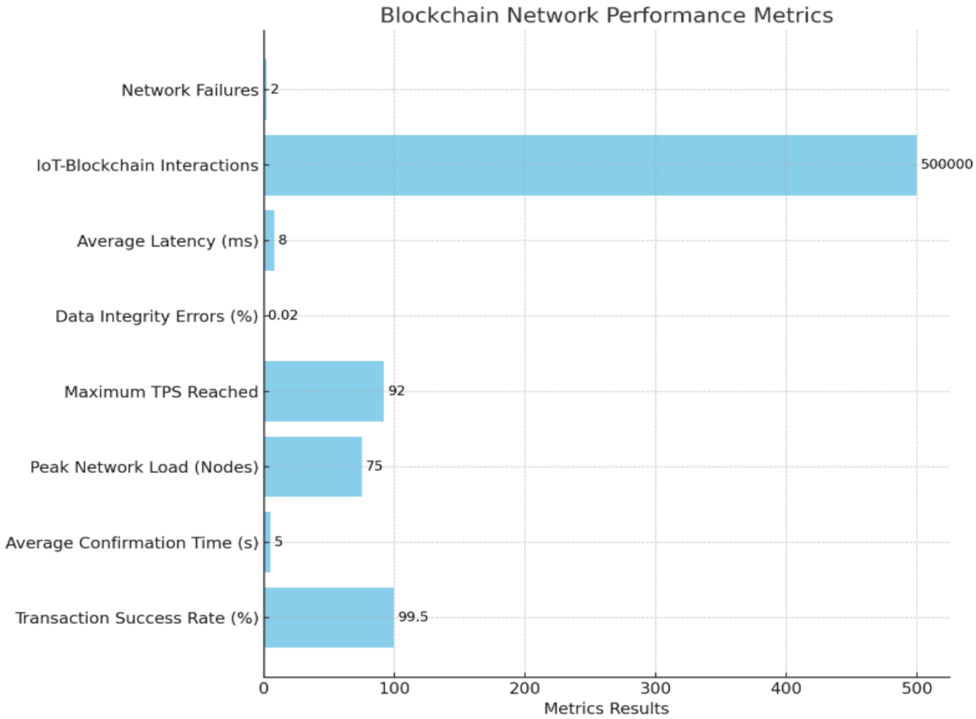

Figure 5. Results analysis

CONCLUSION

The future of supply chain management is bright with the integration of Blockchain and IoT. By combining the Internet of Things' (IoT) ability to gather and transmit data in real time with Blockchain's immutable, transparent ledger system, we can rethink the whole nature of trust, efficiency, and visibility in supply chain processes. This state-of-the-art technology eliminates issues like counterfeiting, human error, and a lack of transparency by recording every purchase and product transfer. As a bonus, this unified system's automated features reduce the need for human intervention, hence reducing costs and accelerating processes. There is a lot of potential here, but it will not be realized without a solid foundation, buy-in from all the right people, and consistent work toward standardization and security. Since businesses are starting to understand the potential benefits of this paired technology, it is essential that continued efforts be made to fund research, development, and education in this field. The global trade and logistics industry is on the cusp of a revolutionary change brought on by an interconnected Blockchain and Internet of Things (IoT) powered supply chain.

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