

SmartDSC: Innovative Architecture for Digital Supply Chain

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Abstract -- The purpose of block-chain technology is to synchronize data and transactions throughout a network of supply chains. This study shows how supply chain operations using block-chain technology can become more adaptable and nimble. Block-chain and other newly developed technologies can be used to address supply chain uncertainty as well as other problems impacting the industry. A system for categorizing supply chain problems is developed by combining block-chain technology, machine learning, and Internet of Things (IoT). Collaboration shows how different block-chain and supply chain-related technologies are used to complete tasks. Digital supply chains (DSC) with intelligence and efficiency are changing standards in a number of industries. Implementation of technical innovation makes it easier to create economically viable and globally conscientious supply networks. The study paper talks about how hard it is to set up a digital supply chain. This will lay the foundation for next studies on supply chain technologies.

Keywords: Smart digital supply chain operations, Smart contracts, Smart chain, Block-chain technology, Machine learning, Internet of things

I. INTRODUCTION

ALL the steps from sourcing materials to delivering the final product are part of a supply chain. The supply chain architecture and foundation can be quite complex. In order to enhance profitability and efficiency in business, it is crucial for all sectors to bolster their supply chains. It can be difficult to maintain efficiency, clarity, and trust between stake holders at every point of the supply chain. The supply chain's flexibility and agility may be improved via block-chain technology. Block-chain enables communication, trade, and data verification amongst all ecosystem members.

In the context of centralized brokers overseen by a sole trusted entity, block-chain can be seen as a means of storing financial transactions that exclusively allows for the addition of new information. This article examines the challenges commonly encountered in traditional supply chains and classifies them according to a feasible technological solution. Utilizing current technologies such as block-chain, the Internet of Things (IOT), and Machine Learning (ML) offers numerous advantages

for problem-solving. The research utilizes the block-chain technology framework and how communication between block chain and other emerging technologies is done to identify difficulties in supply chain management and propose practical solutions. The research considers the entire supply chain, encompassing the sourcing of raw materials, the product's life cycle and ultimately the client.

The study aims to achieve the following objectives:

1. Identifying common supply chain challenges.
2. Classification of problems and selection of appropriate technologies.
3. Analyze the potential of integrating block-chain with other technologies to enhance the efficiency and flexibility of supply chain operations.
4. The development of a unified framework that combines block-chain and other contemporary technologies to enhance transparency throughout the entire process.

This paper showcases a process flowchart to encapsulate the blending of block-chain technology with IoT and ML. It presents a debate and conclusion after illustrating the challenges encountered by different participants in the supply chain. Next, the solutions are implemented, utilizing block-chain technology and integrating contemporary technologies.

II. LITERATURE REVIEW

Walmart Canada [1, 4, 5, 8] implemented use of block-chain technology in partnership with logistics providers to facilitate inventory transfers. Logistics companies may efficiently coordinate and track shipments, logistical information, and financial transactions by leveraging a shared node on a block-chain server, without requiring any changes to their operations or IT infrastructure.

According to the Food Waste Index Report [2, 8] 2021 published by the UN Environment Programme, the retail sector is accountable for 13% of food-waste worldwide. Walmart uses block-chain technology to track and account the temperature within the transportation unit during the food shipment process,

in order to address these issues. This enables the swift tracking of food provenance within minutes, as opposed to the days required by conventional paper-based approaches.

Maersk and IBM [3,5] are employing block-chain technology to digitalize trade processes and techniques, create an unchangeable worldwide network, and oversee shipments and deliveries from start to finish, encompassing costly point-to-point connections. Block-chains offer enterprises a current digital record of all transactions and movements involving each member in their supply chain network.

IBM and Samsung [4,7] are making progress in applying block-chain technology for energy management by connecting IoT devices that consume electricity. If all participants in the supply chain successfully adopt block-chain technology, it may considerably improve both the safety and the transparency of the supply chain, resulting in substantial profitability and stability.

In late January 2020 [6, 8], Ford Motor Company announced its intention to utilize block-chain technology for the purpose of monitoring and tracing the supply of cobalt. Cobalt is considered an essential element in the composition of electric car batteries. Ford and IBM want to monitor the origins of raw minerals, such as cobalt. The automotive company intends to utilize block-chain technology to authenticate the receipt of authentic products, thereby ensuring the preservation of their quality. The ledger is continuously updated upon cobalt extraction, enabling the company to track its subsequent advancements.

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block-chain technology for energy management by connecting IoT devices that consume electricity.

De Beers, the leading diamond producer in terms of the value of its jewellery, is employing block-chain technology to monitor the journey of every natural diamond from the mine to the point-of-sale. The Tracr block-chain technology enables the authentication of diamonds, ensuring that they do not originate from conflict zones where they could potentially be used to fund violent actions.

Bruce Cleaver, the CEO of De Beers, affirmed that the block-chain powered network Tracr possesses the capacity to meticulously monitor a diamond's journey across the supply chain, guaranteeing the asset's traceability in a manner that was before unattainable.

III. METHODOLOGY USED

Supply chain operations involve the implementation of all procedures and the integration of all systems. In order to enhance their financial and operational performance, it is imperative for all firms to enhance their supply chain operations. The participation of numerous entities in the supply chain results in operational challenges while reducing direct communication among various actors.

Figure 1 illustrates the sequential stages required for the execution of block-chain technology throughout the whole supply chain. A block-chain server consists of four layers: a ledger, a smart contract, a transaction, and a data input. These layers work together to gather, process, validate, and store data. Each participant or stakeholder in the supply chain functions as a node that is linked to a server.

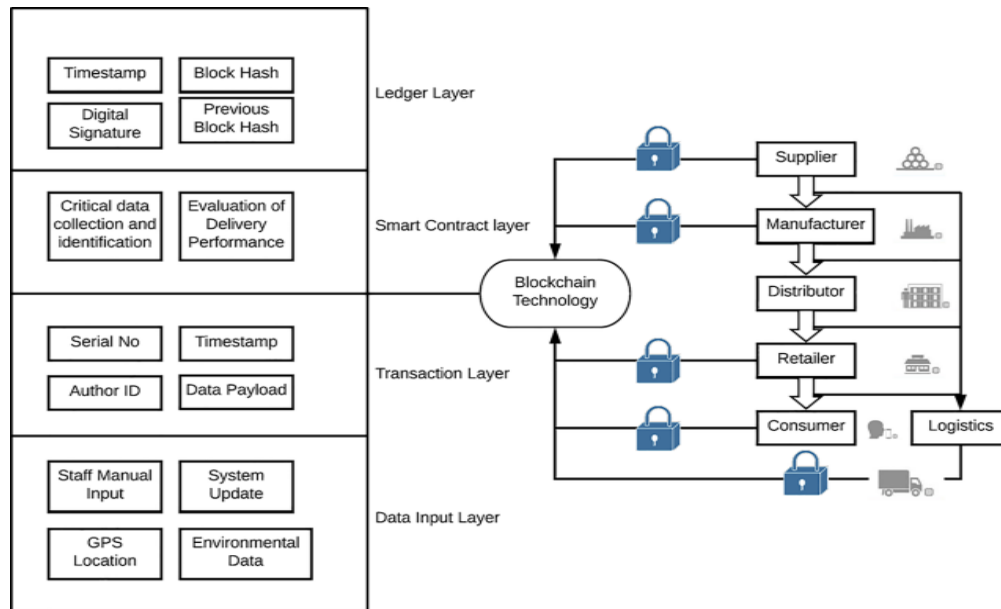


Figure 1. Deployment pathway of block-chain technology across the supply chain.

Smart Contracts and Blockchain: Smart contracts, which are immutable software applications, are stored on a block-chain server. Distributed, immutable, self-executing, and designed in the Solidity programming language, they possess the capability to execute themselves. They possess the capability to independently administer and execute payments, authenticate, and generate function libraries. By automating the process of contract creation and processing and reducing the financial and temporal inefficiencies that arise from the manual integration of delivery platforms and payment systems into digital contracts, block-chain technology possesses the capacity to revolutionize numerous industries and businesses. On the ledger, each component of the product is registered via smart contracts. The supply chain is an intricate process that encompasses a multitude of participants. Trademarked product, stakeholder and contractual agreements for investments, employment and land contracts, ownership and registry of all products / assets, peer-to-peer transactions, and copyrighted material are all protected by smart contracts. Moreover, they have the capacity to assist organizations in reducing the risk of money laundering and fraudulent activities, in addition to tax deductions and legal repercussions linked to overdue payments. The supply chain applications of blockchain technology and smart contracts

include safeguarding of copyrighted information, the storage of employee and land contracts, stakeholder and financial contributors, ownership and registry of all assets / products, and peer-to-peer transactions.

Exploring Technologies for Integration with Block-chain: By leveraging block-chain technology alongside IOT and AI, supply chain operations can be significantly improved in terms of adaptability and efficiency. Many companies fail to integrate technology, resulting in separate systems used across different industries. Here, we delve into the intricate details of information flow and the seamless integration of IOT and ML with the block-chain network. Investigating the convergence of block-chain and IoT involves the retrieval of data from a server and its storage online, enabling convenient access for administrators, regardless of their location or the time. The smart digital supply chain (SmartDSC) showcases smooth integration of blockchain and IOT. Managing sensors and actuators, Internet gateways, edge IT analytics, and data centre administration play a vital role in the implementation of IoT in the supply chain. Asset tracking plays a vital role in integration of block-chain and IoT within supply chain.

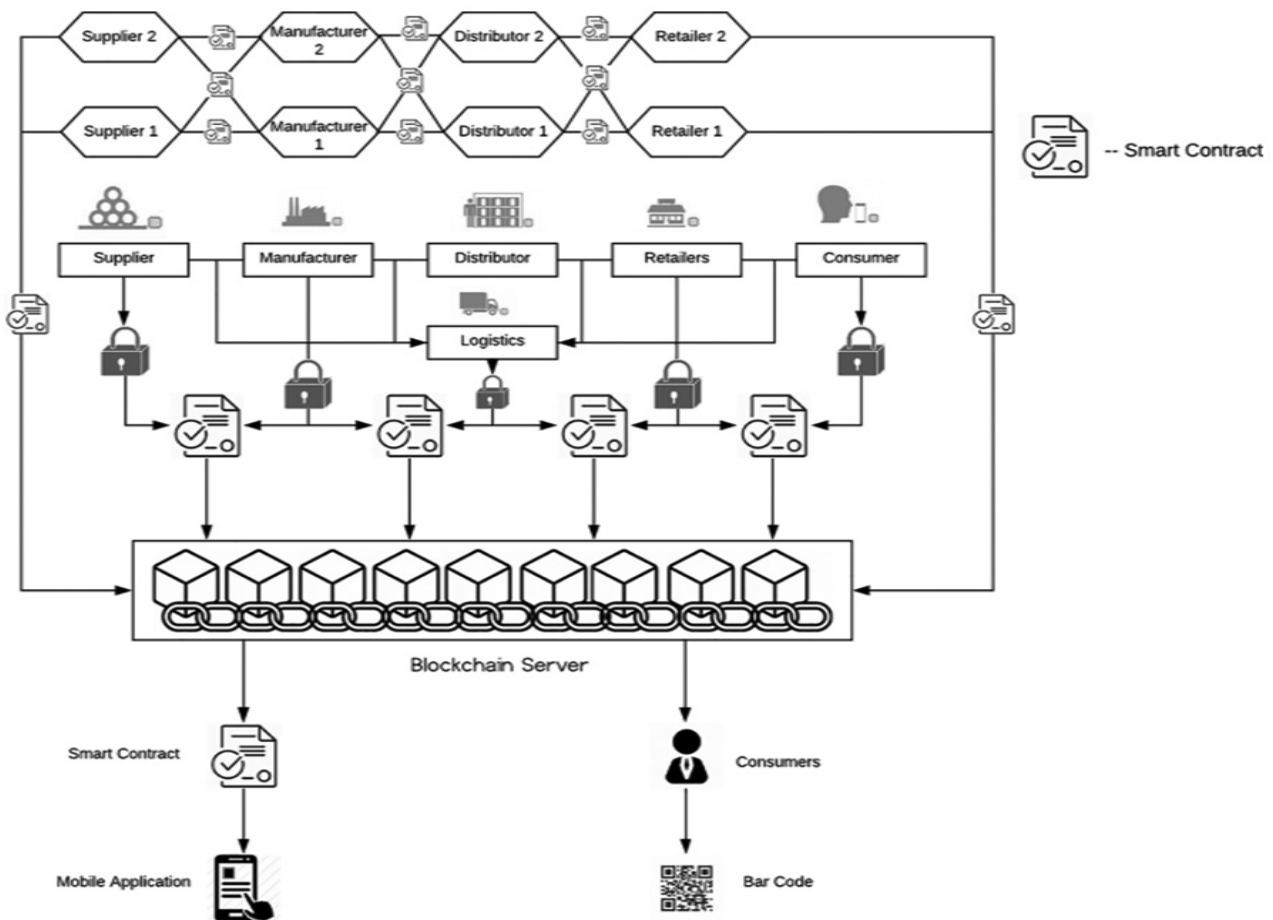


Figure 2. Smart contract implementation in DSC.

It enables all participants in the chain to conveniently access this information via a decentralized block-chain server. Integrating block-chain with IoT offers distributors the valuable capability of efficiently tracking each item in their expansive warehouse through the use of RFID tags. Integrating block-chain and IOT into the supply chain effectively addresses concerns related to trust and data sources that are spread out. In addition, it helps to decrease the number of employees required for traditional supply chain management, leading to cost savings. Data is

constantly being uploaded onto the block-chain server and meticulously tracked using RFID and barcodes on various commodities and items. To efficiently identify product damage and seamlessly upload the relevant information to the block-chain server, the utilization of sensors and machine learning techniques can prove to be highly effective. These connections help in the creation of a fresh supply chain and the enhancement of existing conventional supply chain operations.

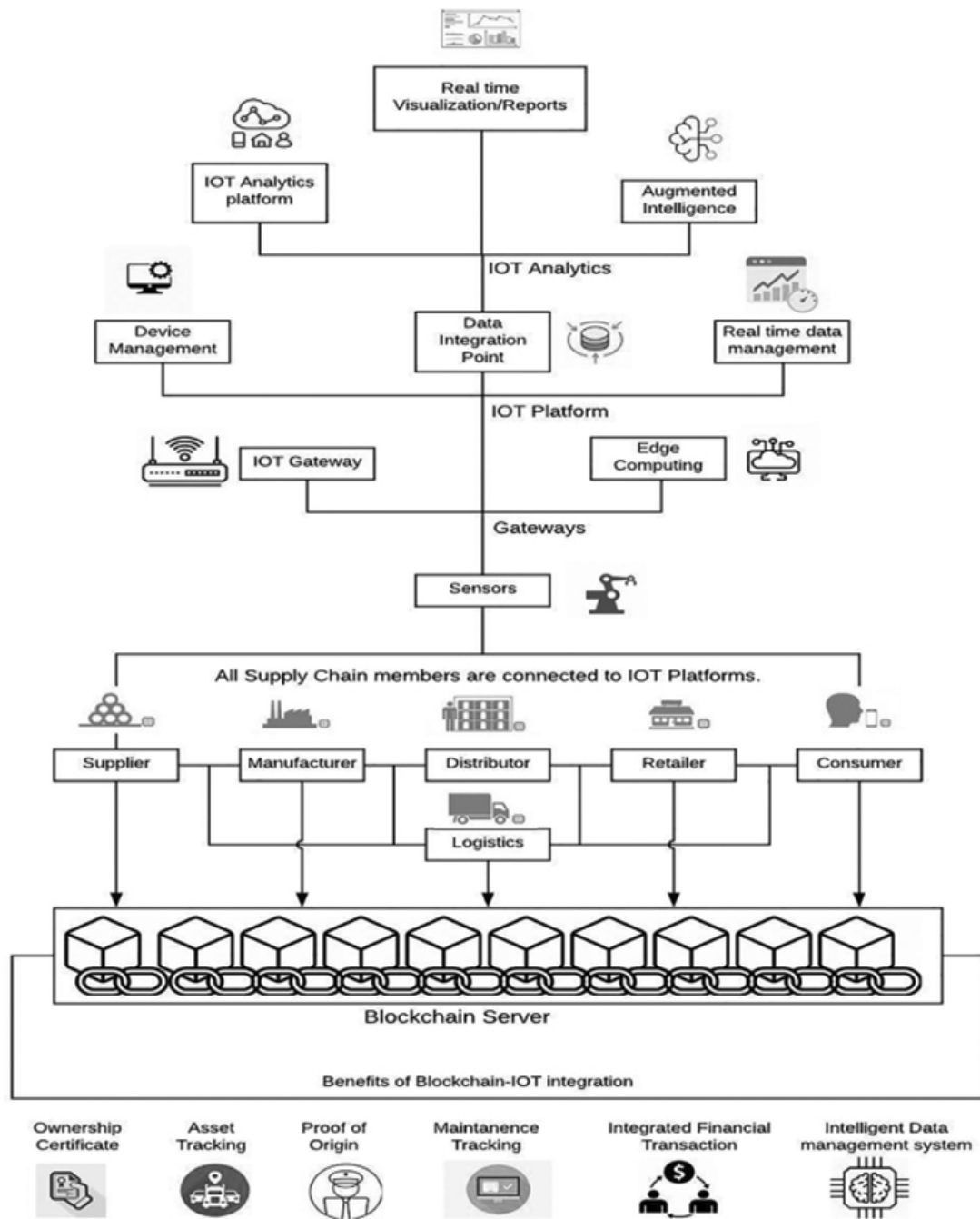


Figure 3. Blockchain-IOT integration in DSC.

With their ability to process real-time data, optimize operations, and ensure secure storage of information, the integration of block-chain and IoT has the potential to completely transform manufacturing supply chains. It can be helpful in managing inventory, ensuring quality control, handling raw materials, maintaining machinery, and organizing and monitoring production, among other tasks. Real-time information is uploaded on the block-chain server to assist businesses in planning and strategizing their operations.

Exploring the fascinating world of block-chain and AI Computers and other devices are imbued with intelligence through the utilization of AI. Utilizing it can enhance the security of data storage, optimize data utilization, and facilitate informed decision-making within the supply chain. IBM has entered the realm of block-chain-based AI management with its supply chain management suite. Intelligent Decentralised Autonomous Agents (DAOs) are enabled by the fusion of block-chain and AI technology, which also enhances data security. Through the automation of the entire process, the integration of AI into block-chain-based business transactions has the potential to enhance the efficiency of the supply chain. Examining supply chain records, AI-enabled NLP analyzes data to identify patterns and enhance SCM. Integrating block-chain with AI enables the identification of data trends, predictive analysis, inventory management data, and demand forecasts. Utilizing components and parts in personalized goods can effectively reduce supply chain delays. Artificial intelligence assists in the management of operations and the monitoring of costs and financial performance. By leveraging AI algorithms and integrating block-chain technology, the supply chain can experience significant advantages such as process automation and the discovery of untapped revenue opportunities.

The suppliers, producers, transportation providers, and distributors can utilize predictive modeling to optimize supply chain processes and improve collaboration with IOT devices. AI algorithms and block-chain integration are increasingly being utilized by the banking industry to securely store data and make informed decisions. Using AI-driven smart contracts can enhance the efficiency and reduce the maintenance uncertainty associated with conventional smart contracts.

IV. OUTCOMES

Embracing the latest technologies can greatly enhance the efficiency of operations, personnel, and organizations. An interesting example is the integration of block-chain with IOT and AI. Additionally, there are various obligations and regulations that the organization and its supply chain actors must adhere to. Here are some criteria that supply chain participants in their organization must follow: Every company has its unique operational strategy, along with its own way of monitoring operations and fulfilling responsibilities. Companies should thoroughly evaluate their business practices

before creating an implementation plan in order to maximize the benefits of technology in their supply chain operations. Creating a well-designed technology usage flow is essential in order to include and benefit all stakeholders involved in the supply chain, both internal and external.

Prior to implementing any technology in the company, it is crucial to develop a robust financial plan and ensure accurate unit economics. This is particularly important when introducing new, modern technology into a traditional supply chain, as it can be a costly endeavor. A company should prioritize long-term focus when considering technical investments and returns. These technologies are quite advanced and can be difficult for older workers to learn. However, they greatly enhance the flexibility and efficiency of supply chain operations. It is essential for businesses to organize training sessions and seminars for all staff members, laborers, managers, and other stakeholders involved in the operations. This will ensure the effective and seamless implementation of technology.

When it comes to implementing new technology, organizations and supply chain participants need to carefully analyze all legal documents and ensure compliance with legal requirements. Smart contracts, block-chain servers, and IOT legislation may all hold significant value due to the fundamental role of data in these technologies.

V. CONCLUSION AND FUTURE SCOPE

This article delves into the latest findings and uses of block-chain technology in improving the flexibility and effectiveness of supply chain operations. Exploring the potential of block-chain technology and its integration with other modern technologies to address the challenges faced by industries in the traditional supply chain. This chart provides a thorough analysis of different problems and their solutions when combined with block-chain technology. This analysis is based on thorough research, including literature reviews and surveys with industry experts. In the future, block-chain technology has the potential to revolutionize supply chain management.

The research tackles some of the concerns by creating a supply chain architecture that combines blockchain technology with the supply chain. Just like a data scientist, delving into the possibilities of blockchain technology and its incorporation with smart contracts, IOT, and AI can open up fresh avenues for generating revenue and improving the financial and operational aspects of the business model. This design can be a valuable resource for businesses seeking to shift their supply chain from traditional to digital using blockchain technology. The design showcases the utilization of blockchain technology and its seamless integration with cutting-edge advancements like IOT, AI, and smart contracts for all supply chain operations. By implementing these technologies, services are enhanced, instilling trust in stakeholders, legal entities and financial institutions.

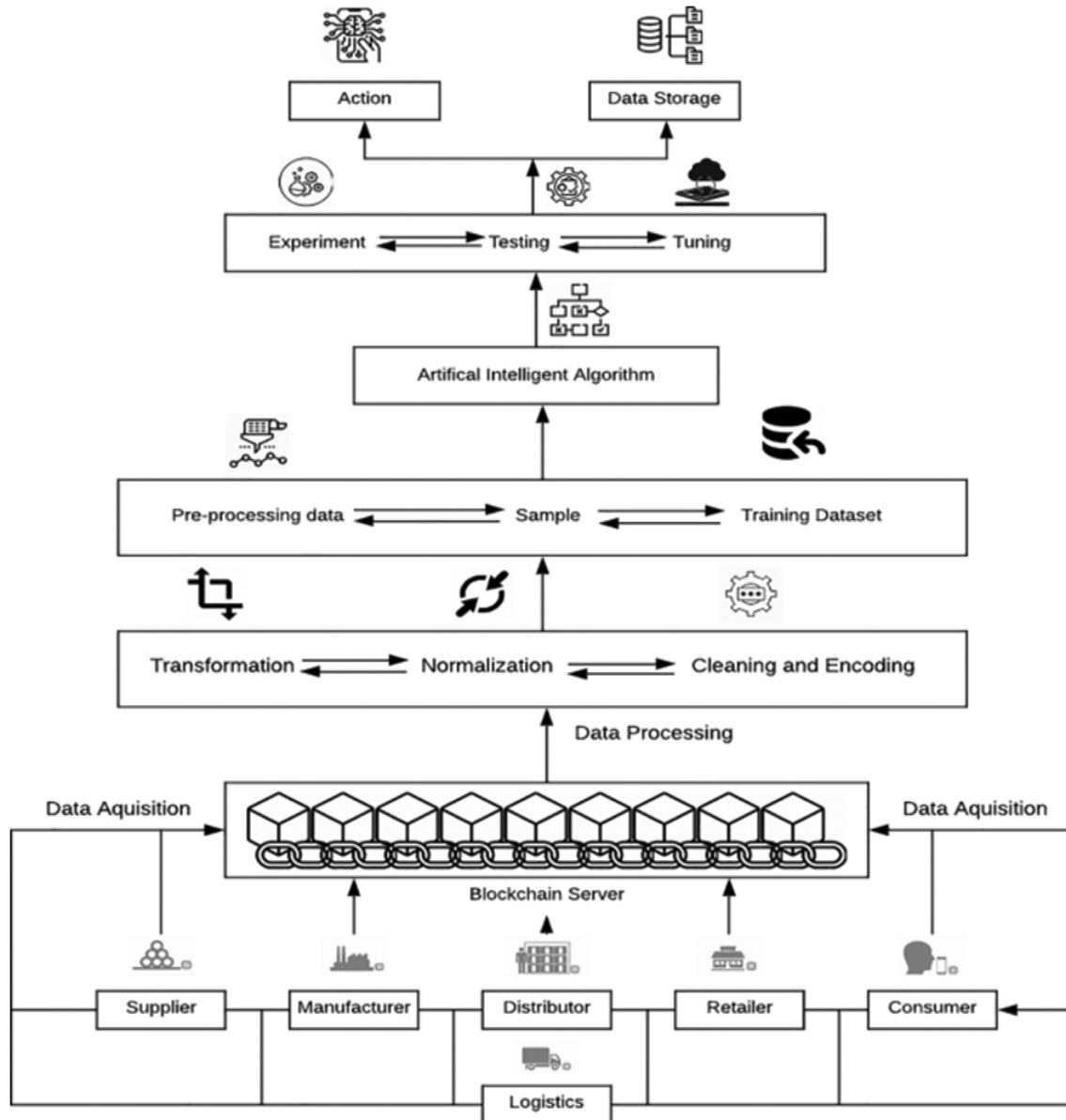


Figure 4. AI agents-IOT device integration in DSC.

Supply chain operations face numerous challenges, despite the use of advanced technologies. Supply chain operations encounter various challenges related to timing, reliability, visibility, and trust among all parties involved. While block chain technology and its integration with AI and IoT are innovative and have the potential to remove obstacles, certain companies may not be prepared to openly disclose information on a platform accessible to all stakeholders. Government legislation around the world results in different international procurement criteria for supply chain partners from different nations. For optimal integration of these technologies into the supply chain network, it is essential to establish standard operating procedures (SOPs) for all supply chain activities, processes and operations. Smaller companies and firms with

lower wealth may encounter challenges in adopting this technology because of limited technical expertise and resources. Ensuring that the company's objectives, assets and personnel are aligned with the transformation of the digital supply chain is of utmost importance.

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