

Integrating Blockchain and Digital Twin for Smart Warehouse Supply Chain Management

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스마트 웨어하우스 공급망 관리를 위한 블록체인과 Digital Twin의 통합

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Abstract

This paper presents the integration of Digital twin and Blockchain-based Supply Chain Management (DB-SCM) in a smart warehouse to create a more efficient, secure, and transparent facility. The process involves creating a digital twin of the warehouse using sensors and IoT devices and then integrating it with a blockchain-based supply chain management system to connect all stakeholders. All data are collected and tracked in real-time as goods move through the warehouse, and smart contracts are automatically executed to ensure accountability for all parties involved. The study also highlights the critical role of effective supply chain management in modern business operations and the significance of smart warehouses, which leverage advanced technologies such as robotics, AI, and data analytics to optimize warehouse operations. Later, we discuss the importance of digital twins, which allow for creating a virtual representation of a physical object or system, and their potential to revolutionize a wide range of industries. Therefore, DB-SCM offers numerous benefits, including enhanced efficiency, improved customer satisfaction, and increased sustainability, and provides a valuable case study for organizations seeking to optimize their supply chain operations.

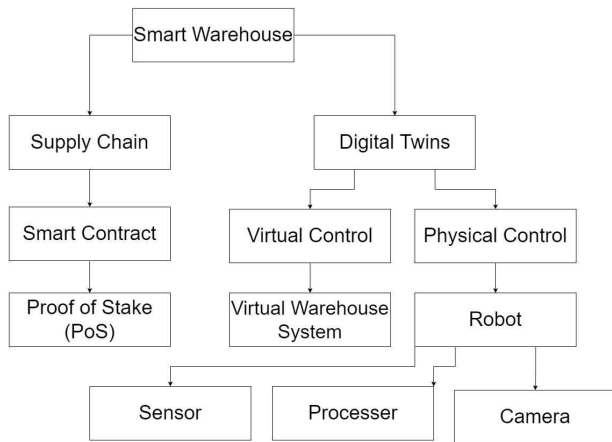
1. Introduction

In the current fast changing and complicated business environment, the optimization of supply chain operations via the integration of current technologies such as artificial intelligence, and the Internet of Things (IoT) has become important. Efficient supply chain management is a vital feature of current corporate operations that involves technical skills and a strategic strategy to assure competitiveness and sustainability. One strategy to improve warehouse operations is the implementation of a smart warehouse that leverages modern technology like as robotics, AI, and data analytics. The combination of digital

twin and blockchain supply chain management in a smart warehouse may give various advantages, including greater efficiency, higher customer satisfaction, and increased sustainability. This article suggests the combination of digital twins and blockchain supply chain management in a smart warehouse to produce a more efficient, safe, and transparent facility. The research will explore the need of excellent supply chain management, the relevance of smart warehouses, and the potential of digital twins to disrupt a broad variety of sectors. The proposed effort intends to offer a meaningful case study for organizations wishing to strengthen the supply chain operations.

2. Literature Review

In this section, will be review about various technologies that will be used in the research paper.



(Figure 1) Overview of a Smart Warehouse Combine Technology.

2.1. Smart Warehouse

Smart warehouses are highly automated, technology-driven facilities that leverage modern technologies to maximize their operations. They involve the integration of robotics, artificial intelligence, the Internet of Things, and data analytics which enable real-time tracking and monitoring of products, employees, and equipment. Sensors and devices capture information on numerous elements such as the location, temperature, humidity, and the condition of items, which is then evaluated using machine learning and other sophisticated approaches. Smart warehouses may also interface with other supply chain technologies, such as blockchain and digital twins, to enable real-time visibility and transparency. Smart warehouses demand significant technological competence and a strategic strategy to improve warehouse operations and boost customer satisfaction. Inspired by [1].

2.2. Supply Chain

Blockchain technology, on the other hand, has attracted substantial interest in the previous decade owing to its potential disruption in the

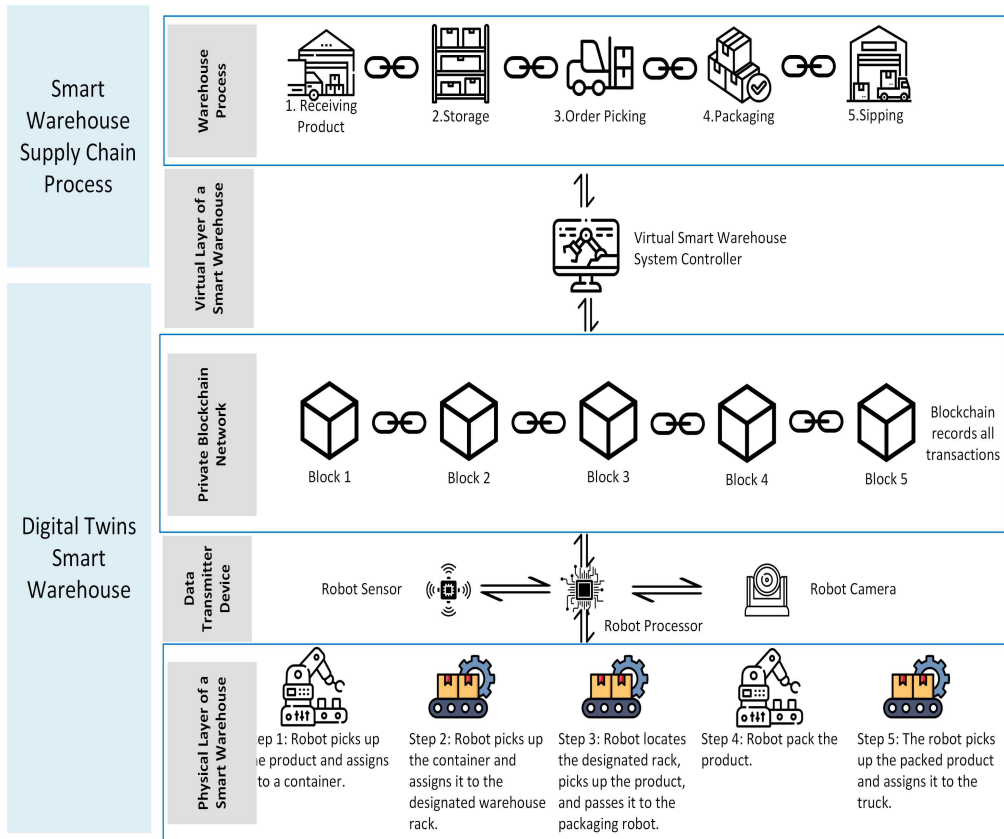
supply chain area. At its foundation, a blockchain is a decentralized digital ledger that provides for safe and transparent record-keeping. In a supply chain context, every player may have access to the same information regarding a product's passage from raw materials to the end customer. By recording every transaction on the blockchain, it becomes nearly hard to change the data, producing a permanent and tamper-proof record of every step in the supply chain. Smart contracts, self-executing contracts with the conditions of the agreement between buyer and seller explicitly written in lines of code, may be leveraged to automate certain aspects of the supply chain, such as payment processing and inventory management [2]. This may lead to greater efficiency and cost savings for all parties participating in the supply chain and better transparency and traceability for consumers.

2.3. Digital Twin

Digital twins is a type of technology that allows for the construction of a virtual version of a real item or system. It happens by gathered data from sensors, Internet of Things (IoT) devices, and other types of data-gathering approaches, which is then incorporated into a complex digital model. This model may be used to replicate the performance of the actual thing in real-time, allowing engineers and operators to monitor and adjust its behavior. Digital twins are extensively utilized in domains such as aerospace, manufacturing, and healthcare and are predicted to become more prevalent in many other industries in the future years. They may help firms cut costs, enhance safety, and boost efficiency by giving real-time insights into complex systems and processes. Inspired by [3].

3. Proposed Model

The process of integrating Digital twins and Blockchain Supply Chain Management (DB-SCM) in a smart warehouse involves a series of stages. Firstly, a digital twin is established using data



(Figure 2) Overview of DB-SCM in Smart Warehouse System

from sensors, IoT devices, and other sources to simulate and optimize warehouse operations. Subsequently, the digital twin is interconnected with a blockchain-based supply chain management system to link all stakeholders in the supply chain. As goods traverse through the warehouse, data is collected and monitored using sensors and IoT devices. Smart contracts are then automatically executed to ensure accountability for all participants in the supply chain. It enhances transparency and security while reducing the likelihood of fraudulent activities. Lastly, continuous improvement is achievable through the data collected, which can help optimize inventory management, minimize wastage, enhance customer satisfaction, and improve sustainability. Consequently, combining digital twin and blockchain supply chain management can transform a warehouse into a smarter, more efficient, and transparent facility [4].

Figure 2 presents our proposed model to form an upgrade of an innovative warehouse framework with blockchain and digital twins technology. First, the information (i.e., recorded transaction) will be sent to the Virtual Smart Warehouse Management System (VS-WMS) while each step has been done. After retrieving the information from the warehouse process, the VS-WMS will begin processing information from each step of the warehouse record process. DB-SCM utilizes advanced technology to analyze and make sense of the data as well as provide valuable insights into the performance of the warehouse. It involves visualizing the warehouse performance within a virtual environment. Thus, DB-SCM allows for a comprehensive operation overview, highlighting areas that require optimization or improvement.

On the other hand, VS-WMS will verify data through a consensus mechanism, i.e., Proof of

Sake(PoS), before it is stored in the blockchain network. Unlike Proof of Work (PoW), which requires nodes to solve complex mathematical problems to validate transactions, PoS selects a validator to add new blocks to the chain. Here, we consider the VS-WMS controller as a validator in DB-SCM. Once the performance data has been processed and stored on the blockchain network, the robot processor retrieves the necessary command information from the data stored on the blockchain. The robot executes the required tasks within the virtual environment using this information, replicating the same steps previously performed within the smart warehouse.

Upon completing the assigned tasks, the robot saves the data to the blockchain network using the same smart contract techniques, similar to a virtual process. This allows for a complete and detailed record of each task performed within the warehouse, creating an invaluable resource for future analysis and optimization. Integrating blockchain technology, visual intelligence, and robotics within the warehouse provides an innovative and efficient solution for managing complex operations.

4. Conclusion

We proposed the concept of DB-SCM in a smart warehouse operations environment. It leverages advanced technologies such as IoT, AI, data analytics, and blockchain to create a secure and transparent facility. DB-SCM offers a valuable case study for organizations seeking to optimize their supply chain operations and stay competitive. The potential for further optimization and innovation in supply chain management using digital twins and blockchain is vast and holds promise for the future of supply chain operations. Further research and experimentation in improving security with AI-based decision-making are required to provide valuable insights and best practices for real-world use cases.

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