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Dr. Yasmeen Sultana
Assistant Professor, Department of Management and Commerce, Maulana Azad National Urdu University, Hyderabad, Telangana, India

SM Rawoof
Associate Professor, Department of MCA, Anwarul Uloom College of Business Management, Hyderabad, Telangana, India

Correspondence Author:
Dr. Yasmeen Sultana
Assistant Professor, Department of Management and Commerce, Maulana Azad National Urdu University, Hyderabad, Telangana, India

Blockchain integration in supply chain logistics: Opportunities and Challenges

Yasmeen Sultana and SM Rawoof

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Abstract
The planning of several operations, including manufacturing, warehousing, transportation, distribution, and client sales, is known as supply chain management, or SCM. Each of these processes requires the design and development of distributed processing activities, transparent transaction handling, privacy protection, trust modeling, and safe product tracking. Supply chain management (SCM) systems need to be designed with high security and quality of service (QoS) in mind while storing and processing data. Blockchains can be readily matched to these operational features since they offer distributed mining activities, transparency, traceability and immutability. As a result, blockchain technology is rapidly becoming recognized as one of the best options for SCM modeling. Many blockchain based solutions have been presented by researchers over the years to model supply chain management (SCM), and each of these methods has different performance metrics. Researchers suggest a wide range of security models to accomplish these objectives and it has been found that blockchain based SCM implementations perform better than other models in terms of security and quality of service metrics.

Keyword: Blockchain technology, supplychain management, supply chain transparency, supply chain traceability, industry 4.0, trust

Introduction
The supply chain is crucial to adapting the business to the changing environment because it mostly relies on collaboration, integration, and adaptability. Various specialized applications are being utilized to improve supply chain flow control, and many entrepreneurs have expressed interest in supply chain apps. One of the most important new developments in supply chain technology is blockchain. Because of its quick adaptation to shifting market conditions and the business environment, it has drawn the attention of numerous business owners. Our effort aims to demonstrate the aspects and potential of blockchain technology that enhance supply chain resilience. The market has seen significant change in recent years becoming more dynamic and demanding, which has created a competitive atmosphere.

Literature Review
Research on block chain's potential to enhance supply chain performance is examined by Mahyuni *et al*. [18]. However, this article contrasts the advantages of blockchain technology with the drawbacks of supply chain management, focusing on how they complement each other to increase supply chain resilience rather than the potential. In addition to analyzing the economic effects of blockchain on the environment and populace, the authors [19] also looked at the cutting-edge supply chain trends and their crucial success criteria in light of the current advancements in modern technology. The supply chain interruptions that blockchain can resolve are being studied by Alkhudary *et al*. [1]. However, according to [10], supply chain management is the practice of managing the complete integrated flow of commodities from a raw material source to production warehousing and transportation to the users. Other definitions of supply chain management vary. In supply chain management, there are many different approaches, and it's critical to recognize their limitations [9]. A key component of the traceability level is transparency, according to [12]. Nevertheless, [13] has identified three categories of SC transparency. The SC transparency component must be analyzed and correlated with the opportunity and list viewpoint analysis in order to aid in determining the mystery gains or loses. Blockchain plays a key role in improving tracking and reporting, as well as improving logistics transparency.

Moreover, enhancing the delivery schedule can help the business [15]. There is a greater chance of mismatch conflicts and inconsistencies associated with the traditional supply chain due to the extensive distribution of supplies. Blockchain technology can be a key component in solving this problem, and merging blockchain technology with GPS-based vehicle tracking can be beneficial. Additionally, because blockchain technology incorporates truck location tracking to lower costs and boost efficiency, it's an excellent choice for logistics.

An further blockchain component that fosters confidence in the supply chain process is a smart contract. Financial transactions, insurance returns, and business transactions are just a few of the domains in which blockchain and smart contract applications can be used [16].

The numerous uses of blockchain and smart contracts have grown over time simply for this reason. In a supply chain with several levels of suppliers and subcontractors, the blockchain's smart contract capability is readily implemented [17]. Blockchain technology is essential to the industry of the 4.0 era because to its distributed secure technology, as illustrated in Figures 1, 2, and 3. Both industry and academics are taking notice of the technology [2]. Distributed ledger technology, or blockchain, provides participants with safe transaction and transfer settlement at a very low cost [3].

Blockchain

It is recognized as a series of encrypted data blocks that include the data itself, which is locked to allow access by the key holder [4]. Numerous files on the chain are connected to one another, and each file contains data, including historical details about the blockchain's blocks and a timestamp that indicates when the data was created [5]. The blockchain is the collective name for all of the blocks.

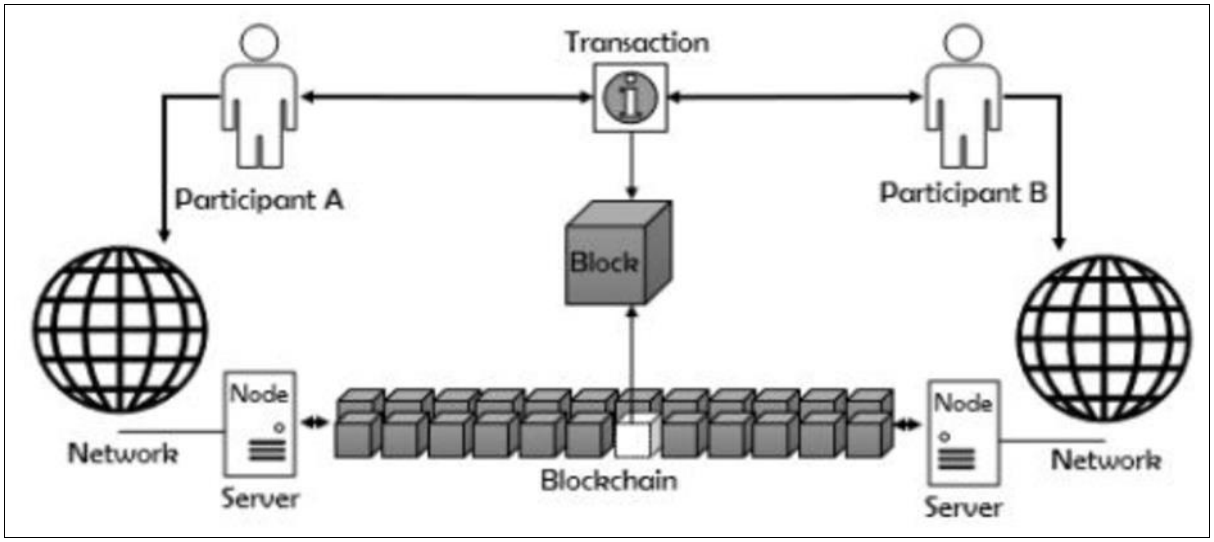

Fig 1: Blockchain Concept

Blockchain Infrastructure

Blockchain is only accessible through a computer, laptop, or server that is linked to the internet. All of the connected devices are called blockchain nodes. Supply chain blockchain research will address how nodes store the blockchain and grant access to particular users [6]. When the blockchain is maintained on nodes which are recognized as a system where data is stored and shared among many places, countries, or organizations a ledger is created [4]. Traditional databases are compared to the distributed ledger, which stores digital data in a single location. In blockchain, the nodes hold identical data.

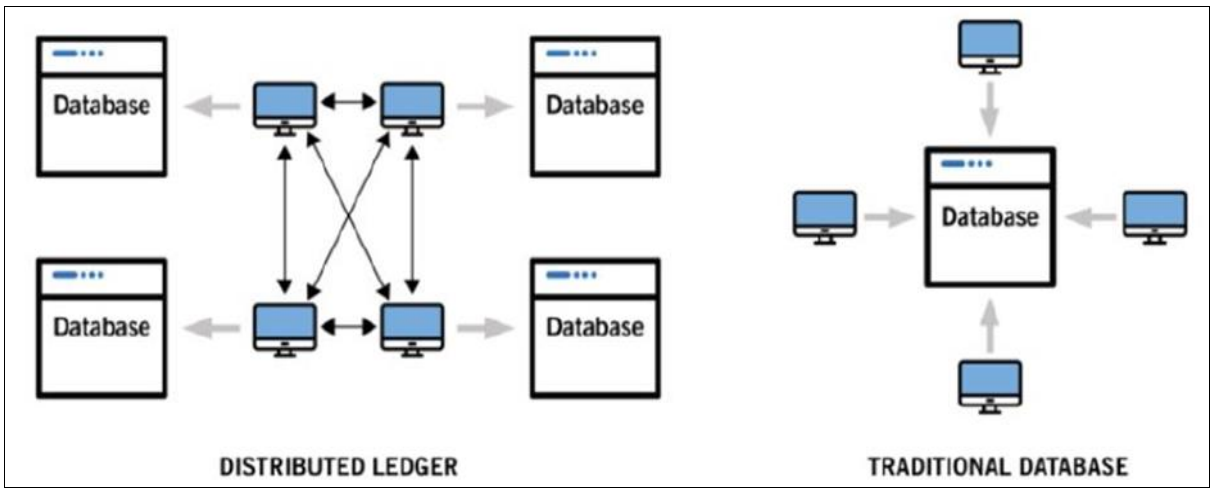

Fig 2: Blockchain Infrastructure

Blockchain based supply chain

A key component of the traceability level is transparency. Nevertheless, three forms of supply chain transparency have been developed. They include transparency, participatory transparency, and a variety of transparency solutions. The supply chain transparency element must therefore be analyzed and correlated with opportunity and list viewpoint analysis in order to adopt blockchain-based supply chains and aid in determining the mystery benefits or loses. Interdisciplinary research must be taken into account in order to develop theories and design for blockchain technology in order to comprehend it in the supply chain [14]. The businesses can also benefit from social sustainability and responsibility based on blockchain technology, which can increase visibility and ensure due diligence. Along with a lack of knowledge and awareness of the technology, there is a labour skill gap with blockchain technology that needs to be filled. Moreover blockchain technology for business must be managed properly due to the high expectations that could lead to its industry acceptance.

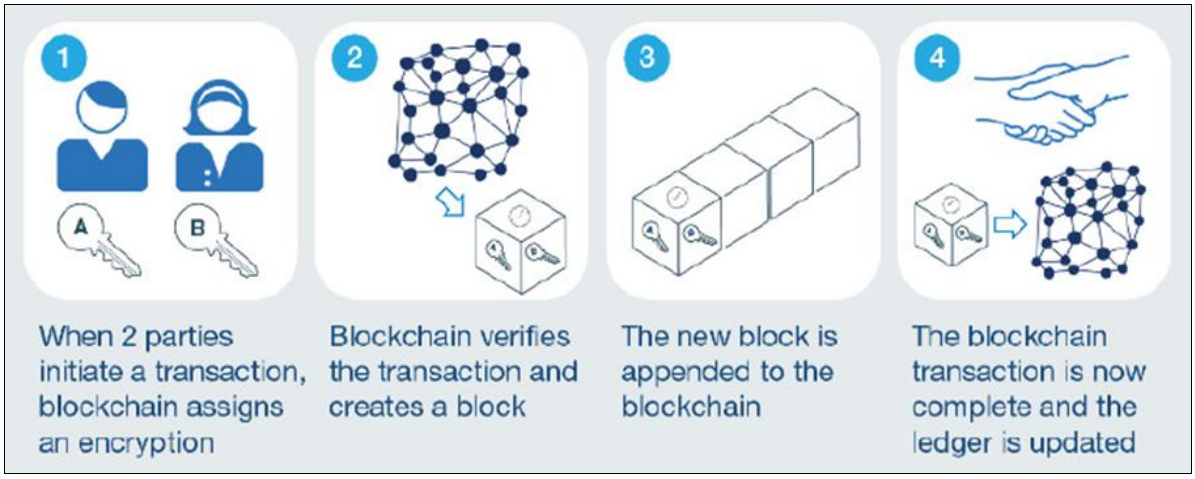

Fig 3: How the transaction works with Blockchain

Research Objective

The study's goal is to talk about blockchain technology and how supply chain and logistics management might benefit from it.

1. The main objective is to monitor high-level business requirements, such as capability requirements.
2. In order to provide innovative services, the second component is a technological exploration study that will take into account new information and communication technologies.

Blockchain Based SCM Model

Blockchain-based supply chain management modeling is a challenging process that requires a wide range of skills, including designing block structures, choosing consensus models, identifying hashing and mining rules, designing security constraints, archiving and retrieving models, designing parametric controls, and more. The distributed ledger gains a new block as raw materials are transformed into final products, according to the model. The blockchain network confirms the accuracy of this entry through its consensus models and miner nodes. A logistics and tracking record is uploaded to the blockchain whenever the goods are packaged and prepared for shipment. Each transaction will have a separate record after the products are delivered to the store and then sold to customers. The blockchain stores this record, which can be tracked in real time on the customer's device through link validation processes.

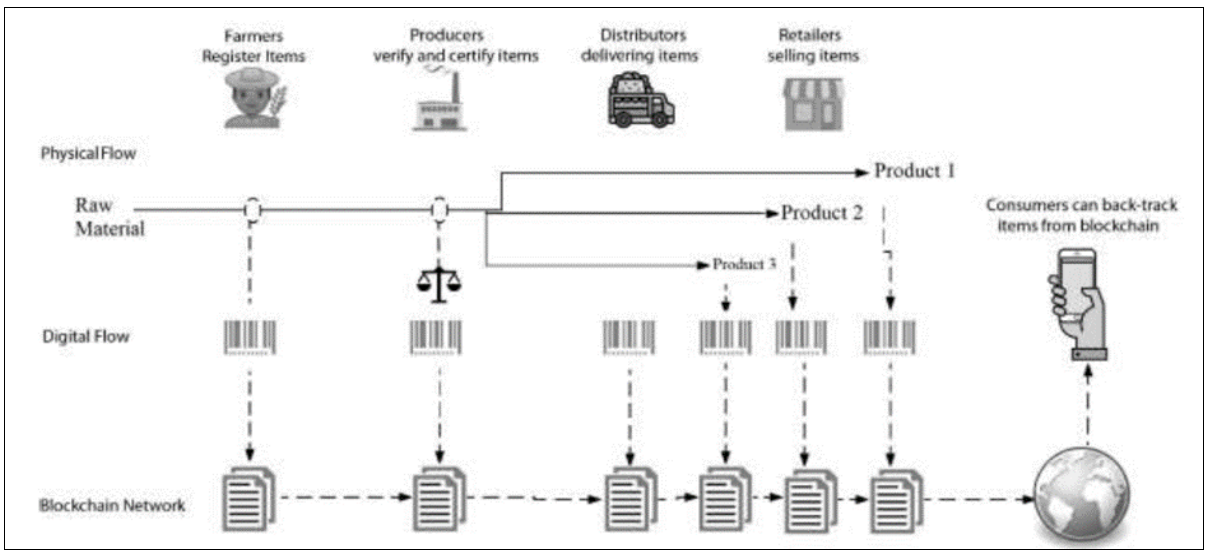

Fig 4: Typical blockchain based SCM model

Methodology

In order to access recent and relevant work, a comprehensive literature search was conducted to locate articles on supply chain management and blockchain technology. We used the following search term (abstract, title, or keywords) to look through the meta database Scopus: (blockchain) and (database) and ("supply chain management").

Only worldwide peer-reviewed conferences and journals were utilized in our search, which was based on the Scopus meta-database to guarantee that we only used scholarly information. We found that 22 of the 42 publications were pertinent to supply chain management using blockchain databases after manually reviewing them. A manual decision made by two reviewers with a 95.6% reliability rate served as the basis for the identification. The following exclusion criteria were used to weed out papers from the initial result set of 42 papers:

- **Exclusion Criteria 1:** Work that wasn't applicable to all supply chain domains, such as the supply chain for fish or agriculture, and was overly specialized.
- **Exclusion Criteria 2:** Work where supply chains and blockchain were either inconspicuously addressed or not the primary emphasis.
- **Exclusion Criteria 3:** Meta-analyses of blockchain and/or supply chains.

Blockchain Process

Enhancing the blockchain

A blockchain block cannot be produced unless a node sends out a transition request with the data to other nodes in the blockchain network [5]. The new block cannot be added to the chain until it has been approved for inclusion in the blockchain. The new block's correct structure and the absence of duplicate transactions at the time of validation are confirmed by the node mist [7]. The encrypted block is subsequently stored by the other nodes and added to the blockchain and blockchain network upon verification. The blockchain's distributed ledger architecture and encryption, which guards against hacking, make it extremely reliable [8].

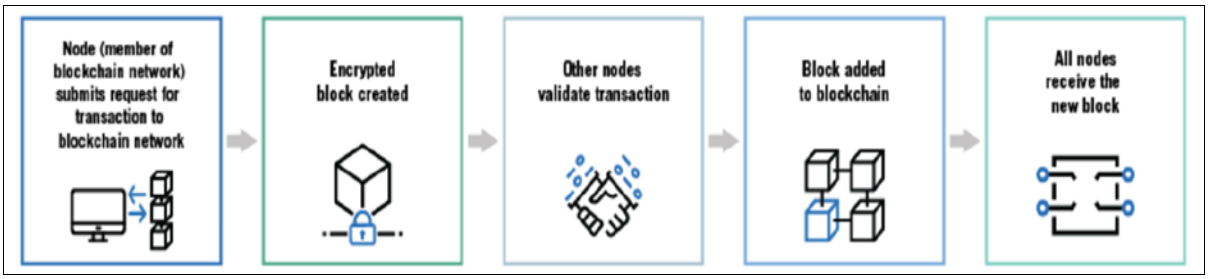

Fig 5: Blockchain Process

Conclusion

Blockchain technology has been recognized as having the ability to completely transform a number of industries; however, a number of problems must be resolved before it can reach its full potential. These concerns include technological, governmental, and governance challenges because Blockchain technology's ability to cut out middlemen could challenge current legal frameworks and make regulation difficult. In any case, blockchain technology can improve a number of industries, including government, healthcare, banking, and supply chain management, by introducing decentralization, security, efficiency, and transparency. But in order to fulfill its potential, issues like scalability, interoperability, and regulation must be resolved. Research has indicated that Blockchain technology holds promise for enhancing transparency, traceability, and safety in the food industry, nevertheless, its full potential will require the resolution of technological, economic, and regulatory challenges.

Future work & open challenges for applications

Blockchain is a new technology that has the potential to improve supply chain operations. Future studies could concentrate on figuring out how to better integrate blockchain technology in supply chains, as we have found a lot of unresolved issues. Blockchain technology has great promise for supply chains. Our investigation, however, made it evident that there are still challenges with system implementation. Finally, we discovered that blockchain technology has the ability to address some of the present supply chain issues, such as those pertaining to transaction security and transparency.

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