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Design and Implementation of Blockchain Based Approach for IoT Enabled RPA in Supply Chain Management

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Abstract: In recent times, various sectors of the corporate realm have undergone significant transformations due to the emergence of the Internet of Things (IoT) and the fourth industrial revolution. Efficiency is a shared duty for both individuals and businesses. Rogue operators pose a significant threat to the security and privacy of supply chains through various malicious activities such as falsification, privacy breaches, node impersonation, and fraudulent financial transactions. In order to establish a secure supply chain for any industry, numerous inventive techniques have been suggested, encompassing financial strategies and systems based on trust. On the other hand, trust mechanisms are fragile and susceptible to attacks such as Sybil and whitewashing. However, trusted centres play a crucial role in monetary systems, yet they are vulnerable to both attacks and the potential compromise of users' privacy for financial benefit. Blockchain technology provides a distinctive platform that enables distributed networks to carry out secure financial transactions without depending on trusted intermediaries. The goal is achieved by the integration of an immutable ledger, a digital form of currency, and the execution of intelligent contracts.

Keywords: *Blockchain, Technology, IOT, RPA, Supply, Chain, Management.*

1. Introduction

Since its establishment in 1990, businesses have utilised the World Wide Web to connect with one another and exchange information. The implementation of this innovative technology has enabled firms to enhance both their efficiency and their degree of competitiveness [1]. Blockchain, social media, machine learning, and robotic process automation are among the emerging technologies that are revolutionising company operations and facilitating the interchange of information [2]. All of these events are occurring concurrently.

The popularity of blockchain technology has increased because to its distinctive features, such as immutability, incorruptibility, and the ability to guarantee full transactional transparency [3]. The specific characteristics mentioned are the primary factors contributing to the widespread popularity of blockchain technology. It is widely acknowledged that blockchain technology has the capacity to profoundly transform the entire supply chain and logistics industry. The logistics and supply chain businesses are looking to enhance their operating framework by integrating blockchain technologies with data from Internet of Things devices, aiming for greater unity and efficiency[4][6]. The expression consists of the numbers 7 and 8 enclosed in brackets. The objective of these continuous attempts is to enhance the framework's strength and cohesiveness.

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2. Related Work

Nielsen et al., (2023): Published in IEEE Access, this study investigates the tangible advantages of robotic process automation (RPA) in the context of supply chain management. It focuses on how RPA may streamline processes, save expenses, and enhance efficiency in supply chain management.

Sai et al., (2022): This written work, showcased at the sixth International Conference on Computation System and Information Technology, examines the utilisation of chatbots, a type of robotic process automation (RPA), in the procurement stage of supply chains. The main focus is on improving the effectiveness of both communication and decision-making processes.

Waiyanet et al., (2022):This case study, presented at the seventh International Conference on Business and Industrial Research, analysed the impact of robotic process automation (RPA) on reducing the time spent by a firm on documenting its operations.

Özkan et al., (2023): This presentation, presented at the Innovations in Intelligent Systems and Applications Conference, highlights SAP's implementation of Robotic Process Automation (RPA) in the management of sales orders.

Reungyu et al, (2022): This study, presented at the 7th International Conference on Business and Industrial

Research, investigates the impact of robotic process automation (RPA) on employee attitudes and behaviours.

Sharma et al, (2021): This post aims to examine how an online travel business utilised robotic process automation (RPA) to handle its email communication. The research presentation took place at the Optimisation, Infocom Technologies, and the 9th International Conference on Reliability.

Blockchain Technology

The decentralised and distributed nature of blockchain technology's open ledger structure has generated interest among researchers [9]. The reason for this curiosity derives from the fact that blockchain technology has the capacity to be incorporated into many management systems. Intermediaries are rendered redundant in a blockchain network due to the fact that each node possesses its own duplicate of the ledger. Furthermore, the system functions as a peer-to-peer network, eliminating the need for intermediaries. Robust cryptographic techniques and hash algorithms are utilised to guarantee the security of the blockchain. These functions [10] handle the validation and connecting of blocks of transactions. Concealing the manipulation of every one transaction or block becomes extremely challenging, if not entirely unfeasible (Esposito et al., 2018).

2.1 Blockchain, Internet of Things and Big data

In recent years, numerous novel technologies have surfaced, and the supply chain and logistics industries have swiftly adopted these advancements. While certain entities have gained significant recognition and widespread use, others are only beginning to gain momentum [12]. The blockchain holds significant potential. Deloitte conducted a survey of 1,400 senior executives employed by global companies from various nations. According to the 2019 Global Blockchain Survey conducted by Deloitte, a significant majority of respondents (53%) indicated that blockchain technology has become a crucial focus for their organisations [13]. The current year's outcome exhibits a 10% improvement compared to the previous year's. Failure to adopt blockchain technology is perceived by 77% of individuals as detrimental to a company's competitive advantage.The utilisation of blockchains has had a consistent rise in the number of individuals involved [14]. The financial sector is evidently assuming a leading role, while other industries are adopting a more cautious approach in response. While individuals generally experience faster personal growth compared to others, there are occasional deviations from this pattern [18]. 3D printing has gained widespread adoption, despite initial scepticism from a few years ago.

2.2 Supply chain management and blockchains

The introduction of blockchain technology into supply chain management (SCM) has led to the disintermediation of transactions, thereby necessitating a reevaluation of existing relationship models. This technological advancement has the potential to bring about disruptive changes in various industries. Consider a scenario where a producer (A) and a supermarket (B) engage in a transaction facilitated by a smart contract (21). After both parties have successfully completed their responsibilities under the agreement, the contract can be formalised and saved in a blockchain framework [22]. Once all the mutually agreed conditions are fulfilled, the contract is activated, and the parties proceed to exchange the items and payments in accordance with the provisions of the contract, eliminating the intermediary [23]. Through this approach, the transaction is expedited, expenses are reduced, and trust is enhanced as each node in the network possesses a duplicate of the ledger.

There is a wide range of protocols and platforms currently accessible, each of which exhibits technological variations from the original Bitcoin blockchain. Ethereum's expansion marked the onset of the second phase of Blockchain 2.0, whilst the ongoing third phase is primarily concerned with achieving interoperability among different blockchains. Distributed ledger technology, commonly known as Blockchain, adheres to several principles regardless of how it is implemented: Every node in the peer-to-peer network verifies and stores the unchangeable transaction records [32].

Transactions can encompass a diverse range of data kinds, such as information[33], value, and other types. Through the consolidation of many transactions into a unified block, the network can determine the specific block that should be appended to the chain of blocks on the blockchain. This can occur under the existing consensus approach [34]. The ledger and all transactions are safeguarded through the utilisation of cryptographic methods [35]. Two of the mechanisms used are hash functions, which connect consecutive blocks, and private keys, which authenticate transactions. The network's design may change depending on the requirements of multiple stakeholders [36]. Blockchains can be categorised as either permissionless or permissioned, and they can also be classified as either public or private. The immutability and irreversibility of transactions, transparency, disintermediation, and the capacity to automate smart contracts are key attributes of blockchain that have positioned it as a potential disruptor in the corporate realm [39]. Smart contracts are computerised transaction protocols that execute predetermined contracts automatically upon meeting specific circumstances. The user's text is "[40]". Smart contracts are the term used to describe automated contracting solutions. As a result, these network entities have the capability to carry out business logic[41], and external data can be connected through oracles.

2.3 IoT for Logistics and Supply Chain Management

Logistics and supply chain management are essential components in the manufacturing industry. The fundamental stages in the supply chain encompass logistics, demand forecasting, procurement, and inventory control [42]. Logistics encompass a diverse array of operations, including the administration of transportation, control of inventories, and maintenance of warehouses. The Internet of Things provides significant advantages to the industrial sector. Firstly, let us analyse how the supply chain leverages the Internet of Things.

The Internet of Things (IoT) plays a significant role in the logistics process.

The implementation of IoT devices has brought about significant transformations in supply chain management. The Internet of Things has greatly facilitated the process of tracking the storage, location, and estimated arrival time of objects [47].

2.4 Track Location of Goods 24/7

Connecting storage containers that store raw materials and completed items to Internet of Things devices is possible. Additionally, it allows for uninterrupted GPS monitoring of the containers' locations.

2.5 Forecast Product Arrival

IoT devices aid in forecasting the movement of goods in the supply chain by considering factors such as shipment velocity, traffic patterns, and disruptions. This enables manufacturers, suppliers, and distribution facilities to schedule the receipt of goods, hence minimising delays caused by handling. It also facilitates the development of contingency plans to enhance the efficiency of the supply chain.

2.6 Monitor Stored Products and Raw Materials

Ensuring an appropriate storage environment for food and chemicals is essential. The Internet of Things (IoT) monitors characteristics such as weather conditions, humidity levels, and temperature in order to ensure the security of products. The Internet of Things produces notifications when any parameter surpasses predetermined levels to prevent potential issues.

3. Objectives of the Study

1. Engaging in research on the Internet of Things as it pertains to supply chain management and logistics.
2. With the aim of exploring supply chain management and blockchain technologies,

4. Research Method

This is an illustration of a suggested system for incorporating Internet of Things (IoT), robotic process automation, and blockchain technology into the field of supply chain management:

Robotic process automation (RPA), the internet of things (IoT), and blockchain technology have the potential to enhance various supply chain tasks. Procedures like as quality control, order tracking, inventory management, and other related processes may be included within this category.

When building the architecture of the blockchain, it is crucial to meticulously evaluate the requirements of the supply chain operations. Furthermore, this task necessitates several elements, including determining the data format, creating intelligent contracts, and selecting the appropriate blockchain platform.

Incorporating IoT devices into the supply chain is crucial for gathering data and offering immediate insight into chain operations. The necessary steps for this procedure entail identifying the suitable Internet of Things devices, devising a method for collecting data, and selecting the format of the data.

Robotic process automation (RPA) can enhance the efficiency of supply chain operations by automating repetitive jobs. Identifying the tasks that can be automated, developing RPA protocols, and designing the complete data framework are essential measures to achieve this objective.

Testing the system is crucial to verify its compliance with the supply chain operations' criteria. In addition, it includes the examination of RPA techniques, blockchain architecture, and IoT devices.

It is advisable to install the system in a real-life environment and closely monitor its performance to ensure it functions optimally. Continuous monitoring is necessary for Robotic Process Automation (RPA) processes, Internet of Things (IoT) data, and blockchain transactions.

illustration

L = The letter L represents the concept of "set of logistics operations," encompassing activities such as transportation and warehousing.

B = B represents the various activities carried out by the blockchain, encompassing transactions and smart contracts.

M =The metaverse comprises various elements, such as virtual commodities and virtual supply chain operations.

T =The variable "t" represents discrete or continuous units of time.

C = The costs related to logistics activities are represented by the variable C.

R =R represents the amount of money saved or profits generated as a result of effective logistics.

P = When P is equivalent to the probability of a successful transaction or delivery

D = D represents the level of consumer demand for products and services.

S = There is a range of products and services that can be accessed.

One possible goal is to achieve optimal balance between efficiency and dependability while minimising costs.

The equation expresses the correlation between the income generated by logistics activity i at time t, the cost, and the probability of the operation's success, denoted as Ri(t), Ci(t), and Pi(t) accordingly.

$$max \sum_{i \in L, t \in T} (R_i(t) - C_i(t).P_i(t))$$

- Equilibrium of Supply and Demand: ∑i∈LMi(t)=D(t)=S(t)
- The validity of the blockchain is determined by whether it is valid for TXij(t) or Bi(t).
- The prerequisites for both "Smart Contract Compliance" (SCi) and "mi(t)" have been fulfilled.
- The functional aspects of logistics are limited by time and capacity restrictions.

5. Proposed Algorithm

```
Program MetaverseLogistics
    blockchain = new Blockchain()
    while (true) {
        data = receiveData()
        for each item in data {
            processedItem = processItem(item)

blockchain.addBlock(processedItem)
        }
        command = checkForCommands()
        if (command is not null) {
            do {
                executeCommand(command)
                command = getNextCommand()
            } while (command is not null)
        }
        sleep(timeInterval)
    }
    Function receiveData()
        return data
    Function processItem(item)
        return processedItem
    Function checkForCommands()
        return command
    Function executeCommand(command)
    Function getNextCommand()
        return nextCommand
    Class Blockchain
End Program
```

6. Analysis Methodology

Metaverse Logistics is an organisation that seeks to accomplish this objective by utilising blockchain technology. This strategic initiative by the corporation aims to disrupt the supply chain industry. Accenture's study suggests that a new approach to supply chain logistics networks may be emerging in the metaverse. Anticipating and predicting market developments and the associated risks inside the supply chain network could greatly enhance customer convenience. By adopting a comprehensive approach that considers growth, profitability, sustainability, diversity, and inclusion, the organisation can effectively manage its performance and make informed decisions. Streamlining processes for customers is one method to implement this transformation. The constructed model use the interplanetary file system in combination with the Ethereum blockchain to ensure that the supply chain can uphold its traceability, transparency, and reliability. The primary objective of this is to ensure the efficient functioning of the supply chain. Moreover, blockchain technology can assist in the comprehensive mapping of the entire supply chain network, spanning from its inception to its conclusion. Consequently, all connections within the supply chain can be perceived with greater clarity. If successful, this might provide more precise and current information regarding the lead times, costs of logistics, delays, and delivery of items simultaneously. Metaverse Logistics, a firm, is utilising blockchain technology to enhance the efficacy of currently developing supply chain systems. The business's strategy for preserving the traceability, transparency, and reliability of the supply chain involves utilising the Ethereum blockchain in conjunction with the interplanetary file system. This is the company's intended course of action. The metaverse has the potential to revolutionise supply chain networks by simplifying customers' experiences, analysing and predicting market fluctuations and associated risks across the entire network, and providing comprehensive insights to guide company decisions and enhance performance in terms of growth, profitability, diversity, and inclusion. These examples illustrate the potential of the metaverse to profoundly transform supply chain networks. Here are some examples of how the metaverse could significantly revolutionise supply chain networks.

7. Data Analysis

7.1 Results of the Content Analysis

Figure 1 illustrates the percentage distribution of recording unit hits across different categories. One perspective to consider regarding this distribution is its representation of the frequency of each group. The frequency of strikes on the recording devices can be determined by examining the percentages. In this instance, a technological potential percentage of 31.4% signifies that out of the 107,375 hits obtained from the document analysis using the dictionary, 33,693 (equivalent to 31.4% of the total) pertain to technological potential.

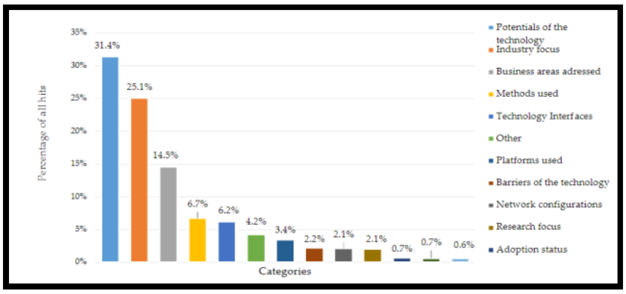

Fig 1. An analysis of the recording unit's success rates in all thirteen areas.

The ratio of publications that addressed the limitations of the technology to those that explored its potentials was 2.65:1. The attainment of this result demonstrates that researchers remain enthralled by the ongoing possibilities of this technology. The prospective applications of Blockchain Technology (BCT) in Operations Management (OM) and Supply Chain Management (SCM) are currently under investigation, and the advantages it provides have not yet been established. There is a limited amount of research that has investigated the distinct difficulties encountered by individuals considering adopting the technology, as well as the potential solutions to these issues. An additional evidence supporting this discovery is the relatively small percentage (1.7%) of hits recorded for the adoption status category. Another notable conclusion is that theory-driven studies constitute a mere 0.7% of the overall papers. Undoubtedly, there is ample scope for inquiry in this domain. Next, in order to determine the significance of recording units in the literature, we examine the top 10 results for recording units in general, as well as the top 10 results categorised by article count. The recording units that have received the highest number of hits are recognised, indicating that the technology's category has substantial potential. This is consistent with the overall percentage distribution shown in Figure 1. The substantial volume of searches related to the 'food' industry underscores the importance of Blockchain Technology (BCT) in this area. The food industry is characterised by a fragmented retail market, which greatly benefits from the traceability and provenance aspects of this technology. Researchers worldwide have identified the "traceability" use case as the most promising use enabled by BCT. Following that are "smart contracts" which facilitate automated and transparent commercial processes. The potentials of "security," "transparency," "trust," and "cost savings, increased efficiency" are frequently exaggerated.

Table 1 Facilitating electronic data transfer among all nodes in the supply chain.

S. no	Responses	Respondents	Percentage
1	Towards the end user only	40	44.44
2	Towards the supplier only	20	22.22
3	Between the end user and the operation only	10	11.11
4	Both towards the end user and the supplier	20	22.22

Interpretation: The subsequent analysis of replies resulted from the preceding one: 44.44 percent of the participants were only concerned with the end user, while 22.22 percent focused on the supplier. Another 11.11 percent directed their attention towards the interaction between the end user and the operation, and the remaining 22.22 percent concentrated on the flow of information along the supply chain.

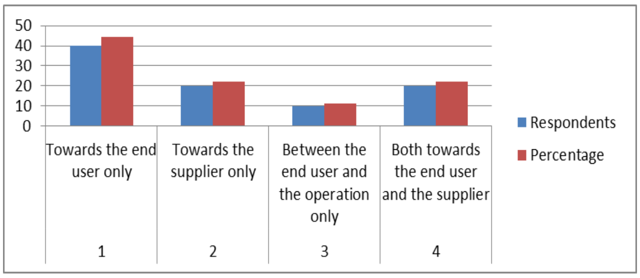

Fig 1 Facilitating the exchange of electronic data among all nodes within the supply chain.

Table 2 Methods for enhancing the visibility and desirability of products

S. no	Responses	Respondents	Percentage
1	Over the internet	30	33.33
2	Through retail distributors	40	44.44
3	Via a trade magazine	10	11.11
4	Directly to customers	10	11.11

Interpretation: A total of 90 responses were received, with the following distribution: 33.33% from online sources, 44.44% from retail distributors, 11.11% from a prominent trader, and 11.11% from direct customers. This portion represents the car businesses, whose primary business is the sale of new products.

Fig 2 Methods for enhancing the visibility and desirability of products

Table 3 The advantages of employing multiple sources for a task

S. no	Responses	Respondents	Percentage
1	Consistent Quality	20	22.22
2	Speed of delivery	35	38.88
3	Continuity of supply	15	16.66
4	Flexibility of products	20	22.22

Interpretation: Out of the 90 participants in the poll, the particular reaction was seen. The findings indicated that 22.22% of respondents expressed satisfaction with the quality of the product, 38.88% were content with the speed of delivery, 16.66% were pleased with the availability of the product, and 22.22% reported satisfaction with the flexibility of the product.

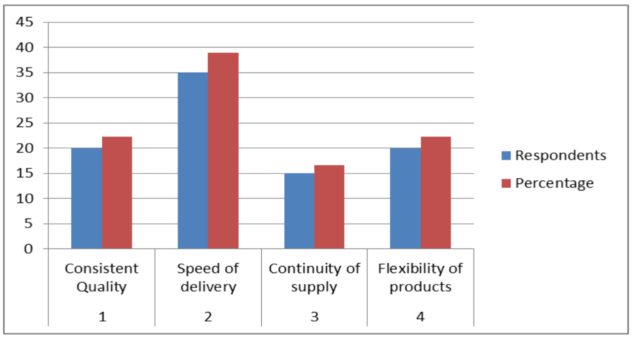

Fig 3 Advantages of employing a diverse range of resources for a project

Table 4: Advantages of Utilising Multiple Operational Sources

S. no	Responses	Respondents	Percentage
1	Safety and maintenance	10	11.11
2	Sales and marketing	60	66.66
3	Selecting suppliers	10	11.11
4	Recruiting employees	10	11.11

Interpretation: Based on the previous answer, 11% of the sample consisting of 90 individuals were not accountable for safety and maintenance, 66.6% were responsible for sales and marketing, 11.1% were in charge of supplier selection, and another 11.1% were involved in rehiring employees for an operations manager.

Fig 4 Advantages of employing a diverse range of resources for a project

Table 5: Services exhibit four distinct characteristics that set them apart from manufactured commodities. The key attributes include the capacity to establish connections with individuals, recognizability, indivisibility, and susceptibility.

S. no	Responses	Respondents	Percentage
1	Homogeneity	40	44.44
2	Heterogeneity	10	11.11
3	Intractability	10	11.11
4	Invisibility	30	33.33

Interpretation: The survey results indicate that among the respondents, 134% were homogenous, 111% were heterogeneous, 111% were unreasonable, and 33.3% were irrational. The percentage of services differs from produced goods in four significant aspects. The four ways are interactability, intangibility, perishability, and inseparability.

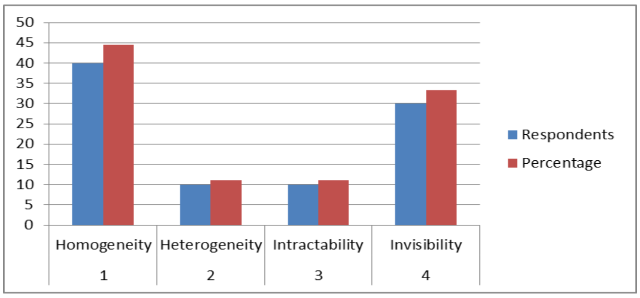

Fig 5 Services differ from manufactured commodities in four fundamental aspects. The attributes encompassed are the capacity to establish connections with individuals, recognizability, indivisibility, and susceptibility.

8. Conclusion

We successfully differentiated across sectors that require distinct research and explored the diverse perspectives on technology held by individuals in the analysed study fields. Quantitative methods can enhance the understanding of how Behaviour Change Techniques (BCT) impact management and supply chain performance levels, despite the broad range of conceptual approaches and the increasing popularity of qualitative research. There are still numerous unresolved inquiries regarding the relationship between BCT and prominent theories like as principal-agent theory, innovation diffusion theory, and dynamic capacity theory. By integrating many technological components, BCT becomes highly advantageous when synergized with other systems, such as the Internet of Things (IoT). Subsequently, BCT demonstrates its effectiveness by enhancing the information flow security of the SC while also increasing its transparency. To obtain valuable insights into the advantages of business continuity technology (BCT), it is necessary to investigate methods for connecting and filling gaps across various business domains. The potentials of tracing transactions, establishing network confidence, utilising smart contracts, and gaining efficiency gains have been acknowledged and extensively addressed in the related literature. An efficient material and production network is essential for the successful execution of any creative or small-scale production endeavour. Without the establishment of this network, every endeavour may be destined for failure as a result of time-consuming setbacks and intricate complications. Implementation of improved material management techniques and selection models is anticipated to boost the operational efficiency of the electrical company. The result will be a reduction in expenses and a boost in effectiveness. To ensure the efficiency of the executive's framework, it is crucial to minimise material shortages, scatterings, misfortune, and burglary. These issues can lead to decreased productivity, increased group idleness, and delayed operations. This framework is essential for monitoring effective material administration. Small-scale electrical firms must build an effective material management system due to the frequent need to cut their offers in order to keep the project within budget. Inadequate material management in such a scenario could lead to a decrease in benefits or even a depletion of riches. Ensuring the availability, quantity, and quality of resources is a very crucial responsibility. Although superior, the majority of material management systems used by electrical companies are capable of meeting their 205 needs. Institutionalising the material administration framework has the potential to enhance its existing state and overcome certain obstacles. This article presents the findings of an investigation that sought to develop a comprehensive system of decision-making tools for the procurement requirements of small-scale industries, namely in the field of electrical equipment. By employing a comprehensive strategy for acquiring materials, more informed choices may be made on what items to buy, the appropriate quantity to order, and the optimal distribution channels for supplies. Subsequent studies should prioritise the development of a comprehensive framework that considers additional decision-making aspects, such as prefabrication material scheduling and supplier selection. An extensively integrated strategy will enhance communication and reduce the occurrence of information flow gaps, benefiting all involved parties and departments.

Author contributions

Chanda Chouhan: Conceptualization, Methodology, Software, Field study, Data curation, Writing-Original draft preparation, Software, Validation., Field study. **Dr. Monika Saxena**: Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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