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A Blockchain Security Based IoT-Enabled System for Safe and Effective Logistics Management in IR 4.0

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Abstract: As a result of the revolution brought on by industrial 4.0, the global logistics industry is growing at a rapid rate. Concurrently, logistics operations are undergoing constant change as new technologies such as the internet of things (IoT), cloud computing, and big data are implemented. These Internet of Things devices enhance the functionality of the logistics function by enhancing real-time product tracking, improving data collection, and intelligently storing logistics data, among other things. Because of the centralised database structure of these logistics systems, certain of these new technologies open the door to the possibility of cyberattacks on these systems. The parties involved in the logistics operations must communicate with one another in order to share confidential information about customers and details about products. This is due to the fact that so many logistics stakeholders are being engaged in the process. It is vulnerable to unauthorised access, which may result in fraudulent activity or the production of counterfeit goods by a malicious actor operating within the system. All of these challenges are significant because maintaining the integrity of the logistics data is essential to providing good service to customers. The application of Blockchain's special features, such as immutability, efficient cryptography, and a distributed decentralised storage system, will be used to address these challenges once it is deployed as an innovation. In conclusion, Blockchain has the potential to improve operational efficiency while also ensuring the safety of the data involved in the logistics process. According to the findings of the study, the technologies underlying Industry 4.0 have the potential to make supply chains more agile, transparent, and resilient. In addition, the study demonstrates that despite the fact that the advantages of integrating technologies related to Industry 4.0 into supply chains are widely acknowledged, there is still a dearth of applications, related research, and actual-world use cases. Nevertheless, it is abundantly clear that companies that do not adopt the technologies will eventually go out of business. In the event that the pandemic has revealed bottlenecks in the practises we use for our supply chain, the solution is to integrate advanced technologies from Industry 4.0.

Keywords*: Blockchain, Security, IoT, Logistics, IR 4.0*

1. Introduction

The "Industrial Revolution" was the transition from conventional industrial methods to more innovative ones, as dictated by the state of the art at the time. So far, humanity has experienced not one but three distinct waves of industrialization. Around the middle of the 18th century, steam-powered engines and mechanisation were introduced, marking the beginning of the first industrial revolution. Because of this, many villagers abandoned their homes and moved to urban areas in search of factory work. The result was the first steps of the industrial revolution. Beginning in the middle of the 19th century, technological developments like the mechanisation of "agriculture, textile industries, railroads, machinery, internal combustion engines, and electric power" drove the second industrial revolution. The 1950s marked the beginning of the third industrial revolution, which was propelled by the development of transistors and microprocessors, which led to the incorporation of computers and other electronic devices into manufacturing facilities. We are living in the midst of what many are calling the "fourth industrial revolution," or Industry 4.0. This movement, also known as the "computerization of manufacturing," is characterised by the integration of state-of-the-art digital technologies with time-tested manufacturing tools and processes for the purpose of optimising efficiency, productivity, and automation. The four major cutting-edge technologies that form the basis of Industry 4.0 are as follows (figure): "networking, data, and computational (Smart sensors, Internet of Things, Blockchain, and cloud computing); analytics and intelligence ("Artificial Intelligence, Machine Learning, and Big Data Analytics); human-machine interaction (Automation, Robotics, COBOTS, and Drones); and advanced manufacturing (Additive manufacturing)". Since the fourth industrial revolution

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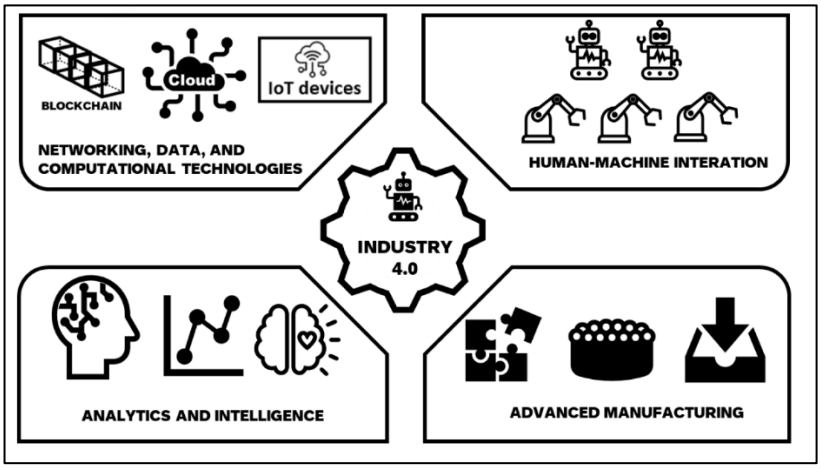
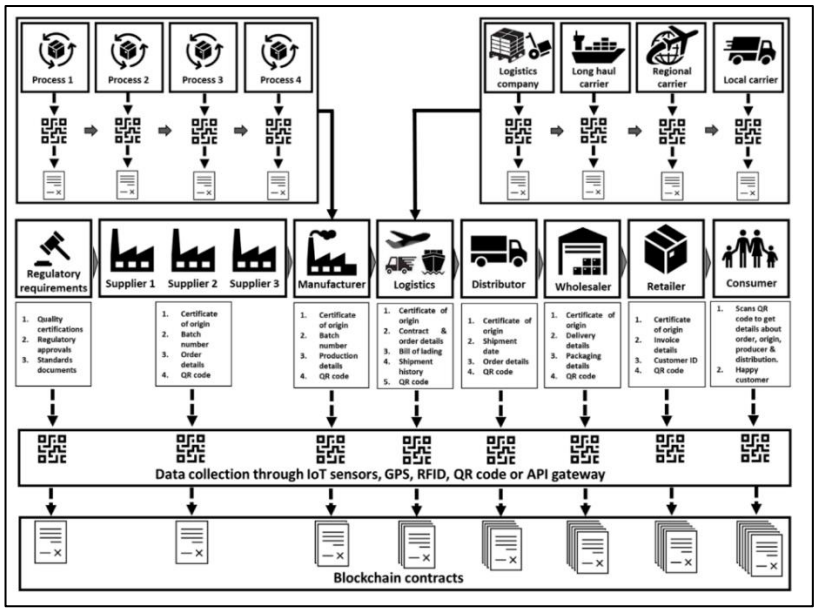
will cause massive changes in the production process as a whole, it is only natural to assume that the supply chain and logistics will also undergo significant transformations (Aslan, E., 2021).



The traditional understanding of supply chain management and logistics administration as a network of functions working together to convert raw materials and deliver finished products to the end user or customer has changed. The time for that is long past. The modern supply chain encompasses a much wider area than in the past, and it faces new pressures on a regular basis to help businesses become more competitive and grow more quickly. The day-to-day operations of a business are put under tremendous stress due to the interconnected nature of the supply chain and the myriad internal and external factors involved. Seventy-plus percent of participants from seventeen different countries in the Geodis supply chain survey 2017 characterised their supply chain as "very" or "extremely" complex, with increased visibility serving as a top priority for effective management. This number, from Geodis. (2017), neatly summarises the difficulty of supply chain management and the importance of digital tools. Six main factors contribute to the improved supply chain transparency. They encompass the ability to see into areas like purchasing, stock management, operations, logistics, finance, quality assurance, and sales and customer service.

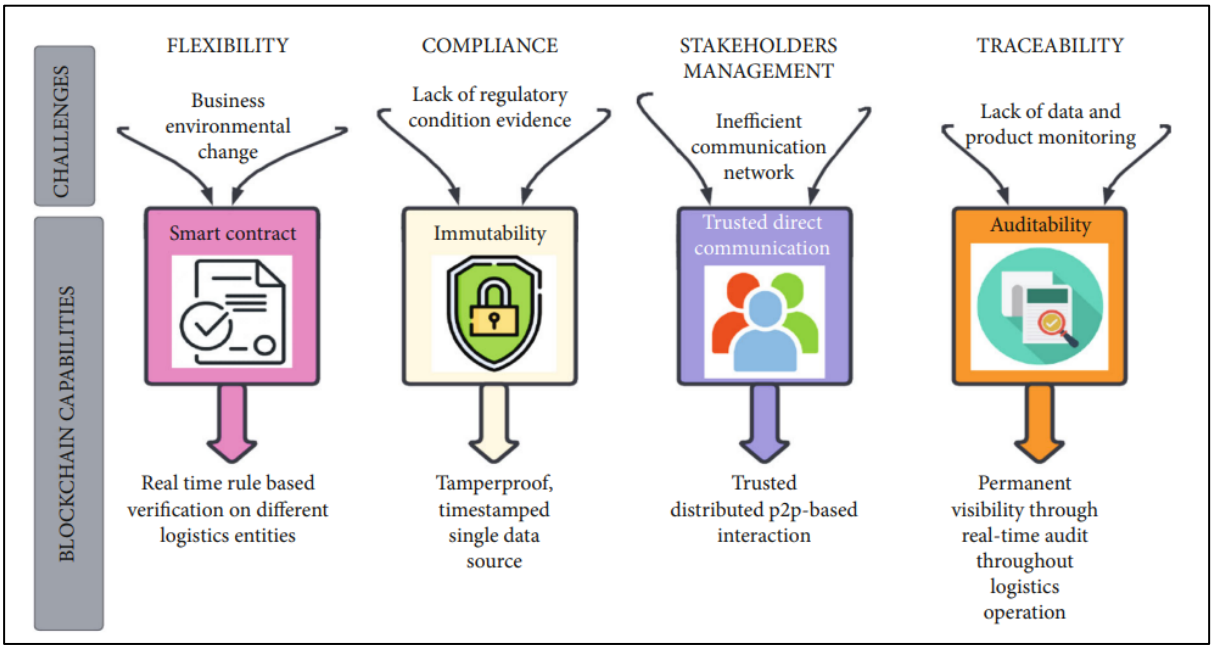
2. Blockchain

A blockchain is a distributed, decentralised, and immutable digital ledger. Used for recording transactions in an unchangeable format. It combines elements from several areas of technology, such as computing, networking, cryptography, and mathematics (Yaga et.al, 2019). The technology's distinctive qualities and features, such as immutability, decentralisation, distributed ledgers, and consensus mechanisms, make it attractive for use in a wide variety of applications, including those involving the processing of transactions. Research shows that the technology can be used to manage upstream, operational, downstream, and external supply chain complexities (Raja Santhi et.al., 2022). The use of blockchain technology in a variety of supply chain and logistics operations is illustrated in the figure that follows. Santhi et al. discussed this very issue.



Logistics, when used in the context of the supply chain, refers to a strategic management process that includes the acquisition, movement, and storage of goods, parts, and finished products, as well as the flow of information between the relevant organisation and its various marketing channels. The seven requirements are the end goal of the logistics process, which is a networking procedure involving many parties (such as the logistics company, suppliers, customers, transporters, and distributors) have privacy and security flaws due to their centralised database storage system (A. Panarello et al., 2018) that leaves them open to cyberattacks. [Footnote required] Data can be easily compromised by an attack on a system's single weak point. There is a lot of private information about customers and products stored in logistics data, making all of these issues crucial (such as product specifics and prices, as well as customer addresses, phone numbers, and credit card numbers, among other things). All of these threats to the logistics management system may be lessened through the use of Blockchain technology. Since blockchain is a distributed (R. P. Sarode, 2008) and decentralised peer-to-peer technology, it can be used for any kind of transaction. It was first implemented in Bitcoin, a decentralised digital currency. Recent studies suggest that Blockchain innovation is being adopted in many fields, including the Internet of Things (IoT) (F. Casino et al., 2017), the healthcare sector (C. Tory, 2022), the financial industry (A. Tapscott et al., 2017), and supply chain management (W. Kersten et.al., 2017).

Many aspects of supply chain management have been the subject of study, such as operations management and environmentally responsible business procedures. However, not enough support systems exist to guarantee optimal outcomes in terms of efficacy, efficiency, and sustainability. Companies like IBM (International Business Machines) that control a large portion of their industry have a history of success. There has been a sea change in the healthcare industry's approach to cyber security since the advent of Blockchain technology.



Before Blockchain technology can be fully integrated into the logistics management system, a few issues must be resolved. Information security for customers and products in a decentralised Blockchain system necessitates a new system design, which in turn necessitates expertise in logistics management. Blockchain technology, in conjunction with the Internet of Things, has made the logistics industry smarter, simpler, and more transparent. In order to accomplish this, it provides data that is scalable, transparent, and trustworthy throughout the entire transportation and logistics management system. Having a method like this in place simplifies monitoring and confirmation.

On the other hand, a more efficient Blockchain structure paradigm is necessary due to the massive amounts of data generated by IoT in logistics operations. Irrefutably, this must be done. Concerns about the safety of the distributed ledger technology's open-access system are also important. Improved data encryption and key management systems are needed to protect logistics data. To deliver a safe and effective logistics management system, it is necessary to take a solution approach based on Blockchain technology and enabled by the internet of things. In this research, we propose a framework for a Blockchain-based IoT-enabled system to protect customers' personal data and increase logistics management's throughput with the help of a smart

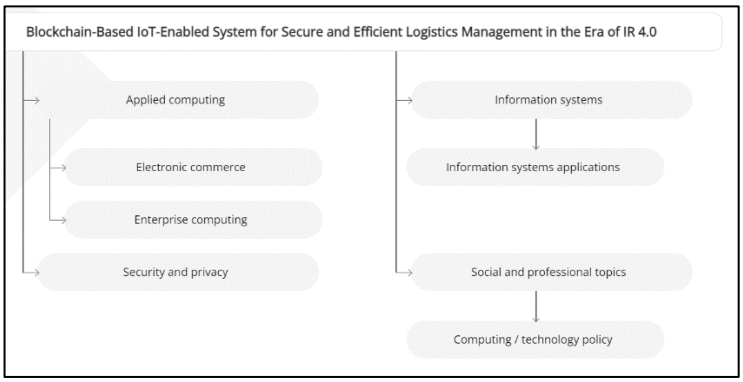
contract. The capabilities of the Internet of Things will also be improved by this framework.

3. Review Literature

Controlling Logistical Operations with Intelligence Logistics has risen to prominence as a key part of the modern supply chain as a result of the rise of e-commerce and the retail sector. Numerous investigations have been conducted to better understand how logistics networks can be made more efficient. When it comes to logistics computing, fog computing was first introduced by (Lin and Yang et al., 2018). They set out to find a workaround for the issue of a centralised cloud computing system's inability to handle the massive processing load generated by thousands of IoT devices in factories. In addition, they proposed an effective architecture for rolling out fog computing to cut down on the money spent on computing by IoT devices. To combat energy waste and lengthy wait times associated with the process of integrating production and logistics in industrial workshops, Zhang et al. (2018) incorporated IoT and cloud based storage technologies into a device layer interconnection design and data processing. The goal was to enhance the effectiveness of production and logistics integration. (Zhang et al., 2018) introduces a smart logistics framework that uses cyber-physical systems and the industrial Internet of Things to solve the problem of resource coordination in the logistics process (IIoT). (Zhang, 2018) also focuses on the integrated planning challenge of smart food logistics systems. The authors employ a fuzzy logic approach to optimise the logistics planning. Recently, blockchain technology has been used as a possible strategy for bettering logistics system efficiency. (Perboli et al., 2018) proposed using Blockchain technology to create a digital backbone logistics network. Blockchain technology has the potential to improve the overall supply chain's efficiency, reliability, and transparency by making data immutable and making data streams publicly accessible. A smart contract-based approach to logistics system management was proposed recently (Wang et al., 2019). The prescribed smart contracts are triggered by an event response mechanism in this approach. Therefore, smart contracts are used to implement a distributed ledger for recording the transactional histories of all product transfers. Blockchain has been proposed for use in smart logistics systems (Fu and Zhu, 2019). To combat threats to security and privacy in smart logistics systems, this strategy was developed. In recent years, the logistics industry has widely adopted the use of smart contracts and distributed ledger technology (Blockchain).

Fundamentals of Logistics Management

Logistics refers to the entire chain of events that occurs between the time a product is ordered and received by the customer until it is finally delivered to the customer (Bucea-Manea-T et.al., 2021). Information is also exchanged, including customer data and product details. Delivering the right product, in the right quantity and the right condition, to the right place at the right time for the right customer at the right price is the top priority on the list of the seven right conditions, as shown in the figure below. Logistics operations are being digitalized and transformed into smart logistics as a result of the revolution brought on by industrial 4.0 (Punathumkandi et al., 2021). There is no universally accepted definition of the term "smart logistics," and its use is fraught with ambiguity (Yangke et.al. 2021). When contrasting this with conventional approaches, the term "smart logistics" is commonly used to refer to a wide range of logistical processes, such as shipping, storage, and customer service, that are intelligently planned, managed, and controlled.



Logistics Management in Industry 4.0

A company's logistics department is responsible for carrying out the "implementation" stage of its intricate operations. Blockchain architecture unifies the smart contract, a central component of business logic. Tags, Internet of Things sensors, actuators, and so on can trigger a smart contract, which is an autonomous computer programme “(Pervez et al., 2019; Tan et al., 2020; Abubakar et al., 2020; Mastos et al., 2021)”.

Pharmaceutical Industry

They come to face challenges of wellbeing, trust, shortcoming, traceability, and invisibility of pharmaceutical products and devices in the supply chain when working with a traditional pharmaceutical supply chain. All of these issues can be solved, however, by utilising Internet of Things devices such as radio frequency identification, sensors, locators, and QR codes. At the same time, with the assistance of Blockchain-dispersed record technology, the information is made simple and detectable, and it is not altered, sold, or stored at each connection of the supply chain. The blockchain ensures confidentiality and fulfils the need for personalization of valuable data (Attique, M et.al., 2020).

Industrial Area

The use of Blockchain in IoT devices that are enabled by 5G for communication can be broken down into three distinct sections: the fundamentals of Blockchain, IoT, and individual contemporary 5G applications. In industrial settings, the Blockchain helps to maintain data security while also facilitating faster data flow. A distributed storage system that is underpinned by cryptography and agreement calculations is at the heart of this innovation. At this time, a great number of applications have been put into action in the areas of horticulture, payment, and medication. This application of blockchain technology is used in air traffic controllers (ATCs), with the goal of reducing instances of fracture, failure, and other disgraceful activities in the airport terminal industry (Iqbal et.al. 2021)

Food Supply Chain

Down the line of food production, a framework for distinguishability has been established, and its characteristics have been enhanced. In order to collect data and keep users up-to-date on the whereabouts of each product, the system employs Internet of Things devices to track and trace items. At present, the food distribution network most frequently employs the Hyperledger Sawtooth and Ethereum algorithms. Ethereum's scalability and dependability can be problematic under certain conditions, and the platform can be difficult to use on devices with low processing power. Sawtooth is a Hyperledger implementation that works well on small devices. For the purpose of tracking inventory, the Blockchain can be implemented in IoT-based supply chain management. Blockchain technology also provides privacy, fast data transfers, and effective multi-hop routing at low cost.

Healthcare

Blockchain technology has the potential to disrupt established industries like the Internet of Things and the medical services supply chain by virtue of the high ethical standards it upholds. For businesses, blockchain technology highlights momentum requests and identifies potential exploration holes "(Awan et al., 2019; Childerhouse et al., 2003)".

Automotive

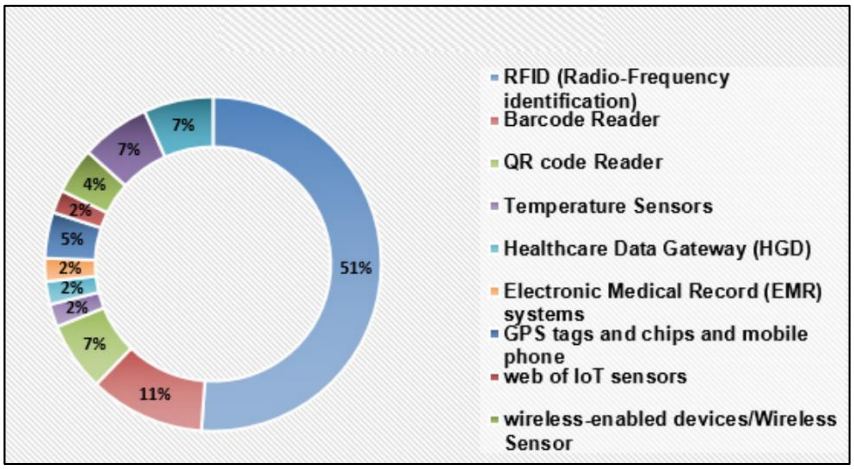
Smart contracts, truly distributed shared frameworks, and the ability to collaborate with peers in a trusted and auditable manner are just a few of the ways in which blockchain technology strengthens supply chains. Fundamental requirements in the manufacturing plant include the timely and elegant transport of components, the coordination of insect outsiders, transportation organisations, multipliers, and other such things. Devices in the Internet of Things ecosystem release the real things in the production network from the typical constraints of fake news by providing them with a new territory and the means to do so materially (Lohmer et al., 2020). This was found to be the case (Wang et al., 2019).

Authenticity and Cyber Security

As infrastructures have evolved, so too has the number of energy technologies that can be hacked via the internet and put at risk. It is still difficult for energy utilities, especially those without sufficient resources, to acquire these devices and recognise consistency requirements. These high-level and increasingly complex digital issues called for innovative approaches to fixing them. In order to improve and acquire the complex programming and equipment store network that constitutes modern energy utilities, this research looked into other opportunities and challenges in applying Blockchain-based circulated record technology (Cole et al., 2019). This paper presented the study's findings (Mylrea et.al., 2018).

How Effective Is the Use of Blockchain-Based IoT Devices in Logistics?

If humans can't interact with the devices in real time, they serve no purpose. Through connecting the digital and physical worlds, the Internet of Things makes our surroundings more adaptable and responsive. Because of the wide variety of tools available to humans, this is possible. However, there are concerns about security and privacy in the IoT that can be addressed by implementing blockchain technology.



The data that is incorporated into the countless corporeal devices across the globe is safeguarded by the Blockchain system. The devices are linked together through the Internet, and they exchange data using a trustworthy structure called Blockchain. IoT devices that use blockchain technology have revolutionised SCM. "(Pundir et.al., 2019), (Negka et.al., 2019)" state that "they gradually follow the area of merchandise, quantity, and other helpful data, improving assembling plants, arranging a production plan, and improving material and data stream frameworks."

In practice, there are a few global positioning frameworks accessible through GPS (Global Positioning System), RFID (Radio-Frequency identification), Barcode Readers, QR code Reader, Temperature Sensors, Healthcare Data Gateway (HGD), Electronic Medical Record (EMR) systems, GPS tags and chips and mobile phones, the web of IoT sensors, wireless-enabled devices, Wireless Sensors, HACCPs (Hazard Analysis and Critical Control Points), and Near Field Communication (NFC).

As the sensory system follows and monitors the goods at various retail locations, coordination points, or capacity thresholds within the logistics, the corresponding data is updated within a Blockchain framework. Members of the network search the log for relevant entries in order to learn more about the item in question. With RFID-based supply chain management using Blockchain, data is more secure, transparent, and trustworthy than with a conventional decentralised database system, and administrative costs are reduced. This is a secure means of exchanging data with the RFID tags that are appended to the blockchain's nodes.

4. Future Work and Limitations

Despite the incomprehensibility of blockchain-based IoT in logistics as a viable future research direction, fitter away time primarily notion and orchestrations make sense and can advance the field. However, the future of big data across a variety of industries hinges on the extension of hardware architecture within the appropriate proposed framework for implementations comprising actual IoT devices and gateways. There are many factors that will make this true (Awan et.al., 2021). By analysing the two technologies side-by-side, we can better understand the advantages of presenting data at the network's edge in terms of idle time, I/O throughput, central processing unit utilisation, Internet of Things device utilisation, and transaction costs.

Our research has limitations, including the fact that Blockchain intelligent contracts do not adequately tackle the problem of how to verify the veracity of logistics management IoT transaction data.

Second, the main topics of future research will be security and the problems it brings, as well as how technology has changed in the modern world. As time goes on, information security is held to stricter standards, and these standards are met with a wider range of problems, such as tracability, data provenance, and cyberattacks. Important parts of deployment include lowering the amount of CPU power needed to run blockchain code on moderate Internet of Things smart objects and building fault tolerance into how devices and networks talk to each other.

There will also be research into lightweight network protocols for device-to-device communication that spreads through the infrastructure and algorithms for reaching network consensus. Recent work in the field of future studies has shown that deep learning models based on images show promise (Nadeem et al., 2020; Mujahid et al., 2021). We can use convolutional neural networks and other models to make use of the IoT data that has already been published for supply chain pictures. The strategy includes both figuring out how to build a smart contract management framework for logistics and putting it into practise.

Findings of the Study

Over the past few decades, the supply chain has had to deal with a lot of problems. Because of these problems, the supply chain has had to adopt a wide range of cutting-edge technologies and strategies that have completely changed how it works. Artificial intelligence (AI), the internet of things (IoT), big data and analytics, blockchain, automation and robotics, and additive manufacturing are all examples of cutting-edge Industry 4.0 technologies that, when used, give industries the chance to reach the highest level of operational efficiency, agility, innovation, and customer service, turning the supply chain into a digital supply chain. By putting sensors in all assets and putting all processes into an automated workflow and making a closed network, the technologies allow for the most efficiency. The vertical and horizontal integration of these technologies into the product life cycle could change the supply chain network and make it more stable.

5. Conclusion

The decisions made in the 4.0 industrial revolution have led to smarter logistics. These changes are being driven by new technologies, some of which are vulnerable to cyberattacks like network or physical attacks. A major privacy and security risk is posed to both customers' and products' sensitive information whenever logistics systems are attacked or sensitive data is shared or transferred between logistics stakeholders. Since this information can easily be accessed by the wrong people, it poses a serious security risk. Disruptive technologies like the blockchain may provide answers to the identified issues. We started by giving a definition of smart logistics and then zeroed in on the technological tools that make it possible. We then moved on to a discussion of the logistics industry's need for Blockchain and IoT integration. We put forth an infrastructure for logistics management that utilises Blockchain and is empowered by the Internet of Things. For operations spanning multiple levels and involving a wide variety of parties involved in logistics management, this framework will be able to record the flow of relevant data. In addition to enhancing the efficiency of logistics operations, it will also ensure the safety and confidentiality of sensitive customer and product data.

This study's findings suggest that by using an encryption mechanism, Blockchain has the potential to safeguard the privacy of customers' payment information and the integrity of the goods they purchase from unauthorised parties. Logistics operations can also benefit from its use. Future studies ought to concentrate on the following areas: increasing awareness of the capabilities of the Blockchain, promoting government acceptance of it, and reducing the cost of putting it into action; implementing and testing the dependability of the Blockchain framework in this article; integrating the Blockchain technology in logistics to solve the & testing the Blockchain framework.

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