DE-CENTRALIZED SUPPLY-CHAIN WEB APPLICATION WITH BLOCKCHAIN

PROJECT REPORT

Submitted by

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This is to certify that the project entitled

DE-CENTRALIZED SUPPLY-CHAIN WEB APPLICATION WITH BLOCKCHAIN

is the bonafide record of project work done by

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The Project entitled, "De-Centralized Supply-Chain Web Application with Blockchain" was carried out under my direct supervision. No part of the dissertation was submitted for the award of any degree or diploma prior to this date.

Sanjeev Kumar Mandel
Guide / Mentor
JAIN (Deemed-to-be University)

Name of the Examiner **Signature with Date**

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School Of Computer Science and IT

DECLARATION

I affirm that the project work titled "De-Centralized Supply-Chain Web Application with Blockchain", being submitted in partial fulfillment for the award of BACHELOR OF COMPUTER APPLICATIONS WITH SPECIALIZATION IN INFORMATION SECURITY MOBILE APPLICATION is the original work carried out by us. It has not formed the part of any other project work submitted for award of any degree or diploma, either in this or any other University.

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ABSTRACT

The traditional supply chain management practices have long been associated with inefficiencies, inconsistencies, and the lack of transparency. This has led to significant challenges for businesses that have struggled to ensure the smooth movement of goods from the manufacturer to the end consumer. However, the advent of blockchain technology has paved the way for a decentralized supply chain web application that has the potential to revolutionize the traditional supply chain management practices.

The decentralized nature of this system eliminates the need for a centralized authority, reducing the risk of fraud and tampering of records. The use of blockchain technology provides a transparent, secure, and efficient way of tracking the movement of goods. The implementation of a smart contract system enables automated execution of transactions, reducing the time and effort required for manual reconciliation.

This project aims to leverage the benefits of blockchain technology to develop a supply chain web application that provides a secure, transparent, and efficient way of managing the movement of goods. The application will be based on the Hyperledger Composer Business Network, which provides a robust platform for developing blockchain-based applications. The use of Hyperledger Composer will enable the development of a scalable and robust application that can be customized to meet the specific needs of different businesses.

The project will also include the development of a REST server to generate APIs, enabling easy integration with existing systems. This will allow businesses to seamlessly integrate the supply chain web application into their existing systems, reducing the need for extensive training and minimizing disruption to existing workflows.

The decentralized supply chain web application will provide businesses with a range of benefits, including increased transparency, reduced risk of fraud, and improved efficiency. The transparent nature of the system will enable businesses to track the movement of goods at every stage, ensuring that they are aware of any potential issues or delays. The reduced risk of fraud and tampering of records will provide businesses with greater confidence in the accuracy of their supply chain data.The automated execution of transactions will reduce the time and effort required for manual reconciliation, enabling businesses to focus on other areas of their operations.

This project focus on the development of a decentralized supply chain web application with blockchain technology. The benefits of this system are numerous, and it has the potential to revolutionize the traditional supply chain management practices. development that is set to transform the industry.

INTRODUCTION

This project intends on providing a working model of augmenting blockchain technology into supply chain with the aim of providing a much more efficient and a reliable system.

In recent years, the supply chain industry has experienced significant growth and transformation, with businesses seeking to improve their efficiency, transparency, and security. Blockchain technology has emerged as a potential solution, offering a decentralized and transparent way to track the movement of goods across the supply chain. This project aims to explore the potential of blockchain technology in supply chain management and develop a working model that can demonstrate its benefits.

Supply chain management is a complex and challenging process that involves multiple parties, including manufacturers, distributors, wholesalers, and retailers, working together to move a consumer good from its production phase to the end point of consumption by a customer/user. The efficiency of the supply chain is measured by its speed and low cost, and it is expected to be highly competitive and flexible to succeed in the market.

Blockchain technology is a distributed ledger technology that enables secure and transparent transactions between parties without the need for a central authority. It provides an immutable and auditable record of all transactions, which is stored in a decentralized network of computers known as nodes. This makes it highly secure and resistant to tampering, as any attempt to alter the record would require the consensus of the majority of the network.

Hyperledger Composer is a set of collaboration tools developed by IBM that enables developers and business owners to create smart contracts and blockchain applications quickly and easily. It is built with JavaScript and leverages modern tools such as node.js, npm, CLI, and popular editors. It offers business-centric abstractions and sample apps with easy-to-test Dev-Ops processes to create robust blockchain solutions that align with business requirements and technical development.

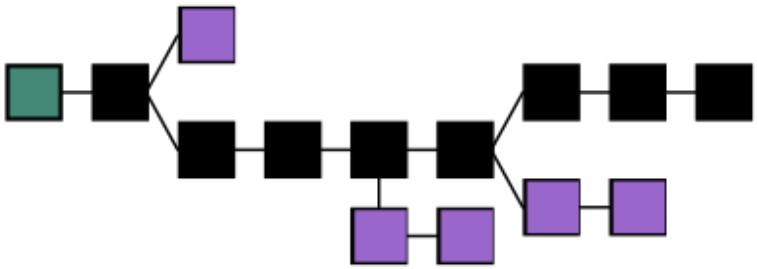

Figure 1: Blockchain formation. The main chain (black) consists of the longest series of blocks from the genesis block (green) to the current block. Orphan blocks (purple) exist outside of the main chain.

The combination of blockchain technology and Hyperledger Composer can provide significant benefits for the supply chain industry. For example, it can enable the creation of a secure and transparent system that provides real-time visibility into the movement of goods across the supply chain. This can help businesses to track the status of their products, identify potential issues or delays, and respond quickly to customer needs.

In addition, blockchain technology can provide a secure and efficient way to manage transactions and contracts between parties, reducing the time and effort required for manual reconciliation. The use of smart contracts can enable the automation of transactions, ensuring that payments are made on time and reducing the risk of fraud or errors.

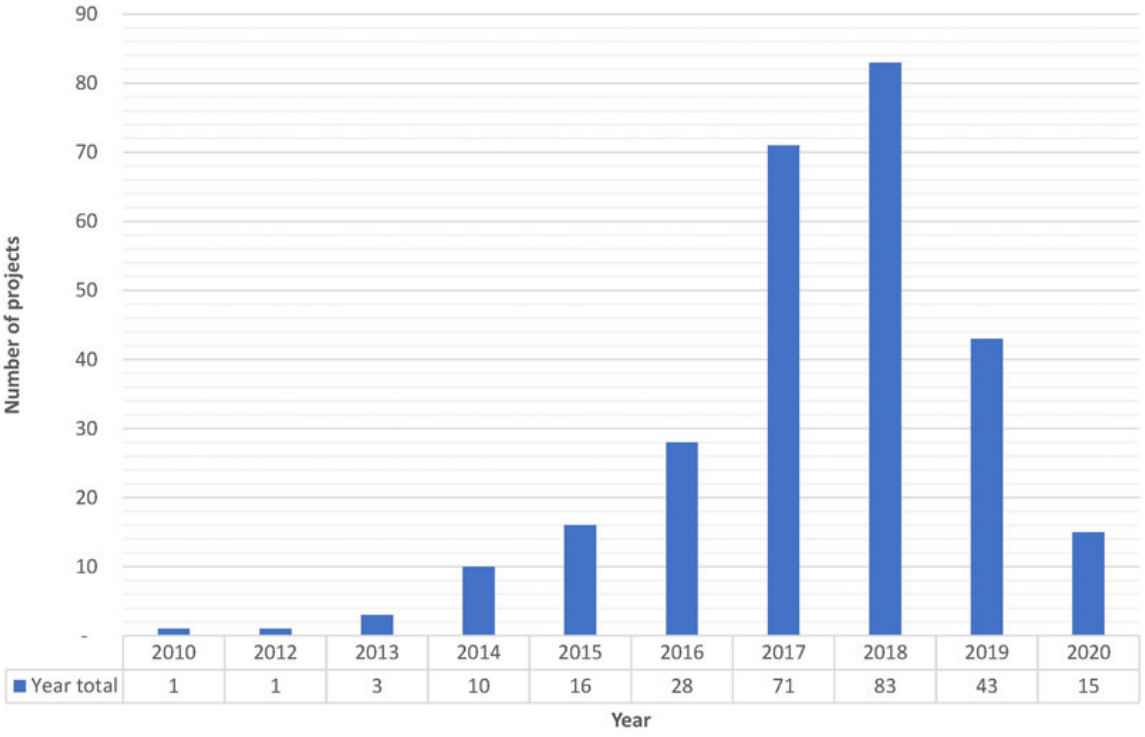

Figure 2: The adoption of blockchain technology in supply-chain year-wise from 2010-2020.

One example of a successful implementation of blockchain technology in the supply chain industry is the partnership between Walmart and IBM. In 2018, Walmart announced that it would require its suppliers of leafy greens to use a blockchain-based system developed by IBM to track the movement of their products. The system, known as IBM Food Trust, enables suppliers to upload data about their products onto the blockchain, including information about their origin, packaging, and transportation. This provides Walmart with real-time visibility into the movement of the products and enables it to quickly identify the source of any potential contamination.

Another example is the partnership between Maersk and IBM, which developed a blockchain-based platform for managing the movement of goods across the global supply chain. The platform, known as TradeLens, enables shippers, carriers, and other parties to exchange information about their products and shipments in a secure and transparent way. It provides real-time visibility into the movement of goods and enables parties to quickly respond to any issues or delays.

In conclusion, the combination of blockchain technology and Hyperledger Composer has the potential to revolutionize the supply chain industry, providing a secure, transparent, and efficient way to track the movement of goods across the supply chain. The use of smart contracts can enable the automation of transactions, reducing the time and effort required for manual reconciliation. While there are still some challenges to overcome, such as the need for standardization and interoperability between different blockchain platforms, the potential benefits of this technology are significant. With further development and refinement, blockchain-based supply chain solutions can help businesses to improve their efficiency, transparency, and security.
Furthermore, the implementation of smart contracts in the supply chain network can enable automated execution of transactions, reducing the time and effort required for manual reconciliation. Smart contracts are self-executing contracts with the terms of the agreement directly written into code. They can automate various steps in the supply chain, such as payment processing, quality control, and order fulfillment. For example, a smart contract could automatically release payment to a supplier once the product has been delivered and verified by the buyer. This eliminates the need for intermediaries and reduces the risk of fraud or delays in payment processing.

Overall, the integration of blockchain technology and Hyperledger Composer in the supply chain industry can bring numerous benefits, including increased transparency, security, efficiency, and reduced costs. By leveraging the capabilities of blockchain, businesses can improve their supply chain processes, streamline operations, and gain a competitive edge in the market.

LITERATURE REVIEW

1."Boundary conditions for traceability in food supply chains using blockchain technology" by Behnke and Janssen explores the use of blockchain technology for traceability in food supply chains.The paper highlights the importance of establishing clear boundary conditions for traceability in the food supply chain using blockchain technology. The authors note that these boundary conditions should take into account the legal and regulatory frameworks governing the industry, as well as the specific needs of different stakeholders, including producers, distributors, retailers, and consumers.

One of the key contributions of the paper is its discussion of the various challenges and barriers to the adoption of blockchain technology in the food industry. These include technical challenges such as scalability and interoperability, as well as cultural and organizational barriers, such as a lack of trust and resistance to change. The authors suggest that addressing these challenges will require collaboration among different stakeholders and the development of appropriate governance structures and standards.

Overall, the paper provides valuable insights into the potential of blockchain technology to address the challenges facing the food industry and the need for clear boundary conditions to ensure effective traceability. The authors provide a framework for understanding the factors that influence the adoption of blockchain technology in the food supply chain and suggest strategies for addressing the challenges and barriers to adoption.

Overall, the paper is a valuable contribution to the literature on blockchain technology in the food industry. The authors provide a useful framework for understanding the potential of blockchain technology to enhance traceability in the food supply chain and suggest strategies for addressing the challenges and barriers to adoption.

2."Blockchain adoption in the fashion sustainable supply chain: Pragmatically addressing barriers" by Caldarelli, Zardini, and Rossignoli explores the potential of blockchain technology to address sustainability challenges in the fashion industry. The paper discusses the challenges faced by the fashion industry in terms of sustainability, including issues such as waste, pollution, and unethical labor practices. The authors note that these challenges are exacerbated by the complexity and fragmentation of the fashion supply chain, which makes it difficult to track the movement of goods and ensure compliance with sustainability standards.

The authors then propose blockchain technology as a potential solution to these challenges, highlighting its ability to enhance transparency, accountability, and traceability in the supply chain. They suggest that blockchain technology can enable the creation of a decentralized, immutable ledger that can track the movement of goods from the manufacturer to the end consumer, enabling greater transparency and accountability.

However, the authors also acknowledge that there are significant barriers to the adoption of blockchain technology in the fashion industry. These barriers include technical challenges such as scalability and interoperability, as well as cultural and organizational barriers such as a lack of trust and resistance to change.

To address these barriers, the authors propose a pragmatic approach to blockchain adoption in the fashion industry. They suggest that organizations should focus on developing a clear business case for blockchain adoption, engaging with stakeholders and building trust, and leveraging existing standards and frameworks to ensure interoperability.

The paper concludes by highlighting the potential of blockchain technology to enhance sustainability in the fashion industry and the need for a pragmatic approach to adoption. The authors suggest that blockchain technology can enable greater transparency and accountability in the supply chain, which can in turn support the adoption of more sustainable practices.

Overall, the paper is a valuable contribution to the literature on blockchain technology and sustainability in the fashion industry. The authors provide a useful framework for understanding the potential of blockchain technology to address sustainability challenges in the fashion supply chain and suggest strategies for addressing the barriers to adoption. However, the paper is limited by its focus on the fashion industry and may not be applicable to other industries. Future research could explore the potential of blockchain technology in other industries and provide a more comprehensive analysis of its benefits and limitations.

3.“Designing blockchain systems to prevent counterfeiting in wine supply chains: A multiple-case study”by P. Danese, R. Mocellin, and P. Romano aims to explore how blockchain technology can be used to prevent counterfeiting in wine supply chains.The paper adopts a multiple-case study approach, analyzing the implementation of blockchain technology in four wineries located in different countries. The authors examine the key design features of the blockchain systems used, including the type of blockchain, the smart contracts employed, the integration with existing systems, and the level of transparency offered. The findings reveal that blockchain technology can effectively prevent counterfeiting in wine supply chains by providing a secure, transparent, and immutable record of the product's journey.

The authors note that the success of blockchain implementation depends on the ability to address several design challenges, such as ensuring compatibility with existing systems, establishing trust among supply chain partners, and defining clear ownership and access rights. The paper provides practical insights into how these challenges can be overcome through the use of smart contracts, digital identities, and data sharing agreements.

Overall, the study highlights the potential of blockchain technology to enhance supply chain security and integrity, particularly in industries where counterfeiting is prevalent. The paper concludes with suggestions for future research, including the need for more extensive case studies and the exploration of the role of blockchain in fostering consumer trust and engagement in sustainable supply chains.

In conclusion, the paper by Danese et al. (2021) provides a valuable contribution to the literature on blockchain in supply chain management by offering insights into the use of blockchain technology to prevent counterfeiting in the wine industry. The study highlights the importance of addressing design challenges and provides practical guidance for implementing blockchain systems in supply chains. The findings suggest that blockchain technology has significant potential to enhance supply chain security and integrity and pave the way for more sustainable and transparent supply chains in the future.

4.“The impact of the blockchain on the supply chain: a theory-based research framework and a call for action” by Treiblmaier aims to develop a theory-based research framework to understand the impact of blockchain technology on supply chain management.The research framework presented in the study includes three major components: antecedents, mechanisms, and outcomes. Antecedents refer to the factors that influence the adoption of blockchain technology in the supply chain, such as organizational culture, IT infrastructure, and regulatory environment. Mechanisms refer to the ways in which blockchain technology can improve supply chain management, such as enhanced transparency, reduced transaction costs, and increased trust. Outcomes refer to the benefits that can be derived from using blockchain technology in the supply chain, such as improved efficiency, reduced fraud, and enhanced customer satisfaction.

The study highlights the potential of blockchain technology to transform supply chain management by providing a secure and transparent platform for tracking goods and services. The use of blockchain technology can enhance the traceability of products, reduce the risk of counterfeiting and fraud, and improve the efficiency of supply chain operations. The study also highlights the need for further research on the factors that influence the adoption of blockchain technology in the supply chain and the mechanisms through which this technology can improve supply chain management.

The study proposes a call for action for practitioners to explore the potential of blockchain technology in their supply chains. The study suggests that organizations should consider the unique features of their supply chains when deciding on the adoption of blockchain technology. Additionally, organizations should collaborate with other stakeholders in the supply chain to develop a shared understanding of the potential benefits of blockchain technology.

In conclusion, the study by Treiblmaier provides a useful framework for understanding the impact of blockchain technology on supply chain management. The study highlights the potential of blockchain technology to transform supply chain operations and improve efficiency, traceability, and transparency. The study also provides a call for action for practitioners to explore the potential of blockchain technology in their supply chains and collaborate with other stakeholders to realize the benefits of this technology.

5. "Blockchain technology in the supply chain: An integrated theoretical perspective of organizational adoption," by M. A. N. Agi and A. K. Jha provides an integrated theoretical perspective on the adoption of blockchain technology in the supply chain. The authors highlight the importance of this technology in enhancing the efficiency, transparency, and security of supply chain operations. The paper provides an overview of the characteristics of blockchain technology and its potential applications in the supply chain. The authors highlight the decentralized nature of blockchain technology, which makes it highly secure and resistant to tampering. They also discuss the potential benefits of blockchain technology in enhancing the traceability and visibility of supply chain operations.

The article then goes on to provide a comprehensive review of the existing literature on the adoption of blockchain technology in the supply chain. The authors analyze the different theoretical perspectives that have been used to understand the factors that influence the adoption of this technology, including the Technology Acceptance Model, the Innovation Diffusion Theory, and the Institutional Theory.

The authors argue that while these theories provide valuable insights into the adoption of blockchain technology in the supply chain, they are often used in isolation and do not provide a comprehensive understanding of the adoption process. To address this gap, the authors propose an integrated theoretical perspective that combines these theories to provide a more holistic understanding of the factors that influence the adoption of blockchain technology in the supply chain.

The authors highlight the importance of factors such as perceived usefulness, perceived ease of use, compatibility, complexity, trialability, observability, legitimacy, and social norms in shaping the adoption of blockchain technology in the supply chain. They argue that these factors are interrelated and influence each other, and therefore need to be considered together when examining the adoption process.

The authors conclude by providing some practical implications of their integrated theoretical perspective for organizations looking to adopt blockchain technology in the supply chain. They highlight the importance of understanding the needs and preferences of different stakeholders in the supply chain and tailoring the adoption strategy accordingly. They also emphasize the need for organizations to develop a clear vision and strategy for the adoption of blockchain technology and to invest in the necessary resources and infrastructure to support its implementation.

Overall, the article provides a valuable contribution to the literature on the adoption of blockchain technology in the supply chain. By integrating different theoretical perspectives, the authors provide a more comprehensive understanding of the factors that influence the adoption process, and provide practical implications for organizations looking to implement this technology in their supply chain operations.

6. "How TradeLens delivers business value with blockchain technology," by T. Jensen, J. Hedman, and S. Henningsson provides insights into the TradeLens blockchain platform and its impact on the global supply chain industry. The authors highlight the need for a more efficient and transparent supply chain system that can provide accurate tracking and documentation of goods as they move across borders. They argue that the traditional paper-based approach to tracking goods is outdated and prone to errors, leading to inefficiencies and delays in the supply chain.

The TradeLens blockchain platform was developed by IBM and Maersk to address these issues by providing a secure, transparent and efficient way of tracking goods in real-time. The platform uses distributed ledger technology to create a shared database that allows all participants in the supply chain to access and update information about the goods being transported. This includes information about the origin, destination, and status of the goods, as well as any necessary customs and regulatory documentation.

The authors provide several examples of how the TradeLens platform has delivered business value to its users. For example, by using the platform, one customs agency was able to reduce its processing time for import declarations from several days to just a few hours. Another user, a global shipping company, was able to reduce its documentation processing time by up to 90%.

The authors also highlight the challenges faced by the TradeLens platform, such as the need to overcome resistance from traditional stakeholders in the supply chain industry who are resistant to change. Additionally, there are issues around data privacy and security, as well as the need for interoperability between different blockchain platforms.

Overall, the authors argue that the TradeLens platform has the potential to revolutionize the global supply chain industry by providing a more efficient, transparent, and secure way of tracking goods. The platform has already delivered significant business value to its users, and its continued success will depend on its ability to overcome the challenges it faces and adapt to the evolving needs of the industry.

7. "Implementing Blockchain Technology in Supply Chain Management," by A. Anand, A. Seetharaman, and K. Maddulety provides a comprehensive overview of the potential impact of blockchain technology on supply chain management. The authors identify the inefficiencies in traditional supply chain management systems, such as data discrepancies, lack of transparency, and risk of fraud, and discuss how blockchain technology can address these issues.

The article explains the fundamentals of blockchain technology and its potential applications in supply chain management. The authors emphasize that blockchain's distributed ledger technology can provide a single source of truth that is transparent, immutable, and secure. This can help to reduce costs, increase efficiencies, and mitigate risks across the supply chain.

The article then provides an overview of the key features of blockchain technology that make it suitable for supply chain management, including decentralization, immutability, and smart contract capabilities.

The authors discuss how these features can be leveraged to create a secure and transparent supply chain system that reduces the potential for errors, fraud, and counterfeiting.They also highlight several challenges associated with the implementation of blockchain technology in supply chain management, including scalability, interoperability, and regulatory issues. They suggest that these challenges can be overcome by developing industry-wide standards, establishing governance frameworks, and fostering collaboration between stakeholders.

The article includes several case studies that demonstrate the potential of blockchain technology in supply chain management. One such case study involves Walmart's use of blockchain to track the origin of food products, which has helped to reduce the time and cost associated with tracing the source of contaminated food products. Another case study involves the use of blockchain technology by Maersk and IBM to streamline the global shipping industry, which has led to increased transparency and reduced transaction costs.

Overall, the article provides a detailed overview of the potential impact of blockchain technology on supply chain management. The authors highlight the potential benefits of using blockchain to create a secure, transparent, and efficient supply chain system, while also acknowledging the challenges associated with its implementation. The article is a valuable resource for academics, practitioners, and policymakers seeking to understand the potential of blockchain technology in supply chain management.

8. "Blockchain technology in supply chain management: an organizational theoretic overview and research agenda," by R. Manzoor, B. S. Sahay, and S. K. Singh provides a comprehensive overview of the use of blockchain technology in supply chain management (SCM). The authors utilize an organizational theoretic perspective to identify key issues and challenges related to the adoption of blockchain technology in SCM, as well as to develop a research agenda for future studies in this area.

The authors provides an overview of blockchain technology and its potential benefits for SCM, including increased transparency, traceability, and efficiency. They then identify three key issues that must be addressed for successful adoption of blockchain technology in SCM: organizational readiness, governance, and trust.

Organizational readiness refers to the level of preparedness of an organization to adopt blockchain technology in its SCM practices. The authors highlight the importance of aligning the technology with the organization's goals, culture, and resources, and of ensuring adequate training and support for employees.

Governance refers to the rules and regulations that govern the use of blockchain technology in SCM. The authors suggest that a collaborative approach to governance, involving multiple stakeholders such as regulators, suppliers, and customers, is necessary to ensure effective and efficient use of the technology.

Trust is a critical issue in blockchain-based SCM, as the technology relies on decentralized networks and peer-to-peer transactions. The authors discuss the importance of establishing trust among all parties involved in the supply chain, and suggest that blockchain technology can help build trust by providing a secure and transparent platform for transactions.

Based on these key issues, the authors develop a research agenda for future studies in the area of blockchain-based SCM. They suggest that future research should focus on developing a theoretical framework for understanding the organizational factors that influence the adoption and use of blockchain technology in SCM, as well as on exploring the impact of blockchain technology on supply chain performance and on the relationship between supply chain partners.

Overall, the paper by Manzoor, Sahay, and Singh provides a valuable contribution to the literature on blockchain technology in SCM by offering a comprehensive overview of the key issues and challenges related to its adoption and by developing a research agenda for future studies. The authors highlight the need for a collaborative and multidisciplinary approach to the adoption of blockchain technology in SCM, and suggest that further research is necessary to fully understand the potential benefits and challenges of this technology for supply chain management.

9. "Consensus protocols for blockchain-based data provenance: Challenges and opportunities," by D. K. Tosh, S. Shetty, X. Liang, C. Kamhoua, and L. Njilla explores the challenges and opportunities of using blockchain-based data provenance in various industries. The authors emphasize the need for consensus protocols to ensure the integrity and transparency of data stored on a blockchain network.The paper begins by discussing the importance of data provenance in ensuring the authenticity and credibility of data. The authors explain that data provenance is especially crucial in industries such as healthcare, finance, and supply chain, where the accuracy of data can have significant impacts. The authors then highlight the limitations of traditional data provenance systems and how blockchain technology can address these limitations.

The authors then dive into the technical details of consensus protocols and how they can be used in blockchain-based data provenance. The paper provides a comprehensive overview of different types of consensus protocols, including Proof of Work (PoW), Proof of Stake (PoS), and Practical Byzantine Fault Tolerance (PBFT). The authors discuss the advantages and disadvantages of each protocol and provide a comparative analysis of their suitability for different use cases.

Furthermore, the authors examine the potential opportunities of using consensus protocols in blockchain-based data provenance. They suggest that the use of consensus protocols can improve the transparency and accountability of data, enhance data sharing among different stakeholders, and reduce the risk of fraudulent activities.

Overall, the paper provides valuable insights into the challenges and opportunities of using consensus protocols for blockchain-based data provenance. The authors provide a comprehensive overview of the different types of consensus protocols and highlight their advantages and disadvantages. The paper also emphasizes the need for further research to address the challenges of scalability and energy consumption in consensus protocols.

SYSTEM ANALYSIS

Limitations of the existing system

1. Lack of transparency: The current supply chain systems often lack transparency, making it difficult to trace the origin of goods and monitor their journey through the supply chain. This can result in the loss of valuable data, as well as difficulties in identifying the source of any problems that may arise.
2. Inefficient processes: The traditional supply chain processes can be slow and inefficient, leading to long lead times and higher costs. The lack of automation and reliance on manual processes can result in delays in the delivery of goods, which can cause issues in meeting customer demand.
3. Data integrity issues: In many cases, supply chain data is stored in disparate systems that are not integrated, which can lead to data integrity issues and errors. This can result in inaccurate or incomplete data, making it difficult to make informed decisions.
4. Limited visibility: Companies often have limited visibility into the status of their supply chain, making it difficult to make informed decisions about inventory and resource allocation. This can result in inventory shortages, delays in delivery, and increased costs.
5. Counterfeit goods: Counterfeit goods are a significant problem in many supply chains, and it can be difficult to detect and prevent the distribution of these goods. This can result in lost revenue for legitimate businesses and pose risks to consumer safety.
6. Poor collaboration: Collaboration between supply chain partners can be poor, leading to inefficiencies and missed opportunities for cost savings. Communication and coordination issues can lead to delays, quality issues, and increased costs.
7. Human error: Traditional supply chain processes are often prone to human error, which can lead to inaccuracies and mistakes in the supply chain. These errors can result in lost or damaged inventory, delivery delays, and increased costs.
8. Vulnerability to cyber-attacks: Supply chain systems can be vulnerable to cyberattacks, which can disrupt operations and compromise sensitive information. These attacks can result in the theft of valuable data, lost revenue, and reputational damage.

Overall, these limitations can lead to increased costs, decreased efficiency, and decreased customer satisfaction. Implementing a blockchain-based supply chain system can help address many of these issues by improving transparency, automating processes, improving data integrity, and enhancing collaboration between supply chain partners.

Advantages of proposed system

Real-time tracking and tracing of goods: The platform can enable real-time tracking of goods from the raw material stage to the end-user, making it easier for supply chain stakeholders to keep track of the movement of goods.

Increased transparency: The decentralized nature of blockchain technology makes it possible to create a tamper-proof record of transactions, providing increased transparency in supply chain operations.

Improved efficiency: By digitizing shipping documentation and enabling realtime data sharing between supply chain stakeholders, the platform can help to reduce delays, increase efficiency, and minimize the risk of errors.

Reduction in fraud: The blockchain-based platform can help to reduce the risk of food fraud, counterfeit products, and other types of supply chain fraud by creating a digital record of the journey of goods that is difficult to manipulate.

Verification of authenticity and sustainability: The platform can provide consumers with greater transparency and confidence in their purchases by enabling them to verify the authenticity, origin, and sustainability of products.

Secure data sharing: The platform can allow for secure and private sharing of data between supply chain stakeholders, enabling them to share sensitive information with each other without having to worry about data breaches or theft.

Improved supply chain visibility: The platform can improve overall supply chain visibility by enabling all stakeholders in the shipping process to share and access data in real-time.

Enhanced supply chain collaboration: The blockchain-based platform can facilitate greater collaboration between supply chain stakeholders, leading to increased efficiency, reduced costs, and improved customer service.

Improved inventory management: The real-time tracking and tracing of goods can help companies to better manage their inventory levels, reducing the risk of stockouts or overstocking.

Increased consumer trust: The ability to verify the authenticity, origin, and sustainability of products can increase consumer trust in the brand, leading to higher customer loyalty and repeat business.

Reduced waste: The platform can help to reduce waste in the supply chain by enabling better inventory management, reducing the risk of spoilage or obsolescence.

Enhanced regulatory compliance: The blockchain-based platform can help companies to comply with regulations related to food safety, environmental sustainability, and labor standards by providing a tamper-proof record of compliance.

Improved supply chain financing: The real-time data sharing and transparency provided by the platform can enable better supply chain financing by providing banks and other lenders with greater visibility into the supply chain.

Faster dispute resolution: The platform can facilitate faster and more efficient dispute resolution by providing a transparent record of transactions that can be easily audited.

Overall, the proposed blockchain-based platform has the potential to transform supply chain management by providing increased transparency, efficiency, and collaboration. By leveraging cutting-edge technologies like blockchain, node.js, and AngularJS, the platform can help companies to overcome the limitations of existing supply chain systems and unlock new opportunities for growth and innovation.

Feasibility Analysis

Economic feasibility analysis is an important aspect of evaluating the cost-effectiveness of a proposed project, and it is critical to consider the hardware and software requirements for developing a decentralized supply chain web-app using blockchain. The hardware requirements for the development platform include a computer system with sufficient processing power and memory, a high-speed internet connection, and a reliable backup system. The software requirements include a stable operating system, a code editor, a development environment such as Node.js, and a blockchain platform such as Hyperledger Composer or Ethereum.

To perform an economic feasibility analysis, it is important to assess the potential benefits and drawbacks of the project, as well as the expected costs and revenues. For example, the benefits of using a decentralized supply chain web-app include improved efficiency, transparency, and security. However, the costs associated with development and deployment, as well as ongoing maintenance, must be balanced against these benefits to determine the overall economic feasibility of the project.

On the deployment platform side, hardware requirements include a server with medium processing power, storage capacity, and sufficient memory. These servers must be reliable and secure, with backup and disaster recovery mechanisms in place. The software requirements for deployment include a stable operating system, a blockchain platform, and a web server such as Apache or Nginx.

In terms of cost, the hardware and software requirements can significantly impact the overall budget of a project, during production. The cost of hardware depends on the specific components and their specifications, while the cost of software depends on the licensing fees and the number of users. In addition, the cost of maintenance and upgrades must also be considered. For our project, since we will be running both the software & hardware in the same device for testing purposes, our cost incurred in this process will be equivalent to null, since we already have capeable hardware.

In conclusion, the economic feasibility analysis of development and deployment platform requirements is an important aspect of any blockchain development project. It helps in determining the viability of the project and assists in making informed decisions regarding the choice of hardware and software.

SYSTEM DESIGN AND ARCHITECTURE

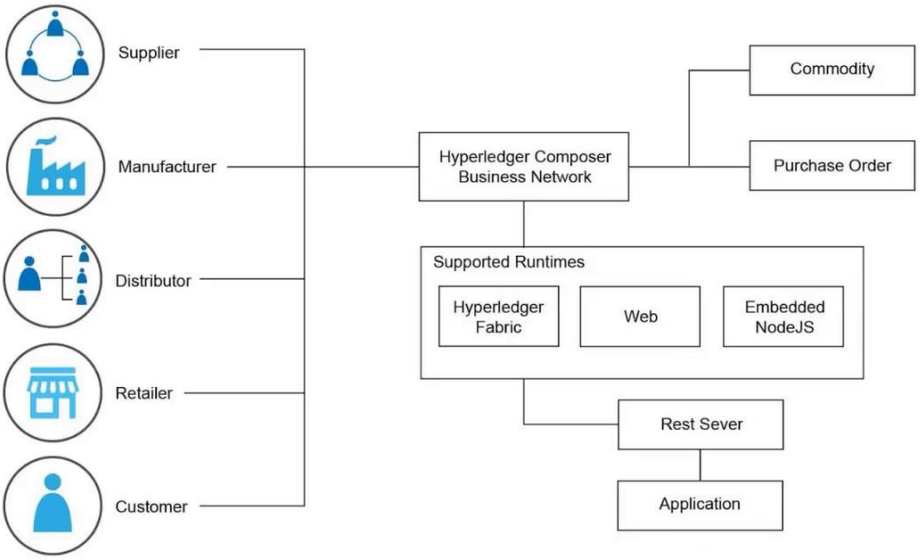

Figure 3: The system design.

Participants: The system includes five participants in the supply chain:

Supplier: Provides the raw materials or finished goods to the manufacturer

Manufacturer: Receives raw materials from the supplier and manufactures finished goods

Distributor: Distributes the finished goods to retailers or wholesalers

Retailer: Sells the finished goods to consumers

Consumer: Buys the finished goods from the retailer

Assets: There are two main assets in the system:

Commodity: Represents the finished goods that are being transferred in the supply chain

Purchase Order: Represents the order for the commodity that is initiated by a participant

Transactions:

Initiate Purchase Order: When a participant initiates a purchase order, a new asset is created under Purchase Order. This entry includes the details of the ordered items, their supporting accessories, the supplier, and other relevant information.

Transfer Commodity: When this transaction is called, a new owner is assigned to the commodity based on the stage of the supply chain. This transaction is called against the Purchase Order.

Business Network Structure:

The business network structure includes all the initial participants in the supply chain. This structure is defined and archive files are generated for it using Hyperledger Composer.

The business network is deployed over a runtime environment, which includes Hyperledger Fabric, web, and embedded NodeJS for convenient access by the stakeholders.

REST Server and API:

A REST server is generated to create APIs that can be utilized with the front-end application.

The API endpoints allow the participants to interact with the blockchain-based supply chain system and access the relevant information.

Front-end Application:

With the help of the Composer CLI, the final front-end application is generated, which combines all utility APIs and provides the information requested based on the participant's role.

The front-end application allows the participants to view the status of the commodity, track its progress through the supply chain, and access other relevant information.

The proposed system includes five participants, namely supplier, manufacturer, distributor, retailer, and consumer. The system is designed to track the movement of two primary assets, namely commodity and purchase order. The two primary transactions in the system include "Initiate Purchase Order" and "Transfer Commodity."

The first transaction, "Initiate Purchase Order," is initiated by the participant who needs to place an order for a commodity. This transaction results in the creation of a new asset under the Purchase Order category, including the details of the commodity, supporting accessories, and supplier information.

The second transaction, "Transfer Commodity," is initiated when a participant needs to transfer the ownership of the commodity to the next participant in the supply chain. This transaction is called against the Purchase Order and results in a new owner being assigned to the commodity based on the current stage in the supply chain.

The proposed system is based on a decentralized network architecture that consists of a series of nodes that communicate with each other using a peer-to-peer protocol. Each node in the network stores a copy of the blockchain ledger, which records all the transactions that take place on the network. The blockchain ledger ensures that the data stored on the network is immutable, transparent, and secure.

The system is built using the Hyperledger Composer framework, which offers a set of collaboration tools for building blockchain-based business networks. The Composer framework enables the developers to create smart contracts and blockchain applications that can solve business problems.

The proposed system architecture includes five main components, including the Composer REST server, the Hyperledger Fabric network, the Node.js server, the frontend application, and the user interface. The Composer REST server provides an API layer for the frontend application, enabling it to interact with the blockchain network. The Hyperledger Fabric network acts as the backbone of the system, enabling the nodes to communicate with each other and store the blockchain ledger. The Node.js server provides a backend for the frontend application, enabling it to access the Composer REST server and the Hyperledger Fabric network.

The frontend application is the main user interface of the system, enabling the participants to interact with the blockchain network and perform various transactions. The frontend application is built using the Angular framework, which provides a rich set of features and tools for creating modern web applications.

In summary, the proposed blockchain-based supply chain management system is designed to enhance the efficiency and reliability of the existing supply chain. The system is built using the Hyperledger Composer framework and is based on a decentralized network architecture that consists of a series of nodes that communicate with each other using a peer-to-peer protocol.

SYSTEM REQUIREMENTS

Hardware configuration Deployment Platform

Processor: Intel i7 or equivalent
Memory (RAM): 16GB or more
Storage: 250 GB or more solid-state drive (SSD)
Operating System: Windows 10 or later, MacOS X 10.12 or later, or a Linux distribution
Network: A stable and fast internet connection

Development Platform
Processor: Intel Core i5 or equivalent
Memory: 8 GB RAM
Storage: 250 GB hard disk
Operating System: Ubuntu Linux 14.04 or Mac OS X 10.12.6 or higher o Internet connection

Software configuration Deployment Platform

Node.js and NPM (Node Package Manager): npm v3 to be installed, & node accordingly. o Yeoman generator: You can install it using the NPM command: npm install -g yo o Hyperledger Composer: You can install it from the official Hyperledger Composer website.
Yeoman generator for Hyperledger Composer: You can install it using the NPM command: npm install -g generator-hyperledger-composer
Internet connectivity: You need to have an active internet connection to install the required dependencies and packages.
Web Browser: A modern web browser like Google Chrome, Firefox or Safari, for testing and debugging the REST API.

Development Platform
Docker Engine: Version 17.03 or higher
Docker-Compose: Version 1.8 or higher.
Node: v6.x (Note: v7 is not supported).
npm: v3.x or v5.x
git: 2.9.x or higher
Python: 2.7.x
VS Code or Hyperledger Composer Playground

IMPLEMENTATION

The following are the primary modules and resources used:

Hyperledger Fabric: This is a blockchain platform that allows for the creation of decentralized applications. It is a modular architecture that allows for flexible deployment and consensus mechanisms. In this project, it will be used as the underlying blockchain platform to store and manage the supply chain data.

Hyperledger Composer: This is a development tool that allows for easy creation of blockchain applications. It provides a set of abstractions to define assets, transactions, participants, and access control rules. In this project, it will be used to define the business network structure, create smart contracts, and deploy the application to the blockchain.

Node.js: This is a popular server-side JavaScript runtime environment that allows for the creation of scalable and high-performance applications. In this project, Node.js will be used to develop the backend application that interacts with the Hyperledger Fabric network. Specifically, Node.js will be used with the Hyperledger Composer framework to create business network models, define transaction logic, and define access control rules.

Node.js will also be used to generate a RESTful API for the business network using the Composer REST Server. The REST server provides a convenient way to interact with the blockchain network through a standardized API. This API can be accessed by any application that can make HTTP requests, such as a web application or a mobile application.

Furthermore, Node.js can be used to develop the front-end application, which will consume the REST API to display the relevant information to the user. The front-end application can be developed using any popular web framework, such as React or Angular, which can communicate with the REST API and display the information in a user-friendly manner.

AngularJS: This is a popular front-end JavaScript framework that allows for the creation of dynamic and responsive web applications. In this project, it will be used to create the user interface for the supply chain application.

The Angular components can be used to represent different parts of the user interface, such as the login page, dashboard, purchase order form, and commodity transfer form. The templates can be used to define the layout and structure of the components, while the services can be used to handle the business logic of the application.

The Angular application can communicate with the blockchain network through the REST API exposed by the Composer REST server. The application can use the API to fetch data from the blockchain, submit transactions, and listen for blockchain events.

Docker: This is a containerization platform that allows for easy deployment and management of applications. In this project, it will be used to create a containerized environment for the Hyperledger Fabric and Hyperledger Composer.

Docker provides an easy-to-use interface for building, packaging, and deploying applications using containers. Docker containers are based on images, which are lightweight, read-only templates that contain everything needed to run an application, including the code, runtime, system tools, libraries, and settings.

By using Docker, developers can build and test applications locally in a consistent environment and then package them into Docker images that can be easily shared and deployed to other environments without any changes.

In the context of the supply chain project using blockchain, Docker is used to create a development environment for building and testing the blockchain network. It is used to set up the necessary dependencies and tools, including the Hyperledger Fabric runtime environment, Node.js, and other required software components, in a containerized environment that is isolated from the host system. This ensures that the development environment is consistent and can be easily reproduced across different machines and environments.

Composer REST Server: The Composer REST server is a component of the Hyperledger Composer framework that allows developers to expose their business networks as RESTful APIs. This means that clients can interact with the blockchain network by sending HTTP requests to the REST server, which in turn communicates with the blockchain network and returns the appropriate response to the client.

The Composer REST server provides a simple way for web applications and mobile apps to interact with the blockchain network, without having to deal with the complexity of the blockchain technology. It generates a set of APIs that expose the assets, transactions and participants of the business network. These APIs can be accessed through a web browser or integrated into an application using client-side JavaScript libraries or other programming languages.

To use the Composer REST server, the developer first deploys their business network on a Hyperledger Fabric blockchain network. They then start the REST server and configure it to connect to the blockchain network. Once the REST server is running, the developer can interact with the blockchain network by sending HTTP requests to the server's endpoints.

Overall, the Composer REST server simplifies the process of building blockchain applications by providing a standardized interface that developers can use to interact with the blockchain network.

Usage and workings

Installation of Node.js, Docker, and Hyperledger Composer on the development environment.

Defining the business network structure using Hyperledger Composer. This involves defining the assets, transactions, participants, and access control rules. we can use the Composer Playground to experiment with the business network definition.

Creating the smart contracts using Hyperledger Composer. This involves writing the transaction logic in JavaScript and defining the queries that will be used to retrieve data from the blockchain.
Deploying the business network to the blockchain using Hyperledger Composer. This involves creating a business network archive file and deploying it to the Hyperledger Fabric network.
Creating the REST API using the Composer REST Server. This involves configuring the REST API endpoints and securing them using access control rules.

Create the user interface using AngularJS. This involves creating the views, controllers, and services that will interact with the REST API to retrieve and display data.

Deploying the application using Docker. This involves creating a containerized environment for the Hyperledger Fabric and Hyperledger Composer, and deploying the REST API and front-end application to separate containers.

RESULTS & OUTPUTS

CONCLUSION AND FUTURE ENHANCEMENTS

In conclusion, the blockchain-based supply chain system presented in this project provides a secure, transparent, and efficient way of tracking commodities through the entire supply chain process. The system provides participants with a single source of truth that is accessible to all authorized parties, enabling them to verify the authenticity of goods and their origin. The use of smart contracts automates processes such as purchase orders, transfers of commodities, and payments, improving efficiency and reducing the risk of errors or fraud. The use of blockchain technology also enhances data security and privacy, ensuring that sensitive data remains confidential and immutable.

Future Enhancements:

There are several ways in which this blockchain-based supply chain system can be enhanced in the future. Firstly, the system can be integrated with other emerging technologies such as Internet of Things (IoT) sensors and Artificial Intelligence (AI) to enable more accurate and real-time tracking of goods. For example, IoT sensors can be used to track the temperature and humidity of perishable goods, ensuring that they are transported under the optimal conditions. Similarly, AI algorithms can be used to predict demand for commodities and optimize supply chain processes, reducing costs and improving efficiency.

Secondly, the system can be extended to include more participants in the supply chain process, such as customs officials and regulators, to ensure compliance with regulations and prevent fraud. By including these additional participants, the blockchain-based supply chain system can become a more robust and transparent system that provides value to all stakeholders.

Finally, the system can be extended to include more complex smart contracts that support more complex business processes. For example, the smart contracts can be designed to support escrow agreements or provide financial incentives for participants that meet certain performance metrics. These enhancements will make the system more versatile and flexible, allowing it to support a wider range of use cases and industries.

Usage:

The blockchain-based supply chain system presented in this project can be used in a wide range of industries, including food and beverage, pharmaceuticals, and electronics. For example, in the food and beverage industry, the system can be used to track the origin and authenticity of perishable goods, ensuring that they are transported under the optimal conditions and comply with health and safety regulations.

In the pharmaceutical industry, the system can be used to track the entire supply chain of drugs, from manufacturing to distribution, to ensure that they are authentic and have not been tampered with. Similarly, in the electronics industry, the system can be used to track the origin of electronic components and prevent counterfeit products from entering the supply chain.

Overall, the blockchain-based supply chain system presented in this project provides a secure, transparent, and efficient way of tracking commodities through the entire supply chain process. The system provides a single source of truth that is accessible to all authorized parties, enabling them to verify the authenticity of goods and their origin. With the potential for future enhancements and widespread usage, this system has the potential to revolutionize supply chain management across a wide range of industries.

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