An online blockchain based sustainable logistics management system (OBSLMS) enabled by the Internet of Things for the textile industry

DOI: 10.35530/IT.074.06.202364

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ABSTRACT – REZUMAT

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Blockchain technology and IoT have been beneficial for information sharing, supply-chain management, product tracking and device control in multiple fields. Now, their combined potential has become an emerging concept, one that can be implemented in the textile industry. In most cases, textile industries are the backbone of the economy of a country. The major textile fibres are cotton, jute, wool, silk, bamboo, linen, etc. In theory, the fibre producers' profit and their products' market price may vary depending on the fibre's demand, aggregate supply and the current market structure. But, in real-life textile markets, intermediaries between the producers and buyers lead to significant decreases in the producers' profit. This results in the producer incurring losses and not being able to get back their initial investments as revenue. This research paper aims to provide a solution to the above-stated critical issue. In this paper, we have proposed an Online Blockchain-based Sustainable Logistics Management System (OBSLMS) for textile businesses. The implementation mechanism of the OBSLMS consists of blockchain based business transactions, an IoT based GPS tracking system and a unique QR (Quick Response) code verification for the endpoint delivery of textile fibres from producers to buyers. This sustainable solution also has a bidding feature. Moreover, OBSLMS has been programmed, implemented and tested. The OBSLMS uses the availability and efficiency of the openly available online platform, blockchain technology and IoT to help both the textile fibre producers and the buyers gain a fair profit.

Keywords: *bidding, blockchain, business transaction, online platform, tracking, verification*

Un sistem online de management al logisticii durabile bazat pe blockchain (OBSLMS) disponibil prin internetul obiectelor (IoT) pentru industria textilă

Tehnologia blockchain și IoT au fost foarte utile pentru partajarea informațiilor, managementul lanțului de aprovizionare, urmărirea produselor și controlul dispozitivelor în mai multe domenii. Acum, potențialul lor combinat a devenit un concept în curs de dezvoltare, unul care poate fi implementat în industria textilă. În cele mai multe cazuri, industria textilă reprezintă coloana vertebrală a economiei unei țări. Principalele fibre textile sunt bumbacul, iuta, lâna, mătasea, bambusul, inul etc. În teorie, profitul producătorilor de fibre și prețul de piață al produselor lor pot varia în funcție de cererea de fibre, de oferta agregată și de structura actuală a pieței. Dar, pe piețele textile reale, intermediarii dintre producători și cumpărători duc la scăderi semnificative ale profitului producătorilor. Astfel, producătorul înregistrează pierderi și nu își poate recupera investițiile inițiale ca venituri. Această lucrare de cercetare își propune să ofere o soluție la problema critică menționată mai sus. În această lucrare, am propus un sistem online de management al logisticii durabile bazat pe blockchain (OBSLMS) pentru întreprinderile textile. Mecanismul de implementare al OBSLMS constă dintr-o tranzacție comercială bazată pe blockchain, un sistem de urmărire GPS bazat pe IoT și o verificare unică cu cod QR (răspuns rapid) pentru livrarea de fibre textile de la producători la cumpărători. Această soluție durabilă are și o funcție de licitare. Mai mult, OBSLMS a fost programat, implementat și testat. OBSLMS folosește eficiența platformei online disponibile în mod deschis, tehnologia blockchain și IoT pentru a ajuta atât producătorii de fibre textile, cât și cumpărătorii să obțină un profit echitabil.

Cuvinte-cheie*: licitare, blockchain, tranzacție comercială, platformă online, urmărire, verificare*

INTRODUCTION

As stated in the abstract, the textile industry is vital for the world to function. Factually speaking, it is the traditional occupation for many people from all around the world. The textile fibre producers provide raw materials such as cotton, jute, wool, silk, bamboo, linen, etc., to many textile industries. Depending on the hard work of the producers, the profit they gain from selling their products to buyers might vary. One of the major limitations of the existing textile business system is the lack of transparency in business transactions. With intermediaries involved in a majority of the business dealings, it can be difficult for producers and buyers to know the original price of fibre products. As mentioned earlier, intermediaries often take a significant part of the profits on the fibre products as commission, which results in higher costs for buyers and lower profits for producers. This might create a financial burden for producers and may demotivate them from expanding production. Another limitation of the existing system is the tracking and proof of endpoint delivery of textile fibre products.

The textile sector may experience a transformation to blockchain technology. Producers and buyers can communicate directly with one another utilizing blockchain technology, eliminating the presence of intermediaries. Additionally, it can increase efficiency, lessen fraud, reinforce security, and promote producer-to-buyer transparency. According to Hakius and Petersen, the significant features of blockchain are distributed, verified, immutable and provide peer-to-peer system services with no dependency on centralized authority. The transactions between peer-end systems are also secured with public-private key cryptography and are maintained in immutable blocks [1]. The blocks are not easily tampered with because of the 51% attack rule [2]. The Internet of Things [IoT] is used to integrate the Global Positioning System (GPS) with Google API [3] and to generate a unique Quick Response (QR) code for allocating a unique identity for fibre products based on the transaction.

The OBSLMS aims to impart sustainable supply chain processes ranging from raw materials supply to transformation processes like storing, bidding, transaction, packing, distribution and management. The data of producers and buyers, as well as their communication details, are maintained in this sustainable system. The business transactions are maintained under the Ethereum public blockchain. This system also enables tracking through GPS and provides proof of endpoint delivery through a QR code, thus helping to improve fibre product safety and legitimacy. This proposed approach will be beneficial to the large community of producers & buyers, and will also provide a more user-friendly interface for interactions between them, through an online platform that runs based on the blockchain and IoT.

RELATED WORK

Recently, it has been widely agreed that the applications of blockchain and IoT in textile industries reduce the burden of business transactions and logistics management. The potential benefit of blockchain and IoT has previously been reaped in various domains such as agriculture, healthcare, production engineering, and education. Logistics management in the textile industry is a very tedious process in terms of business transactions and endpoint delivery. Currently, many large-scale textile producers or businesses establish their trademarks to sell their fibre products to respective buyers on an agreement basis to ensure that they earn more return on investment. However ordinary fibre producers are forced to rely upon centralized or government-based regulatory bodies and intermediaries to sell their products. This kind of logistics management is not transparent, not secure and not profitable. It negatively impacts the producers' profit. This research paper mainly focuses on addressing these issues to provide transparency, security and faithful endpoint delivery through the OBSLMS.

The results of Nosirova [4] highlighted the application of blockchain in the textile industry by integrating information sharing and supply chain traceability with production and marketing activities. Agrawal et al. [5] mentioned the challenges and limitations of blockchain based traceability systems. ElMessiry et al. [6] proposed a blockchain-based framework for textile quality improvement and supply chain management. Agrawal et al. [7] gave the operational mode of blockchain based framework for supply chain traceability in the textile and clothing industry. They explained how information is exchanged between supply chain stakeholders. Tripathi et al. [8] discussed briefly the opportunities and challenges of blockchain technology in the fashion industry.

Ülkü et al. [9] gave the system dynamics modelling for the textile industry for sustainable cotton production logistics. They investigated the likelihood of environmental and operational risks and their impacts in four aspects such as variable costs, fixed costs, quality performance, and yield. Zimon and Domingues [10] have provided the guidelines for sustainable supply chain management in the textile industry in terms of internal decision-making, external decision-making, choice of strategy and resource allocation. The results of Rajagopal et al. [11] indicated that by following the capabilities of logistics such as organizational flexibility and customer service rather than cost leadership and organizational performance, a positive impact is acquired.

Helo & Hao [12] presented the blockchain model and implementation architecture for supply chain management. However, they have not clearly explained the step-by-step implementation process of the application with the list of required software in an online platform. Saberi et al. [13] discussed about sustainable supply chain management through blockchain technology and its relationships. Narayanan et al. [14] gave an introduction to the technical and economic aspects of cryptocurrencies. They also covered topics such as cryptography, mining, transaction processing, and blockchain governance. Zohar [15] discussed an in-depth technical overview of the Bitcoin protocol, including its peer-to-peer network, consensus mechanism, and transaction processing.

Kshetri [16] discussed a systematic review of the integration of blockchain and IoT in supply chain management. The author discussed the potential benefits and challenges of using blockchain and IoT together in the supply chain process. They also identified the current research gaps and future research directions. Buterin [17] introduced Ethereum, a decentralized platform for building smart contracts and decentralized applications. He also described the technical features of Ethereum, including its virtual machine, programming language, and consensus mechanism. Xu et al. [18] provided blockchain solutions for green technology in the coordination of a supply chain with an online platform. Faridi et al. [19] proposed a product traceability system with blockchain and IoT. This system could facilitate all stakeholders involved in the supply chain. Pal [20] proposed a solution for transaction services in apparel business supply chain networks with blockchain-based architecture and IoT.

ARCHITECTURE OF THE OBSLMS

The purpose of the OBSLMS is to reduce the reliance on intermediaries and to improve the efficiency of logistics management. It provides a sustainable architecture for textile businesses with verified endpoint delivery of fibre products between producers and buyers. The significant features of the OBSLMS are: the implementation of bidding activity for selling fibre products without any intermediaries; GPS-based tracking facility and conversion of business transaction details into QR codes that can be scanned by buyers, providing them with proof of endpoint delivery of fibre products. Figure 1 illustrates the block diagram of the OBSLMS. The producers produce textile fibres and store them in the warehouse. Then they register their personal and business details on the OBSLMS website. The buyers also register their details on the same website.

The producers auction their textile fibres to the buyers through the bidding activity. The winner of the bidding is selected through an automated target CPA algorithm. Then, the business transactions between producers and the chosen buyer could occur transparently in the blockchain network through smart contracts. The business transactions are stored in a block under the blockchain network securely. After the completion of the business transaction, the textile fibre product can be delivered to the buyer with GPS tracking and QR code verification features of IoT.

Scope and objectives

- Eliminate the intervention of intermediaries
- Provide transparency in business activities
- Increase the profit of producers
- Enable security for the private data of producers and buyers
- User-friendly online system and verified endpoint delivery
- Increase the ease of maintenance for inventory details about textile fibres.

EXPERIMENTAL

Experimental setup

The technical architecture of OBSLMS was designed, developed and implemented through an online platform and open-source software. The blockchain network used in the OBSLMS is permissionless. It is used to develop a decentralized system at commodity prices. This architecture is comprised of four layers as shown in figure 2. This layered architecture is more compatible with the sustainable logistics management system. The layers are as follows:

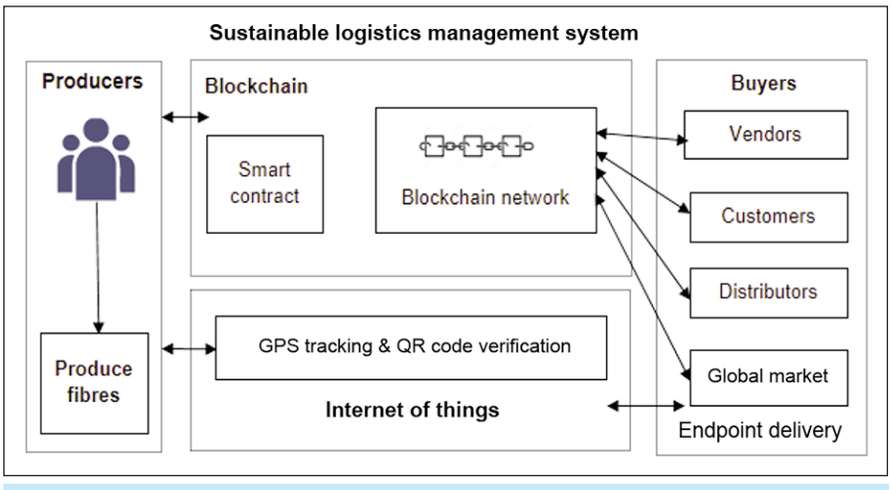

Fig. 1. Block diagram of the OBSLMS

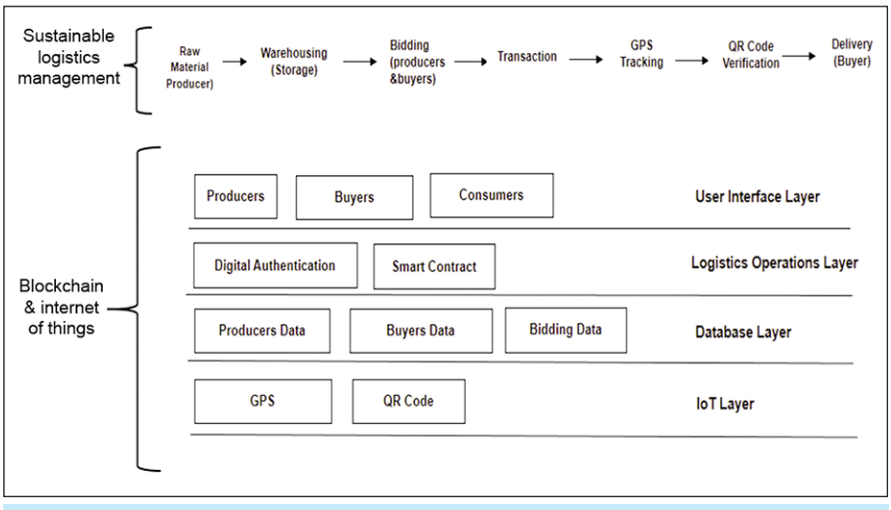

Fig. 2. Layered architecture of the OBSLMS

- **User interface layer** – The top layer is the user interface layer. This layer includes various logistics operators like producers, buyers and customers. Each operator can perform various logistics operations transparently. It is a front end.
- **Logistics operations layer** – The second layer is the logistics operations layer. The cryptography-based digital identity is used to verify the authorities involved in the transaction. The smart contract is a solidity program that can define the business logic and assess the buyers involved in the transaction. It is also used to connect the front end with the back end.
- **Database layer** – The third layer is the database layer. It is used to store producers' data, buyers'

data, bidding data and logistics management information. The data in this layer is processed to improve the efficiency of the sustainable logistics management system and acts as an inventory system for fibre products. The business transaction details are stored in a block that is immutable under the Ethereum public blockchain network. It acts as a back end for the OBSLMS.

- **IoT layer** – The bottommost layer is the IoT layer. The IoT devices enable the tracking of textile fibre products with verified endpoint delivery to provide safety and authorized delivery.

Software, tools and framework used for implementation of OBSLMS

- **Ganache** – Ganache CLI in OBSLMS is a local public blockchain environment for testing and developing smart contracts before deploying them to the Ethereum main net.
- **Django** – Django, a web framework written in Python, is widely used for building web applications. It follows the Model-View-Template (MVT) architecture, which separates the business logic, user interface, user input and output management, making it easy to build complex applications.
- **Solidity programming** – Solidity and solc are powerful tools for developing smart contracts on the Ethereum blockchain. The solc compiler generates an Application Binary Interface (ABI) and a byte code (BIN) file that is used to deploy the contract to the blockchain. It then uses these files to deploy the contract to the blockchain using a tool like Web3.py.
- **Web 3** – Web3.py is a Python library used for interacting with the Ethereum blockchain. It allows developers to build applications that can read data from and send transactions to the Ethereum network.
- **Python 3** – In the OBSLMS, python was used to create the backend server to handle HTTP requests and responses. Python's smtplib was used to send emails. Overall, Python has been a crucial component of the OBSLMS, enabling the creation of a robust and scalable backend server that interacts with the Ethereum blockchain.
- **AJAX** – It is a powerful technique used in web development, and to send data from the HTML frontend to the Python backend without the need for a page refresh.
- **FireBase** – Firebase is a cloud-based platform that provides a suite of tools and services for building web and mobile applications. It offers real-time database, authentication, hosting, cloud storage, and many other features.
- **HTML & CSS** – HTML (Hypertext Markup Language) is the standard markup language used to create web pages. CSS (Cascading Style Sheets) is a style sheet language used to add style and layout to web pages. It provides a visual appearance of HTML elements.

IMPLEMENTATION DETAILS

Web page design details of OBSLMS

The homepage of OBSLMS has quick navigation for all the mandatory links and it mainly contains the newsroom. The producer and buyer registration page collects details such as name, password, email, business ID, location and Aadhar number. The registration data of both the producer and the buyer are stored in FireBase. The producer and buyer login pages are validated from already stored authentication information in the database with Django and FireBase. The producer dashboard is the main interface for the registered producers to manage their accounts, inventory and orders received from buyers. It provides the producers with analytics on their business sales and revenue trends. The buyer dashboard is used to view the available fibre products and to participate in the bidding process. After logging in, the buyer is presented with the list of currently available fibre products with their descriptions and the minimum bid price set by the producers. The bidding page is designed to operate in full-screen mode, which allows users to focus solely on the bidding process without any distractions. One of the key features of OBSLMS is its live updating functionality, which allows users to view real-time updates on the bidding process. The bidding is automated with a target CPA algorithm which is a smart bidding strategy that delivers the best results at every auction. This is implemented using Python's Google APIs. The transaction page is deployed in the Ethereum public blockchain network through Ganache CLI. Application Binary Interface and Byte codes will be generated in the solidity compiler. They are connected through the Web3 module, through which the transaction is performed. It has modules such as the mail module, QR code generation module and GPS location tracking module. In the mail module, the transaction links and the QR codes are being shared through email. The QR code generation module generates a QR code based on each business transaction hash value. This contains information such as the amount, quantity, buyer name, and producer name and business transaction address. This QR code is used to verify the authenticity of the buyer and the fibre products during endpoint delivery.

Procedural steps for technical implementation architecture of the OBSLMS

The technical implementation architecture of the OBSLMS is shown in figure 3.

Sustainable Logistics Management

1. Create HTML files for the following: registration pages, login pages, dashboard pages for both producer and buyer and then a bidding page.
2. Now configure the Django server with the HTML files
3. Configure FireBase with the requirements
4. Configure FireBase with the Django server
5. Configure the settings file for the server and set the debugging options as False

6. Create the appropriate function for each HTML file in the views.py file and alter the urls.py with the corresponding namespace
   6.1. For data on the registration Page: Get data from the page and upload it to FireBase
   6.2. For data in Login Page: Validate the credentials by data==data in FireBase
   6.3. For adding an action in the producer Dashboard: Upload the data of the item in FireBase, in Nosql format
   6.4. For each product in "Items of Producer": Display to the buyer for bidding with necessary actions
   6.5. For each action on the bidding page: Update the values in the database and also display them in HTML
   6.6. For data on the verify page, decode the data using the decryption algorithm
7. Configure the mail server with the Django views function to send a mail to the buyer
8. Create the QR code display function using the QR code module for each bid winner in the bidding list, mail sent to the buyer with a link for the transaction and after successful completion of payment.

Blockchain

1. Start the blockchain server in the (Ganache-CLI)
2. Configure the blockchain server with Django views.py using the web3 module
3. Wait for the invoking of payment from the buyer
   3.1. If paymentInvoked () ==True:
   If amount < walletAmount:
   ProceedTransaction () else: Throws Error
   3.2. If paymentSuccess () ==True: Create, and store the block in the blockchain network
   else: Return "Error in payment"
   3.3. Return the transaction hash to the Django server and display it on the webpage

Internet of Things

1. Once the transaction is complete, Invoke genQR()
2. Copy the text scanned from the QR code using a scanning application and verify through the webpage
3. Manage the order through the GPS tracking (link attached in QR).

Workflow of the OBSLMS

The workflow of OBSLMS is illustrated in figure 4. The textile fibre producers could register their data on the OBSLMS textile business website, likewise, buyers also register their data on the same website. All of the data will be stored in the database. The producers produce fibres and then publish the details of those fibres on this system.

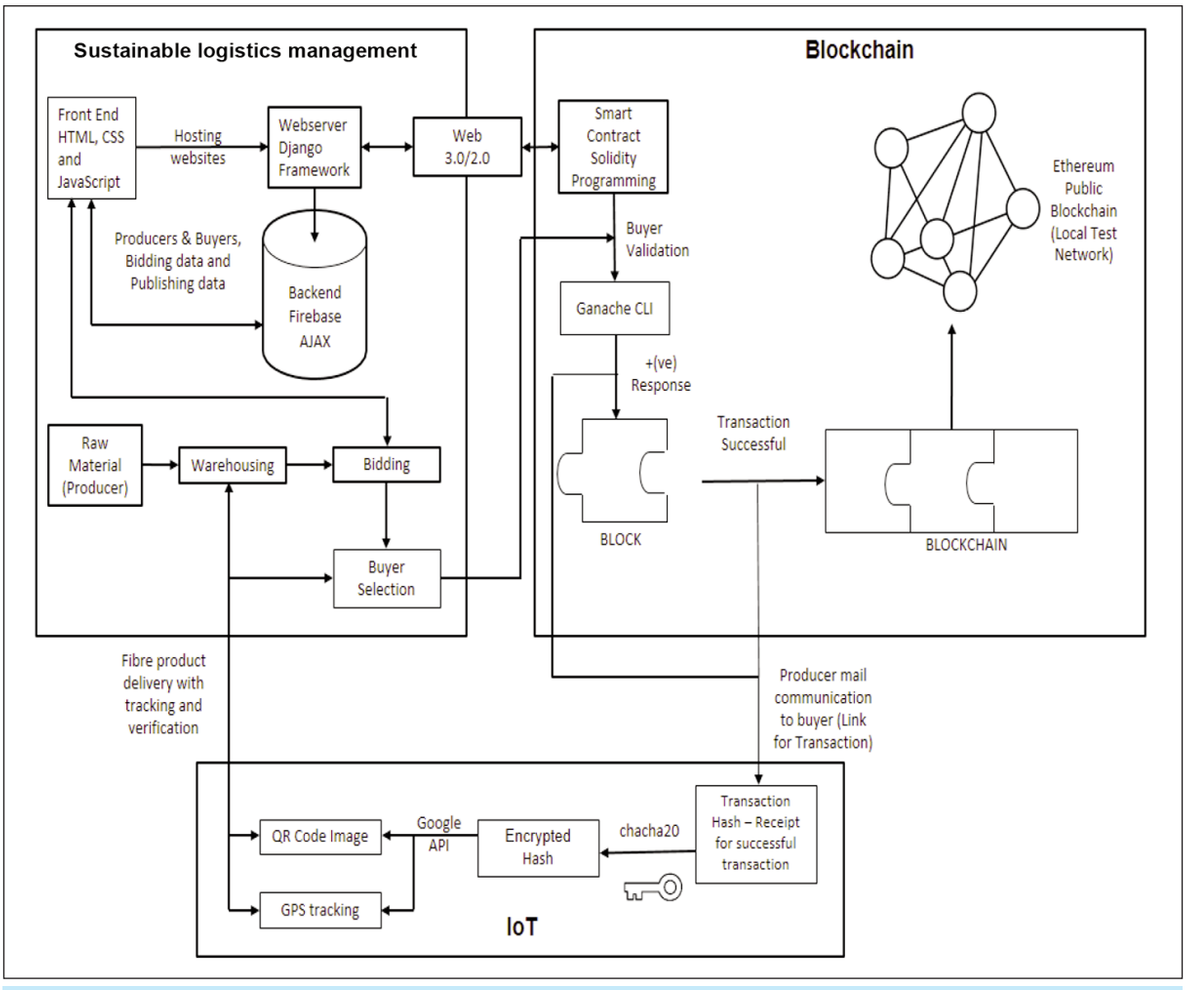

Fig. 3. Technical implementation architecture of the OBSLMS

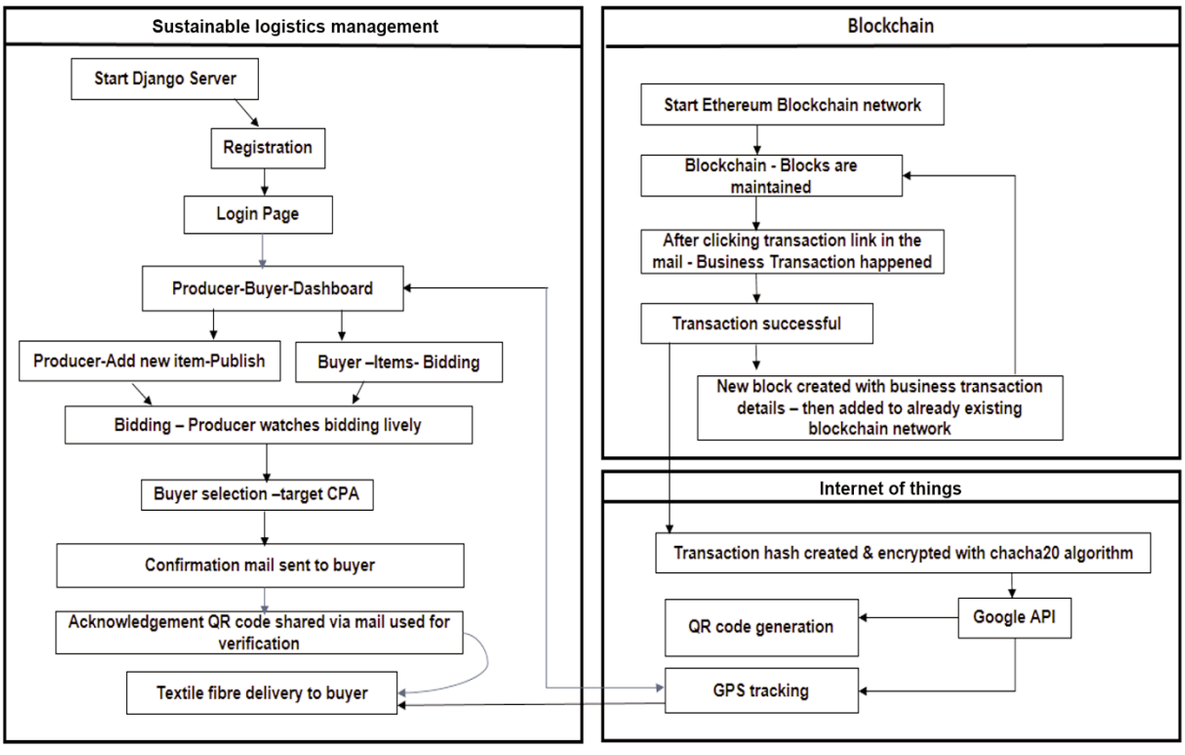

Fig. 4. Workflow of the OBSLMS

On the buyer's side, the buyer initiates the bidding based on their fibre demand or requirements. Once the producers publish their fibre product, the bidding activity is initiated. The notification messages about the bidding with the specified time slot are sent to the buyers who have requested it. The bidding is automated with a target CPA (Cost per Action) algorithm. Once the bidding time slot is over, the producer selects and declares the buyer who won the bid, with the help of this algorithm. Then the auto-generated electronic mail will be sent to the buyer to complete the business transaction with the producer. This business transaction will be carried out by the smart contract in blockchain technology. Once the transaction is completed a new block is created with the block number, previous hash, current hash, and business transaction details. After the successful completion of the business transaction and a positive response from the server, the block gets added to the pre-existing blockchain network. The transaction hash is created and it is encrypted with the chacha20 algorithm. Then, the order confirmation mail is sent to the buyer which contains the GPS tracking information and QR code generated based on encrypted transaction hash, which has all the data such as transaction hash, producer details, and buyer details of the fibre that has been ordered. Also, during the delivery of the textile fibre products, the QR code can be used for verification of the buyer as well as the fibre product, using the link provided in the order confirmation mail.

CONCLUSION AND FUTURE ENHANCEMENTS

Using blockchain, GPS tracking, and QR code verification with IoT, this research paper describes the implementation of OBSLMS for textile businesses that promote direct market dealing between producers and buyers, without intermediaries. As this is the first digital sustainable logistics solution for transaction management, it has to be improved. Some potential future work includes integrating additional payment methods such as other cryptocurrencies and credit card transactions to expand the user base and provide more flexibility to the users. Secondly, adding a reputation system based on feedback from customers can enable trust between producers and buyers, motivating producers to provide high-quality products. Thirdly, implementing a shipment and delivery system can provide a seamless experience for customers and producers. Additionally, expanding the scope of the application beyond a local market is also crucial. Finally, developing a mobile application that can provide more accessibility to end users and enhance the user experience, especially for customers who may want to place bids on products on the go will dramatically improve the accessibility of this system. Overall, the possibilities for future work on the application are vast, and continued development can help enhance the online platform's capabilities, further establishing it as a dependable and effective marketplace for textile fibre producers and buyers.

REFERENCES

[1] Hackius, N., Petersen, M., *Blockchain in logistics and supply chain: trick or treat? In Digitalization in Supply Chain Management and Logistics: Smart and Digital Solutions for an Industry 4.0 Environment*, In: Proceedings of the Hamburg International Conference of Logistics (HICL), Berlin: epubli GmbH, 2017, 23, 3–18

[2] Önder, I., Treiblmaier, H., *Blockchain and tourism: Three research propositions*, In: Annals of Tourism Research, 2018, 72(C), 180–182

[3] Luthfi, A.M., Karna, N., Mayasari, R., *Google maps API implementation on IOT platform for tracking an object using GPS*, In: IEEE Asia Pacific Conference on Wireless and Mobile (APWiMob), IEEE, 2019, 126–131

[4] Nosirova, C., *Marketing and production activities of textile companies? Blockchain technology study*, In: Proceedings of the 6th International Conference on Future Networks & Distributed Systems, 2022, 152–158

[5] Agrawal, T.K., Sharma, A., Kumar, V., *Blockchain-based secured traceability system for textile and clothing supply chain*, In: Artificial Intelligence for Fashion Industry in the Big Data Era, 2018, 197–208

[6] ElMessiry, M., ElMessiry, A., *Blockchain framework for textile supply chain management: Improving transparency, traceability, and quality*, In: Blockchain–ICBC 2018: First International Conference, Held as Part of the Services Conference Federation, SCF 2018, Seattle, WA, USA, 2018, Proceedings of Cham: Springer International Publishing, 213–227

[7] Agrawal, T.K., Kumar, V., Pal, R., Wang, L., Chen, Y., *Blockchain-based framework for supply chain traceability: A case example of textile and clothing industry*, In: Computers & Industrial Engineering, 2021, 154,107–130

[8] Tripathi, G., Tripathi Nautiyal, V., Ahad, M.A., Feroz, N., *Blockchain Technology and Fashion Industry-Opportunities and Challenges,* In: Blockchain Technology, 201–220

[9] Ülkü, M.A., Akgün, M., Venkatadri, U., Diallo, C., Chadha, S.S., *Managing environmental and operational risks for sustainable cotton production logistics: system dynamics modelling for a textile company*, In: Logistics, 2020, 4, 4, 34

[10] Zimon, D., Domingues, P., *Proposal of a concept for improving the sustainable management of supply chains in the textile industry,* In: Fibres & Textiles in Eastern Europe, 2018, 2,128, 8–12

[11] Rajagopal, S., Krishnamoorthy, B., Khanapuri, V.B., *Competitive logistics capability for sustainable organisational performance: a study of the textile industry in India*, In: International Journal of Logistics Economics and Globalisation, 2018, 7, 2,105–124

[12] Helo, P., Hao, Y., *Blockchains in operations and supply chains: A model and reference implementation*, In: Computers & Industrial Engineering, 2019, 136, 242–251

[13] Saberi, S., Kouhizadeh, M., Sarkis, J., Shen, L., *Blockchain technology and its relationships to sustainable supply chain management*, In: International Journal of Production Research 2019, 57, 7, 2117-2135

[14] Narayanan, A., Bonneau, J., Felten, E., Miller, A., Goldfeder, S., *Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction,* Princeton University Press, 2016

[15] Zohar, A., *Bitcoin: under the hood,* In: Communications of the ACM, 2015, 58, 9, 104–113

[16] Kshetri, N., *Blockchain and IoT integration: A systematic review*, In: International Journal of Production Research, 2020, 58, 15, 4617–4639

[17] Buterin, V., *A next-generation smart contract and decentralized application platform*, In: Ethereum white paper, 2014, 1, 1, 1–32

[18] Xu, X., Zhang, M., Dou, G., Yu, Y., *Coordination of a supply chain with an online platform considering green technology in the blockchain era*, In: International Journal of Production Research, 2021, 5, 1–8

[19] Faridi, M.S., Ali, S., Duan, G., Wang, G., *Blockchain and IoT based textile manufacturing traceability system in industry 4.0*, In: Proceedings of International Conference on Security, Privacy and Anonymity in Computation, Communication and Storage, Cham: Springer International Publishing, 2020, 331–344

[20] Pal, K., *Internet of things and blockchain technology in apparel manufacturing supply chain data management,* In: Procedia Computer Science, 2020, 170, 450–457

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