A blockchain-based approach to providing technically expressed trust in the supply chains of the fashion industry

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Abstract. This paper addresses the lack of research into the use of the blockchain technology to provide trust in fashion supply chain collaboration systems, which in practice leads to an empirical approach and leads to the implementation of ineffective solutions. The aim of the study is to develop an approach to build an information system for the interaction of high fashion supply chain participants based on the Hyperledger blockchain framework to ensure technically explicit trust. In the process of research, the authors have found and developed as follows: 1) Blockchain technologies can be used to provide technically explicit trust in the supply chains of the high-fashion industry through decentralization, data consistency and security, and the use of smart contracts; 2) The approach of applying Hyperledger framework in the context of supply chain processes in the fashion industry is to be justified by criteria such as open architecture, modularity, support for data access management, and the ability to manage smart contracts; 3) A conceptual model of an interaction system for fashion supply chain actors based on the Hyperledger framework has been developed; 4) A blockchain-based approach to building a blockchain-based supply chain collaboration IS for accelerating supply chain processes in the haute couture industry has been proposed.

1. Introduction

The growing market and competition in the fashion industry forces all participants in the supply chain to look for new solutions to optimize their business processes. A distinctive feature of the fashion industry is the social nature of the consumption of the products of this industry. The following features of the fashion market can be highlighted: dynamic consumer preferences and pronounced segmentation in the supply chain. A typical supply chain involves the following actors: manufacturers, suppliers of the materials, transport companies, retailers, regulatory authorities and end consumers. Fashion products are to be represented by such goods as clothing, shoes and various accessories. The choice of consumer preferences is determined by the following properties of fashion products: brand, season and fashion collection. Fashionable products usually have a higher price compared to conventional goods, which determines the increased attention of future consumers to the quality of materials and the speed with which they can receive the goods. Speed is one of the important parameters that is affected by the built supply chain. A typical delivery process consists of the following steps:

- delivery of materials to the manufacturer by suppliers;
- production of products at the factory;
transportation of finished products through a network of transport companies;

- purchase of goods by the end user in a retail store.

A development of the network interaction infrastructure allows companies to gain new competitive advantages in terms of supply chain management and interaction optimization [1, 2]. Supply chain companies should work closely together and share important information quickly to achieve goals such as reducing costs and increasing the speed of delivery of goods to the end user. The modern supply chain is a business ecosystem in the form of a distributed (decentralized) system of equal participants [3]. The organisation of information and financial flows in such a system is regulated by means of contractual arrangements and controlled through international and local legislation by institutional intermediaries such as customs services, banks and other supervisory bodies. At the moment, these structures act as guarantors of trust between the other participants in the chain. The issue of trust assumes an important role when supply chain actors use distributed systems to communicate [4]. Such systems of transmission, storage and processing of information are built on the principle of a geographically distributed network, in which data is transmitted over the Internet.

Research shows that trust is an important component in the process of digitalization [5]. In the business environment, trust is expressed in such paradigms as optimizing information flows between partner companies, as well as increasing the transparency of transactions. From the end user's point of view, trust prescribes the need to have transparent access to information about the product being purchased. In the context of supply chain communication under consideration, trust can be defined as a company's willingness to bear the risk of dealing with another company. Information sharing involves risks associated with the possibility of other parties gaining access to private information, such as access to financial information or trade secrets. There is an explicit connection between the level of trust of supply chain actors and their financial performance [6].

At the technical level, trust is reflected in the information systems (IS) used by the companies involved in the supply chain. A typical solution is to use an industry-specific solution in the form of a centralised Enterprise Resource Planning (ERP) system. In this approach, the control of information integrity is the responsibility of each party to the interaction and is controlled by the intermediaries, and if a failure occurs on the side of one of the parties in the supply chain, the negative consequences will spread throughout the supply chain. This is where the notion of technically expressed trust emerges, i.e. trust secured through technical methods rather than the services of institutional intermediaries. The following problems can be highlighted that arise when using trusted intermediaries in the supply chain:

- The problem of increasing overhead costs. An intermediary charges a fee for the provision of trust services. For example, bank transactions on mutual settlements between organizations are paid at a floating percentage – the larger the amount transferred, the higher the payment for services;
- The problem of speed reduction, the occurrence of delays in the process. These can be either bureaucratic delays or technical ones. As an example, there are mandatory customs control procedures for imported goods, where problems may arise with the customs declaration due to inaccurate or insufficient information;
- The problem of the human factor. When processing information by a person, mistakes can be made, which affects its reliability, timeliness and completeness.

The use of technology to enable technically expressed trust will help to mitigate these issues, namely to reduce overhead costs, increase the speed of processes and reduce the risk of human error in information processing, which is relevant to the specifics of fashion products and the fashion industry.

To ensure trust at a technical level, the authors propose to consider the use of blockchain technology. This technology involves the use of a distributed register in which each block of information is technically dependent on the control information recorded in the previous block, making the stored information more reliable. In a distributed registry, block chains shall be stored and processed on different computers. A network of such computers communicating through a common protocol for processing transactions and building blocks of data shall form a blockchain network. The
data transmitted in the blockchain network can be either public or private. Data access and processing is carried out within the administrative node. Currently, research is widely describing various applications of blockchain technology [7, 8]. However, one may note that in the context of the fashion industry, the specifics of the application of blockchain technology to provide technically explicit trust in supply chains have not been sufficiently described.

To use effectively all the possibilities of blockchain technology, it is reasonable to use a ready-made enterprise-class distributed registry software platform. The software for developing and combining the various components of a software system structure is called a framework. To support the blockchain technology at the software level, the framework must have certain specifics. For example, provide cloud support, have standard component communication protocols and ensure that all distributed registry functions are implemented. Let's define such a framework as a blockchain framework. In cloud technologies, the following models of organizing the provision of a software product can be distinguished:

- Infrastructure as a service (IaaS). In this approach, the computing resources of the hardware shall be provided and the entire organisation of the software shall fall on the consumer;
- Platform as a Service (PaaS). Here, the consumer is given the option of deploying their applications within the infrastructure already in place;
- Software as a Service (SaaS). Here, the consumer is offered a ready-made software solution within which to set their own parameters and data processing algorithms, but with a minimum possibility of changing the software environment.

The use of the framework in the design of PaaS and SaaS solutions using the blockchain technologies allows to reduce development costs. The authors have identified several relevant frameworks which support distributed registries in IS design. The problem arises of choosing a particular framework. To solve it, it would be necessary to analyse the features of the frameworks presented and identify those that can meet the needs of implementing technically expressed trust in the fashion industry's supply chain. This will enable the development of a conceptual model of the fashion supply chain actors' interaction system, which will further serve as the basis for the development of an approach to building the IS of interaction between the participants of the high fashion supply chain. The use of this approach in the IS design will increase the level of information integration, implement the provision of trust at the technical level and will allow to implement effective solutions for organizing the interaction of participants in the supply chain in the high fashion industry. However, at present, it can be noted that there is insufficient research on the use of blockchain technology to ensure trust in the interaction systems of supply chain participants in the fashion industry, which in practice leads to the use of an empirical approach and entails the implementation of inefficient solutions. The formation of an approach to the IS building of interaction between participants in the high-fashion supply chain based on the blockchain framework involves solving a number of research problems:

- No specific features of the use of blockchain technology to ensure technically expressed trust in the supply chains of the high fashion industry have been identified;
- The use of blockchain frameworks in the context of supply chain processes in the fashion industry has not been sufficiently explored;
- There is no conceptual model of the system of interaction of participants in the supply chain of fashion goods based on the blockchain framework;
- There is no described approach to building an IS of interaction between participants in the haute couture supply chain.

The purpose of this study is to develop an approach to build an IS system for the interaction of high fashion supply chain participants based on a blockchain framework to ensure technically explicit trust. To achieve this objective, it is assumed that the following tasks shall be solved:

- Identifying the specific application of blockchain technology to create technically expressed trust in the supply chains of the high-fashion industry, allowing us to determine which framework will enable the design of blockchain-enabled systems;
• Defining a blockchain framework that will allow you to build a conceptual model of the system of interaction between participants in the supply chain;
• Building a conceptual model of the system of interaction between participants in the fashion supply chain based on the blockchain framework, which is the basis for developing an approach to building the IS of interaction between participants in the high fashion supply chain;
• Developing a conceptual approach to building an IS of interaction between participants in the high fashion supply chain, which will allow implementing effective solutions for organizing interaction between participants in the supply chain in the high fashion industry.

2. Blockchain as a method of providing a technically expressed trust

Kari Korpela, Tomi Dahlberg and Niels Hackius note the prospects for solving the issue of ensuring technically expressed trust between participants in the supply chain using blockchain technology [7, 9]. This technology allows you to create a decentralized database, the information in which is stored and processed on the nodes of all network participants. A consensus in such a peer-to-peer network shall be achieved using special algorithms using principles such as: Proof-of-Work, the process of choosing an authorised person (Proof-of-Stake), and others. A block in a distributed registry is a record of multiple transactions. Several blocks linked by service information form a block chain, in which it is difficult to change the information in any block. This approach ensures that the stored and processed information is trusted at the technical level. To enable an automation of business functions in the blockchain, there is support for smart contracts (when pre-fixed agreements are executed, business functions such as a transaction shall be performed).

The main features of using blockchain technology to provide technically explicit trust in the supply chains of the fashion industry include as follows:
• Decentralization. All participants store and process information on their own workstations on the local network and exchange it with each other over the Internet, instead of using a single data center;
• Data consistency. To achieve consistency in data processing, various algorithms are used to achieve consensus between;
• Data protection. Modern cryptographic algorithms are used to ensure that data is protected against unauthorised changes;
• Support for smart contracts. Guarantee of business logic execution at the technological level when the specified conditions are met;
• Cost reduction. Data transaction overhead costs are reduced by using conventional workstations instead of a central server;
• High stability. Reduced downtime by allowing the system to function even if some participants are disconnected, with data synchronisation occurring automatically when they connect to the network;
• Reliability. The information contained in the chain of blocks is linked to each other by control information.

For the use of blockchain technology in the design of the IS interaction of participants in the supply chain, it is advisable to use a blockchain framework. Based on the identified features of providing technically expressed trust, we describe in Table 1 the requirements for such a framework:
At the moment, there are several software frameworks that use blockchain technology at their core: Hyperledger, Exonum, and Openchain. Table 2 shows the compliance of these frameworks with the requirements.

**Table 2. Blockchain framework compliance**

| Framework | Compliance with the requirements |
|-----------|-----------------------------------|
|           | Open architecture | Modular architecture | Data access management support | Smart contract management support |
| Hyperledger | full | full | full | full |
| Exonum | full | partially | full | full |
|          | full (payment for anchoring service) |          |          |          |
| Openchain | full | partially | partially | full |
Based on the presented data, we will define the Hyperledger framework as more suitable for designing a system for managing the interaction of participants in the supply chain using blockchain technology.

3. A conceptual model of the supply chain interaction system based on the Hyperledger framework

The Hyperledger blockchain framework is an open source project that allows you to develop ISs for processing, storing and transmitting information using blockchain technology and cloud technologies [10]. Its main feature is its focus on corporate use. Therefore, its development was carried out taking into account the need to ensure high speed of transactions and their low cost, as well as the identification of all participants. These advantages can be achieved by separating the transaction verification service and the formation of new distributed registry blocks, as well as the use of a certification and authorisation centre for participants.

The system built using Hyperledger is a distributed blockchain network consisting of various components that are installed on the network nodes. The network components function in Docker containers, which are freely available for download.

Various programming languages, such as Golang, Java, and others, are used to implement smart contracts. The nodes run the business logic of smart contracts, store the state of the distributed registry, and execute other system services. Nodes are grouped and associated with blockchain functions.

The identified capabilities of the Hyperledger framework allow it to be used to build an IS for the interaction of fashion supply chain participants, offering the opportunity to take advantage of technically expressed trust. To expand the methodological framework, the authors propose a conceptual model of the supply chain interaction system based on the Hyperledger framework, presented in Figure 1.

![Figure 1. Conceptual model of the system of interaction between participants in the supply chain based on the Hyperledger framework.](image)

This model shows a supply chain consisting of the following elements [11]:

- **Suppliers.** They supply raw materials for the production of products;
• Manufacturers. These companies are manufacturers of finished products from the obtained raw materials;
• Logistics companies. They provide services for the transportation of finished products;
• Retail enterprises. They are engaged in the sale of finished products to end consumers;
• End users of the products. Buyers of finished products.

Each of the participants in the supply chain uses its own corporate IS, which stores and processes all information about business activities. The Hyperledger framework allows you to build a network of linked nodes that communicate with each other via a REST protocol from the member's CIS. The following types of information exchange are provided: sending transactions (the fact of a business transaction) and receiving the current state of a certain data object (document, reference). It also provides for an interaction via the WEB Socket protocol, for example, to quickly receive changes that have occurred in the Hyperledger network.

In the presented model, a special peer-to-peer central node shall be used to coordinate data synchronization in the Hyperledger network. This node applies consensus protocols, such as Practical Byzantine Fault Tolerance (PBFT), to ensure the consistency of each blockchain [12]. Such a node sends notifications every time a new block is added to the blockchain or when a certain condition in the smart contract is triggered.

A special database is used to store the current states of objects. It stores only the current data, not the entire history of parameter values. This is necessary to get information out of the blockchain quickly to process some business logic.

When providing open information on the fashion supply chain to the end customer, it is envisaged that he will interact with the Hyperledger network via a WEB interface, for example, using a mobile application.

The presented conceptual model of the system of interaction between participants in the fashion supply chain based on the Hyperledger framework is the basis for developing an approach to building the IS of interaction between participants in the fashion supply chain.

4. An approach to building information systems for the interaction of supply chain participants based on blockchain technology

An information system is a hardware and software system that can be used to securely store information, execute business logic and provide a user-friendly interface for interaction. The following main components ensure the functioning of the IS:
• Data storage and transmission subsystem;
• Applications for data processing and user interaction;
• User interfaces;
• Infrastructure of technical means.

At the heart of the proposed approach to building the IS of high fashion supply chain participants is the principle of data storage and processing in Hyperledger using blockchain technology. Let's consider the proposed solution schematically in the form of a cloud SaaS model in Figure 2.
Figure 2. SaaS solution model based on Hyperledger blockchain framework.

The cloud service is implemented as a combination of an application, platform, and infrastructure. In our case, the platform is implemented by the Hyperledger blockchain framework. Overall, the solution provider and its consumer (a member of the supply chain) establish a generated SaaS solution. The supplier shall provide a solution to the consumer in which the consumer builds its data in a distributed registry and interacts with other actors in the supply chain. A business user interacts through an interface with an application deployed in the cloud infrastructure to implement their tasks.

Figure 3 illustrates the use of a blockchain framework in the design of a supply chain collaboration system.

Applying this approach to building a blockchain-based, high-fashion supply chain participant interaction IS will increase trust in the interaction through technically expressed trust, which distinguishes this approach from other proposed solutions. This solution is applicable to enterprises that are part of the supply chain. It is supposed to use data from various sensors and smart devices. Support for smart contract functions is provided. Within the system, data such as material composition, transport, production and financial figures are exchanged. Smart contracts allow you to automate business processes, such as the implementation of mutual settlements between counterparties. The system architecture consists of several functional blocks that support different functions.

The “Data sources” block presents the available data sources. These can be various logistical processes using sensors and information input by operators. It is possible to obtain information about the materials and production technology used during the production process. During product delivery, information on transit time and storage conditions is recorded. The recorders of such information are GPS and RFID sensors, a barcode scanner.
Figure 3. Diagram of using blockchain in the design of interaction systems for participants in the supply chain.

The generated data is stored and processed in the Hyperledger network. In this blockchain, the data is captured in blockchain units, and the current value of object states is stored in a state database. This data is exchanged through open channels of communication with data protection. Also, when pre-fixed business conditions occur, smart contracts are executed and new data blocks are fixed.

The functions for supporting interaction between the participants of the supply chain shall be reflected in the block under the same name. For example, the participant Identification function performs the authentication procedure.

Each participant in the supply chain can control and manage the processes using blockchain and smart contracts. The use of the Hyperledger blockchain framework allows for technically explicit trust. This approach distinguishes the author's solution from others, which involve the use of institutional intermediaries as a confidence-building measure and leads to solutions to the problems identified earlier by reducing overheads, increasing process speed and reducing the risks of human error.

Supply chain participants make their purchasing and production decisions using information contained in the blockchain network, significantly accelerating the fashion industry's supply chain processes and adding value to the end consumer.

5. Conclusion
The following results have been obtained in the course of the study: 1) Blockchain technology applications for technically expressed trust in the supply chains of the high-fashion industry have been identified, allowing us to determine which framework will enable the design of blockchain-enabled systems; 2) An approach to using the Hyperledger framework in the context of supply chain collaboration processes in the high-fashion industry has been defined, allowing a conceptual model of the supply chain collaboration system to be constructed; 3) A conceptual model of fashion supply chain participants' interaction system based on Hyperledger framework has been built, which is the basis for developing an approach to build an IS for the interaction of high fashion supply chain participants; 4) An approach to establishing an IS of interaction of participants in the supply chain of
high fashion has been developed, which allows to implement effective solutions for organizing the interaction of supply chain participants in the high fashion industry.

The authors have found that: 1) The possibilities of using blockchain technology to ensure technically expressed trust in the supply chains of the high fashion industry are decentralization, consistency and data protection, smart contracts, support for smart contracts; 2) The approach of using the Hyperledger framework in the context of supply chain collaboration processes in the fashion industry is justified by criteria such as an open architecture, a modular architecture, a support for data access management, and a support for smart contract management; 3) A conceptual model of an interaction system for fashion supply chain actors based on the Hyperledger framework has been developed; 4) An approach to building an IS for the interaction of haute couture supply chain actors based on the presented model has been proposed to accelerate supply chain processes in the haute couture industry.

As a further direction of the research, the authors envisage testing the findings in designing a system of interaction between supply chain actors in the fashion industry in real-world enterprises.

References
[1] Liao S H, Hu D C, Ding L W 2017 Assessing the influence of supply chain collaboration value innovation, supply chain capability and competitive advantage in Taiwan’s networking communication industry Int J Prod Econ 191 143–53
[2] Li Y, Zhao X, Shi D, Li X 2014 Governance of sustainable supply chains in the fast fashion industry Eur Manag J. 32(5) 823–36
[3] Martino G, Fera M, Iannone R, Miranda S 2017 Supply chain risk assessment in the fashion retail industry: An analytic network process approach. International Journal of Applied Engineering Research 12 140–154
[4] Xu J 2020 Understanding Trust in Construction Supply Chain Relationships. In: Successful Construction Supply Chain Management (Wiley) pp 307–33
[5] Pashkov P, Soloviev V 2020 Research of the phenomenon of implicit knowledge, its structuring and management in the digital economy based on trust 56th International Scientific Conference on Economic and Social Development-Aveiro
[6] Zhang M, Huo B 2013 The impact of dependence and trust on supply chain integration Int J Phys Distrib Logist Manag 43(7) 544–63
[7] Korpela K, Hallikas J, Dahlberg T 2017 Digital Supply Chain Transformation toward Blockchain Integration In: Proceedings of the 50th Hawaii International Conference on System Sciences
[8] Pilkington M 2016 Blockchain technology: Principles and applications. In: Research Handbooks on Digital Transformations (Edward Elgar Publishing Ltd) pp 225–53
[9] Hackius N, Petersen M 2017 Blockchain in Logistics and Supply Chain: Trick or Treat? Reinf Plast. 23
[10] Perboli G, Musso S, Rosano M 2018 Blockchain in Logistics and Supply Chain: A Lean Approach for Designing Real-World Use Cases. IEEE Access. 6 62018–28
[11] Werner H 2013 Supply Chain Management - Grundlagen, Strategien, Instrumente und Controlling (Springer Gabler) 534
[12] Castro M, Liskov B 2002 Practical Byzantine Fault Tolerance and Proactive Recovery. ACM Trans Comput Syst. 20(4) 398–461