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FOOD TECH BLOCK CHAIN USING PYTHON

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ABSTRACT

Ensuring high quality and safety of food products has become a key factor on one hand to protect and improve consumers health and, on the other one, to gain market share. For this reason, much effort in the last year has been devoted to the development of integrated and innovative Agriculture and Food (Agri-Food) supply chains management systems, which should be responsible, in addition to track and store orders and deliveries, to guarantee transparency and traceability of the food production and transformation process. In this paper, differently from traditional supply chains which are based on centralized systems, we propose a fully distributed approach, based on blockchain technology, to define a supply chain management system able to provide quality, integrity and traceability of the entire supply chain process. The proposed framework is based on the Hyperledger Fabric technology, which is a permissioned blockchain system: a prototype has been developed and, by using some use cases, we show the effectiveness of the approach.

I.INTRODUCTION

The recent attention on food safety and product quality requires more reliable and efficient processes for the management of agri-food supply chains ([15, 21]). Government authorities need to respond more promptly to food scan- dals and accidents to maintain customer confidence in the food industry. To this end, ensuring the traceability of food products allows to provide consumers with a complete view of the different phases of product harvesting, processing and distribution ([5, 10, 20]). Many of the management processes of current supply chains have been automated to reduce operational costs and errors and to improve the monitoring and collection of information related to the various activities within the supply chain. Therefore, by collecting and making accessible the set of traceability information of a product, it is possible for consumers to know about the entire life cycle of that product, its related transactions and chain of owners and its provenance. However, one of the issues of today's supply chain management systems is that they are often based on centralized systems: supply chain processes and product traceability data are managed by a single authority on which supply chain members rely on to transfer and share their informa tion. These centralized systems are often nontransparent, monopolistic and asymmetric information systems. This can pose a serious threat to the security and reliability of the traceability information and make fraud, corruption and data falsification easier ([23]). Furthermore, another issue with such centralized systems is related with the

risk of a single authority to become the weak link and single point of failure. Also operation throughput and scalability are limited. To deal with such issues, the usage of blockchain technology in this domain has recently been proposed to support the management of supply chain traceability ([2, 12, 27]). Blockchain technology in particular offers cryptographic primitives to store data within a distributed ledger, guaran- teeing their immutability and authenticity. The decentraliza tion that blockchain provides reduces the risk of data loss and corruption. In particular, whenever an actor attempts to change data on the blockchain, network participants would be immediately aware of the tampering upon inspection of the chain. This eliminates the need for supply chain members to trust a single entity to manage their traceability information. Furthermore, being a distributed system, the blockchain can mitigate the problems of limited scalability and single point of failure. If, on the one hand, the use of a blockchain implies an additional overhead with respect to a centralized system, on the other one the higher management costs are compensated by a higher traceability and visibility on supply chain operations. In this paper, by extending our previous work presented in [17], we propose a complete model of a blockchain based agri-food supply chain traceability system providing a proto- type implementation to show the applicability of blockchain technology in this domain. The main focus of the system is to take advantage of the blockchain features to allow supply chain members to store and manage product-related trace- ability information in a transparent, reliable and tamper- proof way. Using this information final consumers can then reconstruct a complete history of the transactions related to a product during its life cycle. Transactions of the real world, involving transformations and exchanges of registers and stores information about these transactions, but how this information are generated and retrieved is out of the scope of our work. The main goal of the proposed approach is to make supply chain transactions traceable and verifiable by external users. The business logic of the system is executed by a smart contract that allows to automate some of the management processes related to supply chain activities. The smart contract offers operations that can be invoked by the supply chain members to store and update traceability information. The proposed system also makes it possible to associate rules with supply chain products, allowing the expression of product-specific quality control mechanisms.

II. LITERATURE SURVEY

There is a variety of works that propose the use of blockchain technology to build agri-food supply chain management systems and in some cases implementations of such systems are also proposed. Some of these works are briefly described below. In Malik et al. [16] a permissioned blockchain system, called Product Chain, is proposed. The system is administered by a consortium of entities participating in a generic food supply chain, including governmental and regulatory entities. It stores product traceability information made accessible to consumers. The authors propose the use of a three-tier sharded architecture that ensures reliability and availability of data for consumers and

scalability with respect to transaction execution throughput. They also propose the use of a transaction vocabulary and the implementation of access control mechanisms to manage read and write privileges on the blockchain. Wang et al. [24] propose a product traceability system based on the Ethereum blockchain and the smart contract primitive. The system stores information related to the products life cycle and also provides for the implementation of event response mechanisms to verify the identities of both parties of all transactions at the time of their sub- mission, so that their validity is guaranteed. All the events are kept in the system permanently so that any disputes can be managed and the responsible for certain actions can be traced. In Caro et al. [6] the AgriBlockIoT is proposed, a totally distributed and blockchain-based supply chain management system, able to integrate multiple IoT devices that collect and produce digital data along the supply chain. To efficiently evaluate AgriBlockIoT, the authors defined a use case based on the from-farm-to-fork model. This use case was then implemented using two different blockchain systems, namely Ethereum and Hyperledger Sawtooth. Casino et al. [7] propose a distributed functional model based on blockchain to create distributed and automated traceability mechanisms for a generic agri-food supply chain. To evaluate the feasibility of the proposed model, a use case is presented. The applicability of the model is also illustrated through the development of a fully functional smart contract and a private blockchain. Tian [11] propose a food supply chain traceability system for real-time food tracing based on HACCP (Hazard Analysis and Critical Control Points), blockchain and the Internet of Things, which provides a platform that ensures openness, transparency, neutrality, reliability and security for trace- ability information. The proposed system uses big chain DB, which combines the key benefits of distributed databases and blockchain. Biswas et al. [4] propose a blockchain-based system to achieve the traceability of the activities that occur within the supply chain related to wine production. The proposed traceability system uses MultiChain to implement a private blockchain. Shahid et al. [22] present a complete solution for block-chain-based agri-food supply chains. The proposed solution leverages the key features of blockchain and smart contracts, deployed over Ethereum blockchain network. All transactions are written to the blockchain which ultimately uploads the data to Interplanetary File Storage System (IPFS). The storage system returns a hash of the data which is stored on blockchain and ensures an efficient, secure and reliable solu- tion. Authors provide simulations and evaluation of smart contracts along with the security and vulnerability analyses.

III.METHODOLOGY

Blockchain Technology and Hyperledger Fabric Blockchain technology represents a particular class of dis- tributed systems and as such was born with the aim of over-coming some of the problems related to centralized systems ([13, 14]). The application area in which the blockchain was initially introduced is that of transactional systems, in particular electronic payment systems. That is the case, for example, of the

Bitcoin blockchain ([19]). However, today blockchain technology is increasingly being adopted in a lot of different application domains. In general, operations within a blockchain are carried out by nodes connected to each other through a peer-to-peer network. In public blockchains, like Bitcoin, every node can participate in network operations and can decide to exit at any time. Each node participating in the blockchain maintains a local copy of a distributed ledger which contains a set of append-only logs that encode the status information of the blockchain. More specifically, an ordered sequence of blocks is stored inside the ledger. Each block consists of a header and a body that contains an ordered list of transactions which are validated and executed by the peers of the network. To guarantee the immutability and reliability of the data in the ledger, each block of the sequence contains a cryptographic hash of the previous block within a header field. In this way a malicious attempt to change the content of a block would require to correspondingly modify the header of all the fol- lowing blocks in the sequence, which is a computationally expensive task thanks to the non-invertibility property of hash functions. Peer nodes of a blockchain coordinates with each other throughout a consensus protocol. Public block- chains typically use secure but computational expensive consensus protocols, like for example the proof of work protocol. This is motivated by the fact that any node can join a public blockchain and this makes this type of block- chains an untrusted environment. The use of a computational expensive consensus protocol poses some scalability issues and transaction throughput limitations. Permissioned blockchains are another category of block- chains. In a permissioned blockchain, only authorized peers can participate in blockchain operations. Permissioned blockchains often set aside proof of work consensus protocol because of its nondeterminism and the computational burden it imposes on peer nodes. Instead, they adopt weaker but more performant consensus mechanisms based on traditional protocols from distributed computing, such as Paxos, Raft and Byzantine fault-tolerant algorithms. This is possible because in a permissioned blockchain membership is limited only to a well-known set of entities and this involves less security risks. Agrifood supply chains fit well in the context of permissioned blockchains ([26]). In an agri-food supply chain scenario a limited set of organizations, whose identities are known, are supposed to actively participate in supply chain operations. Organizations typically don't trust each other, but they need read and write access to a trusted shared data repository. While the presence of an always-online trusted third-party authority that manages all supply chain operations allows to avoid the use of a blockchain, this is not always a realistic scenario. In some situations it is not possible to have a single authority trusted by all parties and delegating all the write operations to a centralized entity can cause it to become a single point of failure. Although the use of a blockchain can limit transaction throughput, the decentralized nature of the blockchain technology allows to obtain better scalability and to solve the single point of failure issue. Hyperledger Fabric is an open-source blockchain

platform, which falls within the category of permissioned block- chains ([1]). Hyperledger Fabric is a distributed operating system that runs applications written in general-purpose programming languages, such as Go, Java, JavaScript, and Python. It introduces the executeorder-validate blockchain model for transaction processing unlike other traditional blockchain systems that use the order-execute model. In the order-execute model a protocol for consensus first orders the transactions and propagates them to all peers that execute the transactions sequentially.

IV.CONCLUSION

A complete model of a blockchain-based agri-food supply chain traceability system has been proposed in this work, also showing a prototype implementation. The system is based on the Hyperledger Fabric permissioned blockchain, a category of blockchain where participation is limited to a well-defined set of members. This type of blockchain fits well in the context of agrifood supply chains because typically only a limited set of organizations can participate in supply chain operations. By using blockchain technology, supply chain traceability data can be stored in a more trans- parent and reliable way with respect to using a centralized entity. Furthermore, as a fully distributed system, blockchain mitigates the problems of limited scalability and single point of failure. The proposed system allows to automate supply chain management operations with the use of the smart con- tract primitive and maintain traceability information in a transparent, secure and immutable way. Moreover, the system gives the possibility to add and modify rules at runtime and this allows to implement product-specific quality control mechanisms. Finally, the system provides a complete view of the different phases of harvesting, processing and distribution to which batches of product are subject allowing to reconstruct the entire life cycle of each batch, also obtaining provenance information.

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