POLITECNICO DI BARI

DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING

Master Degree in Computer Engineering

Business Report

SOFTWARE ARCHITECTURE AND PATTERN DESIGN

Market - Data Traceability System

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Introduction

The traceability of fruit and vegetables is a growing need, aimed at ensuring the safety and authenticity of the product for a wide range of stakeholders, from the agronomist to the final consumer. This need originates from the desire to prevent fraud and malicious practices that could compromise the quality and safety of products.

Transforming the agriculture and food industry through a software platform is achievable through the integration of IoT, blockchain, and e-commerce. This combination facilitates real-time monitoring, traceability, and efficient management of the supply chain, spanning from the farm to the market. The key features of this system include enhancing transparency, reducing waste, and enabling online sales, auctions, and collective buying.

The objective is to establish a system that provides instantaneous access to product information and incorporates Blockchain-based transparency. This system is designed to guarantee the safety, quality, and traceability of products, fostering trust among stakeholders and mitigating the risk of fraud within the agri-food supply chain.

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Project Scope and Structure

1.1 Goals and objectives

The main goal is to implement a system that provides real-time access to information about products within a supply chain, ensuring complete transparency. This system must be capable of addressing some of the most relevant challenges currently faced by the agri-food industry. Among these objectives are:

- **Product Safety:** Ensuring that agri-food products are safe for consumption.
- **Product Quality:** Maintaining high standards of quality.
- **Product Origin Tracking:** Monitoring the entire supply chain, from producer to consumer.
- **Strengthening trust among stakeholders:** Transparency from both the producer and consumer perspectives.
- **Preventing fraud in the agri-food chain**, such as product counterfeiting.

1.2 Gantt diagram

This section presents the Gantt diagram (figure 1.1) that illustrates the planning and timetable of the project. The Gantt diagram is a visual tool that provides a clear representation of the activities planned throughout the project, allowing for efficient time management and immediate visualization of dependencies between activities. The diagram covers the period from 14 November 2023 to 31 December 2023, highlighting the main phases of the project and related activities.

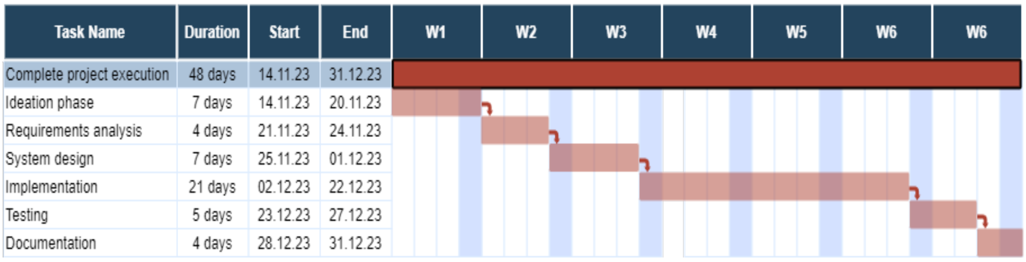

Figure 1.1: Gantt diagram

1.3 System architecture and used technologies

To achieve these objectives, it was chosen to use blockchain technology, which is a distributed register that provides data immutability and transparency, allowing every participant to access to the register and contribute with accurate data. The choice fell on Ethereum (figure 1.2) as the blockchain platform to implement this application for several reasons: firstly, it is one of the currently most established platforms with a highly active developer community, and also for its support of smart contracts. These are protocols that automatically execute pre-established agreements when certain conditions are met. In the agri-food supply chain, this means that contracts can automatically perform various activities without the need for intermediaries. Lastly, Ethereum ensures high scalability, making it a more sustainable choice for a distributed application requiring the recording and access to a large volume of real-time data.

Figure 1.2: Ethereum

During the development activity on Ethereum, the Integrated Development Environment (IDE) called Remix (figure 1.3) was used, which is a rich toolset that can be used for the entire journey of contract development by users of any knowledge level, and as a learning lab for teaching and experimenting with Ethereum.

Figure 1.3: Remix

1.4 Requirements

In the ideation phase, the fundamental requirements that the distributed application had to meet were defined, thus creating a clear guide for subsequent development.

1.4.1 Functional requirements

- The system must be able to enter a batch specifying its processing (environmental parameters, quality, etc.)
- The system must allow the input of the quantity and the storage time of the batches
- The system must be able to insert transactions made by various users (producers, consumers, etc.), specifying the type of transaction and price.
- The system must be able to provide the certification generated by specialized entities (laboratories) to those who want to purchase the batch.

1.4.2 Non functional requirements

Compatibility

The platform will be accessible through various devices such as smartphones and tablets, allowing different users (buyers, consumers, producers, etc.) to verify at any time the origin, the product information, the chemical-physical characteristics of the product, the varietal origin, and monitor the product's agri-food supply chain through access to detailed information on the production phases, from sowing to sale, also including the transformation phases.

Usability

The system has the ambitious goal of maximizing usability and accessibility for users, aiming to provide a fluid and intuitive experience. For this purpose, user interfaces characterized by maximum simplicity and clarity will be adopted, in order to facilitate interaction and ensure easy use even for less experienced users.

Security

The server side implements a user registration system on the blockchain that allows verifying a user's presence and role based on their authorized actions.

Additionally, contracts are decoupled according to their functionalities, ensuring a greater separation of responsibilities.

1.5 UML diagram

This section examines the UML diagram (figure 1.4, 1.5) that represents the structure of the classes in the system. Using the UML diagram is critical to clearly display relationships between classes, identify responsibilities, and facilitate understanding of the overall structure of the system. The diagram, which follows the UML class paradigm, covers crucial aspects of the system and will provide a visual guide for the development and maintenance of the project.

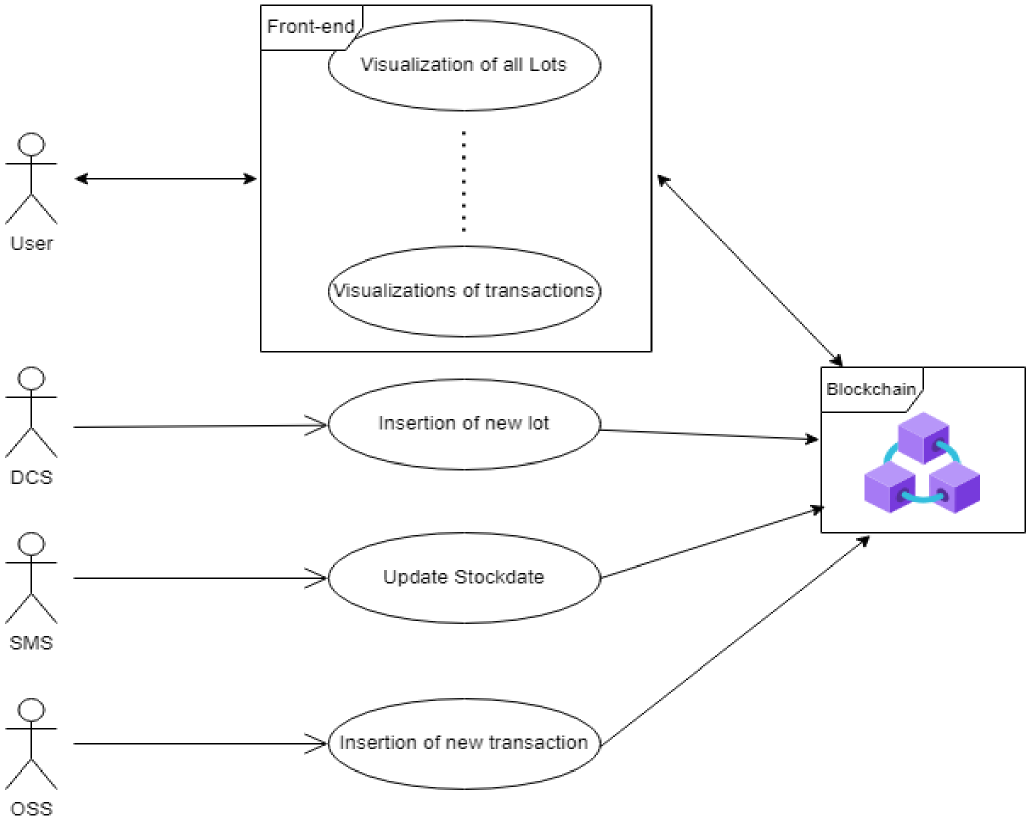

Figure 1.4: UML diagram

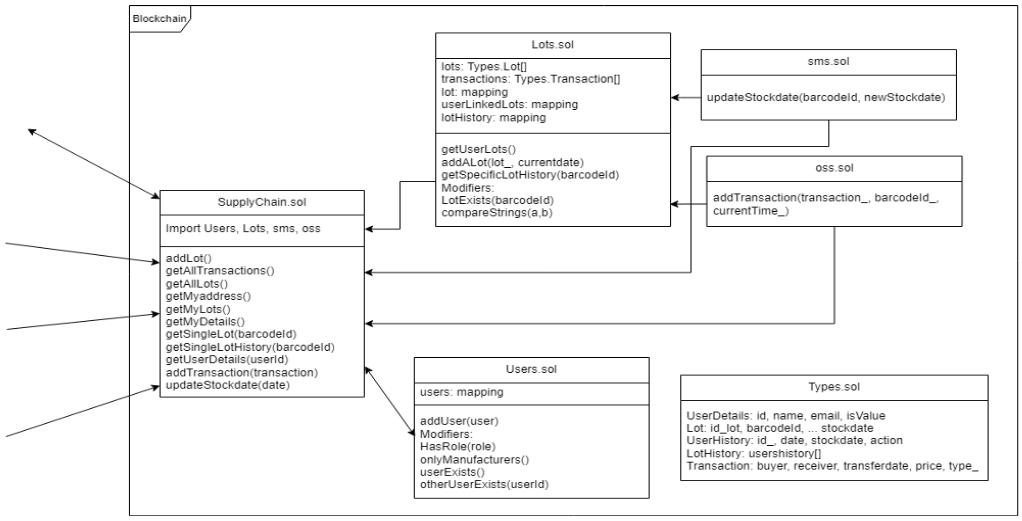

Figure 1.5: UML blockchain diagram

2

Implementation

2.1 Development technologies

The following programming languages were used to develop this system: HTML, CSS, JavaScript for the front-end development and Solidity for the blockchain development.

3
Testing

Future developments and conclusion

Looking to the future, the intention is to significantly expand and enhance the system through the implementation of advanced technologies that promote decentralization and integration with the blockchain. Two key aspects in this evolutionary path include the adoption of IPFS (InterPlanetary File System) to decentralize the parsing process and the integration of MetaMask to enable deployment on a real blockchain.

The implementation of IPFS will be crucial to ensure a more efficient and resilient distribution of information extracted through parsing. This decentralized solution will leverage the peer-to-peer network of IPFS for secure and resilient storage and sharing of data. Such an approach will not only increase the robustness of the system but also provide distributed access to information, reducing dependency on individual central points.

Concurrently, there is a plan to integrate MetaMask to enable deployment on a real blockchain. This implementation will harness the secure and transparent features of a blockchain, ensuring the integrity and traceability of the processed data.

These future developments will lead to a subsequent phase of system evolution, enhancing its efficiency, security, and adaptability to emerging challenges in the context of advanced data management and analysis.

Furthermore, the integration of carbon credits into the system is planned. This feature will allow users to offset the carbon emissions associated with transactions made on the platform, actively contributing to environmental sustainability efforts. The implementation of carbon credits aims to promote eco-sustainable practices and increase awareness of the environmental impacts of the activities carried out within the system.

As a final enhancement, the current front-end, which is currently a mockup, is set to be seamlessly integrated with the blockchain in upcoming developments. These iterations will encompass the implementation of all functionalities for resource visualization, establishing a comprehensive and integrated connection between the user interface and the blockchain.