Development of a **blockchain-based ecosystem** that allows an **improved positioning of small producers of honey** on local and international markets

DELIVERABLE

D4.2.2 End-to-End PoC traceability system for Techoney supply chain

DUE DATE OF DELIVERABLE	30 April 2024 (M24)
START DATE OF PROJECT	30.September.2022
DURATION	36 months
LEAD PARTNER FOR DELIVERABLE	LIGM
DISSEMINATION LEVEL	PU (Public)

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DOCUMENT CHARTER

TITLE BLOCK

PROJECT	PROJECT FULL TITLE	DEVELOPMENT OF A BLOCKCHAIN-BASED ECOSYSTEM THAT ALLOWS AN IMPROVED POSITIONING FOR SMALL SCALE PRODUCERS OF HONEY ON LOCAL AND INTERNATIONAL MARKETS		TECHONEY
	PROJECT ACRONYM	TECHONEY		
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		THEMATIC AREA 3	Agri-food chain	
		TOPIC 2.3.1	Increasing the resilience of small-scale farms to global challenges and COVID-like crisis by using adaptive technologies, smart agri-food supply chain and crisis management tools	
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	PROJECT URL	TECHONEY.org	E-MAIL	**info@techoney.org**
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	WORK PACKAGE	WP4: Implementation of the blockchain distributed network		
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	APPROVER	Dra. Tiziana de Magistris (CITA)		
	FILENAME	TECHONEY_Deliveable_4.2.2		
	Abstract of the Deliverable	The objective of this deliverable is to report on the successful implementation of a proof of concept (PoC) architecture for an end-to-end traceability system for the techoney supply chain. This PoC demonstration encompasses the blockchain network based on Hyperledger fabric, user interface design for each participating stakeholders in the honey supply chain and a chaincode for asset creation and change of ownership as the honey package traverses through the supply chain. The chaincodes were written in a way that give the privilege of creating asset only to the beekeepers. The different participants in between the beekeepers and the end consumers are only given the privilege of changing the ownership. As a result, during traceability, the root or origin of the asset will be the beekeepers themselves. Such design will help beekeepers to be the source of the product so that anyone willing to transact over the Techoney supply chain have to buy the product directly from the beekeepers.		

VERSION TRACKER

VERSION	REVIEWER	PARTNER	ISSUE DATE	CHANGES
1	Hakim Badis	LIGM	05.Feb.2024	Initial draft
2	Hakim Badis	LIGM	05.March.2024	Peer review input
4	Muluken Eressa	LIGM	16.April.2024	Peer review input
5	Hakim Badis	LIGM	29.April.2024	Final version

STATEMENTS

ORIGINALITY

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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REQUEST TO PARTNERS

This document fulfills **Project milestone #3** of **TECHONEY** PRIMA Proposal:[1]

- What: "Design and architecture of the consortium blockchain platform".
- When: M12 (month 12 – May 2023).
- How: Document uploaded in the private area of the project website

All partners are kindly asked to

- Read and understand this Deliverable.
- Use it for regular checking of actual performance vs project objectives.
- Report to project coordinator potential deviations of the project.

[1] Depicted at "Project Milestones". Section 3.2 ("Management structure, milestones and procedures") of the PRIMA Full Proposal - Technical Annex (Part II)

TABLE OF CONTENTS

GLOSSARY: ACRONYMS

- **AI**: Artificial Intelligence
- **AR**: Augmented Reality
- **BDVA**: Big Data Value Association
- **C&D**: Communication and Dissemination.
- **CAP**: Common Agricultural Policy
- **CM**: Communication Manager
- **D**: Deliverable
- **DIAS**: Data and Information Access Services
- **EC**: European Commission
- **EU**: European Union
- **HILE**: Honey Innovation and Learning Living Lab
- **ICT**: Information and Communication Technologies
- **ICT**: Information and Communications Technology
- **KPI**: Key Performance Indicator
- **SC**: Steering Committee
- **SO**: Specific Objective
- **URL**: Uniform Resource Locator
- **WP**: Work Package

PROJECT ABSTRACT

TECHONEY project's main objective is to identify strategies and establish lines of resilience to the new challenges determined by the COVID-19 pandemic for beekeepers in the Mediterranean (Med) agricultural systems through the implementation, definition, enhancement and transfer of competitive, profitable, efficient and trustful honey supply-chain alternatives that address beekeepers' capacities and attractiveness to fulfil consumer needs on unexpected food market changes.

TECHONEY project proposes the development of a **traceability system to guarantee the quality and safety of honey within the supply chain** for more effective communication to consumers and to strengthen access to different markets (e-commerce, direct sales, etc.). This approach will be unfolded by the joint creation of two levels of interaction: **(1)** physical: characterization of honey; **(2)** "living laboratory": creation of a *Honey Community Living Lab* (**HCLL**) and a *Honey Innovation and Learning Ecosystem* (**HILE**) that will be the arena to collect information from beekeepers, stakeholders, and consumers to transfer and apply the new optimized models.

TECHONEY is structured in 4 main technological pillars: **(1)** creation of a consortium IoT (*Internet of Things*) Blockchain platform that involves various actors in the honey supply chain to ensure transparency and traceability, in addition to reducing costs and ensure the traceability in the honey supply chain; **(2)** creation of a transformative learning community to ensure a smart-short-resilient shared supply chain; **(3)** characterization of the quality of honey to guarantee its traceability within the Blockchain directly by consumers; **(4)** ICT tools for honey supply chain participants and consumers.

TECHONEY will be committed not only to promote the continuation of the direct sales of honey from producers to consumers even after the COVID crisis but also **develop a common methodology and clear new optimized resilience protocol** to be used by small-scale farmers, beekeepers, smallholders as a new business model with a more efficient added-value chain, sustainable with fair profit, accepted by final consumers, which will be replicable to other food products and supply chains.

TECHONEY will **help beekeepers to**: **(1)** generate a traceability mechanism for honey produced in the Med. Area; **(2)** diversify markets and distribution channels offers business flexibility and freedom from dependence on a single market, which will reduce risk in the event of a crisis; **(3)** cooperate and pool resources among themselves (pooling of the workforce, etc.) for logistical flexibility and solidarity in the supply chain, which will also reduce the risks in the event of a crisis.

TECHONEY proposes to design and develop a **multidimensional framework** to analyse 6 full honey supply chains (farm to table) that will integrate economic, social and environmental indicators and a traceability system, with a *bottom-up* approach considering the stakeholders´ perspectives. A consortium blockchain, coupled with IoT (*Internet of Things*), system will be created to offer real-time tracking and complete traceability of honey along the supply chain from the characterization of honey in a certified laboratory, the retailer, until the end consumer.

The characterization of the quality and safety aspects of local honey through **local certified laboratories jointly with the use of e-commerce and quality labeling schemes** will increase the opportunity for beekeepers to be identified locally, and allow them to gain access to new markets (foreign markets). The implementation of e-commerce with the mobile application will enable local honey to be **better traced by consumers who attach more value to local food and local beekeepers**.

TECHONEY contributes to increasing farm profitability and increasing flexibility and risk mitigation capabilities. A shared, short and circular supply chain will allow actors in the honey supply chain to **access markets** and have **higher incomes**, **share resources and skills** and **save money** by reducing costs (economies of scale) and increase the efficiency, sustainability and flexibility of processes to strengthen resilience and flexibility to face crises and lower risks. The learning community lab and the use of the Blockchain network will secure the storing of records, will **strengthen intellectual property rights**, as well as **bring transparency throughout the supply chain**; it will **reduce frauds**, **enhance food safety** and **improve the communication** between retailers and beekeepers. The traceability system offered will also allow consumers to give direct feedback to beekeepers.

To reach the overall objective, several **specific objectives** (SO) are set out as intermediate goals:

- **SO1:** Map the current added-value chains and complexity level for honey products in six case studies (Spain, Algeria, Tunisia, Turkey, Luxembourg and Morocco).

- **SO2:** Increase the competitiveness and power of the beekeeping supply chain by understanding consumers' and retailers' opinions and acceptance through non-hypothetical methods.
- **SO3:** To promote the traceability to differentiate local honey and guarantee food safety of honey produced in the Med. area by characterizing it in a reliable, certifiable, and documentable manner.
- **SO4:** Design and explore the feasibility of a new traceability ecosystems and effective business models across different stakeholders.
- **SO5:** Development of a new "Multichannel distribution" e-commerce platform implementing new business model as well as integrating and scaling up the outcomes from WPs 1, 2, 3 and 4.
- **SO6:** Maximize outreach and beneficial influence of the project results and reach the target users (beekeepers, small-scale food manufacturers and local distributors, canteens and retailers, local public authorities) through an effectively established communication and dissemination plan, including innovative training capsules.

Moreover, a **TECHONEY** web ICT tool consumer/farmer-centred will be developed, by testing and evaluating several machine and deep learning algorithms, providing small-scale beekeepers with key information on new markets and opportunities, contributing to a better decision making and to ensure the traceability of their product. Consumers will have exhaustive knowledge of the different honeys of the Med. area, knowing their traceability from the initial producer, guaranteeing the quality and safety of each product.

TECHONEY *is a project coordinated by CITA (Spain) and funded through the PRIMA Section 2 Multitopic 2021 – Thematic Area 3-Agrofood chain – Topic 2.3.1 Increasing the resilience of small-scale farms to global challenges and COVID-like crisis by using adapted technologies, smart agri-food supply chain and crisis management tools. (RIA*[5])" under the funding scheme of "Collaborative Project" and type of Action "Research and Innovation Actions (RIA)."*

EXECUTIVE SUMMARY OF THE DELIVERABLE

This Deliverable D4.2.2 is about the successful implementation of an end-to-end PoC traceability system for the honey supply chain. The blockchain for the proof-of-concept traceability system is based on Hyperledger Fabric. For an easier interaction with the underlying blockchain, we have created a user-friendly web-based interface tailored for various stakeholders, including beekeepers, wholesalers, retailers, and laboratories, each with interfaces customized to their specific needs. Through this system, we have successfully demonstrated the traceability of honey packages as it traverses through the supply chain, from production to consumption. This demonstration signifies an important stage in the implementation of the blockchain based e-commerce for honey supply chain and serves as a crucial mechanism for understanding user specific data, preference, addressing concerns, defining the business logic and adherence to the rules & regulation pertaining to the specific country & participating organizations. In addition to the package traceability, the chaincode or smart contract was written in a way that grants the privilege of honey product creation to beekeepers only. This approach not only ensures that beekeepers have greater control over the production process but also empowers them economically by enabling them to capture more value from their products. By allowing beekeepers to engage in the creation of honey products, we can facilitate a more equitable distribution of profits along the supply chain. Such scenarios might incentivize beekeepers to invest in quality production practices, so that wholesaler, retailers and the end-consumer can have a product worthy of their investment. Hence, this PoC together with the questionnaire that we have distributed in the previous deliverable to gather stakeholders' preferences when it comes to the interface design, data privacy and the governance of the blockchain network, will be paramount for the next full implementation of the blockchain based Techoney's traceability system.

DOCUMENT STRUCTURE

This D4.2.2 document is organized according to the following structure:

- **INTRODUCTION:** Depicts the importance blockchain based honey supply chain
- **TRANSACTION & SMART CONTRACT IN TECHONEY SUPPLY CHAIN:** states the transactional flow in the Techoney PoC market model and the corresponding smart contract to facilitate the underlying business logic
- **HYPERLEDGER FABRIC CONSORTIUM FOR HONEY SUPPLY CHAIN:** Depicts the development of a blockchain based honey supply chain application using Hyperledger fabric
- **END TO END POC TRACEABILITY SYSTEM DEMONSTRATION:** reports the SUCCESSFUL implementation of the PoC during the PRIMA's annual meeting in Tunisia on 2nd May 2024.
- **ANNEXES:**

INTRODUCTION

This deliverable D4.2.2 is about the end-to-end PoC realization of the honey supply chain from production to consumption encompassing four participating organizations: beekeeper, wholesaler, retailer and laboratory. The researches we conducted on honey supply chain, the questionnaire we prepared for a more inclusive user-friendly interface design, the functional requirement site map we developed and the logical choice we made for the blockchain framework to use for the honey supply chain have led us to this PoC traceability system implementation using the Hyperledger fabric. It is well known that traditional tracing systems for honey don't offer easy traceability of the honey at any point with in the supply chain as it moves from producers to consumers. This is due to several reasons:

- Some stakeholders on the supply chain still record data of honey on papers;
- Each actor in the honey supply chain (i.e., suppliers, beekeepers, distributors, retailers, and customers) manages its own data using a centralized system. This could create a problem for an objective assessment of truth in the event of fraud and corruption due to an easier possibility for falsifying information;
- Data sharing between stakeholders in the supply chain can be slow and complicated. Thus, identifying responsible actor or areas for honey loss, pinpointing sources of contamination, reducing the risk of honey spoilage or expired honey product before reaching the end consumer and reducing delays in recalling become difficult to control and enforce.;
- Even when using barcode for product tracing, consumers have a limited amount of information available on the item such as type of product, manufacturer, country of origin, etc. Therefore, important data such as the origin of honey ingredient, how a honey is produced or processed (ethical honey), etc., are difficult to trace.

This gap in information for a traceable honey product can easily be mitigated through an IoT based blockchain business model. Furthermore, beyond tracing the provenance or authenticity of the honey product, such traceability system will be beneficial for all direct stakeholders (i.e., Beekeepers, Distributors, /Retailers, End-consumers) and indirect participants (i.e., Ministry of Agri, Laboratories, Farmer Ass., etc.). For instance, for beekeepers:

- It enhances the visibility and accessibility of their products in the local and international markets. This can create alternative market to the honey that could have been potentially wasted due to lack of access to the market and resulting in an increased income to the beekeeper;
- It can be used to manage the production of honey efficiently according to the needs of the end-consumers;
- Furthermore, it can also be used for monitoring the health status of the hives and bees in real time for risk mitigation and insurance.

For wholesalers, retailers and end-consumers:

- It can be used to ascertain the quality and authenticity of the product so that they get a product that is worthy of their investment;
- Especially, end-consumers by scanning the product they can retrieve & track the whole history of the honey product such as its production, transportation, quality, authenticity, etc.

And yet blockchain based supply chain is not without its own challenges. Deploying a blockchain system in the food industry is still at the embryonic stage and facing two main challenges:

- Data privacy and digital identity management;
- Scalability due to the increasing number of peers, transactions and channels in blockchain.

Taking all this into consideration, in this deliverable we will demonstrate a sample traceability system based on the Hyperledger fabric. This demo will constitute client interface (front-end), back-end interface, asset definition, smart contract design for Techoney transaction and the blockchain based on Hyperledger fabric. The front-end was designed to encapsulate the needs of the majority participants based on the functional requirement site map

we prepared in the previous deliverable and considering the diverse nature of the expectations, scale, size and reach of the participating stakeholders. This client interface design will serve as a temporary gateway for the stakeholders to interact with the blockchain and will be modified once we gather the response to our questionnaire for a more user-friendly interface design. This demo will follow the PoC architecture we submitted in the previous deliverable and is shown in Figure 1 below.

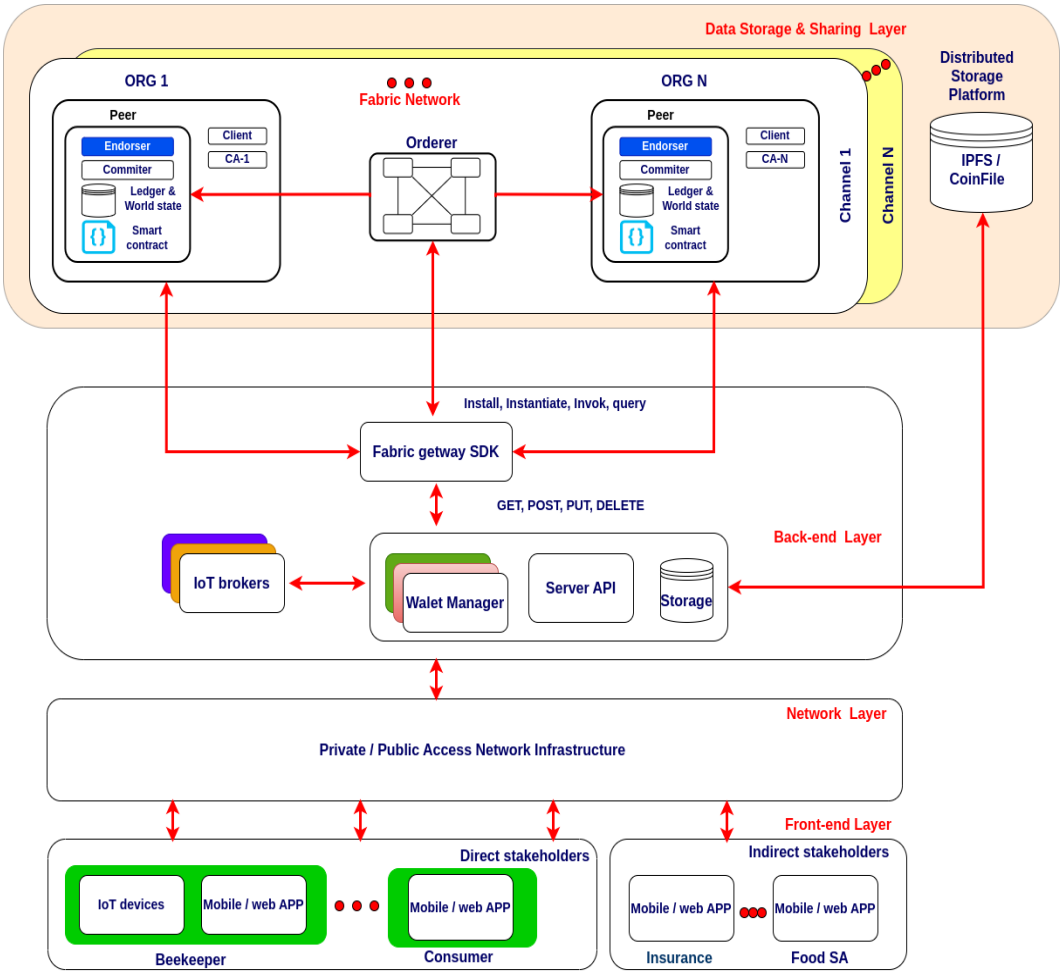

Figure 1. *Three-tier Techoney PoC architecture.*

TRANSACTION & SMART CONTRACT IN TECHONEY SUPPLY CHAIN

As we have stated in the previous deliverables, our objective is to design a universal gateway (Web/Mobile) platform for the participants in the honey supply chain to utilize blockchain(HF) technology for business in a way that simplifies product traceability and put in place measures and regulations to ensure the quality and safety of honey, guaranteeing wholesalers, retailers, and consumers receive the expected level of quality commensurate with their investment. Furthermore, to write the chaincodes to facilitate the existing transaction and empower beekeepers by granting them exclusive rights to process and package honey, ensuring they retain the advantage in honey production and distribution. As such, based on the PoC architecture given in Figure 1, in the following sections we will show the implementation of a sample traceability system for the Techoney supply chain. However, since the business logic/chaincodes and the layout of the web interface depend on the honey product details, we will start the PoC implementation from the asset or product definition and its importance.

Asset definition

In honey supply chain the most important item is the honey product itself. It represents the asset whose ownership changes as it traverses through the supply chain. The business logic or smart contracts basically outlines the conditions that must be met for this change in ownership to happen. As a result, the honey is regarding as the primary asset and defining it plays an important role in enhancing transparency and efficiency within the honey supply chain. By accurately defining assets at every stage of production, from hive to shelf, stakeholders gain a full understanding of the flow of goods and resources throughout the ecosystem. This not only simplifies tracking and tracing of honey products but also enables real-time monitoring of inventory levels, quality metrics, and production processes. Moreover, asset definition serves as the foundation for implementing smart contracts and automated workflows. Whether identifying individual honey batches, beehives, or packaging materials, accurate asset definition ensures that the product is accounted for at each stage of the supply chain for full traceability.

Furthermore, asset definition in the honey supply chain is crucial for ensuring compliance with regulatory requirements and industry standards. By accurately categorizing assets based on their attributes, such as origin, quality grade, or certification status, stakeholders can demonstrate adherence to legal and ethical guidelines governing honey production and distribution. This transparency not only builds trust among consumers but also mitigates risks related to fraud, adulteration, and counterfeit products. Additionally, clear asset definition enables stakeholders to implement targeted quality control measures, such as batch testing and inspection protocols, to safeguard the integrity and safety of honey products. Hence, by prioritizing asset definition within the honey supply chain, we can uphold a reputation for trust and purity, authenticity and goodness of the product for consumers. In that spirit, For this demonstration, we have researched labeling requirements for a honey product in different countries and identified some of the attributes that are regarded as the minimum requirements and defined the asset as shown in Figure.2.

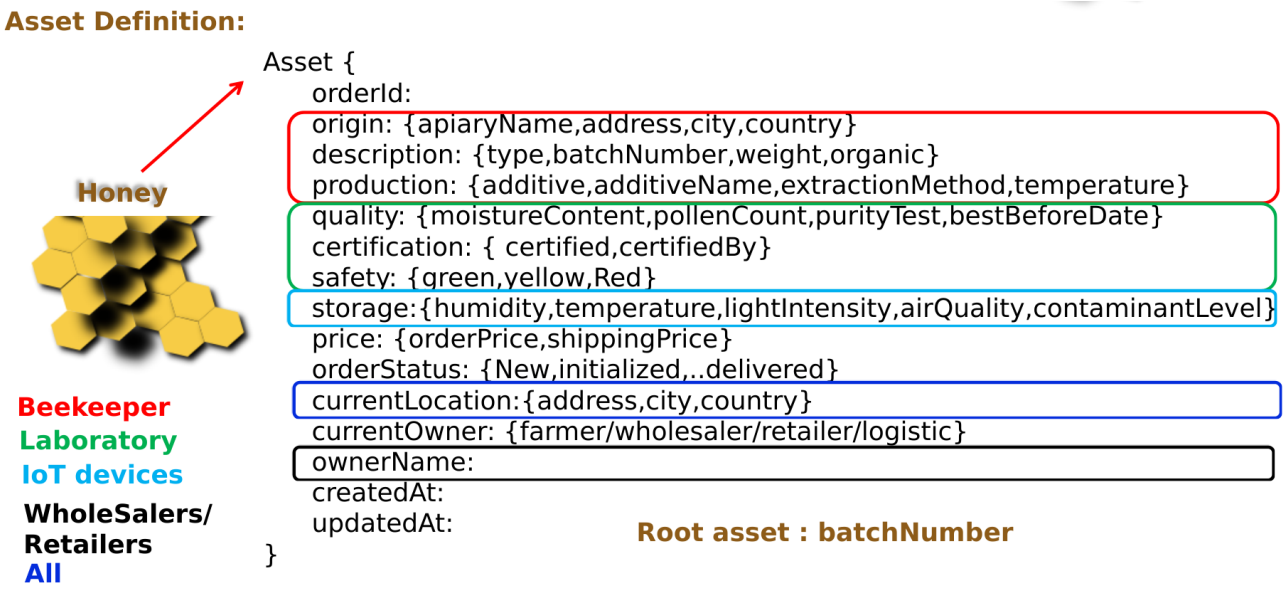

Figure 2. *Honey product asset definition.*

The asset in Figure 2 has many attributes from its Id, origin to the date at which it was created and updated. As the asset moves through the supply chain, its attributes change accordingly. However, there are some attributes that stay constants such as the origin, description and production of the honey. And also, not all attributes will be accessible to all participants. For instance, as the product creator, beekeepers will have the privilege of defining the attributes related to the origin, description and production of the honey as shown in Figure 2. Laboratories will access and define the quality, certification, and safety of the honey. While wholesalers and retailers can change ownership by accessing the current owner attributes. The storage attributes is related to environmental condition at which the honey is stored. As a result, these attributes will be defined by the IoT devices installed at the beekeepers, wholesaler and retailers' sides. Even then, there are also attributes such as the current location that can be defined by every participant in the honey supply chain depending on where the product is at specific moment in time. To monitor product expiration date, the createdAt and updatedAt attributes in Figure.2 are monitored by the chaincode internally and are not accessible to any of the participants. However, it should also be known that this asset definition is used only for this demonstration. The asset definition will be updated after based on the opinions of the other work package. Once the asset attributes are fixed, it is now time to design the business transaction flow.

Hyperledger fabric and Techoney business transaction flow

In the deliverable 4.1.3, we have gone through the detail of the blockchain framework (i.e., The Hyperledger fabric) the Techoney project will based on and the associated transaction flow. As a refreshment, Hyperledger fabric follows a modular architecture and the entirety of its components can be operated in a plug-and-play fashion. Due to this modular architecture, the transactional flow in fabric, reassembles more like the transaction we expect to see in a real-world scenario as shown in Figure.3. However, this transactional flow is at network level between the client application and fabric components independent on the role or identity of the stakeholders. Every participant interaction with the underlying framework follows this path. The Techoney business transaction flow is

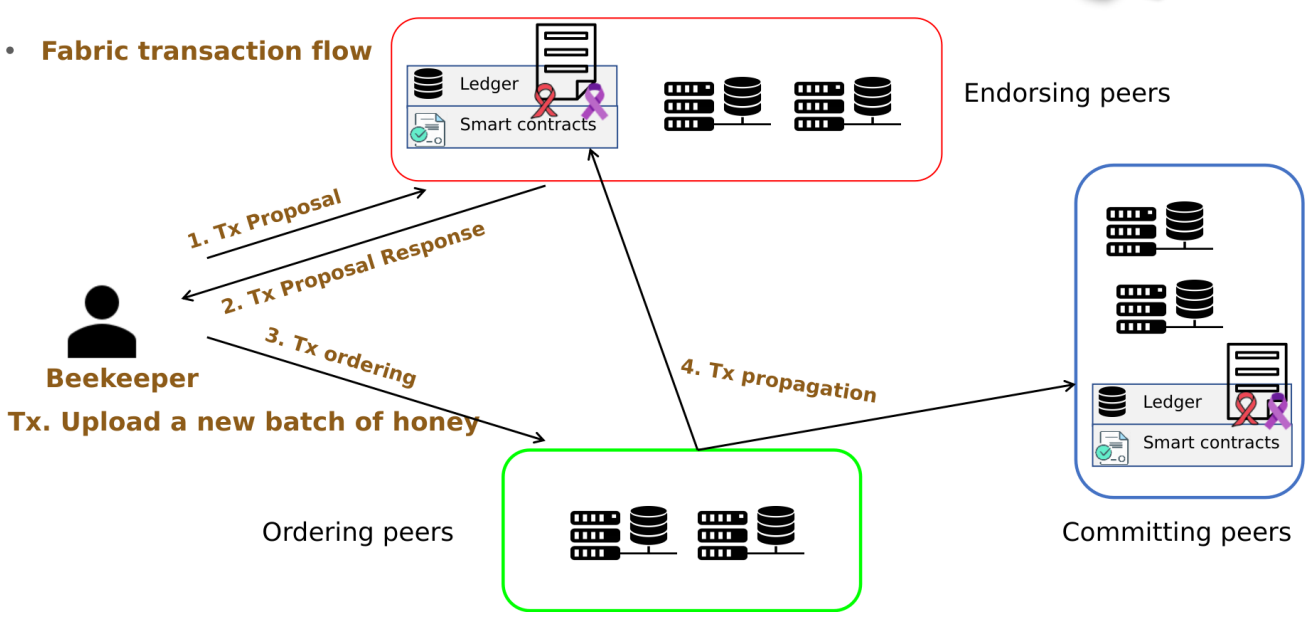

Figure 3. *Fabric transaction flow.*

defined at the application level and the flow is highly dictated by the design of the smart contract/chaincodes and the business/ Market model. For this PoC demonstration, we followed the business transaction model shown in Figure 4.

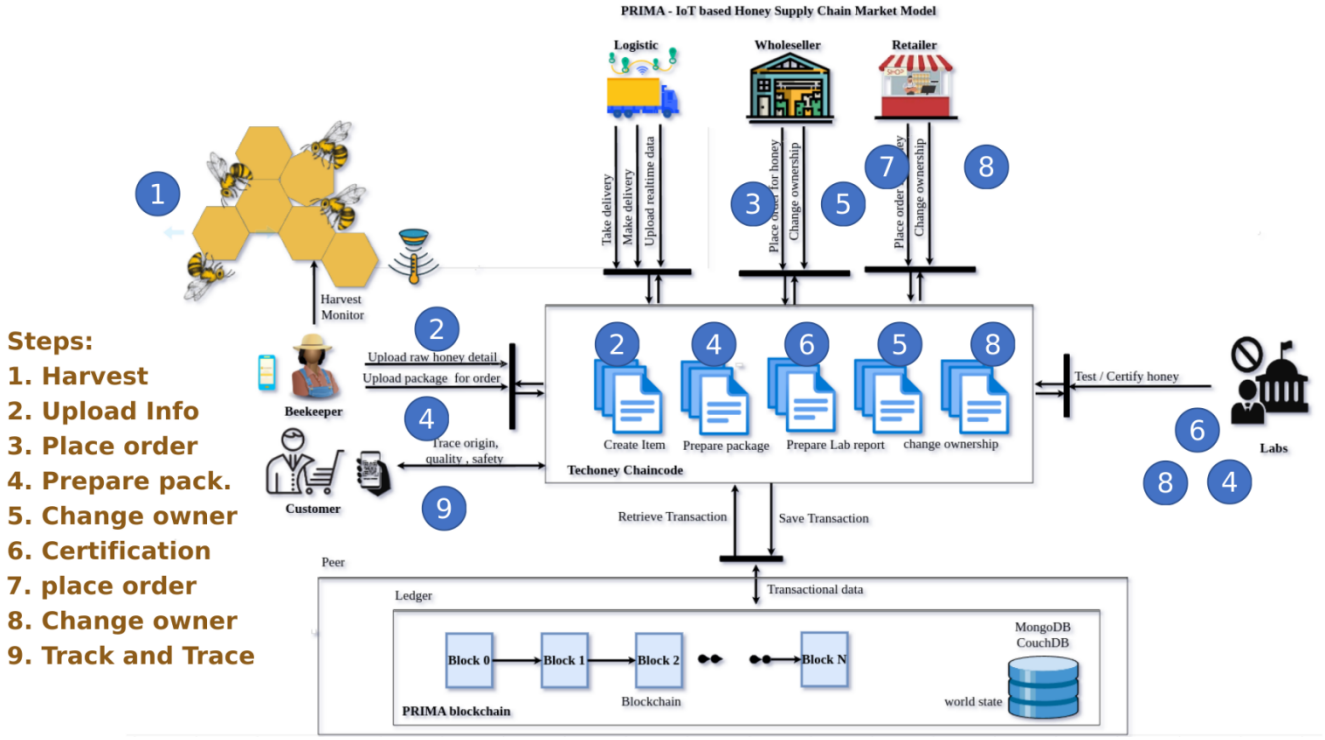

Figure 4. *PRIMA Techoney sample market model.*

In this market model, we have all the actors we expect to see in the blockchain based honey supply chain. We have the beekeeper, logistic, wholesalers, retailers, laboratories, customers and smart contracts designed to facilitate the underlying business transaction. Four organization mainly participate in this sample market model: beekeeper, wholesaler, retailer and laboratories. They have their respective part to play and individual smart contracts to utilize to interact with the blockchain. The PoC Techoney business transaction is summarized in the following steps

Steps in the PRIMA sample business market model:

Step 1. The beekeeper harvests the honey;

Step 2. The beekeeper upload harvest information into the blockchain by invoking the create Item smart contract. This information will be accessible to all participants willing to transact with the beekeeper. The details include the origin, description and production attributes we mentioned in the asset definition in the previous section.

Step 3. The wholesaler places an order;

Step 4. The beekeeper accepts the order and prepare package by invoking the prepare package smart contract;

Step 5. Once the wholesaler accepts the package. He/She can invoke the change ownership smart contract to update the current owner of the package and the location the package is currently at.

Step 6. The wholesaler might decide to certify the honey he bought from the beekeeper and sends a sample to the Laboratories for a quality certification. The laboratory will invoke the prepare lab report smart contract to insert the quality and safety of the honey into the blockchain. This specific step can also be performed at the beekeeper, wholesaler or retailer side. A certified honey can be sold at a higher price compared to certified. So, if performed at the beekeeper side, this can add a value to the beekeepers;

Step 7. The retailer places an order to the wholesaler and sends package to the retailer;

Step 8. Once the retailer receives the package, he/she can invoke his/her respective change ownership smart contract to update the current owner and the location the package is currently at.

Step 9. Then any customer buying the product from the retailer can use the product ID to track and trace the origin, quality and authenticity of the honey product.

Smart contract design for the PoC

In blockchain context, smart contracts are what gives meaning to the objectives of participating in the given network. It represents the terms of agreement and rules of engagement between the participating organizations who agreed to transact within the blockchain. These agreements are later changed into a self-executing code on the blockchain where under the right endorsement criteria, can facilitate business transactions without intermediary oversight. As they represent the underlying business logic and binding agreements, they are mostly bundled together into a chain code and deployed across the blockchain network so that it can be accessible to all participating stakeholders. Hence, smart contract design goes hand in hand with understanding the business process and legal frameworks.

For the PoC market model shown above, we followed a Chaincode design methodology where the transition of package is strictly from beekeepers to wholesalers then to retailers and then finally to customers. To enforce this rule, the smart contract first checks the previous owner before assigning the package to a new owner. This rule strictly enforces the direct customer to the beekeeper is a wholesaler and retailer cannot buy from a beekeeper. As a result, this design approach is only for a demonstration purpose and in the real implementation, the wholesaler, retailer and the end-customer can directly buy from the beekeeper. As given in steps for the Techoney's market model shown above, for instance, the beekeeper can invoke the create item smart contract to upload information about a new harvest as shown in Figure.5.

```
/**CREATE ITEM */
async createItem(ctx,batchNumber,apiaryName,address, city,country,
    type,weight,organic,additive,additiveName,extractionMethod,temperature) {
    console.info('============= initialize :  createItem call ===========');
    const Asset ={
        orderId:{},
        apiaryName,
        address,
        city,
        country,
        type,
        batchNumber,
        weight,
        organic,
        additive,
        additiveName,
        extractionMethod,
        temperature,
        moistureContent:{},
        pollenCount:{},
        purityTest:{},
        bestBeforeDate:{},
        certified:{},
        certifiedby:{},
        storage:{} ,
        safety:{},
        price:{},
        orderStatus:'New',
        currentLocationAddress:address,
        currentLocationCity:city,
        currentLocationCountry:country,
        currentOwner:'farmer',
        ownerName:apiaryName,
        createdAt:0,
        updatedAt:0
  }
    let dt = new Date().toString();
    Asset.createdAt = dt
    Asset.updatedAt = dt
    await ctx.stub.putState(batchNumber, Buffer.from(JSON.stringify(Asset)));
    console.info('============= END : asset created successfuly==========');
}
```

Figure 5. *Smart contract for uploading new harvest information.*

This function takes parameters such as the batch number, apiary name, beekeeper address information, the honey description and production information to create the item and save it on the blockchain ledger. Likewise, we have also a chaincode to apply a change in ownership, to upload IoT device reading and upload quality certification from laboratories. However, the only binding agreement that exist is a strict flow of honey package from beekeeper to wholesaler to retailer and then to the customer.

HYPERLEDGER FABRIC CONSORTIUM FOR HONEY SUPPLY CHAIN

To test the smart contract developed in the previous section and perform a traceability test for provenance, in this section we will build the blockchain network and the accompanying interfaces for each stakeholder to interact with the underlying blockchain and their respective chaincodes based on the PoC architecture shown in Figure.1. The front-end design is based on the questionnaire and functional requirement site map we submitted in the previous deliverables.

Front-end layer

The front-end design is divided into two major parts. A main page and a user specific portal.

Main page

The main page shown in Figure 6 will serves as an entrance page for first time users' registration and a page where we provide information about the Techoney general mission, contract agreements, the rules, regulation and quality standard every participant needs to adhere to. Furthermore, it is the page where information about offense that might lead to certificate revocation and dismissal from the Techoney consortium will be provided.

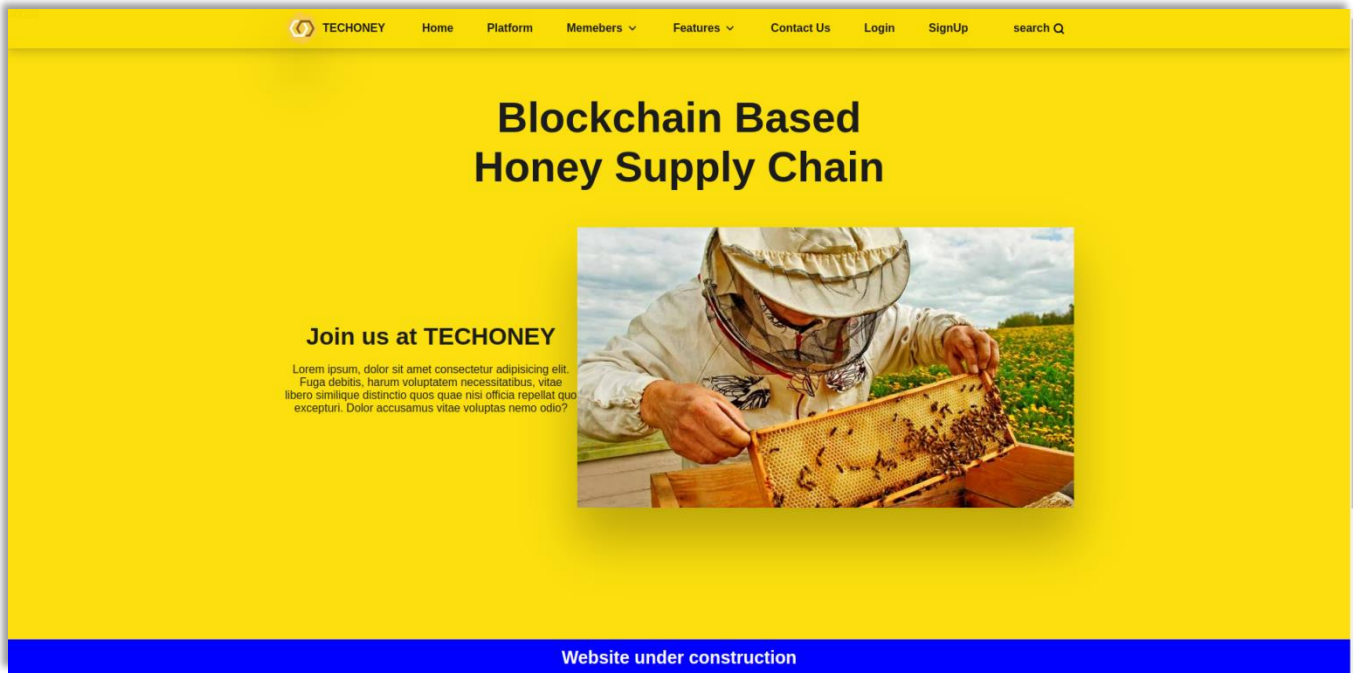

Figure 6. *Techoney's initial main page design.*

User specific page

For the user-interface we followed a design that is flexible enough to accommodate and meet the demands of all stakeholder in the honey supply chain. However, not all beekeepers or any of the stakeholders involved in production, processing, transportation and trading of honey have similar concerns when it comes their business representation on the blockchain. For instance, the size & reach of their trade horizon makes a difference in terms of the services and product type they provide. The type of stories they would like to tell to their potential clientele, how their information should be structured, how they describe the type and quality of honey they produce: raw, bottled or processed etc., all goes toward designing not only a client interface but also dictate the very transactional data that will be used for recording into the ledger and product tracking during traceability. As such, in the previous deliverables we have already prepared and disseminated a questionnaire to participating stakeholders whose response would help us in designing a more user-friendly interface. However, in the mean time we have taken the opportunity to design an initial page layout for beekeepers, wholesalers, retailers and laboratories based on the functional requirement site-map we submitted as shown in Figure 7, Figure 8 and Figure 9 respectively. And for a more information regarding the attributes considered for each stakeholder, the site map and the corresponding excel sheet can be reviewed.

Beekeeper web-interface

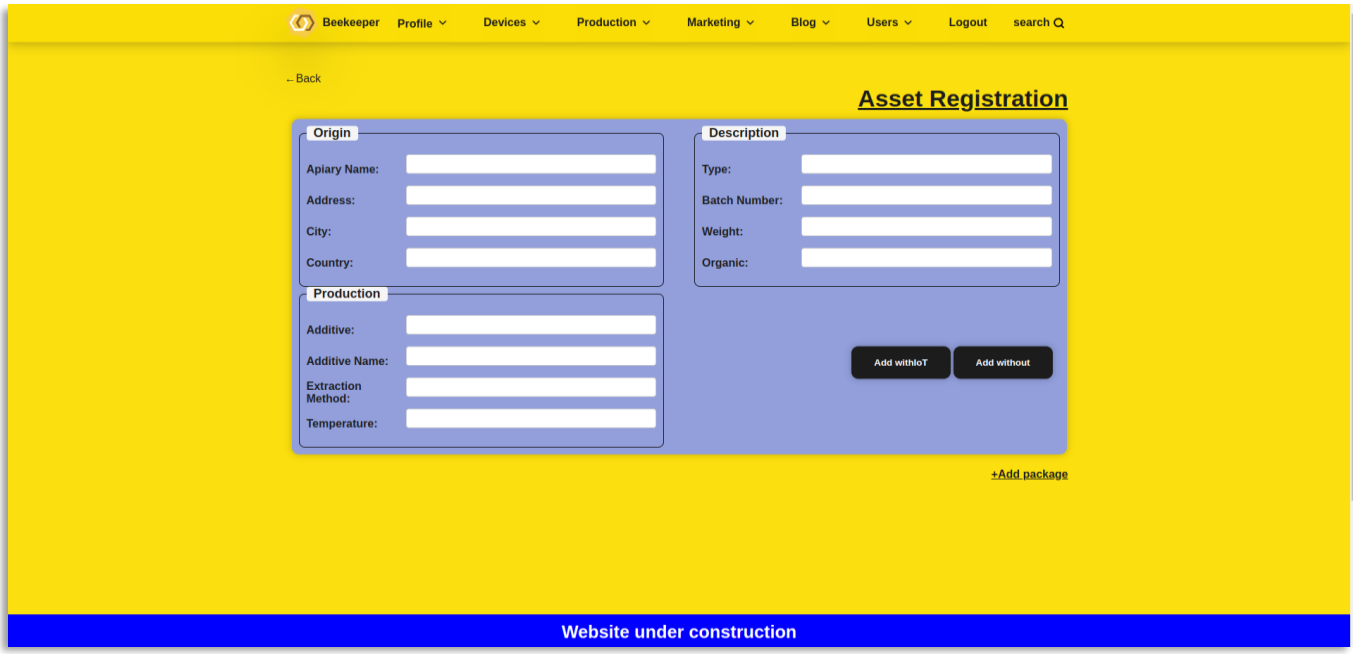

Figure 7. *Beekeeper sample interface page.*

The beekeeper page shown in Figure 7 has a profile page for user specific data, a device page for IoT device registration and a monitoring page for recording environmental condition of the storage areas, a page for asset registration (creating Item), a page for preparing packages for received orders, among other things.

Wholesalers & Retailers:

The wholesalers and retailers shown in Figure.8 share the same page layout. Like in the case of beekeepers, they have a profile page for a user specific data, a device page for IoT device registration and monitoring, a page for asset registration, among other things. However, the smart contract invoked will be different depending on identity of the stakeholder (i.e., meaning that whether the stakeholder is a beekeeper, a wholesaler or a retailer).

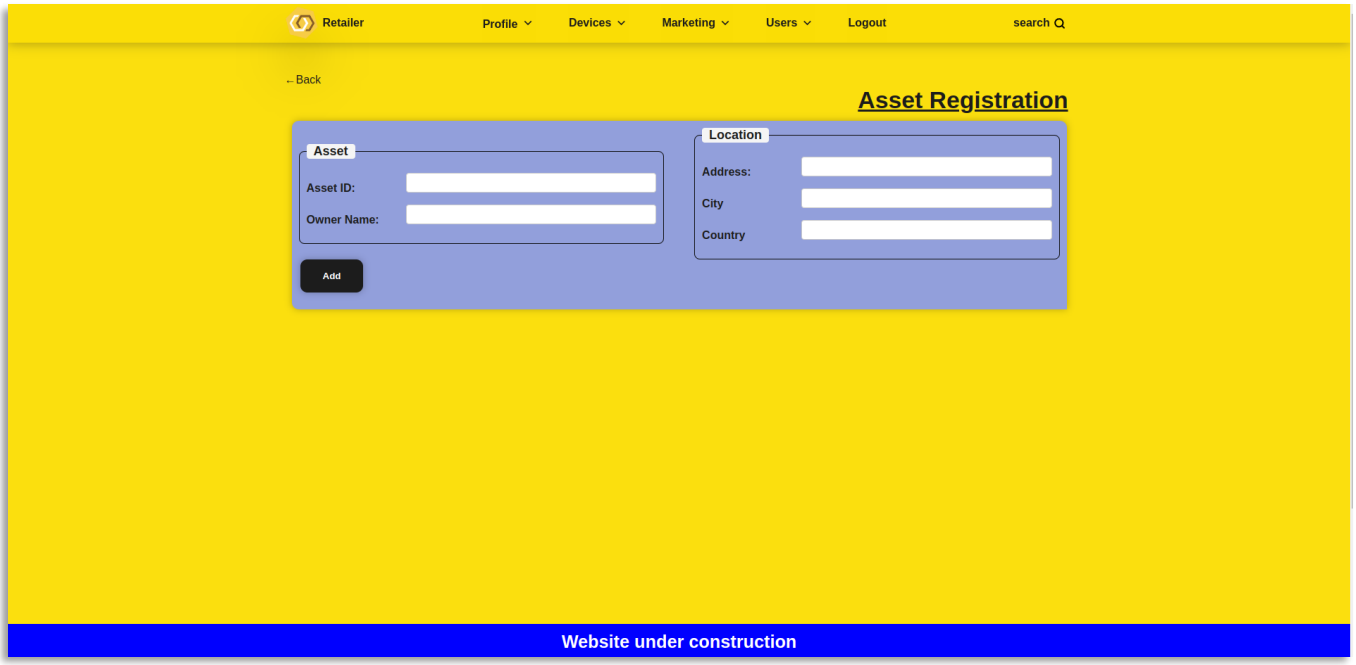

Figure 8. *Wholesalers and retailers sample interface page.*

Laboratories

The laboratories interface shown in Figure.9 has a smaller detail compared to the beekeepers and wholesaler/retailer page. It has a profile page like the beekeeper/wholesaler/retailer and an asset registration page to insert quality metrics as part of the product certification for a given asset.

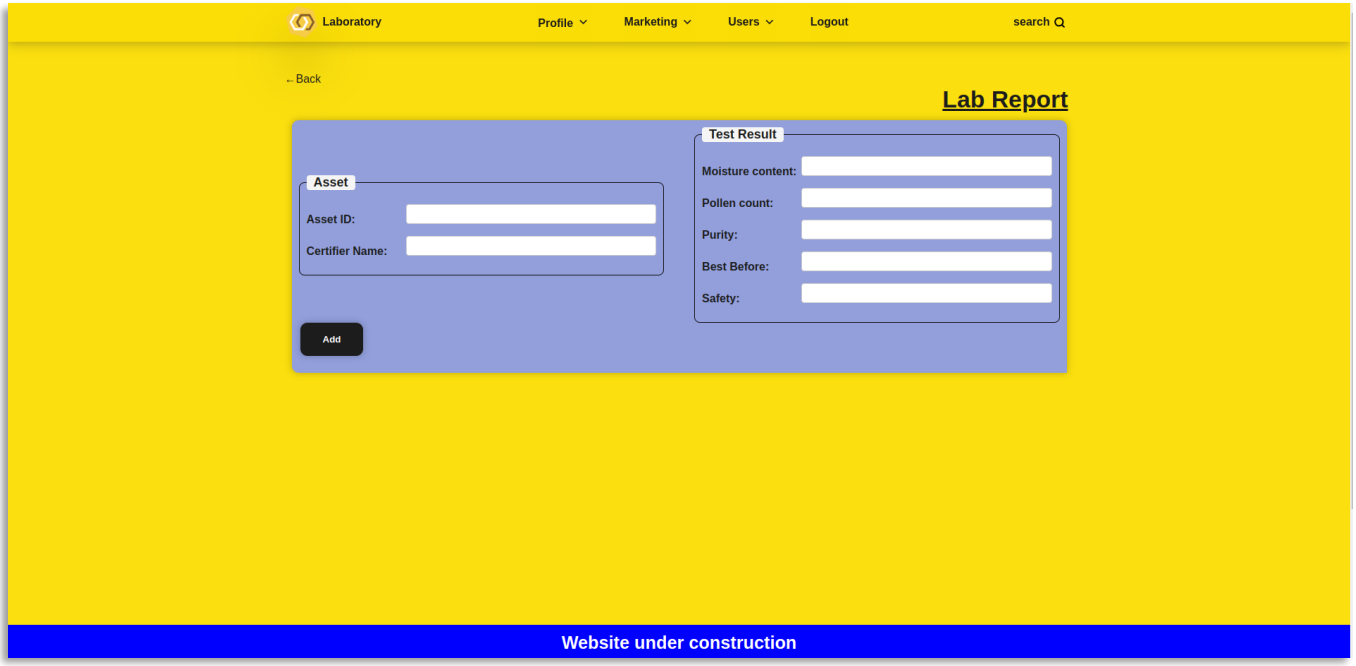

Figure 9. *Laboratoires sample interface page.*

Blockchain layer:

For this sample PoC traceability system implementation, we considered a Fabric consortium consisting of three participating organizations: a beekeeper organization, a wholesaler organization and a retailer organization. And assumed the laboratories as an affiliate to the wholesaler organization. As such they have the permission to utilize the resources of the wholesaler's organization. Consequently, we created a network configuration file for three Org Techoney consortium with a single channel for business transaction as shown in Figure.10 and Figure.11. With Org1, Org2 and Org3 representing the beekeepers, wholesalers and retailers' organization in the PRIMA blockchain network. Furthermore, we created single users for the beekeeper and retailer organization as a representative to transact in the honey trade. However, for the wholesaler organization, we generated two users: one representing the wholesaler and the other one for the laboratories.

```
Profiles:

    TecHoneyOrdererGenesis:
        <<: *ChannelDefaults
        Orderer:
            <<: *OrdererDefaults
            Organizations:
                - *OrdererOrg
            Capabilities:
                <<: *OrdererCapabilities
        Consortiums:
            TecHoneyConsortium:
                Organizations:
                    - *Org1 /* Beekeepers organization */
                    - *Org2 /* Wholesalers orgnaization */
                    - *Org3 /* Retailer organization */
    TecHoneyChannel:
        Consortium: TecHoneyConsortium
        <<: *ChannelDefaults
        Application:
            <<: *ApplicationDefaults
            Organizations:
                - *Org1
                - *Org2
                - *Org3
            Capabilities:
                <<: *ApplicationCapabilities
```

Figure 10. *A three Org Techoney Consortium for PoC implementation.*

Demonstration Architecture

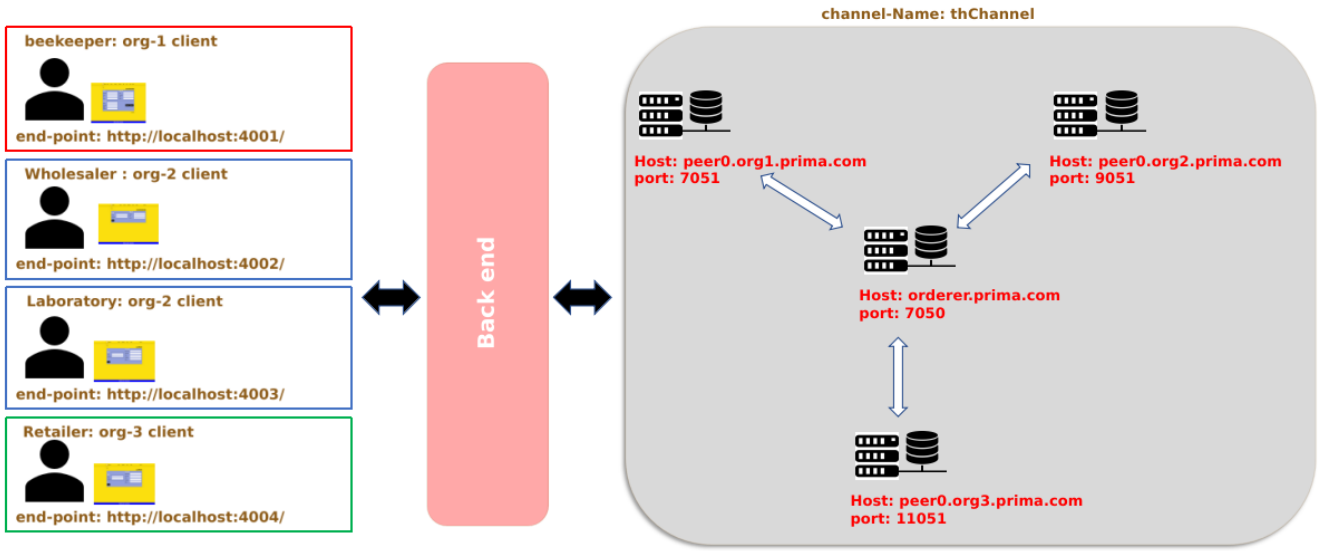

Figure 11. *A three Org Techoney Consortium for PoC implementation.*

END-TO-END POC TRACEABILITY SYSTEM DEMONSTRATION

We have already presented the successful completion of this end-to-end PoC traceability system demonstration at the PRIMA's annual meeting in Tunisia on 2nd May 2024. Instantiating a blockchain network in Fabric requires numerous steps. From generating certificates for identity management, creating channels, specifying anchor peers for each participating organization, joining peers to the channels up-to the chaincode deployment and its installation on the given channel goes through a number of steps depending on the agreed policies as shown in Figure.12.

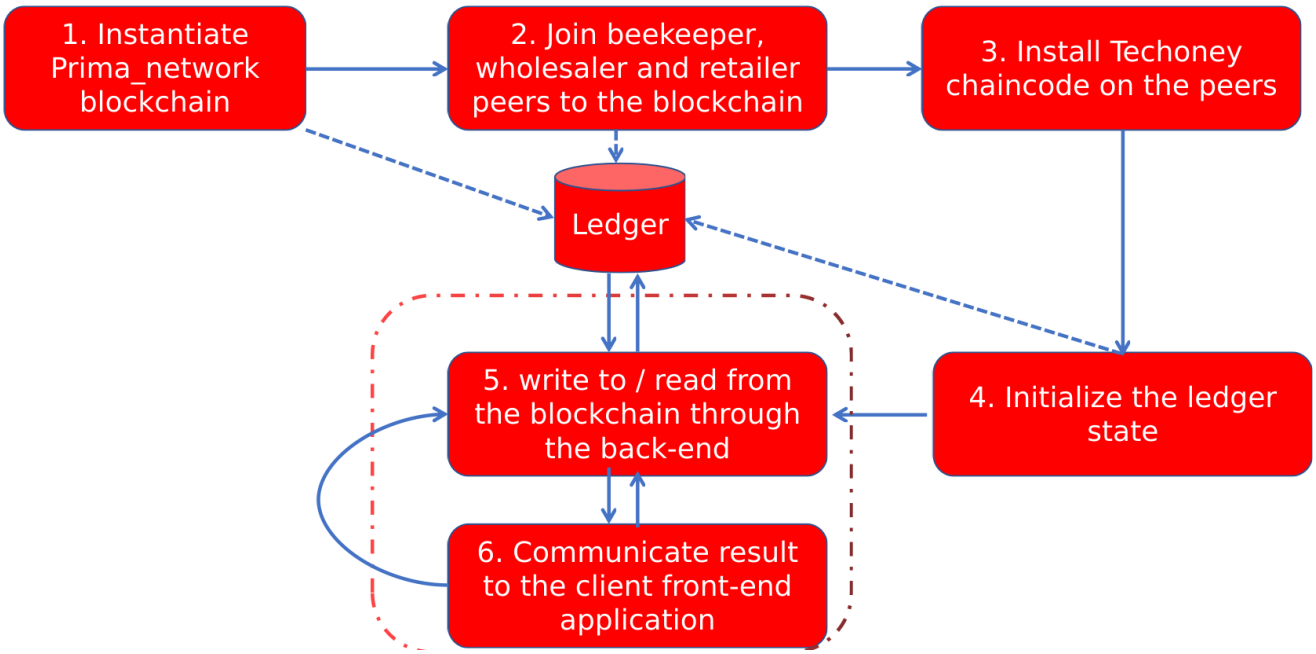

Figure 12. *A Complete Flow: from web application to committing block in ledger.*

To automate these processes, wwe have created a bash script and going through each detail in itself takes even longer. In the annual meeting in Tunisia, following the nine steps that are given in the transactional flow of the market model described in the previous section and the user interaction with the blockchain through the web-interface given in Figure.11, we successfully demonstrated the efficiency of blockchain based supply chain in automating traceability report for provenance. However, during the demonstration, the traceability report was given in-terms of a JSON data. We exposed all information pertaining to the product just to make it easier for the participants from other work packages to review the relevance of the attributes we used for asset description. As a result, in the next part of the implementation, we will hide information that are not relevant to the end-consumer and also data that should be private to the participating organizations. And we will dedicate a more user-friendly page for asset tracking and tracing.