# D7.4 IPR Authoring tool & Transaction Management Strategies for iPRODUCE Social Manufacturing Missions

CERTH

June 2021

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| **Abstract** | This document reports the results of the activities carried out by M18 within the context of WP7 (Sharing Economy Business Models and Execution Tools), particularly in the Task 7.4 “IPR & Transaction Management Strategies & Automation”. IPR Management strategies, Blockchain technologies and frameworks have been investigated in order to reinforce the Design Thinking processes of product co-creation. In addition, the architecture and functional overview of the IPR Authoring Tool has been defined and presented. |

| DELIVERABLE HISTORY | | | |
|---|---|---|---|
| **Date** | **Version** | **Author (Partner)** | **Summary of main changes** |
| 31th March 2021 | draft | CERTH | Initial Table of Contents |
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| 11th June 2021 | V0.1.1 | EDLUX | 1st Review |
| 30th June | V0.2 | CERTH | Final Version |

| DISSEMINATION LEVEL | | |
|---|---|---|
| PU | Public | |
| PP | Restricted to other programme participants (including the EC services) | |
| RE | Restricted to a group specified by the consortium (including the EC services) | |
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# Executive Summary

This document is a deliverable of the iPRODUCE project, funded by the European Commission's Directorate-General for Research and Innovation (DG RTD), under its Horizon 2020 Research and innovation programme (H2020). The document reports the results of the activities carried out by M18 within the context of WP7 (iPRODUCE Sharing Economy Business Models and Execution Tools), particularly in the Task 7.3 "IPR & Transaction Management Strategies & Automation".

The objectives of the WP7 are:

- To devise novel business models and IPR management strategies and tools to simplify and automate multi-stakeholder interactions. (Business models for shorter time-to-market product engineering. Build trust through smart contracts)

The work performed by M18, introduces a functional prototype of the iPRODUCE, IPR Authoring Tool. Within the components of the IPR Authoring Tool, a local Blockchain framework accompanied by a comprehensive and intuitive user interface has been developed, facilitating the reinforcement of the Design Thinking processes of product co-creation.

Initially, in order to define and justify the component's architectural and functional specifications, extensive research about existing Blockchain technologies, frameworks and verifications tools related to the Ricardian Contracts has been carried out. The benefits of the Ricardian Contracts emerged as results.

Additionally, the steps of the IPR management strategies and the Ricardian Contract template functionalities are presented in chapter 2. The interconnection of the IPR Authoring Tool with the rest of the OpIS platform components such as the Marketplace and the OpIS Data Repository as well as the business scenario analysis are introduced in chapter 3.

Finally in this first version deliverable, the main focus is to create a Blockchain based smart contract platform and a graphical interface that empowers users to create simple NDA contracts for a team product. Moreover, the connection with the OpIS platform and the OpIS data repository components has been established.

In the deliverable D7.5, which is going to be the updated version of D7.4, additions such as the complete integration with the OpIS platform components, including the Matchmaking and the Marketplace, will be implemented. A detailed description of the updated IPR Authoring Tool integration process will also be provided along with its extensive functional capabilities covering all essential operational needs.

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# 1. Introduction

Intellectual Property (IP) functions as a comprehensive representation of the intangible assets owned by a company and legally protected from authorized use and conversion by third parties. The basis of this term, referring to the non-physical assets an organization holds, is resolved around the fact that products which are the results of human effort and intellect should be properly protected by laws and legislations equivalent to their physical property counterparts. Thus, most of the developed economies of the world have issued legal measures in place to safeguard both forms of property. All the above measures, provide economic incentives to people as they allow them to profit from the knowledge and exploitation, they create through them.

The non-physical existence of intellectual property presents difficulties when compared with traditional property which has physical forms. Specifically, unlike physical goods, the indivisible nature of intellectual assets means that there is an unlimited capacity for copying and redistributing and idea, patent or trade secret. This creates the need for finding the golden mean between the giving the incentives for the creation of intellectual assets while also being protective enough to not prevent the sharing and advancement of them. All the above lead to the necessity of Intellectual Property Rights Management (IPRM).

Intellectual Property Management covers the decisions and strategies which are deployed to protect and preserve the integrity of the intellectual property rights of an organization while also helping the maximization of profits from the commercialization benefits.

For this reason, CERTH as part of the iPRODUCE initiative aims to provide an intellectual property management system through Smart Contracts using modern technologies such as Blockchain and visual web tools for the authoring and deployment of them.

## 1.1. Scope of the Deliverable

The scope of this deliverable is to provide an overview of the Intellectual Property Rights authoring tool and Transaction Management Strategies for iPRODCUE's social manufacturing platform. Specifically, the first version of the designed and developed tool as well as its architectural and technical implementations will be overviewed.

Moreover, Blockchain technology and its role in all stages of an Intellectual Property Rights management system along with its technical description and the way they facilitate the proof-of-authenticity of the aforementioned rights will be also thoroughly presented. Furthermore, the importance of the Smart and Ricardian Contracts as well as the methods the visual tool employs to encode and compile the Contract compatible high-level language into machine language will be also outlined.

Finally, this deliverable aims to cover the technical details of the alpha version of an intuitive User Interface (UI) for contract template creation aimed at non-experienced users, along with the underline server-client backend technologies deployed for the purposes of the project.

## 1.2. Structure of the Deliverable

In this deliverable the main objectives and relevant technologies that the Intellectual Property Rights authoring tool employs to encounter the use cases defined by the iPRODUCE platform are described in detail. In addition, a thorough outline of the design of the components and their underline architecture is also provided.

All systems developed for the aims of the deliverable are thoroughly described in the following chapters:

- **IPR Management Strategies:** Description of the intellectual property management and transaction strategies, Contract Templates and Non-Disclosure agreements employed, that comprise the whole of the operations and the dynamics of the MMCs teams in a collaborative production platform.

- **Internal & External Architecture:** Detailed overview of the IPR Tool's architecture and technical decisions that governed the design and implementation process of the current version of the tool presented in this deliverable.

- **Blockchain Technology:** A comprehensive investigation of the role Blockchain technologies play with Smart Contracts, their underline specifics and the leading tools and platforms used in the various processes involved such as the Ethereum and EOS platforms as well as the role Ricardian Contracts play.

- **IPR Authoring Tool Implementation:** Detailed description of the design, development and technical details that were necessary for the construction of the iPRODUCE IPR Authoring Tool visual authoring tool responsible for managing everything related to Rircardian Contracts through an intuitive User Interface.

- **Next Steps:** Overview of future corrections and additions that will move the IPR Authoring Tool towards the end goal of the iPRODUCE project that will be presented in the next and final iteration of the deliverable – D7.5 on M36.

- **Conclusions:** Review of the results which came from the initial design and implementation phase of the IPR Authoring Tool's first version.

## 1.3. Relation with other Tasks and Deliverables

This deliverable reports the first version (v1) of the IPR Authoring tool & Transaction Management Strategies for iPRODUCE Social Manufacturing Missions. At M36 is expected to be delivered the second and final version (v2) of the material contained in this document, as well as corrections and improvements, which will be specified in Deliverable 7.5.

Related Task and Deliverables from the rest of the iPRODUCE Toolchain include the following:

- The basis of the iPRODUCE platform social manufacturing architecture is described in WP4-T4.1 – D4.1, which dictated the overall design decisions in Internal and external Architecture
- The KPIs and Use Case definition of the iPRODUCE initiative is defined in T2.4 that the IPR Authoring tool Implementation section aims to cover
- An outline of the issues regarding current IPR management techniques and issues is provided in the processes of T2.5. The IPR Management strategies chapter offers the solution of Ricardian Contracts to combat said issues.

- In WP3, the first concepts of the OpIS platform, training toolkit and local CMDFs are examined which affect the incorporation of the solutions offered in the IPR Management strategies and IPR Authoring tool Implementation sections
- D7.1 describes the commonly used tools and technologies as well as the upcoming relevant ones, regarding the makerspace contexts, serving as the initial state of the art for this report.

# 2. IPR Management strategies

## 2.1. Introduction

iPRODUCE identifies a set of IPR and transaction management mechanisms inside the OpIS platform that can be used to facilitate the formation and operation of ad hoc multi-sided teams, that take on collaborative manufacturing jobs under accountability. For the 'seamless' implementation of such strategies the project will use Ricardian contracts.

The legal advantages of a Ricardian contract arise from the use of mark-up language embedded in a mostly legal prose document, resulting in reduced transaction costs, faster dispute resolution, better contract enforcement and increased transparency.

The benefits of a Ricardian contract from a data processing perspective come from the software design plan that digitizes documents and lets them participate in financial transactions, such as payments, without losing the richness of the contract tradition. One important thing that should be mentioned is that publishing the content and referencing it through the unique cryptographic message nullifies frauds based on multiple presentations.

## 2.2. Template functionalities

During the iPRODUCE project, the implementation of an IPR Authoring Tool will be compassed. IPR Authoring Tool is a visual authoring tool to determine a set of simple, yet relevant, ruse that are involved in the context of Design Thinking process stages for product co-creation. Its operational sequent steps include:

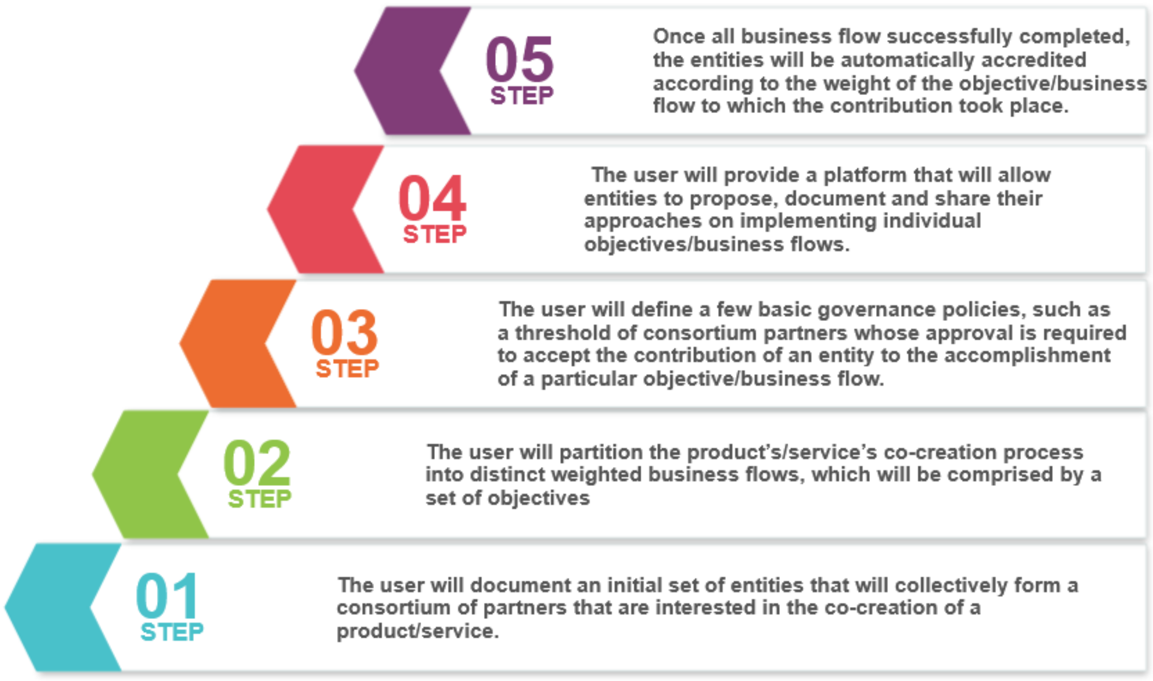

05 STEP
Once all business flow successfully completed, the entities will be automatically accredited according to the weight of the objective/business flow to which the contribution took place.
04 STEP
The user will provide a platform that will allow entities to propose, document and share their approaches on implementing individual objectives/business flows.
03 STEP
The user will define a few basic governance policies, such as a threshold of consortium partners whose approval is required to accept the contribution of an entity to the accomplishment of a particular objective/business flow.
02 STEP
The user will partition the product's/service's co-creation process into distinct weighted business flows, which will be comprised by a set of objectives
01 STEP
The user will document an initial set of entities that will collectively form a consortium of partners that are interested in the co-creation of a product/service.

Figure 2-1: Operational Sequent Steps of IPR Authoring Tool.

As the above figure indicates, the first step is that the user will create a list of entities that will get together to form a consortium of partners interested in co-creating a product or service. As a second step, the user will divide the co-creation process for the product/service into discrete weighted business processes, each with a set of objectives. Subsequently, the user will set a few fundamental governance policies, such as a minimum number of consortium partners required to accept an entity's contribution to the achievement of a specific objective/business flow. Furthermore, the user will provide a platform for entities to propose, document, and communicate their approaches to achieving specific goals/business objectives. Finally, once all business flows have been completed successfully, the entities will be automatically accredited based on the weight of the contribution to the objective business flow. All the above steps constitute the necessary requirements in a high-level overview. In the following sections the internal architecture is presented as well as the interconnection of the IPR Authoring Tool with the other components of the OpIS platform is introduced.

## 2.3. Business Scenarios Analysis

As the deliverable D2.5 "Definition of iPRODUCE demonstration" indicates, six cMDFs represent the consumer goods from different industrial sectors (furniture, automotive, microelectronics, medical and electronics) and define sixteen business scenarios describing the application areas of the OpIS platform. These business scenarios essentially analyse the functionalities which the OpIS platform offers by providing a comprehensive description on how the user will interact with the platform and the other stakeholders in order to improve the co-creation process under of the protection of a cMDF ecosystem. A business scenario is a complete description of a business problem, both in business and in architectural terms, which enables individual requirements to be viewed in relation to one another in the context of the overall problem. From the OpIS platform perspective, all the functionalities of the co-creation ecosystem are provided inside the long description of each use case of the D2.5.

All the users who are involved in the co-creation process of a new product or idea, they are called to cover and protect their product/idea. Inside the OpIS platform, it is going to be developed a tool which will protect the legal rights of everyone involved. As the technology is improved, the need to find an efficient, secure and fast way to protect the idea of a product becomes imperative. One of the most important roles of the social manufacturing missions consists the protection of the intellectual rights of the stakeholders during all the co-creation process (from the initial idea to the prototyping of the product). The IPR Authoring Tool using Ricardian Contracts is coming to support IPR during various phases of the co-creation process of a product by providing a legal document in a digitized form. It is important this document will be human-readable and machine-readable as well, so that both machines and people will be able to read and edit this. So, a Ricardian Contract was created as a means of associating a legally binding and digitally connected document with a specific object or value. A Ricardian Contract converts all information from a legal document into a computer readable format. In this sense, it serves as both a legal agreement and a mechanism for securely integrating the agreement into a digital infrastructure, while also providing a high level of security due to cryptographic identification.

The following Greek UC example may help to better appreciate the significance of the IPR Authoring Tool.

Greek cMDF mission is to bridge the gap between SME's and Makerspaces. Aidplex – CERTH, with expertise in medical and 3D printing sector, is going to help any company or customer to achieve better treatment experience. The orthopaedic back brace solution is designed by Aidplex with the aim of higher comfort levels and retrofitting the resulted design with IoT sensors, for scoliosis, hyphosis, or similar spinal deformities. The overarching goal is to finetune the design of a back brace by examining aspects like weight distribution, modularity, size adaptability and overall comfort, whilst IoT sensors will help patients self-assess and adapt their back braces leading to higher degrees of adherence and outcome. In this scenario as well as in all the scenarios which regards the social manufacturing, the need of IPR protection constitutes an important point in the co-creation missions. For co-creation works, the author or creator of the work is the first owner and it is important to protect his/her rights. Inside of this UC, there are 3 involved users (User 1 – Aidpex as designer/manufacturer, User 2 – consumer as patient, User 3 – CERTH as manufacturer). All the users have the need to protect their rights from eavesdropping and copying. Using this iPRODUCE social manufacturing platform is offered the IPR Authoring Tool which comes to protect all the rights of the co-creation and production process by providing a legal binding agreement which will include the following: (1) who is the product, (2) who are the involved manufacturers, and (3) between who the product has been created. It is important to be mentioned some essential parts of this agreement which are:

- Parties: How many parties are involved? Who are the parties making this agreement? Who are their representatives?
- An element in Time: What is the validity of the Contract? Is it applicable for a limited period of time or forever? What does it define in terms of time? For example, a deal needs to be reached withing three months, or the Contract gets null and void.
- Adding Exceptions for Different Possibilities: For example, what happens when one of the parties dies or what happens when an involved company go bankrupt? Or similar exceptions.
- Conditions: Any condition can be claused.

Covering all these parts inside of the agreement, all the users could feel legally guaranteed. Furthermore, one more crucial point of the IPR Authoring Tool is how much security this provides. Each document in the Contract has unique identification by its hash as result Ricardian Contracts are very secure as they use a cryptographic signature. This also offers protection from a commonly used tactic in legal agreements called frog boiling. Under traditional legal agreements, an issuer with the upper hand keeps changing the terms in the agreement during the execution. This is not possible with this IPR Authoring Tool.

By using the IPR Authoring Tool from the starting point of the co-creation and production process, all the involved users (patients, designers, manufacturers) feel the sense of the security from the legal perspective. As they are legally secured for the starting to the end (prototyping) stage, they can move forward to the co-creation and prototyping process without any constraint.

In the above scenario, the new technology which is offered is that the doctor and the patient can be informed when the right time for a new brace has come, due to child's growth, achieving the best possible fit of the medical device using an IoT system. This IoT system constitutes the new technology which do this product unique and innovative. If this product will be co-created using this social manufacturing platform which the iPRODUCE offers, all the involved parties will be legally protected in all the co-creation and prototyping stages. For example, CERTH as 3D manufacturer has an important role during the co-creation and prototyping process as it is responsible to print the 3D printed parts of the back brace solution using its expert premises. In case, CERTH and Aidplex which are the most crucial parties, because they should exchange knowledge (for example 3D CAD models of the back brace), are not legally secured, they will not be able to trust one each other as result, their cooperation becomes uncomfortable and difficult.

So, the IPR Authoring Tool constitutes a necessary component of the co-creation process as this save effort, costs and time by providing machine-readable legal contracts which are not open to any interpretation, which is the main drawback of human-readable legal contracts.

# 3. Internal and external Architecture

In this section, the internal and the external architecture will be introduced. The “internal” architecture deals with the sub components related to the overview of the system. The “external” architecture concerns the interconnection of the system with the other components of an IoT system, such as the social manufacturing platform.

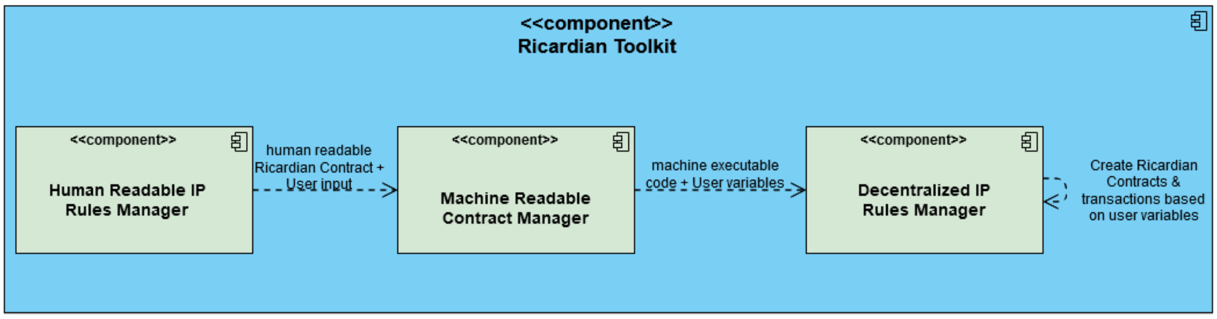
## 3.1. Internal Architecture

The sub components of the IPR Authoring Tool are depicted in the Table 1:

Table 3-1: Subcomponents - Ricardian Toolkit

| ***Main Component*** | **Sub - components** |
|---|---|
| *IPR Authoring Tool - Ricardian Toolkit* | Human readable IP rules manager |
| | Machine readable contract manager |
| | Decentralised IP rules manager |

In the following Figure 3-1 the interconnection between the sub components of the IPR Authoring Tool - Ricardian Toolkit is illustrated:



<<component>>
Ricardian Toolkit
<<component>>
Human Readable IP Rules Manager
human readable Ricardian Contract + User input
<<component>>
Machine Readable Contract Manager
machine executable code + User variables
<<component>>
Decentralized IP Rules Manager
Create Ricardian Contracts & transactions based on user variables

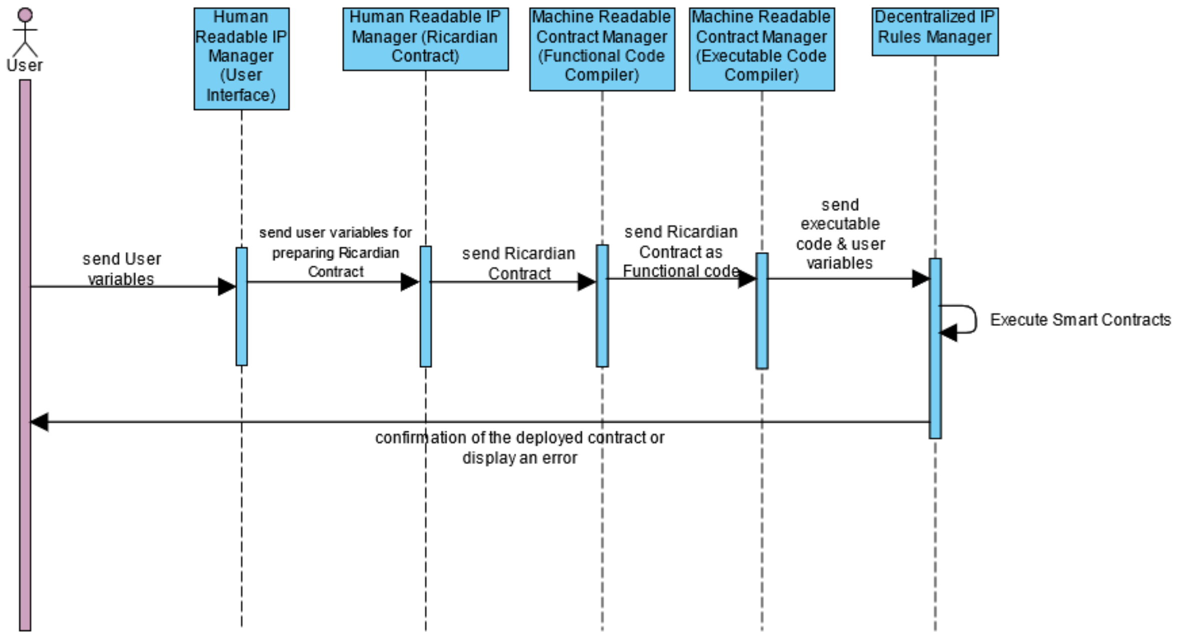
Figure 3-1: Component diagram of the IPR Authoring Tool.

The following Table 3-2 describes the component diagram of the IPR Authoring Toolkit:

Table 3-2: Subcomponent description.

| **Sub-components** | **Description** |
|---|---|
| Human Readable IP Rules Manager | The ‘Human Readable IP Rules Manager’ which will enable the Users to compile the human readable Ricardian contracts by adding input to a dedicated User Interface |
| Machine-Readable Contract Manager | The Machine-Readable Contract Manager that will translate the human readable Ricardian contracts into machine executable code |
| Decentralised IP Rules Manager’ | The ‘Decentralised IP Rules Manager’ which will instantiate the Ricardian contracts deployed to the Blockchain network (using blockchain/DLT) and will submit transactions that will call the functions of these Smart Contracts using the User input added to the first component as parameter values for the calls. |

On figure 3-2 is shown the IPR Authoring Tool service sequence diagram.

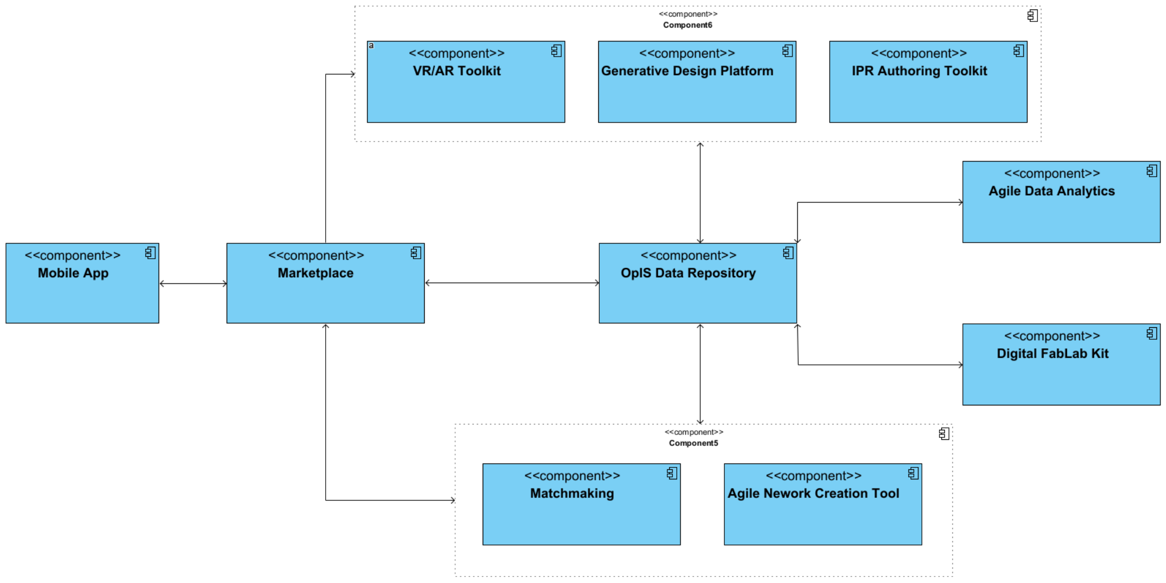


User
Human Readable IP Manager (User Interface)
Human Readable IP Manager (Ricardian Contract)
Machine Readable Contract Manager (Functional Code Compiler)
Machine Readable Contract Manager (Executable Code Compiler)
Decentralized IP Rules Manager
send User variables
send user variables for preparing Ricardian Contract
send Ricardian Contract
send Ricardian Contract as Functional code
send executable code & user variables
Execute Smart Contracts
confirmation of the deployed contract or display an error

Figure 3-2: IPR Authoring Tool - Ricardian Toolkit service sequence diagram.

## 3.2. External Architecture

According to the D4.1 “OpIS Architecture and Design for Social Manufacturing”, the interconnection of the IPR Authoring Tool with the other main components of the OpIS platform is illustrated in the figure below:



<<component>> Component6
<<component>> VR/AR Toolkit
<<component>> Generative Design Platform
<<component>> IPR Authoring Toolkit
<<component>> Agile Data Analytics
<<component>> Mobile App
<<component>> Marketplace
<<component>> OpIS Data Repository
<<component>> Digital FabLab Kit
<<component>> Component5
<<component>> Matchmaking
<<component>> Agile Nework Creation Tool

Figure 3-3: External architecture - Interconnection between the main components of the OpIS platform.[1]

[1] D4.1 OpIS Architecture and Design for Social Manufacturing

As the figure indicates, the main component of the iPRODUCE OpIS platform is the OpIS Data Repository, which connect all the other components under the umbrella of a REST API backend. Specifically, this constitutes the connector plugin which interconnect all the components of the OpIS platform by providing a data exchanging method. The Marketplace is responsible for the navigation of the user inside the OpIS platform and provide accessibility to the products, activities and users' data. Through the Matchmaking and Agile Network Creation Tools, user is able to search for the suitable partners. These tools aim at fostering the creation of collaborative networks and empowering them to jointly address specific business opportunities. Regarding the AR/VR Toolkit, this is a real time social manufacturing space for co-creation process under Augmented and Virtual environments. Similarly, the Generative Design Platform is a digital toolkit which is used so that user will participate to the co-creation process. Using a mobile application which is developing to obtain Voice of Customer feedback, users can actively solicit input (such as surveys) about new ideas. Additional, iPRODUCE defines a number of IPR and transaction management strategies that can be applied to facilitate the formation and operation of multi-party ad hoc teams, which will undertake collaborative manufacturing missions (using the IPR Authoring Tool – Ricardian Toolkit). From the visualization perspective, the Agile Data Analytics and Visualization Suite is a tool which focus on analysis and storage of Big Data (Analysis of the feedback from the cMDFs potential users, trainees, user preferences about the products/services, market trends, datasheet and technical manual of equipment). Finally, the Digital FabLab Kit constitutes a toolkit which is responsible for digitizing existing knowledge and common practices in makerspaces. It mainly addresses two aspects: (1) Digitization of training content and (2) digitization of production processes.

It is important to be mentioned in which time the user interacts with the IPR Authoring Tool. The Marketplace constitutes the starting point of a user in the OpIS platform. Through the Marketplace, a user will be able to navigate in all the components of the iPRODUCE platform. When a user is interested to create a new team in order to trigger the co-creation process, (s)he is able to use the Matchmaking and Agile Network Creation Tools so that a team will be defined by inviting SMEs / makerspaces / FabLabs. Each team which is created can co-design a lot of products based on the team's preferences. In case the co-creation process has been started, all the involved users can modify a product by using the relevant tools (Generative Design Platform, AR/VR Tool). Each one of these tools has its properties and functionalities which are described in the corresponding deliverables (D5.3, D5.4). In the time of the submission of a new product, all the involved users have been informed about the new contract which defines their collaboration. A user will be able to navigate to his/her pending / accepted / rejected contracts by clicking a notification button or by navigating through the Marketplace to the corresponding page. In Section 5 IPR Authoring Tool Implementation, the User Interface of the IPR Authoring Tool is presented as well as all the functionalities of this tool are analyzed.

# 4. Blockchain technology

Distributed ledger technology (DLT) has become a hot topic in a variety of industries in recent years, sparked by early interest in blockchain and then expanding into a more in-depth discussion of the underlying technology. DLT offers higher speed and efficiency, reimagined business models, more transparency, and higher confidence along the transaction value chain. In this section, a benchmarking study is presented by providing details about (1) the existed blockchain Frameworks, (2) the functionalities and the components of the blockchain contracts, (3) on how the Ricardian and the Smart contracts were created by using the initial blockchain contracts and finally (4) the analysis from the legal perspective. The results of this study are presented inside the following sections and conclude to these:

- The EOS system is more suitable for the IPR and transaction methods which are introduced inside the iPRODUCE project, in contrast of the Ethereum
- The Ricardian Contracts have a lot of benefits in order to be used as transaction method inside the iPRODUCE platform, instead of the Smart Contracts.

## 4.1. Frameworks

The blockchain is a tried-and-true technology that can be used in any situation. Blockchain-based applications are gaining popularity across the board. An evaluation of the two most useful blockchain frameworks can be found below.

### 4.1.1. Ethereum

Ethereum is the most frequently used development platform for smart contracts (section 4.2.1) and it may be thought of as a transaction-based state machine that starts with a starting state and incrementally performs transactions to turn it into certain end states. These are the final states that have been regarded as the canonical "version" in the universe of Ethereum.[2] Unlike Bitcoin's UTXO model, the idea of accounts is introduces in Ethereum. There are two types of accounts: 1) Externally Owned Accounts (EOAs) and 2) Contract Accounts. The difference is that the former is controlled by private keys with no associated code, but the latter is controlled by contract code that has an associated code.

An EOA is the only way for users to start a transaction. Binary data (payload) and Ether can both be included in the transaction. A smart contract is generated when the recipient of a transaction is zero-account 0. The account is activated and the corresponding code is executed in the local EVM if the receiver is a contract account (the payload is provided as input data). The transaction is sent to the blockchain network where it is verified by miners, as shown in the figure below.

[2] Ethereum Yellow Paper. (2018). [Online]. Available: https://ehtereum.github.io/yellowpaper/paper.pdf

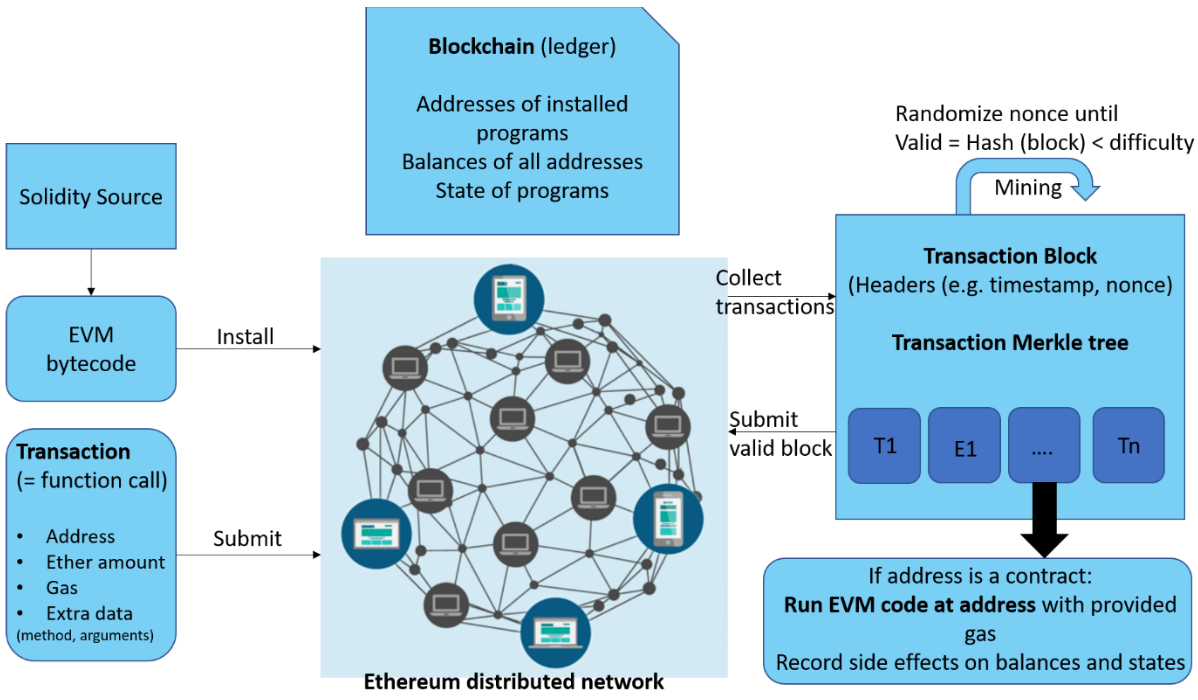

**Blockchain** (ledger)
Addresses of installed programs
Balances of all addresses
State of programs
Solidity Source
EVM bytecode
Install
**Transaction**
(= function call)
Address
Ether amount
Gas
Extra data
(method, arguments)
Submit
Ethereum distributed network
Collect transactions
Submit valid block
Randomize nonce until
Valid = Hash (block) < difficulty
Mining
**Transaction Block**
(Headers (e.g. timestamp, nonce)
**Transaction Merkle tree**
T1
E1
....
Tn
If address is a contract:
**Run EVM code at address** with provided gas
Record side effects on balances and states

Figure 4-1: Overview of workflow in the Ethereum network.[3]

To avoid network abuse issues and circumvent the inevitable problems that arise from Turing completeness, all programmable computations (e.g., creating contracts, executing message calls, using and accessing account storage, and performing virtual machine operations) are chargeable in Ethereum – a reward for miners who donate their computational resources. The gas unit is used to measure the amount of feed necessary for computations.

### 4.1.2. EOS

EOSIO is a decentralized enterprise system that runs DApps (Decentralized Applications) at industrial scale – software that relies on the EOSIO blockchain to cryptographically record transactions. The transfer of the EOSIO currency token is the most popular transaction, called EOS. EOSIO, unlike Bitcoin and Ethereum, is a DPoS-based (Delegated Proof-of-Stake) system that can scale to millions of transactions per second, making it an appealing alternative for new DApp developers.

Within EOSIO, there are four fundamental ideas to grasp. To engage with the EOSIO blockchain, an entity must first create and account. A transaction, which consists of one or more actions to be done, can then be used to trigger a smart contract using this unique identity. A transfer of an EOS token from one account holder to another, for example, is an activity. Accounts that intend to invoke a contract must first delegate proper permissions to it, granting it the ability to act on their behalf. The rest of this section delves deeper into each of these four topics.

#### *4.1.2.1. EOSIO's Smart Contract and Transactions*

The official language for DApp developers to construct smart contracts on EOSIO is C++. Specifically, the source code of Smart Contract is compiled down to WebAssemply bytecode. When the bytecode is called, it is performed in EOSIO's Wasm VM, which results in transactions being recorded on the

[3] K. Bhargavan et al., "Formal verification of smart contracts: Short paper", in Proc. ACM Workshop Program. Lang. Anal. Security (PLAS), Vienna, Austria, Oct. 2016, pp. 91-96

blockchain, such as transferring EOS. An action is a base32 encoded 64-bit integer that may be used to represent a single operation and is a fundamental aspect of smart contract communication. There are two sorts of actions: external and inline. An external action is when the user initiates an action from the outside, while an inline action is when the user invokes another action from within a smart contract (the same or external).

One or more actions can be included in each transaction. There are two sorts of actions that can be sent for communication in EOSIO: inline actions, which execute activities in the same transaction as the original action, and deferred actions, which execute operations in a future (delayed) transaction. .If deferred actions are planned, they will always run asynchronously ,inline actions, on the other hand, are guaranteed to run in a synchronous manner. If an inline action fails or throws an exception, the transaction is rolled back.

#### *4.1.2.2. EOSIO's Account Management*

In EOSIO, accounts are the entities that can conduct transactions. A human-readable name (up to 12 characters) is recorded in the blockchain as an EOSIO account. Accounts are permission structures which can define contract senders and receivers in practice. Accounts can also grant contracts permissions and be set up to allow a single user or a group of users to submit or push any lawful transaction to the blockchain.

It is important to mention that an EOSIO account is not the same as (and more complicated) an Ethereum account. First and foremost, accounts are hierarchical in nature and can only be established from an existing account, resulting in a tree structure. This means that the resources required to construct new accounts must be taken from current accounts (with the exception of eosio, the root of the tree, which was produced by the blockchain system when the mainnet was deployed). This will unavoidably deplete system resources (RAM) and therefore EOSIO account creation is not free.

An EOSIO account's permissions are used to authorize actions and transactions for other accounts.[4] Specifically, the account can assign specific actions to public/private keys, and a given key pair can only perform the corresponding action. An EOSIO account comes with two public keys by default: the owner key (which identifies the account's owner) and the active key (which identifies the account's current state) (which grants access to activities with the account). These two keys allow you to manage accounts with two native named permissions: owner and active. EOSIO additionally provides for customized named permissions for advanced users in addition to the native permissions. EOSIO provides you customizable named permissions in addition to native permissions for enhanced account management.

### 4.1.3. EOS in comparison with Ethereum within iPRODUCE

As there are several different platforms out there that offer somewhat similar services, such as the ones presented in this study, there needs to be some points of differentiation and categorization. Firstly, it is crucial to be mentioned that inside the OpIS platform, iPRODUCE identifies a set of IPR and transaction management methods that can be utilized to assist the formation and operation of ad hoc multi-sided teams that take on collaborative manufacturing activities under supervision. The project will use Ricardian Contracts as the DoA indicates and form the following section proves as the best choice, in order to ensure that such techniques be implemented in a 'seamless' manner.

[4] Y.Huang, H. Wang, Understanding (Mis)behaviour on the EOSIO Blockchain Proc. ACM Meas. Anal. Comput. Syst., Vol. 4, No. 2, Article 37. Publication date: June 2020.

Comparison EOS to Ethereum, the EOS system exceeds that the capabilities of Ethereum in some ways. Ethereum was developed and designed in a way where the system can only manage 15-20 transactions per second. On the other hand, EOS was created to address the demand for large-scale decentralized applications. This means that the EOS system is designed to be scalable, fast, and flexible. On other blockchain networks, the lack of these features can act as a bottleneck, necessitating a unique solution in order to grow correctly.

Parallel execution and an asynchronous network communication mechanism allow the EOS system to reach this level of scalability and flexibility. In order to achieve more efficiency, the system also isolates numerous modules, such as the authentication and execution processes.[5]

By technical perspective, the EOS system (as its benefits indicate) is deemed suitable to be used inside the iPRODUCE project in order to execute transactions using its blockchain technology.

## 4.2. Blockchain contracts

In this section, the blockchain contracts are introduced. It is deemed necessary all the components of the blockchain contracts to be analysed in order to be known their architecture and their structure. In the following subsections, the meanings of the Smart and Ricardian Contracts are presented by providing a detailed analysis as well as a comparison methodology. Specifically, through this study, it is critical to end up the importance of the Ricardian Contracts under the umbrella of iPRODUCE project.

Blockchains are 'tamper evident' and 'tamper resistant' digital ledgers implemented in a distributed manner (i.e., without a central repository) and usually without a central authority (i.e., a bank, company or government). At their most basic level, they allow a group of people to keep track of their transactions in a shared ledger within that community, so that in the normal operation of the blockchain network, no transaction, once published can be altered. The blockchain concept was integrated with other technologies and computer principles in 2008 to create modern cryptocurrencies: electronic cash protected by cryptographic processes rather than a central repository or authority.

With the creation of the Bitcoin network in 2009, the first of several modern cryptocurrencies, this technology became well known. In Bitcoin, and similar systems, the transfer of digital information representing electronic money takes place in a distributed system. Users of Bitcoin can digitally sign and transfer their rights to this information to another user, and the Bitcoin blockchain records this transfer in a public way so that other network members may independently verify the transactions' legitimacy. A distributed set of people maintains and manages the Bitcoin blockchain independently. This, along with cryptographic mechanisms, makes the blockchain resistant to attempts to alter the ledger after the fact (modify blocks or forge transactions). Blockchain technology has enabled the development of many cryptocurrency systems such as Bitcoin and Ethereum. For this reason, blockchain technology is often seen as tied to Bitcoin or possibly cryptocurrency solutions in general. However, the technology is available for a broader selection of applications and is being explored for a variety of industries.

The complexity of blockchain technology, as well as its reliance on cryptographic primitives and distributed systems, makes it difficult to comprehend. However, each component can be easily described and used as a building block to understand the larger complex system. Blockchains can be informally defined as:

[5] https://academy.ivanontech.com/blog/smart-contract-platforms-eos-vs-ethereum-vs-rsk-vs-cardano

Blockchains are block-based distributed digital ledgers comprising cryptographically signed transactions. After validation and a consensus decision, each block is cryptographically linked to the one before it (making it tamper-proof). It becomes more difficult to change order blocks as new blocks are introduced (which increases tamper resistance). New blocks are propagated across the network's copies of the ledger, and any conflicts between blocks are automatically resolved according to specified rules. Distributed Ledger Technology (DLT) is a decentralized database that is administered by various people.

Blockchain is a type of DLT in which transactions are recorded with an immutable cryptographic signature called a hash.

The properties of Distributed Ledger Technology (DLT) are presented according the following scheme:

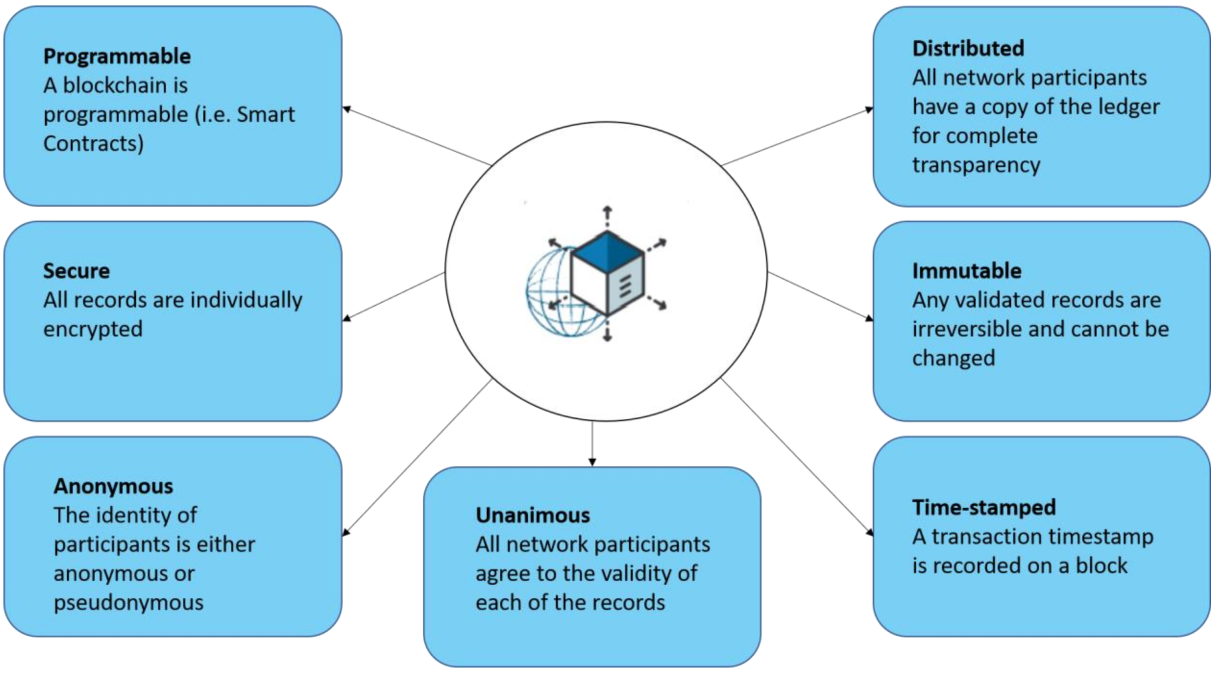

**Programmable**
A blockchain is programmable (i.e. Smart Contracts)
**Distributed**
All network participants have a copy of the ledger for complete transparency
**Secure**
All records are individually encrypted
**Immutable**
Any validated records are irreversible and cannot be changed
**Anonymous**
The identity of participants is either anonymous or pseudonymous
**Unanimous**
All network participants agree to the validity of each of the records
**Time-stamped**
A transaction timestamp is recorded on a block

Figure 4-2: The properties of Distributed Ledger Technology (DLT).[6]

Although blockchain technology appears to be complex, it may be simplified by looking at each component separately. From a high level overview, blockchain technology uses well-known informatics mechanisms and cryptographic primitives (cryptographic hash functions, digital signatures, asymmetric cryptography) mixed with data storage concepts (such as append-only ledgers). In the following points, it is discussed each major component: cryptographic hash functions, transactions, asymmetric-key cryptography, addresses, ledgers, blocks and how blocks are chained together.

**Cryptographic Hash Functions**

The usage of cryptographic hash functions for many processes is a key aspect of blockchain technology. Hashing is a way of applying a cryptographic hash function to data in order to produce a somewhat unique output (called a message digest, or simply digest) for nearly any size input (e.g., a file, text, or image).It allows individuals to independently take input data, hash that data, and get the same result-proving that the data has not been altered. Even the tiniest modification in the input (such as a single bit) results in a completely different output digest.

[6] https://en.wikipedia.org/wiki/Blockchain

Cryptographic hash functions have these important security properties:

1. They are preimage resistant.
2. They are resistant to a second preimage.
3. They are collision resistant.

One particular cryptographic hash function used in many blockchain implementations is the Secure Hash Algorithm (SHA) with an output size of 256 bits (SHA-256). Many computers support this algorithm in hardware, allowing it to be computed quickly. SHA-256 has an output of 32 bytes (1 byte = 8 bits, 32 bytes = 256 bits), which is generally displayed as a 64-character hexadecimal string.

**Transactions**

A transaction represents an interaction between parties. For example, in cryptocurrencies, a transaction represents a transfer of cryptocurrency between users of the blockchain network. In business-to-business scenarios, a transaction could be a way of recording activity that take place on digital or physical assets. A blockchain block can have zero or more transactions in it. For some blockchain implementations, preserving the security of the blockchain network requires a steady supply of new blocks (even if there are no transactions); a constant supply of new blocks being published prevents malicious users from ever “catching up” and producing a longer, modified blockchain.

The data that makes up a transaction may be different for each blockchain implementation, but the mechanism for the transaction is largely the same. Information is sent to the blockchain network by a user of the blockchain network. The information sent may include the sender’s address (or other relevant identifier), the sender’s public key, a digital signature, transaction inputs, and transaction outputs.

A single cryptocurrency transaction usually necessitates at least the following information, but may include more:

- **Inputs** – The inputs are typically a list of the digital assets to be transferred. The source of the digital asset is referenced in a transaction — either the previous transaction when it was provided to the sender, or the origination event in the case of fresh digital assets.
- **Outputs** – The outputs are usually the accounts that are the recipients of the digital assets, along with the set of digital assets they will receive.

**Asymmetric-Key Cryptography**

Blockchain technology uses asymmetric-key cryptography (also called public key cryptography). Asymmetric-key cryptography uses a pair of keys: a public key and a private key that are mathematically linked. The public key is made public without compromising the process' security, but the private key must stay secret if the data's cryptographic protection is to be maintained. Even if there is a relationship between the two keys, the private key cannot be efficiently determined from knowledge of the public key. One can encrypt with a private key and then decrypt with the public key. Alternatively, one can encrypt with a public key and then decrypt with a private key.

By offering a way to check the integrity and authenticity of transactions while allowing the transactions to remain public, asymmetric-key cryptography establishes a trust relationship between users who do not know or trust each other. To achieve this, the transactions are ‘digitally signed’. This means that a private key is used to encrypt a transaction in such a way that anyone with the public key can decrypt it.

The following points will introduce the use of asymmetric-key cryptography in many blockchain networks:

- Private keys are used to digitally sign transactions.
- Public keys are used to derive addresses.
- Public keys are used to verify signatures generated with private keys.
- Asymmetric-key cryptography makes it possible to verify that the user transferring value to another user is in possession of the private key that can sign the transaction.

**Addresses and Address Derivation**

Some blockchain networks utilize an address, which is a short alphanumeric string obtained from a cryptographic hash function and some additional data from the blockchain network user's public key (e.g., version number, checksums). Most blockchain implementations use addresses as the “to” and “from” endpoints in a transaction. Addresses are shorter than public keys and are not secret. One method of generating an address is to create a public key, apply a cryptographic hash function to it, and convert the hash to text:

Public key → cryptographic hash function → address

Each blockchain implementation may implement a different method for deriving an address. For permissionless blockchain networks, that allow anonymous account creation, a blockchain network user can generate as many asymmetric-key pairs, and thus addresses as desired, allowing varying degrees of pseudo-anonymity. Addresses can act as a public identifier for a user on a blockchain network, and often an and address is converted to a QR code for ease of use with mobile devices.

**Ledgers**

A ledger is a list of all the transactions that have occurred. Pen and paper ledgers have been used to record the transaction of commodities and services throughout history. In modern times, ledgers are stored digitally, frequently in huge databases administered on behalf of a community of users by a centralized, trusted third party (i.e., the owner of the ledger). These centralized ownership ledgers can be deployed either centralized or distributed (i.e., single server or coordinating cluster of servers).

**Blocks**

Software is used by users of the blockchain network to submit candidate transactions to the blockchain network (desktop applications, smartphone applications, digital wallets, web services, etc.). These transactions are sent to a node or nodes within the blockchain network by the software. The selected nodes can be both non-publishing full nodes and publishing nodes. The submitted transactions are subsequently propagated to the rest of the network's nodes, but this does not guarantee that the transaction will be included to the blockchain.. In many blockchain implementations, once a pending transaction has been propagated to nodes, it must wait in a queue until it is added to the blockchain by a publishing node.

When a publishing node publishes a block, transactions are added to the blockchain. A block is made up of two parts: a block header and block data. The metadata for that block is contained in the block header. A list of approved and legitimate transactions made to the blockchain network is contained in the block data. Validity and authenticity are ensured by ensuring that the transactions are properly formed and that each of the digital asset providers in each transaction (specified in the transaction's "input" values) has cryptographically signed the transaction. This verifies that the digital asset providers for a transaction had access to the private key with which to sign the available digital assets.

Other full nodes verify the legitimacy and authenticity of all transactions in a published block before accepting it, and reject it if it contains invalid transactions.

**Chaining Blocks**

The blockchain is formed by a chain of blocks, each of which contains the hash digest of the previous block's header. If a previously published block was updated, the hash value would be changed. This in turn causes all subsequent blocks to also have different hashes as well, since they contain the hash of the previous block. In this way it is possible to easily detect and reject modified blocks. The figure below shows a generic chain of blocks.[7]

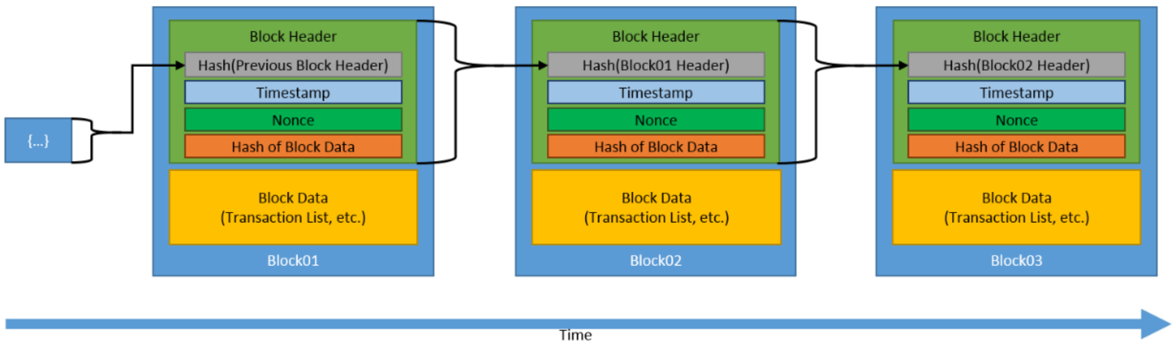


Figure 4-3: Generic Chain of Blocks

### 4.2.1. Smart Contracts

Nick Szabo, who coined the phrase smart contract in 1994, defines it as "a computerized transaction protocol that performs the provisions of a contract." Smart contract design aims to meet common contract terms (such as payment terms, liens, secrecy, and even enforcement), reduce malicious and unintentional exceptions, and eliminate the need for trusted intermediates. Smart contracts extend and leverage blockchain technology. A smart contract is a collection of code and data (also known as functions and state) that is put on the blockchain network via cryptographically signed transactions (e.g., Ethereum's smart contract, Hyperledger Fabric's chaincode). The smart contract is executed by nodes in the blockchain network; all nodes that execute the smart contract must get the same outcomes from it, and the results are recorded on the blockchain.

Users of the Blockchain network can create transactions that send data to public functions offered by a smart contract. The smart contract executes the appropriate method using the data provided by the user to perform a service. Also, because the code resides on the blockchain, it is tamper-proof and can therefore be used as a trusted third party (among other purposes). A smart contract can perform calculations, store information, expose properties to reflect a publicly available state, and automatically send money to other accounts if necessary. It does not even necessarily have to perform a financial function.

Smart contract code can represent a multi-party transaction, typically in the context of a business process. In a multi-party scenario, the advantage is that it can provide provable data and transparency that promotes trust, provides insights that enable better business decisions, reduces the costs of

[7] D. Yaga, P. Mell, N. Roby, K. Scarfone, Blockchain Technology Overview, National Institute of Standards and Technology, 2018

reconciliation that exists in traditional business-to-business applications, and reduces the time to complete a transaction.

Smart contracts must be deterministic, meaning that given an input they must always produce the same output based on that input. Also, all nodes executing the smart contract must agree on the new state that will be reached after execution. To achieve this, smart contracts cannot process data that it is not passed directly to them (e.g., smart contracts cannot obtain data from web services from the smart contract – it would have to be passed as a parameter). Any smart contract that uses data from outside the context of its own system is called an 'Oracle'.

When publishing new blocks on many blockchain implementations, the publishing nodes run the smart contract code at the same time. Some blockchain implementations include publishing nodes that do not run smart contract code but rather validate the outcomes of the nodes that do. The user making a transaction to a smart contract on permissionless blockchain networks with smart contracts (such as Ethereum) will have to pay for the cost of the code execution. Based on the intricacy of the code, there is a limit on how much execution time can be consumed by a call to a smart contract. When this limit is reached, the transaction is discarded and the executions are halted. This technique not only pays the publishers for running the smart contract code, but also discourages malicious users from deploying and then accessing smart contracts that will perform a denial of service on the publishing nodes by using all available resources (e.g., using infinite loops).[8]

The operational mechanism of smart contracts is shown in Figure below.

[8] D. Yaga, P. Mell, N. Roby, K. Scarfone, Blockchain Technology Overview, National Institute of Standards and Technology, 2018

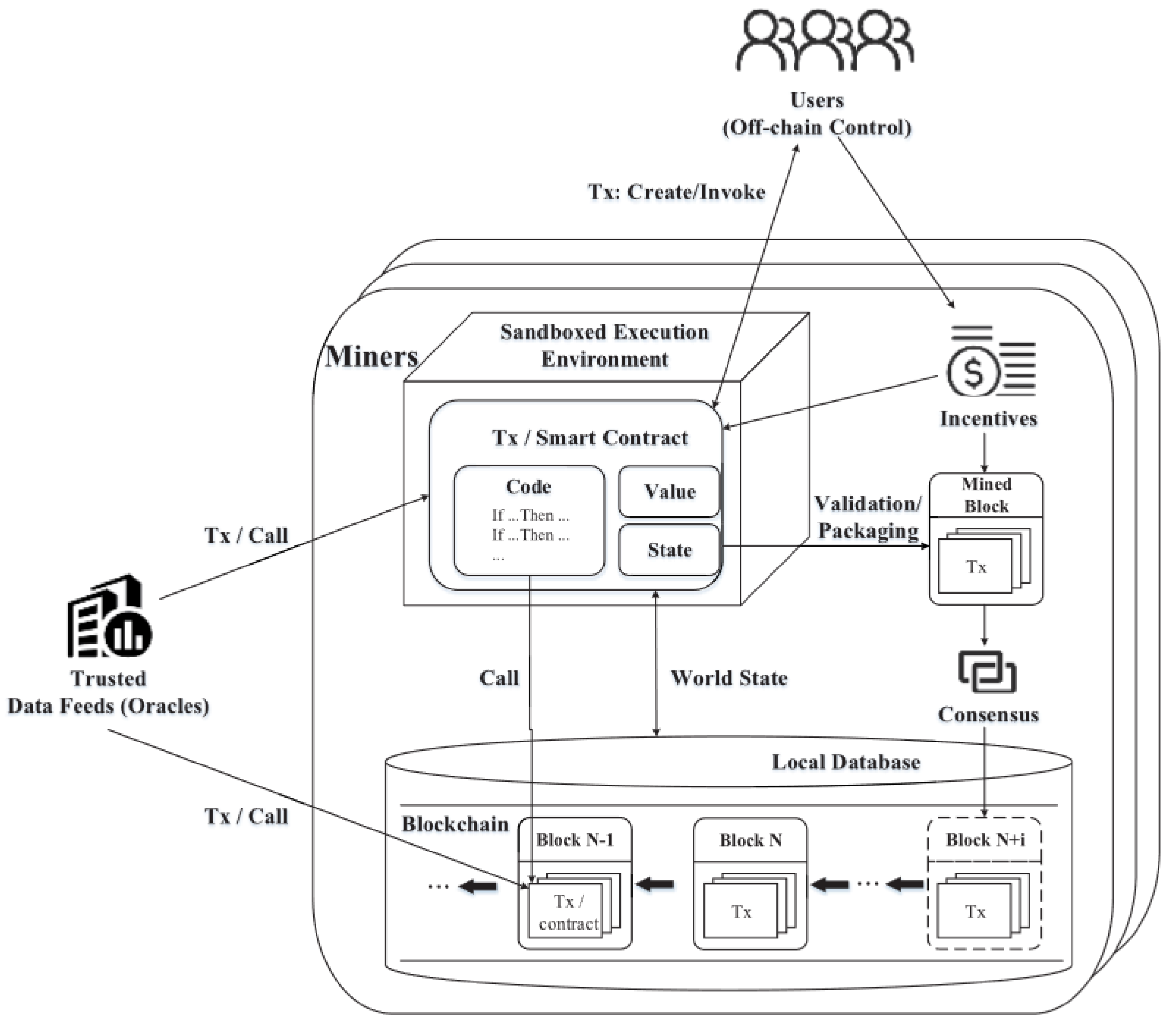


Figure 4-4: Operational mechanism of smart contract.

Smart contracts usually have two attributes: 1) value and 2) state. The activation conditions of the contract terms and the corresponding response actions are shown by activation condition statements such as “If-Then” statements. All parties agree on and sign the smart contract, which is then sent to the blockchain network as a transaction. The transaction is then transmitted through the P2P network, verified by the miner, and stored in a specific block on the blockchain. The contract creator gets the returned parameters (for example, the contract address) and the user can call the contract by submitting a transaction. More specifically, after receiving the contract creation or call transaction, the miner creates the contract or executes the contract code in its sandbox execution environment (EVM). Based on input from a trusted data source (also known as Oracle) and system status, the contract determines whether the current plan meets the trigger conditions. If the conditions are met, the response action will be strictly executed. After verifying the transaction, pack it into a new block. After the entire network reaches a consensus, the new block will be linked to the blockchain.

### 4.2.2. Ricardian Contracts

This type of contracts is derived from the work of financial cryptography expert Ian Grigg, which was completed in the mid-90s as a contributions to Ricard (an asset transfer system established in 1995-

1996). The design system and style are named after David Ricardo in order to recognize his formative contribution to international trade theory.

The Ricardian contract, according to its author, is a “cryptographically signed and validated digital contract that establishes the terms and circumstances of an interaction between two or more peers.” Importantly it is both human and machine readable and digitally signed”.

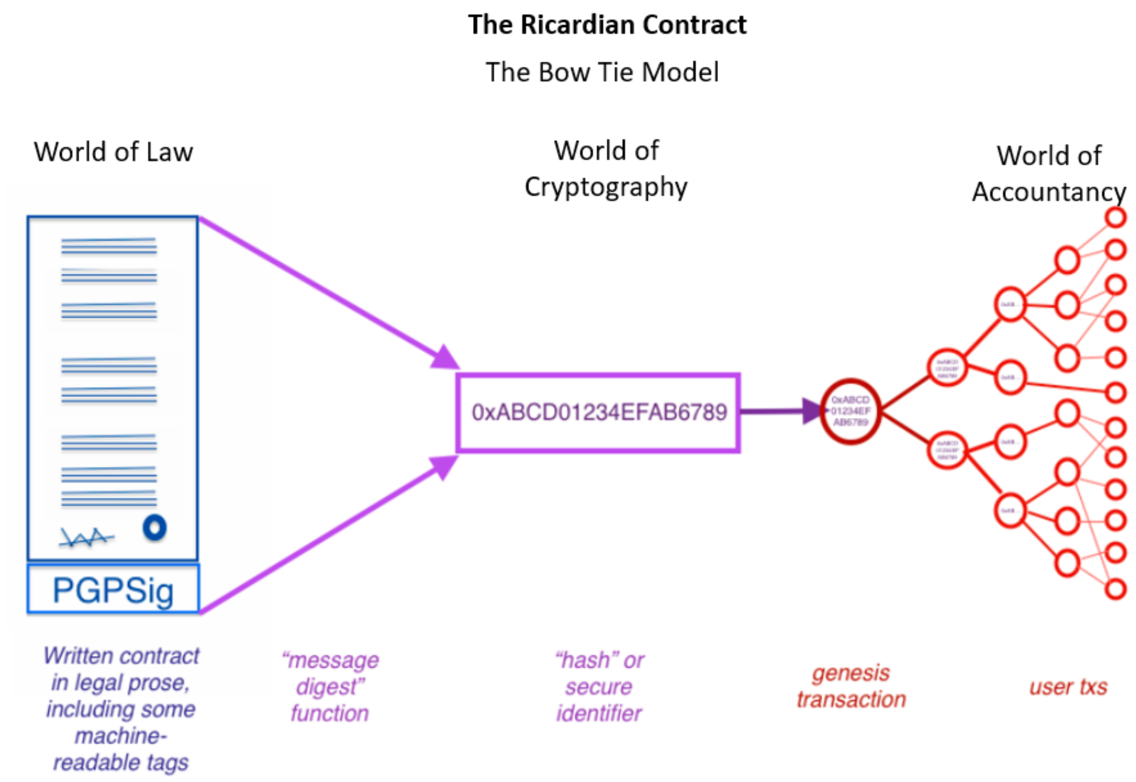


Figure 4-5: Overview of Ricardian Contracts.[9]

A Ricardian contract is a legally binding agreement that is digitally linked to a specific object or value. Its implementations could differ. A Ricardian contract puts all the information of the legal document on a format that can be executed by software. In this way, it's both a legal agreement between the parties and a protocol that combines an agreement with cryptographic identification to provide a high level of security.

The main characteristics of this type of contract are the following:

- Human parsable;
- Document is printable;
- Program parsable;
- Every form (displayed, printed, and parsed) is clearly equivalent;
- Signed by issuer;
- Can be identified securely, where security means that changing the link between a reference and the contract is impractical;

[9] https://medium.com/ltonetwork/ricardian-contracts-legally-binding-agreements-on-the-blockchain-4c103f120707

#### *4.2.2.1. Difference Between Smart and Ricardian Contracts*

There is a slight misunderstanding as to whether or not it is correct to equate a smart contract with a Ricardian. Although they share a number of similarities, they are distinct concepts. Sure, it is possible to implement a Ricardian contract as a smart contract, but not every Ricardian contract is a smart contract. Accordingly, not every smart contract is a Ricardian contract.

Smart contracts are a sort of digital contract that can be performed automatically after it has been agreed upon. A Ricardian contract, on the other hand, adheres to the contract model, which records a contract's "intentions" and "actions" regardless of whether the contract has been implemented or not. Ricardian contracts can relate to code by employing hashes that refer to external documents. In the future, there will be more interaction between this type of contract and smart contracts, and transactions will likely be conducted based on various hybrid forms.[10] In the following table, a comparison analysis of the Smart and Ricardian Contract is presented.

**Table 4-1: Smart versus Ricardian Contracts.**

| | **Smart Contracts** | **Ricardian Contract** |
|---|---|---|
| Purpose | Execute the term of an agreement | As a legal document, record the conditions of an agreement |
| Flow | Actions on blockchain-based applications can be automated | It can also automate blockchain-based application activities |
| Validity | It is not a legally binding document | It is a legally binding document or agreement |
| Versatility | They can not be Ricardian Contracts | Any Ricardian Contract can be a Smart Contract as well |
| Readability | Smart Contracts are machine-readable but not necessarily human-readable | Ricardian Contracts are both machine-readable as well as human-readable |

As the table indicates, Ricardian Contracts are superior to Smart Contracts. Firstly, the purpose regarding the Ricardian Contracts includes the legal perspective. From iPRODUCE point of view, it is necessary to present a legal document in terms of an agreement. Regarding the validity, it is important to be mentioned that Ricardian Contract constitutes a legally binding document or agreement. The IPR and transaction mechanisms of the iPRODUCE project require that an agreement should be both machine-readable as well as human-readable, so that users and machine can read and edit an agreement in terms of Ricardian Contract.

## 4.3. Legal Analysis

In the above sections, the blockchain technology was introduced. In this section, the legal perspective of the blockchain technology is explained. To illustrate this point, the focus is on the various ways in which blockchain technology is being used to create structures that resemble existing legal concepts, including contracts, companies and securities. In what follows, it is analyzed how existing law will apply to these new blockchain-based structures.

[10] https://www.elinext.com/industries/financial/trends/smart-vs-ricardian-contracts/

### 4.3.1. Smart Contracts and Contract Law

The term smart contract is arguably misleading, as it refers to automatically executed computer code (Section 4.2.1). This raises the question of whether a smart contract qualifies as a legal contract.

A legal contract is usually defined as a legally enforceable agreement or promise. It is typically entered into by voluntary offer and acceptance and, in common law jurisdictions, by considerations of: the value offered by each party. Many types of contracts can be formed in any way: orally, in writing, or by actions, such as agreeing to terms in electronic media by clicking. However, the law in some countries may requires that certain types of contracts be recorded in a particular form or concluded in a particular manner, for example real estate transactions must be recorded in writing and notarized by a notary public.

Since smart contracts self-execute predetermined code, it could be argued that they cannot be broken. The smart and the Ricardian contract will always do exactly what their code says. However, as noted above, it is likely that the legal contract between the parties will contain obligations that go beyond the code itself and are based on other communications. If that is the case, not all obligations can be fully and correctly captured by the underlying smart contract. As a result, there may be a mismatch between what the parties have agreed to do and what the smart contract code executes, leading to non-performance. Smart contracts are, by their nature, limited to the terms of the contract that can be specified in computer – readable code, and further constrained by any limitations imposed by the blockchain system in which the contract operates. As a result, they are unable to capture the real-world complexity of all but the simplest transactions.

As mentioned in Section 4, the code of a smart contract is executed by all nodes in the network and is publicly visible. However, many contracts contain commercially sensitive information. Therefore, smart contracts are unsuitable for contracts that contain information that would otherwise be subject to a non-disclosure agreement or confidentiality clause. In the worst-case, disclosure of information through a smart contract could result in an unintended loss of trade secret protection or a breach of confidentiality. This is less of an issue on centralized platforms, where trusted nodes can control the visibility of the blockchain.[11]

[11] J. Bacon, J.D. Michels, C. Millard, J. Singh, Blockchain Demystified: A technical and legal introduction to distributed and centralised ledgers, 25 Rich.J.L. & Tech, no. 1, 2018

# 5. IPR Authoring tool Implementation

## 5.1. Overview

The IPR Authoring Tool aims to become a visual authoring tool that defines a set of rules that are involved in the context of Design Thinking process stages for product co-creation process of the cMDF. The IPR Authoring Tool can be accessed through its dedicated domain name or through the Marketplace, which is the starting point of the OpIS platform. As described in section 3.2 that covers the External Architecture of the IPR Authoring Tool after a product is submitted, the involved users are notified regarding the new contract. The notification panel at the "Contracts" tab component of the Marketplace redirects the involved OpIS platform users to the IPR Authoring Tool to review the new contract that defines their collaboration.

The IPR Authoring Tool was created from scratch and the design and implementation until M18, is based to the functional requirements that are extracted from the WP4. Specifically, the following functional requirements are depicted:

- User will document an initial set of entities that will collectively form a consortium of partners
- User will partition the product's co-creation process into distinct weighted business flows.
- User will define a few basic governance policies
- User will provide a platform that will allow entities to propose, document and share their approaches on implementing individual business flow.
- The entities will be automatically accredited according to the weight of the business flow.

The purpose of the iPRODUCE IPR Authoring Tool is to provide a simple and comprehensive interface to define the terms of the Ricardian Contracts to extend the potential and accrued benefits of open collaboration for the co-creation products. The IPR Authoring Tool supports two types of users the Administrator and the Normal User. The normal user can use the platform in the following cases:

1. Accept Ricardian Contract
2. Edit Ricardian Contract
3. Retrieve Ricardian Contract
4. Reject Ricardian Contract

The Administrator user is responsible for reviewing, creating and deploying the accepted Ricardian Contracts created by the normal users in the blockchain. The Administrator dashboard contains the required information to monitor, create and deploy the Ricardian Contracts on iPRODUCE's block-chain. Administrator user can use the platform in the following cases:

1. Create Ricardian Contract
2. Deploy Ricardian Contract
3. Reject Ricardian Contract
4. Retrieve Ricardian Contract

To cover all the requirements, the architecture of the IPR Authoring Tool follows the client-server model. The front-end (client-side) contains the Web Interface and the back-end (server-side) manages the requests, the data and the inter-process communication with the back-end components of the platform. The front-end includes the following components: i) Menu (Dashboard, User Contracts Page, Administrator Contracts Page), ii) Pending Contracts, iii) Accepted Contracts, iv) Rejected Contracts,

v) Deployed Contracts. The back-end includes a REST API layer and a KAFKA connector, in which all web services are defined and allow communication with the layer containing the core component functions of the backend. Specifically, the back-end communicates with the i) iPRODUCE block-chain platform ii) OpIS Data Repository. Through the Kafka connector and the OpIS data repository the connection, which encapsulates the users data and the product co-creation data, with the Marketplace can be established.

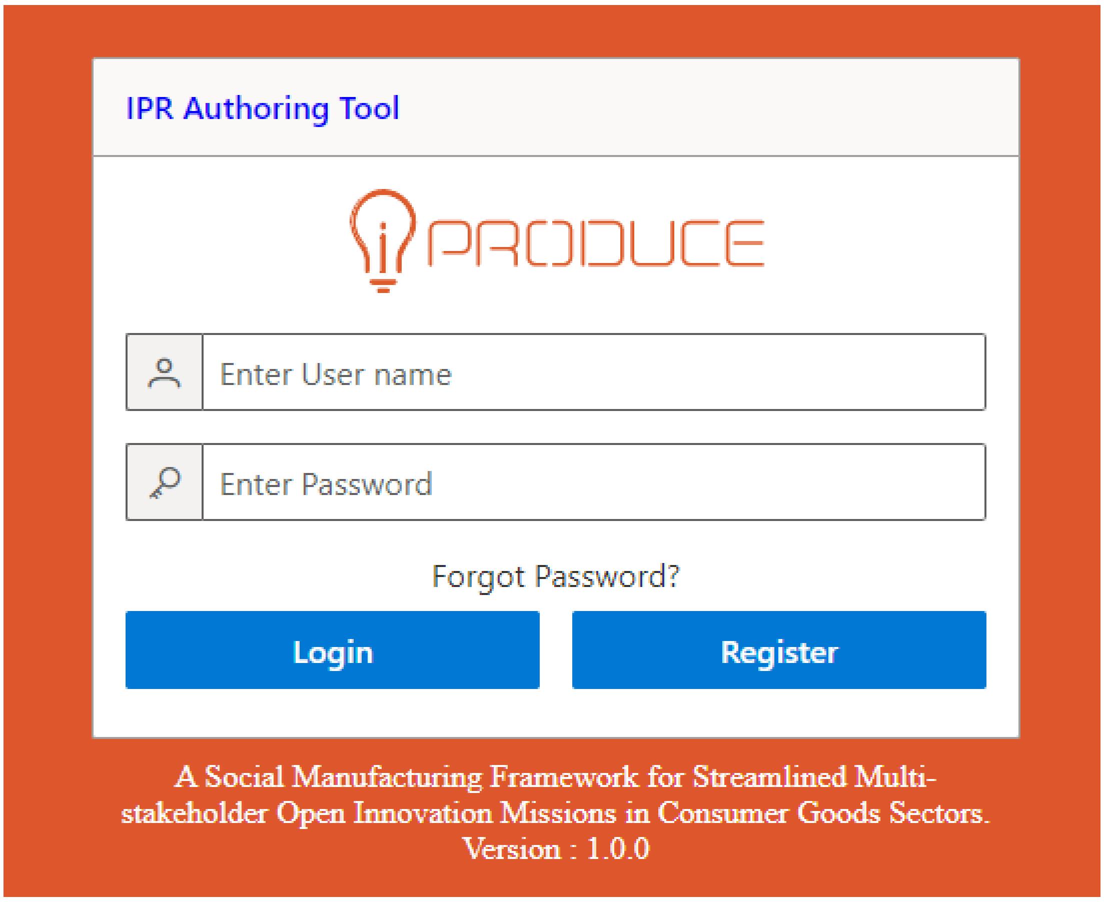
The functionalities that are presented, are supported by the current version of the IPR Authoring Tool. These functionalities will be enriched and enhanced, as the project work cycle progresses.

## 5.2. Front-end

In this section, we present the User Interface implementation by the current version of the IPR Authoring Tool. The initial page of the IPR Authoring Tool is the "Welcome Page" and the user or the administrator can log-in to the IPR Authoring Tool providing the necessary credentials. In the next sub-sections the functionalities regarding the user interface are depicted,

### 5.2.1. Welcome Page

The platform supports two types of user interface formats. The user can log in either as a normal user or as an Administrator user. The content of the User Interface is personalized depending on the role of the user. The information required for the login can be seen in Figure 5-1.



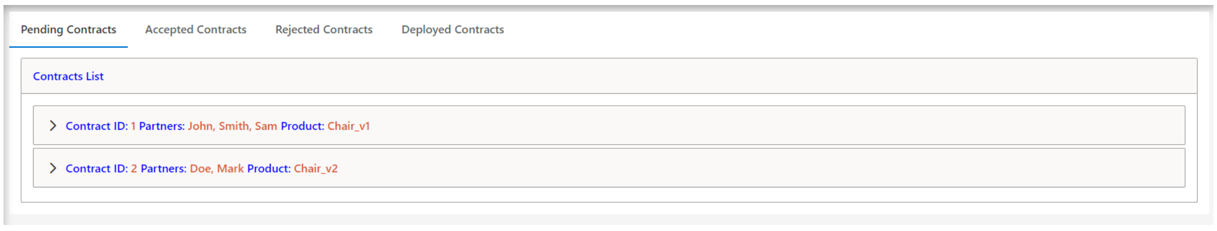
A Social Manufacturing Framework for Streamlined Multi-stakeholder Open Innovation Missions in Consumer Goods Sectors.
Version : 1.0.0

Figure 5-1: Login page

### 5.2.2. Contracts Page

In the figure below, we present the overview of the page were user can see basic information concerning the status of the Ricardian contracts that is involved. More specifically, the user can check about its:

- Pending Contracts
- Accepted Contracts
- Rejected Contracts
- Deployed Contracts


Pending Contracts Accepted Contracts Rejected Contracts Deployed Contracts

Contracts List

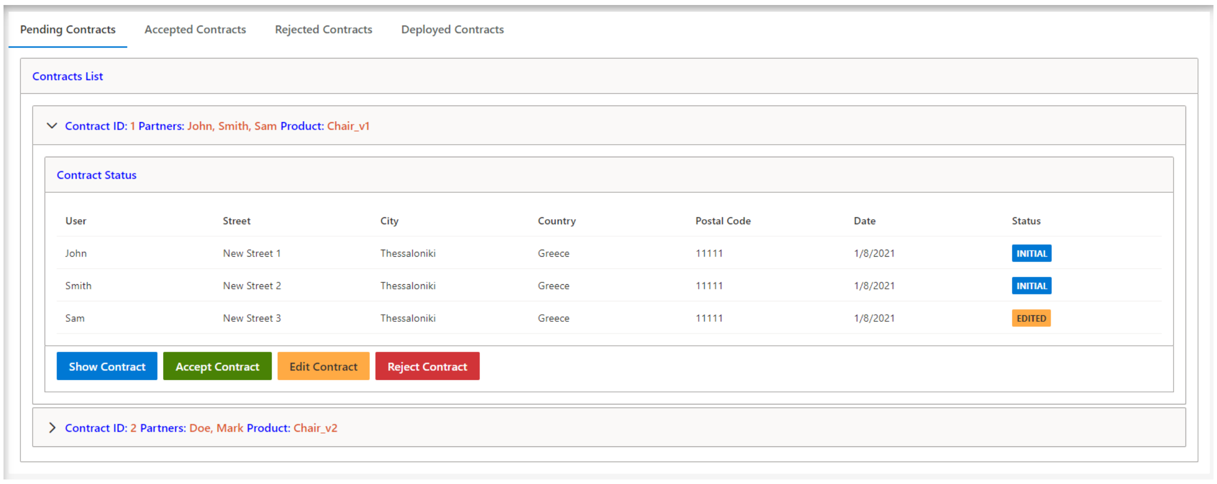
Contract ID: 1 Partners: John, Smith, Sam Product: Chair_v1

Contract ID: 2 Partners: Doe, Mark Product: Chair_v2

Figure 5-2: Contracts Page

#### *5.2.2.1. Pending Contracts*

In the IPR Authoring Tool contracts page, there is a tab referring to the "Pending Contracts". Pending contracts are the contracts that need to be accepted by the user before created and deployed by the Administrator. Moreover, pending contracts can also be edited, and rejected by the user. The tab referring to pending contracts, shows the Contract ID, the Product and the Partners involved at the Ricardian Contract. Clicking at a contract, an accordion style component allows the user to examine the Ricardian Contract details and the status of the contract. The figure below depicts the pending contracts page.


Pending Contracts Accepted Contracts Rejected Contracts Deployed Contracts

Contracts List

Contract ID: 1 Partners: John, Smith, Sam Product: Chair_v1

Contract Status

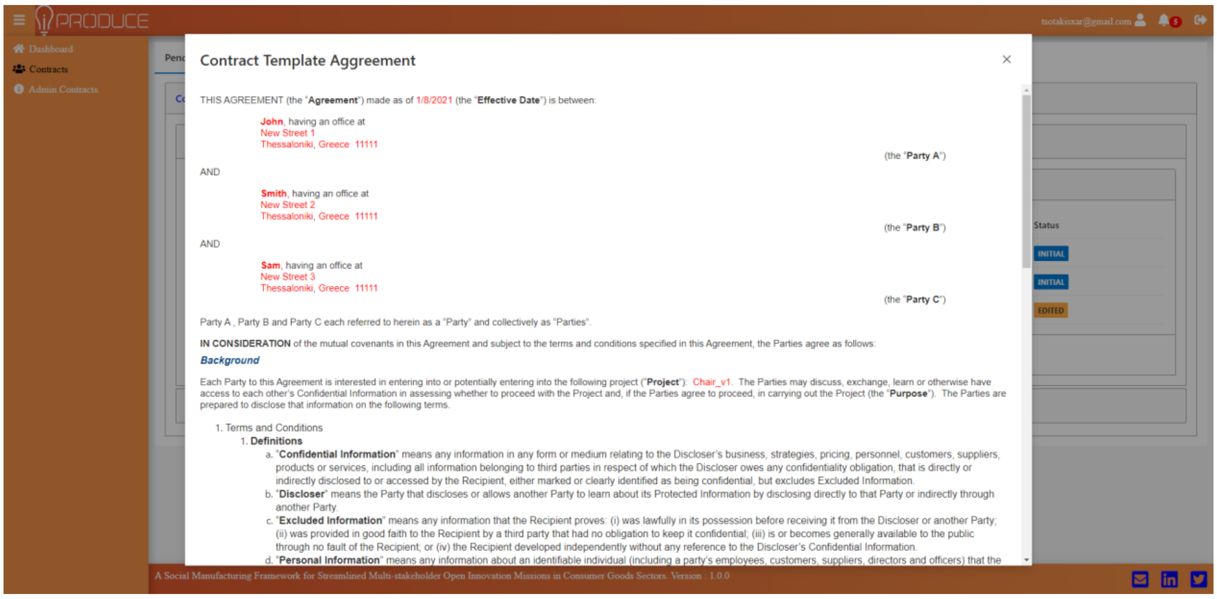
| User | Street | City | Country | Postal Code | Date | Status |
|---|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 | EDITED |

Contract ID: 2 Partners: Doe, Mark Product: Chair_v2

Figure 5-3: Pending Contracts

The “Pending Contracts” tab in addition contains the button components i) “Show Contract” ii) “Accept Contract” ii) “Edit Contract” iv) “Reject Contract”.

- **Show Contract**
  Clicking Show Contract component a Dialog box with the Template Ricardian Contract created by the IPR Authoring Tool appears. Figure 5-4 depicts a three-party template Ricardian Contract.



Contract Template Aggreement

THIS AGREEMENT (the "**Agreement**") made as of 1/8/2021 (the "**Effective Date**") is between:

**John**, having an office at
New Street 1
Thessaloniki, Greece 11111
(the "**Party A**")

AND

**Smith**, having an office at
New Street 2
Thessaloniki, Greece 11111
(the "**Party B**")

AND

**Sam**, having an office at
New Street 3
Thessaloniki, Greece 11111
(the "**Party C**")

Party A , Party B and Party C each referred to herein as a "Party" and collectively as "Parties".

**IN CONSIDERATION** of the mutual covenants in this Agreement and subject to the terms and conditions specified in this Agreement, the Parties agree as follows:

***Background***

Each Party to this Agreement is interested in entering into or potentially entering into the following project ("**Project**"): Chair_v1. The Parties may discuss, exchange, learn or otherwise have access to each other's Confidential Information in assessing whether to proceed with the Project and, if the Parties agree to proceed, in carrying out the Project (the "**Purpose**"). The Parties are prepared to disclose that information on the following terms.

1. Terms and Conditions
   1. **Definitions**
      a. "**Confidential Information**" means any information in any form or medium relating to the Discloser's business, strategies, pricing, personnel, customers, suppliers, products or services, including all information belonging to third parties in respect of which the Discloser owes any confidentiality obligation, that is directly or indirectly disclosed to or accessed by the Recipient, either marked or clearly identified as being confidential, but excludes Excluded Information.
      b. "**Discloser**" means the Party that discloses or allows another Party to learn about its Protected Information by disclosing directly to that Party or indirectly through another Party.
      c. "**Excluded Information**" means any information that the Recipient proves: (i) was lawfully in its possession before receiving it from the Discloser or another Party; (ii) was provided in good faith to the Recipient by a third party that had no obligation to keep it confidential; (iii) is or becomes generally available to the public through no fault of the Recipient; or (iv) the Recipient developed independently without any reference to the Discloser's Confidential Information.
      d. "**Personal Information**" means any information about an identifiable individual (including a party's employees, customers, suppliers, directors and officers) that the

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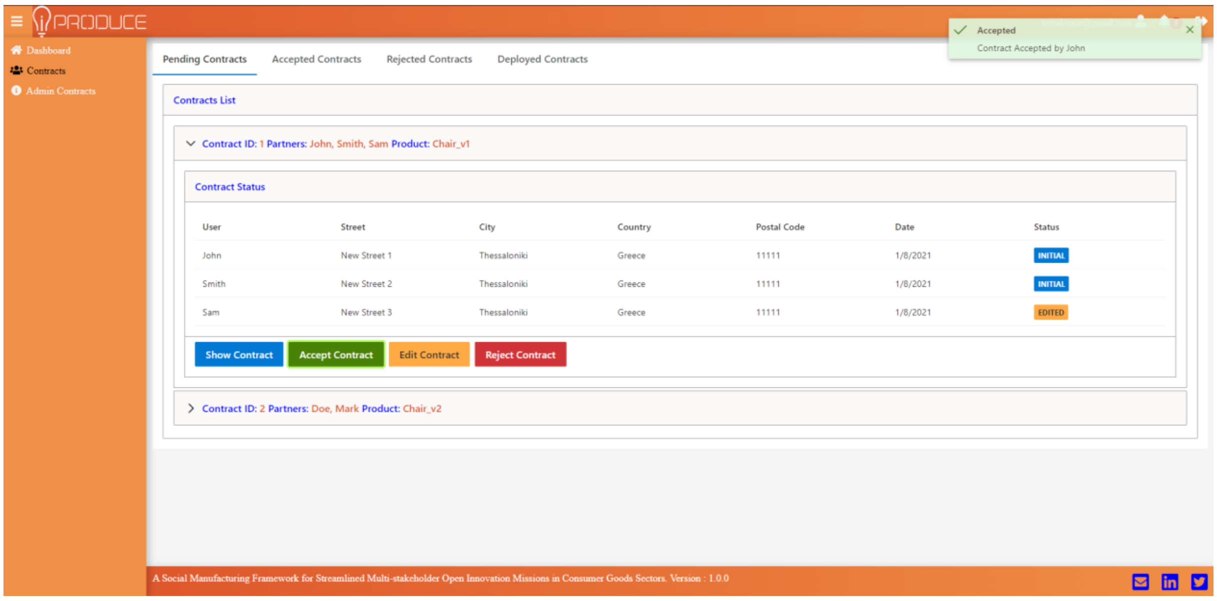
Figure 5-4: Template Ricardian Contract

- **Accept Contract**
  Clicking at the Accept Contract component the user accepts the Ricardian Contract and informs the Administrator. In case of success, a pop-up notification message appears informing the user that the contract, successfully accepted. If the Ricardian Contract is accepted by all the users. The administrator can create and deploy it.



Accepted
Contract Accepted by John

Contracts List

Contract ID: 1 Partners: John, Smith, Sam Product: Chair_v1

Contract Status

| User | Street | City | Country | Postal Code | Date | Status |
|---|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 | EDITED |

Contract ID: 2 Partners: Doe, Mark Product: Chair_v2

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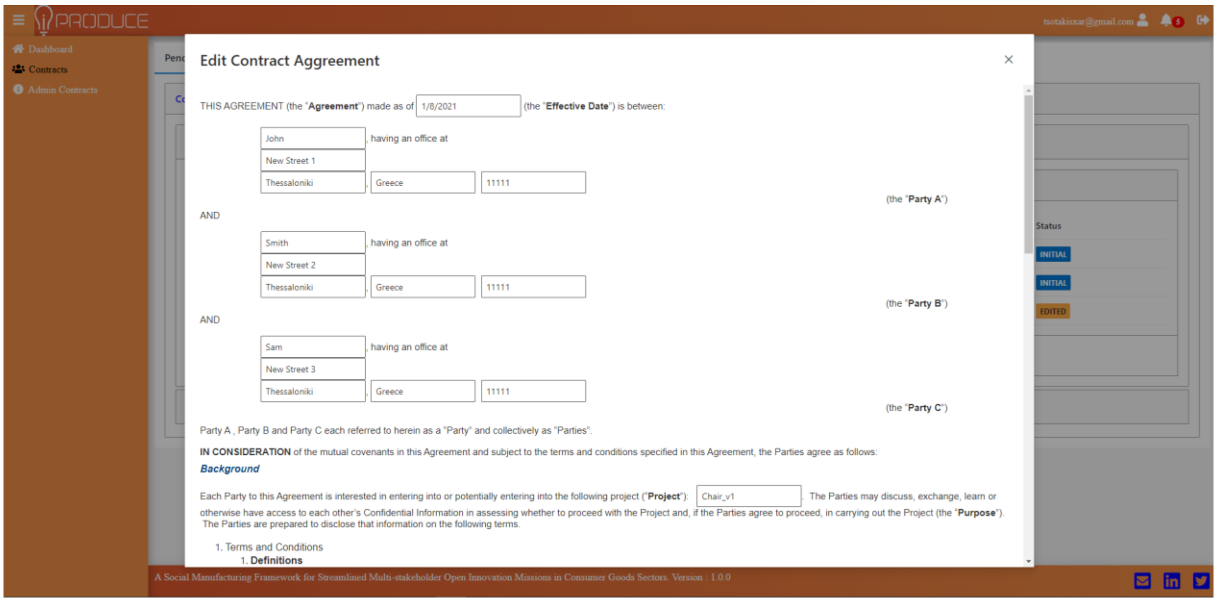
Figure 5-5: Accept Contract pop-up

- **Edit Contract**
  Clicking at the Edit Contract component a Dialog box with the Template Ricardian Contract created by the IPR Authoring Tool appears. The user can edit the initial set of entities of the contract and update it. If a user edits a contract, all the involved users must accept the contract again.



Edit Contract Aggreement

THIS AGREEMENT (the "**Agreement**") made as of 1/8/2021 (the "**Effective Date**") is between:

John, having an office at
New Street 1
Thessaloniki, Greece 11111
(the "**Party A**")

AND

Smith, having an office at
New Street 2
Thessaloniki, Greece 11111
(the "**Party B**")

AND

Sam, having an office at
New Street 3
Thessaloniki, Greece 11111
(the "**Party C**")

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1. Terms and Conditions
   1. **Definitions**

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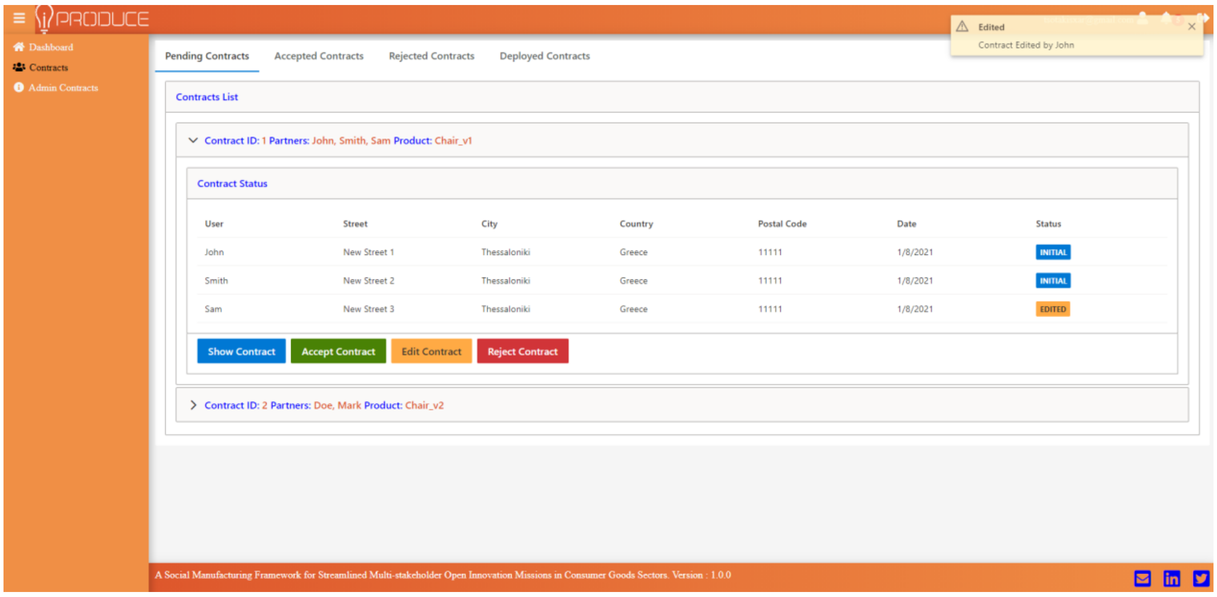
Figure 5-6: Edit Contract

In case of a successful edit, a pop-up notification message will appear to inform the user that the contract has been edited successfully.



Edited
Contract Edited by John

Contracts List

Contract ID: 1 Partners: John, Smith, Sam Product: Chair_v1

Contract Status

| User | Street | City | Country | Postal Code | Date | Status |
|---|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 | EDITED |

Show Contract | Accept Contract | Edit Contract | Reject Contract

Contract ID: 2 Partners: Doe, Mark Product: Chair_v2

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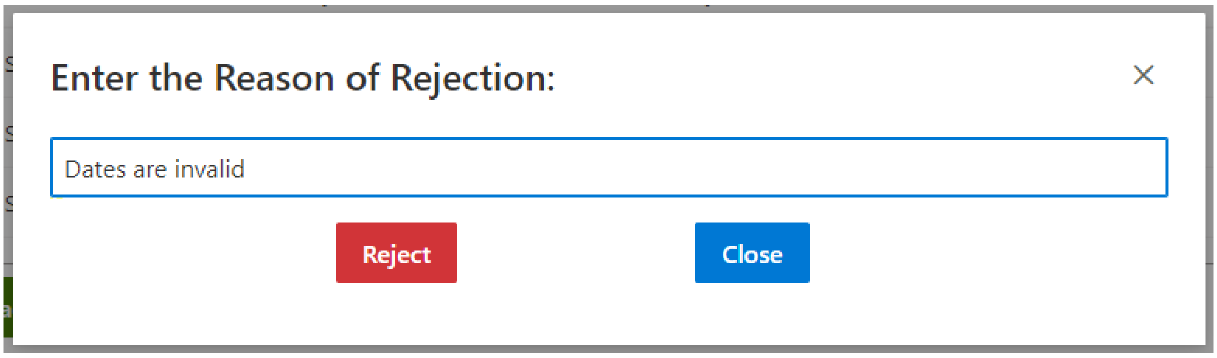
Figure 5-7: Edit Contract pop-up

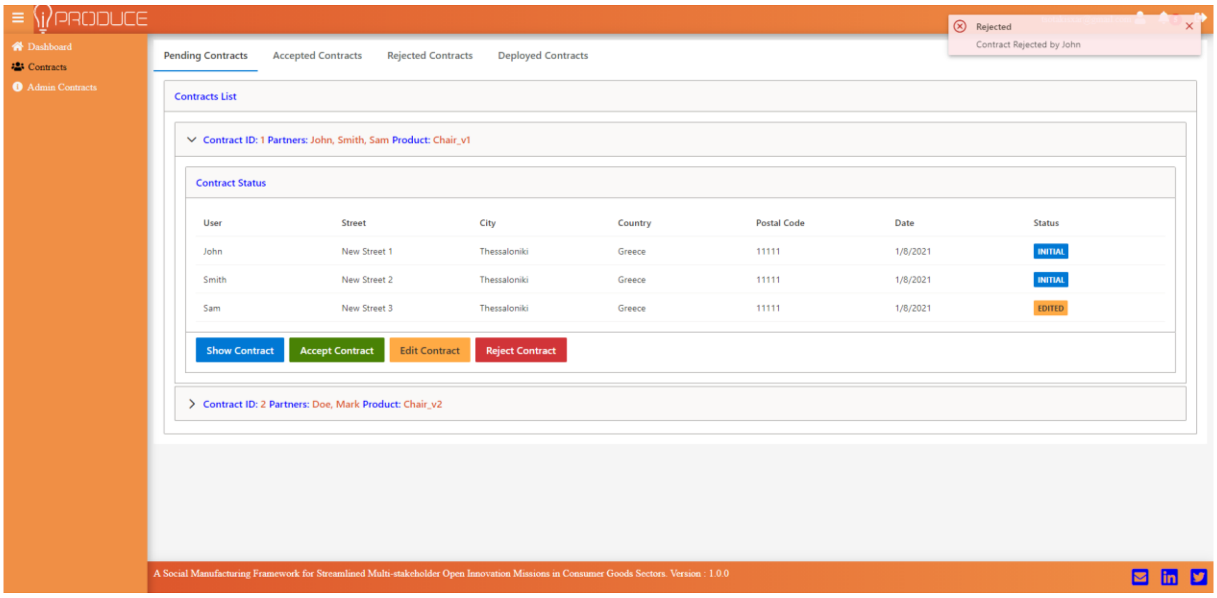
- **Reject Contract**
  Clicking at Reject Contract component, a Dialog Box appears where the user can insert the reason of this Ricardian Contract rejection. In case of a successful contract rejection, a pop-up notification message will appear to inform the user that the contract has been rejected.



Enter the Reason of Rejection:

Dates are invalid

Figure 5-8: Reject Contract Dialog box



Rejected
Contract Rejected by John

Contracts List

Contract ID: 1 Partners: John, Smith, Sam Product: Chair_v1

Contract Status

| User | Street | City | Country | Postal Code | Date | Status |
|---|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 | EDITED |

Contract ID: 2 Partners: Doe, Mark Product: Chair_v2

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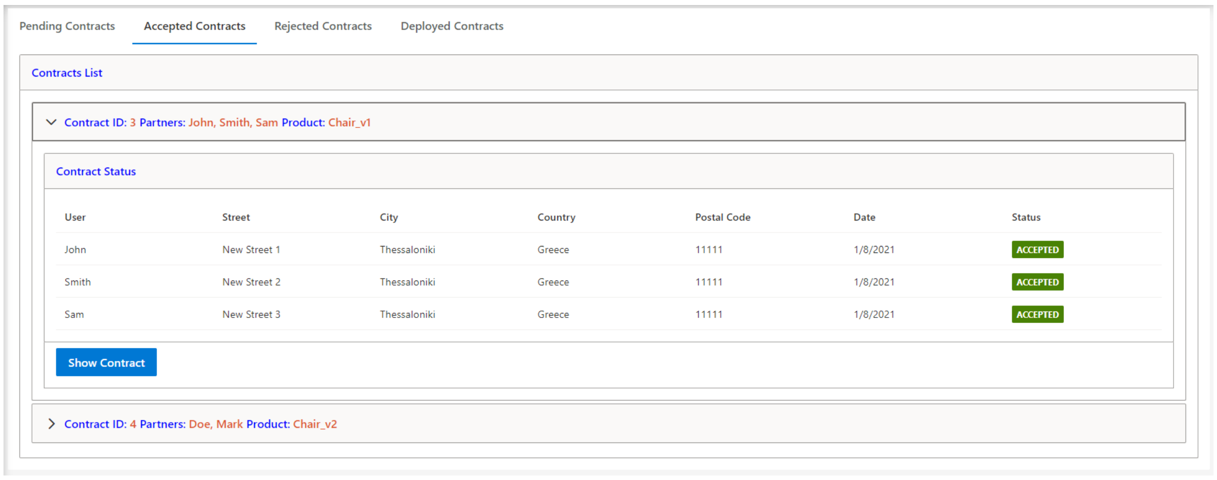
Figure 5-9: Reject Contract pop-up

### 5.2.2.2. Accepted Contracts

In the IPR Authoring Tool contracts page, there is a tab referring to the “Accepted Contracts” which depicts the contracts reviewed and accepted by the involved users. Moreover, it shows the Contract ID, the Product and the Partners involved in the Ricardian Contract. Clicking at a contract, an accordion-style component allows the user to examine the Ricardian Contract details. The figure below depicts the accepted contracts page.



Contract ID: 3 Partners: John, Smith, Sam Product: Chair_v1

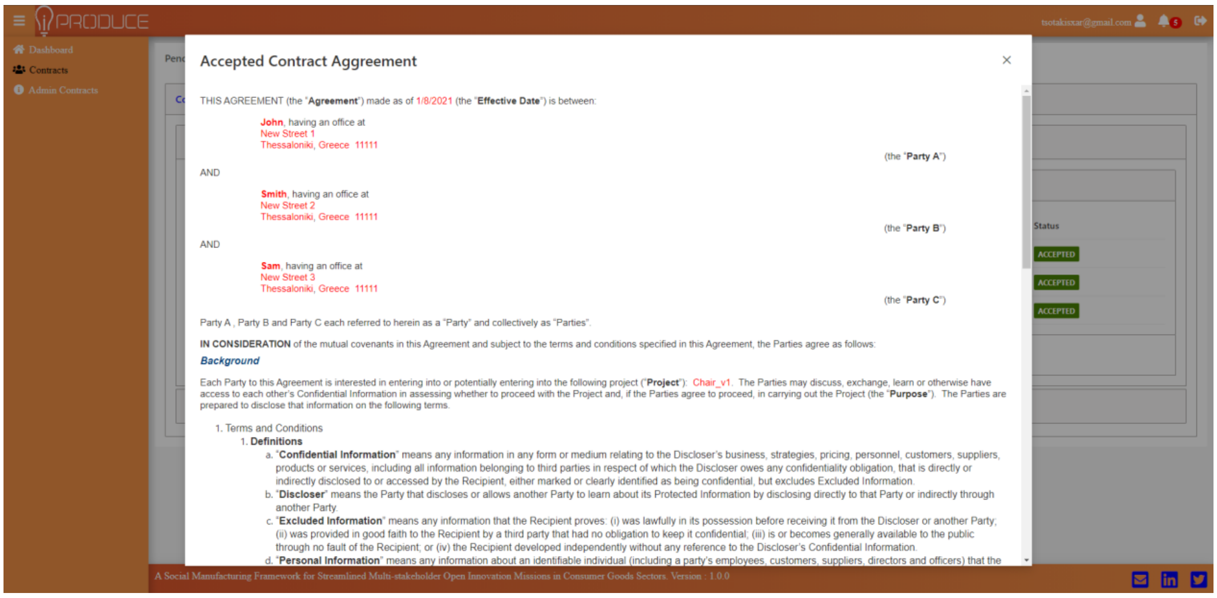
Contract Status

| User | Street | City | Country | Postal Code | Date | Status |
|---|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |

Contract ID: 4 Partners: Doe, Mark Product: Chair_v2

Figure 5-10: Accepted Contracts

The “Accepted Contracts” tab in addition contains “Show Contract” button component. Clicking Show Contract component a Dialog box with the Accepted Ricardian Contract appears. Figure 5-11 depicts a three-party Accepted Contract.



Accepted Contract Aggreement

THIS AGREEMENT (the "**Agreement**") made as of 1/8/2021 (the "**Effective Date**") is between:

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Thessaloniki, Greece 11111

(the "**Party A**")

AND

**Smith**, having an office at
New Street 2
Thessaloniki, Greece 11111

(the "**Party B**")

AND

**Sam**, having an office at
New Street 3
Thessaloniki, Greece 11111

(the "**Party C**")

Party A , Party B and Party C each referred to herein as a “Party” and collectively as “Parties”.

**IN CONSIDERATION** of the mutual covenants in this Agreement and subject to the terms and conditions specified in this Agreement, the Parties agree as follows:

***Background***

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1. Terms and Conditions
   1. **Definitions**
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      b. "**Discloser**" means the Party that discloses or allows another Party to learn about its Protected Information by disclosing directly to that Party or indirectly through another Party.
      c. "**Excluded Information**" means any information that the Recipient proves: (i) was lawfully in its possession before receiving it from the Discloser or another Party; (ii) was provided in good faith to the Recipient by a third party that had no obligation to keep it confidential; (iii) is or becomes generally available to the public through no fault of the Recipient; or (iv) the Recipient developed independently without any reference to the Discloser's Confidential Information.
      d. "**Personal Information**" means any information about an identifiable individual (including a party's employees, customers, suppliers, directors and officers) that the

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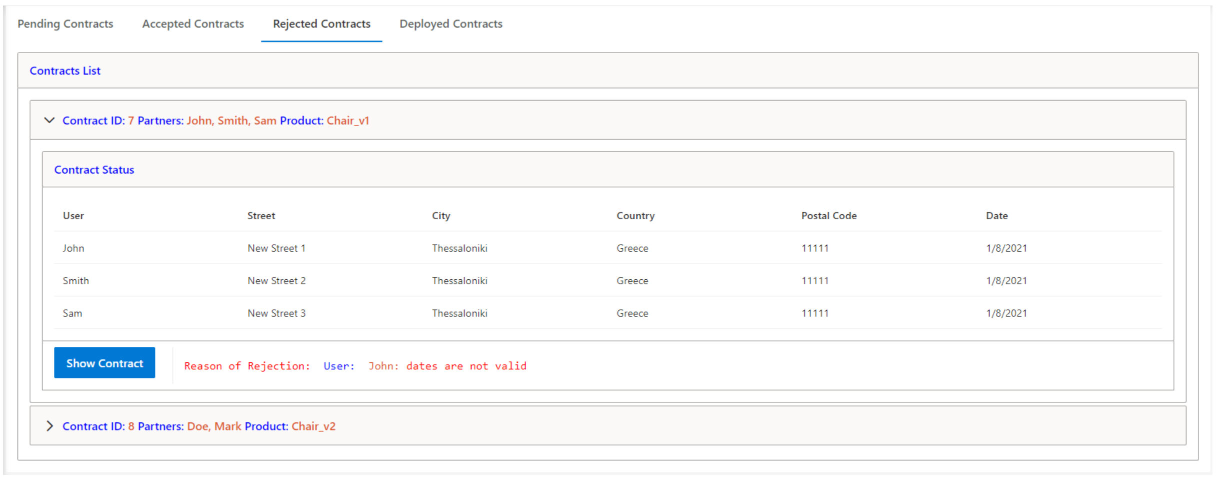
Figure 5-11: Three-party Accepted Contract Agreement

### 5.2.2.3. Rejected Contracts

In the IPR Authoring Tool contracts page, there is a tab referring to the “Reject Contracts” which depicts the contracts rejected by at least one of the users involved. In addition, it displays contract identifiers, products and partners linked to Ricardian contracts. Clicking at a contract, an accordion-style component allows the user to examine the Ricardian Contract details and reason of rejection. The figure below depicts the rejected contracts page.



Contract ID: 7 Partners: John, Smith, Sam Product: Chair_v1

Contract Status

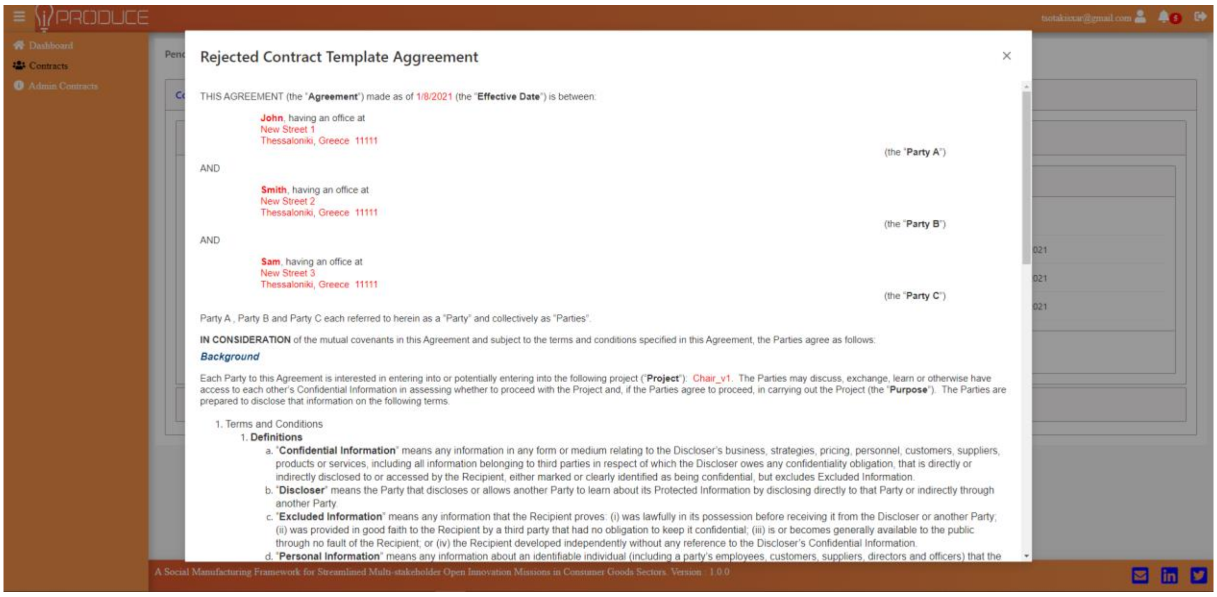
| User | Street | City | Country | Postal Code | Date |
|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 |

```
Reason of Rejection:  User:  John: dates are not valid
```

Contract ID: 8 Partners: Doe, Mark Product: Chair_v2

Figure 5-12: Rejected Contracts

In addition, the "Rejected Contract" tab contains the "Show Contract" button component. Clicking on Show contract component, a dialogue box with the rejected Ricardian contract will appear. Figure 5-13 shows the contract rejected by three parties due to an invalid date.



Rejected Contract Template Aggreement

THIS AGREEMENT (the "**Agreement**") made as of 1/8/2021 (the "**Effective Date**") is between:

**John**, having an office at
New Street 1
Thessaloniki, Greece 11111

(the "**Party A**")

AND

**Smith**, having an office at
New Street 2
Thessaloniki, Greece 11111

(the "**Party B**")

AND

**Sam**, having an office at
New Street 3
Thessaloniki, Greece 11111

(the "**Party C**")

Party A , Party B and Party C each referred to herein as a "Party" and collectively as "Parties".

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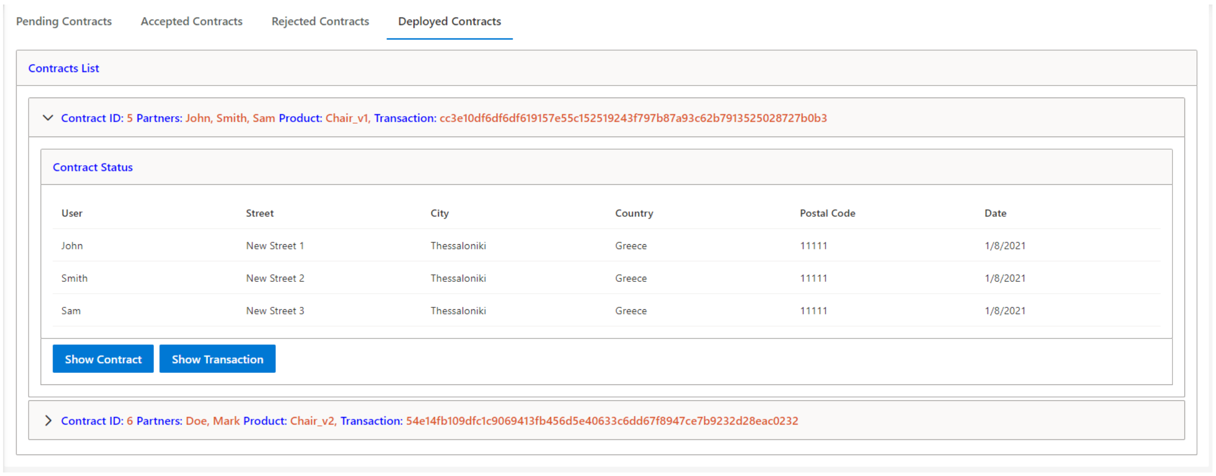
Figure 5-13: Rejected Contract Agreement

### 5.2.2.4. Deployed Contracts

In the IPR contracts page, there is a tab referring to the "Deployed Contracts" which displays the user's contracts deployed by the Administrator. Moreover, it displays the contract ID, the product, the partners linked to Ricardian contracts and the blockchain transaction id. Clicking at a contract, an accordion-style component allows the user to examine the Ricardian Contract details. The figure below depicts the deployed contracts page.



Contract ID: 5 Partners: John, Smith, Sam Product: Chair_v1, Transaction: cc3e10df6df6df619157e55c152519243f797b87a93c62b7913525028727b0b3

Contract Status

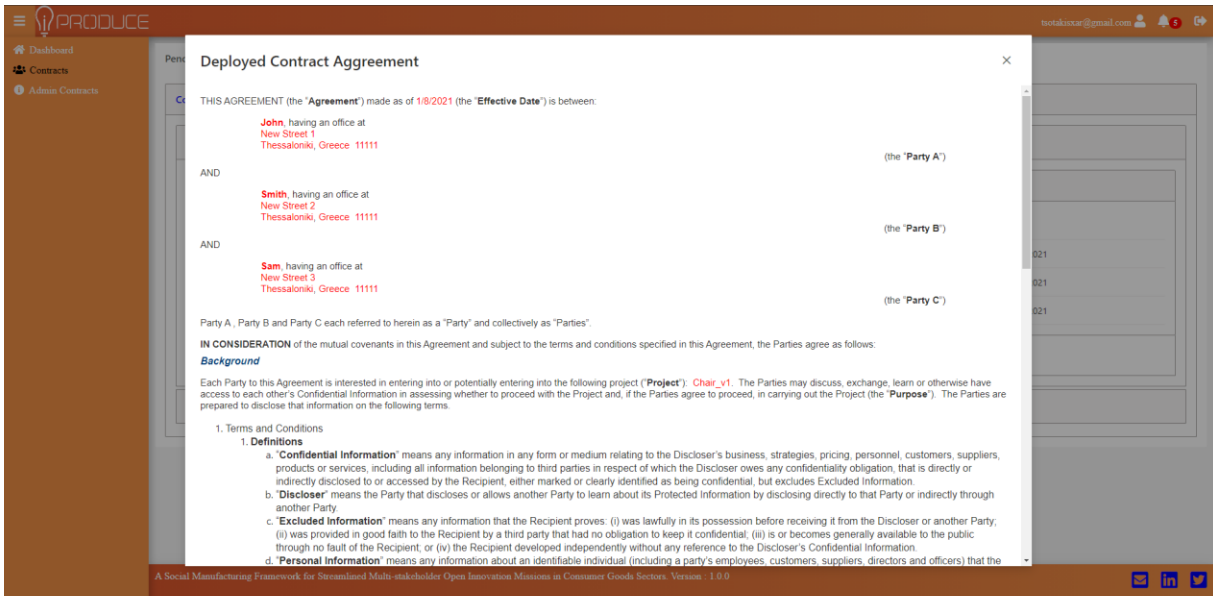
| User | Street | City | Country | Postal Code | Date |
|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 |

Contract ID: 6 Partners: Doe, Mark Product: Chair_v2, Transaction: 54e14fb109dfc1c9069413fb456d5e40633c6dd67f8947ce7b9232d28eac0232

Figure 5-14: Deployed Contracts

The "Deployed Contracts" tab in addition contains the button components i) "Show Contract" ii) "Show Transaction".

- **Show Contract**
  Clicking Show Contract component a Dialog box with the Deployed Ricardian Contract is shown. Figure 5-15 depicts a deployed Ricardian Contract.



Deployed Contract Aggreement

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(the "**Party A**")

AND

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(the "**Party B**")

AND

**Sam**, having an office at
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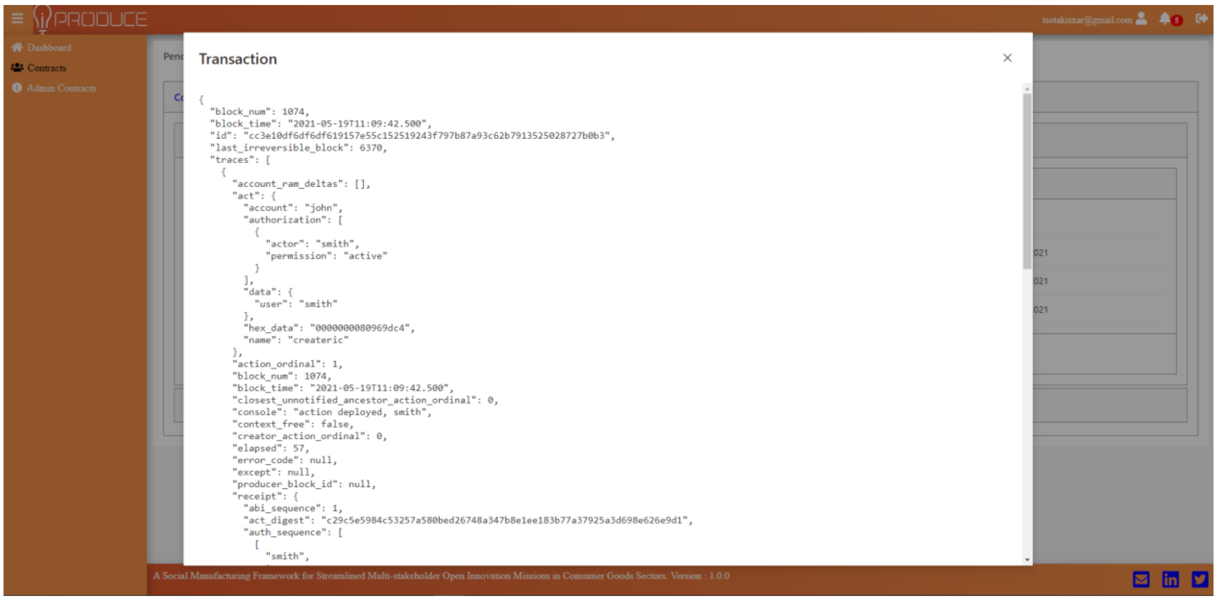
Figure 5-15: Deployed Contract Agreement

- **Show Transaction**
  Clicking Show transaction component a Dialog box with the retrieved transaction information of the Deployed Contract from the blockchain appears. Figure 5-16 depicts the transaction information.



Transaction

```
{
  "block_num": 1074,
  "block_time": "2021-05-19T11:09:42.500",
  "id": "cc3e10df6df6df619157e55c152519243f797b87a93c62b7913525028727b0b3",
  "last_irreversible_block": 6370,
  "traces": [
    {
      "account_ram_deltas": [],
      "act": {
        "account": "john",
        "authorization": [
          {
            "actor": "smith",
            "permission": "active"
          }
        ],
        "data": {
          "user": "smith"
        },
        "hex_data": "0000000080969dc4",
        "name": "createric"
      },
      "action_ordinal": 1,
      "block_num": 1074,
      "block_time": "2021-05-19T11:09:42.500",
      "closest_unnotified_ancestor_action_ordinal": 0,
      "console": "action deployed, smith",
      "context_free": false,
      "creator_action_ordinal": 0,
      "elapsed": 57,
      "error_code": null,
      "except": null,
      "producer_block_id": null,
      "receipt": {
        "abi_sequence": 1,
        "act_digest": "c29c5e5984c53257a580bed26748a347b8e1ee183b77a37925a3d698e626e9d1",
        "auth_sequence": [
          [
            "smith",
```

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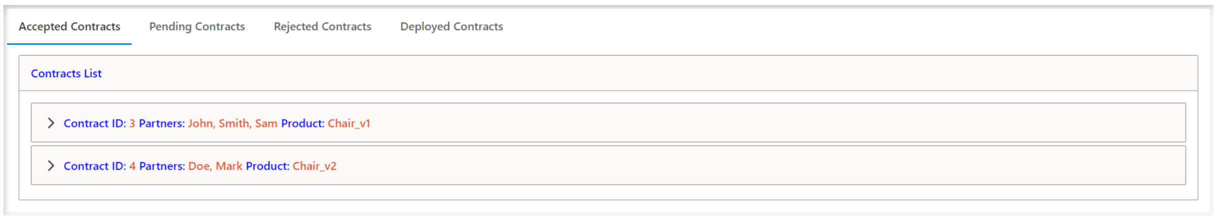
Figure 5-16: Show Transaction Dialog-box

### 5.2.3. Administrator Page

At the Administrator page, all the information concerning the Ricardian Contracts status is shown. Users logged in as Administrators access the Administrator page. The figure below depicts the administrator page were the user can create, deploy, reject and review the Ricardian Contracts.



Accepted Contracts | Pending Contracts | Rejected Contracts | Deployed Contracts

Contracts List

Contract ID: 3 Partners: John, Smith, Sam Product: Chair_v1

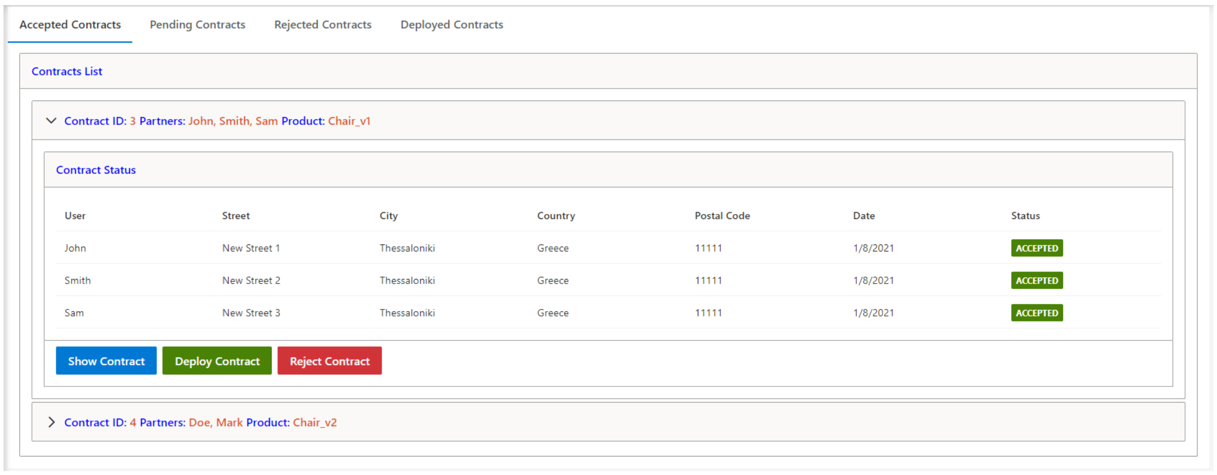
Contract ID: 4 Partners: Doe, Mark Product: Chair_v2

Figure 5-17: Administrator Contracts page

:

#### *5.2.3.1. Accepted Contracts*

In the Administrator page, there is a tab referring to the "Accepted Contracts". Which depicts the contracts accepted by all involved users therefore are ready to by created an deployed by the Administrator. In addition, it shows the Contract ID, the Product ,the Partners involved in the Ricardian Contract and the status of the Contract (Accepted or Created). Figure 5-18 depicts the administrator accepted contracts page.



Contract ID: 3 Partners: John, Smith, Sam Product: Chair_v1

Contract Status

| User | Street | City | Country | Postal Code | Date | Status |
|---|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |

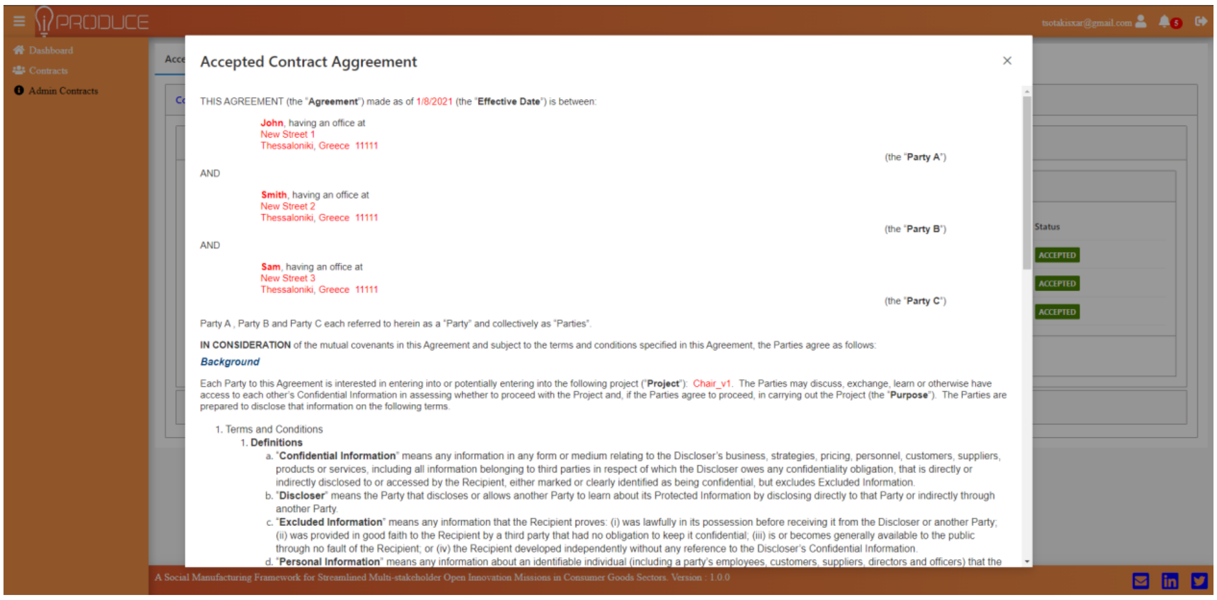
Contract ID: 4 Partners: Doe, Mark Product: Chair_v2

Figure 5-18: Administrator Accepted Contracts

The “Accepted Contracts” tab in addition contains the button components i) “Show Contract” ii) “Deploy Contract” iii) “Reject Contract”.

- **Show Contract**

Clicking Show Contract component a Dialog box with the Template Ricardian Contract created by the IPR toolkit appears. Figure 5-19 depicts a three-party template Ricardian Contract



Accepted Contract Aggreement

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**IN CONSIDERATION** of the mutual covenants in this Agreement and subject to the terms and conditions specified in this Agreement, the Parties agree as follows:

***Background***

Each Party to this Agreement is interested in entering into or potentially entering into the following project ("**Project**"): Chair_v1. The Parties may discuss, exchange, learn or otherwise have access to each other's Confidential Information in assessing whether to proceed with the Project and, if the Parties agree to proceed, in carrying out the Project (the "**Purpose**"). The Parties are prepared to disclose that information on the following terms.

1. Terms and Conditions
   1. **Definitions**
      a. "**Confidential Information**" means any information in any form or medium relating to the Discloser's business, strategies, pricing, personnel, customers, suppliers, products or services, including all information belonging to third parties in respect of which the Discloser owes any confidentiality obligation, that is directly or indirectly disclosed to or accessed by the Recipient, either marked or clearly identified as being confidential, but excludes Excluded Information.
      b. "**Discloser**" means the Party that discloses or allows another Party to learn about its Protected Information by disclosing directly to that Party or indirectly through another Party.
      c. "**Excluded Information**" means any information that the Recipient proves: (i) was lawfully in its possession before receiving it from the Discloser or another Party; (ii) was provided in good faith to the Recipient by a third party that had no obligation to keep it confidential; (iii) is or becomes generally available to the public through no fault of the Recipient; or (iv) the Recipient developed independently without any reference to the Discloser's Confidential Information.
      d. "**Personal Information**" means any information about an identifiable individual (including a party's employees, customers, suppliers, directors and officers) that the

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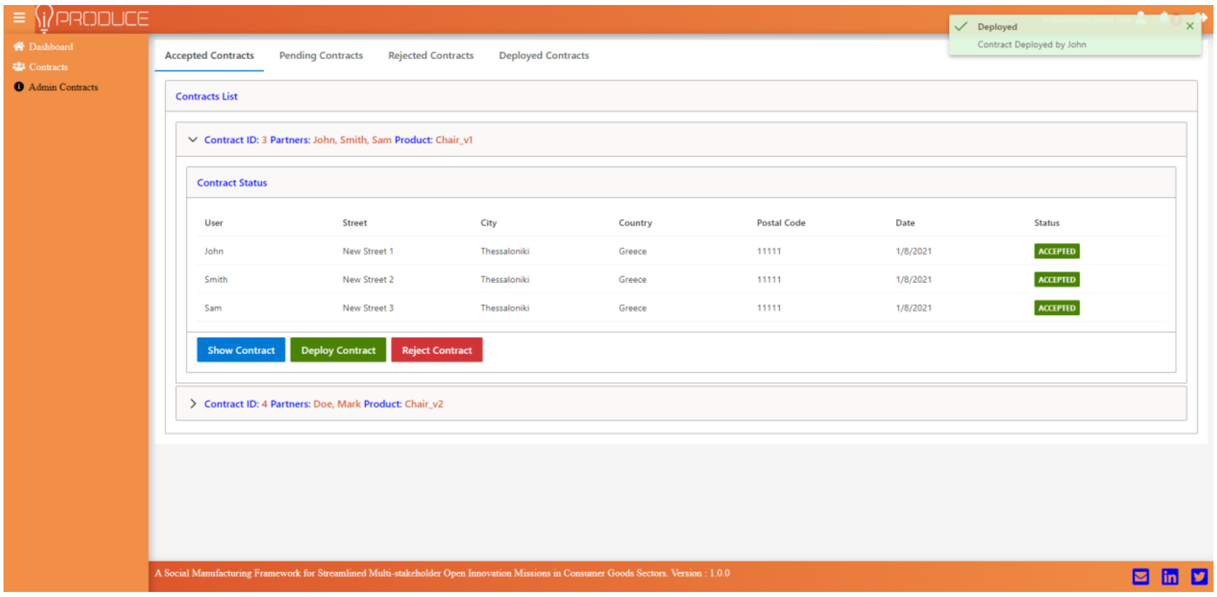
Figure 5-19: Administrator Accepted Contract Agreement

- **Deploy Contract**

Clicking at Deploy Contract component, the IPR creates, deploys and stores the Accepted NDA as a Ricardian Contract in the blockchain. In success, a pop-up notification message appears informing the Administrator that the contract successfully deployed in the blockchain.



Deployed
Contract Deployed by John

Contracts List

Contract ID: 3 Partners: John, Smith, Sam Product: Chair_v1

Contract Status

| User | Street | City | Country | Postal Code | Date | Status |
|---|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 | ACCEPTED |

Contract ID: 4 Partners: Doe, Mark Product: Chair_v2

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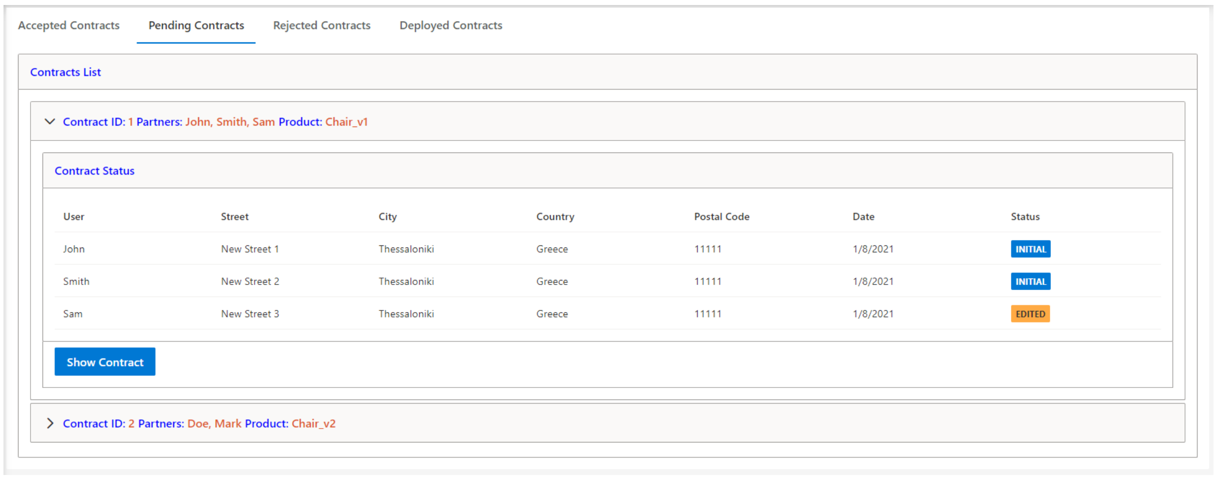
Figure 5-20: Deploy Contract pop-up

- **Reject Contract**

Clicking at Reject Contract component the Administrator can insert the reason of rejection in the Dialog box that appears and an information pop-up notification message appears in case of a successful operation. Figures 5-8 and 5-9 depicts the Dialog-box and pop-up notification message respectively.

### *5.2.3.2. Pending Contracts*

In the Pending contracts tab the administrator can review the associated contracts that need to be accepted by the involved users before deployed by the Administrator. The accordion style component depicted in the tab shows the Contract ID, the Product and the Partners involved at the Ricardian Contract. Moreover, expanding the component, it allows the administrator to examine the Ricardian Contract details and the status of the contract. The figure 5-21 depicts the pending contracts page.



Contract ID: 1 Partners: John, Smith, Sam Product: Chair_v1

Contract Status

| User | Street | City | Country | Postal Code | Date | Status |
|---|---|---|---|---|---|---|
| John | New Street 1 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Smith | New Street 2 | Thessaloniki | Greece | 11111 | 1/8/2021 | INITIAL |
| Sam | New Street 3 | Thessaloniki | Greece | 11111 | 1/8/2021 | EDITED |

Contract ID: 2 Partners: Doe, Mark Product: Chair_v2

Figure 5-21: Administrator Pending Contracts

In addition, the “Pending Contracts” tab contains a button component named “Show Contract”. Clicking on the component, a dialog-box with the Ricardian contract appears. Figure 5-4 depicts a three-way pending contract non-disclosure agreement.

### 5.2.3.3. Rejected Contracts

In the IPR Administrator contracts page, there is a tab referring to the “Reject Contracts”. Rejected contracts are the contracts rejected by at least one involved user or the administrator. The rejected contract tab depicts all the contract information as described in section 5.2.2.3.

### 5.2.3.4. Deployed Contracts

The Administrator Deployed Contracts tab, displays all the contracts deployed to the blockchain by the Administrator. This tab is identical to the users Deployed Contracts tab described in section 5.2.2.4.

## 5.3. Template Creation & Verification

In this section, we provide the implementation of the Creation and Verification of the Ricardian Contracts. On the IPR Authoring Tool backend, basic template functionalities that capture fundamental concepts of real-world contracts are defined. To formally verify the correctness of each template, the IPR Authoring Tool encodes them as predefined expressions in Scala language. The advantage of encoding the Ricardian contracts in a functional programming language such as Scala is that it empowers the formal verification of the correctness of each template which is a feature of Scala functional programming language. Moreover, more complex procedures such as auctions, revenue distribution schemes and simple asset lifecycle management can be encoded. The figure below depicts the Ricardian Contract template Creation and Verification procedure.

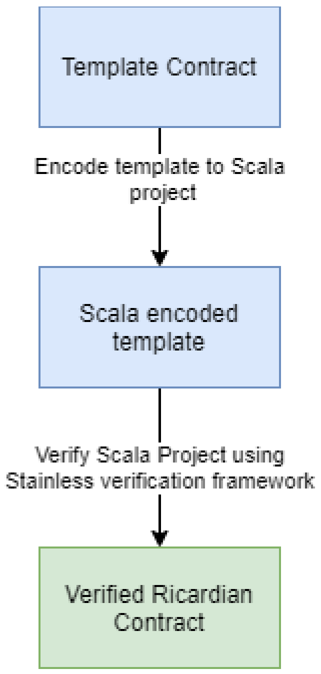

Template Contract
Encode template to Scala project
Scala encoded template
Verify Scala Project using Stainless verification framework
Verified Ricardian Contract

Figure 5-22: Contract Creation & Verification

In the development view of Ricardian Contract creation and verification, the Template is predefined as a simple HTML file. Using HTML to Scalatags converter extension of Scalatags library for Scala, empowers to encode the template in plain Scala code thus, it gives the ability to create a Scala Project with the encoded template. Using the Stainless verification framework, the Scala Project can be verified.

## 5.4. Ricardian Contract Deployment

In this section, we provide the Ricardian Contract Deployment in the blockchain implementation. The IPR Authoring Tool employs the EOSIO platform to create a local blockchain environment. As described in 4.1.2.1 the EOSIO adopts C++ as the official language for the development of smart contracts. Using the EOSIO WebAssembly compiler, the Ricardian Contract can be deployed to the blockchain and the verified template contract can be submitted as a transaction to the Ricardian Contract. The IPR Authoring Tool after a successful transaction, saves the transaction ID to be able to retrieve a Ricardian Contract through its ID.

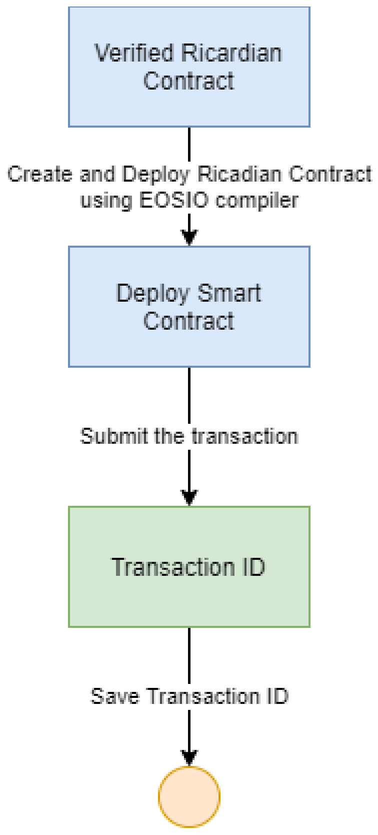

Verified Ricardian Contract
Create and Deploy Ricadian Contract using EOSIO compiler
Deploy Smart Contract
Submit the transaction
Transaction ID
Save Transaction ID

**Figure 5-23: Ricardian Contract Deployment**

## 5.5. The Application Layer

### 5.5.1. Component Specifications and Functional View

In this section, the IPR Authoring Tool components are presented. In a common template for all the components, all the functionalities, inputs/output, functional and non-functional requirements are reported. All the components fulfil the Functional requirements described in section 2.2.

**Table 5-1: Human Readable IP Rules Manager**

| | Description |
|---|---|
| Name of Component/Service: | Human Readable IP Rules Manager. |
| Type: | Component |
| Functionality: | The Human Readable IP Rules Manager component, providing a User Interface enables the user and administrator to create, edit, reject, compile and deploy a human readable Ricardian Contract. |
| Input components | • User input |
| Output components | • Machine-Readable Contract Manager. |
| Non-Functional Requirements | • The application must be responsive.<br>• The application must have a login.<br>• The application must be accessible via web.<br>• The connection with the other modules must be safe.<br>• The user interface shall be user-friendly and intuitive. |

Table 5-2: Machine-Readable Contract Manager

| | Description |
|---|---|
| Name of Component/Service: | Machine-Readable Contract Manager. |
| Type: | Component |
| Functionality: | The Machine-Readable Contract Manager component, translates the human readable Ricardian Contract into machine executable code. The component is responsible for the template creation and verification of the Ricardian contract. After a successful creation of the contract, the Machine-Readable Contract Manager sends the machine executable code plus the user valuables to the Decentralized IP rules manager. |
| Input components | • Human Readable IP Rules Manager. |
| Output components | • Decentralized IP Rules Manager. |
| Non-Functional Requirements | • The application must be responsive.<br>• The connection with the other modules must be safe.<br>• IP protection for product owner.<br>• IP protection for cMDF data. |

Table 5-3: Decentralized IP rules manager

| | Description |
|---|---|
| Name of Component/Service: | Decentralized IP rules manager. |
| Type: | Component |
| Functionality: | The Decentralized IP rules manager, instantiates the Ricardian contracts deployed to the Blockchain network and is responsible to submit the proper actions and transactions, -based on the User Input- included in the Deployed Smart contracts. |
| Input components | • Machine-Readable Contract Manager. |
| Output components | • Smart contracts actions<br>• Transaction block/ID. |
| Non-Functional Requirements | • The application must be responsive.<br>• The connection with the other modules must be safe.<br>• IP protection for product owner.<br>• IP protection for cMDF data. |

### 5.5.2. Back-end services

In this section, we present the endpoints exposed by the IPR Authoring Tool back-end (server-side) for proper communication with the Web interface (Client application). The JSON objects provided in the input and output rows of the template tables are the example Data models of the IPR Authoring Tool. The data models will be enriched and improved, as the project workflow progresses.

Table 5-4: LogIn

| | Description |
|---|---|
| Functionality description | This service call authorizes the users to log in to the Ricardian Toolkit. |
| | This module is developed by utilizing NodeJS and mongoDB database. |

| | |
|---|---|
| Technical specifications | *Server Hardware* CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz Memory: 16GB *Software* Operating System: Windows 10 Pro mongoDB: 4.2.14 NodeJS version: 15.6.0 |
| Endpoint | /login |
| Method | Post |
| Input Data | { "username": "user_name", "password": "password" } |
| Output Data | { "objectId": "WCTFc", "username": "user", "email": "user@user.com", "full_name": "John Doe", "createdAt": "2021-02-11T08:10:59.655Z", "updatedAt": "2021-02-11T08:10:59.655Z", "role": "Admin" "sessionToken": "r:f8fadf1ad151890d53249e4502ee9f70" } |

**Table 5-5: Retrieve Accepted Ricardian Contracts**

| | **Description** |
|---|---|
| Functionality description | This service call retrieves the **Accepted** Ricardian Contracts. |
| Technical specifications | This module is developed by utilizing NodeJS and mongoDB database. *Server Hardware* CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz Memory: 16GB *Software* Operating System: Windows 10 Pro mongoDB: 4.2.14 NodeJS version: 15.6.0 |
| Endpoint | /getAcceptedContracts |
| Method | GET |
| Input Data | user, sessionToken |
| Output Data | [ { "Id":3, "Partners":[ { "name":"John", "street":"New Street 1", "city":"Thessaloniki", "country":"Greece", "postalCode":"11111", "status":1, |

| | |
|---|---|
| | "date":"1/8/2021"<br>},<br>{<br>"name":"Smith",<br>"street":"New Street 2",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"status":1,<br>"date":"1/8/2021"<br>},<br>{<br>"name":"Sam",<br>"street":"New Street 3",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"status":1,<br>"date":"1/8/2021"<br>}<br>],<br>"Product":"Chair_v1",<br>"date":"1/8/2021"<br>}<br>] |

**Table 5-6: Retrieve Pending Ricardian Contracts**

| | Description |
|---|---|
| Functionality description | This service call retrieves the **Pending** Ricardian Contracts. |
| Technical specifications | This module is developed by utilizing NodeJS and mongoDB database.<br><br>*Server Hardware*<br>CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz<br>Memory: 16GB<br><br>*Software*<br>Operating System: Windows 10 Pro<br>mongoDB: 4.2.14<br>NodeJS version: 15.6.0 |
| Endpoint | /getPendingContracts |
| Method | GET |
| Input Data | user, sessionToken |
| Output Data | [<br>{<br>"Id":1,<br>"Partners":[<br>{<br>"name":"John",<br>"street":"New Street 1",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"status":0,<br>"date":"1/8/2021"<br>}, |

| | |
|---|---|
| | {<br>"name":"Smith",<br>"street":"New Street 2",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"status":0,<br>"date":"1/8/2021"<br>},<br>{<br>"name":"Sam",<br>"street":"New Street 3",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"status":2,<br>"date":"1/8/2021"<br>}<br>],<br>"Product":"Chair_v1",<br>"date":"1/8/2021"<br>}<br>] |

Table 5-7: Retrieve Rejected Ricardian Contracts

| | Description |
|---|---|
| Functionality description | This service call retrieves the **Rejected** Ricardian Contracts. |
| Technical specifications | This module is developed by utilizing NodeJS and mongoDB database.<br><br>*Server Hardware*<br>CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz<br>Memory: 16GB<br><br>*Software*<br>Operating System: Windows 10 Pro<br>mongoDB: 4.2.14<br>NodeJS version: 15.6.0 |
| Endpoint | /getRejectedContracts |
| Method | GET |
| Input Data | user, sessionToken |
| Output Data | [<br>{<br>"Id":7,<br>"Partners":[<br>{<br>"name":"John",<br>"street":"New Street 1",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"date":"1/8/2021"<br>},<br>{<br>"name":"Smith",<br>"street":"New Street 2", |

| | |
|---|---|
| | <pre>        "city":"Thessaloniki",<br>        "country":"Greece",<br>        "postalCode":"11111",<br>        "date":"1/8/2021"<br>      },<br>      {<br>        "name":"Sam",<br>        "street":"New Street 3",<br>        "city":"Thessaloniki",<br>        "country":"Greece",<br>        "postalCode":"11111",<br>        "date":"1/8/2021"<br>      }<br>    ],<br>    "Product":"Chair_v1",<br>    "date":"1/8/2021",<br>    "reason":{<br>      "user":"John",<br>      "msg":"dates are not valid"<br>    }<br>  }<br>]</pre> |

**Table 5-8: Retrieve Deployed Ricardian Contratcs**

| Description | |
|---|---|
| Functionality description | This service call retrieves the **Deployed** Ricardian Contracts. |
| Technical specifications | This module is developed by utilizing NodeJS and mongoDB database.<br><br>*Server Hardware*<br>CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz<br>Memory: 16GB<br><br>*Software*<br>Operating System: Windows 10 Pro<br>mongoDB: 4.2.14<br>NodeJS version: 15.6.0 |
| Endpoint | /getDeployedContracts |
| Method | GET |
| Input Data | user, sessionToken |
| Output Data | <pre>[<br>  {<br>    "Id":5,<br>    "Partners":[<br>      {<br>        "name":"John",<br>        "street":"New Street 1",<br>        "city":"Thessaloniki",<br>        "country":"Greece",<br>        "postalCode":"11111",<br>        "date":"1/8/2021"<br>      },<br>      {<br>        "name":"Smith",<br>        "street":"New Street 2",<br>        "city":"Thessaloniki",</pre> |

| | |
|---|---|
| | "country":"Greece",<br>"postalCode":"11111",<br>"date":"1/8/2021"<br>},<br>{<br>"name":"Sam",<br>"street":"New Street 3",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"date":"1/8/2021"<br>}<br>],<br>"Product":"Chair_v1",<br>"date":"1/8/2021",<br><br>"trx":"cc3e10df6df6df619157e55c152519243f797b87a93c62b7913525028727b0b3"<br>}<br>] |

**Table 5-9: Retrieve transactionID from the blockchain**

| | Description |
|---|---|
| Functionality description | This service call retrieves the **Deployed** Ricardian Contracts from transaction ID in the blockchain. |
| Technical specifications | This module is developed by utilizing Python and EOSIO blockchain platform.<br><br>*Server Hardware*<br>CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz<br>Memory: 16GB<br><br>*Software*<br>Operating System: Kubuntu 20.04<br>Python version: 3.6<br>Flask version: 2.0<br>EOSIO version: 2.0 |
| Endpoint | /getTransaction |
| Method | GET |
| Input Data | transaction |
| Output Data | {<br>"block_num": 1074,<br>"block_time": "2021-05-19T11:09:42.500",<br>"id":<br>"cc3e10df6df6df619157e55c152519243f797b87a93c62b7913525028727b0b3",<br>"last_irreversible_block": 197914,<br>"traces": [<br>{<br>"account_ram_deltas": [],<br>"act": {<br>"account": "john",<br>"authorization": [<br>{<br>"actor": "smith",<br>"permission": "active"<br>}<br>],<br>"data": { |

```
                    "user": "smith"
                },
                "hex_data": "0000000080969dc4",
                "name": "createric"
            },
            "action_ordinal": 1,
            "block_num": 1074,
            "block_time": "2021-05-19T11:09:42.500",
            "closest_unnotified_ancestor_action_ordinal":  0,
            "console": "action deployed, smith",
            "context_free": false,
            "creator_action_ordinal": 0,
            "elapsed": 57,
            "error_code": null,
            "except": null,
            "producer_block_id": null,
            "receipt": {
                "abi_sequence": 1,
                "act_digest":
"c29c5e5984c53257a580bed26748a347b8e1ee183b77a37925a3d698e626e9d1",
                "auth_sequence": [
                    [
                        "smith",
                        1
                    ]
                ],
                "code_sequence": 1,
                "global_sequence": 1089,
                "receiver": "john",
                "recv_sequence": 1
            },
            "receiver": "john",
            "trx_id":
"cc3e10df6df6df619157e55c152519243f797b87a93c62b7913525028727b0b3"
        }
    ],
    "trx": {
        "receipt": {
            "cpu_usage_us": 265,
            "net_usage_words": 13,
            "status": "executed",
            "trx": [
                1,
                {
                    "compression": "none",
                    "packed_context_free_data": "",
                    "packed_trx": "14f2a4603004f65ee203000000000100000000000301b7d0
00040eeaa6cd445010000000080969dc400000000a8ed3232080000000080969dc400
",
                    "signatures": [
                        "SIG_K1_KdRk9YS89YfAd1xv8g1da9LLG97kZpKkuVv4bgFw9C
XcdU5RYwBSfaHy8evHS7rHyCELR99avx6woi4343fE5aMeydPyhX"
                    ]
                }
            ]
        },
        "trx": {
            "actions": [
                {
```

| | |
|---|---|
| | "account": "john",<br>"authorization": [<br>{<br>"actor": "smith",<br>"permission": "active"<br>}<br>],<br>"data": {<br>"user": "smith"<br>},<br>"hex_data": "0000000080969dc4",<br>"name": "createric"<br>}<br>],<br>"context_free_actions": [],<br>"context_free_data": [],<br>"delay_sec": 0,<br>"expiration": "2021-05-19T11:10:12",<br>"max_cpu_usage_ms": 0,<br>"max_net_usage_words": 0,<br>"ref_block_num": 1072,<br>"ref_block_prefix": 65167094,<br>"signatures": [<br>"SIG_K1_KdRk9YS89YfAd1xv8g1da9LLG97kZpKk uVv4bgFw9CXcdU5RYwBSfaHy8evHS7rHyCEL R99avx6woi4343fE5aMeydPyhX"<br>],<br>"transaction_extensions": []<br>}<br>}<br>} |

**Table 5-10: Reject Ricardian Contract**

| | Description |
|---|---|
| Functionality description | This service call rejects a Ricardian Contract. |
| Technical specifications | This module is developed by utilizing NodeJS and mongoDB database.<br><br>*Server Hardware*<br>CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz<br>Memory: 16GB<br><br>*Software*<br>Operating System: Windows 10 Pro<br>mongoDB: 4.2.14<br>NodeJS version: 15.6.0 |
| Endpoint | /rejectContract |
| Method | POST |
| Input Data | {<br>"Id":7,<br>"Partners":[<br>{<br>"name":"John",<br>"street":"New Street 1",<br>"city":"Thessaloniki",<br>"country":"Greece", |

| | |
|---|---|
| | "postalCode":"11111",<br>"date":"1/8/2021"<br>},<br>{<br>"name":"Smith",<br>"street":"New Street 2",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"date":"1/8/2021"<br>},<br>{<br>"name":"Sam",<br>"street":"New Street 3",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"date":"1/8/2021"<br>}<br>],<br>"Product":"Chair_v1",<br>"date":"1/8/2021",<br>"reason":{<br>"user":"John",<br>"msg":"dates are not valid"<br>}<br>} |
| Output Data | {<br>“msg”: “Contract ID:7 rejected”<br>} |

**Table 5-11: Add Ricardian Contract to Pending Contracts Page**

| | Description |
|---|---|
| Functionality description | This service call adds a Ricardian Contract to the pending contracts page. |
| Technical specifications | This module is developed by utilizing NodeJS and mongoDB database.<br><br>*Server Hardware*<br>CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz<br>Memory: 16GB<br><br>*Software*<br>Operating System: Windows 10 Pro<br>mongoDB: 4.2.14<br>NodeJS version: 15.6.0 |
| Endpoint | /addContract |
| Method | POST |
| Input Data | {<br>"Id":3,<br>"Partners":[<br>{<br>"name":"John",<br>"street":"New Street 1",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111", |

|  |  |
|---|---|
|  | "status":1,<br>"date":"1/8/2021"<br>},<br>{<br>"name":"Smith",<br>"street":"New Street 2",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"status":1,<br>"date":"1/8/2021"<br>},<br>{<br>"name":"Sam",<br>"street":"New Street 3",<br>"city":"Thessaloniki",<br>"country":"Greece",<br>"postalCode":"11111",<br>"status":1,<br>"date":"1/8/2021"<br>}<br>],<br>"Product":"Chair_v1",<br>"date":"1/8/2021"<br>} |
| Output Data | {<br>"msg": "Contract ID:3 added to the pending contracts page"<br>} |

**Table 5-12: Deploy Ricardian Contract**

| Description |  |
|---|---|
| Functionality description | This service call **deploys** a Ricardian Contract to the blockchain. |
| Technical specifications | This module is developed by utilizing NodeJS and mongoDB database.<br><br>*Server Hardware*<br>CPU: Intel(R) Core (TM) i5-9600K CPU @ 3.70GHz<br>Memory: 16GB<br><br>*Software*<br>Operating System: Windows 10 Pro, Kubuntu 20.04<br>mongoDB: 4.2.14<br>NodeJS version: 15.6.0<br>Python version: 3.6<br>Flask version: 2.0<br>EOSIO version: 2.0 |
| Endpoint | /deployContract |
| Method | POST |
| Input Data | {<br>"Id":3,<br>"Partners":[<br>{<br>"name":"John",<br>"street":"New Street 1",<br>"city":"Thessaloniki",<br>"country":"Greece", |

```
    "postalCode":"11111",
    "status":1,
    "date":"1/8/2021"
   },
   {
    "name":"Smith",
    "street":"New Street 2",
    "city":"Thessaloniki",
    "country":"Greece",
    "postalCode":"11111",
    "status":1,
    "date":"1/8/2021"
   },
   {
    "name":"Sam",
    "street":"New Street 3",
    "city":"Thessaloniki",
    "country":"Greece",
    "postalCode":"11111",
    "status":1,
    "date":"1/8/2021"
   }
  ],
  "Product":"Chair_v1",
  "date":"1/8/2021"
}
```

Output Data

```
{
  "msg": "Contract ID:3 deployed successfully"
  "transaction": {
   "block_num": 1074,
   "block_time": "2021-05-19T11:09:42.500",
   "id":
"cc3e10df6df6df619157e55c152519243f797b87a93c62b7913525028727b0b3",
   "last_irreversible_block": 197914,
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           {
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             "permission": "active"
           }
         ],
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         },
         "hex_data": "0000000080969dc4",
         "name": "createric"
       },
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       "block_num": 1074,
       "block_time": "2021-05-19T11:09:42.500",
       "closest_unnotified_ancestor_action_ordinal": 0,
       "console": "action deployed, smith",
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            "except": null,
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                "act_digest":
"c29c5e5984c53257a580bed26748a347b8e1ee183b77a37925a3d698e626e9d1",
                "auth_sequence": [
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                        1
                    ]
                ],
                "code_sequence": 1,
                "global_sequence": 1089,
                "receiver": "john",
                "recv_sequence": 1
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            "receiver": "john",
            "trx_id":
"cc3e10df6df6df619157e55c152519243f797b87a93c62b7913525028727b0b3"
        }
    ],
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            "net_usage_words": 13,
            "status": "executed",
            "trx": [
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                {
                    "compression": "none",
                    "packed_context_free_data": "",
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",
                    "signatures": [
                        "SIG_K1_KdRk9YS89YfAd1xv8g1da9LLG97kZpKkuVv4bgFw9C
XcdU5RYwBSfaHy8evHS7rHyCELR99avx6woi4343fE5aMeydPyhX"
                    ]
                }
            ]
        },
        "trx": {
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                    "authorization": [
                        {
                            "actor": "smith",
                            "permission": "active"
                        }
                    ],
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                        "user": "smith"
                    },
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                    "name": "createric"
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R99avx6woi4343fE5aMeydPyhX"
            ],
            "transaction_extensions": []
        }
    }
}
}
```

## 5.5.3. Approach and used technologies for IPR

The software packages that were used to develop the IPR Authoring Tool are described in detail in this section.

### *5.5.3.1. Angular*

Angular is an HTML and TypeScript-based open-source platform and framework for creating single-page client applications. Angular is the successor of AngularJS, and all references to Angular are for versions 2 and higher. Features such as generics, static-typing and ES6 capabilities are available in Angular. AngularJS was initially released by Google on October 20, 2010. The latest stable version of Angular is v12.0.1.

### *5.5.3.2. NodeJS*

Node.Js is a scalable network application runtime that is asynchronous and event-driven in JavaScript. It is often used for the implementation of web servers among others. Node.Js is open-source MIT-licensed and can run on various platforms such as Windows, Linux, Unix, Mac OS X, etc. Node.Js performance is fast due to the asynchronous way of handling the requests. Moreover, it is memory efficient. The Node package manager of Node.JS which is widely used for installing JavaScript libraries, includes hundreds of thousands of packages.

### *5.5.3.3. RESTful web API*

Representational State Transfer (REST) is frequently used for the creation of interactive applications that use Web Services. REST is a software architectural style that uses a subset of HTTP. The architectural style of REST was presented by Roy Fielding in 2000[12]. The following six constraints must be satisfied for an interface to be referred as RESTfull.

[12] https://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm

- Uniform interface
- Client-server
- Stateless
- Cacheable
- Layered system
- Code on demand

#### *5.5.3.4. Flask*

Flask is a Python-based web application framework. Flask framework is based on the Werkzeg WSGI toolkit and the Jinja2 template engine, which are both Pocco projects. Python web application implementations use Web Server Gateway Interface (WSGI) as a standard. The Werkzeg WSGI toolkit used in the Flask framework, implements all the required WSGI requests, response objects, and utility functions. In addition, the Jinja2 template engine included in Flask manages the rendering of dynamic web pages. Flask is designed to keep the core of the application simple and scalable and in addition, supports extensions for database support.

# 6. Next Steps

This report is mainly focused on the architectural and functional description of the IPR Authoring tool & Transaction Management Strategies for iPRODUCE Social Manufacturing Missions. The IPR Authoring Tool includes several software components developed in the first 18 months of the Task.

In the next months, the focus will be shifted to the integration and interconnection with the other OpIS platform components including the Marketplace and the Matchmaking toolkit. In addition, the User Interface, the back-end services and the template functionalities will be enhanced to cover the use cases, functional and non-functional requirements and provide a user-friendly and intuitive interface. Moreover, further additions such as purchases of products in the OpIS platform will be implemented. To cover all the essential operational needs regarding the purchases of the products, a smart contract for fungible tokens will be introduced to model a one-to-one correspondence with a real-world fiat currency digital coin.

# 7. Conclusions

An overview of the basic technologies used and features implemented in the design and development process of the IPR Authoring tool & Transaction Management Strategies for iPRODUCE Social Manufacturing Missions was presented in this deliverable. Additionally, thorough information has been provided about Blockchain Technology and the various leading platforms as well as the role of Smart and in particular the Ricardian Contracts.

Next, an overall description of the processes involved in the creation of the IPR Authoring Visual tool was presented with a complete detailing of both the internal, backend and frontend, workings of it. In addition, the procedure of user authentication and contract template processing and deployment was described in depth.

Lastly, an outline of the general additions, improvements and fixes (regarding purchases between the OpIS users, digital coins, connection with matchmaking and marketplace etc.) that will be implemented in the next and final version of the platform and presented in the respective deliverable were also presented, in accordance to the iPRODUCE platform's needs and expectations.

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## ANNEX

| | |
|---|---|
| Address | A short, alphanumeric string derived from a user's public key using a hash function, with additional data to detect errors. Addresses are used to send and receive digital assets. |
| Assets | Anything that can be transferred |
| Asymmetric-key cryptography | Users have a private key that is kept secret and is used to generate a public key in this cryptographic scheme (which is freely provided to others). Users can use their private key to digitally sign data, and anyone with the associated public key can verify the signature. |
| Block | A data structure containing a block header and block data. |
| Block data | The portion of a block that contains a set of validated transactions and ledger events. |
| Block header | Block metadata is the part of a block that comprises information about the block itself, such as a timestamp, a hash representation of the block data, the hash of the preceding block's header, and a cryptographic nonce (if needed). |
| Blockchain | Blockchains are block-based distributed digital ledgers comprising cryptographically signed transactions. After validation and consensus, each block is cryptographically connected to the one before it (making it tamper obvious). Older blocks become increasingly difficult to change as new blocks are added (creating tamper resistance). New blocks are replicated across copies of the ledger within the network, and any conflicts are resolved automatically using established rules |
| Cryptocurrency | Within the system, a digital asset/credit/unit that is cryptographically sent from one blockchain network user to another. The publishing node comprises a transaction that sends the freshly minted cryptocurrency to one or more blockchain network users in the case of cryptocurrency creation (such as the reward for mining). |
| Cryptographic hash function | A function that maps a bit string of arbitrary length to a fixed-length bit string. |
| Digest | See hash digest |
| Hash chain | An append-only data structure in which data is organized into data blocks, each of which contains a hash of the previous data block's data. Because any update to a data block changes the hash digest recorded by the succeeding data block, this data structure gives evidence of manipulation. |
| Hash digest | The output of a hash function (e.g., hash(data) = digest). |
| Hashing | By applying a cryptographic hash function to the input data, a way of producing a relatively unique output (called a hash digest) for an input of practically any size (a file, text, image, etc.). |
| Ledger | A record of transactions. |
| Node | An individual system within the blockchain network. |
| Permissionless | A system where all users' permissions are equal and not set by any administrator or consortium. |
| Public key cryptography | See Asymmetric-key cryptography. |
| Smart contract | A collection of code and data (also known as functions and state) that is put on the blockchain network using cryptographically signed transactions. The smart contract is executed by nodes in the blockchain network; all nodes must produce the same |

| | |
|---|---|
| | results, and the results are recorded on the blockchain. |
| Tamper evident | A process which makes alterations to the data easily detectable. |
| UTXO | A transaction output that has not yet been spent is referred to as a UTXO. Only unspent outputs can be utilized as inputs in an accepted transaction in a valid blockchain payment system (such as Bitcoin). When a transaction occurs, inputs are deleted and new UTXOs are created, which can then be consumed in future transactions. |