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RESEARCH REPORT

Blockchain for Business

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Chapter 1

Introduction

1.1 Report Overview

The research report outlines the implementation details of a Blockchain business network modeling solution that aims to encourage non-technical people to adopt the Blockchain technology in their business or job.

Also the report argues the reasons of choosing this solution, the business motivation of it and what's our contribution to the Blockchain world. In order to be able to understand these reasons it's important to have a clear view of the context and the existing open-source solutions in this area.

Last but not least, we are going to present a complete use case of the application and how its output integrates with open-source solutions.

1.1.1 Project Description

Business Network Modeling is a generic business network modeling application that enables leaders and non-technical people to envision how Blockchain technologies will revolutionize the industry they activate in.

The business network is build accordingly to the Blockchain paradigm therefore the network is composed by three entities: participant, asset and transaction.

Another important aspect is that the application is going to work as an extension of Hyperledger Composer framework, therefore, the model format will be compatible with Hyperledger Composer Model Files.

1.1.2 Project Objectives and Motivation

Developing a Blockchain based application requires knowledge from different fields from networking, protocols, cryptography, encoding, digital signatures, algorithms, etc. Therefore, implementing a Blockchain system can be very complicated and complex even for experts and professionals in the field. In addition, innovation is about building upon existing technologies and take advantage of the already knowledge of the communities so developing a Blockchain based solution from scratch is not necessary anymore. Another reason why business people and decision makers are skeptical is the fact that traditional Blockchain projects allows anyone to connect to the network and their identity cannot be verified.

Starting from these perspectives, we have decided to implement an extension to a powerful framework developed by the Linux Foundation, Hyperledger Project. Hyperledger Project is offering a solution to all the issues metionated above. The idea behind Hyperledger is to develop and nurture an ecosystem for the future of business blockchain technologies. Hyperledger represents an alternative to the cryptocurrency-based blockchain model, and it offers blockchain frameworks and modules to support global enterprise solutions. The main focus of Hyperledger is to provide a transparent and collaborative approach for Blockchain development community.

Our Blockchain business network modeling application is fully compatible with the Hyperledger Composer framework and its main purpose is to help non-technical businessmen or other leaders to envision their work after adopting the Blockchain technology. The idea of this application is the result of one year research work in the Blockchain world and it has arisen due to some difficulties encounter when testing the Hyperledger Composer framework. We discovered that the Hyperledger Composer Framework has some limitations when it comes to creating the business network model and we want to fill in these gaps by developing an extension to this framework. Therefore the solution proposed has the following objectives:

- to offer the first modeling storage system of Blockchain business networks that doesn't require human technical assistance;
- to get a fast sample of the business network from one of the areas where Blockchain will revolutionize the business flux;
- to reduce the time and costs of manually designing a Blockchain solution from scratch;
- to keep the compatibility with open-source projects that have the similar scope;
- to determine the fields that could be innovated by the adoption of Blockchain;

By reaching these objectives, we will gone fill in the gaps of the Hyperledger Composer framework and we will provide a classification of business networks suitable for Blockchain by envisioning how IT&C world will evolve.

Chapter 2

Project Technologies and Software

Business Network Modeling is an application developed in Python that has two main functionalities.

The first functionality refers to the possibility to download a business network from one of the available categories. The downloaded files is an archive with a basic business network that can be deployed in the Hyperledger Composer Playground or in a local Hyperledger Composer Environment. The second functionality enables an user to upload samples of business networks for each category. More then that, an user can add an new category if needed. This action requires a validation from the system's administration.

The application is an extension of the Hyperledger Composer framework that aims to fill in the gaps of the business network modeling process. Right now, the framework requires business network model in order to connect to the Hyperledger Fabric and start doing businesses using the Blockchain power.

This project helps users to obtain samples of Blockchain business network from different areas of expertise. In order to determine all the areas that can make use of the Blockchain technologies, we used a classification done by Don and Alex Tapscott [3].

2.1 Hyperledger Project

As mention in section 1.1.2, the Blockchain technology requires advanced technical skills and professionals to help businessmen and leaders use its power.

In order to solve the expertise issue and to encourage non-technical people use and test the power of Blockchain, organizations and companies (that understand the Blockchain revolution) had developed frameworks to facilitate the use of the Blockchain technology. IBM is one of the first organization involved into Blockchain that initiated the Hyperledger project and that released it to the public under the Linux Foundation.

IBM Blockchain platform has the following properties:

- Permissioned network - the participants of the network are known therefore the network offers decentralized trust
- Confidential transactions - expose only the information you want to share and only with the participants you want to share it
- Pluggable architecture - the size of the network can be customized

- Easy to Get Started - develop smart contracts in any programming language

Minting for proof-of-work, the ledger distribution, decentralization and immutability are already integrated into Hyperledger frameworks and modules, thus making use of the power of Blockchain was simplified.

Hyperledger provides an alternative to the cryptocurrency-based blockchain model, and focuses on developing blockchain frameworks and modules to support global enterprise solutions. The focus of Hyperledger is to provide a transparent and collaborative approach to blockchain development. Hyperledger blockchains are generally permissioned blockchains, which means that the parties that join the network are authenticated and authorized to participate on the network. Hyperledger's main goal is to create enterprise grade, open source, distributed ledger frameworks and code bases to support business use cases.

If you look at permissionless blockchains, like the Bitcoin blockchain or the Ethereum blockchain, anyone can join the network, as well as write and read transactions. The actors in the system are not known, which means there could be some malicious actors within the network. Hyperledger reduces these security risks and ensures that only the parties that want to transact are the ones that are part of the transaction and, rather than displaying the record of the transactions to the whole network, they remain visible only to the parties involved. So, Hyperledger provides all the capabilities of the blockchain architecture - data privacy, information sharing, immutability, with a full stack of security protocols - all for the enterprise. For more information on Blockchain and distributed ledger technologies check [1].

The cryptocurrency-based blockchain model, popularized by public blockchains like Bitcoin and Ethereum, currently falls short of fulfilling a host of requirements that many types of organizations would have to fulfill in order to be compliant when using blockchain and distributed ledger technologies - for instance, in the areas of financial services, healthcare, and government.

Hyperledger is a unique platform that is developing permissioned distributed ledger frameworks specifically designed for enterprises, including those in industries with strong compliance requirements. Enterprise use cases require capabilities such as scalability and throughput, built-in or interoperable identity modules for the parties involved in a transaction or a network, or even access to regulators who can access all data in the ledger as read-only to ensure compliance. The latter is particularly important because, regardless of the innovation, it has to operate within the current regulatory framework, as well as comply with any new rules that come into place specifically targeted at blockchain technologies.

Hyperledger business blockchain frameworks are used to build enterprise blockchains for a consortium of organizations. They are different than public ledgers like the Bitcoin blockchain and Ethereum. As of May 2018, Hyperledger consists of eight projects, five of which are distributed ledger frameworks. The other three projects are modules that support these frameworks. For a better understanding, check Figure 2.1.

The Hyperledger frameworks include the following components, described also in Figure 2.2:

- An append-only distributed **ledger**
- **A consensus algorithm** for agreeing to changes in the ledger
- **Privacy** of transactions through permissioned access
- **Smart contracts** to process transaction requests.

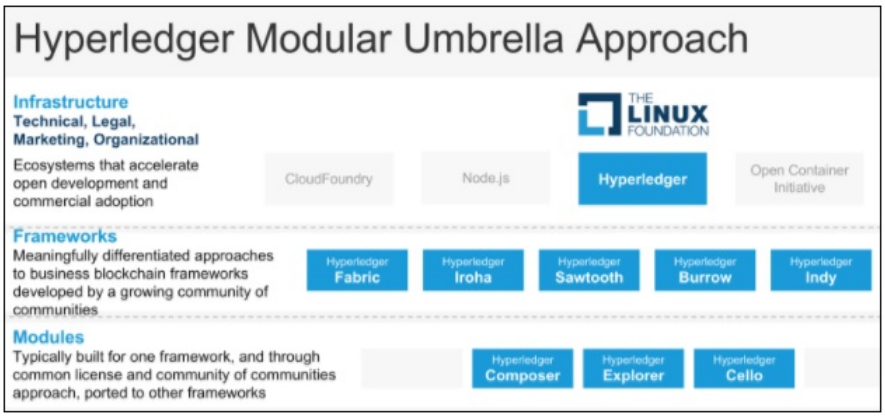

Figure 2.1: Hyperledger Modular Umbrella Approach(source [4])

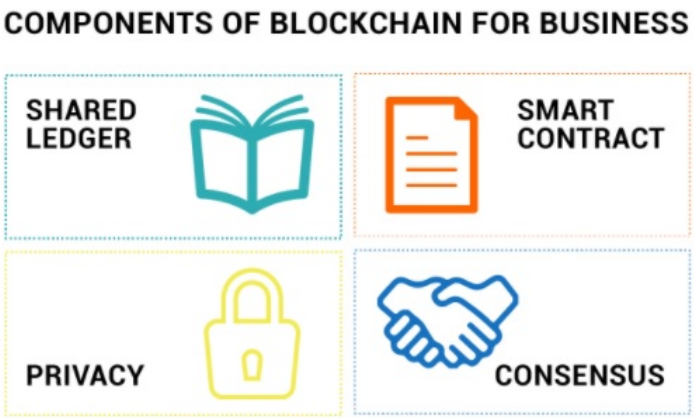

Figure 2.2: Components of Blockchain for Business(source [4])

2.2 Hyperledger Composer

The Hyperledger consortium has many different projects that focus on different aspects of how ledgers can work and what use cases they can be applied for.

Hyperledger Composer has created a modelling language that allows you to define the assets, participants, and transactions that make up your business network using business vocabulary. In addition, the transaction logic is then written by developers using Javascript. This simple interface allows business people and technologists to work together on defining their business network. The framework main goal was to reduce time and accelerate the Blockchain adoption and to make it easier to integrate business systems with the Blockchain.

The Hyperledger Composer is using the Hyperledger Fabric blockchain infrastructure and runtime that has pluggable blockchain consensus protocols to validate transactions accordingly with the participants policy.

This framework is using a business network model to quickly model the business by defining the assets, participants and the transactions. The framework provides with some sample of business network or require the users to deploy their network models. The business network model is an archive that contains a list of files:

- *Model file .cto* - assets, participants and transactions

- *Script File .js* - transactions functions
- *Access Control .acl* - access control rules
- *Query File .qry* - query definitions

All this files are stored in a business network archive that has the extension *.bna*. The Business Network Archive *.bna* is deployed in one of the distributed ledger Hyperledger solution such as Hyperledger Fabric Cloud or Local or in a simulated online environment (web browser/ node.js). See Figure 2.3 for a better description of the *.bna* file.

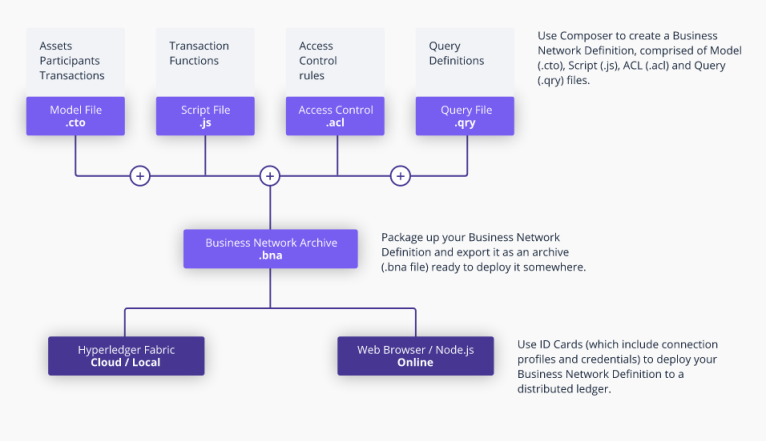

Figure 2.3: Business Network Archive Structure(source [2])

Hyperledger Composer provides a suite of tools for building blockchain business networks. These tools allow you to:

- Editors for modeling your business blockchain network
- Generate REST APIs for interacting with your blockchain network
- Generate a skeleton Angular application.

Built in Javascript, Hyperledger Composer provides an easy-to-use set of components that developers can quickly learn and implement. The project was contributed by Oxchains and IBM.

The benefits of Hyperledger Composer are:

- **Faster creation of blockchain applications**, eliminating the massive effort required to build blockchain applications from scratch
- **Reduced risk** with well-tested, efficient design that aligns understanding across business and technical analysts
- **Greater flexibility** as the higher-level abstractions make it far simpler to iterate.

After using this framework we reached the conclusion that it's a great choice for beginners that want to test the Blockchain technology and make use of its power. The framework can be install easily and the composer playground or a local Hyperledger Fabric are sufficient to start testing the business network. The main limitation we've noticed was related with the business network modeling process. In the composer playground environment were some samples of business networks but not enough to cover the hole areas that will be revolutionized by Blockchain.

Business Network Modeling is a tool that solves the modeling issues of the Hyperledger Composer by creating samples for twelve fields of the business world. The purpose of the tool

is to created the bigest *.bna* repository of *.bna* files. The application allows users to deploy and download *.bna* files by selecting one of the existing business fields. If an user create a new category, the request is validated by the tool's administrator before accepting the proposed category and the file uploaded.

Each *.bna* file must pass some validation rules before being stored in the repository.

The programming language used to develop this application is Python. The user interface is a simple website interface build using Django Framework. The motivation of using Python is related with the fact that the application requires file processing for validation and this programming language is very powerful and has a simple syntax for implementing parser solutions and file syntax validation rules.

In addition to this, the Django framework offers an abstraction layer for structuring and manipulating the data of the web application.

Chapter 3

Project Implementation

3.1 Functionalities

Business Network Modeling is an application build for Hyperledger Composer integration that stores models of business networks and enables user to upload and download the business network archives from the one of the industries fields defined.

The application has three main functionalities:

- upload business network archive in one defined category
- validate business network archive structure and files syntax
- download business network archive from one of the available categories

The project has three modules, each module is responsible for one of the functionality mentioned above. These functionalities are available from a web interface.

Don and Alex Tapscott [3] have defined the twelve important directions that will be reformed by the Blockchain revolution:

- **Transport** - cars wallet for paying fines and penalties or for paying an overtaking price in a traffic jam in case of an emergency
- **Infrastructure Administration** - a connecting infrastructure that applies road taxes based on the degree of deterioration
- **Energy, Water and Garbage Management** - using IoT based on Blockchain to track production, distribution, consumption and collecting
- **Resource Extraction and Agriculture** - keep a complete history of an animal nutrition, health and medication consumed; collect ground and plants parameters to notify institutions if there is an exploitation
- **Environment Monitoring and Emergency Services** - global monitoring agents to improve the prediction and to warn early by using weather sensors, chemical dangerous product' sensors or fire sensors in case of a forest fire or a lightning strike
- **Medical Insurance** - medical supply administration and patient medical history store on Blockchain ledger; self monitoring pills and medical prostheses
- **Financial Services and Insurance Companies** - financial institutions can store their wright on financial assets and the assets can be easily tracked; digital currencies enable

the storage and value transfer for big and small participants hence it allows rick evaluation and management

- **Evidence Tracking** - all physical assets are digitized and stored on Blockchain such as patents, properties, insurance, approvals, etc.
- **Buildings Administration and Properties** - a better management of the space available by replacing the main functionality of a building or office with other activities after work hours
- **Industrial Operations and Manufacturing** - create a industrial Blockchain to monitor the production lines, stock inventory, distribution, quality, etc.
- **House Management** - "smart houses" had a relatively heavy start, but the market is growing constantly and adding Blockchain power to it will support its growth; automatic payments for energy and water consumption or a proper estimation for plumber services payment
- **Retail Sale** - receive alerts about goods you want to buy when you're in front of the store and pay for them with your Blockchain wallet

This classification takes into account both the existing technologies and the future of IT&C world.

Adding a new sample of one of the categories is followed by a validation step. Only the *.bna* file that respects the content and the syntax defined by Hyperledger Composer framework will be added in the application repository. For one category, the user can download one or more samples. The list of samples for each category is available after selecting the category.

Adding a new category to this list can be done via the application interface when trying to upload the business network model from an area that is not listed above. This action requires a system administrator validation therefore the administrator is notified by an email and can decide whether or not the category is needed.

For each category there is at least a business network model defined by the *.bna* file and it can be downloaded by anyone that needs the sample. The *.bna* file then is deployed on the Hyperledger Composer Playground to start using the network.

3.2 Project Modules

The project has a client-server architecture, therefore the application has two main components: the client and the server. The client component is represented by a intuitive dashboard that allow users to select one category and download samples from that category or to upload the business network models they designed in the application repository using the upload functionality. The server component is composed by two modules that ensure the upload and download functionalities. The upload module is responsible with the archive validation and storage in the proper category. The download module is returning the archive based on its id and responds to REST calls to return the categories defined and the list of archive for a specific category.

The programming language is Python which is an interpreted high-level language that enables clear programming both for small and large scales. The communication between the server and the client is done via a REST API. The client is an web application based on Django framework. Django is a high-level Python Web framework that enables fast development and clean design for a simple web solution.

The server stores the *.bna* files in the same file system where it runs. The space is not consider an issue in this stage due to the fact that the number of *.bna* files is relatively small and the

size of the *.bna* file too.

The web browser is available by accesing the following url: http://<bnmc_ip>:8000/bnm

The server exposes the following REST API to the client application:

- `/rest/bna` - type: GET, query parameter type: String query parameter name: id, response: a *.bna* file
- `/rest/bna` - type: POST, response type: application-json, response: id:<val>
- `/rest/category` - type: GET, response: application-json
- `/rest/category` - type: POST, query parameter type: String, query parameter name: categoryName, payload: *.bna* file, response: external

Chapter 4

Project Use Case

4.1 Use Case Description

We choose to demo a business use case for the field "Evidence Tracking and Documents" starting with downloading the business network model from Business Network Modelingapplication and deploying the *.bna* file to the Hyperledger Fabric.

For this demo, we created a virtual machine that runs a Linux OS (Ubuntu 18.04) with a full environment configured. For simplification, both the Business Network Modelingand the Hyperledger Composer run on the same VM.

We want to create a system that helps business organizations and universities store the students' profile. Having a Blockchain solution that stores data about students such as their courses and studies level. The idea is to offer the participants of the network information about students based on their role in the business network. For example, the university can access information about students' degrees and personal data, the student has full access to his/her profile and external institutions such as other universities or companies can access only information that the student agrees to display. One possible information that a student may want to share with companies can be the level of study and the courses he attended to or other certifications.

Such a system guarantees that nobody can change the student's history and simplifies the process of validating diplomas. Therefore, it is useful for all the network participants:

- for students that want to transfer to another university or that want to prove that they have the skills to get the desired job
- for universities by improving the time and costs of students' data collecting and transferring to other academic institutions
- for companies and organizations that want to validate the resume information they receive

4.2 Use Case Steps

The use case described above requires executing the following steps:

- download a business network model suitable for the business field chosen
- deploy the business network archive to the Hyperledger Composer

- check that all the business logic and business network definition is correct for the business use case
- add some test data about student/s and do some testing to check that the business network is correctly defined; if you are play the role of the student you should have full access to the data from the Blockchain ledger; if you are the student' university or other institution the access level should be the one defined by the student in the *Access Control* file from the *.bna*

From the web application we can download a sample of the *.bna* file for Identification Profiling and then update it for the current scenario. (see Figure 4.1)

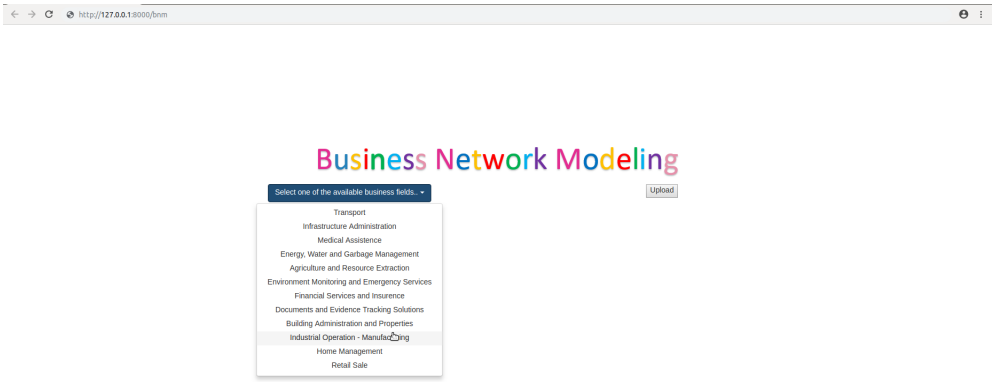

Figure 4.1: Business Network Modeling Dashboard

For the selected category *Documents and Evidence Tracking* we can download one of the two samples available: *Identification Profiling* or *Digital Property*(see Figure 4.2).

The downloaded archive contains the files described in section 2.2.

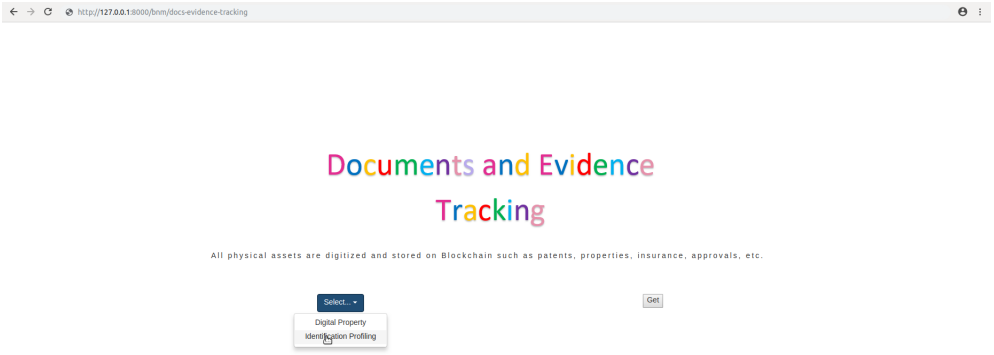

Figure 4.2: Documents and Evidence Tracking Page

In the *.bna* file we can see the business network definition that has the following structure:

```
**Participant**
'Student'
'University'
'Organization'

**Asset**
'StudentProfile'

**Transaction**
'StudentProfileTransaction'

**Event**
'StudentProfileEvent'
```

StudentProfile/s are owned by *Student/s*, and the value property on a *StudentProfile* can be modified by submitting a *StudentProfileTransaction*. The *StudentProfileTransaction* emits a *StudentProfileEvent* that notifies applications of the old and new values for each modified *StudentProfile*. The list of *Student* participants is defined in Figure 4.3. The list of *University* participants is defined in Figure 4.4. The list of *Organization* participants is defined in Figure 4.5.

Figure 4.3: Participant - Student

Figure 4.4: Participant - University

After defining the participants we have to create the assets. In our example, the asset is the *StudentProfile* (see Figure 4.6).

To test the Hyperledger Composer framework, we submitted a transaction (see Figure 4.7), where we changed the value of a *StudentProfile*. The new value can be seen in Figure 4.8.

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Figure 4.5: Participant - Organization

Figure 4.6: Asset - StudentProfile

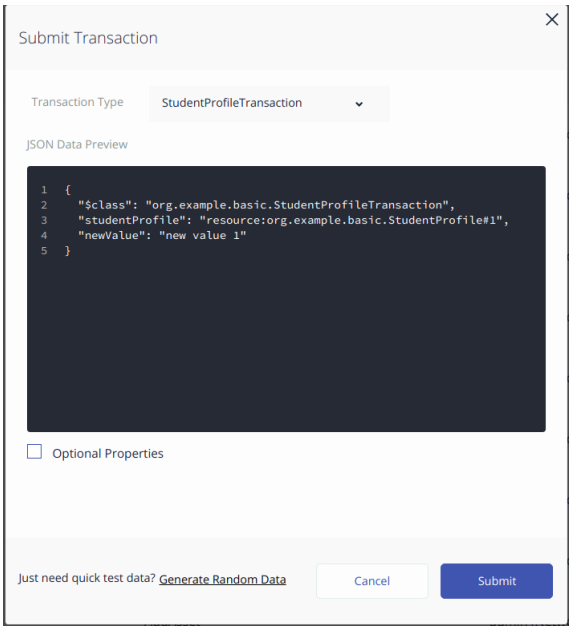

Figure 4.7: Submit a StudentProfileTransactions

Figure 4.8: Asset - Updated data of a StudentProfile

Chapter 5

Conclusion

In conclusion, **Business Network Modeling** is an application that manages the business network archives in order to offer a complete storage repository for the Hyperledger Composer *.bna* files. The contribution of this application is represented by the fact that users can download and upload *.bna* files based on a defined list of areas of applicability.

The application aims to fill in the gaps of the Hyperledger Composer framework by offering non-technical users access to already created business network archives to start testing the Hyperledger Fabric and the power of Blockchain technology.

Another important contribution is the validation mechanism that make sure that only the *.bna* files compatible with the Hyperledger Composer framework can be uploaded on this application.

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