APPLICATION OF BLOCKCHAIN TECHNOLOGY AS A SUPPORT TO DECENTRALIZE THE INFORMATION ACROSS THE SUPPLY CHAIN IN THE ORGANIC FOOD INDUSTRY FOR THE COLOMBIAN MARKET

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ABSTRACT

New information technologies can generate value for companies and industries in a disruptive way and, depending on their scope and projection of growth, also change the world and the way to connect it. Blockchain is one of them and affects the current business model, in industries such as finance and real estate, generating an improvement in services to provide higher value to the customers.

Studies has shown that organics are taking avantage of the market, due to a increase interest of health care. People is changing their food habits, making it everytime more and more important and relevant; however, there is a lack of confidence in the products their buying, not always the source and origin are clear; that is why this research seeks to explore the operation and functionality of the Blockchain technology, to support the transactions along the supply chain for organics, in order to create the origin tracebility of the product, to provide the final custumer with sufficient data to make a informed purchase.

This research was made using a structured analytical – exploratory methodology, given the early-development-state of the Blockchain technology, beginning with the analisys of the current state, course of implementation, similar study cases and finishing with a prove of concept to validate its applicability. The result, it is a novel methodology to integrate the Blockchain technology in the food industry supply chain, which gathers the best practices in marketing, process engineering and the technology itself, alongside the authors' experience during its application based on the organic coffee industry in the Colombian market. The Author has extracted the best out of the practices and made it simple for anyone interested in its uses and application. The result is a simple and straightforward methodology that suits any product, supply chain, and required system configurations, due to its versatility and adaptability.

Moreover, it exhibits the results of implementing a Blockchain on a supply chain study case, based on an implementation of a Blockchain business network for Colombian

Coffee supply chain, using Hyperledger, which is is an open source collaborative effort created to advance cross-industry blockchain technologies (The Linux Foundation, n.d.). The objective is to understand how to implement a Blockchain over a process like the supply chain; the authors explain the study case and the steps through the business network configuration. Which, with the recent interest of adopting Blockchain to leverage business process capabilities, the results of this case study validation confirms the viability of using Blockchain with the objective to trace product origin. It analyses the results of this implementation and proposes a course of improvements to consider different scenarios. Presented are the current general process used in the market for coffee production, the technological architecture proposed to support this scope and the process to store the data into the Blockchain.

KEYWORDS: Blockchain, Supply Chain, Cadena de Bloques, Cadena de suministros, Organic food, Methodology, Process

RESUMEN

Las nuevas tecnologías de la información pueden generar valor para las empresas e industrias de una manera disruptiva y, dependiendo de su alcance y proyección de crecimiento, también cambian el mundo y la forma de conectarlo. Blockchain es uno de ellos y afecta el modelo de negocio actual, en industrias como las finanzas y los bienes raíces, generando una mejora en los servicios para brindar mayor valor a los clientes.

Los estudios han mostrado que los porductos orgánicos están tomando ventaja del mercado debido al aumento del interés en el cuidado de la salud. Las personas están cambiando sus hábitos alimenticios, lo que hace que cada vez sea más importante y relevante; Sin embargo, hay una falta de confianza en estos productos, no siempre la fuente y el origen son claros. Es por eso que esta investigación busca explorar el funcionamiento y la funcionalidad de la tecnología Blockchain, para respaldar las transacciones a lo largo de la cadena de suministro de productos orgánicos, con el finde crear la trazabilidad de origen del producto, para proporcionar al cliente final los datos suficientes para realizar una compra informada.

Esta investigación se realizó utilizando una metodología analítica-exploratoria estructurada, dado el estado de desarrollo temprano de la tecnología Blockchain. Comenzando con el análisis del estado del arte, la forma de implementación, casos de estudio similares y terminando con una prueba de concepto para validar su aplicabilidad. El resultado es una metodología novedosa para integrar la tecnología Blockchain en la cadena de suministro de la industria de alimentos orgánicos, que reúne las mejores prácticas en mercadeo, ingeniería de procesos y la tecnología en sí, junto con la experiencia de los autores durante su aplicación tomando como base la industria del café orgánico en el Mercado colombiano. El autor ha extraído lo mejor de las prácticas y lo ha hecho simple para cualquier persona interesada en sus uso y aplicaciones. El resultado es una metodología simple y directa que se adapta a cualquier producto, cadena de

suministro y configuraciones de sistema requeridas, debido a su versatilidad y adaptabilidad.

Por último, muestra los resultados de la implementación de una Blockchain en un caso de estudio de la cadena de suministro, basado en una implementación de una red de negocios de Blockchain para la cadena de suministro de café colombiano, utilizando Hyperledger. El objetivo es comprender cómo implementar una cadena de bloques en un proceso como la cadena de suministro, los autores explican el caso de estudio y los pasos a través de la configuración de la red de negocios. Los resultados de esta implementación confirman la viabilidad de usar Blockchain con el objetivo de rastrear la trazabilidad del origen del producto. Aquí los resultados de esta implementación y propone una serie de mejoras para considerar diferentes escenarios a tener en cuenta. Se presentan el proceso general actual utilizado en el mercado para la producción de café, la arquitectura tecnológica propuesta para respaldar este alcance y el proceso para almacenar los datos en Blockchain.

PALABRAS CLAVES: Blockchain, supply chain, cadena de bloques, cadena de suministros, comida orgánica, metodología, procesos.

DEDICATION

I dedicate this work to my family and friends. A special thanks to my parents Soriana and Jose Luis whom have always encourage me to pursue my dreams and goals; to my sister Olga Lucia and my niece Luciana, you always fill my heart with joy and lift me up to be a better a person.

I also dedicate this thesis to Ruben, who has accompanied me along the way and have celebrated with me every single victory… all the love.

To my friends, classmates and coworker, who have been listening to me to talk about this subject for two years (thanks for hanging in there).

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1. INTRODUCTION

Trade has always been a part of the human civilization, the direct exchange of services and resources for mutual advantage is intrinsic to the symbiotic relationships between plants, insects and animals, so that it should not be surprising that, in some form or other, is as old as man himself (Capie, 2003). Commodities were chosen as prefer trade items, or as it was called back then, barter; this has many reasons, it could be, because they were easy to store, or because they were portable or maybe because they were more durable. The more quality the item showed, the higher the opportunity for exchange. As civilizations were evolving, thus the way for trading did. A “coin" with multiple forms was introduced as a method to facilitate the exchange of products, assuming that everyone was able to establish a fair price for their commodities using the same “rate of exchange," it would make the exchange easier. Those first “coins" were, for example, wheat or cattle; in that way, it was easy to set up a price for different products, based on how many cows you could give in exchange of cereals. Soon after, this method was replaced with the arrival of the metallic coins, made of an alloy of gold and silver. First metallic coins were used for tax collection and then, migrated as an asset that allows people to exchange commodities one another, its value was given according to the figure, usually of a god, which was engraved on one of its faces, it was also proof of its quality and purity (Robertson, 2007).

This mechanism of exchange continues to evolve, as we know it today; banks and governments played an essential role in this evolution process, as they became its guardian and guarantees. In 2009, it was introduced, the Bitcoin, a new mechanism for exchange products or services, with a digital coin (Satoshi Nakamoto, 2008). Is safe to say, that digital coins have had existed since the mid-80s with David Chaum, inventor of digital cash and blind signatures (Chaum, Fiat, & Naor, 2007). However, there was a big problem, it was impossible to avoid the double spend of a coin; this is where Bitcoin becomes interesting, the underlying technology behind this new digital coin, breaks with this paradigm, make it feasible to transact, and the most relevant, that transaction needed

no third parties or intermediates to make it, thanks to the groundbreaking technology behind Bitcoin, nowadays known, as Blockchain.

Given the constant evolution of technology and taking into consideration that every ten years in average we are having "the next" big technological paradigm, it pays to be at the vanguard of the most recent events in this field. During the 70s it was the punch cards, which in the 80s open up the path for the computers. During the 90s we have the internet, which has been the most revolutionary advancement of all times, this has helped us to interconnect the whole world; in the new millennium, the 2000s, we witness the birth of the social media, this particular tech helps us not only to connect and bring people closer but allow us to speak up through microblogging our thoughts and finally, in this decade we have, as mentioned, the Blockchain.

However, before we started talking about the Blockchain, we have to talk about Bitcoin, the digital coin that was published in a paper called Bitcoin: A Peer-to-Peer Electronic Cash System, in 2008, under the authorship of Satoshi Sakamoto. Bitcoin allows people to transact directly without a central authority.

Bitcoin as digital cash was released in 2009 becoming more than an idea that was written and published on a paper. Satoshi created the Bitcoin network along with the first block of the chain or the genesis block, which back in the days, its notion and concept were way too far to be what it is today and known as the Blockchain.

This revolutionary technology, which name means, a block of chains, it is a decentralized database connected peer to peer, that allow us to store information of any asset, it could be tangible or intangible (Swan, 2015). The information stored on the Blockchain cannot be edited, mutable or altered by anyone (Gates, 2017). Therefore, being decentralized and immutable breaks with the current schema of the need for an intermediary to transact one another, for example, banks, governments, among other regulatory entities. Blockchain technology provides this, through mathematical algorithms

(puzzles) using cryptography and proof-of-work that generate trust among the participants of the network.

> We should think about the blockchain as another class of thing like the Internet—a comprehensive information technology with tiered technical levels and multiple classes of applications for any form of asset registry, inventory, and exchange, including every area of finance, economics, and money; hard assets (physical property, homes, cars); and intangible assets (votes, ideas, reputation, intention, health data, information, etc.). However, the blockchain concept is even more; it is a new organizing paradigm for the discovery, valuation, and transfer of all quanta (discrete units) of anything, and potentially for the coordination of all human activity at a much larger scale than has been possible before (Swan, 2015, p. VII).

That was Blockchain from the financial perspective, but we need to point out that it goes beyond Bitcoin and financial transactions enabling digital currencies. “Blockchain enables a potentially evolving and open set of parties to maintain a safe, permanent, and tamper-proof digital ledger of transactions, without a central authority” (Milani, García-Bañuelos, & Dumas, 2016, p 1.). Businesses learned, however (sometimes the hard way), that process automation per se rarely or never produced significant value. Instead, the value of process automation came from the fact that it enabled fundamentally new business process improvement opportunities. Likewise, the business potential for blockchain technology lies not so much in its technology substitution ability, but rather in its ability to enable new business process improvement opportunities (Milani et al., 2016, p. 1). The grand breakthrough with this technology is, that the information it is not stored centralized but, replicated among the whole network along with the keys for a transaction to be valid, also, the majority of computers connected to the network must approve the transaction.

Hence, what is pursued with this research is to apply this technology to the supply chain in the organic food industry in the Colombian market in order to decentralize the information, provide trust among all participants and discover a new range of opportunities for an application that can provide the customer with information beyond a supermarket label. This also will help us to validate its scope as part of a business

process, keeping in mind that Blockchain technology at this point of its development cannot be call itself a new methodology for process improvement, optimization or automation. Basically, in the end, we are going integrate both worlds, this new technology, and the process as it is, to validate the added value that can be achieved.

This research follows a course of development based on a analytical – exploratory methodology and for each particular objective the approach may vary. The first objective is mostly interpretative, based on the literature review of the technology and what it shown accordingly the technology advances; the second objective has a deductive approach, which results in the understanding of the supply chain process in the organic food industry and, the third and four objectives were worked and developed together, with a heuristic approach and the results are based on the information collected, but, mostly it is self-production. For all purpose on this research, a case of study was made to analyzed and evaluate the information and its results, which shows the viability to apply this methodology to integrate Blockchain technology in the supply chain process in order to achive product origin tracebility; the results after the validation, helped the author to understand the Blockchain in business processes.

2. PROBLEM STATEMENT

Nowadays, personal care and health have become imperative among generations; this is what Nielsen (Di Giammarco & Marinelli, 2019) shows we are what we eat: healthy eating trends around the world. In this growing market, the proliferation of training centers, gyms, bicycle use and above all, improving eating habits. People are more concerned about knowing what kind of food they include in their diets, what nutrients they have, where they come from, how there were cultivated, how their selection has been made, among other questions regarding its origins; but sadly, there are some questions that, in most cases, are left unanswered, and there is nothing more than trust in the goodwill and response of those who place it at our disposal, whether on a shelf or in a restaurant.

In addition to that, according to (Ha et al., 2018), in Table 1 it can appreciate the raising of some of the global indicators that are being monitored each year. Organic agricultural land has grown 525% since 1999, which mean that more organic food has been cultivated globally; also procedures globally has increased by 1350% during the last two decades. This reflects how more people are depending on this and the impact of organics across the world and last the market value in the period has grown 501%, make it relevant considering how people had been changing their food habits.

Table 1: Organic Agriculture: Key Indicators and Top Countries

Indicator	World	Top Countries
Countries with organic activities	2016: 178 countries	

Indicator	World	Top Countries
Organic agricultural land	2016: 57.8 million hectares (1999: 11 million hectares)	Australia (27. 1 million hectares) Argentina (3.0 million hectares) China (2.3 million hectares)
Organic share of total agricultural land	2016: 1.2%	Liechtenstein (37.7%) French Polynsia (31.3%) Samoa (22.4%)
Wild collection and further non-agricultural areas	2016: 39.9 million hectares	Finland (11.6 million hectares) Zambia (6.7 million hectares) India (4.2. million hectares)
Producers	2016: 2.7 million producers (1999: 200.000 producers)	India (835.000) Ugandda (210.352) Méxio (210.000)
Organic market	2016: 89.7 billion US dollars (2000: 17.9 billion US dollars)	US (43.1 billion US dollars) Germany (10.5 billion US dollars) France (7.5 billion US dollars)
Per capital consumption	2016: 12.1 US dollars	Switzerland (304 US dollars) Denmark (252 US dollars) Sweden (218 US dollars)
Number of countries with organic regulations	2017: 87 countries	
Number of affiliates of IFOAM - Organics International	2017: 1.003 affiliates from 127 countries	India (111 affiliates) Germany (88 affiliates) United States (63 affiliates) China (56 affiliates)

Source: FiBL survey 2018, based on national data sources and data from certifiers.

Being aware of what we buy and eat favors proper nutrition, as well as the care and maintenance of our health. It is essential to identify nutritional information, ingredients and other recommendations when buying packaged foods [Translated to English from the source] (Abreu, Bejarano, & Camacho, 2014).

With that being said, we must point out that customers have never been able to know in detail the characteristics, attributes and valuable information about the food they are purchasing. In Colombia, according to the Ministerio de la Protección Social (2006), there are labeling requirement that every product has to have; however, labels for organic product do not showcase relevant information about the different stages and processes to which they are subjected from their cultivation, throughout the supply chain and finally the final consumer.

In an interview conducted by Casa Editorial El Tiempo (2016), the president of Almacenes Éxito, Carlos Mario Giraldo, said - the market for products with benefits moves about 20 percent of food consumption in the country and grows 10 percent per year, twice the industry as a whole - [Translated to English from the original source], which evidence the potential market that is behind a good food habits. Now, let us imagine the same scenario but providing information to the customer, that never have been accessed or shared before.

2.1. Research question

It Is possible through the use of blockchain technology to generate value and optimize the current process flow model used in the supply chain for the organic food industry by the decentralization of the information and provide the customer with the sufficient information to make an informed purchase by generating trust along the process?

2.2. Hypothesis

Through the use of blockchain technology for the support and optimization of the supply chain in the organic food industry can be achieved the decentralization of information, making it more transparent to the consumer the origin of products.

The researcher believes that this research might provide valuable information to the development of the new application of Blockchain technology as an alternative system for process support and optimization across the value chain. For educational theorist and researchers interested in this topic, it is hoped that this research also contributes to a better understanding of the nature of this technology and its multiple applications. Besides, the researcher also hopes that this research will contribute to set up the foundations for a feasible model for supply chain implementation and offer suggestions for better practices in different industries.

3. JUSTIFICATION

According to the World Health Organization, WHO (2018), People are now consuming more foods high in energy, fats, free sugars or salt/sodium, and many do not eat enough fruit, vegetables and dietary fiber such as whole grains. Just as the Blockchain technology is transforming the way we carry out transactions, it will do so with many other industries, including the organic food industry by allowing people to know the origin and traceability (along the process) of what they are eating.

With the growing demand in the fitness market, in line with NIELSEN (Di Giammarco & Marinelli, 2019, p 20.) "Consistent with consumers' rating of the importance of attributes, sales of products with natural and organic claims have grown 24% and 28%, respectively, over the two-year period". With this information, we can appreciate how important it has become for people to change their eating habits; based on Nielsen Global Survey on Health and Wellness. 3rd semester of 2014, specifically in Colombia, people tend to look for food with local ingredients, natural and organic alternatives, which make us think about the current state of the transformation process that experience food across the value chain, since its plantation until its placement on a supermarket shelf.

> Companies commercialize new ideas and technologies through their business models. While companies may have large investments and processes for exploring new ideas and technologies, they often have little if any ability to innovate the business models through which these inputs will pass (Chesbrough, 2010, p. 1).

We have always experienced technology in different scenarios that have helped us to generate some improvement in the way we perceive or do things on our daily basis even technology has changed how we do businesses. This phenomenon is known as a disruptive technology; according to Cambridge English Dictionary, this overturns a traditional business model, which makes it much harder for an established firm to embrace. A clear example of this meaning is the e-mail, it replaced the postal office's service, this has been more vividly for recent generations, nevertheless, no matter the age, people look for a laptop with internet to send a letter.

In order to be more related to the objective of this research, here are some recent examples of this kind of disruptive technology. (1) Uber, the world's largest taxi company, owns no vehicles; (2) Facebook, the world's most popular media owner, creates no content; (3) Alibaba, the most valuable retailer, has no inventories; (4) Airbnb, the world's largest accommodation provider, owns no real estate; and finally (5) Bitcoin, fastest growing bank and currency, has no banks, nor central authority and even, nor actual currency. Most of this technology has come, not to replace the current business, but to provide a new competitor in an open market. Each one of these technologies (that we access through a mobile application) has its business model that has evolved from the traditional ones, and they have proven to be very useful when it comes to evolution.

Along with this technology offered through applications, during the past few years, new terminology in the background of that application has arisen, some of this new terminology is, Internet of Things (IoT), which are objects with computing devices in them that connect to each other and exchange data using the internet. Cloud, a computer network where files and programs can be stored, especially the internet; Smart-contracts and Blockchain are being the most recent of those terms, both work together, Blockchain as a decentralized database and smart contract as an application who takes the whole technology infrastructure together and replace conventional contracts to binding electronically obligations among different parties.

The revolutionary innovation in this research will lead us to use a completely new technology as it is the Blockchain, which from the beginning was conceived to avoid double spending in Bitcoin, in a disruptive way and creating the foundations for new applications starting from its primary objective the decentralization of information.

4. AIM OF THE WORK

4.1. General objective

To develop a methodology that would help support and decentralize the information in the supply chain process of the organic food industry for the Colombia market by creating trust among participants along the process by using Blockchain technology.

4.2. Specific objectives

- To explore the state of the art of Blockchain and its possible applications in the food industry.
- To describe the supply chain process for the organic food industry in Colombia in order to define the specifics points in which Blockchain would act.
- To propose a methodology to make Blockchain suitable for the supply chain process in the organic food industry.
- To simulate the implementation of the methodology through a study case in order to validate its impact in the supply chain process.

5. LITERATURE REVIEW

5.1. Blockchain

5.1.1. The technology behind Bitcoin

A Blockchain according to (Swan, 2015), in its most precarious form is the public ledger of all Bitcoin transactions that have ever been executed. However, since its conception, the Blockchain has evolved further than the platform to store financial transactions managed by a cryptocurrency. The Blockchain It is like a database; it's a way of storing records of value and transactions (Gates, 2017). In general matters, that last sentence explains very quickly and, in simple words, the aim of the Blockchain.

However, the technology goes beyond a shared database; a lockchain is essentially a distributed database of records, we can also call it a public ledger of transactions or even digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified by the consensus of a majority of the participants in the system. Moreover, once entered, the information can never be erased, modified or altered (Crosby et al., 2015).

The very first appearance of a block of chains was back in 2008, where an individual (or group) writing under the name of Satoshi Nakamoto published a paper entitled "Bitcoin: A Peer-To-Peer Electronic Cash System." This paper described a peer-to-peer version of electronic cash that would allow online payments to be sent directly from one party to another without going through a financial institution concept. Now cryptocurrencies, which is a digital type of currency that makes use of encryption to carry out and verify/validate transactions (Icahn, 2017), is the label that is used to describe all networks and mediums of exchange that uses cryptography to secure transactions against those systems where the transactions are channeled through a centralized trusted entity (Crosby et al., 2015)

In this paper, Satoshi (Satoshi Nakamoto, 2008) explains how Bitcoin will serve as a financial payment method between two willing parties without an intermediator, like bank institutions or governments. As a digital currency and online payment system allows encryption techniques to be used to regulate the generation of units of currency and verify the transfer of funds, operating independently of a central bank (Swan, 2015).

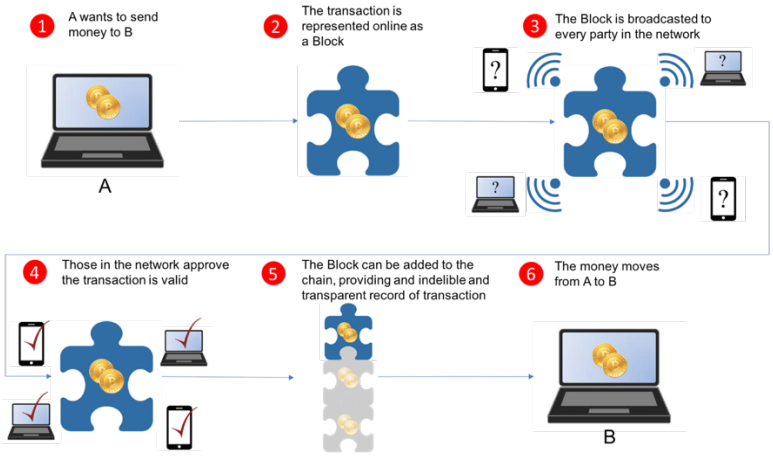
Satoshi (Satoshi Nakamoto, 2008), also stated that each transaction will be stored in a digital ledger (the Blockchain), with each recent block or transaction connected or added to a preceding block and the preceding block to another preceding block, in that order, to form a chain of blocks or transaction, using a digital signature. It is going to be built on trust and transparency because participants can authenticate the signatures by running various sophisticated algorithms (Icahn, 2017).

5.1.2. How does the Blockchain works?

As explained, Blockchain may have been born because of Bitcoin and nowadays is used as the primary foundation for any cryptocurrency and its transactions. However, it goes beyond due to the Blockchain architecture, gives participants the ability to share a ledger that is updated, through peer-to-peer replication, every time a transaction occurs peer-to-peer replication means that each participant (node) in the network acts as both a publisher and a subscriber. Each node can receive or send transactions to other nodes, and the data is synchronized across the network as it is transferred (Laurence, 2017, p. 6), as it is shown Figure 1.

To use a basic analogy, “it is easier to steal a cookie from a cookie jar, kept in a secluded place, than stealing the cookie from a cookie jar kept in a marketplace, being observed by thousands of people” (Crosby et al., 2015, p 8.).

Figure 1: Financial transaction using Blockchain technology



Source: (Crosby et al., 2015)

With that simple example of how a transaction occurs in the Blockchain, where subject A wants to transfer money to subject B, we are going to review what is behind the entire process. Once the transaction is created by subject A (1), this is represented online as a Block along with many other transactions that were made at the same period of time (2); At this point, in order to certificate the validity of this transaction, different mathematical algorithms, known as hash functions (takes some input data and creates some output data (Sean, 2016), are used to encrypt the digital signature that was used to send the transaction. This Block that was created now is being broadcasted to the entire network of nodes connected (3), all nodes connected to the Blockchain network start to verify the whether the transaction is valid or not, this process is known as proof-of-work, that will allows each blockchain connected node to keep transactions secure and reach a tamperesistant agreement (Icahn, 2017), which can take up to 10 minutes approximately. Once the transaction is valid and approved by all nodes connected (4), the Block is finally added to the Chain 5, this whole process from 1 to 5 is known as mining, This refers to add new blocks of records (transactions) to the public ledger of Blockchain. In the end, subject B can see the transaction reflected in its balance (6).

It is safe to point out that, as mention before, with Blockchain we are allowed to transact, in this case, digital currency, without the intermediation of a third-party entity, like a bank, a government or any other regulatory entity.

5.1.3. Component of a Blockchain network

Table 2, describe the most important components for a Blockchain network, enphisisyn the ones that are used in this research.

Table 2: Principal components of a Blockchain software solution

Blockchain Components	Description
Node Application	Each Internet-connected computer has to run a specific application to be a participant on the Blockchain Network. In a more technical look, each computer must be able to process application-specific messages to generate an update on the ledger (Neocapita, 2017).
Shared Ledger	It is a logic component; a data structure management inside the node application. Each of the participants of the network, once they have installed the node application, have access to the Shared Ledger of the ecosystem they have access in. Each participant can run as many applications they have permitted to use, according to they specific rules, smart contract and payment when applying (Neocapita, 2017).
Consensus	Is the process by which a network or node, guarantee the ordering of transactions and confirm its validity, in order to validate the block of a chain (Hyperledger.org, n.d.).

Blockchain Components	Description
Smart Contracts	These are an essential component of a Blockchain, which help to encode automatic validation for a transaction that before were specified on a written contract (Mery & Selman, 2017).
Alerts	These are applications that work together in the Blockchain to monitor the smart contract results and produce events (Auberger & Kloppmann, 2017).
Participants	In a permission Blockchain Network like the one suggested in this paper, participants will be everyone involved within the organization that needs to communicate with the Blockchain for a public Blockchain like Bitcoin, anyone with a virtual wallet (The application that allows participant to transact one another) will be a participant of the network.
Virtual Machine	It is a representation of a machine by a machine in software development, a virtual machine assigns specific capabilities for the software (disk space, processor and memory) that would help to improve performance (Smith & Nair, 2005). In Blockchain, as the last logic component, it lives in the node application, and some of these virtual machines are call wallets (Neocapita, 2017).

Source: The authors.

5.1.4. Characteristics of Blockchain

Throughout this chapter we have mentioned some of the characteristics of Blockchain technology, how does it works and some of its potential uses, however, in here and according to Gates (Gates, 2017) and Swan (Swan, 2015) we are going to emphasize the most essential benefits and disadvantages of the Blockchain technology.

Benefits

- Compared to existing technologies of record keeping and traditional databases, transparency is one of the most significant improvements of Blockchain.
- No intermediaries involved during the process; whether, it is used as a record keeping or transfer of assets.
- It uses a decentralized network, which reduces the possibility of hacking, downtime system or loss of data.
- All of the above mentioned, in conjunction, create trust among participant of the network which is one of the principal characteristics. This feature allows participant that have never even met before transacting one another with the confidence that this technology provides.
- Security is provided through traceability. All data entered / register on the Blockchain cannot be mutable, altered or change, which allows a clear record from the very start of any transaction. The above means a Blockchain can be easily auditable.
- The Blockchain provides multiple uses, almost any kind of assets can be recorded on it. Different industries (we will be covering this later) are already developing applications based on Blockchain.
- The technology is pretty accessible, no need for significant investments nor complex infrastructures there are already platforms based on Blockchain like Ethereum, which is a Blockchain platform that is public and has a programmable transaction functionality (Bresett, 2017), that will allow us to create Decentralized Applications (dApps), these are applications that run on a P2P network of computers rather than a single computer (blockchainhub.net, n.d.).
- Reduced cost of maintaining a big network of multiple ledgers can be avoided using Blockchain and its one-single ledger to keep records all of the transactions across companies.
- Being distributed has one more benefits, increases the transaction speed. This affirmation is because it removes all the intermediaries, and everyone can audit and verify the information recorded on the Blockchain.

Disadvantages

- Usually, Blockchain networks are public, which provides a lack of security, when talking about a financial Blockchain public network, everyone will be able to see everybody's transaction and balance. It is safe to say that, there are also private Blockchains, that will be used for a process like supply chain.
- Public and private keys, similar to the username and passwords that most people use as identifiers in any other application. in Blockchain provides the user with the capacity to make transactions of any kind, depending on the type of Blockchain network that uses. Hence once it loses any of the two keys (public or private) it loses everything, and there is no way to recover it, and people will have to write down such practical information which reflects the security concerns in the industry.
- Even though decentralization is something why this technology excels, it may be one of the reasons because its adoption can take longer, due to no single organization has control over the Blockchain.
- The Blockchain network still has scalability issues; currently, the Bitcoin platform can support up to 7 transactions per second, this is way under the average amount of transaction the visa network is capable of handle per second.
- Trust is a big deal regarding transactions between parties; nevertheless, the uses of a Blockchain network are related to cryptocurrencies, and there is a lack of trust in people to use digital cash.
- Due to this is a new technology, people are trying to understand how it works, it uses and applications. Likewise, as financial-transaction services are the most common used by Blockchain networks, people are afraid of the ledgers being public.
- Regulation of governments and bank institutions with be an issue that will face the Blockchain technology along the way.
- Integration with existing and legacy systems are one of the critical points of the technology, especially for bank institutions, due to the cost of migration and replacing systems.

This technology still has a long way to go; most of its disadvantages are a result of the natural cause of the state of its development. Something particular about it, is the constant evolution due to its recent birth, it is immersing in an everyday creation environment, in terms of content, application, development, and researchers in order to determine more applicability and provide industries with a wide range of uses. However, the counterparty is its benefits, nobody planned for this technology to be so disruptive, even though, the direction is clear. Few people know in detail all about the technology, this is not a lethal threat to industries, but they need to know how to work with innovation and use it for growth.

There is one thing to keep in mind, right now we have a hype with this technology, that will continue maybe for the next decade, but, the real focus is on the strategic applications and uses that can contribute to real development. Here is to take an in-depth look at what is this technology has to offer and what is needed to adopt it.

5.1.5. Applications of Blockchain across industries

In Financial Services

A prime area for blockchain businesses is interfacing cryptocurrencies with traditional banking and financial markets. Venture capital-backed Ripple Labs is using blockchain technology to reinvent the banking ecosystem and allow traditional financial institutions to conduct their own business more efficiently. Ripple's payment network lets banks transfer funds and foreign exchange transactions directly between themselves without a third-party intermediary, as is now required: Regional banks can now move money bilaterally to other regional banks without having to relay those funds through an intermediary (Swan, 2015).

In Fundraising

The idea is that peer-to-peer fundraising models such as Kickstarter can supplant the need for traditional venture capital funding for startups. Where previously a centralized service like Kickstarter or Indiegogo was needed to enable a crowdfunding campaign, crowdfunding platforms powered by blockchain technology remove the need for an intermediary third party. Blockchain-based crowdfunding platforms make it possible for startups to raise funds by creating their digital currencies and selling "cryptographic shares" to early backers. Investors in a crowdfunding campaign receive tokens that represent shares of the startup they support (Swan, 2015).

With Smart contracts

Can be used to exchange anything of value, many of the industries utilizing blockchain technology will be using smart contracts, that, according to the Smart Contracts Alliance — In collaboration with Deloitte, Nick Szabo (2016) described a Smart Contract, as a digital set of promises, including protocols and conditions, that parties agreed and perform on those promises. When a smart contract is run on the blockchain, it operates automatically. If the conditions of a contract are met, payments or value is exchanged based on the terms of the contract. Likewise, if conditions in the contract are not met, payments may be withheld if written into the smart contract (Swan, 2015).

With the Internet of Things (IoT)

IoT, is a term used for a network of devices comprising refrigerators, security cameras, cars, planes, computers etc. has been around for a while under different forms and names (Intrinsic-Id, 2017). Currentrly, is an increasingly rate, becoming an accessible technology in both the consumer and the enterprise space. A vast majority of IoT platforms are based on a centralized model in which as broker or hub controls the interaction between devices. However, this approach has become impractical for many

scenarios in which devices need to exchange data between themselves autonomously. This specific requirement has led to efforts towards decentralized IoT platforms. The blockchain technology facilitates the implementation of decentralized IoT platforms such as secured and trusted data exchange as well as record keeping. In such an architecture, the blockchain serves as the general ledger, keeping a trusted record of all the messages exchanged between smart devices in a decentralized IoT topology (Crosby et al., 2015).

In Supply Chain

In a blockchain implementation, a blockchain based smart contract can trigger automatic value transfers based on conditions. Imagine a GPS tracker in a ship that triggers a payment that is instantly settled on a blockchain once the GPS location of the ship proves that the ship has reached the destination of the buyer (Hua & Notland, 2016, pp. 22, 23).

At this point it is important to mention a research conducted by (Wang, Han, & Beynon-Davies, 2019), during 2017 and 2018; where 29 articles out of 232, were identified related to supply chain, freight operations, warehousing, integrated logistics, retail/global/cross-border supply chain operations, humanitarian logistics, global trading including shippers and intermediaries; in order to assets the Blockchain state of art in supply chain process, distributed as shown in Table 3.

The findings for its use, taking into account the top 3 applied areas are: in the pharmaceutical industry, it proposes the use of Blockchain to monitor temperature and humidity over the transport of medical products, also discussed for security and anti-counterfeiting purposes, other authors suggest that Blockchain will enable advances in authentication and validation of supply chain information to audit processes likewise, it could have the potential to improve the traceability of a clinical trial supply chain and track patient responses. Another use would be, serializations of products and tracking of origin will be the significant value of pharmaceutical supply chains; in the Agri-food industry, it is suggested to decentralized traceability conceptual system based on IOTs, integrating RFID and blockchain technology to trace the origin of products across complex supply

chains. This blockchain system requires a transparent, tamper-proof metadata infrastructure that is also adaptable to changing environments and regulations.

In Manufacturing/physical distribution, it will enable hyper-levels of supply chain integration with end-to-end integration of product and process data, trace the sources of insecurity in supply chains and in handling crisis situations like product recalls that occur after safety and security vulnerabilities are found. It is proposed as a framework that supports supply chain visibility by using a hybrid (semi-open) P2P architecture, also for providing the cost-effective real-time tracking information of shipments to all stakeholders, others suggest to integrate blockchain into the choreography of processes in such a way that no central authority is needed, but trust maintained in a collaborative process execution. It can be used as a protection mechanism to prevent supply information stored on the ledger from being accessed by unauthorized participants;

In Global supply chains, it addresses the problems of double marginalization and information asymmetry in the supply chain, it can contribute to disintermediation and digitization of supply chain finance enabled by blockchain will enhance and increase the efficiency in cross border trade settlement, it also can help to end-to-end traceability and the encrypted inclusion of human beings to the supply chain audit is a significant value of blockchain, other application would be a single trusted source of data from blockchain will contribute to streamlined data sharing and dispute resolution.

Smart contracts will prevail in supporting supply chain collaboration, but several challenges need to be addressed, diversity and variation in country policies, product types, transport and tax rates; programming language, solution architectures, interoperability and verification process.

Table 3: Classification of Blockchain papers related supply chain

Applied areas	Number of paper
Advanced transport systems development	2
Agri-food industry	3
Construction industry	1
Electronics industry	1
Global supply chains	7
High value product supply chains	1
Manufacturing/physical distribution	5
Multiple sectors	1
Personal computer industry	1
Pharmaceutical industry	5
Pharmaceutical, gemstones, airline industries	1
Reverse logistics and product recycling	1
Total	**29**

Source: The authors, according the data provide by (Wang et al., 2019).

As a conclusion, this author belief Blockchain can influence future supply chain practices and policies, given the fact that, this technology is particularly interested in allowing organization and individuals to make transaction with the need of no third party.

5.1.6. The future of Blockchain

> "The technology most likely to change the next decade of business is not the social web, big data, the cloud, robotics, or even artificial intelligence. It's the blockchain."
> -Don Tapsott

Supply chain, as proposed in this research, may be one of the process that right now has more flexibility to adopt this technology. However, its application is currently under investigation by big tech companies which surely will integrate the Blockchain thorough the whole value chain of process, where companies will be able to transact one another

with a single shared ledger for all transactions, where the time and paperwork they are spending can be considerably reduced. As part of this evolution will come its integrations with the current system, in order not to make traumatic the adoption process, where the technology will run on a different technology layer than the ones we know now, which make it transparent for the final user.

On the other hand, this technology still has a long way to go, many obstacles to overcome and confidence to be a win. Entities and governments have to establish more regulation to help with its adoption and companies begin to move forward this technology; also, the infrastructure around Blockchain will shape the future of the technology in order to reduce its cost and fast adoption which eventually will help to include a shared ledger in our daily basis.

Here are some of the future industries the will include Blockchain as a foundation for its process: tracking taxes, regulatory entities will have the opportunity to know in real time every financial movement of everybody and to know in advance their patrimony. Online voting, due to its transparency is most likely the technology to look up for this ; Cloud Storage, information will be distributed in many servers connected to the network and still maintaining privacy of information; Digital identity, it will be possible to track the identity of a person since its birth, through every single document that relates to it (Icahn, 2017). Those are to make an example of the capacity of the technology and what is come shortly.

5.2. Supply chain

5.2.1. Context

Christopher (2011, p 13.) stated that supply chain objective refers to “processes and activities that produce value in the form of products and services in the hands of the ultimate consumer" this can be used as an objective of the supply chain management,

and for this research, added value is one of the most essential ingredients of the whole process. Currently, the general supply chain management process, no matter the perspective, offers no information to the final consumer. As seen in the definition above, the process foundation's relays on the communication and integration of a set of actors that manufacture or produce the good or service.

This particular definitions links with the justification of this investigation, due to the importance of providing valuable information to the final consumer and being an important piece of the chain. Also, it is essential to note the definition of the Council of Supply Chain Management professional (Council of Supply Chain Management Professionals, 2013), but mostly, this statement, - Starting with unprocessed raw materials and ending with the final customer using the finished goods, the supply chain links many companies together- our focus will be working specifically with the food industry, this is merely raw material, that needs to be transformed or processed in order to deliver a finished good to the final consumer. Between those actors raw material and final consumer, there are several other, some of those participants of the supply chain according to Hugos (Hugos, 2006) are (a) Producers or manufacturers, organizations that make a product. This can include transformation of raw material or the production of finished goods (b) Distributors, are mostly known as a wholesaler, (c) Retailers, manage stock inventory and sell in smaller quantities to the general public, (d) Customers or consumers, may be the final end user of a product who buys the product in order to consume it, (e) Service providers, these are organizations that provide services to producers, distributors, retailers, and customers.

Beside this participant this author, Hugo (Hugos, 2006) talks about a set of integrated processes that drive its direction within a company, this may change among industries, but for this purpose we are going to cover its generalities regarding (a) Production, refers to the capacity of a company to make and store products; (b) Inventory, this includes everything, from raw material to work in process to finished goods and it goes throughout the whole supply chain; Location, this is the geographical location of the supply chain facilities and the activities to be performed in each; Transportation, refers to the movement of the raw material to finished goods between facilities, also includes

different modes of transportation that interacts in the supply chain; and Information, is the base to make decisions regarding the other processes.

5.2.2. Types of Supply Chains

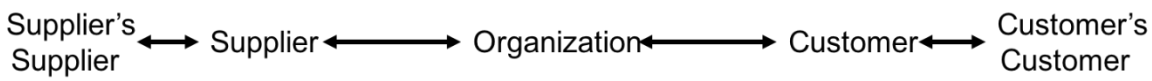
We can identify three degrees of supply chain complexity: (1) A direct supply chain (Figure 2), that consists of a company, a supplier, and a customer involved in the upstream and/or downstream flows of products, services, finances, and/or information.

Figure 2: Direct Supply Chain

Author: Self-made

(2) an extended supply chain (Figure 3) includes suppliers of the immediate supplier and customers of the immediate customer, all involved in the upstream and/or downstream flows of products, services, finances, and/or information.

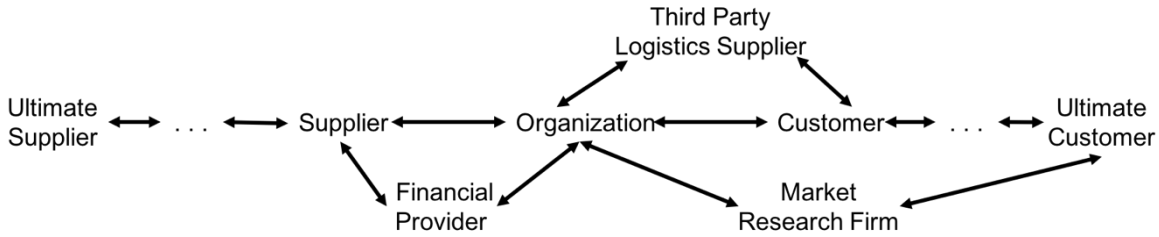
Figure 3: Extended Supply Chain



Author: Self-made

And finally (3), an ultimate supply chain (Figure 4) includes all the organizations involved in all the upstream and downstream flows of products, services, finances, and information from the ultimate supplier to ultimate customer (Mentzer et al., 2001).

Figure 4: Ultimate Supply Chain



Author: Self-made

5.2.3. Supply Chain in the Food Industry

The competitiveness of the food industry would thus be the ability to sell products that, on one hand, meet demand requirements (price, quality and quantity) and, at the same time, ensure profits over time that enable the companies to do well economically, develop their business and thrive (Turi, Goncalves, & Mocan, 2014, p. 134). Therefore, there is constant, the customer that demands better products due to its sophisticated taste this change necessarily obligate the industry to adapt very quickly to these changes and respond accordingly.

The structural adjustment of the food sector is therefore linked to consumer preferences, which have an increasing impact on the industry as a result of income developments, shifts in the population structure, and new lifestyles. Other essential impacts that influence the food sector are globalization, liberalization of world trade and agricultural markets and the emergence of new markets from Central and Eastern Europe to India and China. Finally, significant shifts and changes in technology, including information technology, have led to new products and methods to organize the supply chain (Turi et al., 2014).

For this research, we are going to concentrate our focus on the most critical challenges that can affect the supply chain in the food industry. For our purpose, these

are: Cold Chain, Hygienic safety of food depends mostly on the respect of the cold chain, throughout all stages of storage and transport between producer, carrier, distributor, and consumer; Traceability, is a crucial concern to all participants and stakeholders in the food chain and refers to the ability to trace, through all stages of production, processing and distribution, the path of a food product, a food feed, a food-producing animal or a substance to be incorporated or even possibly incorporated into a food product or a food feed. It can also provide support to public health and help authorities determine the causes of contamination or help the companies reassure customers and increase competitiveness on the market through sales and market share; And Quality, this is an essential concept in the food industry. The compliance certification attests that a non-alimentary and unprocessed food or agricultural product complies with specific characteristics or previously set rules concerning the production, packaging, or origin (Turi et al., 2014).

In Figure 5, it is shown, in general terms, for the food industry, its composition regarding actors: Suppliers, Farming, Processing, Distribution, Retail, Customer. The process here will be based on the ultimate supply chain process that in one end, has the farmer and at the other end, has the final consumer of the organic product. Moreover, across the process has a different figure that complements the chain.

Figure 5: Actors of the Agricultural Supply Chain

Source: Self-made.

Currently in the process, besides from the customer, each of the actors has its own ledger, where entries supply information for the business itself and its decision-making process; for example, a farmer, controls through a ledger all of the information regarding the

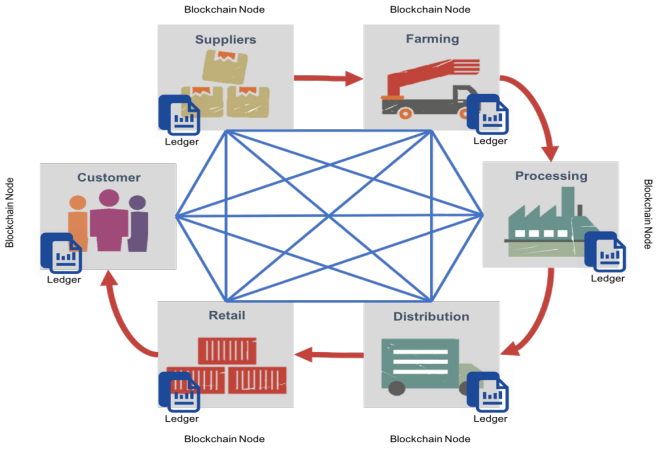
pesticides he uses, and entries the information by type of product, food lot, soil properties among any other information he may uses. However, nothing happens with this information besides being a record, in the best-case scenario, for future plantations.

Going through the complete process of the supply chain for the agricultural industry, the final actor (customer), will never know such information. As the product passes through different processes along the supply chain more and more attributes and characteristics it may receive; but, in the end, people rely on the information placed on a label, which basically includes minimum information requested by national authorities.

Also, the food industry as we know it right now, mostly for our agricultural target, is paper-based, processes are very manual, has a lot of administrative tasks involved in the process; also, there are many intermediaries in the supply chain process, all the data in this ecosystem is very limited to a group of actors or individual, but no-one has a complete understanding of the end-to-end process, this causes issues around the management of the whole process, the lack of information and misguided negotiations to name a few, and all of this because the information comes from different sources and formats causing misinterpretation of the data (“The food industry gets an upgrade with blockchain - IBM BLockchain: Blockchain Unleashed,” 2017).

Here is where the technology comes alive, Blockchain with its decentralized database can help us to take advantage of this gap in information management in the supply chain process and led us to a new horizon, where collaborative networks among actor in the agriculture supply chain process can interact and transact one another to provide every stakeholder with the precise information about the whole process, and this is possible due to every actor of the network will have its own copy of the ledger as soon as transactions are being validated and chained to the block, as shown in Figure 6.

Figure 6: How it will look at the supply chain for agriculture with Blockchain



Source: Self-made.

With this new technology contributing to the support of the supply chain process for this specific industry what is expected, it is to open up doors for new business opportunities. At this moment in history, we are disrupting into traditional processes and creating new platforms to manage businesses in a completely different way. There is no true at this point when it comes to Blockchain, there is an only expectation for what comes next, many types of research and center of investigation are point out at whatever new application for Blockchain may arise, furthermore with the investigation, in our country, in the industry, we are pioneers.

5.3. Organic Agriculture

The Research Institute of Organic Agriculture FiBL and IFOAM - Organics International (Willer, 2018), defines organic agriculture as a production system that sustains the health of the ecosystem as a whole, it also relies on ecological process, biodiversity and cycles adapted to local conditions; all of the above, promote right conditions for the environment and good quality of life for all involved. Other authors cited by (Sánchez Castañeda, 2017), defines organic agriculture as a production system that uses natural inputs and

particular practices, such as crop rotation, and prohibits the use of pesticides, synthetic fertilizers, and pesticides, medicines for use in animals, genetically modified seeds, as well as preservatives and additives.

In Colombia, since 2002, the term "ecological production system" has been established, although in general, the terms ecological, organic, or biological are synonymous (Rural, 2005).

According to (Sánchez Castañeda, 2017) whose research stated that, internationally, two sources of principles and requirements have been determined, which govern organic agriculture; one is proposed by the Codex Alimentarius for the production, processing, labeling and commercialization of organically produced food, stating that organic agriculture is a system of holistic production management that promotes and improves the health of the ecosystem, including biological cycles and the biological activity of the soil (Fao, 2013), which includes reducing the use of chemical elements such as fertilizers, fungicides, herbicides, insecticides or other types of substances of this type. The second source is proposed by the International Federation of Organic Agriculture Movements (IFOAM), where organic agriculture is an integrated approach based on a set of processes that results in a sustainable ecosystem, safe food, good nutrition, well-being animal and social justice (FAO, 2003).

In Colombia, the Ministerio de Agricultura y Desarrollo Rural introduces the - Reglamento para la producción primaria, procesamiento, empacado, etiquetado, almacenamiento, certificación, importación y comercialización de Productos Agropecuarios Ecológicos - which objective is to guarantee the sustainability and renewal of the natural base, to improve the quality of the environment through limitations in the use of technologies, fertilizers or pesticides, antibiotics and others of synthetic chemical origin, which may have harmful effects on the environment and human health. Table 4 shows a list of legislation that should be consider for organic / ecologic agriculture. In line with this, since 2004, the same office, created the - Sello de alimento ecologico - which aims to leverage the raising demand of the organic product. As of December 2018, in

Colombia, there are 102 ecological operators (MADR, 2016) and as of February 2019, 6 certification bodies (Minagricultura, 2017), distributed as shown in Table 5 and Table 6 respectively.

Table 4: Legislation of the sector

LEGISLATION	DESCRIPTION
DECRETO 3144 DE 2008	Requisitos Técnicos, Modifica Decreto 2269 de 1993
DECRETO 3075 DE 1997	B.P.M.
RESOLUCIÓN 0148 DE 2004 MADR	Sello Ecológico
RESOLUCIÓN 5109 DE 2005 MIN PROTECCIÓN	Etiquetado
RESOLUCIÓN 187 DE 2006 MADR	Sistema de Control Productos Agropecuarios Ecológicos
RESOLUCIÓN 036 DE 2007	Modifica Res.148 de 2004
REGLAMENTO PARA LA PRODUCCIÓN ORGÁNICA MADR	Reglamento Producción Orgánica
PROTOCOLO ELABORACIÓN ABONOS ORGÁNICOS – ICA	Abonos orgánicos fermentados líquidos para Producción Ecológica
RESOLUCIÓN 3888 DE 2015	regulación de semillas
RESOLUCIÓN 3168 de 2015 MODIFICA 2674 2013	regulación de semillas
RESOLUCIÓN 000199 de 2016	Regulación Semillas y otros

Source: Self-made

Table 5: Ecological operators by department

Department	No. Of Operator
Antioquia	6
Bogotá d.c.	19
Caldas	5
Cauca	5
Cesar	10
Cundinamarca	14
Magdalena	13
Nariño	3
Quindío	1
Santander	8
Tolima	4
Valle del cauca	13
Cúcuta	1

Source: Ministerio de Agricultura y Desarrollo Rural

Table 6: List of Certification Bodies accredited and authorized to certify under the Regulation for organic production adopted by Resolution 0187/2006, and authorized to administer the use of the Food Stamp

No.	Certification Body	Accreditation on ONAC	Product categories (Scope of Accreditation)	Authorization of the Competent Authority
1	BCS ÖKO GARANTIE COLOMBIA S.A.S	13-CPR-002	Non-processed agricultural products Non-processed livestock products; Processed products intended for human consumption	Resolution of the Ministry of Agriculture and Rural Development No. 438 of 2018
2	CERTIFICADORA BIOTRÓPICO S.A.S.	12-CPR-002	Agricultural Products Processed Agricultural Products	Resolution of the Ministry of Agriculture and Rural Development No. 442 of 2018
3	CERES CERTIFICATION OF ENVIRONMENTAL STANDARDS COLOMBIA S.A.S.	14-CPR-001	Organic Primary Products Ecological Primary Products Ecological ProductsProductos procesados destinados a la alimentación humana	Resolution of the Ministry of Agriculture and Rural Development No. 441 of 2018
4	CONTROL UNION PERÚ SUCURSAL COLOMBIA	15-CPR-005	Non-processed vegetable agricultural products; Processed products intended for human consumption	Resolution of the Ministry of Agriculture and Rural Development No. 440 of 2018
5	ECOCERT Colombia Ltda.	10-CPR-006	Primary Products Ecological Agricultural Primary Products Ecological Livestock Processed Products Ecological Agricultural Processed Products Livestock Ecological	Resolution of the Ministry of Agriculture and Rural Development No. 439 of 2018
6	MAYACERT S.A.S	18-CPR-001	Ecological Agricultural Primary Products Ecological Agricultural Processed Products	Resolution of the Ministry of Agriculture and Rural Development No. 23 of 2019

Source: Ministerio de Agricultura y Desarrollo Rural

5.4. Practical case of study using blockchain technology for supply chain transparency

In 2016, Walmart, the big retail store in the United States, partnered with IBM to explore business opportunities to improve the supply chain process through Blockchain technology. The experiment started with two products, one located in the US and the other in China. The objective was to know food traceability and authenticity; for this context, the product to track from Chine was pork meat (Koonce, 2017).

After all the effort in research, combining the power of Blockchain, using smart contracts and IoT, to track the entire supply chain, the use of this technology helped to reduce the time that usually takes to track food, from days to minutes, which also helped to provide faster responses to customers where tainted food is discovered. According to the site, blokchainlive (2017) Walmart stated that “this will help enable precise and rapid recalls to preserve consumer trust in the food industry, while increasing traceability and transparency of the food system”.

The whole process involved the end-to-end supply chain perspective, this means, from the farmer to the final costumer, this was possible thanks to the use of codes to add information to the food, along in the supply chain, all of the farmers, manufacturers, shipping companies, and all of the actor involved in the process knew in almost real time the information of each piece of pork-meat. And also through smart contract they were able to control the delivery dates and pay the provider as long as all of the clauses were met. There were control points to verify the estate of the food along the way that helped to minimize the risk of tainted food.

As we can see, the entire supply chain process, depending on the industry, will have its way to manage, and the proposal will be based on the requirements of the market, also, each endpoint of the supply chain and its intermediary process will have to be carefully analyzed in order to deliver the best solution for the process.

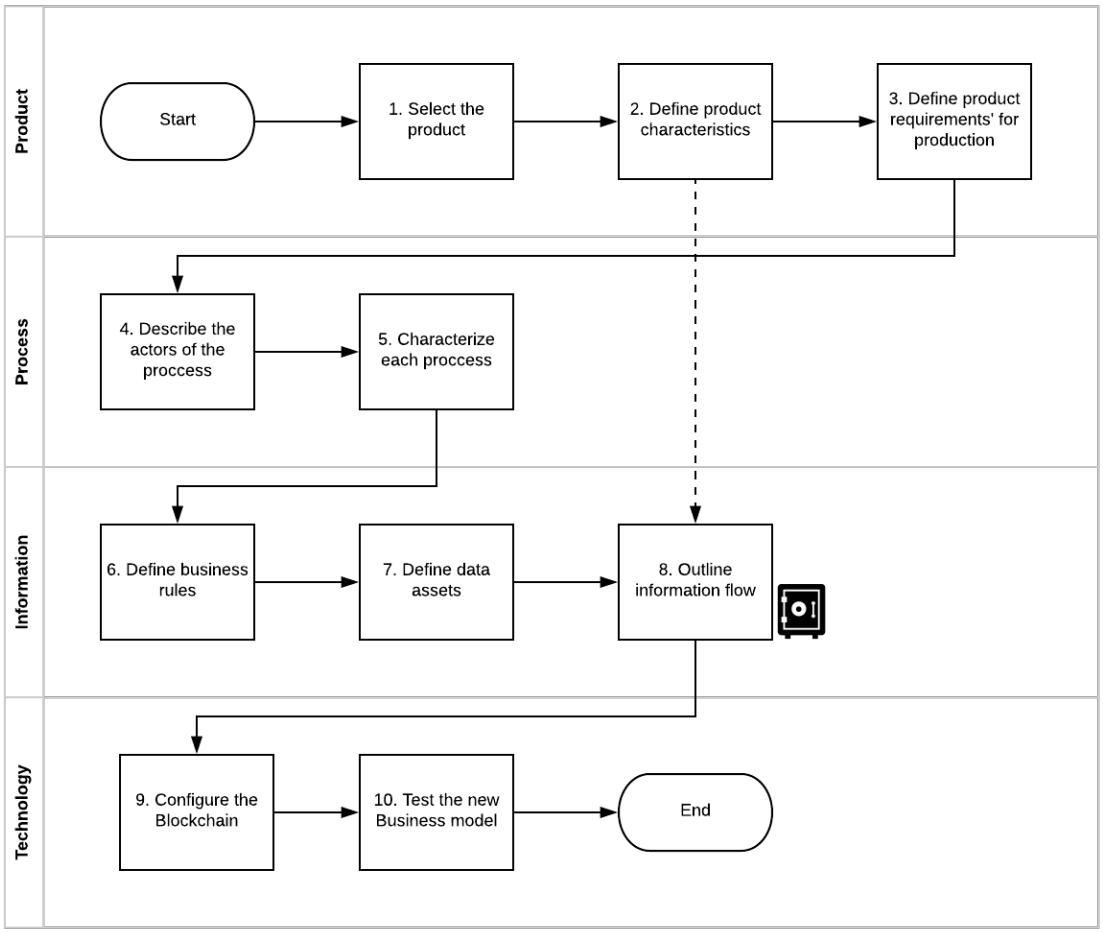
6. PROPOSE MODEL

For the integration between Blockchain and Supply chain, this research proposes to develop a methodological approach and a realistic view to understand the generalities of this methodology. In summary, Figure 7 shows four layers to understand the development of this methodology; The first one has to do with the product definition, where is important to gather as much as information about it, such as the characteristics and processes associated to its production. Then, we have the process, knowing the actors, and a detailed definition or characterization of the process to produce the product, according to the definition made earlier following these steps. After that, comes the information layer, where business rules, assets, and the information flow layout have to be defined; it's important to note that for this Data Flow Diagram (DFD) it is essential to consider the definitions made related to product characteristics, that is the information that will add more value to system. At last, the technology layer, which is where definitions are made about the platform to be used for the deployment of the Blockchain according to the process and the descriptions made.

As this methodological approach is presented, the author will showcase a practical use, for the Colombian coffee Supply Chain that will be explained accordingly in the following chapters.

This methodology was presented and validated by peers for ICCSA 2018: International Conference on Computational Science and Its Applications, it was published in Lecture Notes in Computer Science LNCS, Springer under the DOI https://doi.org/10.1007/978-3-319-95165-2_2, for detailed information see *Annex* 1.

Figure 7: Methodology summary for Blockchain applicability



Source: Self-made.

6.1. Characterization of the product and the supply chain

6.1.1. Select the product

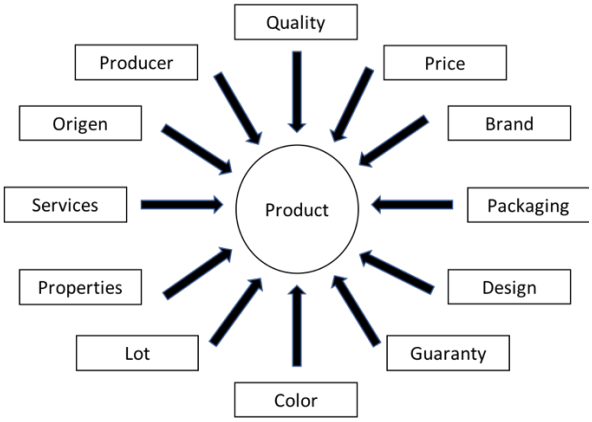
As simple as it may seem, the nature of the product to be selected will define in a significant proportion the scope of the architecture to be developed, at the level of understanding processes, operations and the different components that are part of the product's identity. At this point, it is recommended to know about the industry or productive sector of the product that is selected to work.

6.1.2. Define the characteristics of the product

A product is defined as a set of fundamental attributes united in an identifiable way (Stanton, Etzel, & Walker, 2007). Based on product design methodologies, in this stage, we seek to describe all the characteristics associated with the product selected, as shown in the Figure 8 The detail in the definition of these characteristics is important because the meaning of the supply chain and all the processes immersed in it, for the elaboration of this, will depend on them.

Behind this particular point, the experience of the author was based on describing the final product; ¿what do we what to see at the end of the process? That's a question that would help define characteristics, instead of describing every characteristic based on the process, it is recommended to visualize the final product and build from that, especially, because not all the characteristics will be worthy of tracking during the process, just the ones that will add value or the ones that are needed by law ar certification.

Figure 8: Product characteristics



Source: Self-made.

6.1.3. Establish the requirements for production

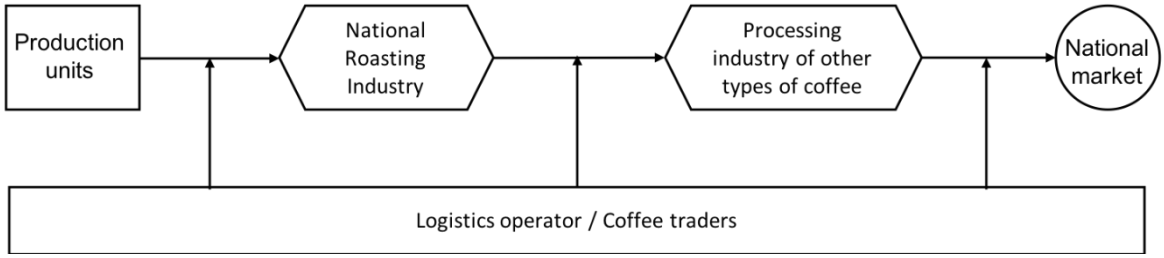
A fundamental part of the definitions to be made is to consider all the requirements that are necessary to obtain the product; these are technical, functional, legal, and regulatory. As a fundamental part of this implementation, that seeks to generate interaction among different parties, it is that the information for all processes, for everyone involved, is available.

For every product there is a process, those processes are regulated by different entities and has a specific requirement when talking about the food industry, there are many legal and sanitary entities that regulate its production; hence, it is important to validate these requirements. In Colombia, for example, we have several entities like, ICA (Instituto Colombiano Agropecuario), Ministerio de Agricultura, INVIMA (Instituto Nacional de Vigilancia de Médicamentos, SIC (Superintendencia de Industria y Comercio), ICONTEC (Instituto Colombiano de Normas Técnicas y Certificación), ISO (Organizacional Internacional de Normalización), among others. This topic is talking local, when the final product is for exportation, many other entities are valuable to look, in order to accomplish the requirements for productions, which may be significant depending on the objective of the project.

6.1.4. Define the actors of the process

It is necessary within the initial characterization made for the value chain, in this case, the supply chain, to identify the primary entities that generate or add value to the final product. These are original items in this definition because they are the locations where the information is born, where the processes and the central points for the interconnection of the processes are developed, see Figure *9*. For this research, the supply chain in the coffee industry was created, considering the most important actors (García Cáceres & Olaya Escobar, 2006).

Figure 9: Actors in the supply chain for the Colombian coffee industry.



Source: Self-made.

6.1.5. Define unit operations and processes

For each actor, there will be unitary operations and processes that will shape each one of the characteristics defined for the product. Knowing in detail what these are, the components of each one of them and the process that occurs in them will provide us with relevant and sufficient information to know what information should be extracted from that operation. These processes can be detailed thought a BDF (Block Diagram Flow) or BFPD (Block Flow Process Diagram) according to (Turton, Bailie, Whiting, & Shaeiwitz, 2005).

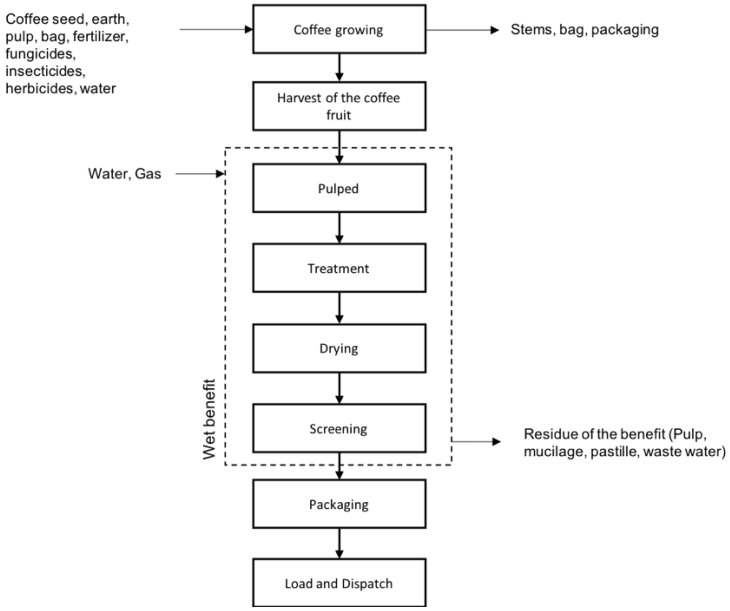
According to the research of (García & Olaya, 2006), agroindustry supply chain for coffee is composed of a series of processes that integrate its transformation process describes as follows.

Cultivation, the seeded grains that germinate as healthy plants are transferred to the nursery and reach a height of 60cm; they are cultivated in the plantation, where production starts from the first year. *Harvesting*, the coffee trees are reviewed again and again, collecting only the cherries that reach a reddish color, until all the fruits mature entirely. *Pulping*, separation of the skin and part of the pulp that covers the coffee bean. *Treatment*, the grains are treated by a method of cleaning based on water, which consists of removing the mucilage, making it soluble in cold water by fermentation; there is also the so-called dry method. At the end of the process, the grain takes the name of

parchment coffee. *Drying*, this is done in three steps, pre-drying (wet parchment coffee), sun drying (wet parchment) and machine (dry parchment), then the screening of the grains of higher quality, selection by size and quality; see Figure 10.

Distribution and storage, the grains are placed in burlap sacks and loaded in jeeps or mules, to take them from the farms to the collection center. In this, the buyer reviews the aroma, color, size, moisture, and texture of the beans. Only the best harvests are sold and distributed for export, and the rest is distributed for internal consumption.

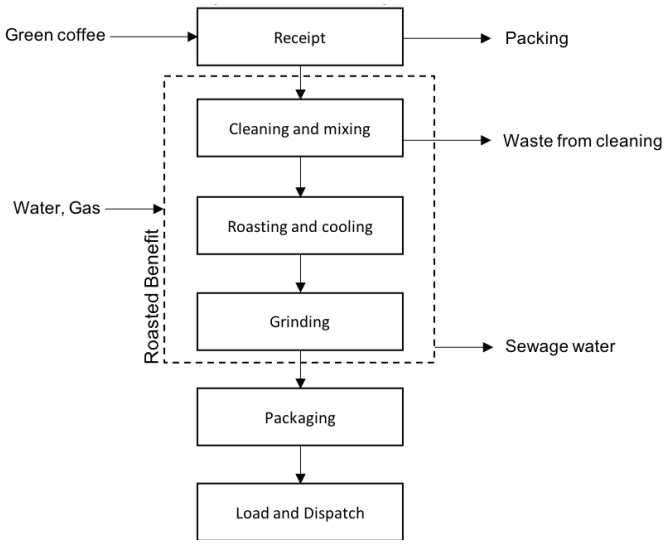
Figure 10: Stages of the process of coffee harvesting.



Source: Self-made.

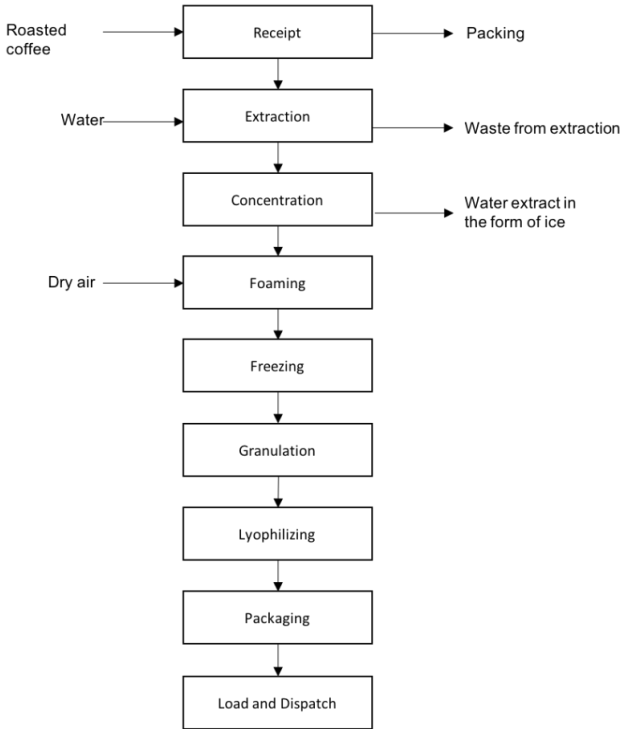
Torrefaction, the process by which the ordinary Green Coffee, by the appropriate action of the heat, takes dark coloration and the characteristic aroma. *Grinding*, crushing process of the grain, to give the characteristics of granulometry to the product. *Solubilization*, in the traditional process of soluble coffee, takes the liquid extract resulting from the percolation process and dries it with hot air at a very high temperature. *Lyophilization*, in the process, the water of the frozen substance is eliminated, skipping the passage through the liquid state; This way of drying coffee at shallow temperatures prevents deterioration due to overheating.

Figure 11: Stages of the production process of the roasting industry.



Source: Self-made.

Figure 12: Stages of the soluble coffee production process



Source: Self-made.

Packaging and distribution, stages of the process in which each marketer is responsible for giving the conditions of packaging, labeling, and distribution to ensure the preservation of product quality; see Figure 11 and Figure 12.

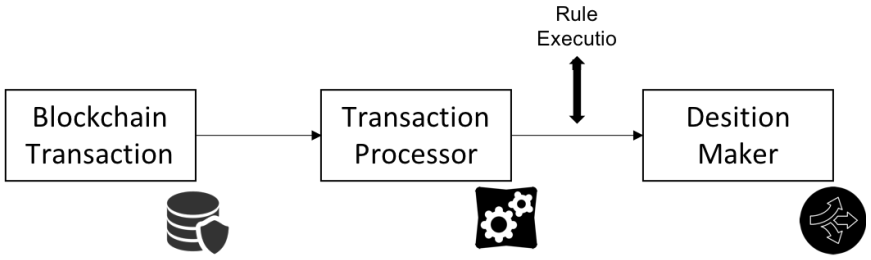
6.2. Definition of the Blockchain architecture to be implemented

6.2.1. Establish business rules

In a Blockchain, this will help to apply rules anytime to process a transaction. In this case, a transaction can be a purchase, a sale, a payment, even a control point along the process chain. As it is shown in

Figure *13*, once a transaction is stored in the Blockchain, a transaction processor will validate the rules for that specific transaction, and if applicable, it will decide what to do with it, depending on its configuration.

Figure 13: Business Rules Execution Process.



Source: Self-made.

The process also covers reviewing the rules, registering agreement between the parties, testing the rules on transaction data, simulating scenarios to understand their business impact, and storing them in a secure and transparent way. In addition, the same attention must be applied to data models and the business domain models they represent. The parties also must define how rules are governed: who can define rules, who can deploy rules, and the processes for changing rules (Mery & Selman, 2017).

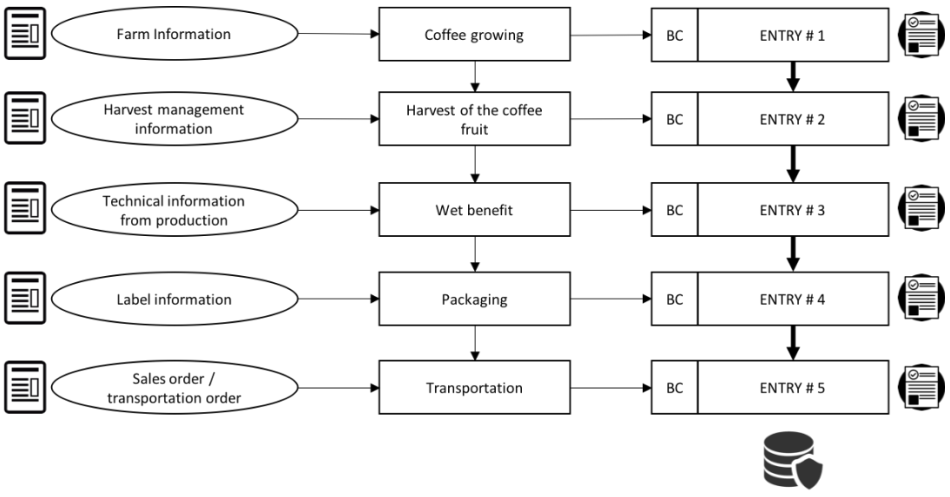
6.2.2. Define digital assets

Digital asset is a floating claim of a particular service or good ensured by the asset issuer, which is not linked to a particular account and is governed using computer technologies and the Internet, including asset issuance, the claim of ownership, and transfer (Group, 2016). That being said, a Digital asset, for this particular case, are the documents that will allow the transaction to be valid. For each process in the supply chain, there will be several assets that are going to be needed to make this a successful process; however, it will depend on the number of transactions required for the specific system.

6.2.3. Perform information flows

Using Data Flow Diagram (Tao & Kung, 1991) will help you to understand how the information interacts across processes. For this, it is necessary to have an accurate definition of the assets and the data involved in each process. This will create the transactions on the Blockchain, as shown in Figure 14, where we have the information defined, the process where that information is processed, and the outcome for the Blockchain.

Figure 14: Productive units information flow chart.



Source: Self-made.

6.3. Technological implementation (Hyperledger)

6.3.1. Configure the Blockchain

First of all, it is imperative to define what kind of Blockchain to need and its technological architecture as defined by (Wu et al., 2017). For example, a private Blockchain will only allow a few nodes connected to the network to transact with the information and use the ledger, in this kind of networks participant are very limited on what they can do, unlike a public Blockchain, that allows anyone to see or send transactions and actively participate in the process (Lai & LEE Kuo Chuen, 2018; O'Leary, 2017).

Then, it is necessary to select the most suitable consensus mechanism for the specific scenario, some of them are, proof of work (Satoshi Nakamoto, 2008), proof of stake (Siim, n.d.), proof of activity (Bentov, Lee, Mizrahi, & Rosenfeld, 2014), proof of luck (Milutinovic, He, Wu, & Kanwal, 2017), among others. This should be chosen in conjunction with the Blockchain application to be used in the network; there are many of them out there.

In Table 7 are shown some examples of the most popular Blockchain applications; according to the authors' experience, here are some of the parameters to take into consideration to validate which platform suits your business model the best: (a) Maturity, this refers to how long this platform has been in the market, its support model and documentation, (b) Easy of development, depending on your development skills, this point is of importance to consider, (c) Confirmation time, this will much depend on the consensus mechanism, this is why these two must be evaluated together, and (d) Privacy between nodes, as explained before some platform will allow you to configure public or private networks, this is according to the specific type of network for your business model. The parameters that need to be configured will vary depending on the platform, some of them can be changed during run-time, but some cannot, this is a very crucial step during configuration.

Table 7: Blockchain applications

Name	Application	Smart Contract Execution	Smart Contract Language	Consensus
BigChainDB (https://www.bigchaindb.com/)	Blockchain Database	N/A	N/A	Federated voting
Corda (https://www.corda.net/)	Smart contract	JVM	Kotlin, Java	Pluggable (RAFT, BFT, etc.)
Dfinity (https://dfinity.network/)	Smart contract	EVM	Solidity, Serpent, LLL	'Blockchain Nervous System' - Randomised POS
Monax (https://monax.io/)	Smart contract	EVM	Solidity	Tendermint (BFT)
Ethereum (https://www.ethereum.org/)	Smart contract, Cryptocurrency	EVM	Solidity	Ethash (PoW)
Hyperledger Fabric (https://hyperledger-fabric.readthedocs.io/en/latest/)	Smart contract	Dockers	Golang, Java	Pluggable (default PBFT)
MultiChain (https://www.multichain.com/)	Digital tokens	-	-	Randomised round- robin (mining diversity)
Ripple (https://ripple.com/)	Smart contract	-	-	Ripple Consensus Ledger (PoS)
Hyperledger Sawtooth (https://intelledger.github.io/)	Smart contract	TEE	Python	Proof of Elapsed Time
Stellar (https://www.stellar.org/)	Smart contract	Dockers	JavaScript, Golang, Java, Ruby, Phython, C#	Stellar Consensus Protocol
Tezos (https://www.tezos.com/)	Smart contract	Dockers	Tezos Contract, Script Language	Proof of Stake

Source: taken from Blockchain for Agriculture and Food, Findings from the pilot study (Ge, Brewster, Spek, Smeenk, & Top, 2017).

The last two steps during configuration are, user interface design, it is important to define the front end design and to choose the programming language, and APIs (Application Programming Interface) building, this is an interface to a software component that can be

invoked at a distance over a communications network using standards-based technologies (RED HAT, n.d.); some of the Blockchain platforms come with pre-built APIs but, mainly, the categories of APIs you would need are for: Generating key pairs and addresses, Performing audit related functions, Data authentication through digital signatures and hashes, Data storage and retrieval, Smart-asset life-cycle management issuance, payment, exchange, escrow and retirement and Smart contracts (Rohas Nagpal, n.d.).

Once the Blockchain platform is configured, the application (user front end) is designed and ready, it is time to integrate both with the APIs, to have the data flowing to one another.

6.3.2. Validation of the model

Based on the objective of the project and the definition made for the Blockchain system, it is recommended before going live to define a set of tests. It should include, unit tests, to ensure each component of the complete architecture is working as expected; and integrated tests, to verify the flow along with the Blockchain architecture. It is essential to consider for these test scenarios, definitions such: participants, permissions, assets and transactions and the outcome expected for each one of those tests.

This study case was presented for peers evaluation, at the Second International Conference on Applied Informatics (ICAI) 7th to 9th November 2019, Madrid, Spain For detailed information on the paper, see *Annex 4*.

7. CASE STUDY: ORGANIC COFFEE

Personal care and health have become imperative among generations; this is what (Di Giammarco & Marinelli, 2019) and (Nielsen Holdings plc, 2016) shows in its study, We are what we eat and what is in our food and on our mind respectively. In this growing market, the proliferation of training centers, gyms, bicycle use and above all, improving eating habits; people are more concerned about knowing what kind of food they include in their diets, what nutrients they have, where they come from, how there were cultivated, how their selection has been made, among others questions regarding its origins. But sadly, there are some questions that, in most cases, are left unanswered, and there is nothing more than trust in the goodwill and response of those who place it at our disposal, whether on a shelf or in a restaurant. Being aware of what we buy and eat favors proper nutrition, as well as the care and maintenance of our health. It is very important to identify nutritional information, ingredients and other recommendations when buying packaged foods (Abreu et al., 2014) With that being said; we must point out that customers have never been able to know in detail the characteristics, attributes and valuable information about the food they are purchasing. In Colombia, according to (Ministerio de la Protección Social, 2006), the following information is currently necessary for the labeling of food:

- Name of the food
- List of ingredients
- Net content and drained weight
- Name or business name and address of the manufacturer
- Lot identification
- Date of expiration and date of minimum duration
- Instructions for use
- Sanitary registration

However, none of the above presented, actually provide information about the different stages and processes to which organics food products are subjected from their harvesting throughout the supply chain to the final consumer.

According to World Health Organization (2015), “People are now consuming more foods high in energy, fats, free sugars or salt/sodium, and many do not eat enough fruit, vegetables and dietary fiber such as whole grains”. Just as the Blockchain technology is transforming the way we carry out transactions, it will do so with many other industries, including the organic food industry by allowing people to actually know the origin and traceability (along the process) of what they are eating. With the growing demand in the fitness market, in line with (The Nielsen Company, 2015) and (Around & World, 2016), over the two-year period demand of organics productus has grown arount 24%; with this information, we can appreciate how important it has become for people to change their eating habits; specifically, in Colombia, people tend to look for food with local ingredients, natural and organic alternatives1 which makes us think about the current state of the transformation process that experience food across the value chain, since its plantation until its placement on a supermarket shelf.

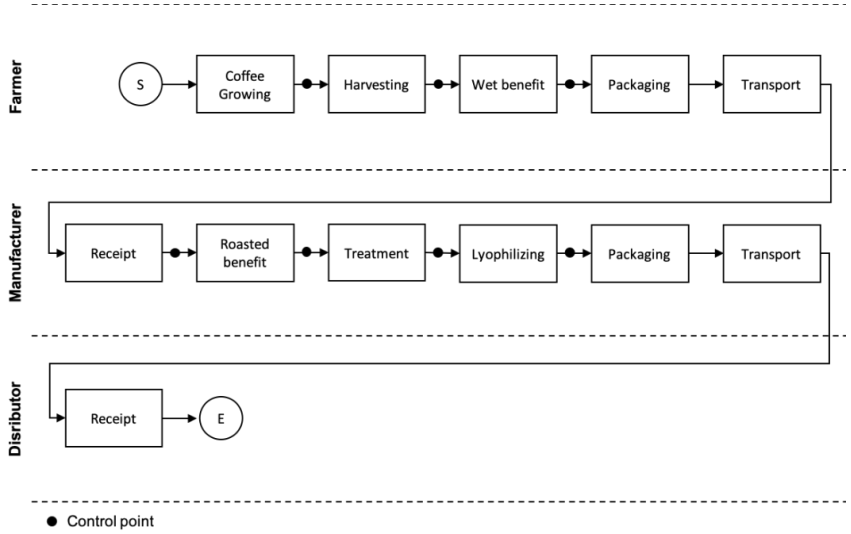
7.1. Implementation of the business network

In order to validate the methodology prior explained, we have used the online software Hyperledger composer provided freely by IBM following the next URL: https://composer-playground.mybluemix.net/.

7.1.1. Define Unit Operations and Processes

In Figure 15: General Coffee Production Process (study case) is shown the general process for the coffee production, as well as the main participants of the process chain (García Cáceres & Olaya Escobar, 2006).

Figure 15: General Coffee Production Process (study case)

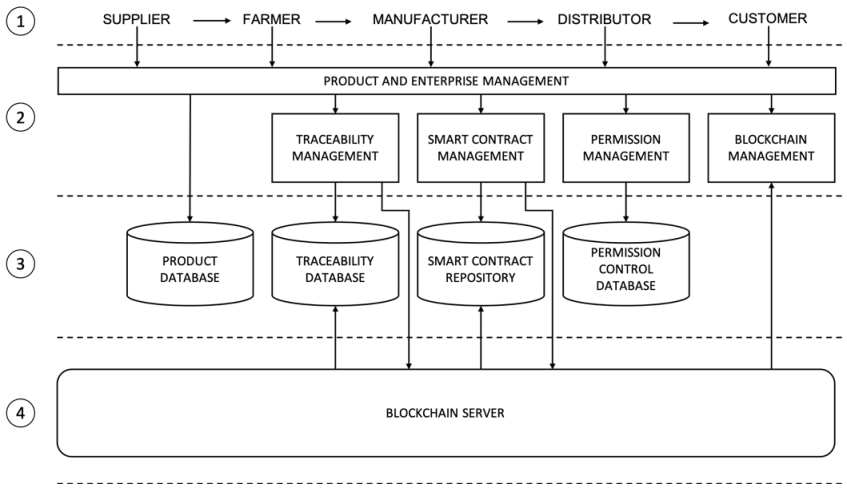


Source: Self-made.

7.1.2. Define the software architecture for the business network

See figure 2: Based on the proposal architecture for originChain (Lu & Xu, 2017), this proposal is considered to use a similar one in order to accomplish the traceability of the product.

Figure 16: Business Network Proposed Architecture



Source: Self-made.

a) The first layer of the architecture defines the life cycle of the product; this takes into consideration the upstream and downstream process of the supply chain.
b) The layer number two will be considered the application end for the user; this can be an ERP, a BPMN, or any other software able to manage this process.
c) Then, there is a third layer, this a relational database, that will host all the information and transaction generated across the business network. It will manage the product information, the tractability database as a master for all transactions.
d) And finally, there is the fourth layer or the Blockchain layer; this server will store all the transactions defined to safeguard the origin traceability of the product.

7.1.3. Name the new business network

(See, Annex 1: Business network Configuration): E.g. Organic Colombian Coffee Origin Traceability, this network tracks the supply chain from upstream to downstream processes, from raw material to finished products, which will provide the final customer with information about its origin. A regulator can provide oversight throughout this whole process. The business network defines:

a) Participants: Farmer, Manufacturer, Distributor, Regulator, Farm, Factory
b) Assets: Coffee, Order
c) Transactions: CoffeeMovements, CoffeeMovementArrival, CoffeeMovementDeparture, PlaceOrder
d) Events: PlaceOrderEvent, UpdateOrderEvent, CoffeeMovementEvent

7.1.4. Deploy

7.1.5. Connect the new business network

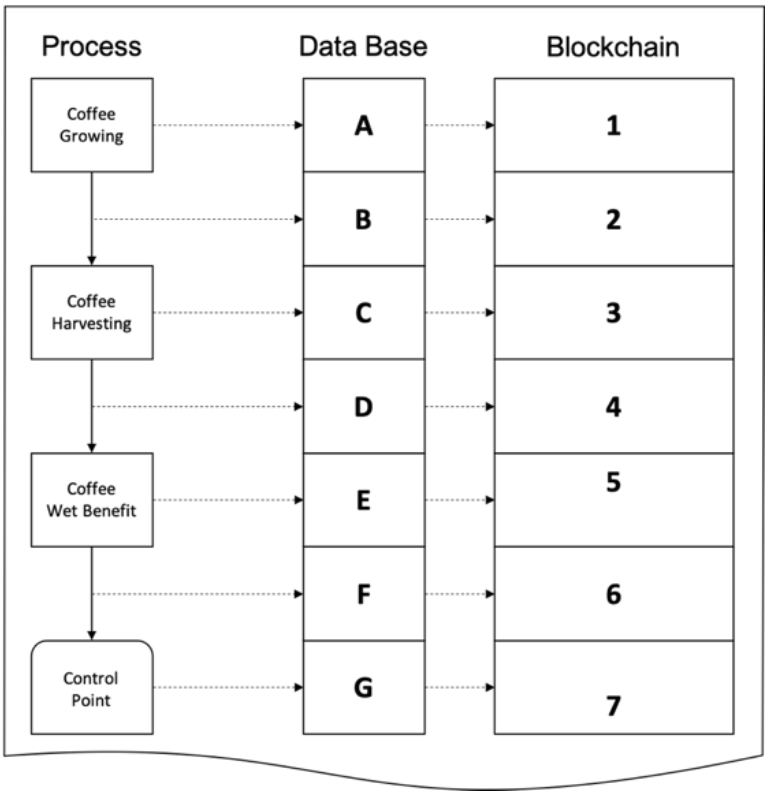
7.1.6. Generate the files and scripts for the business network

a) Generate the model files: This will define assets, participants, transactions and events on our business network.
b) Create the script to manage transactions, as they were defined above.
c) Create the script to manage secure access to the network

7.2. Results

While validating the model, it was determined that the assets that travel along the production process, in the first instance, have the information, data, technical data that should be treated in a relational database, allowing, from the user interface (UI), to generate all types of transactions.

Figure 17: Data Base and Blockchain process storage



Source: Self-made.

Once this information is stored in the business network (Blockchain), which is done through the use of smart contracts, which will have encoded the transactions that go to the Blockchain (this is done from layer 2 of the proposed architecture see Figure 16). Whenever these transactions, such as the generation of an order, the movement from one process to another, change of custody between the participants, among others, have been stored into the Blockchain, it generates a unique and immutable record which will be the basis to generate the product traceability of origin. Likewise, with the assets

defined in the case study it guarantees, on the one hand, to have control of the attributes that are part of the leading asset coffee and, on the other hand, the control through the order everything that happens with the coffee; for example, the changes that the coffee has along the processes, the new attributes that are gained or lost, the movements that are made with it, the events that are triggered throughout the process and the custody that is generated, allowing the construction of the - coffee - traceability of origin.

This is how the While validating the model, it was determined that the assets that travel along the production process, in the first instance, have the information, data, technical data that should be treated in a relational database, allowing, from the user interface (UI), to generate all types of transactions. *Figure 17* shows that the processes and movements between them, send information to a database from which transactions are generated, and once they are validated by the smart contracts capability, they will be stored in the Blockchain.

An example is shown in the following transaction Submit a Transaction - Transaction Type: PlaceOrder, in which, for the first time an order is being generated to obtain a wet benefit, which is the final product, in a series of processes, within the productive unit (farm). This order is made on a specific lot to be cultivated, identified as 5128, whose transaction is generated by the participant - farmer - and is in turn assigned to a - regulator -, in order to validate the veracity of the information. That transaction can be observed in the ledger of the transaction, see Ledger of transactions - Order Placed, with a transactionID and a specific timestamp.

With these records, we generate the validation and traceability of the origin of the final product that was born from lot 5128 and whose movements will be recorded as shown in While validating the model, it was determined that the assets that travel along the production process, in the first instance, have the information, data, technical data that should be treated in a relational database, allowing, from the user interface (UI), to generate all types of transactions.

Figure 17, where we have the process as it happens. In this example, at the productive unit (farm); form each process, there is a transaction that is stored in a Data Base. Transactions A to G, will have information regarding process, for this example, the coffee growing process attributes such as, Farm ID, Farmer ID, Fertilized used for the process, Pest Control assignation, Seed type, Seed Color, Seed Sized, Lot Number and Order Number; this transactions will go straight to the Blockchain, as it is shown in While validating the model, it was determined that the assets that travel along the production process, in the first instance, have the information, data, technical data that should be treated in a relational database, allowing, from the user interface (UI), to generate all types of transactions. In the sequence of number (1 to 7), after a smart contract has verified its validity, and it will create the following transactions, Place Order, e.g. see figure 4, this transaction will be storage on the blockchain with a transaction ID and TimeStamp as shown in figure 5, Make wet benefit, Update Order Coffee Growing, Event Place Order make wet coffee, Event Update Order Coffee Growing. This means that, for every transaction created on the business network, there will be a log on the ledger with all those records.

Figure 18: Submit a transaction, transaction type: PlaceOrder


```
{
"$class":"org.example.scpcoffee.farmer.placeorder",
"orderID":"1234",
"coffeedetails":{
"$class":"org.example.scpcoffee.coffeedetails"
"make":"WET_BENEFIT",
"lotID":5128",
}
"manufacturer:
"resource":"org.example.scpcoffee.farmer.farmer#4578",
"orderer":
"resource":"org.example.scpcoffee.regulator#2382"
}
```


Source: Self-made.

Figure 19: Ledger of transactions, transaction type: PlaceOrder


```
{
"$class":"org.example.scpcoffee.farmer.placeorder",
"orderID":"1234",
"coffeedetails":{
"$class":"org.example.scpcoffee.coffeedetails"
"make":"WET_BENEFIT",
"lotID":5128",
}
"manufacturer:
"resource":"org.example.scpcoffee.farmer.farmer#4578",
"orderer":
"resource":"org.example.scpcoffee.regulator#2382"
"transactionID":"591b6ad6-5bac-4a8d-bb29-a8e15fd774c2",
"timestamp":"2019-02-24T17:50:59.125z"
}
```


Source: Self-made.

7.3. Analysis

a) It is necessary, in the architecture of the business network, to have a relational database that allows storing all the transactions in a traceability repository (as shown in figure 2), to validate the transactions against the information stored in the Blockchain

b) The checkpoints of the model allow to generate audits by a *regulator*, as it is called in this case study because the information manipulated through the entire process must be entered by the different *participants*; even with this technology, the data is not exempt from manipulation before its registration.

c) In order to minimize the risks of altering the information, it is recommended to automate the entire process from start to finish. This will help to have the information from the source, which can be sensors, meters or other Internet of Things (IoT) components that allow the reading of data, considering the scope of a project of this type; however, is essential to consider the limitations for such integration (Reyna, Martín, Chen, Soler, & Díaz, 2018). This information entry would be connected to layer 2 of the proposed architecture, replacing the manual

entries of information. These records would be limited only to entries that affect the administration and the traceability database.

d) To guarantee the traceability of the transactions associated with a particular lot or product, it is recommended to integrate all the participants of the chain. This generates integrity in the information and greater confidence in the data. This particular is of more significant impact because any participant outside of the business network directly affects the confidence of the information and therefore, the final consumer.

e) Based on the model described by (Bettín-Díaz, Rojas, & Mejía-Moncayo, 2018), the steps 1 to 6 mentioned in their methodology, are considered highly important within the definitions to be made; Knowing the product, its characteristics, the production process, the requirements of the process and its participants, these are the main inputs for the definition of the business network. The business rules defined in the initial model can be considered from now on the *transactions* to be carried out by the participants of the network, which are made upon assets. The latter is considered a fundamental piece that must be traceable throughout the process. For this case, the study had two main assets, the coffee as the protagonist of the process and the order that, throughout the process, information is fed to generate the traceability of the product. Finally, there is the information flow; it is an exercise that is not required for the process, it can complement the understanding of the business network; This will depend to a great extent on the transactions that are made and who makes them.

8. CONCLUSIONS

Blockchain technology may have the capacity to revolutionize businesses through a more transparent, secure, and decentralize system, by generating trust among participants. With this research arose the potential and opportunity to develop a methodology to integrate this technology with the processes along the supply chain that would help, in this case, provide the ultimate customer with the tools to make an informed purchase decision. As a result, the authors propose a step by step methodology that it is easy to follow and implement for any product, and it is scalable for other processes different from the supply chain; due to the central principle of its developments, which is to validate various elements that will add value to meet the objectives of the project.

Based on this methodological approach, the authors adopted the best marketing practices regarding product development; process engineering, which helps to understand the life cycle of the product along the entire supply chain, from raw material to finished products. Finally, the technology itself, which is not the purpose of this document; however, a first guide is presented to develop a project from start to finish. It should be noted that anyone who wants to apply this methodology must have the knowledge related to the industry, the processes involved and the product to know what the result of this exercise will concern information that will travel to the Blockchain. The authors know the application of this technology has some specific requirement regarding the socio-cultural environment, such as IT infrastructure, which can be difficult for some of the participants; but this obstacle needs to be overcome with governmental policies and education, which is not in the context of this article.

Additionally, during the research process, the authors have envisioned different applications for this methodology, that can be used to design a certification system based on Blockchain, by automatically gathering required information across the process which will make it easy to audit and track for all participants involved. This scenario will use a centralized network to safeguard the information, which is controlled by a certification authority.

Finally, this is one of the many other methodologies that can be used to adopt Blockchain into a process, either financial, logistics, or any other of the value chain. However, due to the infancy of technology is not easy to get there and find the perfect way to do it. The authors will continue investigating and improving this approach as technology evolves.

Through the application and implementation of this model, for the creation of a business network based on Blockchain, it is feasible to obtain the traceability of origin for a product. Our case study refers to organic products, but, without a doubt, this same methodology can be homologated to any product, as long as the use of Blockchain technology generates value to the process.

It is important to note, that Blockchain as a technology, provides support to the process, to ensure that the information has not been altered and is trusted, with the objective of providing information to the end user of the value chain; however, these information sources cannot be susceptible to manipulation before being stored in a Blockchain. That is why, based on the validation of this model implementation, it is recommended to have a robust technological infrastructure that allows to complement and harmonize the different sources of information that, through the transactions, will take the data to the Blockchain.

In accordance with the above, for the Colombian market, in terms of production of organic coffee, this represents an important cultural challenge; initially, because the processes in coffee farms are carried out mostly manually, it must also be taken into account that automation is an important part of the adoption process of Blockchain technology; Another important point is the reference made to the integration of the participants of the chain, where, currently, each of them has its own repositories of information, which can be manual or digital, their own internal information systems for the control of their processes, which makes it difficult to have information integrity and therefore carry out the origin traceability process.

9. WORK RELATED

During the development of this research, author identifies different applications of Blockchain technology outside the supply chain process and proposed a software architecture to implement Blockchain technology to support ISO 9001:2015 certification.

During the last decades quality has had an essential role in companies, moreover, certifications that guarantee, in fact, the uses of best practices in processes that have been used to generate and deliver a good or service. Nowadays, there are software and tools that help companies to achieve these certifications, most knows as BPMN, that works hand in hand with certification entities as an intermediary. These software solutions are often offered and administered by third parties; however, it is difficult to trust the information due to the database architecture used to manage the information and data needed for the certification process. This work aims to propose a software architecture that supports an ISO 9001:2015 certification process, by taking advantage of the properties, such as immutability that blockchain has to offer in order to guarantee the transparency of the system and facilitate the audit process. For more detailed information on how this will work, see Annex 5: Design of a software architecture for a Blockchain-based quality certification system, was presented for peers evaluation, at the Second International Conference on Applied Informatics (ICAI) 7th to 9th November 2019, Madrid, Spain.

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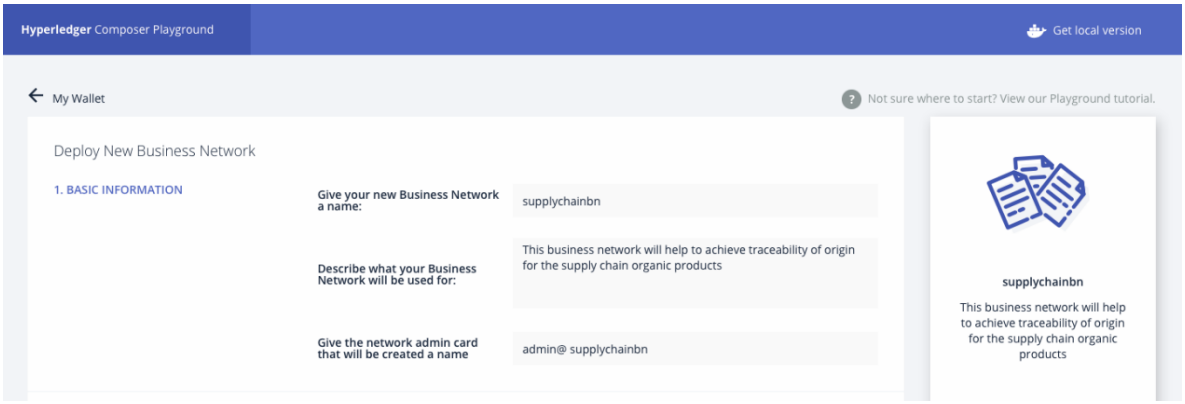
11. ANEEXES

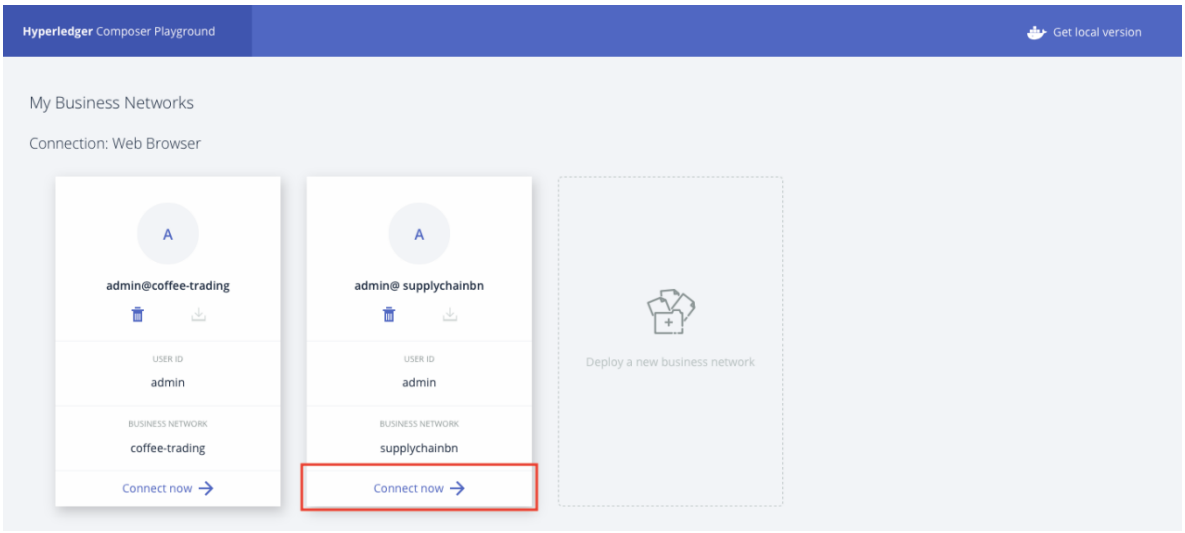
Annex 1: Business network Configuration

Here is described the steps to configure the business network and some examples of the code used for this objective.

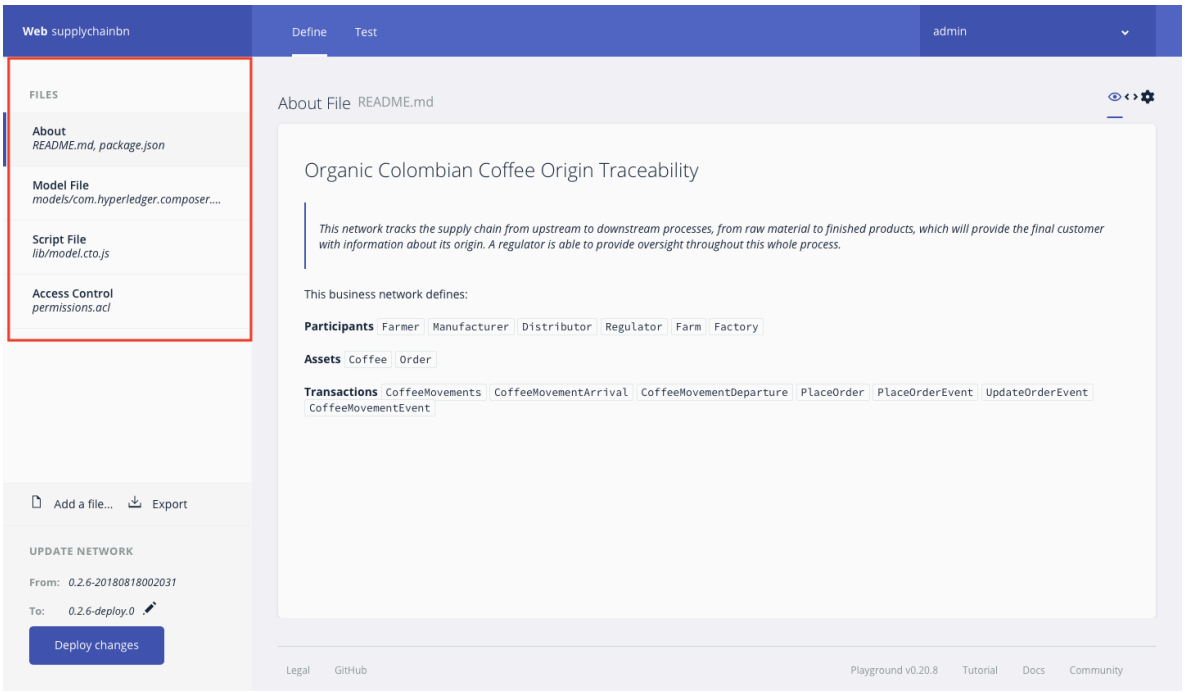
1. Name and describe the new business network



2. Connect the business network



3. Generate the files and scripts for the business network



4. Examples of the code generated for the business network

4.1. Defining Assets for the business network

namespace org.example.scpcoffee
asset commodity identified by tradingsymbol{
String tradingsymbol = "coffee"
String LoteID
String SeedID
String Color
--> farmer owner
}

4.2. Types of coffee to transact with

enum coffee type{
o COFFEE_SEED

o COFFEE_FRUIT
o COFFEE_WET_BENEFIT
o COFFEE_ROASTED
o COFFEE_TREATED
o COFFEE_LYOPHILIZED
o COFFEE_CAN
}

4.3. Type of movements

enum CoffeeMovements type{
o IN_FARM
o IN_FACTORY
o IN_TRANSIT
o IN_MARKET
}

4.4. Type of production associated with the *coffee*

enum Order type{
o COFFEE_GROWING
o COFFEE_HARVESTING
o COFFEE_WET_BENEFIT
o COFFEE_PACKAGING
o COFFEE_ROASTED_BENEFIT
o COFFEE_TREATMENT
o COFFEE_LYOPHILIZING
o COFEE_LOTING
}

4.5. Defining a participant for the business netwotk

participant farmer identifies by farmerID{
String tradeID
String firstname
String lastname
}
transaction trade{
--> commodity commodity
--> trader newowner
}

4.6. Defining a transaction for the types of production

abstract trasaction Order{
o String[ ] logs optional
--> coffee coofee
--> Order from
--> Order to
}

4.7. Create the script to process the transaction

```
async function tradecommodity(trade) {
trade commodity.owner = trade.newowner;
let assetregistry = await
getAssetRegistry('org.example.scpcoffee');
await assetRegistry.update(trade.commodity);
}
```

5. Example of the code generated to test the model

5.1. Create new Participant: In Registry: org.example.scpcoffee.farmer

{
"$class":"org.example.scpcoffee.farmer,
"tradeId":"105492",
"firstname":"Jhon",
"lastname":Vail",
}

5.2. Create New Asset: In Registry: org.example.scpcoffee.coffee

{
"$class":"org.example.scpcoffee.coffee,
"lotID":"4528",
"SeedID":"CD001",
"Color":"lbrown",
}

5.3. Submit a Transaction - Transaction Type: PlaceOrder

{
"$class":"org.example.scpcoffee.manufacturer.placeorder",
"orderID":"1234",
"coffeedetails":{
"$class":"org.example.scpcoffee.coffeedetails"
"make":"COFFEE_ROASTED",
"lotID":5128",
}
"manufacturer:
"resource":"org.example.scpcoffee.manufacturer.manufacturer#4578",
"orderer":
"resource":"org.example.scpcoffee.regulator#2382"

}

5.4. Submit a Transaction - Transaction Type: CoffeeMovement

{
"$class": "org.example.scpcoffee.CoffeeMovement",
"fromPlaceOrder": "resource:org.example.scpcoffee.PlaceOrder#1234",
"Coffee": "resource:org.example.scpcoffee.Coffee#4528",
"from": "resource:org.example.scpcoffee.Orde#COFFEE_GROWING",
"to": "resource:org.example.scpcoffee.Order#COFFEE_HARVESTING",
}

6. Example of the code placed on the ledger of transaction

6.1. Participant Added

{
"$class":"org.hyperledger.composer.system.AddParticipant",
"resource":[
{
"$class":"org.example.scpcoffee.farmer",
"tradeID":105492",
"firstname":"Jhon",
"lastname":"Viel",
}
]
"targetregistry":
"resource:org.hyperledger.composer.system.ParticipantRegistry
#org.axample.scpcoffee.farmer",
"transactionID":"8ad8d2d0-cc13-4f28-af07-50c4c45641d9",
"timestamp":"2019-02-24T17:18:13.822z"

}

6.2. Order Placed

{
"$class":"org.example.scpcoffee.manufacturer.placeorder",
"orderID":"1234",
"coffeedetails":{
"$class":"org.example.scpcoffee.coffeedetails"
"make":"COFFEE_ROASTED",
"lotID":5128",
}
"manufacturer:
"resource":"org.example.scpcoffee.manufacturer.manufacturer#4578",
"orderer":
"resource":"org.example.scpcoffee.regulator#2382"
"transactionID":"591b6ad6-5bac-4a8d-bb29-a8e15fd774c2",
"timestamp":"2019-02-24T17:50:59.125z"
}

6.3. Order Placed Event

{
"$class":"org.example.scpcoffee.manufacturer.placeorder",
"orderID":"1234",
"coffeedetails":{
"$class":"org.example.scpcoffee.coffeedetails"
"make":"COFFEE_ROASTED",
"lotID":5128",
}
"manufacturer:

"resource":"org.example.scpcoffee.manufacturer.manufacturer#4578",
"orderer":
"resource":"org.example.scpcoffee.regulator#2382"
"EventID":"591b6ad6-5bac-4a8d-bb29-a8e15fd774c2#0",
"timestamp":"2019-02-24T17:50:59.125z"
}

6.4. Movement Performed

```
{
 "$class": "org.example.scpcoffee.CoffeeMovement",
 "fromPlaceOrder": "resource:org.example.scpcoffee.PlaceOrder#1234",
 "Coffee": "resource:org.example.scpcoffee.Coffee#4528",
 "from": "resource:org.example.scpcoffee.Orde#COFFEE_GROWING",
 "to": "resource:org.example.scpcoffee.Order#COFFEE_HARVESTING",
 "transactionId": "cdb53572-6abb-45d7-be57-c2ce21369193",
 "timestamp": "2019-03-03T16:28:05.992Z"
}
```

6.5. Movement Performed Event

```
{
 "$class": "org.example.scpcoffee.CoffeeMovement",
 "fromPlaceOrder": "resource:org.example.scpcoffee.PlaceOrder#1234",
 "Coffee": "resource:org.example.scpcoffee.Coffee#4528",
 "from": "resource:org.example.scpcoffee.Orde#COFFEE_GROWING",
 "to": "resource:org.example.scpcoffee.Order#COFFEE_HARVESTING",
 "EventId": "cdb53572-6abb-45d7-be57-c2ce21369193#1",
 "timestamp": "2019-03-03T16:28:05.992Z"
}
```

Annex 2: Blockchain, una mirada a la descentralización de las transacciones y de la información.

Dos

Blockchain, una mirada a la descentralización de las transacciones y de la información

Resumen

Las nuevas tecnologías de la información pueden generar valor a las empresas e industrias en una forma disruptiva y, dependiendo de su envergadura y proyección de crecimiento, también cambiar el mundo y la forma de conectarlo. *Blockchain* es una de ellas e incide en el modelo actual de negocios, en industrias como la financiera y de bienes raíces, generando una mejora en los servicios para brindar mayor valor a los clientes.

Este artículo busca explorar las bases del funcionamiento de la tecnología *blockchain*, sus principales características y las primeras aplicaciones, además de reflexionar hacia dónde se dirige y el impacto que podría generar.

Palabras claves

Blockchain, *bitcoin*, descentralización, base de datos, distribuida.

Rafael Bettín Díaz

Introducción

Dada la constante evolución de la tecnología y teniendo en cuenta que en promedio cada diez años surge el siguiente gran paradigma tecnológico, vale la pena estar a la vanguardia de los acontecimientos más recientes en este campo. Desde los años 70 hemos pasado de las tarjetas perforadas al uso actual de la nanotecnología y los dispositivos móviles inteligentes, sumados a los desarrollos que produjo la aparición de Internet y ahora *blockchain* o bloque de cadenas.

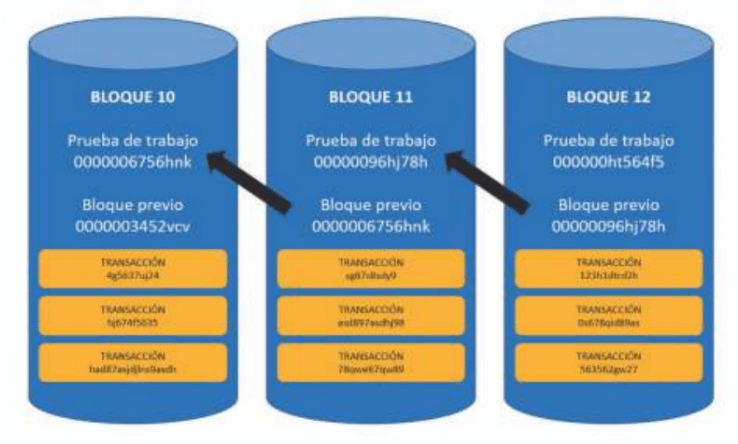
De acuerdo con Swan (2015), *blockchain,* en su forma más precaria, "se comporta como el libro mayor en donde se almacenan todas las transacciones que se han ejecutado" [traducción del autor]. Su funcionamiento es como una base de datos que en una forma descentralizada permite almacenar transacciones e información de valor [traducción del autor] (Gates, 2017, Chapter I), todo esto bajo el concepto de libro mayor distribuido o DLT[1] por sus siglas en inglés. Cada transacción en este gran libro mayor se verifica por consenso de la mayoría de los participantes de la red y, una vez introducida la información, ésta no puede ser borrada, modificada o alterada [traducción del autor] (Crosby, Nachiappan, Pattanayak, Verma, & Kalyanaraman, 2015, p. 1).

Para entender de una forma práctica los conceptos alrededor de *blockchain*, haremos referencia a una de las múltiples aplicaciones que esta tecnología puede tener, como lo es *bitcoin*, la moneda digital dada a conocer en un artículo titulado "Bitcoin: Un sistema de efectivo electrónico Peer-to-Peer" (2008), de Satoshi Nakamoto, cuya identidad sigue siendo desconocida. *Bitcoin* permite a las personas realizar transacciones financieras directamente, sin una autoridad intermediaria y en cualquier otra moneda digital o efectivo electrónico en el mercado, fundamentadas en la tecnología *blockchain.*

Inicialmente, Satoshi describió una versión *peer-to-peer* de efectivo electrónico que permitiría los pagos en línea directamente de una parte a otra, sin tener que pasar a través del concepto de una institución financiera y cuyo almacenamiento de las transacciones se realizaría a través de cadenas de bloques; con cada bloque reciente o transacción, conectado o añadido a un bloque precedente y el bloque anterior a otro bloque precedente; en ese orden se forma una cadena de bloques o transacciones autenticadas y validadas mediante una firma digital. (Ver imagen 1)

[1] Distributed Ledger Technology

Imagen 1 : Almacenamiento de información y transacciones en *blockchain*



***Fuente**: Creación del autor.*

Todo el sistema de *blockchain* por ser descentralizado y distribuido está construido en la confianza y la transparencia debido a que la identidad de los participantes es desconocida y la única autenticación se realiza a través de claves digitales, mediante la ejecución de varios algoritmos matemáticos [traducción del autor](Icahn, 2017, p. 10).

Actualmente, la importancia de esta tecnología recae en las diferentes aplicaciones que, gracias a las investigaciones realizadas alrededor de ella, se han podido desarrollar, ampliando de manera significativa su alcance, rompiendo paradigmas y de una forma disruptiva incursionando en diferentes procesos que funcionan de manera centralizada, entre ellos los servicios bancarios, los bienes raíces y los procesos asociados a la cadena de abastecimiento.

Blockchain: ¿cómo funciona?

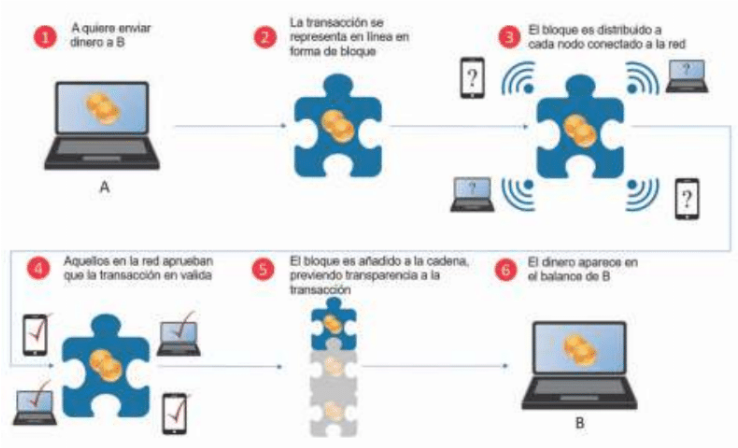
Una de las formas más fáciles para explicar el funcionamiento de *blockchain* es a través de una transacción financiera, simulando una transferencia desde el origen A, hasta el destino B, como se muestra en la Imagen 1.

Una vez que la transacción es creada por el sujeto A (1), se representa en línea como un bloque junto con muchas otras transacciones realizadas en el mismo período de tiempo (2); En este punto, con el fin de verificar la validez del certificado de esta transacción, se utilizan diferentes algoritmos matemáticos (funciones hash[2]) para cifrar la firma digital empleada para enviar la transacción. Este bloque creado, ahora se está transmitiendo a toda la red de nodos conectados (3) y todos los nodos conectados a la red *blockchain* verifican si la transacción es válida o no; este proceso se conoce como prueba de trabajo[3] y puede tardar hasta 10 minutos, aproximadamente. Una vez que la transacción es validada y

[2] Las funciones hash: estas funciones son un algoritmo matemático que "toma algunos datos de entrada y crea algunos datos de salida" [traducción del autor]' (Sean, 2016), Esto significa que una función hash se llevará a una entrada de cualquier longitud y tendrá una salida de longitud fija.

[3] Prueba de trabajo: Se permite que cada nodo *blockchain* conectado a mantener transacciones segura y alcanzar un acuerdo resistente a la manipulación [traducción del autor] (Icahn, 2017, p. 18).

Imagen 2: Transacción financiera utilizando la tecnología *blockchain*



Fuente: *(Crosby et al., 2015, p. 10)*

aprobada por todos los nodos conectados (4), el bloque es finalmente añadido a la cadena (5); todo este proceso de 1 a 5 se conoce como minería[4]. Al final, el sujeto B puede ver la transacción reflejada en su balance (6).

Características de *blockchain*

Durante el desarrollo de este artículo hemos mencionado algunas de las características de esta tecnología, cómo funciona y algunos de sus usos potenciales. Ahora vamos a enfatizar en ciertos beneficios y oportunidades como la descentralización de la información y la trazabilidad en las transacciones, según Gates (2017) y Swan (2015). Adicionalmente, revisaremos algunos de los riesgos asociados, debido al manejo de redes públicas y otros aspectos relacionados con la seguridad.

Beneficios y oportunidades de la tecnología

- La transparencia es una de las mejoras más significativas de *blockchain*.
- No hay intermediarios involucrados en el proceso.
- Utiliza una red descentralizada.
- Crea confianza entre los participantes de la red que, aunque nunca se han visto, pueden realizar transacciones entre sí.
- La seguridad es proporcionada a través de la trazabilidad.
- Todos los datos introducidos en *blockchain* son inmutables, inalterables o inmodificables.
- *Blockchain* puede ser fácilmente auditable.
- Ofrece múltiples usos, casi cualquier tipo de activos se pueden grabar en ella.
- La tecnología es bastante asequible, sin necesidad de grandes inversiones ni infraestructuras complejas. Ya hay plataformas basadas en *blockchain* como *Ethereum*[5] que nos permiten crear aplicaciones descentralizadas (Dapps[6]).
- *Costo reducido*, toda vez que con un solo libro es posible mantener registros de las transacciones realizadas.
- Como es distribuida ayuda a aumentar la velocidad de la transacción. Esto se debe a que elimina los intermediarios y todo el mundo puede auditar y verificar la información registrada en ella.

Riesgos asociados a la tecnología

- Por lo general, las redes *blockchain* son públicas y están envueltas en falta de seguridad; significa que todo el mundo será capaz de ver las transacciones y el balance de todos los participantes de la red. Vale la pena resaltar que también hay *blockchains* privadas, que poco a poco han ido tomando más auge en los mercados.
- Las claves públicas y privadas[7] en *blockchain* proporcionan al usuario la capacidad de realizar cualquier clase de transacción, dependiendo del tipo de red *blockchain* utilizada. Al perder una de las dos claves (pública o privada) se pierde todo y no hay manera de recuperar la información.

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[4] Minería: Se refiere a añadir nuevos bloques de registros (transacciones) en la contabilidad pública de *Blockchain*.

[5] "Es una plataforma *Blockchain* que es pública y tiene una funcionalidad de transacciones programables" [traducción del autor].

[6] "Ejemplos de las aplicaciones que se ejecutan en una red P2P de los ordenadores en lugar de un único equipo".

[7] Es como el nombre de usuario y contraseñas que la mayoría de la gente utiliza como identificadores en cualquier otra aplicación.

A pesar de que la descentralización es algo por lo que sobresale esta tecnología, también puede ser una de las razones para que su adopción tome más tiempo, debido a que ninguna organización tiene control sobre *blockchain*.

- La red *blockchain* todavía tiene problemas de escalabilidad, debido a los tiempos empleados en minería y validación de las transacciones; el proceso puede ser más lento que con otras aplicaciones transaccionales centralizadas.
- Aún existe poca confianza por parte de la gente para utilizar este tipo de tecnologías en las que la información, dependiendo del tipo de *blockchain* implementada, puede ser pública.
- La regulación de los gobiernos y de las instituciones bancarias puede ser un problema al cual se enfrentará *blockchain* a lo largo del camino.
- La integración con los sistemas existentes y heredados es uno de los puntos críticos de esta tecnología, especialmente para las instituciones bancarias, debido al costo de la migración y la sustitución de los sistemas.

Aplicaciones en diferentes industrias

En servicios financieros

La principal área de estudio para los negocios y empresas alrededor de *blockchain*, es la combinación de los servicios financieros tradicionales con esta nueva tecnología. Para ello, la Red de Información Interbancaria (RII) de los más prestigiosos bancos a nivel mundial ha unido esfuerzos con el fin de investigar los posibles usos de esta tecnología y la forma de crear una red global que permita realizar transacciones entre sus clientes y sus mismas entidades filiales. Ahora, los bancos con sucursales a nivel regional podrán realizar movimientos financieros entre éstas sin tener que retransmitir esos fondos a través de un intermediario" [traducción del autor] (Swan, 2015, p. 11).

En recaudación de fondos

Con el uso de tecnologías como *blockchain*, el modelo de negocios actual para los servicios de recolección de fondos de inversión (*crowfunding*) cambiaría completamente; antes se necesitaba un servicio centralizado como *Kickstarter* o *Indiegogo* para permitir una campaña de *crowdfunding*, Ahora, con *blockchain* se elimina la necesidad de un tercero intermediario.

También se habilita la posibilidad de que los *startups* recauden fondos mediante la creación de sus propias monedas digitales y vendan "acciones criptográficas" a los inversionistas interesados. Estos últimos, en este tipo de campañas, mediante *blockchain*, reciben un *token*[8] que representa las acciones de la empresa en la que han invertido [traducción del autor] (Swan, 2015, p. 12).

Con los contratos inteligentes[9]

Muchas de las industrias que utilizan la tecnología *blockchain* van a hacer uso

8 Unidad de valor emitida por una entidad privada (BBVA, 2017).

9 De acuerdo con los contratos de Smart Alliance - En colaboración con Deloitte, Nick Szabo describió un contrato inteligente, como un conjunto de promesas digitales, incluidos los protocolos y condiciones, que las partes estuvieron de acuerdo para llevar a cabo esas promesas [traducción del autor] (2016).

de contratos inteligentes y podrán intercambiar algo de valor en forma automática. Si se cumplen las condiciones de un contrato, los pagos o el intercambio de valor son realizados de acuerdo con sus términos. Del mismo modo, si no se cumplen las condiciones del contrato, los pagos pueden ser retenidos [traducción del autor] (Swan, 2015, Chapter VIII). Actualmente, empresas como Walmart en Estados Unidos, tienen este modelo como piloto para la compra de carne de cerdo desde Asia y gestionar la operación con sus proveedores.

Con Internet de las cosas[10] (IOT)

IoT se está convirtiendo rápidamente en una tecnología popular para el consumidor y las empresas. Una gran mayoría de las plataformas de IoT se basa en un modelo centralizado, en el que como agente o *hub* controla la interacción entre los dispositivos. Sin embargo, este enfoque es poco práctico para muchos escenarios en los que los dispositivos necesitan intercambiar datos entre sí de forma autónoma.

Este requisito específico ha llevado a esfuerzos hacia IoT con plataformas descentralizadas. La tecnología *blockchain* facilita la implementación de estas plataformas descentralizadas para el intercambio de datos seguros y sobre todo para la confianza de la información, así como para el mantenimiento de registros. Este tipo de arquitectura, *blockchain* sirve como el libro mayor y mantiene un registro confiable de todos los mensajes intercambiados entre los dispositivos inteligentes en una topología IoT descentralizada [traducción del autor] (Crosby et al., 2015, p. 17).

En la cadena de suministro

En una implementación *blockchain*, un contrato inteligente puede desencadenar la transferencia de valores automáticos basados en condiciones. Basta imaginar un rastreador GPS[11] en un barco que desencadena un pago realizado en un instante a través de *blockchain*, una vez que la ubicación GPS de la nave demuestra que el buque ha llegado al destino del comprador [traducción del autor] (Hua & Notland, 2016, pp. 22, 23). En la industria de la cadena de suministro, las aplicaciones de *blockchain* están generando nuevos modelos para su mejora y automatización, permitiendo a los diferentes actores conocer toda la información de los diferentes productos, desde su cultivo hasta la entrega al cliente final, pasando por los diferentes procesos de transformación, lo que permite una fácil identificación y generación del certificado de origen de los mismos, sobre todo si hablamos del mercado de alimentos orgánicos.

El futuro de *blockchain*

> *"La tecnología más probable que cambie la próxima década de los negocios no es la web social, los grandes datos, la nube, la robótica, o incluso la inteligencia artificial. Es la blockchain ..." (Tapscott & Tapscott, 2016).*

La cadena de suministro puede ser uno de los procesos que en este mo-

10 Internet de las cosas (IoT por sus siglas en ingles) "Es un término utilizado para una red de dispositivos que comprenden los frigoríficos, cámaras de seguridad, automóviles, aviones, computadoras, etc. ha existido durante un tiempo bajo diferentes formas y nombres" [traducción del autor](Guartime, 2017).

11 Sistema de Posicionamiento Global.

mento tiene más flexibilidad para adoptar esta tecnología; no obstante, su aplicación está actualmente bajo investigación por parte de las grandes compañías tecnológicas que seguramente integrarán la minuciosa de toda la cadena de valor *blockchain* del proceso, donde las empresas podrán realizar transacciones entre sí con un único "libro mayor"compartido para todas las transacciones, donde el tiempo y el papeleo que están gastando se pueden reducir considerablemente. Como parte de esta evolución vendrá sus integraciones con el sistema actual, con el fin de no hacer traumático el proceso de adopción, donde la tecnología se ejecutará en una capa de tecnología diferente a las que conocemos ahora, lo cual la hace transparente para el usuario final.

Por otro lado, esta tecnología todavía tiene un largo camino por recorrer, muchos obstáculos que superar y confianza que ganar. Las entidades y los gobiernos tienen que establecer una mayor regulación para ayudar con su adopción y las empresas empiezan a avanzar hacia nuevos modelos, servicios y propuestas tecnológicas basadas en *blockchain*. También, la infraestructura alrededor dará forma al futuro de la tecnología, para reducir su costo y rápida adopción.

Para el corto tiempo que lleva en el mercado ha avanzado ampliamente en su investigación, dando lugar a *blockchain* 1.0, para el uso en monedas digitales; posteriormente, b*lockchain* 2.0, surgió para los contratos inteligentes y su aplicación con IoT; y, por último, *blockchain* 3.0, el estado actual de esta tecnología para diferentes industrias, a través del desarrollo de *Dapps*. Entre los sectores que en un futuro próximo adoptarán *blockchain* como base para sus procesos figuran: el seguimiento de los impuestos, las entidades reguladoras, las cuales tendrán la oportunidad de conocer en tiempo real los movimientos financieros de todo el mundo y con antelación su patrimonio; la votación en línea y el almacenamiento en la nube. La información se distribuye en muchos servidores conectados a la red que todavía mantiene la privacidad de la información; la identidad digital será posible mediante el seguimiento de una persona desde su nacimiento, por cada documento relacionado con ella (Icahn, 2017).

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Annex 3: Methodological approach to the definition of a Blockchain system for the food industry.

Methodological Approach to the Definition of a Blockchain System for the Food Industry Supply Chain Traceability

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Abstract. In this paper, we present a novel methodology to integrate the Blockchain technology in the food industry supply chain to allow traceability along the process and provide the ultimate customer with enough information about the origin of the product to make an informed purchase decision. This methodology gathers the best practices in marketing, process engineering and the technology itself, alongside with the authors' experience during its application in the organic coffee industry in the Colombian market. The Authors extracted the best out of the best practices and made it simple for anyone interested in its uses and application. The result is a simple and easy methodology that suits any product, supply chain, and required system configurations; due to its versatility and adaptability.

Keywords: Blockchain · Process · Traceability · Supply chain

1 Introduction

According to the World Health Organization (WHO), "people are now consuming more foods high in energy, fats, free sugars or salt/sodium, and many do not eat enough fruit, vegetables and dietary fiber such as whole grains" [1]. Additionally, with the growing demand in the fitness market, in line with NIELSEN "consistent with consumers' rating of the importance of attributes, sales of products with natural and organic claims have grown 24% and 28%, respectively, over the two-year period" [2]. With this information, we can appreciate how vital has become for people to change its eating habits. Specifically, in Colombia people tend to look for food with local ingredients, natural and organic alternatives[1] which makes us think about the current state of the transformation process that experience food across the value chain, since its plantation until its placement on a supermarket shelf. In Colombia, the government has delivered some regulation around the production of organic products [3,4]; however, concerning

[1] Nielsen Global Survey on Health and Wellness. 3rd semester of 2014.

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https://doi.org/10.1007/978-3-319-95165-2_2

execution, we are very late, most of the natural stores have not certification whatsoever. Ultimate customers only trust people's goodwill when they talk about the organic origin of a product and, the final customer is not aware of the roots of the food they are paying for. Here is where technology comes in; we have always experienced technology in different scenarios that have helped us generate some improvement in the way we perceive or do things on a daily basis, even technology has changed how we do businesses. The Blockchain is what we call a disruptive technology, thus, overturns the traditional business model, which makes it much harder for an established firm to embrace[2]. A clear example of this is the e-mail, it replaced the postal office service, this has been more vivid for recent generations, nevertheless, no matter the age, people look for a laptop with Internet to send a letter [5].

In this context, this research pursues the integration of the Blockchain technology with the supply chain in the organic food industry in the Colombian market. It seeks to decentralize the information, provide trust among all participants, trace the data along the supply chain [6,7], and discover a new range of opportunities for applications that can provide the ultimate customer with information beyond a supermarket label. This will help validate its scope as part of a business process, keeping in mind that the Blockchain technology at this point of its development cannot be called itself a new methodology for process improvement, optimization or automation [8–10]. In the final stage of this research, with this integration, the Blockchain technology, and the process as it is, we will provide a methodological approach for its implementation in any supply chain. This document begins with a brief review of Blockchain and its main characteristics, it also covers the foundations of the supply chain, followed by the presentation of the methodological approach for its implementation and the final conclusions.

2 Blockchain

According to [6], cited by [5], "in its most precarious form, is the public ledger of all Bitcoin transactions that have been executed; but, since its conception, the Blockchain has evolved further than the platform for storage financial transactions managed by a cryptocurrency". The Blockchain is like a database, it is a way of storing records of value and transactions [7]. In general matters, that last sentence explains very quickly and, in simple words, the aim of Blockchain. However, the technology goes further than a shared database; a Blockchain is essentially a distributed database of records, we can also call it a public ledger of transactions or even digital events that have been executed and shared among participating parties (nodes). In the general ledger each transaction is verified by consensus of a majority of the participants in the Network, and once entered, the information cannot be erased, modified or altered [11].

[2] Definition taken from Cambridge Dictionary.

2.1 How Does a Blockchain Works?

Blockchain may have been born because of Bitcoin, and nowadays it is used as the underlying technology for any cryptocurrency and its transactions. But, it goes beyond that, due to its architecture, it gives the participants the ability to share a ledger that is updated, through peer-to-peer replication, every time a transaction occurs, it means that each participant (node) in the network acts as both a publisher and a subscriber.

To make this simple each node can receive or send transactions to other nodes, and the data is synchronized across the network as it is transferred [12]. The transactions on the network would look like this: Where subject A wants to transfer a digital asset to subject B, for this case, it is electronic cash, most known as a cryptocurrency, which underlying technology is Blockchain. Once subject A creates the transaction it is broadcasted to all the nodes connected to the network with many other transactions that were made at the same period. This is represented online as a block; at this point, in order to certify the validity of this transaction, different mathematical algorithms are being resolved, these were used in the first place to encrypt the digital signature that was used to send the transaction; each node will work on finding a proof-of-work, that can take up to 10 min approximately, once they have found it, the block is broadcasted to the network and other nodes would only accept the block if all the transactions in it are valid. Once this is verified and approved by all the nodes connected, the block is added to the Chain, this whole process is known as mining; in the end, subject B can see the transaction reflected on its side.

2.2 Key Elements of a Blockchain Architecture

- Nodes: It refers to a participant of the network.
- Hash functions: "these functions are a mathematical algorithm that takes some input data and creates some output data" [13], this means that a hash function will take an input of any length and will have an output of a fixed length.
- Proof-of-work: It is a consensus mechanism that allows each Blockchain connected node to keep transactions secure and reach a tamper-resistant agreement [14].
- Mining: This refers to adding new blocks of records (transactions) to the public ledger of Blockchain.
- Timestamp Server: It proves that the data must have existed at the time, obviously, to get into the hash [15].

2.3 Characteristic of a Blockchain Network

According to [6,7], cited by [5], we are going to emphasize the most important benefits and disadvantages of the Blockchain technology:

Benefits:

- Compared to existing technologies of record keeping and common databases, transparency is one of the most significant improvements of Blockchain.
- No intermediaries involved during the process, whether it is used as record keeping or data transfer.
- It uses a decentralized network, which reduces the possibility of hacking, downtime system or loss of data.

All of the above, in conjunction, create trust among participants of the network, which is one of the principal characteristics. Allowing participants that have never even met before transacting one another with the confidence that this technology provides.

- It provides security through traceability. All data entered or registered on the Blockchain cannot be mutable, altered or changed, which allows a clear record from the very start of any transaction. It means a Blockchain can be easily auditable.
- The Blockchain provides multiple uses, almost any kind of asset can be recorded on it. Different industries, like retail, are already developing applications based on Blockchain.
- The technology is pretty accessible, no need for significant investments, nor complex infrastructures. There are already platforms based on Blockchain like Ethereum[3] that will allow us to create Decentralized Applications (dApps[4]).
- Reduced cost of maintaining a big network of multiple ledgers can be avoided by using Blockchain and its one-single ledger to keep records of all the transactions across companies.
- Being distributed has one more benefit, it increases the transaction speed. By removing all the intermediaries and everyone can audit and verify the information recorded on the Blockchain.

Challenges:

- Usually, Blockchain networks are public, which provides lack of security, when talking about a financial Blockchain. In a Blockchain public network everyone will be able to see everyone's transactions and balances. It is safe to say that, there are also private Blockchains, which can be used in processes like supply chain.
- Public and private keys,[5] in Blockchain provides the user with the capacity of making transactions of any kind, depending on the type of Blockchain network uses. Hence, once it loses any of the two keys (public or private) it

[3] Is a Blockchain platform that is public and has a programmable transaction functionality [16].

[4] Are applications that run on a P2P network of computers rather than a single computer (blockchainhub.net, n.d.).

[5] It is like the username and passwords that most people use as identifiers in any other application.

loses everything, and there is no way to recover it, and people will have to write down such sensible information which reflects the security concerns in the industry.
- Even though decentralization is something why this technology excels, it may be one of the reasons why its adoption can take longer, since no single organization has control over the Blockchain.
- The Blockchain network still has scalability issues; currently, the Bitcoin platform can support up to 7 transactions per second, this is way below the average amount of transactions the visa network is capable of handling per second.
- Trust is a big deal regarding transactions between parties; nevertheless, the uses of a Blockchain network is related to cryptocurrencies, and there is a lack of trust in people to use digital cash.
- Because it is a recent technology, people are trying to understand how it works, its uses and applications. Likewise, as financial-transaction services are the most commonly used by Blockchain networks people are afraid of the ledgers being public.
- Regulation of governments and bank institutions will be an issue that will face the Blockchain technology along the way.
- Integration with existing legacy systems is one of the critical points of the technology, especially for bank institutions, due to the cost of migration and replacing systems.

Most of its disadvantages are a result of the natural cause of the state of its development. Something particular about it, is the constant evolution by being immersed in an everyday-changing environment, regarding content, application, development, and researchers to determine more applicability and provide industries with a wide range of uses. But, the counterpart is its benefits, nobody planned for this technology to be so disruptive, even though, the direction is clear, this will revolve many industries. Few people know in detail all about the technology, this is not a lethal threat to sectors, but, they need to know how to work with innovation and use it for growth. There is one thing to keep in mind, right now there's a hype with this technology, that will continue maybe for the next decade, but, the real focus is on the strategic applications and uses that can contribute to real development. Here is important to take an in-depth look at what this technology has to offer and what is needed to adopt it.

3 Supply Chain

Christopher [17], stated that the "supply chain objective refers to processes and activities that produce value in the form of products and services in the hands of the ultimate consumer". It can be used as an objective of the supply chain management, and for this research, the added value is one of the essential ingredients of the whole process. Currently, the general supply chain management process, no matter the perspective, offers no information to the final consumer.

As seen in the definition above, the process foundations relays on the communication and integration of a set of actors that manufacture or produce a good or a service. This particular definition is linked with the objective of this paper, due to the importance of providing valuable information to the ultimate consumer and being an essential piece of the chain as maintaining trust along the process and create trust during purchasing as one of the leading pillars of [18]. Also, it is important to point out the definition of the Council of Supply Chain Management professionals [19], but mostly, this statement, "starting with unprocessed raw materials and ending with the final customer using the finished goods, the supply chain links many companies together".

In the food industry, this is merely raw material, that needs to be transformed or processed to deliver a finished good to the final consumer. In between the entire process, there are different actors, some of the participants of the supply chain according to [20], cited by [5], are (a) Producers or manufacturers, organizations that make a product; this can include the transformation of raw material or the production of finished goods; (b) Distributors, are mostly known as wholesalers; (c) Retailers, manage stock inventory and sell in smaller quantities to the general public; (d) Customers or consumers, may be the end user of a product who buys the product in order to consume it; (e) Service or goods providers are organizations that provide services to producers, distributors, retailers, and customers.

The competitiveness of the food industry would thus be the ability to sell products that, in one hand, meet demand requirements (price, quality, and quantity) and, at the same time, ensure profits over time that enable the companies to do well economically, develop their business and thrive [21].

Therefore, there is a constant, the customer that demands better products due to its sophisticated taste; this change necessarily obligates the industry to adapt very quickly to these changes and respond accordingly. The structural adjustment of the food sector is therefore linked to consumer preferences, which have an increasing impact on the industry as a result of income developments, shifts in the population structure and new lifestyles. Other essential impact that influence the food sector is globalization, liberalization of world trade and agricultural markets and the emergence of new markets from Central and Eastern Europe all the way to India and China. Finally, significant shifts and changes in technology, including information technology have led to new products and methods to organize the supply chain [21].

For this research, this is a Cold Chain, in which the hygienic safety of food depends largely on the respect of the cold chain, throughout all stages of storage and transport among the producer, carrier, distributor, and the consumer. Traceability, is a crucial concern to all participants and stakeholders in the food chain, this mainly refers to the ability to trace, throughout all stages of production, processing and distribution, the path of a food product, a food feed, a food-producing animal or a substance to be incorporated or even possibly incorporate it into a food product or a food feed [22]. It can also provide support for public health and help authorities determine the causes of contamination or help

the companies reassure customers and increase competitiveness on the market through sales and market share. Finally, we have the quality challenge; this is an essential concept in the food industry, the compliance certification attests that a non-alimentary and unprocessed food or agricultural product complies with specific characteristics or previously set rules concerning the production, packaging or origin [22].

4 Supply Chain Meets Blockchain

Today many large industries are taking advantage of the Blockchain main characteristics such as immutability, traceability, and security to boost their business and overcome the counterfeit issues that have affected millions of brands over decades. A 2017 study from the Global Financial Integrity Organization (GFI) estimates the global trade value of counterfeit- and pirated goods to generate between US 923 billion to US 1.13 trillion annually. With this number increasing every day, it becomes imperative to adopt new technologies that make more efficient the whole process; some companies around the globe like, Unilever and FedEx, are using Blockchain to make more efficient the supply chain for some of their products; for Unilever this means, "the company hopes its strategy will build trust with consumers, who may be willing to pay a premium for a sustainably-sourced product" [23]; while FedEx, "is explicitly delving into creating uniform logistics standards for Blockchain applications across the industry" [24]. Therefore, it becomes relevant the proposal for a methodology that would help to meet business needs for the Colombian market in such an important industry, as it is the coffee industry.

4.1 The Application of Blockchain over the Supply Chain

For the integration between Blockchain and Supply chain, this research proposes to develop a methodological approach and a practical view to understand the generalities of this methodology. In summary, Fig. 1 shows four layers to understand the development of this methodology; The first one has to do with the product definition, where is important to gather as much as information about it, such as the characteristics and processes associated to its production. Then, we have the process, knowing the actors, and a detailed definition or characterization of the process to produce the product, according to the definition made earlier following these steps. After that, comes the information layer, where business rules, assets, and the information flow layout have to be defined; it's important to note that for this Data Flow Diagram (DFD) it is essential to consider the definitions made related to product characteristics, that is the information that will add more value to system. At last, the technology layer, which is where definitions are made about the platform to be used for the deployment of the Blockchain according to the process and the descriptions made.

As we present this methodological approach, we are going to showcase a practical use, for the Colombian coffee Supply Chain that will be explained accordingly in the following steps.

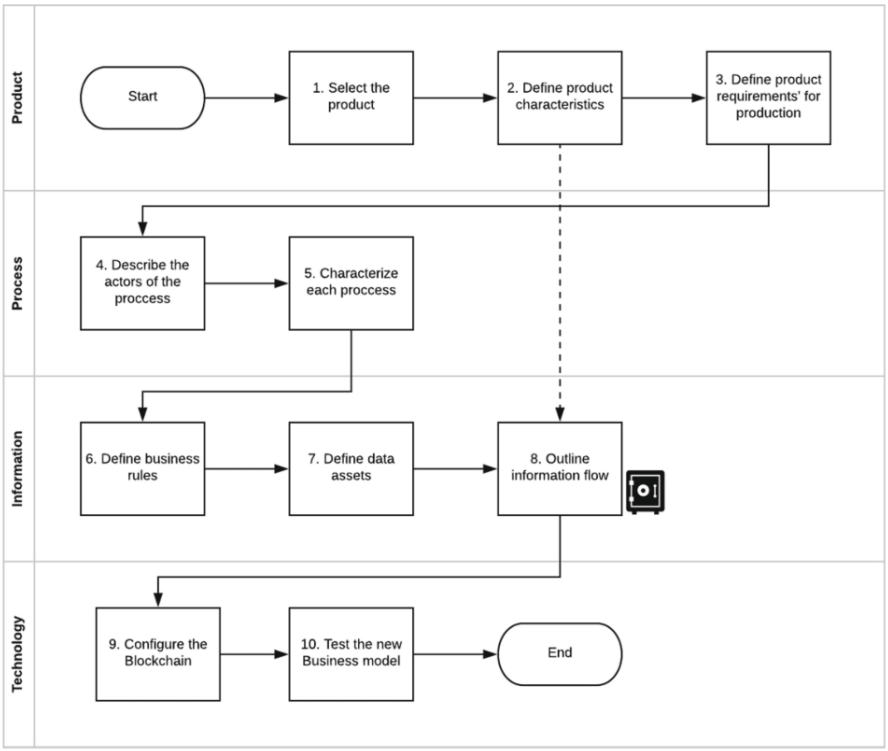

Fig. 1. Methodology summary for Blockchain applicability

1. **Select the product:** As simple as it may seem, the nature of the product to be selected will define in a significant proportion the scope of the architecture to be developed, at the level of understanding processes, operations and the different components that are part of the product's identity. At this point, it is recommended to know about the industry or productive sector of the product you are selecting to work with.
2. **Product characteristics:** A product is defined as a set of fundamental attributes united in an identifiable way [25]. Based on product design methodologies, in this stage, we seek to describe all the characteristics associated with the product selected, as shown in the Fig. 2. The detail in the definition of these characteristics is important because the meaning of the supply chain and all the processes immersed in it, for the elaboration of this, will depend on them.
3. **Requirements for production:** A fundamental part of the definitions to be made, is to consider all the requirements that are necessary to obtain the product, these are technical, functional, legal, and regulatory. As a fundamental part of this implementation, that seeks to generate interaction among

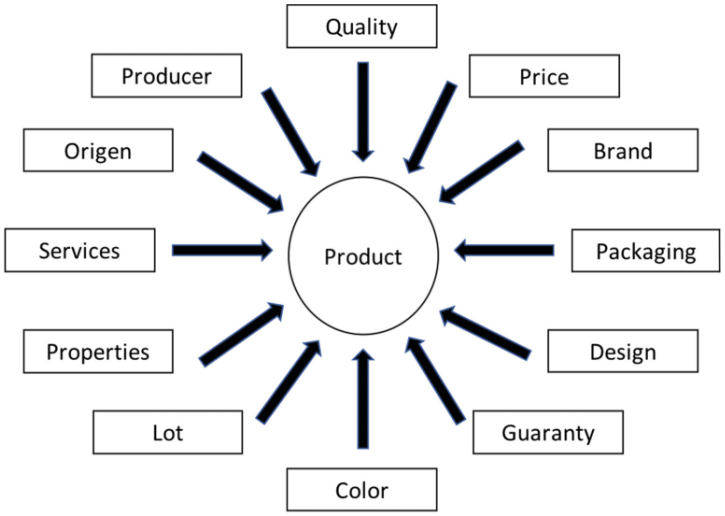

Fig. 2. Product characteristics

different parties, it is that the information for all processes, for everyone involved, is available.

4. **Actors of the process:** It is necessary within the initial characterization made for the value chain, in this case, the supply chain, to identify the primary entities that generate or add value to the final product. These are fundamental items in this definition because they are the locations where the information is born, where the processes and the central points for the interconnection of the processes are developed, see Fig. 3. For this research, the supply chain in the coffee industry was created considering the most important actors [26].
5. **Unit operations and processes:** For each actor there will be unitary operations and processes that will shape each one of the characteristics defined for the product. Knowing in detail what these are, the components of each one of them and the process that occurs in them will provide us with relevant

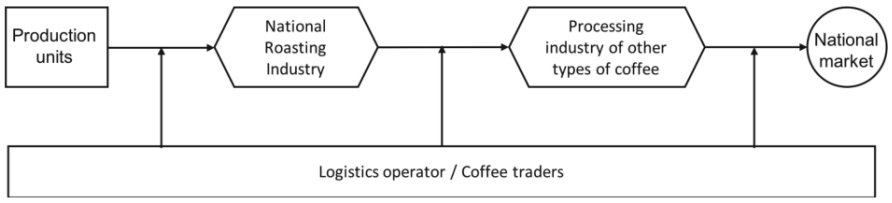

Fig. 3. Actors in the supply chain for the Colombian coffee industry. Depending on the objective of the project, this chain may be longer or shorter; this is a representation of the main actors of the coffee industry in Colombia.

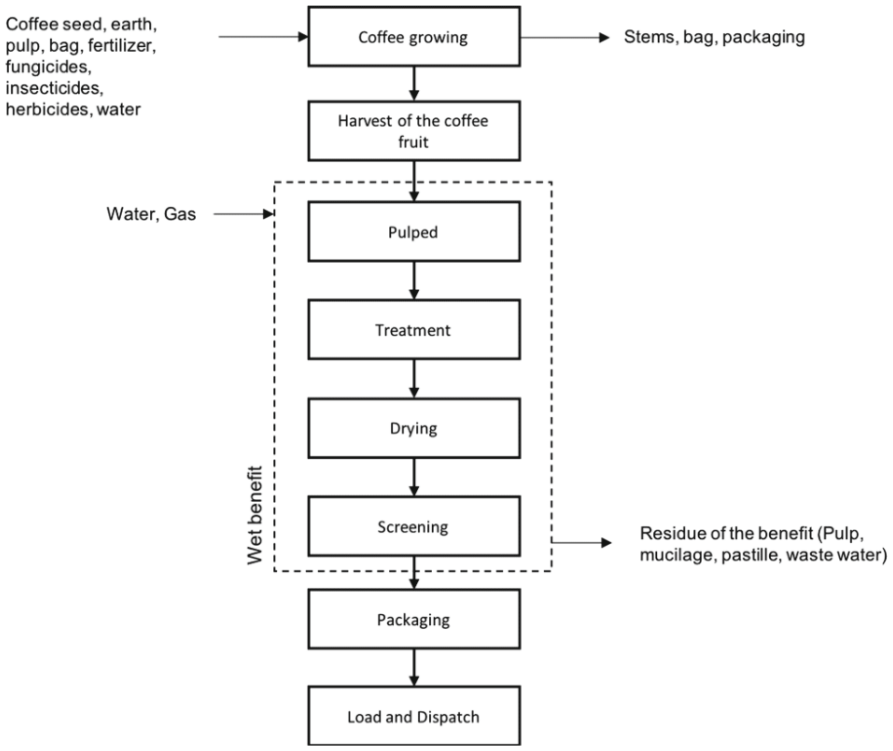

Fig. 4. Productive Units Process. It shows how the process of coffee harvesting is made in a traditional farm in Colombia; this process ends with a wet benefit packed and ready to sell to the manufacturers that produce different types of coffee.

and sufficient information to know what information should be extracted from that operation. These processes can be detailed thought a BDF (Block Diagram Flow) or BFPD (Block Flow Process Diagram) according to [27]. See Fig. 4.

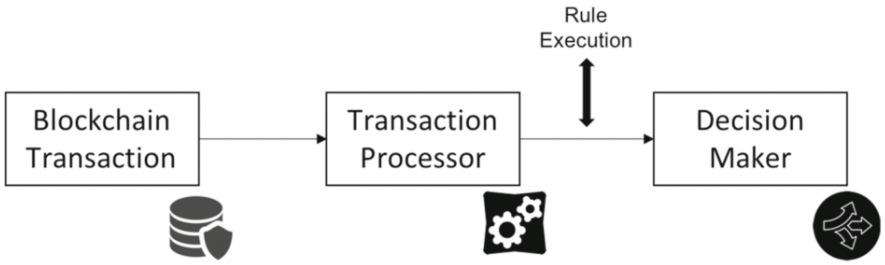

Fig. 5. Business Rules Execution Process. Every time a transaction is generated on a Blockchain, this goes through a transaction processor which will execute rules if defined and decide.

6. **Business rules:** In a Blockchain, this will help you to apply rules anytime you process a transaction. In this case, a transaction can be a purchase, a sale, a payment, even a control point along the process chain. As it is shown in Fig. 5, once a transaction is stored in the Blockchain, a transaction processor will validate the rules for that specific transaction, and if applicable, it will decide what to do with it, depending on its configuration.
   > "The process also covers reviewing the rules, registering agreement between the parties, testing the rules on transaction data, simulating scenarios to understand their business impact, and storing them in a secure and transparent way. In addition, the same attention must be applied to data models and the business domain models they represent. The parties also must define how rules are governed: who can define rules, who can deploy rules, and the processes for changing rules" [28].
7. **Digital asset:** "Digital asset is a floating claim of a particular service or good ensured by the asset issuer, which is not linked to a particular account and is governed using computer technologies and the Internet, including asset issuance, the claim of ownership, and transfer" [29]. That being said, a Digital asset, for this particular case, are the documents that will allow the transaction to be valid. For each process in the supply chain there will be several assets that are going to be needed to make this a successful process; however, it will depend on the amount of transactions required for the specific system.
8. **Information flow:** Using Data Flow Diagram [30] will help you to understand how the information interacts across processes. For this, it is necessary to have an accurate definition of the assets and the data involved in each process. This will create the transactions on the Blockchain, as shown in Fig. 6; where we have the information defined, the process where that information is processed, and the outcome for the Blockchain.

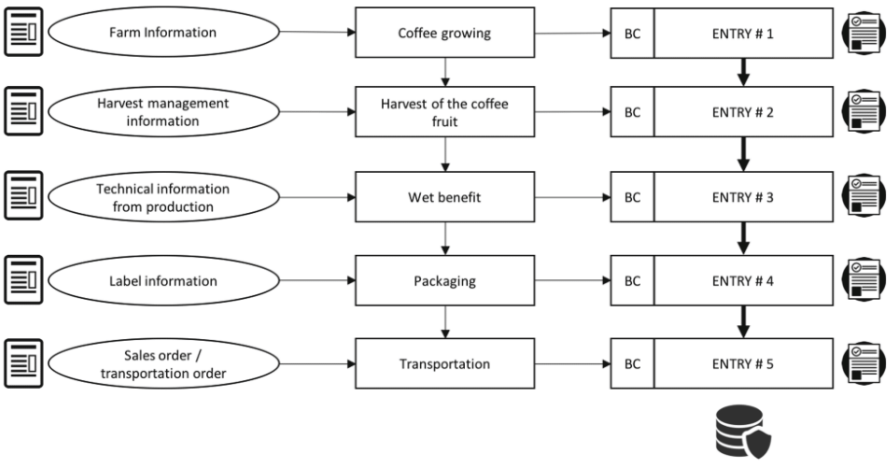

Fig. 6. Productive units information flow chart

9. **Configure the Blockchain:** First of all, it is imperative to define what kind of Blockchain you need and its technological architecture as defined by [31]. For example, a private Blockchain will only allow a few nodes connected to the network to transact with the information and use the ledger, in this kind of networks participant are very limited on what they can do, unlike a public Blockchain, that allows anyone to see or send transactions and actively participate in the process [32,33].
   Then, it is necessary to select the most suitable consensus mechanism for the specific scenario, some of them are, proof of work [15], proof of stake [34], proof of activity [35], proof of luck [36], among others. This should be chosen in conjunction with the Blockchain platform to be used in the network; there are many of them out there, some of the most popular platforms are (in alphabetic order): BigChainDB, Corda, Credits, Domus Tower Blockchain, Elements Blockchain Platform, Ethereum, HydraChain, Hyperledger Fabric, Hyperledger Iroha, Hyperledger Sawtooth Lake, Multichain, Openchain, Quorum, Stellar and Symbiont Assembly [37,38]; according to the authors' experience, here are some of the parameters to take into consideration to validate which platform suits your business model the best: (a) Maturity, this refers to how long this platform has been in the market, its support model and documentation, (b) Easy of development, depending on your development skills, this point is of importance to consider, (c) Confirmation time, this will much depend on the consensus mechanism, this is why these two must be evaluated together, and (d) Privacy between nodes, as explained before some platform will allow you to configure public or private networks, this is according to the specific type of network for your business model.
   The parameters that needs to be configure will vary depending on the platform, some of them can be changed during run-time but some cannot, this is a very crucial step during configuration.
   The last two steps during configuration are, user interface design, it is important to define the front end design and to choose the programming language, and APIs (Application Programming Interface[6]) building; some of the Blockchain platforms come with pre-built APIs but, mainly, the categories of APIs you would need are for: Generating key pairs and addresses, Performing audit related functions, Data authentication through digital signatures and hashes, Data storage and retrieval, Smart-asset life-cycle management issuance, payment, exchange, escrow and retirement and Smart contracts [37].
   Once the Blockchain platform is configured, the application (user front end) is designed and ready, it is time to integrate both with the APIs, to have the data flowing to one another.

[6] An interface to a software component that can be invoked at a distance over a communications network using standards-based technologies [39].

10. **Test the new business model:** Based on the objective of the project and the definition made for the Blockchain system, it is recommended before going live to define a set of tests. It should include, unit tests, to ensure each component of the complete architecture is working as expected; and integrated tests, to verify the flow along the Blockchain architecture. It is important to consider for these test scenarios, definitions such: participants, permissions, assets and transactions and the outcome expected for each one of those tests.

5 Conclusions

Blockchain technology may have the capacity to revolutionize businesses through a more transparent, secure, and decentralize system, by generating trust among participants. With this research arose the potential and opportunity to develop a methodology to integrate this technology with the processes along the supply chain that would help, in this case, provide the ultimate customer with the tools to make an informed purchase decision. As a result, the authors propose a step by step methodology that it is easy to follow and implement for any product, and it is scalable for other processes different to the supply chain; due to the central principle of its developments, which is to validate various elements that will add value to meet the objectives of the project.

Based on this methodological approach, the authors adopted the best marketing practices regarding product development; process engineering, which helps to understand the life cycle of the product along the entire supply chain, from raw material to finished products. Finally, the technology itself, which is not the purpose of this document; however, a fundamental guide is presented to develop a project from start to finish. It should be noted that anyone who wants to apply this methodology must have the knowledge related to the industry, the processes involved and the product to know what the result of this exercise will be concerning information that will travel to the Blockchain. The authors know the application of this technology has some specific requirement regarding the sociocultural environment, such as IT infrastructure, which can be difficult for some of the participants; but, this obstacle needs to be overcome with governmental policies and education, which is not in the context of this article.

Additionally, during the research process, the authors have envisioned different applications for this methodology, that can be used to design a certification system based on Blockchain, by automatically gather required information across the process which will make it easy to audit and track for all participants involved. This scenario will use a centralized network to safeguard the information, which is controlled by a certification authority.

Finally, this is one of the many other methodologies that can be used to adopt Blockchain into a process, either financial, logistics, or any other of the value chain. But, due to the infancy of the technology is not easy to get there and find the perfect way to do it. The authors will continue investigating and improving this approach as the technology evolves.

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Annex 4: Blockchain for Organic Colombian Coffee Origin Traceability on Hyperledger.

Blockchain for Organic Colombian Coffee Origin Traceability on Hyperledger

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Abstract This paper exhibits the results of implementing a Blockchain on a supply chain study case, based on a implementation of a Blockchain business network for Colombian Coffee supply chain, using Hyperledger[1]. The objective of this research is to understand how to implement a Blockchain over a process like the supply chain, the authors explain the study case and the steps through the business network configuration, which, with the recent interest of adopting Blockchain to leverage business process capabilities, the results of this implementation confirm the viability of using Blockchain with the objective to trace product origin traceability. This paper analyses the results of this implementation and proposes a course of improvements to consider different scenarios to keep in mind. Presented are the current general process used in the market for coffee production, the technological architecture proposed to support this scope and the process to storage the data into the Blockchain.

Keywords: Blockchain, Process, Traceability, Supply chain, Hyperledger.

1 Introduction

Trade has always been a part of the human civilization, the direct exchange of services and resources for mutual advantage is intrinsic to the symbiotic relationships between plants, insects and animals, so that it should not be surprising that, in some form or other, is as old as man himself [2]. Commodities were chosen as prefer trade items, or as it was called back then, barter; this has many reasons, it could be, because they were easy to store, or because they were portable or maybe because they more durable. The more quality the item showed, they higher the opportunity for bartering. As civilizations were evolving, thus the way for trading did. A "coin" with multiple forms was introduced as a method to facilitate the exchange of products, assuming that everyone was able to establish a fair price for their commodities using the same "rate of exchange",

[1] "Hyperledger is an open source collaborative effort created to advance cross-industry blockchain technologies. It is a global collaboration including leaders in finance, banking, Internet of Things, supply chains, manufacturing and Technology. The Linux Foundation hosts Hyperledger under the foundation". [1]

it would make the exchange easier. Those first "coins" were, for example, wheat or cattle; in that way, it was easy to set up a price for different products, based on how many cows you could give in exchange of cereals. Soon after, this method was replaced with the arrival of the metallic coins, made of an alloy of gold and silver, first metallic coins were used for tax collection and the migrated as an asset that allow people exchange commodities one another, its value was given according to the figure, usually of a god, which was engraved on one of its faces, it was also a proof of its quality and purity.

This mechanism of exchange continues to evolve, as we know it today; banks and governments played an important role in this evolution process, as they became its guardian and guarantees. In 2009, was introduced, the Bitcoin, a new mechanism for exchange products or services, with a digital coin [3]. Is safe to say, that digital coins have had existed since the mid 80s with [4], inventor of digital cash and blind signatures; however, there was a big problem, it was impossible to avoid the double spend of a coin; this is where Bitcoin becomes interesting, the underlying technology behind this new digital coin, breaks with this paradigm, make it feasible to transact, and the most relevant, those transaction needed no third parties or intermediates to make it possible and all of this was possible thanks to the this break ground technology behind Bitcoin, nowadays known, as Blockchain.

This paper is tend to explain how this technology can be used in a business process like the supply chain. How, through a methodological framework, it is possible to build tools, with the help of technology, that allow adding value to business processes, and to present the results and conclusions, based on the validation of the implementation of the business network.

2 Background

2.1 Blockchain

The most common and accurate definition for Blockchain, would be the underlying technology that will allow you to trade any kind of asset, through validation and consensus of all of the nodes connected to the network, who happens to share the same ledger of transaction; this consensus needs to be reached by the majority of the network, which are all of the participants participants who validate the transaction [5] [6], once the transaction has been validated, it goes through and it is added to the Blockchain [7].

Blockchain networks offers several characteristics, one of them is immutability, which means that this transactions can not be modified or altered by anyone [8]; the next one is traceability, due to all transactions are stored on a single ledger of transaction across the network, which is being updated anytime a transaction is valid, everybody has access to all of the transactions that have ever occurred on the network and traced back to the genesis block [9]; however, participants on the network, depending whether the Blockchain is Permissioned or permissionless, will not be able to see one another identities', this is because all of the transactions

are being encode thanks the cryptography and mathematical algorithms used to ensure the security of all the transaction on the network; at last, one of the most important characteristic, is the uses of a timestamp signature, once a transaction have being validated, it helps the network to trace the information or asset that was stored on the Blocks [10].

Based on this philosophy, a Blockchain has no need of a third party, regulatory entity or a government to make trading happen; this technology allows you to transact with anyone around the globe as long as both participants are connected to the Blockchain network [5]. As it was mention earlier, you can have both, Permissioned or permissionless Blockchains network. A Permissioned Blockchain means, that all the participants of the network are known one another and functions can be segregated for each participant based on a given role; Despite of a permissionless Blockchain, where participants are anonymous, and everybody is equal to the network. This last case, can be referenced with Bitcoin, the cryptocurrency that originated all the Blockchain fuss.

2.2 Supply Chain

It can be define as a set of firms that passes material forward [11]; in line with this, it can also be define as firms that brings, products or services, to the market. Another definition of supply chain, is the network of organization that are involved in the upstream and downstream process in order to add value in the form of product or services delivered to the final costumer [12]. As define by [13] is a set of entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer.

[14] stated that supply chain objective refers to "...processes and activities that produce value in the form of products and services, in the hands of the ultimate consumer", this can be used as an objective of the supply chain management, and for the purpose of this research, added value is one of the most important ingredients of the entire process. Currently, the general supply chain management process, no matter the perspective, has a lack of information for the final consumer. As was seen in the definition above, the process foundation's relays on the communication and integration of a set of actors that manufacture or produce the good or service.

This particular definitions links with the justification of this research, due to the importance of providing valuable information to the final consumer and being an important piece of the chain. Also, it's important to note the definition of [12], but mostly, this statement, Starting with unprocessed raw materials and ending with the final customer using the finished goods, the supply chain links many companies together; our focal point will be working specifically with the food industry, this is simply raw material, that needs to be transformed or processed in order to deliver a finished good to the final consumer, in between those "actors" raw material and final consumer, there are several other, some of those participants of the supply chain according to [15] are (a) Producers or

manufacturers, organizations that make a product. This can include transformation of raw material or the production of finished goods (b) Distributors, are mostly known as a wholesaler, (c) Retailers, manage stock inventory and sell in smaller quantities to the general public, (d) Customers or consumers, may be the final end user of a product who buys the product in order to consume it, (e) Service providers, these are organizations that provide services to producers, distributors, retailers, and customers.

2.3 Supply Chain in the Food Industry

Foot industry will become competitive as long it meets the demand requirements and ensure profit to companies [16]; there always a constant related to the costumer, its taste will change over time, and necessary will obligate the industry to adapt faster to this changes and respond accordingly. With this research we are aiming to attack the most critical challenges that can affect the supply chain in the food industry [17] [18], which are, *Cold Chain*, this means to control and trace the product throughout all stages during transportation and storage in a warehouse; *Traceaility*, it refers to the ability to trace the product across all stages of the production and distribution and *Quality*, this is essential in this industry due to the compliance certification that are needed for agricultural products.

2.4 Organic Agriculture

The Research Institute of Organic Agriculture FiBL and IFOAM - Organics International [19], defines organic agriculture as a production system that sustains the health of the ecosystem as a whole, it also relies on ecological process, biodiversity and cycles adapted to local conditions; all of the above, promote a good conditions for the environment and good quality of life for all involved. Another authors cited by [20], defines organic agriculture as a production system that uses natural inputs and special practices, such as crop rotation, and prohibits the use of pesticides, synthetic fertilizers and pesticides, medicines for use in animals, genetically modified seeds, as well as preservatives and additives.

3 Traceability process for organic Colombian coffee

3.1 Proposed Methodology Approach

The integration of the Blockchain with the Supply Chain, will depend on the product characteristics and the added value Blockchain will offer; in this case, will be the traceability of information to certificate the origin of a product to determinate whether is organic or not, like Colombian coffee. Once all of the product characteristics has been defined, the authors proposes to describe the processes involved in the organic coffee production, in order to understand all of the variables that may affect the process and the ones that should be taken into consideration to use for the Blockchain business network; in line with this,

that article suggest to outline all of the information that goes through the entire production process. All of this information will help us to define participants, assets and how the information should flow across the business network.

As it is describes by [21] in their article, this are the steps to consider to integrate a technology like Blockchain to trace the information in a Supply Chain process;

1. Select the product, this definition will be accordingly with the main asset that will define the scope of the Blockchain architecture, it also will help us define processes, operations and components that will be a part of the product identity.
2. Product characteristics, this are attributes that make a product unique and easy to identify. This definition may be one of the most important, considering that those characteristics are the ones to trace with Blockchain to generate the origin certificate.
3. Requirements for production, technical, functional, legal and regulatory, among others; it is important to define those, taking into account that they will lead us to the process that will transform the product from raw material to finish goods.
4. Actors of the process, it will help us to identify all the participants that needed to configure Blockchain business network, their role and scope for transactions.
5. Unit operation and processes, will define the product transformation into finish goods. This will be consider, as the product itself, as assets of the Blockchain business network, will help us transact and to trace the product characteristic needed to certificate the origin of the product.
6. Business rules, are conditions to the processes that will trigger an action. In order to apply rules every time a transaction is made, this are validated by smart contract[2] and, once it goes through, the transaction is added to the blockchain.
7. Digital Assets, it is the product itself that is going to be traceable and the transnational document that is going to support each transaction and have all the information across the process.
8. Information flow, using a data flow diagram will help to understand how the information, regarding the assets, will flow in the process.
9. Configure the blockchain, this means to define the type of business network that will apply to the process, select the software to create the business network and all of its components.
10. Test the new business model, a business network validation to ensure that everything is working according the objective.

3.2 Study Case Description

Nowadays, personal care and health have become imperative among generations, this is what [23] and [24] shows in its study, We are what we eat and what's in our

[2] "Smart Contracts are computer programs that are stored in a completely distributed manner on a blockchain database" [22]

food and on our mind respectively. In this growing market, the proliferation of training centers, gyms, bicycle use and above all, improving eating habits; people are more concerned about knowing what kind of food they are including in their diets, what nutrients they have, where they come from, how there were cultivated, how their selection has been made, among others questions regarding its origins; but sadly, there are some questions that, in most cases, are left unanswered and there is nothing more than trust in the goodwill and response of those who place it at our disposal, whether on a shelf or in a restaurant. Being aware of what we buy and eat favors proper nutrition, as well as the care and maintenance of our health. It is very important to identify nutritional information, ingredients and other recommendations when buying packaged foods [25]. With that being said, we must point out that customers have never been able to actually know in detail the characteristics, attributes and valuable information about the food they are purchasing. In Colombia, according to the Ministerio de la Proteccin Social (2006), the following information is currently necessary for the labeling of food:

- Name of the food
- List of ingredients
- Net content and drained weight
- Name or business name and address of the manufacturer
- Lot identification
- Date of expiration and/or date of minimum duration
- Instructions for use
- Sanitary registration

However, none of the above presented, actually provide information about the different stages and processes to which, for this case, organics food products are subjected from their harvesting throughout the supply chain to the final consumer. In an interview conducted by [26], the president of Almacenes Exito, Carlos Mario Giraldo, said that "the market for products with benefits moves about 20 percent of food consumption in the country and grows 10 percent per year, twice the industry as a whole, which evidence the potential market that is behind a good food habits. Now, lets imagine the same scenario but providing information to the customer, that never has been accessed or shared before.

According to the [27], "People are now consuming more foods high in energy, fats, free sugars or salt/sodium, and many do not eat enough fruit, vegetables and dietary fiber such as whole grains". Just as the Blockchain technology is transforming the way we carry out transactions, it might do with many other industries, including the organic food industry, by giving people the opportunity to actually know the origin and traceability (along the process) of what they are eating. With the growing demand in the fitness market, in line with [28] and [23] "Consistent with consumers' rating of the importance of attributes, sales of products with "natural" and "organic" claims have grown 24% and 28%, respectively, over the two-year period". With this information, it can be appreciated how important has become for people, to change its eating habits; specifically, in Colombia, people tend to look for food with local ingredients,

natural and organic alternatives which makes us think about the current state of the transformation process that experience food across the value chain, since its plantation until its placement on a supermarket shelf.

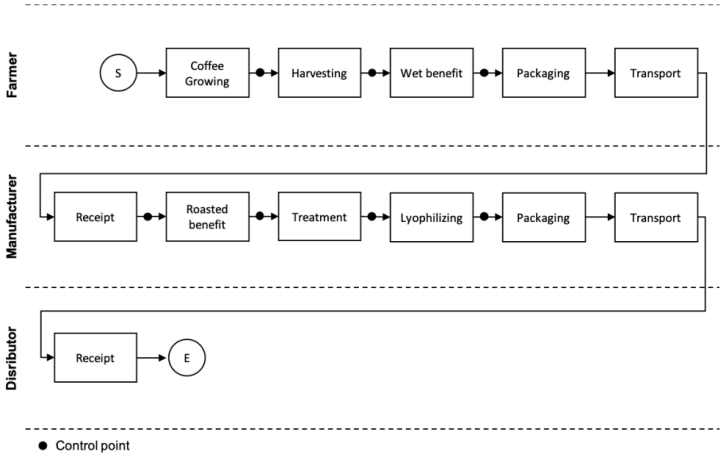


Figure 1. General Coffee Production Process

3.3 Implementation

In order to validate the methodology, prior explained, it has been used the online software Hyperledger Composer Playground provided freely by [29].

1. Define Unit Operations and Processes: In figure 1 is shown the general process for the coffee production, as well as the main participants of the process [30].
2. Define the software architecture for the business network, see figure 2: Based on the architecture for originChain [31], this proposal is considered to used a similar one in order to accomplish the traceability of the product.
   (a) First layer of the architecture defines the life cycle of the product, this takes into consideration upstream and downstream process of the supply chain.
   (b) Layer number two will be consider the application end for the user, this can be an ERP (Enterprise Resource System), a BPMS (Business Process Management System) or any other software able to manage this processes.

(c) Then, there is a third layer, this a relational database, that will host all the information and transaction generated across the business network. It will manage the product information, the traceability database as a master for all transactions, a repository for smart contract and the control of all permissions to access the database.
(d) And last, The fourth layer or the Blockchain layer; this server will store all the transactions defined to safeguard the origin traceability of the product.

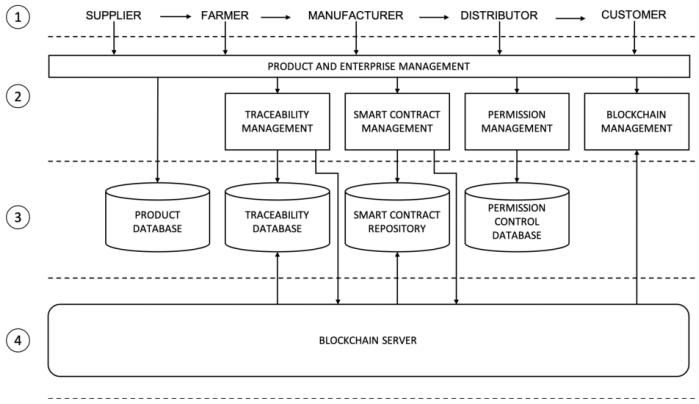


Figure 2. Business Network Architecture

3. Name and describe the new business network: E.g. Organic Colombian Coffee Origin Traceability, this network tracks the supply chain from up stream to down stream processes, from raw material to finished products, which will provide the final customer with information about its origin. A regulator is able to provide oversight throughout this whole process. The business network defines:
   (a) Participants: *Farmer*, *Manufacturer*, *Distributor*, *Regulator*, *Farm*, *Factory*
   (b) Assets: *Coffee*, *Order*
   (c) Transactions: *CoffeeMovements*, *CoffeeMovementArrival*, *CoffeeMovementDeparture*, *PlaceOrder*
   (d) Events: *PlaceOrderEvent*, *UpdateOrderEvent*, *CoffeeMovementEvent*
4. Deploy
5. Connect the new business network

(a) Generate the model files: This will define assets, participants, transactions and events on our business network.
(b) Create the script to manage transactions, as they were define above.
(c) Create the script to manage security access to the the network

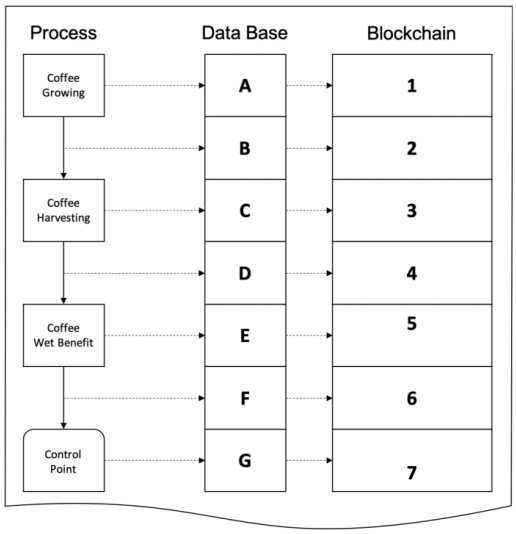


Figure 3. Data Base and Blockchain process storage

4 Results and analysis

4.1 Results

While validating the model, it was determined that the assets that travel along the productive process, in the first instance, have the information, data, technical data that should be treated in a relational database, allowing, from the user interface (UI), to generate all types of transactions. Once this information is stored in the business network (Blockchain), which is done through the use of smart contracts, which will have encoded the transactions that goes to the Blockchain (this is done from layer 2 of the architecture proposal see figure 2). Whenever these transactions, such as the generation of an order, the movement from one

process to another, change of custody between the participants, among others, have been stored into the Blockchain, it generates a unique and immutable record which will be the basis to generate the product traceability of origin. Likewise, with the assets defined in the case study it guarantees, on one hand, to have control of the attributes that are part of the main asset *coffee* and, on the other hand, the control through the *order* everything that happens with the *coffee*; for example, the changes that the coffee has along the processes, the new attributes that are gained or lost, the movements that are made with it, the events that are triggered throughout the process and the custody that is generated, allowing the construction of the - coffee - traceability of origin.

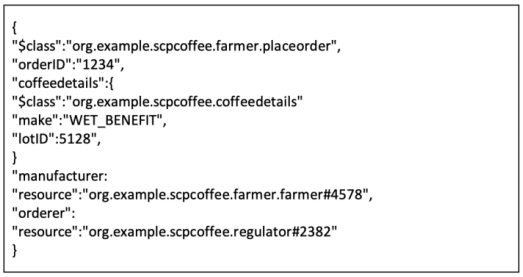
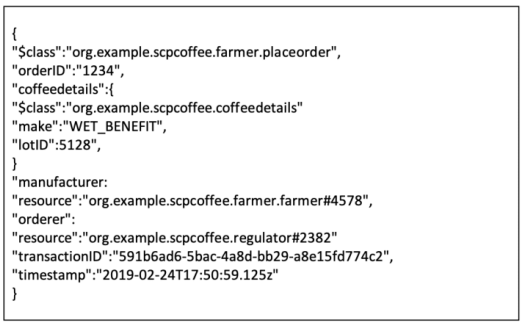


Figure 4. Submit a Transaction, Transaction Type: PlaceOrder

This is how the figure 3 shows that the processes and movements between them, send information to a database from which transactions are generated, and once they are validated by the smart contracts capability, they will be stored in the Blockchain. An example is shown in the following transaction *Submit a Transaction - Transaction Type: PlaceOrder*, in which, for the first time an order is being generated to obtain a wet benefit, which is the final product, in a series of processes, within the productive unit (farm). This order is made on a specific lot to be cultivated, identified as "5128", whose transaction is generated by the participant - farmer - and is in turn assigned to a - regulator -, in order to validate the veracity of the information. That transaction can be observed in the ledger of transaction, see Ledger of transactions - Order Placed, with a transactionID and a specific timestamp. With these records, we generate the validation and traceability of origin of the final product that was born from lot "5128" and whose movements will be recorded as shown in figure 3; where we have the process as it happens. In this example, at the productive unit (farm); form each processes there are transaction that are stored in a Data Base. Transactions A to G..., will have information regarding process, for this example, the coffee growing process attributes such as, Farm ID, Farmer ID, Fertilized used for

the process, Pest Control assignation, Seed type, Seed Color, Seed Sized, Lot Number and Order Number; this transactions will go straight to the Blockchain, as it is shown in figure 3 in the sequence of number (1 to 7...), after a smart contract has verified its validity, and it will create the following transactions, Place Order, e.g. see figure 4, this transaction will be storage on the blockchain with a transaction ID and TimeStamp as shown in figure 5, *Make wet benefit*, Update Order *Coffee Growing*, Event Place Order *make wet coffee*, Event Update Order *Coffee Growing*. This means that, for every transaction created on the business network, there will be a log on the ledger with all those records.



{
"$class":"org.example.scpcoffee.farmer.placeorder",
"orderID":"1234",
"coffeedetails":{
"$class":"org.example.scpcoffee.coffeedetails"
"make":"WET_BENEFIT",
"lotID":5128",
}
"manufacturer:
"resource":"org.example.scpcoffee.farmer.farmer#4578",
"orderer":
"resource":"org.example.scpcoffee.regulator#2382"
"transactionID":"591b6ad6-5bac-4a8d-bb29-a8e15fd774c2",
"timestamp":"2019-02-24T17:50:59.125z"
}

Figure 5. Ledger of Transactions, Transaction Type: PlaceOrder

4.2 Analisys

- It is necessary, in the architecture of the business network, to have a relational database that allows to store all the transactions in a traceability repository (as shown in figure 2), with the aim of validating the transactions against the information stored in the Blockchain
- The check points of the model allow to generate audits by a "regulator", as it is called in this case study, because the information manipulated through the entire process must be entered by the different "participants"; even with this technology, the data it is not exempt from manipulation before its registration.
- In order to minimize the risks of altering the information, it is recommended to automate the entire process from start to finish. This will help to have the information from the original source, which can be sensors, meters or

other Internet of Things[3] (IoT) components that allow the reading of data, considering the scope of a project of this type; however is important to consider the limitations for such integration [34]. This information entry would be connected to layer 2 of the proposed architecture, replacing the manual entries of information. This would be limited only to entries that affect the administration and the traceability database.

- To guarantee the traceability of the transactions associated with a particular lot or product, it is recommended to integrate all the participants of the chain. This generates integrity in the information and greater confidence in the data. This particular is of greater impact because any participant outside of the business network, directly affects the confidence of the information and therefore, the final consumer.
- Based on the model described by [21] , the steps 1 to 6 mentioned in their methodology, are considered highly important within the definitions to be made; Knowing the product, its characteristics, the production process, the requirements of the process and its participants, these are the main inputs for the definition of the business network. The business rules defined in the initial model, can be considered from now on the "transactions" to be carried out by the participants of the network, which are made upon assets. The latter are considered the fundamental piece that must be traceable throughout the process. For this case, the study had two main assets, the *coffee* as the protagonist of the process and the *order* that, throughout the process, information is fed to generate the traceability of the product. Finally, there is the information flow, it is an exercise that is not required for the process, it can complement the understanding of the business network; This will depend to a great extent on the transactions that are made and who makes them

5 Conclusions

Through the application and implementation of this model, for the creation of a business network based on Blockchain, it is feasible to obtain the traceability of origin for a product. Our case study refers to organic products, but, without a doubt, this same methodology can be homologated to any product, as long as the use of Blockchain technology generates value to the process.

It is important to note, that Blockchain as a technology, provides support to the process, to ensure that the information has not been altered and is trusted, with the objective of providing information to the end user of the value chain; however, these information sources cannot be susceptible to manipulation before being stored in a Blockchain. That is why, based on the validation of this model implementation, it is recommended to have a robust technological infrastructure that allows to complement and harmonize the different sources of information that, through the transactions, will take the data to the Blockchain.

[3] "A functioning society depends on things and Ashton [32] proposed that that's where the next-generation Internet would help". [33]

In accordance with the above, for the Colombian market, in terms of production of organic coffee, this represents an important cultural challenge; initially, because the processes in coffee farms are carried out mostly manually, it must also be taken into account that automation is an important part of the adoption process of Blockchain technology; Another important point is the reference made to the integration of the participants of the chain, where currently, each of them has its own repositories of information, which can be manual or digital, their own internal information systems for the control of their processes, which makes it difficult to have information integrity and therefore carry out the origin traceability process.

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Annex 5: Design of a software architecture for a Blockchain-based quality certification system.

Software architecture proposal to implement Blockchain technology to support ISO 9001:2015 standard certification

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Abstract During the last decades quality have had an important role in companies, moreover, certifications that guarantee, in fact, the uses of best practices in processes that have been used to generate and deliver a good or service. Nowadays there are software and tools that help companies to achieve these certifications, most knows as BPMN and BPMS (Business Process Management and Notation, Business Process Management System), that works hand in hand with certification entities as an intermediary. This software solutions are often offered and administered by third parties; however, it is difficult to trust the information due to the database architecture used to manage the information and data needed for the certification process. The aim of this research, is to propose a software architecture that supports an ISO 9001:2015 certification process, by taking advantage of the properties, such as immutability that blockchain has to offer in order to guarantee the transparency of the the system and facilitate the audit process.

Keywords: Blockchain, Business Process, Quality, Software, ISO9000.

1 Introduction

As reported by [1], in 2016 there were more than 1 million ISO 9001 certificates issued (in its 2008 and 2015 version); this reaffirms the fact that, in the last decades, quality has become an important factor in the development of companies. Part of this is associated with compliance of the requirements that the market demands when producing a product or a service. To achieve these certifications, it is required to have a quality management system (QMS) adapted to the international standard, in this case ISO 9001: 2015, which consists of a framework and the path to achieve its implementation.

Currently, to obtain this certification, after the implementation of a quality management system, it is necessary to have good management by processes that can be measure; likewise, it is important to have a document management system that helps support all the necessary information and documentation required throughout the certification process.

It is common for companies to hire external consultants and certifying entities to achieve the objectives of the certification; However, part of this process may include the acquisition of software that supports organizations during this process, such a Business Process Management and Notation (BPMN). Within the architecture of these software, whether on-premise or cloud, they uses relational databases, which are composed of a series of tables organized by fields that store information according to a defined structure; these have become the most common for solving the problems of storing and consulting information [2]

This type of database has some drawbacks, as the data structure, they are centralized databases, there is a database manager, data can be altered, modified and / or eliminated, making the transparency and the trustworthy of the information that is stored in it impossible, especially when we talk about information that will be used by certifying entities. Likewise, the audit of the information in these databases is not reliable, because of everything explained above.

This is why our proposal is to take the essence of a quality management systems, with their requirements and principles, to propose a software architecture that integrates Blockchain technology; which, since its inception in 2008, has had a great growth and acceptance in different industries, in order to provide greater confidence and transparency in the information and documentation needed to carry out an ISO 9001:2015 certification process, that allows the audit of this information perform from anywhere by any person with access to the Blockchain.

2 Literature Review

This section explains the foundations of Blockchain technology, the principal concepts regarding quality management and the ISO 9001:2015 standard for certification and finally the BPMN functionality.

2.1 Blockchain

In 2009, as the world was reeling from a meltdown in the financial sector and politicians were musing about what could and should be done, a project called Bitcoin quietly dropped onto the global stage; Satoshi Nakamoto [3] published the article Bitcoin: A Peer-to-Peer Electronic Cash System in October 2018, where he described the cryptocurrency called Bitcoin. Many electronic cash schemes existed prior to Bitcoin, but none of them achieved widespread use. By adopting Blockchain technology, Bitcoin achieved compelling capabilities that promoted its use. The use of a Blockchain enabled Bitcoin to be implemented in a distributed fashion so that no single user controlled the currency and no single point of failure existed [4].

Blockchain may has been used as the underlaying technology for all Bitcoins transactions; but, its applicability goes beyond. This technology itself can be described as the general ledger for all transaction of any kind of assets ever made [5] [6]. Blockchain enables a potentially evolving and open set of parties

to maintain a safe, permanent, and tamper-proof digital ledger of transactions, without a central authority. The key to the technology is that transactions are not recorded centrally, instead, each party maintains a copy of the ledger. A majority of parties need to approve (verify) a new transaction before it can be recorded in the ledger according to a notion of majority that varies depending on the specific technology. Once a transaction is approved, it is practically impossible to change it or remove it. Hence, Blockchain technology can be seen as a replicated append-only transactional data store, and hence it can be used as a substitute for centralized registers maintained by single trusted authorities [7], it has the potential to revolutionize the digital world by enabling a distributed consensus where each and every online transaction involving digital assets, past and present, can be verified at any time in the future. It does this without compromising the privacy of the digital assets and parties involved. The distributed consensus and anonymity are two important characteristics of Blockchain technology [8].

Due to this technology potential, many industries has been working in order to adapt and adopt it in different business process, the main criteria to decide to use or not Blockchain will be define whether or not the assistance of intermediaries along the process. Here are listed some of the examples [4] on how to use this technology in different industries: (1) Energy, Blockchain platforms will also likely take some role in replacing the systems that now manage the distribution of electricity. As a smarter grid is built, Blockchains may aid in facilitating dynamic signaling between producers and consumers, especially as the line between those roles continues to blur; (2) Finance, several bank entities are working together to adopt Blockchain technology, mostly for the settlement of transactions between financial entities; this will reduce the time in which a transaction is reflected from one entity to another; (3) Identity Management, maintaining identity in emergency is crucial, with Blockchain the use of an identity management system based on Blockchain will facilitate the identification of anyone; (4) Supply Chain, provenance of products and traceability is one the most important application of Blockchain in order to track the life-cycle of a product, information that can be used to made informed purchased. prior works have been made on this field, e.g [9] that would help to understand its applicability; (5) Telemedicine, as a repository for patient records. All the data about the medical records of a patient shared among all practitioners, making this records trustworthy and immutable.

2.2 Quality management and ISO 9001:2015 standard

Quality Management: Quality can be defined as "fitness for purpose" according to [10]; this mean that no matter what you produce, it must satisfy customer needs and meet their requirements, but, also, it must be efficient for greatest business purposes. Another definitions can be found in the American Society for Quality web page [11] (1)"the characteristics of a product or service that bear on its ability to satisfy stated or implied needs", and (2) "a product or service free of deficiencies" and for last, according to Philip Crosby [12], it means "conformance to requirements". All of the above meanings agreed that quality, in

different perspectives, refers to a product or service that satisfies the customer needs by meeting all requirements.

This term, Quality, is being used in all types of industries across the globe; nowadays it is relevant to have a department for quality assurance, which seek to make sure the production is being carried out under international standards; But, this is not new, in 1920, were planted the first seed for a quality movement in the U.S. industries; business plan were not align with the execution and workers had no participation in it; during the late 20s, the Hawthorne experiment was conducted and showed that workers productivity could be impacted by their participation [13]. Walter Shewhart [14] developed the methods for statistical analysis and control of quality. Later on, in the earlies 50s, American, W. Edwards Deming [15], who helped Japanese companies by giving them a massive head start in the quality movement; his methods include statistical process control (SPC) and problem-solving techniques, which results were the change of mentality in the production of high-quality products and services [16]. According to [15], there were two different concepts of process improvement that quality systems needed to address: (1) common (systematic) causes of error, and (2) special causes of error, this can be considered the origin of TQM[1]; Durng the same decade, Joseph M. Juran taught the concepts of controlling quality and managerial breakthrough, Armand V. Feigenbaums book Total Quality Control [17], a forerunner for the present understanding of TQM, was published, and Philip B. Crosbys promotion of zero defects paved the way for quality improvement in many companies [13]. Then, during the late 60s, the Japanese named their approach to total quality company wide quality control. It is around this time that the term quality management systems arises [13]; Kaoru Ishikawas synthesis of the philosophy contributed to Japans ascendancy as a quality leader. And, as of today, TQM is the name for the philosophy of a broad and systemic approach to managing organizational quality. Quality standards such as the ISO 9000 series and quality award programs such as the Deming Prize and the Malcolm Baldrige National Quality Award specify principles and processes that comprise TQM [13].

Today we have been many interpretations of what quality is, beyond the dictionary definition of general goodness. Other terms describing quality include reduction of variation, value-added, and conformance to specifications. ISO 9001:2015 Quality management systemsFundamentals and vocabulary defines quality as the degree to which a set of inherent characteristics of an object fulfills requirements. Simply stated, quality is meeting customer requirements. A system of quality management includes all activities of the overall management function that determine the quality policy, objectives, and responsibilities and their implementation. As ISO 9001:2015 explains, a management system provides the means of establishing a policy and objectives and the means to achieve those objectives.

ISO-9001 standards: The ISO 9001, is a series of quality management systems (QMS), that are generic. These standards applies to the business process within

[1] Total Quality Management

an organization and can be used by manufacturing or service industries. [18]; also accordingly to Yin and Schmeidler [19] This standardized system may be implemented in different ways depending on organization management, given the flexibility and the scope for the certification process, which might explain the heterogeneous performance of these standardized systems.The standard was first release in 1987, since then, it has been the major quality movement and framework for all kind of organization worldwide; it is estimated than more the 1 million companies has adopted this standard since its creation [20].

According to the American Society for Quality [21] ISO 9001 is based on a plan-do-check-act methodology and provides a process-oriented approach to documenting and reviewing the structure, responsibilities, and procedures required to achieve effective quality management in an organization. Specific sections of the standard contain information on topics such as, requirements for a quality management system, including documented information, planning and determining process interactions; responsibilities of management; management of resources, including human resources and an organizations work environment; product realization, including the steps from design to delivery; measurement, analysis, and improvement of the QMS through activities like internal audits and corrective and preventive action.

Principles of a certification system: The foundation of ISO 9001:2015 standard is based on eight of principles that establish the path for any implementation. According to [22], this principles are shown in Table 1.

This principles are not rigid for management to implement, this will vary from organization to organization and their structures, it is important to note that this will provide the organizations with the flexibility they need according to business requirements; however, this may change over the time and evolve to adapt to functional areas and business processes [23].

Structure of the ISO-9001 Standard Certification Process: To be ISO 9001 QMS certified, an organization has its QMS audited by an independent certification body, to access if it fulfills ISO 9001 requirements and achieves the intended results. The certification body should demonstrate that it has competent management and staff and that it is impartial and free from conflicts of interest [24].

The steps to a successful implementation suggested by [25] are:

1. **Make the right choice:** Make sure the standard you have chosen fits your organization needs; also make sure you already have processes that can be assessed.
2. **Reviewing the standard:** You will have to purchase a copy of the standard, sold by ISO themselves. This will help you to learn the quality management system you want to be certified.
3. **Communicating the goal:** An ISO quality management implementation requires team-work from all your collaborators. Additional effort, besides daily

Table 1. ISO Quality Management Principles.

Quality Principles	Description
Customer Focus	Sustained success is achieved when an organization attracts and retains the confidence of customers and other interested parties. Every aspect of customer interaction provides an opportunity to create more value for the customer. Understanding current and future needs of customers and other interested parties contributes to sustained success of the organization.
Leadership	Creation of unity of purpose and direction and engagement of people enable an organization to align its strategies, policies, processes and resources to achieve its objectives.
Engagement of people	To manage an organization effectively and efficiently, it is important to involve all people at all levels and to respect them as individuals. Recognition, empowerment and enhancement of competence facilitate the engagement of people in achieving the organizations quality objectives.
Process Approach	The quality management system consists of inter- related processes. Understanding how results are produced by this system enables an organization to optimize the system and its performance.
Improvement	Improvement is essential for an organization to maintain current levels of performance, to react to changes in its internal and external conditions and to create new opportunities.
Evidence-based decision making	Decision making can be a complex process, and it always involves some uncertainty. It often involves multiple types and sources of inputs, as well as their interpretation, which can be subjective. It is important to understand cause-and-effect relationships and potential unintended consequences. Facts, evidence and data analysis lead to greater objectivity and confidence in decision making.
Relationship Management	Interested parties influence the performance of an organization. Sustained success is more likely to be achieved when the organization manages relationships with all of its interested parties to optimize their impact on its performance. Relationship management with its sup- plier and partner networks is of particular importance.

operations, will be requested; it is important to communicate the objectives and the target to be achieved.

4. **Establish training requirements:** Get prepared to be ready. Based on your team knowledge about the standard, could be beneficial to improve your skills to help the implementation process
5. **Using a consultant:** ISO standards implementation requires a consultant to help companies get certified. It is not consultants responsibility implementing the ISO standard. Each company is responsible for the implementation, senior management should be actively involved during the process to achieve the goal.
6. **Select a certification body:** ISO implementations are based on a 3 year cycle; make sure the certification body can provide you with companionship you need for this specific objective.
7. **Developing a management system:** This standards are applicable for any type of organization in any industry sector. The framework provided for this standard wont tell you how to manage processes in your organization; you have to implement a quality management system base on the standard that applies to your organization in concordance with your resources , production, measurement, analysis and improvements.
8. **The stage 1 audit:** The process starts with a "Stage 1 Audit". The auditor will review your process and provides a gap analysis that will help to identify the actions requires to meet the standard.
9. **The stage 2 audit:** Once your organization has filled the gaps identify during stage 1 audit, it comes the Stage 2 Audit, this will demonstrate the effectiveness of your quality management system and that your organization meets the requirement for certification.
10. **Maintaining the management system:** This can be the hardest part of the certification, it is your responsibility to ensure that your organization applies the quality management system once the certification have been granted. Communication and training will be necessary along the way, internal audits must be implemented to make sure the standards are being met and corrective action should be held to assure quality management.

3 ISO 9001:2015 Quality assurance and certification through a BPMN-Blockchain-based software architecture proposal

In this chapter, we aim to explain the architecture proposal for a BPMN-Blockchain-based software that supports an ISO 9001:2015 certification, based on the main characteristic and components of the Blockchain technology.

3.1 Proposal development

With the use of an information system to achieve ISO 9001: 2015 certification, is proposed to improve the current certification structure. As we have seen in

Figure 1. Example of a software architecture used for Total Quality Management.

section 2.2, there is currently a well-defined process to achieve this, involving third parties in the process, in terms of consulting and auditing.

An information system architecture without the use of Blockchain, such as those that currently exist in the market, see Figure 1, may make unnecessary to use a consulting company to generate pre-audit readiness; However, this same information system, using Blockchain technology, can facilitate the audit process, due to the way in which the Blockchain is constructed, the traceability of the transactions generated during the preparation of the certification process can be determined. In this case, the proposal of using Blockchain to support a quality certification under a specific standard, this means, the same software architecture we already know with an additional layer, see Figure 2, must consider the use of specifics Blockchain components as presented in Table 2, with the purpose of being able to validate conditions and business rules that are present in the information that is being stored into the Blockchain [26]. Given the fact, that an audit model must generate action plans regarding the findings, they must be parameterized a priory, so that the necessary alarms can be generated to comply with the standard.

The main component of this architecture proposed in Figure 2, is the Business Process Management Layer, which consist on a BPMN (Business Process Management and Notation), This is a standard developed by the Business Process Management institute, that was release in 2004; nowadays, there is a new version of this standard BPMN 2.0, which is used to communicate information among different audiences [27]. It uses a flowchart technique tailored to generate graphi-

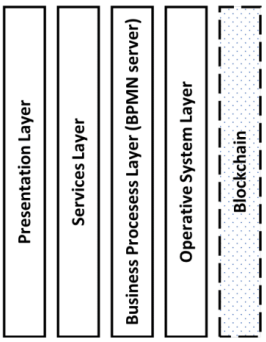

Figure 2. Blockchain-based Software architecture proposal.

cal business process operations. These networks are a set of common elements that are familiar to any business analyst, the flow basic categories are, (1) flow objects (event, activity and gateways), (2) connecting objects (sequence flow, message flow and associations),(3) swim-lanes (pool and lane) and (4) artifacts (Data object, group and annotation) [28].

This standard has been developed into software solutions that allow organizations to model their business process. With a proper implementation of these software solutions, BPMN can be use to support a QMS strategy in any organization; For this, as it is suggested by the ISO, is necessary to involve different organization stakeholders', in order to generate the best model for the organization. Studies such as [34], has shown that BPMN implementations are important for quality management and most cases are needed; however, studies like [35], concluded that standardization of processes among companies facilitates the adoption of BPMN standards and therefore softwares.

Now, due to the nature of each company and the fact that these standards (ISO and BPMN) are a guide rather than something tax, these processes, smart contracts and alerts, must be personalized according to the corporate objective of each company; each one, will have its own processes, indicators and results, which means that the support cannot be provided through a static system.

Previews studies [36], [37] and [32] conducted by IBM, have shown the integration between a BPMN software and a Blockchain; they have managed to integrate these technologies in a unique solution, where "the shared ledger provides the interface for business processes, a process queries asset information and performs transactions directly on the ledger" [36].

As shown in Figure 3 The communication between the two layers will be through REST[3] API[4] Services, which end points are provided by the Blockchain

[3] Representational State Transfer
[4] application programming interface

Table 2. Principal components of a Blockchain-software solution to support ISO certification.

Blockchain Components	Description
Node Application	Each Internet connected computer have to run a specific application to be a participant on the Blockchain Network. In a more technical look, each computer must be able to process application specific messages to generate an update on the ledger [29].
Shared Ledger	Is a logic component, it is a data structure manage inside the node application. Each of the participant of the network, once they have installed the node application, have access to the Shared Ledger of the ecosystem they have access to. each participant is able to run as many applications they have permitted to use, according they specific rules, smart contract and payment when apply [29].
Consensus	Is the process by which a network or node, guarantee the ordering of transactions and confirm its validity, in order to validate the block of chain [30].
Smart Contracts	These are an important component of a Blockchain, which help you to encode automatic validation for a transaction that before were specified on a written contract [31]
Alerts	This are applications that work together in the Blockchain to monitor the smart contract results and produce events [32]
Participants	In a permissioned Blockchain Network like the one suggested in this paper, participants will be everyone involve within the organization that need to communicate with the Blockchain (see Figure 5). For a permissionless Blockchain like Bitcoin, anyone with a virtual wallet [2] will be a participant of the network.
Virtual Machine	It is a representation of a machine by a machine, in software development a virtual machine assigns specific capabilities for the software (disk space, processor and memory) that would help to improve performance [33]. In Blockchain, as the last logic component, it lives in the node application and some of these virtual machines are call wallets [29].

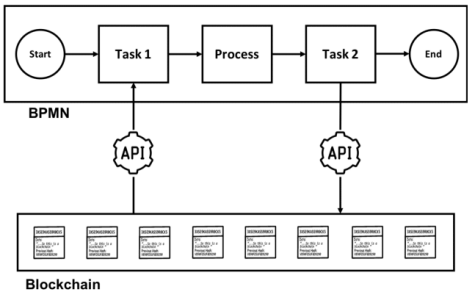

Figure 3. Architecture to communicate the Blockchain with the BPMN.

and will be connected to the BPMN server Creating the Block of chains (Figure 1). For each transaction performed in the BPMN that triggers a call to the Blockchain, will start a process (see Figure 4) to verify the validity of the transaction (consensus), validate the outcome of the process through the smart contract (validation), which will establish whether the processes is inside the control limits or not; with this information it will send a response to the BPMN server (alert) for the business process owner to take actions on the process, that, at the end, for this kind of certification will be a consider an opportunity for improvement and finally store the information on the Blockchain (Block 1).

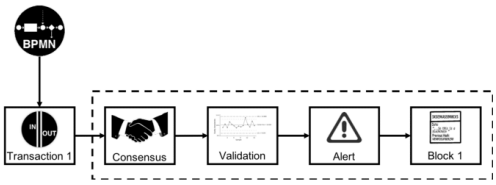

Figure 4. Process that occurs inside the Blockchain every time, prior to stored a transaction.

With this proposal, we are attempting to make ISO certifications more transparent. Due to the Blockchain architecture, information regarding certification will be available for review and verification by anyone with permissions; Also business will have an integrated system that will ensure that all processes involve for certification are being monitored all the time, sending sign when needed; collecting information regarding quality inspections, materials, products and

more, this information is constantly being verified by the smart contract on the Blockchain and then make it available for audit [26].

This software architecture is propose to work under a permissioned Blockchain, which means, the administrator, in conjunction with the organization, will decide who gets to participate and their roles as shown in Figure 5.

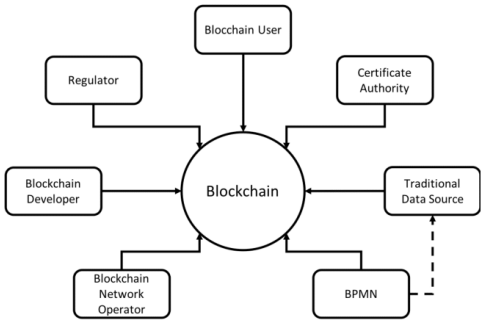

Figure 5. Participants in a Permissioned Blockchain Network.

4 Conclusions

Blockchain is having a hype among different industries, proposing disruptive business models and embracing new concepts in this era of technology.

On the other hand, quality has been always present, not only for organizations, but for humanity in general, everyday people empowered themselves to strive for excellence and quality in daily activities; however, organization has taken a step forward with the ISO 9001 certification, that certifies an organization quality standard application for its product or services.

A proposal for a software architecture that support this certification, as well as an idea of the different component that should have to do so, is presented in this paper. Blockchain seeks to improve the ISO 9001:2015 certification audit process by maintaining traceability and immutability of all the record stored in it.

Also, is important to conclude that an information system architecture that includes Blockchain to support this kind of certification process, can be related with the eight principles of the ISO 9001:2015 standard, explained in Table 1. An architecture like this is completely oriented to process, due to the BPMN; the Blockchain, with its components (see Table 2) allows the organization to be in a constant improvement environment, have evidences to make important

decisions; Leadership and engagement of people will be immerse in each aspect of the organization, at the end, will be the participants of the network (employees) the ones that interact with the processes and the data; additionally, as long as the processes are being performed and improved along the way, more quality products and services will be delivered; and for last, a permissioned Blockchain-based (Figure 5) system will allow your enterprise architecture expand to be integrated with the ecosystem of organizations that works with yours such as providers, customer, third parties and governmental entities, can have access to the information you allow them to see, in order to verify compliance, and standard certifications like ISO 9001:2015.

5 Future work

Next steps of this work, will be applying the software architecture presented here in a practical situation.

For this, will be required to develop the entire software based on this proposal, and work together with an ISO certification entity in order to gather all of the software requirements need to build it. Also, technical details for the Blockchain structure will be objective for another research, in order to guarantee that Blockchain main characteristics, such as traceability, provenance, easy auditability among others, will support this proposal and will improve the certification process.

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