POLITECNICO DI TORINO.

Master of Science Thesis.

Master of Science in Engineering and Management.

Blockchain Technology for Parcel Delivery Systems.

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Abstract.

With the incredible growth of internet shopping over the last years, the delivery sector has gained increasing importance between existing economies, and the same has happened with the pressure, exigencies and expectations from consumers towards home delivery schemes. It is mainly because of this that it is important to pursuit the development of a delivery system that is consistent with this continuous rise of online commerce, while at the same time avoiding the possible negative effects caused by freight transports. It is under this context that the blockchain technology is to be analyzed. Being widely examined and implemented in the finance field, this technology shows great potential for its exploitation within different areas, including logistics.

This dissertation attempts to provide with a general notion of the blockchain's characteristics, its capability and possible applications in the logistics field, particularly into parcel delivery systems. After an information gathering, and properly introducing the principal subjects of interest, this paper makes use of a case study and application case scenario so as to recognize and explore existing projects and research on the matter, as well as to set the ground for further investigation and developments.

Final analysis includes the impact of the technology's implementation upon the actors inside a delivery system and a proposed business model representation, its complexity and compatibility regarding current practices, and how the main problematics concerning delivery services are addressed by employing a blockchain-based alternative.

Key terms: Blockchain Technology; Parcel Delivery; Urban Logistics; Smart Contracts; Supply Chain; Freight Transportation.

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I would firstly like to thank my friends and family, for supporting me through this entire process, and for their constant encouragement and infinite patience.

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Introduction.

Background

The delivery sector has been involved in a continuous grow phase over the past years and so has its repercussion among global economies. Recent estimations show that the approximate cost of global parcel delivery exceeds the €70 billion, with leading economies accounting for most of the market share, and an incredible high dynamism, with grow rates from about 10 percent in mature economies to almost 100 in emerging markets (Joerss, 2016). This rapid expansion is strictly connected to the violent growth of online shopping or E-commerce, and its deviation towards the B2C market. In 2017, for example, the worldwide retail online sales reached the 2.3 trillion dollars, and revenues are expected to continue increasing in the next years (Statista, 2018).

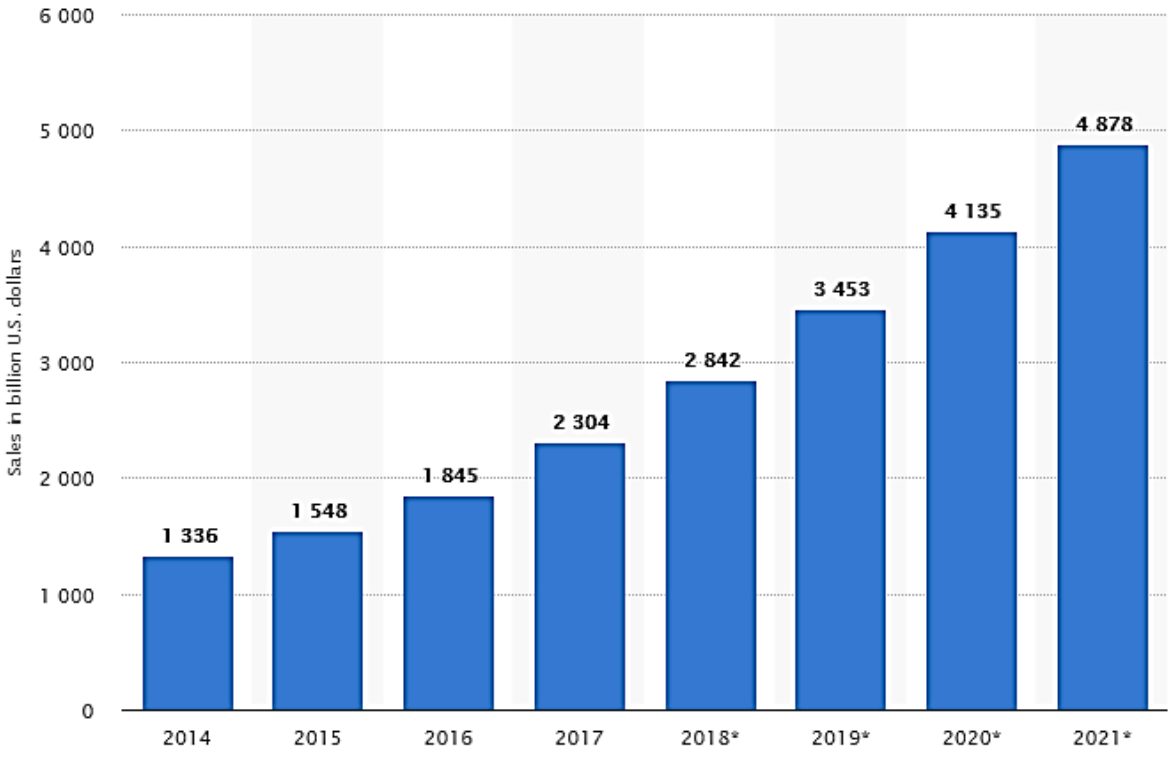

Figure 1 - Worldwide retail e-commerce sales. (Source: www.statista.com)

By shopping on the internet, consumers have access to products and services offered on the market without the need of a physical point of sale. However, most products acquired

online must be physically delivered to the user, and so home delivery stands as one of the key elements in E-commerce, playing a crucial role in the distribution chain. Alongside this raise in the delivery sector, consumer preferences have also gained increased relevance, and delivery services have been identified as a differentiation element among market players. To this end, companies seek to offer customers with the best possible experience, with a wide variety of delivery options and constant efforts to improve delivery times and the service quality perceived.

It is mainly because of this that it is important to pursuit the development of a cargo transportation system that is consistent with this continuous growth of online commerce, but at the same time avoiding the possible negative effects caused by freight transports (Park & Regan, 2004). One of the many complications to achieve this is the so-called 'last mile problem'. While it is relatively simple to transport goods between two of a company's established storage facilities, the issue arises with the need to deliver the product to the costumer's home, mostly because of the extensive diversion of delivery addresses. This matter provides with the opportunity to investigate and innovate searching for improvements, and it is among this possible technological solutions that the blockchain comes in (Jackson, 2018). This technology, based on a distributed ledger, and its principal characteristics could be proven useful to address existing concerns, and provide with a secure and reliable platform on which to conduct the business' activities.

Purpose and Scope

This paper will mainly focus on the Blockchain Technology and its potential implications in the logistics field, more specifically into Parcel Delivery systems. After proper introduction of the core subject, this thesis will aim to provide the reader with a general notion of the technology's capability and its characteristic features outside the financial sector, where it is more commonly associated with, mostly concerning the supply chain, urban logistics and package delivery. What is more, it will attempt to explore and identify possible applications for this technology in the target field, in order to recognize and understand existing projects and ventures regarding the matter, and to set a solid ground for future research and development.

Limitations

The research area is limited to the Blockchain Technology's functioning principle, its pertinent characteristics and applications, and its relation to the logistics and delivery sector. Any specifics regarding deep protocol understanding, technicalities for data processing methods, other high-specified knowledge requiring information and its implication to different fields will be disregarded and left out of the study for being out of scope.

Research and Work Structure.

For the purpose of this paper, the most logical and beneficial first step is to conduct a vast and scope-directed information gathering, including the main subjects to be further developed in the study. Both academic and non-academic sources will be explored in search for papers and documents regarding the following topics: Parcel Delivery Systems, Urban Logistics, Peer to Peer System, Distributed Ledgers, the Blockchain technology, Smart Contracts and Blockchain platforms. After reviewing and analyzing the obtained material, a proper introduction framework can be assembled on which to construct the project's core development. Later on, a case study concerning a start-up's whitepaper (implementing the Blockchain Tech on the parcel delivery field) is to be presented and examined, outlining the technology's main contributions for the improvement of existing delivery systems.

In addition, considering the data acquired on the literature review and the case study model, a hypothetical application scenario will be briefly presented alongside a proposed blockchain based delivery system. Lastly, a final analysis will be carried out comparing the development and performance of delivery processes with and without blockchain technology-based protocols, the actual value perceived after the application of this technology from the point of view of different actors implicated, and a canvas representation of a possible solution.

Theoretical Framework.

Parcel Delivery.

Also known as Package delivery, it consists on the distribution of parcels, mail, or shipping containers, in single shipments. In other words, a determined freight is transported from an original location to an established destination, where it is delivered to a receiver. Four types of main stakeholders can be identified in this system, those being launchers, consumers or receivers, governments and logistic service providers, including carriers and warehouse managers. What is more, the relation between expeditor and receiver can take the forms of B2B (Business to business), B2C (Business to Customer) or C2C (Customer to Customer), depending on the case (Visser, Nemoto, & Browne, 2014). Nowadays, most postal systems provide this service as well as private courier companies and LTL (Less than truckload) shipping carriers.

Depending on the weight and size of the freight, this delivery process can be carried out by Parcel carriers, usually for small and individual packages, LTL shipping when the cargo is relatively small and preferably in the form of a unit load or pallet as to avoid unnecessary handling, or full truckload carriers, which transport freights in semi-trailers, in amounts big enough to allow the process to be profitable. Figure 1 presents a classic distribution of the freight transport market, considering delivery time and weight to be moved.

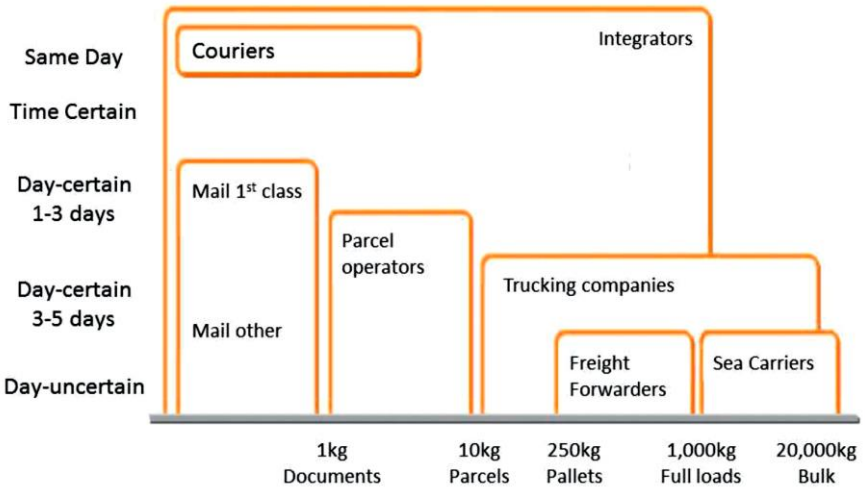

Figure 2 - The freight transport market (Source: TNT Express)

The delivery of a product to the customer's door is logistically challenging due to a number of factors and is potentially very expensive (Boyer, Prud'homme, & Chung, 2009), this is why the above mentioned systems present an extremely detailed action plan containing a network of facilities, warehouses, vehicles and personnel, combined with supply chain and urban logistics, specialized software and defined procedures. Tracking and control systems play an important role in the delivery process as well, in order to label and identify packages, and to monitor their status through the entire process. Each order requires a unique strategy and a different combination of resources depending on the specifics of the case. When dealing with large goods or heavy packages, furniture or appliances for example, the logistical approach to be applied differs from that of small parcels, as they turn out to be more complex and carry a higher risk towards errors and damages. Usually LTL shipping carriers handle the transportation of this kind of goods from the producer/ distributor/ provider to a determined storage facility, accordingly to the delivery destination. Once the order arrives to this facility, a dedicated last mile carrier takes care of the cargo until order completion.

In some cases, freights must be handled several times during transit, stopping at a number of storage facilities, and moved by different carriers and means of transport. It is because of this, that caution and efforts must be considered, not only to protect products while on the move, but also to ensure an adequate delivery route and proper tracking.

Actors.

As it was said before, there are four main types of stakeholders in a Parcel Delivery scheme, each of whom holds its own interests, obligations and rights, and are connected to the system in a different way. At the same time, each of these categories can be further explored so as to unveil its principal actors.

- To begin with, expeditors or senders englobe all those entities, persons or companies, that wish to start a delivery process by launching a determined item. From large retailers and manufacturers distributing their production, to single individuals sending a gift to a friend, every launcher presents a similar set of interests and concerns regarding the process. Mainly, their interest lays in the assurance that the good will be properly handled, according to what was stipulated in the delivery agreement, and will arrive in time and form to its corresponding

receiver, while usually seeking for the most cost-efficient manner. Other concerns may include eco-friendly or time-reducing goals. Simultaneously, they have the obligation to give compensation to the service provider involved, and are bound to any condition previously stated and agreed.

- Customers or receivers are all those who expect to get a certain item delivered. They are the final objective of a delivery scheme and give closure to the process upon receival. Like in the previous case, these aspire to receive the item/s in perfect conditions and in time. Again, any business or individual can take the place of a recipient and, depending on the case, could participate in the delivery planning or not.
- Defining the role of the government or involved state entity in the process is far more complicated, and cannot be generalized for every case. For different situations, different branches may be intricated and in various ways. Local, regional, national or even international administrations can interact with the process, and their laws and regulations rule over it. Taxes, environmental laws and legal requirements are some examples of how regulating authorities affect and conditionate businesses and procedures in the delivery sector.
- Lastly, the service provider segment includes every individual or organization whose business activities focus on aiding, supporting and carrying out delivery processes. This may include logistics planning and management, activity supervision, storage control, product handling and transporting, client services, among other related tasks. Many large enterprises in the “Courier, Express and Parcel sector (CEP)” develop their activities in the delivery market (Ducret, 2014), as well as some public entities like post offices. Even individuals as private carriers can take part in. Their participation implies the execution and accomplishment of the given duties and obligations, in a stipulated time period, in exchange of a retribution.

The following figure presents a categorization of players in the CEP sector according to the mentioned author, considering a clear distinction between actors with a classical approach and behavior in the field (The Heirs) and a rather new group with relatively new ideas regarding strategies and organization, and a more innovative business philosophy.

PLAYERS' FAMILIES	THE HEIRS				THE OTHER PLAYERS		THE NEW PLAYERS			
	National Post Office	Express providers	Logistics providers in the mail-order sales sector	Couriers	Other logistics providers and carriers	Sub-contractors	Pickup point networks	Players from the e-retail sector	Other postal authorized players	Specialized delivery service providers
CORE BUSINESS	Courier, express and parcel delivery				Heavy goods delivery	Transport. No real specialization	Specialization in urban parcel delivery			
STRATEGIC POSITION REGARDING URBAN PARCEL DISTRIBUTION	Adapting and diversifying Strengthening their position or playing a new role				Diversifying Parcel delivery as a secondary activity and a growth area		New services Service innovation and sustainability first			
LOGISTICS ORGANIZATIONS	Classic logistics organizations and innovative ones				Mostly classic logistics organizations		Innovative logistics organizations			
GERMANY	- Deutsche Post-DHL - TNT Post Deutschland, UPS, Fedex, DPD, GLS - Messenger, Gol, Kurier AG, CTS City Transport System Citybiker, Rapid Kurierdienste KG, Sprint Logistik, etc - Hermes.				[insufficient knowledge about the German situation]		Hermes, DPD Parcel Shops, Packstations			
FRANCE	- La Poste - DHL, TNT, UPS, Fedex - Relais Colis, Mondial Relais - Becycle, Les nouveaux coursiers, Dilitrans, etc.				- Deret, Geodis, Green Way, GLS, etc.		- Kiala, Pickup Point, Relais Colis Pickup point network, Point Relais - C-Discount - Colis Privé - Colizen, The Green Link, Vert chez Vous, etc.			
UK	- Royal Mail - DHL, TNT Post UK, UPS, Fedex, GLS, Geopost, - City Bikes, City Sprint, City cycle Courier, Green Link York, etc.				- City Link, Yodel, Parcel Force, etc.		- Hermes, UPS Access Point, CollectPlus - Amazon lockers - Home delivery network, etc.			

Figure 3 - Families of players of the urban parcel delivery sector and examples in European markets. (Source: Ducret, 2014).

Literature Review - Problematics.

Nowadays, almost everyone is somehow involved with delivery processes, either as a service user, provider or manager. It is easy to see that it affects the way in which people live and carry out their economic activities, and for this reason delivery systems are constantly evolving and incorporating new technologies, techniques and methodologies. Despite being a broadly discussed subject, and concerning most people in modern societies, new issues and concerns come up on a regular basis as a consequence of progress itself, and so there is always room for further improvement.

It is mainly because of this continuous progress that such large amount of literature regarding the matter is available on both, academic and non-academic sources. The paper by Ducret, (2014) called “Parcel deliveries and urban logistics: Changes and challenges in the courier express and parcel sector in Europe” is a clear example. It focuses on the mentioned progressive evolution in the study area, and provides with a glimpse of how these main changes took place over the past years. Moreover, it highlights the principal drivers for this changes (like the increasing complexity and merging of B2B and B2C deliveries and the growing implication of authorities over them), and the sector’s reaction towards this progression, including the appearance of new players, market share redistributions, new logistic strategies and further efforts for innovation.

In a similar way, stepping back a few years into this delivery system’s transformation process, the authors (Park & Regan, 2004) analyze this mentioned changes, and present a series of issues strongly linked to home delivery and the boom of E-commerce, that are still present actually and have been shaping delivery services since their appearance. Namely the ‘Not-at-home problem’ that occurs when the customer is not available to receive the package, the constantly increasing need for faster, more efficient and reliable deliveries, and the problem of reverse logistics related to the return of goods. Over time, and with the help of new technologies and expertise, these matters have been approached and solutions have been developed. Take the work by (Jung, Lee, & Chun, 2006), “Integration of GIS, GPS, and optimization technologies for the effective control of parcel delivery service” for instance, regarding the application of optimization technologies into monitoring and control systems, and addressing the issue of delivery logistics planning. But as these systems progress and are further developed, greater and more complicated are the challenges that arise.

Modern shopping habits along with the exponential growth of online commerce and home delivery cause intense pressure over dedicated delivery services, and generate complex logistics planning (Morganti, Seidel, Blanquart, Dablanc, & Lenz, 2014). This high quantity of orders combined with the need to fragmentate shipments, specially in the final part of the delivery process, is one of the principal problems concerning these services, known as the ‘Last Mile Challenge’. In order to achieve the most time and cost-effective delivery scheme, actors in the sector establish different strategies and constantly seek for

improvements, designing innovative and better delivery models. Morganti et Al, 2014, describe on their work "The impact of e-commerce on final deliveries: alternative parcel delivery services in France and Germany" how two well-established markets approach the matter with alternative solutions. Analogously, (Boyer, Prud'homme, & Chung, 2009) express the relevance of this challenge and recognize its effect on costs perceived.

Higher delivery density on a specific area translates to fewer delivery trips, however, this could cause more complicated routing. This is the reason why companies seek for more adequate models taking into consideration different delivery routes and time windows to maximize efficiency. Researchers from the University of Modena and Reggio Emilia, Italy, (Dell'Amico & Hadjidimitriou, 2012) also present a possible solution for improving the situation. They suggest a variant for the typical logistic distribution based on the use of two kind of vehicles and 'Load Units', prepared on warehouses and storage facilities, for reducing distances travelled inside urban areas and thus reducing costs and the environmental impact. This mentioned report, as in many other studies, highlights how the use of pick-up stations can be extremely beneficial in terms of logistics, costs and environmental sustainability.

Since logistics represent a key element in any delivery system, it is common practice to model different scenarios together with their hypothesis and optimization criteria. A number of studies are conducted proposing new models and optimization tools alongside its corresponding case study. An example is the paper by (Guyon, Absi, Feillet, & Garaix, 2012) where a mathematical model is applied to a real case scenario, and optimization software is employed to run different simulations.

Continuing with this analysis, as it was already mentioned, another widely discussed matter in the field is the impact caused by freight transport on traffic and the environment. This can be seen on the study by (Visser, Nemoto, & Browne, 2014), claiming that increasing home delivery means more freight traffic, and not necessarily a reduction in consumer related traffic. Since online shopping does not translate to less shopping-related traffic (the actual situation cannot be considered on such a linear relationship), and specially with the case of small-lot delivery, increased traffic can be caused, predominantly on residential and high-density urban areas. Furthermore, a growing amount of deliveries and vehicle

circulation is strictly connected to ecological concerns, in particular those regarding CO_2 emissions, noise pollution and sustainability issues like fossil fuel dependency.

As an initiative to counter these negative impacts, policies and regulations are established by various entities like governments, administrations and companies themselves. Referred measures may include low emission areas, weight limitations, time and calendar restrictions to mention a few. (Anderson, Allen, & Browne, 2004) from Westminster University give importance to sustainability and conservational objectives stipulated by policy makers, and conduct a research on the vital role of developing adequate strategies for complying with these goals and impositions.

Despite presenting a number of different issues, solutions regarding delivery services mainly spin around arriving to an optimal logistics strategy for every situation. This means that service providers are constantly searching for the most efficient scheme including routing, timing, monitoring and controlling. And since each order requires diverse resources and efforts, these strategies should be as versatile as possible, allowing for proper allocation and planning. An adequate approach could imply fewer routes and transport trips with less mistakes associated, a reduction in costs and delivery times, more efficient transport means with lower ecological impact and an increase in client satisfaction.

Peer to Peer system and Distributed Ledgers.

Peer-to-peer (P2P) technology, or peer computing, is an emerging paradigm that is now viewed as a potential technology to redesign distributed architectures and, consequently, distributed processing (Vu, Lupu, & Ooi, 2010). Contrary to a simple Client-Server model, where resources are stored in the server and can only be accessed by the client upon request, a P2P computing system is composed by a network of peers or nodes which share information and resources without the need for a central entity.

This decentralized organization, where peers work as equals with attributes of both server and client, allows any node holding desired data to respond to a request from another peer, and provides the possibility for nodes to collaborate in order to perform tasks by aggregating the pool of resources (HP Laboratories, 2003). These terminals may belong to different owners, it is common for P2P systems to have several millions of owners, depending on the application (Wai-Sing Loo, 2007). This many-to-many distribution model translates to a faster execution and to an improvement in efficiency compared to a one-to-many model. Furthermore, the hierarchy chain for information sharing can be disrupted, there is no distinction between nodes' roles or contributions, and the system becomes immune to single point failure.

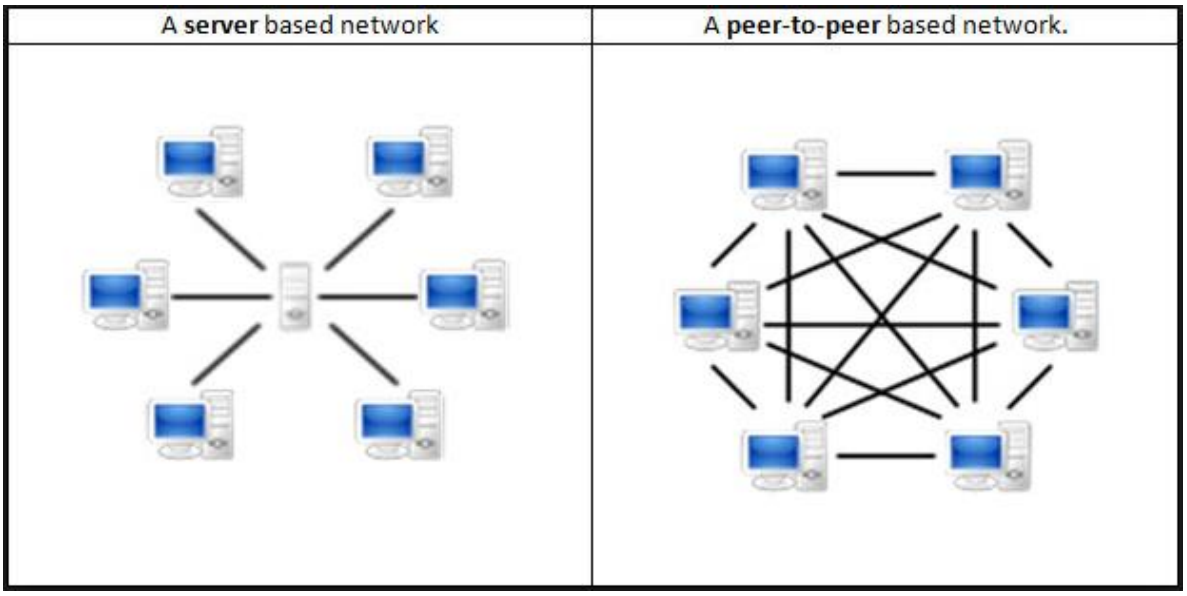

Figure 4 - Server based vs P2P based network (Source: Bitcoinwiki.org)

There are three main aspects in which P2P computing distinguishes itself from traditional distributed computing. In the first place, the scalability of P2P systems exceeds by far that of traditional distributed systems, since P2P systems are able to scale to thousands of nodes, they can employ the power of several computers over the Internet. Secondly, by definition, P2P requires everything to be completely decentralized. Although ideally no centralized structures should exist in P2P systems, there are some exceptions, like hybrid distributions. Finally, and most importantly, P2P applications can perform in highly dynamic environments, particularly in terms of network topology, since P2P nodes can join and leave the system anytime. P2P systems do not present a fixed topology, instead, it adapts accordingly to the nodes in the system, and, in addition, the system's content and load are distributed in real time according to the actual demand and resource capability of nodes (Vu, Lupu, & Ooi, 2010).

The implementation of this system is possible because of internet access and online interaction among peers, and P2P software. P2P architecture can be applied in many different areas, specially when the focus is on exchanging and storing data. The emergence of Peer to Peer systems has led to the widespread use of distributed ledgers. These consist on databases contained among several nodes on a P2P network, in which each device creates and holds an identical copy of the ledger, that is constantly updated. With the lack of a central entity, when an input or modification to the database takes place, an individual node states the event, and the rest of the network must verify by determined algorithms whether if the created copy is correct and accepted. Once consensus is achieved, the rest of the peers are updated with the new complete ledger. To ensure security and trust in this process, the system counts with a series of cryptographic keys as well as safety protocols and procedures.

It is under this concept of Distributed Ledgers that Blockchain Technology can be found and analyzed in depth.

Blockchain Technology.

In a world where cryptocurrency is already widely stablished, and its protagonism in the transaction market increases by the day, take Bitcoin for example (CoinDesk, 2018), the real masterpiece does not lay on the entity itself, but on the system that holds its ground and allows its functionality, the Blockchain Technology. Based on cryptographic proof instead of trust, it enables a digital payment system to conduct transactions between two or more consenting parties directly, instead of relying on centralized intermediaries like banks or other institutions (Mougayar, 2015).

The blockchain, in essence, is a distributed ledger containing information about every transaction made within a P2P system. It is a public consensus system which gets hold of an immutable record of transactions or events on the network, making it impossible for it to be modified afterwards (Apte & Petrovsky, 2016).

The establishment and implementation of blockchain technology into digital currencies solved the so-called double spending problem (Nakamoto, 2008), that had for a long time been associated to it. With the absence of a trusted central authority keeping record, the possibility existed that currency to be used for a transaction has already been spent on another one. This was why timestamps where introduced to register and confirm events in the system in a chronological order. These occurrences need to be validated by a ‘proof of work’ system. This is accomplished by using a hash, which is created from processing original input data with a mathematical algorithm. The results or output of the process represent the hash, that is immediately placed on the blockchain. Once the data is converted, there is no possibility for the process to be reversed, due to the cryptographic function of the hash.

The BC protocol is based on asymmetric encryption mathematics, where the 'key' for encrypting a message or event is different from the one necessary to decrypt it. This is achieved by the existence of both, a private and a public key, mathematically linked. Any transaction can be verified by any terminal on the network with the public key, however, only the parties to a new event can encrypt and decrypt the concerned information by employing their private keys. (Badzar, 2016).

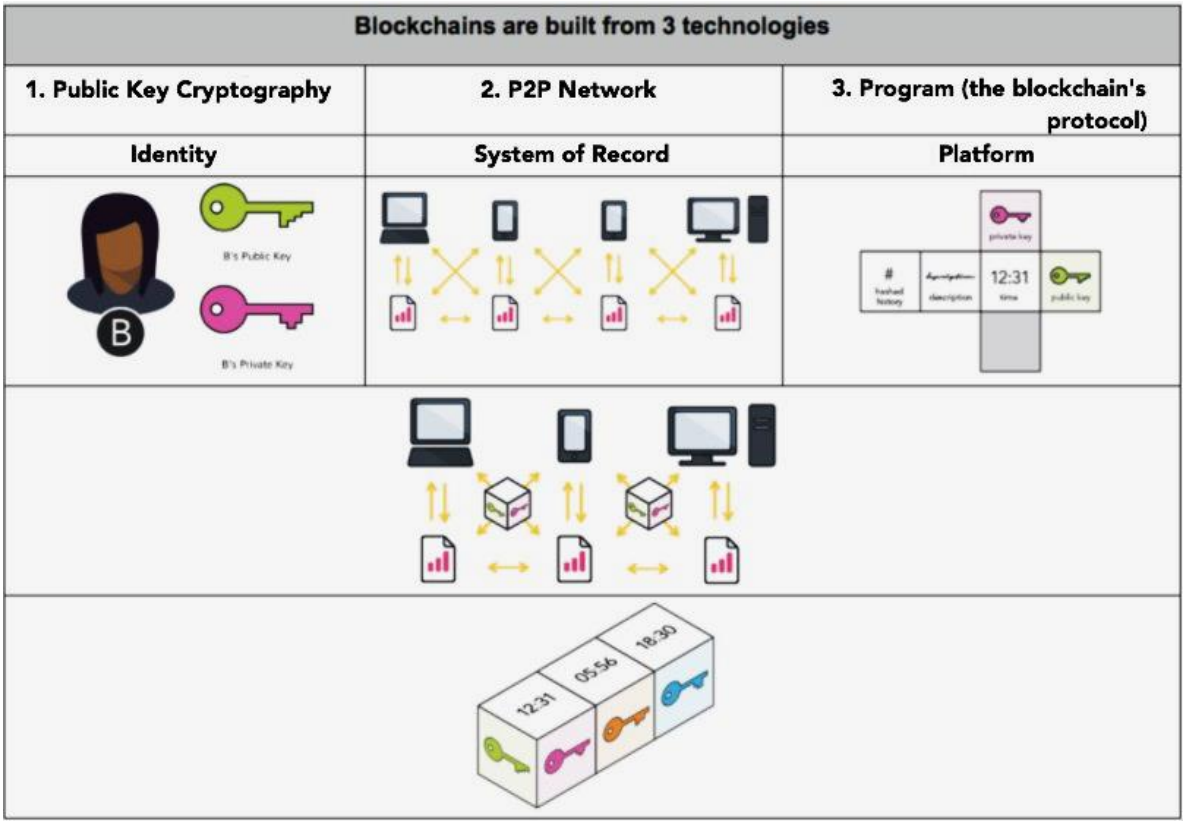

Figure 5 - Elements in a Blockchain. (Source coindesk.com)

The blockchain is a reliable, simple way of transferring information among a series of parties in a fully automated and safe manner, without the need for intermediaries, whereby any involved party has direct access to the complete and unaltered transactional record tracing all the way back to originating party. The first transaction event initiates the process with the creation of a block after an existing arrangement between two members, which is simultaneously verified by multiple terminals distributed around the net. After peer consensus is obtained, the verified block then becomes the starting point for a chain of blocks as the contents are passed from participant to participant, and is stored across the ledger in multiple copies, thereby creating an indestructible single unique record including its whole transactional history. It is worth to say that blocks are not randomly placed in a blockchain, they are linked to each other in proper linear, chronological order with every block, containing a hash of the previous one (Rabah, 2016).

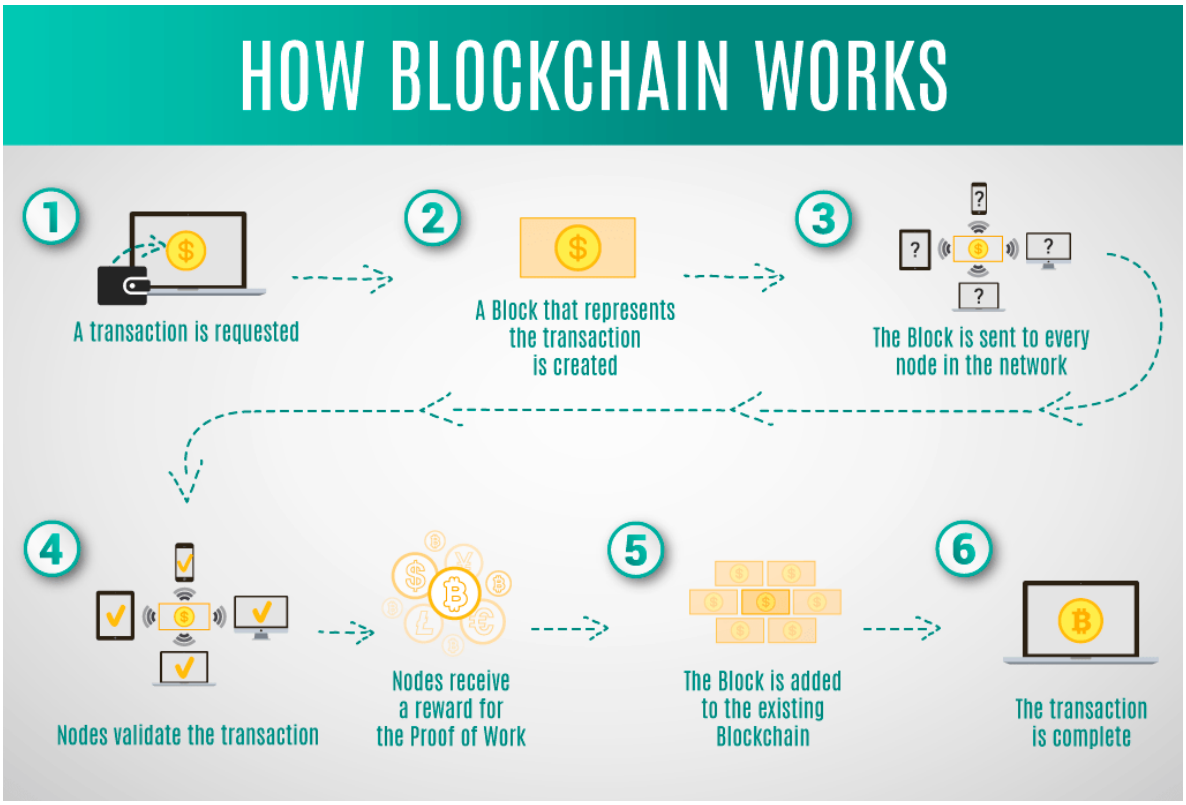

Figure 6 - How Blockchain works. (Source MLSDev.com)

With the lack of a central server or authority, transactions require a considerably lower amount of time to be stated and verified, compared to a centralized system. In terms of pure speed, blockchain is best suited for financial transactions, where no physical goods change hands, but this does not mean that its implication on other areas should be ignored. In fact, nowadays the technology is under increasing analysis and consideration for its implementation regarding the supply chain (Korpela, Hallikas, & Dahlberg, 2017). For instance, this technology can be used for tracking and monitoring assets, for communication purposes and information sharing, as well as for executing long-term and conditioned contracts, making records more robust and reliable.

Smart property and smart contracts.

The term smart property applies to every kind of asset, both tangible and intangible, that can be transformed into hashes by protocols behind Blockchain technology and can later be exchanged, registered or traced in the system (Wired, 2015). Ownership, control and

traceability of this encoded assets is permitted and regulated only with the use of private keys of parties. This control over the hash can be extended into the physical asset with the implementation of additional technology embedded into it, like QR codes, NFC tags, Bluetooth technology or IoT.

Another way to exercise control over smart property is by means of smart contracts. These are computer programs that encode a series of conditions and results (Mougayar, 2015). When an arrangement between parties takes place, the program verifies the fulfillment of stated conditions, and determines and executes the corresponding outcome (Szabo, 1997). Employing smart contracts, which are defined by a computer code, and are automatically enforced and executed by it, translates into a secure, real time completion of the contract, with low marginal costs associated.

Blockchain Platforms.

Nowadays, there are several companies and enterprises developing and applying their own different software and platforms based on the blockchain technology for a wide, and continuously growing, range of areas and objectives. The system behind Bitcoin is merely an example of its broad possible application. The following represent other well-known platforms.

Ethereum

"*Ethereum is a decentralized platform that runs smart contracts: applications that run exactly as programmed without any possibility of downtime, censorship, fraud or third-party interference.*

These apps run on a custom built blockchain, an enormously powerful shared global infrastructure that can move value around and represent the ownership of property." (Ethereum, 2018)

Figure 7 - Ethereum Logo. (Source Ethereum.org)

Ethereum is an open source platform which allows anyone to build and to use decentralized applications employing BC technology. There is no recognizable owner or controller in the project, and it is aimed to be adaptable and flexible, since it is simple for users to create and share new applications inside the system.

Being a programmable blockchain, it enables users to create new operations at will, of desired complexity, instead of providing a pre-defined set of available operations. This opens the doors for an unimaginable amount of different applications for the technology, among which logistics can be found.

All of this is possible thanks to Peer-To-Peer network protocols, and the implementation of the 'Ethereum Virtual Machine', that runs in each of the nodes in the net and allows peer consensus across the Blockchain. The EVM is the runtime environment for the Ethereum platform and can execute computer codes of arbitrary algorithmic complexity. Users' creations can be programmed and modelled on existing languages like C or Python, for example, and are stored on the BC on a specific binary format, independently of the written language, by applying an EVM compiler. (Ethereum Homestead, 2016).

Hyperledger.

"*Hyperledger is an open source collaborative effort created to advance cross-industry blockchain technologies. It is a global collaboration, hosted by The Linux Foundation, including leaders in finance, banking, Internet of Things, supply chains, manufacturing and Technology*." (Hyperledger - The Linux Fundation, 2018)

HYPERLEDGER

Figure 8- Hyperledger Logo. (Source Hyperledger.org)

The Hyperledger project is an open source platform for the Blockchain, established on December 2015 by the Linux Foundation with the goal of supporting BC distributed ledgers. With it, the Linux Foundation aims to create an environment in which communities of software developers and companies meet and coordinate to build blockchain frameworks. With the focus on ledgers designed to assist company transactions, including global tech firms, financing entities and supply chain players, it seeks to improve related aspects like performance and reliability. The project's main objective lays on increasing and converging existing individual efforts to develop standards and open protocols, as well as to provide with a general modular frame that supports different components for different uses (Preukschat, 2018). This means, the existence of a variety of Blockchains, with their own models, consensus and services. Hyperledger incubates and promotes a great number of business based on Blockchain technology, among which frameworks, digital libraries, graphic interfaces, private networks and smart contract motors can be found. All of this enables a faster innovation rate regarding the subject, and a rapid widespread as well.

Contrary to most other blockchain projects, whose focus is on cryptocurrencies and tokens, the Hyperledger projects show strong potential towards the construction of the backbone of non-monetary industrial applications for this technology (Blockgeeks, 2018).

"*The most valuable role the Hyperledger Project can play is to serve as a trusted source of innovative, quality-driven open source software development community; creating modular, open source components and platforms; all focused on distributed ledger and smart contract technologies. If Hyperledger can forge a brand that is widely seen as the accepted default 'safe' deployment platform for enterprise teams, and be seen as a great home for active*

collaboration around new technologies, then I think we can say 'mission accomplished'." (Behlendorf, 2016)

Hyperledger Sawtooth

Created by Intel Corporation and later on moved to the Linux Foundation, Hyperledger's Sawtooth is a modular blockchain suite, written in python language and designed to perform on many diverse fields, not only financials. It is suitable for both, permissioned and permissionless applications and employs a consensus algorithm known as Proof of Elapsed Time – PoET. (Blockgeeks, 2018). In addition, this platform makes use of so-called 'Transactions Families' to englobe business logic. These families can be as simple or as complex as the developer decides, representing from single transactions with its validity and state updates to virtual machines with their own codes and capable of executing smart contracts (Middleton, 2017). Even though users are expected to produce their own transaction families, Sawtooth provides some general ones which cover main applications, the following represent a few examples:

- End Point Registry, to register ledger services.
- Integer Key, to test deployed ledgers.
- Marketplace, to buy, sell and trade digital assets.

Figure 9 - Sawtooth Logo. (Source Hyperledger.org)

Among recent Sawtooth's application tests, there exists one concerning supply chain and logistics that stands out. The platform is used to record the entire process where seafood gets from the ocean to the final consumer. It employs 'Internet of Things' sensors and tracks

ownership, possession and transfers, and a series of parameters throughout the whole supply chain.

This way, the buyer has access to a complete and reliable record of the product history and its condition during the process, before the acquisition (Hyperledger, 2017). On a general basis, the Sawtooth Supply Chain transaction family enables users to track goods as they move through a supply chain. This include the history of ownership and custodianship, as well as relevant data for a variety of properties, like temperature and location, managed through a user-specifiable system of record types.

Based on this, the infrastructure necessary to track physical objects in a real-world supply chain on the Sawtooth Ledger can be identified. Records are tracked on the Ledger and are uniquely linked to the physical objects they represent (Hyperledger Sawtooth, 2017). Every element on the Supply Chain is serialized with protocol buffers before it is stored in state. Agents, Properties, Records and Applications can be present among mentioned elements.

Agents:

They represent the actors in the system, these are entities capable of affecting records by means of transactions and are identified by their public keys. Agents can play the part of both owners and custodians in the system, since they can represent the actual legal holder of the good stated in a record, or merely hold possession over it, like logistics and transport entities for instance. Furthermore, not only companies and legal persons can act as agents, but also some autonomous sensors involved in the transaction process that modify existing records. Agents must be stated on the Blockchain in order to interact with records (Hyperledger Sawtooth, 2017).

```
// Agents are essentially public keys registered with a human readable name on
// the chain. They will be able to create Records and submit Applications for
// ownership or custodianship.
message Agent {
    string identifier = 1; // the hex-encoded public key of the Agent
    string name = 2; // a human readable name
}

// Container for on-chain Agents.
// Allows multiple to be saved at a single address in case of hash collision.
message AgentContainer {
    // List of Agents - more than one implies a state address collision
    repeated Agent entries = 1;
}
```

Figure 10 - Ledger representation of an Agent. (Source Sawtooth.Hyperledger.org/docs)

Records:

These represent physical objects in the world being tracked by the Supply Chain. Each record is associated to its own Natural Key, take the serial number for example, so as to be identified in the system and to allow its interaction with agents. They also list the history of the item's owners and custodians in a chronological order, and may be finalized. This means that the product has finished its course on the supply chain and updates to the record can no longer be made.

Most, if not all, of the transactions in the platform involve previous or brand-new records (Hyperledger Sawtooth, 2017).

```
// A Record tracks a physical item with a history of its owners and custodians.
message Record {
    string identifier = 1; // the natural key of the record, serial number or
    // attached sensor identifier

    int64 creation_time = 2; // the time the record was created

    message AgentRecord {
        string agent_identifier = 1; // the public key of the agent
        int64 start_time = 2; // the time the agent started in the role
    }
    repeated AgentRecord owners = 3; // list of the owners, ordered from oldest
    // to newest. The first by definition is the creator of the record.
    // The last is the current owner of the record.
    repeated AgentRecord custodians = 4; // ordered list of custodians.
    // Same ordering as the owners list.

    bool final = 5; // is the record finalized, finalized records cannot be
    // changed.
}

// Container for on-chain Records.
// Allows multiple to be saved at a single address in case of hash collision.
message RecordContainer {
    // List of Records - more than one implies a state address collision
    repeated Record entries = 1;
}
```

Figure 11 - Ledger representation of a Record. (Source Sawtooth.Hyperledger.org/docs)

Properties:

Represent a list of historical data from a determined field regarding a good tracked on the supply chain, take temperature or location for instance. Values stored are complemented with timestamps and identification of the involved agent. Since it is inefficient to store all this information under one address, properties present their own name code derived from the property itself and the associated record. Without considering this, adding a simple update would mean to revise the whole record's history and rewrite it (Hyperledger Sawtooth, 2017).

```
message Property {
    message Reporter {
        // The public key of the Agent authorized to report updates.
        string public_key = 1;

        // A flag indicating whether the reporter is authorized to
        // send updates. When a reporter is added, this is set to
        // true, and a `RevokeReporter` transaction sets it to false.
        bool authorized = 2;

        // An update must be stored with some way of identifying which
        // Agent sent it. Storing a full public key for each update would
        // be wasteful, so instead Reporters are identified by their index
        // in the `reporters` field.
        uint32 index = 3;
    }

    // The name of the Property, e.g. "temperature". This must be unique
    // among Properties.
    string name = 1;

    // The natural key of the Property's associated Record.
    string record_id = 2;

    // The Property's type (int, string, etc.)
    PropertySchema.DataType data_type = 3;


message PropertyPage {
    message ReportedValue {
        // The index of the reporter id in reporters field
        uint32 reporter_index = 1;
        // Approximately when this value was reported, as a Unix UTC timestamp
        uint64 timestamp = 2;

        // The type-specific value of the update. Only one of these
        // fields should be used, and it should match the type
        // specified for this Property in the RecordType.
        bytes bytes_value = 11;
        string string_value = 12;
        sint64 int_value = 13;
        float float_value = 14;
        Location location_value = 15;
    }

    // The name of the page's associated Property and the record_id of
    // its associated Record. These are required to distinguish pages
    // with colliding addresses.
    string name = 1;
    string record_id = 2;

    // ReportedValues are sorted first by timestamp, then by reporter_index.
    repeated ReportedValue reported_values = 4;
}
```

Figure 12 - Ledger representation of a Property. (Source Sawtooth.hyperledger.org/docs)

Applications:

These are used by agents to change their role regarding a given good, meaning owner or custodianship. When the intention is to change the role of another agent, say authorize a different entity as the new owner, custodian, the application takes the form of a proposal. If a new application concerning a record is created, the current agent in the role must accept or decline the request before updating this last one. In the same way, proposals can also be accepted, rejected or canceled, and it is not possible to create more than one application/proposal for a role involving the same combination of record and agents (Hyperledger Sawtooth, 2017).

```
// Applications are a request for ownership or custodianship of a Record.
message Application {

    string record_identifier = 1; // the natural key of the record
    string applicant = 2; // public key of the applicant
    int64 creation_time = 3;

    // Whether this Application is a request for ownership or custodianship
    enum Type {
        OWNER = 0;
        CUSTODIAN = 1;
    }
    Type type = 4;

    // The current acceptance status
    enum Status {
        OPEN = 0;
        CANCELED = 1;
        REJECTED = 2;
        ACCEPTED = 3;
    }
    Status status = 5;

    string terms = 6; // human readable terms
}

// Container for on-chain Applications.
// Allows multiple to be saved at a single address in case of hash collision.
message ApplicationContainer {
    // List of Applications - more than one implies a state address collision
    repeated Application entries = 1;
}
```

Figure 13 - Ledger representation of an Application. (Source Sawtooth.hyperledger.org/docs)

Blockchain for Logistics and Parcel Delivery.

Case Study.

The following pages will attempt to introduce and summarize a real case study concerning a start-up company's whitepaper. On it, the enterprise seeks to conceive a fully operational delivery network based on a blockchain technology running protocol. The main aspects of the project are to be presented, along with an interpretation of its basic protocol functioning and operational levels.

The PAKET Project:

PAKET global, a decentralized delivery network, is a blockchain driven delivery platform project whose aim is to improve the efficiency in the delivery market. Upon completion, the protocol would allow different players from all around the globe to ship and receive goods in a quick and safe manner thanks to the reliable nature of the BC technology and to the use of smart contracts. Enabling anyone interested in participating to do so would enhance the performance of the system, whether they are individuals or entities, professional or amateur, permanent or occasional participants (Thorpe, 2018). However, this comes together with the challenge of establishing trust and reliability, and it is up to the blockchain foundations of the platform to solve this problem.

What is more, the routing efficiency could be highly improved with the possibility for packages to be passed on to an unlimited number of couriers and storage facilities, accordingly to the most suitable delivery strategy. The PAKET network will be open for other existing organizations to take part in as well. Courier associations, insurance companies and big logistic enterprises could participate in the system and help to achieve high standard performances (PR Newswire, 2018).

Figure 14 - PAKET logo. (Source Bitrebels.com)

"*PaKeT is using blockchain technology to disrupt the industry, enabling a win – win solution for the entire ecosystem: empowering local couriers, reducing operational costs for huge global shipping companies, and enabling faster, cheaper routes for the end user*." (Levin & Gampel, 2018).

With the creation of a decentralized and open market in which anyone can take part, a much more efficient, faster and cheaper good transporting mechanism can be achieved. To this end, the start-up presents a multi-layered cryptographical protocol which establishes trust and cooperation between agents and parties involved. The following paragraphs will attempt to introduce and briefly explain the protocol above which the project stands, based entirely on the public access whitepaper uploaded to the company's web page (PAKET, 2018).

To begin with, the cryptographic token employed in the platform must be introduced. Called BUL, it is intended for payments and represent funds to be handled by a virtual escrow system. The protocol ensures that when a launcher sends a determined item to a receiver by means of a courier, the transportation payment is securely held in a virtual escrow until confirmation on the package arrival. It is only after this that the payment can be approved and executed. Furthermore, in this so-called proven delivery system, the sender might require a collateral from the carrier as an insurance when transporting the good in question.

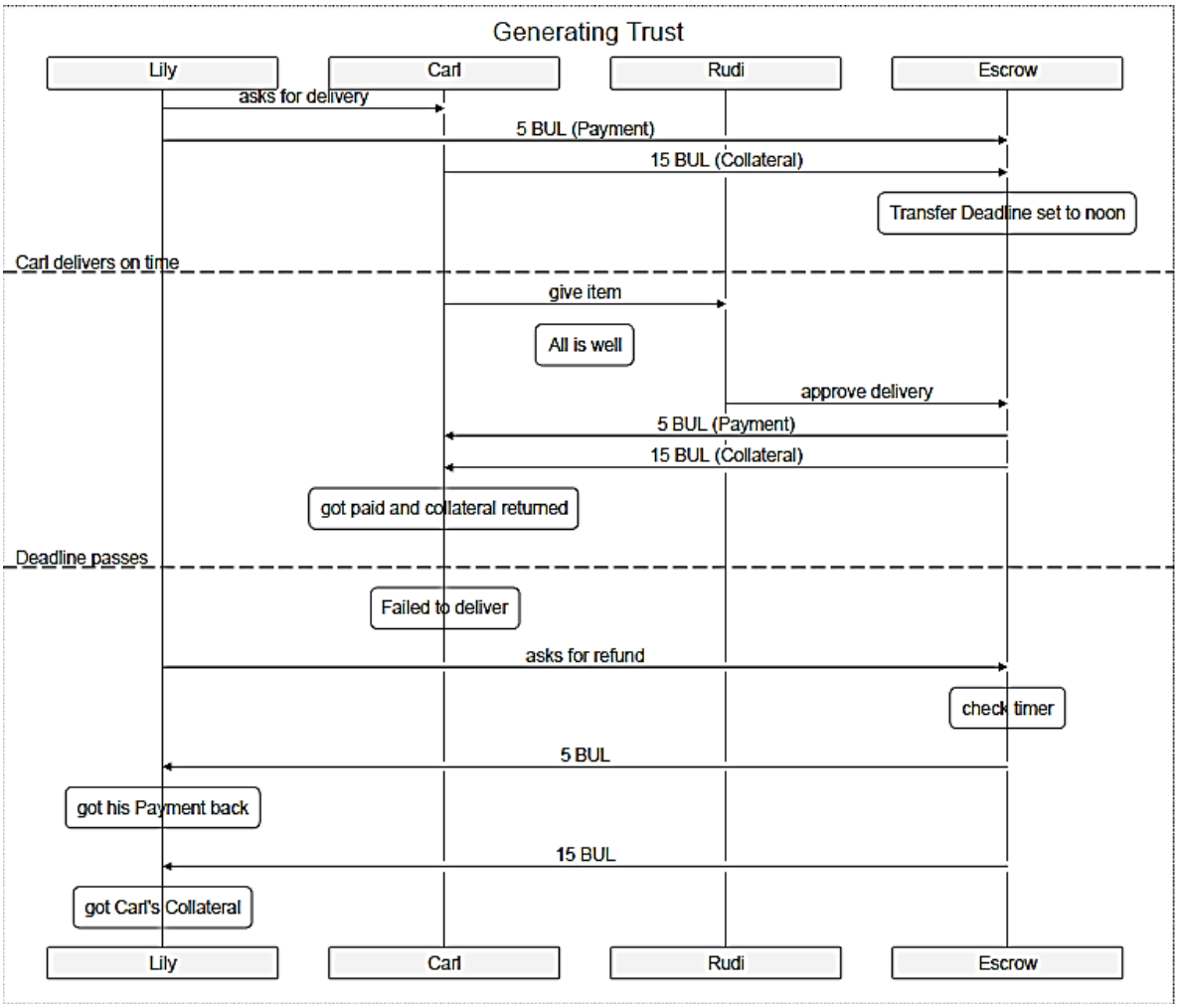

Figure 15 - Simplified PAKET delivery protocol. (Source Whitepaper [The PaKeT Project])

The main structure of the protocol can be subdivided into different layers, each one contributing to the overall functioning, and providing utility to the layers on top of it. The 5 recognizable levels are presented in the following pages:

Layer 0 – Trust

Composed by the blockchain itself and the addresses necessary to identify agents involved, it is the ground of the protocol, providing the framework needed to write, publish and enforce transactions and contracts among parties, while keeping an immutable record. It is in this level that decentralized consensus concerning transfers of value is achieved. The

project currently implements the Stellar[1] platform for the role of layer 0. However, this could be modified in the future by employing other options, like Ethereum for example, or by developing its own distributed ledger technology.

Layer 1 – Token

This level basically establishes the transactional framework necessary for the delivery of goods, binding together launchers and recipients with carriers by means of a token-based payment and collateral system, and providing the cryptographic token and the smart contracts to be employed. In other words, the layer enables the execution of deliveries, from simple and single ones to others more complex and effort demanding. It describes how payments and collaterals are handled, sets delivery deadlines and allows for courier relays, in which the package can be transferred among many participants and HUBs[2] seeking for the optimal and more opportunistic delivery route.

The tool implemented in this part of the protocol is Solidity[3], mainly because of its compatibility with the main Level 0 platform options. It is worth saying that the user would never be expected to get involved with the layer in question, its interaction is strictly linked to the higher levels of the protocol. Nonetheless, its actions present a chain of implications affecting each of the layers in a decreasing order up to the very center of its foundation, the blockchain, where every event is recorded and distributed to the entire network.

Layer 2 – Route

L2 sets a medium in which Launcher and recipient's necessities are matched with the capability of carriers. A certain request from a sender can be answered and fulfilled by the offer of a determined courier. This puts together a sort of supply and demand governed

[1] The Stellar network is a distributed blockchain based ledger and database that facilitates cross-asset transfers of value, including payments. (Source https://cryptocurrencyfacts.com/what-is-stellar/)
[2] Refers to the sorting facility where a package will arrive, be stored and be assigned to a new route or carrier in the delivery process.
(Source https://www.quora.com/Whats-the-meaning-of-arrived-hub-when-delivering-package)
[3] Solidity is a contract-oriented programming language for writing smart contracts, and It is used for implementing them on various blockchain platforms. (Source https://en.wikipedia.org/wiki/Solidity)

market for the delivery system. To this end, a messaging network for establishing contact between the two parts is needed, particularly a decentralized one, where communications are authenticated with the same keypairs and addresses used in the lower layers. This way, agents can be recognized a reached easily through the different levels. In addition, it is on L2 that the optimal and more opportunistic route is defined, according to the requirements previously stated.

In order to create a single route according to what was determined in layer 1, a set of conditions must be met, some of them have already been introduced, and some other are presented in this step as delivery properties. These may include pick-up and delivery times and locations, specific requirements or miscellanea in diverse forms (range of temperatures at which the package must be kept during transportation for instance).

Additionally, the protocol allows the modification of the original routing, which includes the fully detailed path, into an opportunistic one, optimized in real time once the cargo is on route. This can lead to better results by taking into account aspects, conditions and situations unconsidered when developing the initial plan.

The infrastructure for this layer is still under develop, seeking for the most suitable technology among a brunch of options. Nevertheless, the concept behind it is completely defined and feasible. The next figure presents an example similar to that shown before, but with a higher level of complexity and adding the main features introduced in this phase, like Hubs and the messaging network.

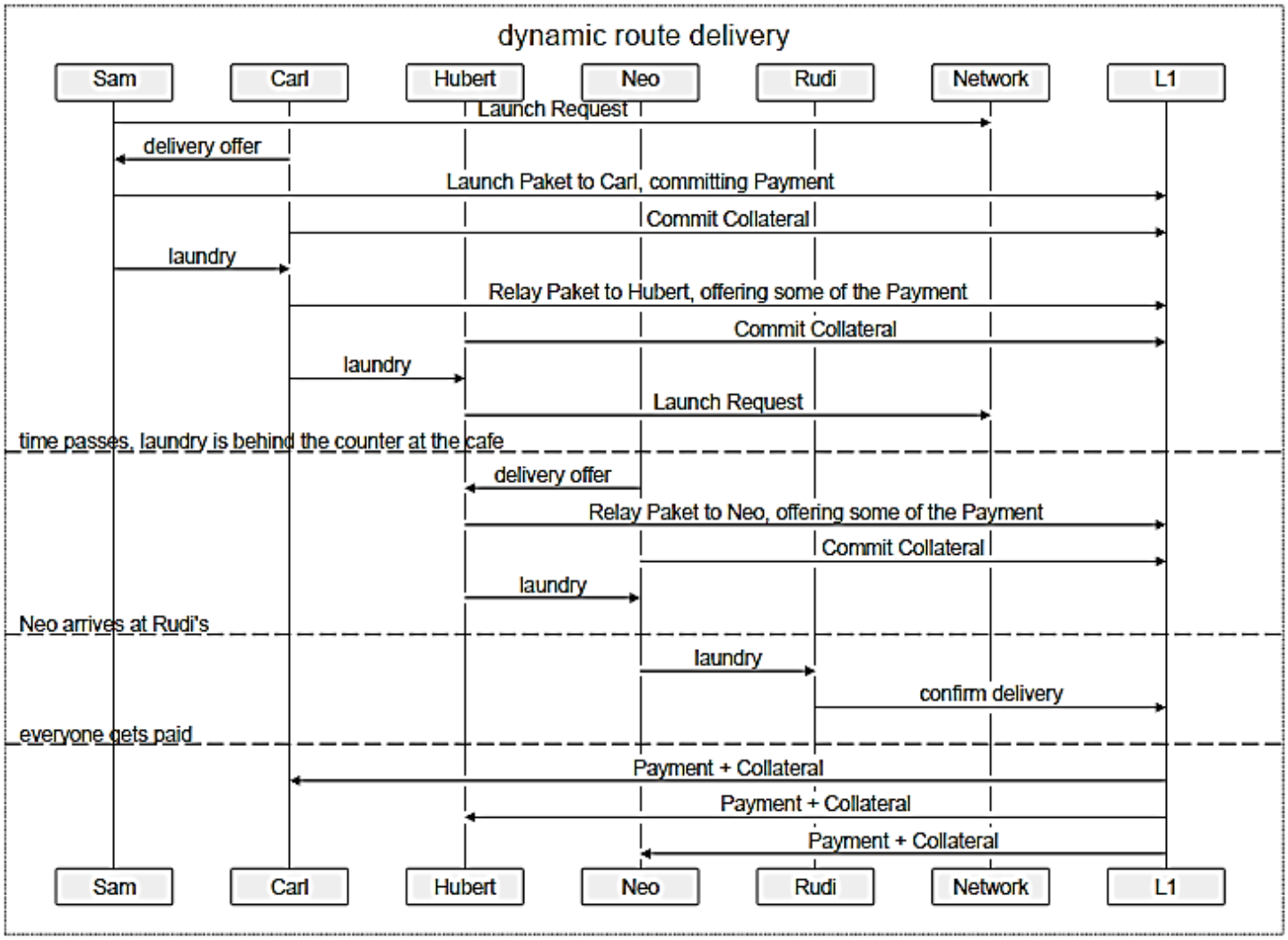

Figure 16 - Dynamic route delivery example. (Source Whitepaper [The PaKeT Project])

Layer 3 – User Application

L3 provides the tools and applications necessary to deal with the interaction among the user and the framework. These allow a simple and intuitive usage of the system and work as a link between participants and the lower levels of the protocol. While mentioned tools are currently in development process, the network already counts with the minimum sufficient applications that allow early functioning, and the general idea is to improve and extend them while encouraging the user community to get involved in the procedure.

The user interface is designed to support and manage the following:

- Wallet app – Permits the possession and transfer of BUL tokens.

- Launcher and receiver app – Enable users to specify delivery requests, to select among different carrier offers, to launch and track packages and to be notified along the process.
- Courier app – Allows participants to publish their capacities and offers as carriers, and to accept and carry out requested deliveries.
- HUB app – Permits the creation and management of Hub storage facilities.
- Data app – Collects, analyses and presents information and statistics regarding the network and its players (Maps of network coverage and utilization for example).

Layer 4 – Economy and Organizations

This layer is in charge of handling and dealing with the different organizations that may get involved and interact with the network. This is done in order to enhance the protocol and to improve the quality and amount of services provided. External entities have the opportunity to develop and add their own applications and services to the user layer, enriching the platform and earning their share in the process. Despite being the less advanced stage of the project, there are some clear objectives and possibilities in the horizon that, amongst others, include existing delivery companies taking part in the program, as well as new courier and Hub associations, insurance companies, publicity agencies and foundations.

Empirical Findings.

Literature Review.

Although Blockchain Technology is a highly discussed topic nowadays, with growing importance and participation on the research field, most of its associated literature only concerns about financial applications, payment systems, the development and widespread use of cryptocurrencies and general descriptions of the BC functioning and characteristics. Alongside with non-excludable literature when referring to the subject, like Nakamoto (2008) and Szabo's (1997) work for example, these texts result useful for setting a general understanding of the technology and a knowledge base ground of its implications. However, it is proof that there is a lack of conducted research within other possible fields of application.

For the sake of this report, in addition to the mentioned writings, other non-academic materials where used to frame the background, including enterprises' web pages (e.g. Hyperledger and Ethereum), online blogs and newsfeed (e.g. CoinDesk), expert quotes and conference reviews. After collection, this information was accordingly screened, categorized and analyzed in order to identify similarities and linking points, and to simplify the working process.

With the goal of focusing the spectrum to the scope of this thesis, a search was conducted containing the term Blockchain combined with other keywords, like logistics, supply chain and parcel delivery on different academic sources (Scopus, ScienceDirect, IEEE, Elsevier, among others), as well as on Google Scholar, that resulted in a relatively small amount of academic papers, of which an even smaller portion turned to be in line with the actual purpose of this study. As stated before, the conducted work centers on exploring the potential of implementing blockchain technology as a tool for improvements in the delivery market, specially concerning parcel or package deliveries. To this end, it is possible to consider previous work on the subject regarding supply chain and logistics in the manufacturing process, leaving aside the production phase, since the same principle of transporting a determined item or good from a sender to a recipient is followed in both, a B2B or a B2C relationship.

As it is highlighted in the work by (Perboli, Musso, & Rosano, 2018), existing literature mostly consider business modelling and technology design processes, and omitting proper strategy methodologies, let us say disregarding the actual value for the actors involved and poor cost – benefit analysis. According to the authors, this is one of the reasons why a great part of these Blockchain projects end up in failure, or with low life expectancy. Nonetheless, it is a reality that this technology is on an early stage, and there is still a lot of space for future development and breakthroughs.

Most of recent writings approach the subject of blockchain in the supply chain by emphasizing how the technology's intrinsic characteristics and nature can be proven useful for the delivery process and can lead to improvements in the field. The authors (Gallay, Korpela, Tapio, & Nurminen, 2017) claim in their paper "*A Peer-To-Peer Platform for Decentralized Logistics*" that a distributed ledger based on the blockchain, together with data sharing mechanisms and internet of things (IoT) could significantly aid the secure tracking of deliveries as well as the background logistics system. This is due to: enabling real-time routing, package and good's tracking along with its relevant conditions, the secure and reliable handle of registered information, and the integration of different agents on the chain in a high-speed, efficient manner. In a similar way, the text "*Blockchain and IoT based Food Traceability for Smart Agriculture*" (Lin, Shen, Zhang, & Chai, 2018) propose a BC and IoT based framework for a food monitoring and traceability system, seeking for a more environmental-friendly solution, while reducing operative costs and substituting the need for trust among parties involved. Taking this one step forward, some authors Like (Álvarez-Díaz, Herrera-Joancomartí, & Caballero-Gil, 2017) highlight the crucial role that smart contracts can play in the sector, added to what has already been mentioned. Allowing for the recognition of agents and users in the scheme, while enabling them to interact with the object/element of interest and the delivery process (changes in the custodian and ownership states). Although in the example proposed by the authors the focus is on luggage logistics management in an airport, the idea can be easily extended to the field of interest of this study.

To continue with this analysis, conducted work by (Meng & Qian, 2018) should be analyzed. On it, the writers propose an assessment model for estimating delivery performances in the supply chain, based on a blockchain structure, which could change the usual post-delivery

evaluation process for a real time one, permitting immediate adjustments and operational decisions. To achieve this, Meng and Qian suggest substituting the most used key performance indicator (KPI) in the supply chain management (known as OTIF[4], denotes the capability of delivery of an entity expressed on a success percentage) with a breakdown representation derived from its principle, considering a weighted average of the individual production and delivery capability of every element on the supply chain. According to the authors, upstream participants of a chain have direct influence over the delivery capacity of a company, and should be considered in the evaluation scheme. But for this to be possible, an extremely complete and detailed information sharing network must exist between different entities on the supply chain, and here is where the blockchain platform excels. The next figure presents a visual representation of a supply chain system based on the blockchain that helps to summarize what has been presented so far.

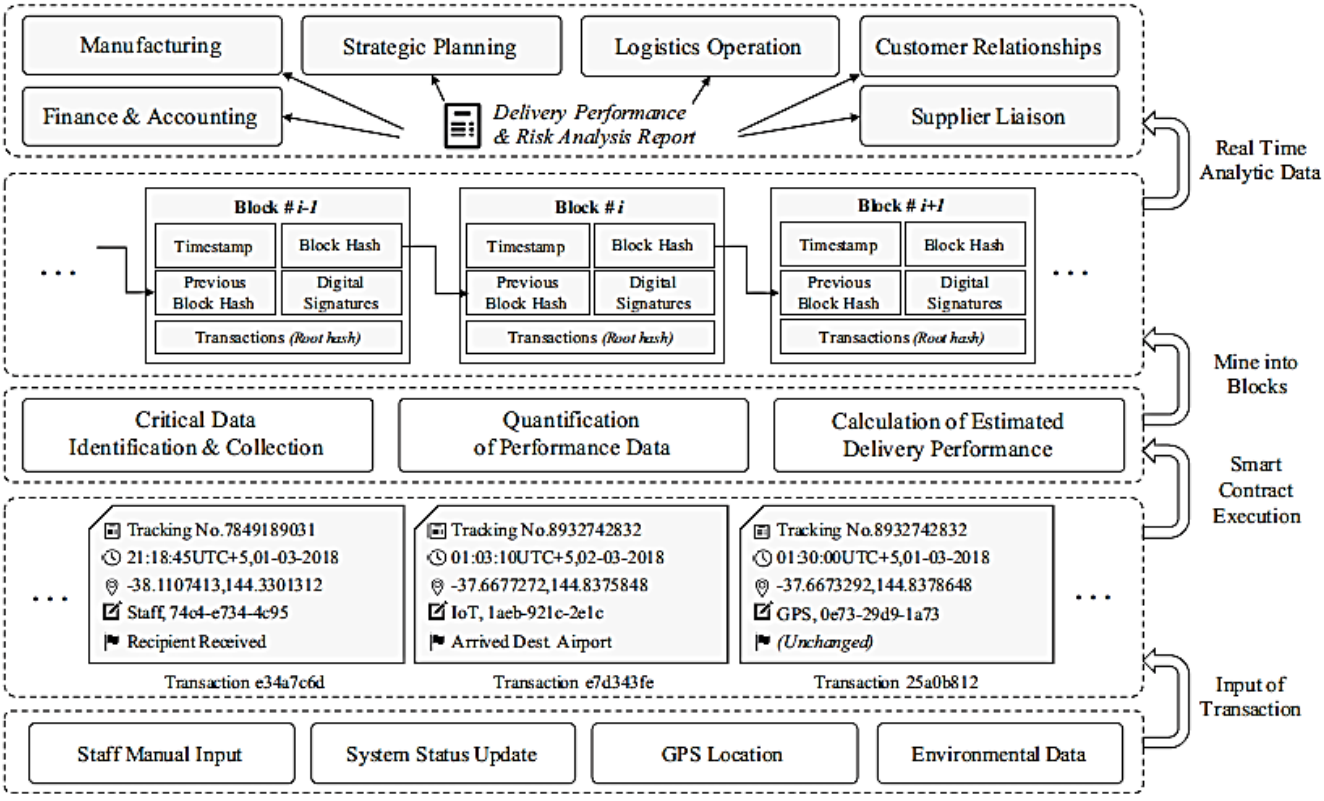

Figure 17 - Architecture of a Blockchain based Supply Chain system. (Source Meng & Qian, 2018)

[4] Delivery OTIF (On-Time, In-Full). [$OTIF\ KPI = \frac{N°\ of\ deliveries\ OTIF}{Total\ N°\ of\ deliveries}\ X100\%$]

This same structure can be simply applied to the Package Delivery Field, where the different participants on the network could be a number of delivery organizations, courier associations, warehouse and storage facilities, logistic service providers, shippers and customers, etc., that at the same time could be sub-divided into independent functional and operational units.

Another aspect worth mentioning when discussing the implementation of the Blockchain Technology in the Parcel Delivery Market is the possibility for anonymity. While this has been one of the pillars of cryptocurrencies since the introduction of the Bitcoin, where real entities could be covered and protected via pseudonyms and cryptography, the opportunity has not been exploited in the delivery sector yet. This came to the attention of authors (AlTawy, ElSheikh, Youssef, & Gong, 2017) from Waterloo and Concordia Universities, in Canada, who presented the project called "*Lelantos: A Blockchain-based Anonymous Physical Delivery System*". The descripted protocol enables and emphasizes the possibility for users to maintain their anonymity throughout the entire delivery process by means of a series of smart contracts, onion routing[5] principles, and braking down the full delivery plan into independent segments. Under this division, players on each segment only manage information regarding that specific part of the plan and are kept unaware of the rest. This way, no entity has full access to the complete profile of the customer and its data.

Case Study.

As stated above, the PAKET project case is proof that the blockchain technology is applicable to the delivery market, and can present some advantages and improvements compared to the current way in which companies on the sector manage and coordinate their efforts. Despite still being in the development phase, and at a very early stage, the project's basic operational functions have already been successfully tested and there is evidence of a clear path for further improvements. Even if the original plan fails, or if the protocol is

[5] Onion Routing is a technique for anonymous communication over a computer network, where messages are encapsulated in layers of encryption. Encrypted data is transmitted through a series of network nodes that "peel" away a single layer, each intermediary knows only the location of the immediately preceding and following nodes. (Source https://en.wikipedia.org/wiki/Onion_routing)

substantially modified in the future, conducted work and obtained results turn to be essential for setting the ground for future investigation and research, and to establish new objectives and horizons of what can be conceivable and achievable. In a similar way, there are other organizations developing and testing their own applications for the technology in the field. Take the case of Hyperledger's Sawtooth for seafood traceability exposed before for example. Even a retail industry giant like Walmart is interested in implementing the BC for their logistic and supply chain management, employing Hyperledger Fabric as the technical platform (Prisco, 2016). Existing efforts combined with the growing interest in the subject clearly indicate that this tendency will continue to gain strength and the number of entities looking to benefit from the implementation of the blockchain will increase in a future not far away.

Application Case Scenario.

The next few paragraphs will attempt to introduce a simplified hypothetical case in which a delivery company "X", that intends to implement a blockchain based structure, will be described and analyzed in order to recognize the main characters involved in its structure, as well as events in the chain and opportunities for the application of the mentioned technology.

With the assumption that company X is already well established in the business, and holds a wide functioning infrastructure which does not depend on external players or third parties, agents involved in the process can be easily identified. Let us consider that X owns a vast network consisting on 10 high capacity storage terminals and 400 branch offices distributed all over the country. It also counts with a known and fixed number of employees, divided into management, working staff, long distance truck drivers and couriers. For the purpose of this case, the whole hypothetical trajectory of a single item will be followed so as to get a notion of the possible number of events to be stated on a record's chain for a general use of the blockchain platform. So, following the idea that every item to be delivered will have a record on the BC to account for it, a block will be created for every delivery order, and each event through the delivery process will be stated and added to it,

giving place to a chain of blocks for the corresponding good. The length of these chains may vary among different orders, depending mostly on the delivery route between the sender and the receiver of the package, and the amount of properties or conditions to be tracked and controlled in the process. While for some orders the transportation might be simple and effortless, specially when distances are short, in some other cases the routing scheme may become complicated and more resource demanding.

It was said before that recognizing the agents intricated in the system could be relatively easy since they were mainly the company's personnel or facilities that interact with the package, and the users, being the launcher and the receiver. These last ones might be interested in checking the real-time state of the freight, and must confirm the proper receival. The next step would include identifying the events and transitions in the procedure. To this end, Item "Z" will be considered, that must be moved from a retailer's warehouse to the customer's address, which are separated by 900km. The first event to be stated would be the registration of the delivery order, where the record of the cargo of interest is created, and details of pick-up and drop-off locations are established [1]. Secondly, after the logistics plan is conceived, a carrier picks the package from the sending address and takes it to the nearest branch office [2]. In this office, the cargo is received and sorted accordingly to the existing delivery scheme [3] later to be loaded into small vans and be transported to the location-corresponding handling terminal [4]. Once again, the freight is downloaded and organized for further transportation [5] and stored until next step. From the terminal, a consolidated shipment composed of different items with the same destination area is loaded into long distance full-truckload carriers and taken to the terminal corresponding to the drop-off location [6]. Upon arrival, shipments are deconsolidated and arranged according to delivery specifications [7] and then the item is sent to a determined branch office, probably with an LTL (Less than Truckload) carrier [8]. When the package arrives to this office, final preparations for the delivery are done [9] and the object is given to a Last-Mile courier, who is in charge of carrying it to the final receiver [10]. Finally, Once the good is received by the client, the payment may be executed [11] and the record on the chain is terminated [12]. In addition to this series of custodian and ownership transfers, the current state of properties and conditions related to the product can be stated in the chain

along the process, enabling stakeholders to check and be assured of a proper handling of their property.

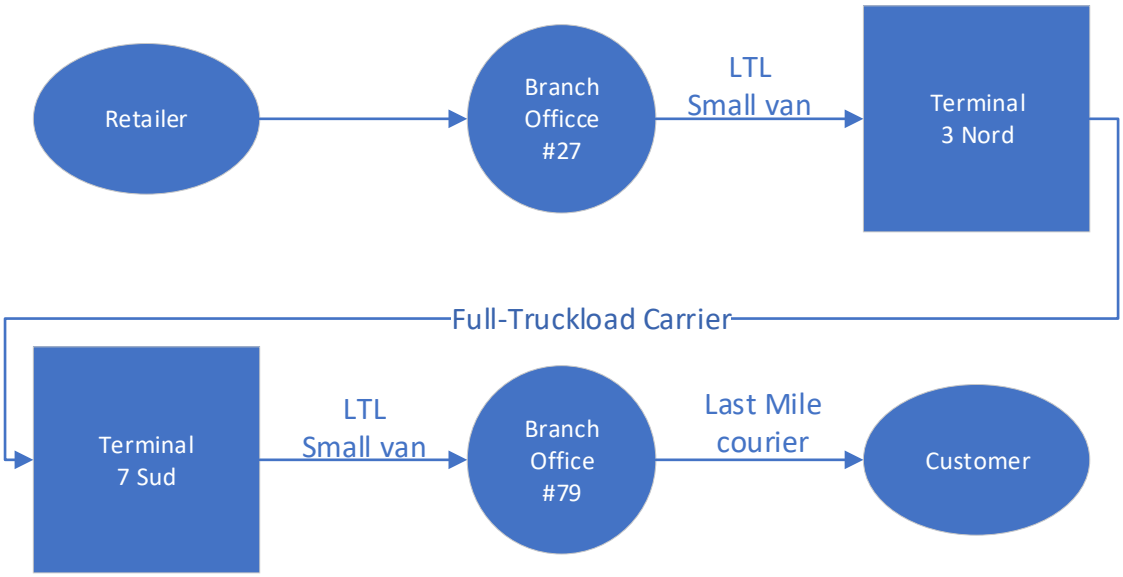

Figure 18 - Graphic representation of item Z's delivery scheme.

Blockchain Technology Delivery System.

As it can be seen, for the previous example a number of 12 events have been acknowledged, disregarding the possible property data to be indexed. Considering also that 11 agents interacting with the records are intricated in the system, it is feasible to implement a blockchain based platform above which the delivery business of company X can be carried out. If instead of a single unit, the whole company's performance is taken into account now, the number of statements increases dramatically, and this narrows the range of complying platforms based on the allowed transactions per second parameter.

After the application of the blockchain protocol to the business structure, each product would have a digital profile with all of its related information throughout the entire distribution process. To achieve this, every item must have corresponding identification in the form of a seral number, bar code, a QR code or NFC tags for example. This label represents the link between a physical element and its digital identity on the network, and works as a cryptographic key for modifying the records. In a similar way, actors must be registered in the system and hold a virtual profile, together with a pair of public and private

keys. These allow the participants to be recognized among the network, and to get authorization for interacting with existing records and other agents. Every actor involved in the structure can access the network via a user interface. This software runs on the blockchain and provides for the entry of new data and its access. Written protocols, programming codes and smart contracts rule the nature of the system and regulate the agent's activities. For instance, one of the protocol conditions could be that only an agent with the owner or custodianship over a given element may modify its associated record or begin a transaction with another agent. Then, due to the intrinsic nature of the blockchain technology, the status of the item's profile is updated, as well as the new set of permissions for the corresponding actors (Abeyratne & Monfared, 2016).

The data needed in order to update an item's profile record can be introduced automatically or manually by authorized actors through the interface application. This information can vary from one good to another, depending on its characteristics and on the delivery order details. Besides ownership and custodianship data, uploaded information might include timestamps, geographical locations, specific info regarding the object, environmental data or transporting conditions to name a few. The Internet of Things and integrated sensors could also play an important role in the proposed system, since they could easily receive, measure, interpret and upload desired information to the network, improving efficacy and reducing the need for human participation.

It is possible for each authorized partaker to access an item's digital profile with the purpose of retrieving information. By employing the product's identification and the user's private key, data will be displayed according to the stakeholder's role in the network. For example, the final costumer may see package details like timestamps, locations and transport means, but will not be able to access personal carrier information. The delivery company, on the other hand, has the clearance to check carriers and employees' personal data, like their social security number for instance, and the same happens with information regarding the company's facilities. The next figure presents an item profile record example, where different data entries might be available or locked depending on the credentials of the interested agent.

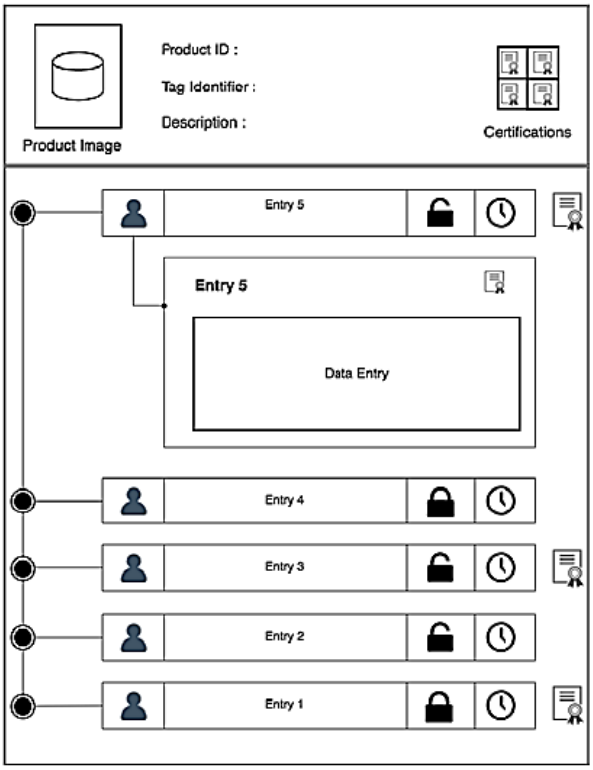

Figure 19 - Template for an item profile record. (Source: Abeyratne & Monfared, 2016)

Analysis.

Value proposition.

This section aims to present the intrinsic value of implementing a blockchain based platform into a dedicated delivery service, as it would be perceived by the different actors involved in the system. To this end, the GUEST methodology (The GUEST Initiative, 2017), presented by a research group from Politecnico di Torino is to be followed as a baseline on which to conduct the analysis. This procedure seeks to aid companies in the creation and application of frameworks for their business development and management via a series of well-stated steps (Go – Uniform – Evaluate – Solve – Test). The GUEST methodology provides with a simple structure that enables players to communicate and interact while controlling the whole decision-making process from conception to late implementation. Standardization is of vital importance the procedure and so each step is properly defined and accurately detailed.

For the correct application of this technique, it is necessary firstly to identify different players in the system, outlining for each one of them their Jobs, Gains and Pains, considering the actor's perspective. To sum up, 'jobs' represent what a determined actor tries to achieve through its work or its involvement with the scheme, 'Gains' stand for concrete benefits sought by the actor, and 'Pains' are problems and negative outcomes related to an actor's job. Only after recognizing these elements it is possible to address the actual value proposition taking into account the so-called pain relievers and gain creators offered by the Blockchain Technology implementation (Perboli, Musso, & Rosano, 2018).

For this study, actors have already been introduced in previous chapters, and were categorized into four main groups: Launchers (including producers and suppliers), consumers or receivers, governments or regulating authorities and logistic service providers (Including carriers, warehouse managers, etc.). Take the launcher to start, it is easy to identify the player's Job as preparing and dispatching a given package to a determined receiver. That is the main task that the actor seeks to achieve by participating in the system. Regardless being a producer, a distributor or an individual, and whether the item to be

delivered is being sold or not, the recognized job does not change substantially. Moving on, and considering that the item is in fact being sold and is to be delivered to a customer, the actor's Gain would be an economical benefit as payment for the sale, and its Pains may include higher and unexpected costs, inefficient planning, time delays, information misunderstanding and resource misuse for example. With a similar analysis, for the case of service providers the Job can be identified as handling and transporting an item from the sender to a receiver while expecting a monetary retribution in exchange (Gain). Problems along the process could involve poor routing and logistics planning, deriving in increasing costs, time delays due to traffic, storage and warehouse issues, loss or damages on the item and breaches in stipulated conditions (Pains). The next category concerns regulating authorities, whose job focuses on ensuring the correct management and development of business activities from entities under their domain by means of regulations and laws. Most of related complications arise from poor information handling and the lack of proper recordings. Finally, recipient's job is to receive the delivered package, and the concrete benefit lays in physically acquiring the expedited item. One again, problems include time delays, damages to the item or arrival under improper conditions and order mistakes, to name a few. Taking all of this into account, it is now possible to present the actual value proposition of implementing a blockchain-based delivery service.

As it was already presented, there is a number of elements that the blockchain technology can offer to any delivery process, and these provide participating actors with advantages compared with current practices and an increase in the value perceived. To begin with, a blockchain-based system enables a fast and efficient integration of the different agents present in the process, which translates into a simple and clear real-time information flow. This full notion of the entire info path allows for the creation of better logistics and improved business planning, and, consequently, a reduction in associated costs. For service providers, lower costs mean an increase in profitability, and service users will not find prices affected by inefficient performance. In addition to this information network, distributed ledgers also offer secure and reliable information management, ensuring the veracity and accuracy of existing records, as well as their immutability without participants' full consent. This reduces the need for trust among parties, and permits them to acknowledge the situation in other parts of the process. Because of this, governments and regulating

authorities can have access to certified information without the need for auditing or other controls, and both, senders and receivers can check the current state of their delivery order at any time. Combined with other technologies, like IoT and tracking devices, this Blockchain network can provide a real-time item monitoring, considering the delivery status along with its relevant parameters and conditions. Not only the whole chain of possession could be accessible, but also the package state and the transport conditions through the entire course. This way, it is possible to guarantee and certify the compliance of the product regarding health regulations, transport normatives and/or customer demands. Applications on this field grow exponentially if the production process is also included in the network and the BC platform. Despite being of huge relevance for final consumers, also carriers and warehouse facility managers benefit enormously from item monitoring and real-time tracking. With this data, more versatile logistic structures can be applied and, together with on-route changes, can considerably reduce costs and unnecessary wastes of time and resources. What is more, the availability of high quality and reliable information helps to reduce human error and enhance forecasts and parameter estimates, achieving more accurate performance indicators that could help to improve the overall system.

Considering all of this, and applying it to a specific situation, it is possible to present a visual representation of the value proposition in the form of a value ring, where gain creators and pain relievers for each recognized player are displayed and ordered according to their priority. Authors (Perboli, Musso, & Rosano, 2018) present an example of a value ring application on their work, centering on a system composed of a producer, a warehouse manager, a distributor and the final user (Figure 20). But on the same way, other schemes can be used for the analysis and different value rings can be obtained. Figure 21 shows a simplified value ring regarding a structure composed by the launcher and receiver, local authorities and a delivery service provider, where priorities assigned are easy to identify and elements can be simply understood.

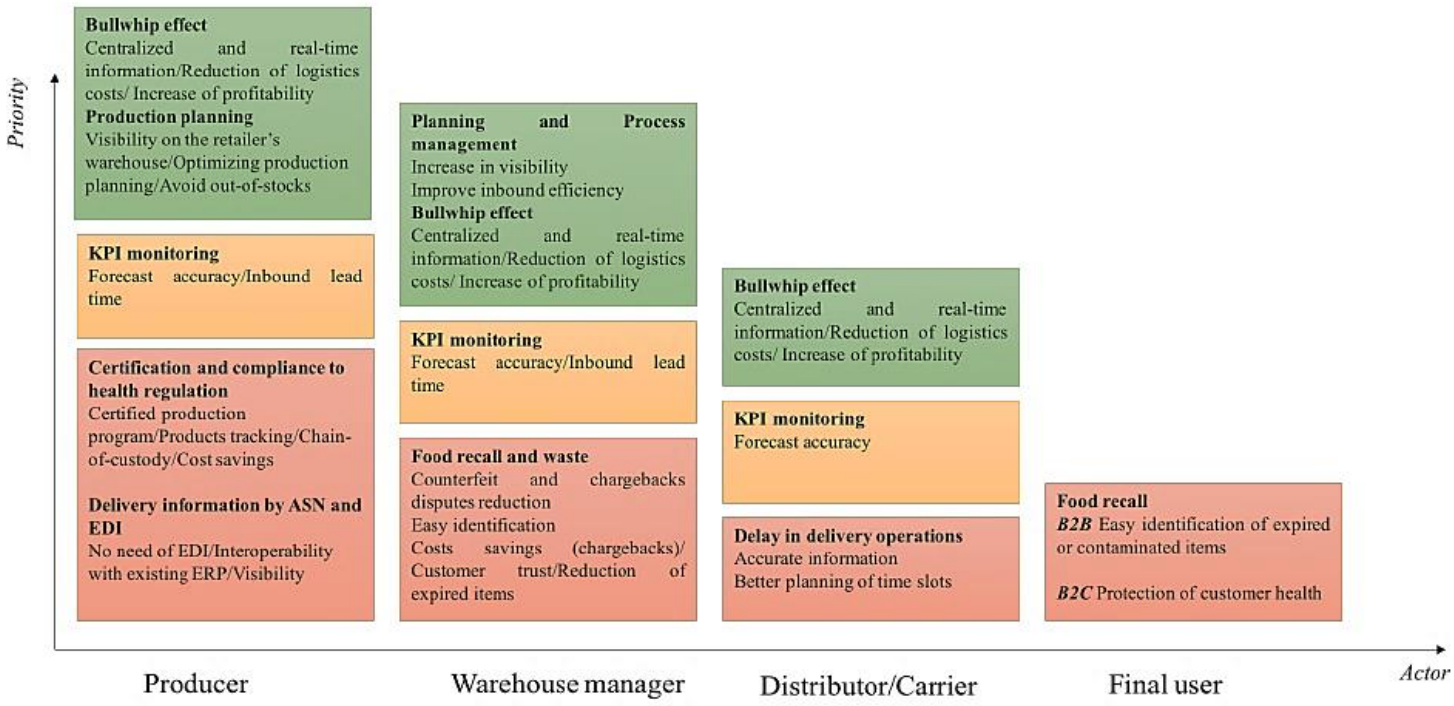

Figure 20 - Value Ring representation (Source: Perboli, Musso & Rosano, 2018)

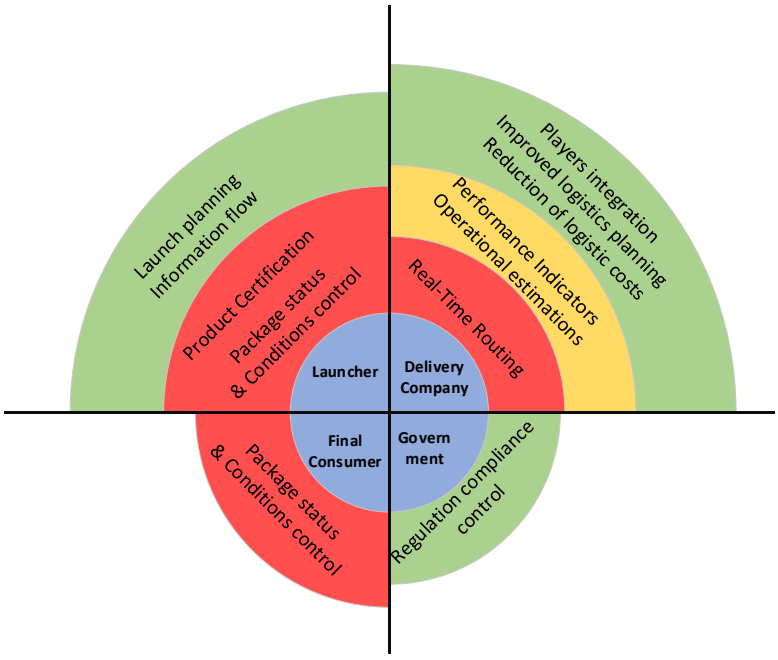

Figure 21 - Value Ring Simplified Example

Solution Canvas.

To continue with the conducted analysis, having already introduced the blockchain alternative, presented the main actors involved and the value proposition, it is now reasonable to conceive a possible solution for a generic dedicated delivery service provider with a canvas model representation. Based on the business model canvas, described by the authors (Osterwalder & Pigneur, 2010) as a tool that provides with a simple way to understand and work on a company's business model as a whole, the solution canvas (The GUEST Initiative, 2017) introduces a few changes and considers, for example, problem constraints and actor's relationship. It is also composed by 9 blocks, where each one represents a company's key area.

With the goal of implementing a blockchain-based delivery service, the decision maker behind the project can be recognized as a delivery service provider, a company developing its business activities in the delivery sector. Other players intricated, as already mentioned, are the service users/clients (Sender and receiver), regulating authorities and the different areas and personnel of the company in question. With a quite tangled scheme, most actors interact with each other and establish relationships and information flows. Warehouse managers gather information from launchers to organize material flows, and coordinate with distributors to set time windows and delivery routes for example. Authorities audit the company's compliance of regulations in force, and recipients obtain delivered goods from carriers.

A possible channel to carry out the proposed solution could be the employment of a pilot project (Perboli, Musso, & Rosano, 2018), where a selected section of the company would apply the presented scheme involving a limited number of users and clients, probably geographically bounded. By adopting the system on a reduced scale, its performance can be assessed and tested with lower risks. Moreover, a trial and observation period could be established, so as not to fully commit to the alternative and examine the system in detail before actually moving on with the implementation.

Once again, the main objectives related to the application of a blockchain technology platform into the system include setting up a decentralized network for actor's interaction that ensures a secure and reliable data management system, allowing real-time tracking

and monitoring in order to assure the compliance with exiting regulations, and the pursuit of improved process efficiency and estimation accuracy. Therefore, key activities and decisions must be in line with those objectives. These may include the selection of monitoring mechanisms, choices regarding information flows and agent interaction, the access to records and process status and the search for improvements and better predictions. To this end, vital resources needed are the blockchain technology itself, and a user interface on which agents can interact with the distributed ledger.

However, there are some obstacles implied that must be sorted during the implementation of the proposed solution. To begin with, for the correct functioning of the system, every actor involved must adopt the same platform and procedures so as to establish permissioned consensus. This means that not only the company in question, but also other agents on the chain must accept and get in line with the proposed system. In addition, the compatibility with current ERP has to be assessed in case modifications to the company's current practices and systems are needed. Also, the structure scalability should be foreseen, since it may be an alternative to migrate the system to a different platform, or increase the amounts of data flows. This way, models and records could be designed so that they can be modified or transferred in the future. Lastly, controls should be employed to ensure that the total volume of elements to be handled is on the records, no item should enter the chain without being accounted for and properly monitored.

The last block of the solution canvas refers to the cost structure. Main costs highlighted include, in the first place, the acquisition of Hardware and the Software platform, the installation of the blockchain and its integration with current systems, and any modification or adequation of existing software and networks. Furthermore, the inclusion of new personnel must be taken into account, specially regarding IP experts and project managers, and the pertinent training of both, new and existing employees. Finally, maintenance costs should also be considered in the solution analysis. In other words, costs mentioned are those necessary to develop, introduce and implement the blockchain alternative, and to maintain it over time.

<table>
<tr>
<td>Limitations/Obstacles

- Actors must adopt the same platform and standard procedures
- Establish a consensus-based permissioned digital ledger
- Compatibility with existing enterprise resource planning
- Predict structure scalability
- Total volume records</td>
<td>Key activities/Decisions

- Information flows and actor interaction
- Tracking and monitoring mechanisms
- Access to records and process status
- Improvements and predictions

Key Resources

- Distributed ledger platform (Stellar, Hyperledger fabric/Sawtooth)
- User interface</td>
<td>Value Proposition

- Implementing a blockchain-based delivered service.

The decision maker is represented by a delivery service provider.</td>
<td>Player Relationship

- Launcher → Service provider
- Service provider → receiver
- Regulating authority → Service provider

Solution Channels

- Pilot project
- Trial and observation period</td>
<td>Stakeholders

- Launcher
- Service providers (Distributors/ Carriers/ warehouse manager)
- Regulating authority
- Receiver</td>
</tr>
<tr>
<td colspan="3">Cost Structure

- Hardware and Software acquisition
- Installation of the blockchain and integration with current systems
- adequation of existing software and networks
- Personnel cost (IT experts, PM)
- Personnel training
- Maintenance costs</td>
<td colspan="2">Objectives

- Install a network for player interaction
- create a distributed, secure and reliable data management system
- Allow real-time tracking and monitoring, assuring the compliance with established regulations
- Increase estimation accuracy and process efficiency</td>
</tr>
</table>

Figure 22 - Solution Canvas

A Blockchain-based Delivery Service Alternative.

As it was already stated, Blockchain Technology can make some crucial contributions for the supply chain and logistics field. Although still being in an experimental phase, it is evident that this technology has much to offer and that it can be used in line with current needs and objectives. To continue with the analysis, it is important to evaluate its compatibility regarding current practices and established systems. Despite representing an innovative solution, the implementation of the blockchain does not imply major changes in today's way, and neither on the actor's needs and expectations. What is more, not only does it fulfill social norms and regulations, but also helps enforce them in a simple and effective manner. While it is true that the application of a blockchain-based service requires a considerable initial investment, most of the systems, structures and platforms in use can still be employed and, in some cases, upgraded. Take the use of coding systems and labelling for example. Nowadays QR codes, RFI or NFC tags are widely used along its corresponding software and technology. These grant the possibility to control and track a shipment through a company's internal platform, but this information is usually limited, not totally accurate or even missing sometimes and only available for a small number of participants. Following a blockchain based alternative, tagged items are turned into smart property and registered on the platform's chain, allowing all actors involved to trace the shipment's movements as well as certifying the correct fulfillment of stated conditions and norms, and thus granting a feeling of trust.

Another aspect worth mentioning when discussing the implementation of an innovative solution is its associated complexity, meaning the grade of difficulty related to its understanding and usage. On one side, the Blockchain Technology holds very complicated functioning protocols that require high levels of expertise for its full understanding and development, and this is mainly because of mining and hashing processes and the algorithms embodied into the system. On the other hand, once a blockchain platform is constructed and installed for a specific purpose, its interface is quite simple to use and manage. Combining a set of private and public keys, different actors can have access to the system and, after being logged in, these keys grant the possibility to conduct and record transactions or to check and update existing data bases, depending on the user's

credentials. Overall, it might be difficult to develop and implement a blockchain platform, also considerably costly, however, once online it should not require substantial efforts for its usage and for personnel training.

Having examined the complexity behind the proposed alternative and analyzed its compatibility with current schemes and methodologies, it is now worth stating some relative advantages over the actual practice, most of which have already been introduced in previous chapters. To start with, probably one of the blockchain main contributions is the opportunity for actor's collaboration and integration. Compared with the present situation, where information flows between different players are often broken or inefficient, a unified blockchain platform results far more beneficial. In addition, combined with the removal of the need for trust, and the exclusion of a central governing authority, operational and business activities can be smoothed, and action planning can be improved. All of this translates into a reduction in operative and transactions costs, and a better access to information, which can be more easily kept and secured by being recorded on the chain. What is more, the blockchain can enhance the use of existing technologies like QR codes, RFID, NFC and the Internet of things, and get more profit out of them. Monitoring and tracking systems can be improved as well. Lastly, the introduction of smart contracts substantially simplifies the exchange of goods and payment processes. As it was stated, the implementation of such a solution requires significant investments, however, expected benefits hold a much greater value, particularly those concerning inbound and outbound efficiency and process optimization. Improved information flows and enhanced logistics planning can reduce human mistake rates, which also implies a significant reduction in incurred costs.

It is a reality that this technology is still on an early stage, and it has not yet been widely implemented, particularly even less in the field of this study. But interest on its possibilities has risen, and some start-ups are starting to test its feasibility and its profitability. Any obtained results from these kind of projects along with other breakthroughs in the area should be closely observed and examined so as to reduce uncertainty of implementation and to get a notion of possible outcomes before actually committing to a blockchain alternative.

Conclusion.

Throughout this dissertation, as with many other academic papers, it has been made clear that the blockchain technology has a great strengths to be exploited outside the financial area. Focusing in the supply chain and logistics field in particular, it has been proven that the blockchain has many possible contributions to offer, and that it is completely feasible to conceive a delivery service based on the BC distributed ledger. The application scenario and case study previously presented provide an overall idea of how the proposed system could perform and its development, and together with what has been reviewed and analyzed from other authors' work, present a simple and clear idea of the technology's potential regarding the subject of interest of this study.

As it was said, the delivery sector is constantly growing and gaining importance among different economies, mainly because of E-commerce raise and the fast widespread of home deliveries. This increase in the sector's relevance makes it worth to invest and innovate on, trying to address its main associated problems, and seeking for improvements on its performance and profitability. These issues, which were introduced earlier, can be considered as opportunities for further development and progress, and thus efforts should be aligned into solving them. The main concerns considered in the conducted work include high incurred costs and unnecessary resource spending due to poor logistics planning, regulations compliance, lack of trust among parties, sustainability issues and environmental impacts, just to mention a few. The implementation of a Blockchain platform represents a way of approaching this complications and amend the situation, while searching for better results. The proposed system is mostly directed towards improving logistics planning and achieving an optimal use of the resources available, while at the same time enabling actors to interact on a secure and reliable network. Also ensuring immutable and accurate records helps counter trust issues and certificate regulation and stated-conditions compliance. However, other concerns like ecological impacts, which are not directly faced, may be reduced as a consequence of solving different situations. For example, by arriving to the optimal route planning for a specific order, transportation times could be reduced, and so would happen with traffic and CO_2 emissions related to that delivery.

Another aspect highlighted on this study that is worth mentioning is the recognition of the actual value proposition from the implementation of a blockchain platform, and its perception from the different actors' point of view. As it could be seen, each of the stakeholders' categories defined in the first sections of this paper would perceive improvements or relative advantages with respect to the current situation, and would obtain benefits from mentioned gain-creators and pain-relievers. Although possibilities for a blockchain application are vast and will probably continue to grow, the implication of the technology in the logistics field and delivery sector is still on an early research and testing phase, with little amounts of on-going projects. This is why it is of vital importance to conduct further investigations and observe in detail the development of existing projects and their results, so as to get a better notion of the technology's potential and only then move on to the next step, in this case, the execution of a fully functional blockchain platform for delivery services.

Finally, another fact worth outlining is that for the proposed alternative to work, different players must interact on the same platform, and this means that the larger the network, the better are the results acquired. Not only actors involved in the delivery system should be considered, but also those who are indirectly linked to the service or the item being transported. For instance, by including the producer of a determined good, and even its up-stream providers, some valuable information regarding the production and its conditions can be recorded and made available for the rest of the network, helping to certify and verify the product's qualities. Ideally, a chain of blocks could be formed, containing information and events from the extraction of the raw materials, through the entire production process, until the delivery of the finished product and its arrival to the final consumer. By extending the network, also the possibilities for blockchain applications are increased. Take auditing and quality control for example, or process standardization in the production system, these are all sectors on which the intrinsic characteristics of the blockchain technology could excel and be proven useful to enhance the process and to better the situation. There is no visible roof for what this technology has to offer to the industry and economies worldwide.

Future prospects.

Everything presented so far, together with other mentioned studies and conducted research, can lead to the consideration of this technology for particular projects and its integration with business strategies, later to conceive complete business models addressing methodologies to be employed, technical design processes and the corresponding cost-revenue analysis. However, this is not to be the final step in the implementation of a blockchain-based system since there is still room for advances and improvements. Besides a constant search for perfecting installed structures, the use of the blockchain could be extended to other fields that are somehow linked the project in question. New applications and possibilities should be investigated and tested within other areas, seeking to set up a network as wide as possible, and enabling a smooth integration of participants and events inside industrial and economical activities.

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